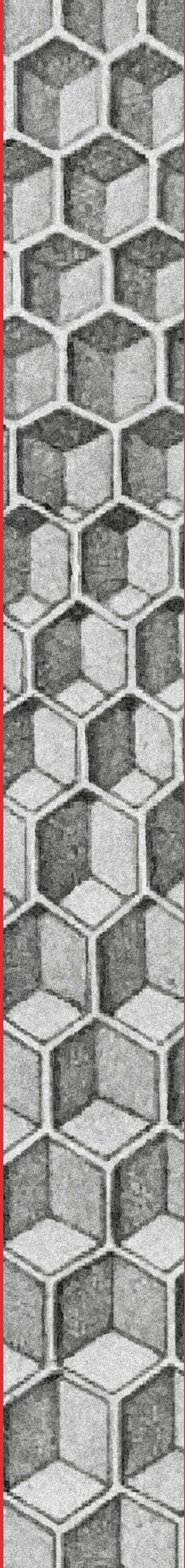

02

The Bee and the Architect

Scientific Paradigms and Historical Materialism

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Marcello Cini
Michelangelo De Maria
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Edited with an introduction by
Gerardo Ienna and Pietro Daniel Omodeo

English translation by Giuliana Giobbi

NOTES ON THIS EDITION AND TRANSLATION

Unless otherwise stated, all quotes are translated from Italian into English by the translator. Wherever an English edition has been found, references can be found it in the footnotes.

Since the parts of the book were written at different times, the reference style changes in the different parts of the book.

Appendix

Critical essays

An Italian Classic in Political Epistemology from the Seventies

Gerardo Ienna and Pietro Daniel Omodeo

1. The Radical Science Movement in Italy

In the wake of the international political turmoil generated by the protests of ’68, a large number of social movements sought to address the problem of politics in science. They also contributed to establishing a new awareness of the social function of science in ‘advanced’ capitalist societies. Although the question of scientists’ social responsibility had already been addressed before (notably by John Bernal)[1] and movements promoting social responsibility among scientists had already emerged after Hiroshima and Nagasaki,[2] they only became part of large radical-democratic and socialist struggles in the 1970s. As such, they became part of class and labor struggles, which went far beyond mere appeals to moral values.

Among the new groups, the *British Society for Social Responsibility in Science* (BSSRS) was founded in 1969. This was an association with a distinctly Marxist structure, which aimed to mobilize those scientists who were concerned about the social effects of their research and work. Shortly afterwards, again in Britain, a community of researchers and scholars began publishing the *Radical Science Journal*. At once, various subgroups formed within the BSSRS, including: Agricapital, Hazards, Women in Science, Politics of Health, Politics and

1 John D. Bernal, *The Social Function of Science* (London: Routledge, 1946).

2 See Kelly Moore, *Disrupting Science: Social Movements, American Scientists, and the Politics of the Military, 1945-1975* (Princeton: Princeton University Press, 2008).

Energy, and Radical Statistics. In 1969, the organization *Scientists and Engineers for Social and Political Action* (SESPA) was created in the United States and soon started the publication of *Science for the People* (the name by which this movement would later be known). In the same period, radical science movements in France disseminated their "critique des sciences" through a wide range of journals, magazines, and bulletins such as *Suivre et vivre* (beginning in 1970), *Labo-Contestation* (1970), *Le Cri des Labo* (1969-1972), and *Impascience* (1975).

The Italian context witnessed similar tendencies, following the social unrest of 1968 and of the "Autunno Caldo" (Hot Autumn) of 1969.[3] The Italian case differed from that of other 'Western' countries due to the general enthusiasm toward science shared by the hegemonic Communist Party (PCI, or Partito Comunista Italiano), which did not question the connection between technological and scientific advances, on the one hand, and societal progress, on the other. It should be recalled that the PCI played a unique political and cultural role in Italy, and was the largest and most influential Communist party in a capitalist country.[4] According to its official line, techno-scientific innovation should automatically foster societal progress. This is why, in order to critically engage with science, Italian radical science movements also had to emancipate themselves from dominant positions within the Left.

Yet, left-leaning political dissidents, such as the initiators of 'operaismo' (workerism), criticized the PCI's political line, including

3 This expression refers to a period of labor and worker struggles (partly inspired by the student protests of 1968) marked by a conspicuous number of strikes and factory occupations. The central theme of these claims was the demand for higher wages and greater labor protections. As a result of these events, the so-called "Statuto dei lavoratori" [Workers' Statute] was signed on May 20, 1970.

4 The period between the late 1960s and the first half of the 1980s marks the maximum expansion of the Italian Communist Party, which established itself as the leading Communist party in the entire Western world. Most notably, in the 1976 elections the PCI reached its peak support by gaining 34.4% of the vote.

in journals and newspapers such as *Quaderni Rossi*, *Quaderni Piacentini*, and *Il Manifesto*. The views expressed by the political thinker Raniero Panzieri are especially noteworthy as regards the reflection on science and technology. In his papers, published in *Quaderni Rossi*, Panzieri addressed the problem of technology from the perspective of Marxist studies by deriving crucial insights from Marx's *Fragment on Machines* (from *Grundrisse*)[5]. In 1963, this capital text was made available in Italian and referred to in much-quoted essays such as *Sull'uso capitalistico delle macchine nel neocapitalismo* (*On the Capitalist Use of Machines in Neocapitalism*) (1961) and *Plusvalore e pianificazione: Appunti di lettura del Capitale* (*Surplus Value and Planning: Notes for a Reading of Capital*) (1963). These publications paved the way to subsequent criticisms of the politics of science of the day.

Beginning in 1969, political conflicts emerged within the scientific community. As was already the case in the United States and France, scientists and technologists occupied research laboratories with increasing frequency. Among the most famous actions of this sort, one ought to mention the first occupation of the headquarters of the *Centro Nazionale delle Ricerche* (National Center for Research) in Rome in 1969, as well as the occupation of the International Institute of Genetics and Biophysics in Naples.[6]

In contrast to the official position of the PCI, Italian radical scientists were united by their criticism of the non-neutrality of science. They opened up a broad debate, marked by at least two ways of

5 Karl Marx, "Frammento sulle macchine", *Quaderni Rossi*, 4, (1963): 257-288. This text is part of Karl Marx, *Grundrisse* (London: Penguin, 1997).

6 On this point see: Laser (ed.), *Valle Giulia e la luna. Lotte dei tecnici e critica della scienza* (Roma, Università di Roma La Sapienza, 1999); Mauro Capocci and Gilberto Corbellini, "Adriano Buzzati-Traverso and the Foundation of the International Laboratory of Genetics and Biophysics in Naples (1962–1969)", *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, *33*, 3, (2002): 489-513; Francesco Cassata, *L'Italia intelligente: Adriano Buzzati-Traverso e il Laboratorio internazionale di genetica e biofisica, 1962-69* (Roma: Donzelli, 2013).

conceiving this problem. They argued that scientific production, like other cultural forms, is influenced by the historical and social conditions in which it occurs and is maintained. In this sense, science and technology are ideologically influenced by forms of cultural and economic hegemony. Moreover, science and technology were envisaged as forms of knowledge that contribute to structuring society, production, and power (thus bringing into play the question of the social function of science). In this sense, science and technology were seen as tools that can be used ideologically and contribute to the creation of cultural hegemonies, including emancipatory ones.

Drawing on these premises, various small groups began to emerge throughout Italy. They investigated issues of common concern and communicated their views by means of a large number of journals bearing titles such as *Sapere*, *SE Scienza Esperienza*, *Rosso Vivo*, *Testi e Contesti*, and *CRS Capitalismo Natura Socialismo*. More or less formal debates took place through meetings, too. In this context, monographs and collective works were published, as well as translations of foreign works that led to the circulation of ideas and the creation of transnational exchange opportunities for social movements belonging to different cultural traditions.[7] This was the case with the book series *Science and Politics* edited by Marcello Cini and Giulio A. Maccacaro (who inspired health struggle movements such as *Medicina Democratica*, that is, Democratic Medicine). Feltrinelli, the publisher of this translation, owned one of Italy's main publishing houses. The series comprised – and made available to the Italian public – seminal texts of the international radical science movement, including: extracts from *The Radicalisation of Science: Ideology of/in*

7 See for example: Simone Turchetti, "Looking for the Bad Teachers: The Radical Science Movement and Its Transnational History," in Elena Aronova, Simone Turchetti (eds.), *Science Studies during the Cold War and beyond: Paradigms Defected* (New York: Palgrave Macmillan, 2016).

the Natural Sciences and *The Political Economy of Science* (under the title of *Ideologia delle scienze naturali*), edited by Hilary and Steven Rose; *(Auto)Critique de la science* (under the title of *(Auto)Critica della scienza*), edited by Alain Jaubert and Jean-Marc Lévy-Leblond; and *China: Science Walks on Two Legs* (under the title of *Scienza e popolo in Cina*), edited by the Science for the People group.

As was the case in other countries, the physicists' community played a leading role in Italy. Within a short period of time, however, the process of radicalization of scientists extended to other disciplinary fields such as medicine, the life sciences in general, ecology, mathematics, and computer science. It was also at the initiative of the group gathered around Cini that De Donato (an academic yet politically engaged publishing house) printed the first Italian translation of *Science at the Crossroads*, the collection of the speeches of the Soviet delegation to the Second Congress of the History of Science (London, 1931), which had laid the foundation for externalism in the history of science.[8]

The Bee and the Architect can be regarded as the most vivid document of the Italian radical science movements of the 1970s and 1980s. Many saw it as a manifesto. First published in 1976 (but also including some articles that had already appeared elsewhere), this text was produced by a group of physicists from the Sapienza University of Rome: Giovanni Ciccotti, Marcello Cini, Michelangelo de Maria, and Giovanni Jona-Lasinio. Cini was the most prominent intellectual and political personality within the group. He was Full Professor of Theoretical Physics in Rome and already held important positions in the Italian Physical Society. As far as his political militancy is concerned, he had been a member of the PCI for many years but had eventually

8 Gerardo Ienna, "The International and Interdisciplinary Circulation of Boris Hessen's Theses," in Boris Hessen, *Manuscripts and Documents on the History of Physics: A Historical Materialist Textbook* (Venice: Verum Factum, 2022): 111–114.

been expelled along with other dissidents on account of his support of the Prague revolt and criticism of Soviet repression. He and others founded the political group and newspaper *Il Manifesto*. Moreover, Cini took part in the Russell Tribunal as a member of the Fourth Commission of Inquiry in Vietnam investigating US American war crimes. Jona-Lasinio, who was slightly younger, was Full Professor of Mathematical Methods for Physics.

2. Epistemology Meets Politics: Thomas Kuhn and Karl Marx

From the viewpoint of science studies, the most striking feature of *The Bee and the Architect* (1976) is its explicit aim to integrate two heterogeneous intellectual legacies, namely the epistemology of Thomas Kuhn's *The Structure of Scientific Revolutions* (1962) and Karl Marx's political theory. The book written by Cini and his group bears the programmatic subtitle: "Scientific Paradigms and Historical Materialism".[9]

"Scientific paradigms" was a reference to Kuhn's theory of the discontinuous progress of science. The group of Italian scientists reinterpreted the idea of the historically mutable frameworks of science – an epistemology of historically changing *a prioris* – in socio-political terms, in spite of the originally apolitical agenda of the American scholar, whose work was linked to the anti-Communist cultural politics of his mentor James Conant.[10] The authors of *The Bee*

9 On the radicalization of epistemology in those years, see Ienna, 2020.

10 On Kuhn's link to Conant and the political agendas underlying his work see Omodeo, "Copernicus as Kuhn's Paradigm of Paradigms: The Epistemological Dimension of *The Copernican Revolution*," in *Shifting Paradigms: Thomas S. Kuhn and the History of Science*, ed. Alexander Blum, Kostas Gavroglu, Christian Joas, and Jürgen Renn (Berlin: Edition Open Access, 2016), 61-86. For insightful remarks on the stakes of post-truth, see Luigi Pellizzoni, "Innocent, Guilty or Reluctant Midwife? On the Reciprocal Relevance of STS and Post-Truth," in *Tecnoscienza: Italian Journal of Science & Technology Studies* 10/1 (2019): pp. 115-130.

and the Architect looked at the 'structures' of 'normal' science and its 'ruptures' as something that did not exist merely in the intellectual realm. In their view, knowledge systems were rooted in society; hence, the connection between epistemological structures and sociological structures needed to be addressed both in relation to their 'normal' and 'stable' forms and in relation to revolutionary phases.[11] To be sure, the sociologization of Kuhn's paradigms is not unique to this line of reception, as British constructivists made similar interpretative attempts. The group around Cini was different, however, insofar as these scholars grounded their sociological views in the Marxist theory of society and confronted it with the class struggles of their time.[12] According to these researchers, far from transcending society, paradigms are the result of political agency. Thus, they deemed the following question to be both pertinent and politically relevant: "Who decides about the paradigm?".[13] *The Bee and the Architect* explicitly tackled this question, which related to a further one concerning the legitimacy of the scientific elites who set the research programs and determine the paradigms of normal science, in spite of being a minority among scientific workers and a very small one within

11 Giovanni Ciccotti, Marcello Cini, Michelangelo de Maria and Giovanni Jona-Lasinio, *L'Ape e l'architetto* (Milano: Franco Anceli, 2011), p. 54.

12 On the sociological reception of Kuhn see, among others, Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge: Cambridge University Press, 1998), pp. 13-27. As regards his own skeptical position vis-à-vis the sociology of paradigms, the remarks in the 1969 postscript to *Structures* are of utmost interest. See Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago-London: The University of Chicago Press, 1996), esp. pp. 176-181.

13 The same question has recently been addressed in the context of post-truth social epistemology. See Omodeo's essay "The Political and Intellectual Entanglements of Post-Truth: A Review of Steve Fuller's Post-Truth: Knowledge as Power Game," in *Public Seminar: In the Spirit of The New School for Social Research, Informing Debate about the Pressing Issues of Our Times* (http://www.publicseminar.org/2019/09/the-political-and-intellectual-entanglements-of-post-truth/) (18 September 2019). Post-truth approaches lack analytical rigor, as they merely point to power relations without considering their socio-economic grounding.

society.[14] Such a problem, which concerns democracy and power relations in scientific intellectual labor, lies at the heart of chapter two of *The Bee and the Architect*, “The Production of Science in an Advanced Capitalist Society”. This chapter emphasizes the central relevance of production. The Marxist analysis-cum-criticism of labor exploitation within historical relations of production was extended from the factory to the realm of scientific research. Hence, this reading of Kuhnian epistemology, far from being a mere sociological translation of statements about the scientific community’s validation of science’s paradigms, linked the latter to systemic considerations about societal formations, labor exploitation, and working-class struggles.

There was also another side to the political-epistemological challenge launched by the book. Alongside the political enframing science and of theory of knowledge, the authors of *The Bee and the Architect* pursued the epistemological integration of societal analysis and politics. They observed that the ‘founders’ of Marxism had not put science and knowledge theory at the center of their analysis.[15] Although Marx and Engels’s work provided many important insights into knowledge theory, and although their historical materialism could be seen as a methodological prototype for historical-natural inquiry, their discussions of epistemology were limited.[16] The reason for this limitation could be explained by considering the more limited role that science had played as a productive force in the nineteenth

14 On the problem of expertise see Gerardo Ienna, Flavio D’Abramo, and Massimiliano Badino (eds.), *Expertise ed epistemologia politica* (Milano: Meltemi, 2022). In general, the problem of the relation between democracy and scientific expertise was at the center of the debates on/against technocracy in the Sixties and Seventies. See, among others, Jürgen Habermas, *Technik und Wissenschaft als ‘Ideologie’* (Frankfurt/Main: Suhrkamp, 1968).

15 Ciccotti et al., *L’Ape e l’architetto*, p. 90. The expression “founders” here is taken from Leszek Kołakowski, *Main Currents of Marxism* (New York-London: W.W. Norton & Company, 2005), book 1.

16 With regard to Marx’s epistemology, Colletti’s work was – and still is – very influential: Lucio Colletti, “Marxism and the Dialectic,” *New Left Review* 93 (1975): pp. 3-29.

century, that is, in the phase of capitalism that Marx and Engels had experienced, analyzed, and criticized. According to the shared approach presented in *The Bee and the Architect*, the full potential of science as an indispensable asset for technology and capitalism in general had become evident over the course of the twentieth century with the emergence of the military-industrial complex and the commodification of science itself. Although the texts of the book date back to the Sixties and Seventies, their remarks still hold true, as the general tendency has not changed. On the contrary, social critique entails an adequate comprehension of the problem of science. Hence, the authors argued that it was necessary for political activists to deal with the problems of science and epistemology. Indeed, epistemology has become one of the indispensable areas of politics today, in relation to pressing themes that range from the multifaceted ecological crisis to pandemics management.[17]

In his contribution to the book, Cini regarded the connection between epistemology and politics as imperative. In a document concerning the political problems of research that he penned for the *Istituto Gramsci* in 1968, he argued that an important task for the workers' movement was "to indicate the times and modes of the bonding between socialist revolution and scientific revolution."[18] The connection between socialism and epistemology, far from being an obvious one in need of no articulation, proved a political aim to be pursued.

Against the programmatic background that we have outlined thus far, the meaning of the quotation in the title, taken from the first

17 See, among others, Naomi Oreskes and Erik Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (London: Bloomsbury, 2012), and Corinna Guerra and Marco Piazza (eds.), *Disruption of habits during the pandemic* (Milan: Mimesis international, 2022). For a general program of political epistemology today, see Omodeo, *Political Epistemology: The Problem of Ideology in Science Studies* (Cham: Springer, 2019).

18 Ciccotti et al., *L'Ape e l'architetto*, p. 33.

book of Marx's *Capital*, becomes clear:

> **A spider conducts operations that resembles those of a weaver, and a bee puts to shame many an architect with the construction of her cells. But what distinguishes the worst of architects from the best of bees is this, that the architect raises his structure in the *imagination* before he erects it in reality. (p. 58)**

This passage points to the central problem of the goals of science. Marx used the contrast between the bee and the architect – and the spider and the weaver, in the title of the French translation of the book[19] – to illustrate the fact that human creations, including marginal forms of production, are dependent on consciousness, knowledge, and intentions. They are fundamental components of human production, which mark the difference between the capacities of humans and those of other animals. Chapter one of *The Bee and the Architect*, "Scientific Planning against Scientism," emphasizes the relevance of goals in relation to the construction and development of science, because they determine what questions are relevant and what abstractions are necessary for the tasks that scientists take upon themselves within their societies. Decisions are always involved in the making of science; therefore, science and technology are marked by the interests that they follow. Since such interests are not individual but correspond to the changing functions of knowledge in society, science is intrinsically political. To use a formula, one could say that the political epistemology of *The Bee and the Architect* brings together: 1.) the problem of the socio-economic roots of science; 2.) the question of the functions of science; and 3.) matters of cultural politics. This

19 Ciccotti, Cini, de Maria and Jona-Lasinio, *L'Araignée et le Tisserand. Paradigmes scientifiques et matérialisme historique*, transl. by Charles Alunni (Paris: Seuil, 1979).

intellectual operation ideally connects Boris Hessen's structural analysis, John Bernal's functions analysis, and Antonio Gramsci's cultural critique of science.[20]

Scientific advancement is neither an internal problem, linked to some autonomous logic of science, nor a mechanical movement, the consequences of which are predetermined. On the contrary, techno-scientific progress is impossible without struggles for social emancipation. Without freedom, science is turned into a means of oppression, as it reinforces power asymmetries. It would be illusory to foster technological advances as a premise for future societal emancipation without political action – and this illusion, in those days, marked technocratic positions both in capitalist countries and in socialist one towing the Soviet line (as well as those communist parties that took the USSR as a reference point, such as the PCI). As Cini observed, scientific advancement without freedom reinforces exploitative dependencies and the means of oppression.[21] According to the introduction to *The Bee and the Architect*:

> The confidence in creating the most advanced technological and scientific bases first, within capitalist social relations, is beginning to appear illusory. These bases could no longer allow us to replace – easily and painlessly – what has become an anachronistic framwork with a social texture suitable to the level of development reached by the productive forces.

20 Omodeo describes a similar political-epistemological move in "L'eredità di Boris Hessen: Per un approccio socio-politico alla scienza in età moderna," in Boris Hessen, *Le radici sociali ed economiche della meccanica di Newton*, ed. Ienna (Roma: Castelvecchi, 2017), pp. 119-150.

21 Although he has often been accused of being anti-scientific, including by the authors of *The Bee and the Architect*, Marcuse argued for the need to free science and technology together with labor very early on. For an STS reappraisal of his ideas, see Andrew Feenberg, "Critical Theory of Technology and STS", in *Thesis Eleven* 138/1 (2017): pp. 3-12.

> **Our attention is now turning to the contradictions of social relationships.**[22]

3. The Impact: Italian Science Wars

The Bee and the Architect was published in the Feltrinelli series *Science and Politics* under the direction of Cini and Maccacaro. The publishing success of this book was tremendous and definitely unexpected for its authors. The first edition was sold out within a few weeks. In the first year alone, six reprints were issued, despite the large print run. In a very short time, the theses of the book began to circulate broadly and sparked lively debates. As soon as it was published, British Marxists Hilary Rose and Steven Rose had the chapter *The Production of Science in Advanced Capitalist Society* translated into English for inclusion in their edited volume *The Political Economy of Science*. A full-length French translation came out in 1979 under the title of *L'Araignée et le Tisserand: Paradigmes scientifiques et matérialisme historique*.[23] It was proposed for publication by one of France's leading radical physicists: Jean-Marc Lévy Leblond, who entrusted Charles Alunni with the translation. Some recently discovered correspondence has revealed that in 1981, after having enthusiastically read the French edition of the book, Bob S. Cohen proposed to Cini to have the whole volume translated into English, offering to promote the work for publication either within his prestigious *Boston Studies in Philosophy of Science* series or by other publishers:

22 Ciccotti et al., *L'Ape e l'architetto*, p. 24.

23 In 1978, a volume by François Mitterrand was published, entitled "*L'Abeille et l'Architecte*", which took inspiration from the same Marx passage that had inspired the Roman physics groups. The French translator and publishers were forced to change the title to "The Spider and the Weaver", drawing upon another passage from *Capital* that made use of the same metaphor.

> I have read with pleasure the French translation of your joint work *L'araignee et le tisserand; Paradigmes scientifiques et materialisme historique*; and this ought to be available in English. I could see it in the Boston Studies in the Philosophy of Science or in the other Reidel Series, Studies in the History of Modern Science, or I could recommend it to Monthly Review Press. Would you like to try this?[24]

Unfortunately, this project was never brought to completion: the book was never translated into English. From the exchange between Cini and Cohen, it is possible to speculate on two main reasons as to why the project failed. First, Cini seemed more interested in having more recent (and 'up-to-date') works of his published than *The Bee and the Architect*.[25] In his reply to the letter quoted above, Marcello Cini sent Cohen the proofs of *Il Gioco delle regole* (written in collaboration with Daniele Mazzonis), which would be published by Feltrinelli a few months after the letter was sent. At the same time, it is likely that Cini did not have the financial resources necessary to have the entire volume translated into English. In any case, correspondence between the two authors shows that Cini participated in the *Boston Colloquium for the Philosophy of Science* and that his ideas were beginning to circulate in the United States.[26]

One of the main reasons for the success of *The Bee and the Architect* lies in the specific Italian cultural and intellectual context of

24 Robert S. Cohen to Marcello Cini, March 1, 1981, in Marcello Cini Papers, Istituto di Fisica, Università 'La Sapienza', Rome, Italy.

25 Marcello Cini to Robert S. Cohen, April 10, 1981, in Marcello Cini Papers, Istituto di Fisica, Università 'La Sapienza', Rome, Italy.

26 Robert S. Cohen to Marcello Cini, October 7, 1980, in Marcello Cini Papers, Istituto di Fisica, Università 'La Sapienza', Rome, Italy. In this letter Bob Cohen invited Cini to give a lecture entitled *The Social Basis of Scientific Theory and Practice* on January 13, 1981 as part of the *Boston Colloquia for the Philosophy of Science*. The discussant was to be the Harvard historian of science Everett Mendelsohn.

the time. The publication of this book arguing for the non-neutrality of scientific knowledge engendered violent reactions on the part of several intellectuals who believed that its authors were questioning the validity of science. In a sense, this text was the spark that set off conflicts that had been latent until then. The Roman physics group gathered around Cini was simultaneously attacked by professional philosophers and historians of science, Marxist scholars, various members of the PCI, and liberals. This wide-ranging public controversy may be seen as an Italian anticipation of the (internationally) better known Science Wars. Indeed, it concerned the problem of the validity of the sciences and their objectivity, social determination, and political orientation. The polemic unfolded in the pages of major newspapers and weekly magazines, in militant journals and newspapers, as well as through typical scientific channels such as conferences. In contrast to the Anglophone "Science Wars", however, a remarkable specificity of the Italian political ones is that they bear witness to two opposing disciplinary and political fronts. While the critics of the neutrality of science were members of the community of natural scientists, who were trained in physics and taught this subject at universities, the champions of the neutrality of science were mostly humanists, historians, and philosophers of science.

The main opposition to the Radical Science Movements in Italy came from three mainstays of Italian academia: Marxist philosopher and historian of science Ludovico Geymonat[27] (and his Milan group

27 Ludovico Geymonat was the first to hold a chair of Philosophy of Science in Italy, which was created for him in 1956. Geymonat was a member of the Italian Resistance and, attracted to neopositivism, he spent several months of the winter semester of 1935 in Vienna in close contact with Moritz Schlick and other members of the Vienna Circle. Politically he was extremely active and, throughout his career he undertook an original attempt to rehabilitate dialectical materialism (after the scandals of the Lysenko affair) by integrating it with a historical perspective and some of the theses of neopositivism. He was one of the most influential Italian philosophers of the 20th century and built a substantial research group around his chair at the University of Milan.

of historians and philosophers of science); liberal historian of science Paolo Rossi;[28] and Marx scholar Lucio Colletti.[29]

In 1974, two years before the publication of *The Bee and the Architect*, Geymonat published a volume that may be regarded as the manifesto of the Milan school of history and philosophy of science. Entitled *The Actuality of Dialectical Materialism*, it was written in collaboration with Enrico Bellone, Giulio Giorello and Silvano Tagliagambe. Its theses were later reiterated and strengthened in Geymonat's essay *Science and Realism* (1977). Geymonat and his group, based in Milan, had been working on this program from 1967-68. They centered their analysis on the relationship between science and socialism, specifically investigating the transformation of Soviet scientific culture in the transition from Leninism to Stalinism. Concerned with the ideological drifts affecting the production of scientific knowledge in the Stalin era (a phenomenon later brought to public attention through the Lysenko affair[30]), this group attempted to rehabilitate the theoretical principles of dialectical materialism. To do so, Geymonat's school tried to connect the neopositivist trust in scientific facts and logic with dialectical materialism. In their view, this encounter would foster a neutral and progressive conception of scientific activity against ideological distortions. Their goals were mainly

28 Paolo Rossi was one of the most influential Italian historians of science. His works are well known internationally, particularly *Francis Bacon: From Magic to Science* (Chicago: Chicago University Press, 1968). In 1985 he was awarded the Sarton Medal by the History of Science Society. In 2007 John L. Heilbron edited the essays in Honour of Paolo Rossi entitled *Advancements of Learning* (Firenze: Leo S. Olschki Editore, 2007).

29 Lucio Colletti was an influential Marxist scholar. The following works have been translated into English: *From Rousseau to Lenin* (New York: NYU press, 1972) and *Marxism and Hegel* (London: Verso Books, 1973). He is also well-known for his celebrated "A Political and Philosophical Interview" published in the July/August issue of the *New Left Review* in 1974.

30 On the Lysenko affair see: Dominique Lecourt, *Proletarian Science?: The Case of Lysenko*, trans. Ben Brewster (Atlantic Highlands: Humanities Press, 2003 [1977]). For a specific analysis of the reception of these debates in the Italian context, see: Francesco Cassata, *Le due scienze. Il "caso Lysenko" in Italia*, (Torino: Bollati Boringhieri, 2008).

two: first, to reinforce the cultural relevance of science in Italy against the neo-idealistic tendency to downplay it in the wake of Benedetto Croce's influential philosophy (and partially that of Antonio Gramsci); second, to restore the credibility of a Marxist approach to science after the scandals of the Lysenko affair. *The Bee and the Architect* moved in a diametrically opposite direction, as it argued for the non-neutrality of science and favored the method of historical materialism against a dubious celebration of dialectical materialism.

Colletti's writings on Marxism and science had been an important theoretical building block for the formulation of the thesis of the non-neutrality of science. Yet, he did not welcome the publication of *The Bee and the Architect*. The theses advanced by these militant scientists turned out to be totally unacceptable because, in Colletti's view, their argument for the non-neutrality of science was theoretically wrong and politically idle. In 1976, he wrote a scathing review of *The Bee and the Architect* in a broadly read Italian weekly magazine, dismissing the book's theses with disconcerting simplicity: "Bodies fall in the same way under the action of gravity in socialist and capitalist countries."[31]

Along similar lines, Rossi – who had also been an early source of inspiration for some of these physicists who came to study the history of science – attacked the radical theses of the book by labeling its authors "Sunday epistemologists and amateur historians." He argued that their scientific training was rather an impediment than an advantage to their understanding of knowledge. The task of criticism, in his view, had to be reserved for professional historians and philosophers. Rossi made no secret of his aversion to Marxist thought: "Those who in their research work in Italy have referred directly to Marxism have generally followed two paths [that of Geymonat and that of post-Sixties culture]. Both lead very far from serious and articulated

31 Colletti, "La dea sragione," *L'espresso,* XXII, 17, April 25 (1976): pp. 66-71.

reflections on the science-society relationship."[32] In particular, Rossi saw the criticisms advanced by the Radical Scientists as a new form of irrationalism. On his part, Rossi embraced an approach that favored the intellectual history of ideas along the idealistic lines of Alexandre Koyré and Arthur O. Lovejoy.[33]

The theses set forth in *The Bee and the Architect* were also criticized by prominent members of the PCI such as Valentino Gerratana (the editor of the critical edition of Gramsci's *Prison Notebooks*) and Giovanni Berlinguer. The clash between Cini and the PCI leadership had already begun in 1968, during a conference on scientific research organized at the Istituto Gramsci by the party's cultural committee. It was only in 1969, however, that this polemic acquired a public dimension through a heated debate about the scientific and political meaning of the Moon landing in a series of articles published in the party journal *L'Unità* and the dissident Communist journal *Il Manifesto*. While the space race and the related techno-scientific progress had been widely celebrated by party members, Cini was skeptical about its real scientific and societal value. In the article "The Satellite of the Moon", which was reprinted as an appendix to *The Bee and the Architect*, he denounced the military, economic, and ideological interests behind space exploration.

4. Relevance to STS and Historical Epistemology Studies

32 Paolo Rossi, "Filosofia di fronte alle scienze: alcune discussioni sui rapporti scienza-società," in Giuseppe Cantillo, Eugenio Mazzarella (eds.), *La cultura filosofica italiana. Dal 1945 al 1980* (Napoli: Guida Editori 1982): p. 146.

33 In addition to these public attacks, Rossi had Ludwik Fleck's *Genesis and Development of a Scientific Fact* translated into Italian for the first time, to which he added an extensive introduction. In Rossi's strategy, Fleck provided a potential antidote to the anti-scientific drifts that the Italian reception of Kuhn was generating in Italian far-left circles. This is clearly a specifically Italian paradox of the reception of both Kuhn's and Fleck's works. On this point see Paola Govoni, "Il Mulino, la storia della scienza e la 'Cultural Cold War'," in Annarita Angelini, Marco Beretta, Giuseppe Olmi (eds.), *Una scienza bolognese? Figure e percorsi nella storiografia della scienza* (Bologna: Bononia University Press, 2015): pp. 347-364.

The originality and relevance of *The Bee and the Architect* – in terms of its historical, theoretical, and sociological understanding of the scientific phenomenon – extends far beyond its original Italian context and should not be neglected. The specific attention that this book devoted to the goals of science in close connection to historical questions about the origin of knowledge, the non-neutrality of science, and its transformative function make it a valuable starting point for reflections both in STS and in historical epistemology.[34]

4.1 Relations with STS as a Field

Marxist studies of science have played an essential role in the development of research on the relationship between science and society. In particular, during the 1960s, 1970s, and 1980s in the English-speaking world various historical and theoretical connections were established between the first generation of scholars in the field of Science and Technology Studies (STS) and radical science movements, because they shared the intention to highlight the problem of the non-neutrality of science. However, these alliances gradually broke up. Indeed, the process of academic institutionalization of STS led to a general loss of the critical Marxist dimension that lay instead at the basis of the approaches proposed by radical scientists.[35]

34 A chapter on *The Bee and the Architect* is featured in the recent introduction to the subject by Massimiliano Badino, Gerardo Ienna, and Pietro D. Omodeo, *Epistemologia Storica. Correnti, temi e problemi* (Roma: Carocci, 2022) and in Gerardo Ienna, "Esiste un canone dell'epistemologia storica italiana?," in Gerardo Ienna, *Genesi e sviluppo dell'*épistémologie *historique* (Lecce: Pensa Multimedia, 2023).

35 Brian Martin, "The Critique of Science Becomes Academic", *Science, Technology, & Human Values*, *18*, 2 (1993): 247-259; Evelleen Richards and Malcom Ashmore "More Sauce Please! The Politics of SSK: Neutrality, Commitment and Beyond". *Social Studies of Science*, *26*, 2 (1996): 219-228; Gary Werskey, "The Marxist Critique of Capitalist Science: A History in Three Movements?," *Science as Culture*, 16/4, (2007): 397-461; Simone Turchetti, "Looking for the Bad Teachers: The Radical Science Movement and Its Transnational History," in Elena Aronova, Simone Turchetti (eds.), *Science Studies during the Cold War and beyond: Paradigms Defected* (New York, Palgrave Macmillan, 2016); Sigrid Schmalzer, Daniel S. Chard, and Alyssa

The authors of *The Bee and the Architect* had no direct relationship with the emerging field of Sociology of Scientific Knowledge (SSK). Furthermore, at least at the time of writing the texts of this volume, they had no knowledge of the general structure of the debate that would lead to the establishment of STS. Indeed, the texts that make up the volume were written around the time when some of the early proponents of SSK such as Barry Barnes, the author of *Scientific Knowledge and Sociological Theory* (1974), and David Bloor, the author of *Knowledge and Social Imagery* (1976), were publishing their main contributions.[36] In *The Bee and the Architect,* there are only a couple of references to two essays contained in the volume *Sociology of Science: Selected Readings* edited by Barry Barnes. No other references to SSK can be found in the book. Nevertheless, many of the theses that were being developed in the English-speaking world were independently argued in the volume by the Roman physics group from a Marxist perspective.[37]

By developing the methodological principles of historical materialism, the authors highlighted that science is a human and historical product subject to the social, political, and cultural factors of its is produced. In contrast to the epistemology of dialectical materialism, according to such a model, nature itself "denotes all that exists: thus

Botelho (eds.) *Science for the People. Documents from America's Movement of Radical Scientist* (Boston: University of Massachusetts Press, 2018); and the special issue edited by Peter J. Taylor and Karin Patzke, "From Radical Science to STS", *Science as Culture*, 30, 1 (2021): pp. 1-116.

36 Although *The Bee and the Architect* was published in its final form in 1976, most of the essays that make up the volume had already appeared in earlier years. References to *Sociology of Science: Selected Readings* (edited by Barnes) were included in the third essay of the *Bee and the Architect* that was published by Ciccotti and Jona-Lasio in the Italian journal *Scientia* in 1973.

37 We would like to emphasize that *The Bee and the Architect* was published in 1976, the same year as David Bloor's *Knowledge and Social Imagery* (Chicago: University of Chicago Press, 1976), which is widely considered the most comprehensive version of the Edinburgh Strong Program. Significantly, Marcello Cini was one of the very few Italians to take part in the first conferences of the European STS association EASST in the mid-1980s. This means that on the European level his research was seen to fall within the STS field at that time.

not only what is pre-existent, i.e., the material on which one operates – as is proper to every historically existing materialism – but also he who performs transformations, the law that allows their occurrence, and their product. [...] Nature is inseparably given and made."[38] Thus, it would therefore be a mistake to construct a methodology based on a clear-cut separation between the analysis of human relations with nature and that of social relations.[39] Rather, one must first of all impartially apply historical materialism to the natural sphere as well as the historical and social spheres. Secondly, for the sake of consistency, one must avoid creating a methodological dissymmetry by understanding the relationship between the natural and the historical-social spheres as a one-way exchange (which would lead to a mechanistic approach).

The authors argued that just as it is impossible to account for the historical evolution of the organization of science without recourse to factors external to scientific knowledge, so it is also necessary to draw on social explanations when it comes to the processes of validation of scientific content. This means that the study of the adequacy of a scientific theory with respect to its empirical context must necessarily take into consideration the ideological elements that condition it.[40]

From this derives the view of the non-neutrality of science, which in strictly epistemological terms is encapsulated by the notion that "with regard to no form of knowledge is it possible to strictly separate factual judgments and value judgments"[41] – i.e., the idea that science and ideology are in close relation. It is therefore necessary to redefine the relationship that has traditionally been assumed

38 Ciccotti et al., *L'Ape e l'architetto*, p. 53.
39 Ibid., p. 87.
40 Ibid., p. 74.
41 Ibid., p. 66.

between praxis – generally understood as the "pure passive mirroring of a given object" – and theory – which would instead represent an "active manifestation of subjective thought" – by envisaging it as a unitary dialectical relationship.[42]

The point just described is precisely one of the most original features of *The Bee and the Architect*. Compared to other attempts to apply the analytical tools of Marxism from a socio-historical perspective, this text opened up the 'black box' of scientific knowledge, to use a key term found in social studies of science. Certainly, the idea of a close correlation between the emergence of the capitalist system, the rise of industrialization, and the birth of modern science was not new within historical materialism. What *The Bee and the Architect* added in terms of both epistemological and historiographical reflection was the thesis that there is a "coherence between theoretical knowledge and practice in any given society," indicating a certain degree of "autonomy of theoretical formulations with respect to facts."[43] In a nutshell, it is not only the social organization of science that is conditioned by the socio-economic structure, but its very theoretical content.

Applied science and the related technological innovations objectively operate as productive forces – that is, they play a cardinal role as structural determinants.[44] However, this is not sufficient to describe the social function of science in advanced capitalist societies, meaning that phase of capitalism in which 'information' becomes a commodity on a large scale: for it leaves totally unexplored the role that pure science acquires as a specific cultural form – that is, as a superstructural force that can be equated with ideology.[45] In this sense,

42 Ibid., p. 88.
43 Ibid., p. 77.
44 Ibid., pp. 92-94.
45 Ibid., p. 101.

the issue at stake is to show in what way representations of human-nature relations influence how individuals envisage their own position in social relations.[46]

Several similarities to some of the foundational theoretical cores of the Strong Program in SSK are quite evident from the passages just quoted.[47] In contrast to SSK, however, the authors of *The Bee and the Architect* came to the conclusion that one cannot open the black box of science without an explicitly critical-Marxist approach, that is, without undertaking a macro-structural analysis of the social function of science. For the authors of *The Bee and the Architect*, the ideology of neutral and pure science is organic to the capitalist system of production. From a historical-materialist perspective, the contents of science are always a reflection of capitalist relations of production, insofar as they are generated within the capitalist mode of production. It is functional to capitalist ideology to consolidate an image of scientific products as fully neutral, based on an objective description of the relations between man and nature, and grounded in a function that is entirely an end in itself and not socially determined.

This kind of description helps justify the undue extension of such descriptive neutrality to the "scales of values, patterns of behavior, forms of organization, and social purposes"' characteristic of the capitalist system of production which, for that reason, claims to absolutize its value of objectivity to the exclusion of other possible alternatives. This mechanism activates a process of technocratization – that is, the selection of expert skills to which decision-making power

46 Ibid., p. 105.

47 See classics such as Barry Barnes, *Scientific Knowledge and Sociological Theory* (London: Routledge & Kegan Paul, 1974); David Bloor, *Knowledge and Social Imagery* (Chicago: Chicago University Press, 1976); Michael Mulkay, *Science and the Sociology of Knowledge* (London-Boston: G. Allen & Unwin, 1979); Andrew Pickering, *Science as Practice and Culture* (Chicago: Chicago University Press, 1992); and Barry Barnes, David Bloor, John Henry, *Scientific Knowledge. A Sociological Analysis* (London: Athlone, 1996).

is attributed – intrinsic to the capitalist system itself. In such a way, the scientific organization of work and social life becomes the very principle ensuring the self-reproduction of capitalist society.

For these reasons, we believe that the translation of this volume into English can help to rethink the theoretical canon of STS, so as to reopen the dialogue between this field and Marxist studies of science.

4.2. The Contribution to Historical Epistemology

As much as *The Bee and the Architect* can contribute to the STS debate, it would be reductive to consider it a sociological essay, without taking into due account the crucial relevance of its historical analysis, epistemological reflection, and political theory as its key contributions to the reflection on science. Hence, we intend to stress the importance of the theses of the book for the political-epistemological debate fostered by Verum Factum. However, we should first take a moment to outline its relevance for historical epistemology more generally, beginning with a clarification of our understanding of this field.

Historical epistemology connects a historicized theory of knowledge with a theoretically-informed history of science.[48] Whithout denying the worth of their perspectives, our collective approach goes further as we here understand historical epistemology as a reflection on scientific knowledge which takes into account the entangled dimensions of 1. the genesis, 2. validity, and 3. the goals of science, in connection to 4. world-transformative praxis. We take 'genesis' to refer to the historical origins (including the socio-economic roots) of

48 Dominique Lecourt, *L'épistémologie historique de Gaston Bachelard* (Paris: Vrin 1969) and Hans-Jörg Rheinberger, *On Historicizing Epistemology: An Essay* (Stanford: Stanford University Press, 2010).

science as well as cognition.[49] The problem of validity concerns method and legitimacy, both intellectual (the accordance with established principles) and social (e.g., the dependence on institutions, canons, and authorities). Thirdly, the problem of the goals of science concerns both the social functions of scientific knowledge and cultural politics (including the ideological dimension).[50] Finally, the transformative element concerns the materiality of the conditions and effects of science. Following Marx, we might call this the problem of metabolism. By that we mean the fundamental relation of material exchange (*Stoffwechsel*) between society and the environment.[51]

Our understanding of historical epistemology is material, historical, and praxeological. All of these connotations are simultaneously present in the program of *The Bee and the Architect*, as is evidenced by its references to Marx's theses on Feuerbach as the theoretical starting point of a reflection on objectivity that is not limited to representation but also includes intervention.[52] The third thesis is discussed in chapter one of *The Bee and the Architect* in order to illustrate

49 As regards the social origins of science, Hessen is still a relevant author. See his classic work Boris Hessen, "The Social and Economic Roots of Newton's *Principia*," in *Science at the Cross Roads* (London: Kniga, 1931): pp. 147–212, reprinted in *The Social and Economic Roots of the Scientific Revolution: Texts by Boris Hessen and Henryk Grossmann*, ed. by Gideon Freudenthal and Peter McLaughlin (Dordrecht: Springer, 2009): pp. 41–102. See also the recently published materials included in Hessen, *Manuscripts and Documents on the History of Physics: A Historical Materialist Textbook*, ed. by Omodeo and Sean Winkler (Venice: Verum Factum, 2022) and Sean Winkler, *Boris Hessen and Philosophy: The Socioeconomic Roots of Classical and Modern Physics* (Lanham: Rowman & Littlefield, 2023). On the connection between history and cognition, see Peter Damerow, *Abstraction and Representation: Essays on the Cultural Evolution of Thinking* (Dordrecht: Springer, 1996).

50 In this context, the problem of ideology proves fundamental too. It has been partly dealt with by Canguilhem, but finds a more nuanced ethnographic treatment in Fleck, whose concept of *Denkstil* translats Lucien Lévy-Bruhl's concept of *mentalité*.

51 John Bellamy Foster, *Capitalism in the Anthropocene: Ecological Ruin or Ecological Revolution* (New York: Monthly Review Press, 2022).

52 The 'representation-intervention' conceptual pair was taken up in a pragmatic sense by philosopher of science Ian Hacking, *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science* (Cambridge: Cambridge University Press, 1983).

the dialectical relation between humans and their environments.[53] Although Marx meant this as a reference to the *social environment* (in German, in the plural: *Umstände*), which at once shapes human action and is shaped by it, a fruitful misunderstanding occurred with the standard Italian translation of this concept as *ambiente* (environment or milieu). In Italian, this can mean either the social milieu or the natural environment, conceived of as the background that makes action possible and is dialectically transformed.[54] In this perspective, Marx's epistemology is directly connected to environmental considerations about the interdependency and mutual transformation of human societies and their natural settings. This could also be seen as a naturalistic (yet not reductive) perspective on the human transformation of the world, which is consonant with Marx's views in general, as well as with the specific argument of *The Bee and the Architect*. Furthermore, the concept of *ambiente* fosters an ontological understanding of scientific processes, because science has proven a fundamental driver of world transformation, especially in the "technological phase" of capitalism.[55]

The transformative interrelation of science and territory via technological intervention and economic activity rests on what can aptly be referred to as the "dialectics of the abstract and the concrete".[56] Determined abstractions emerge in history as suitable instruments of material manipulation. The determinant factor is societal and ultimately political. Following Evald Ilyenkov, the authors of *The Bee and the Architect* argued that it would be a big mistake

53 Ciccotti et al., *L'Ape e l'architetto*, p. 58, n. 14.

54 The translation of *Umstände*, circumstances, as *ambiente*, that is, milieu or environment, is common in Italian, as is also witnessed by Gramsci's *Prison Notebooks*. Omodeo develops an environmental reading of Marx's praxeology in relation to historical geo-anthropology in "Geopraxis: A Concept for the Anthropocene," in *Journal of Interdisciplinary History of Ideas* 11/22 (2022): pp. 10:1-10:52.

55 Ciccotti et al., *L'Ape e l'architetto*, p. 51.

56 Ilyenkov, quoted in ibid., p. 65.

to equate the determined abstractions of science with reality tout-court.[57] Reality is processual. It results from a material interaction between subjectivity and objectivity that cannot be reduced to representation, no matter how accurate the abstract representation might be. Scientific abstractions (quo representations) are never all-encompassing and their objective validity depends on their function, on the goals. Hence, the question of the means and the adequate abstractions is necessarily linked to the question of the goals and the desirability of the society they are consonant with. In other words – taken from Weberian sociology, which is here criticized – 'instrumental rationality' is the (often implicit or ideologically mystified) bearer of value-oriented rationality.[58]

Thus, *The Bee and the Architect* offers a Marxist approach to historical epistemology. To be sure, it is not the only historically given Marxist take on historical epistemology, but it presents markedly original insights compared to other attempts (for instance the socio-economic one by Hessen, the structuralist one by Bogdanov, and Hegelian-Marxist approaches).[59] Its originality lies in the strongly historicist and praxeological orientation adopted, with a focus on subjectivity. Although it is faithful to the Hessenian legacy insofar as it assumes science to be dependent on its contexts, this approach goes one step further compared to standard economicist positions, such as those inspired by Nikolai Bukharin's contextualism: against any form of scientistic bias, the validity of science is not posited as

57 Ibid.

58 In light of this one can understand an important element in the authors' criticism of the Frankfurt School (including Habermas), which is seen as guilty of having reduced science to instrumental rationality without considering the value-dependency of science (ibid., p. 49, n. 2).

59 For an overview we again refer to Massimiliano Badino, Ienna, and Omodeo, *Epistemologia Storica. Correnti, temi e problemi* (Roma: Carocci, 2022).

meta-historical.[60] Science can never transcend history, that is, its cultural and political *a priori*. Moreover, the historical epistemology of *The Bee and the Architect* explicitly revisits historical-political and philosophical arguments against scientism. That is, the 'contexts' of science are traced back to production relations, without any determinism. Owing to this connection to the sphere of labor and injustice, science is not above class struggle, but part of it. It does not constitute an isolated autonomous sphere above the rift that divides society into contrasting groups and interests. Science, which is itself a force of production (but also an exchange commodity), is the outcome as well as the vehicle of power relations and ideologies[61] — hence, the need to develop historical-epistemological reflections in a political direction.

5. Relevant Theses and Problems in Political Epistemology

We should now turn to examine a set of fundamental theses and interventions in political epistemology that illustrate the enduring relevance of *The Bee and the Architect* for present debates on science.

I. The non-neutrality of science: The non-neutrality of science is the most fundamental thesis of the book.[62] This claim derives from the above premises, particularly those concerning the goal-dependency of the questions and validity of science. Claims to neutrality constitute a political problem in themselves because, by ideologically obscuring the social roots of science, they naturalize the objectives

60 Omodeo, "After Nikolai Bukharin: History of Science and Cultural Hegemony at the Threshold of the Cold War Era," in *Social and Human Sciences on Both Sides of the Iron Curtain*, ed. by Ivan Boldyrev and Olessia Kirtchik, special issue of *History of the Human Sciences*, 29/4-5 (2016), pp. 13-34.

61 Ciccotti et al., *L'Ape e l'architetto*, p. 99.

62 Ibid., p. 31.

that are implicit in its abstractions, making them invisible. As a consequence of this mystification, abstractions come to be seen as inescapable forces. This illusion has practical and psychological consequences. *The Bee and the Architect* explicitly deals with this in terms of alienation, as understood in Marx's 1844 economic manuscripts. Indeed, the problem concerns the heteronomy of research programs if they are posited as mechanically depending on pure and disinterested science. This alienation constitutes a problem for scientific workers, who are not in a position to decide about their own activity. Furthermore, the naturalized objectivity of scientific abstractions and their goals obliterates agency, because it fosters heteronomous decisions in the name of technological determinism.

> Therefore, in order to express with a formula what we have been arguing so far, science is not neutral, but rather has ideological overtones, in terms not only of its social implications, but also of its more specifically technical contents and concepts. However, as a general rule, the awareness of the non-neutrality of science is not operational in the modern scientific community. [...] Let us note that scientific theories, which present themselves as neutral in both methods and results, suffer from a substantial mystification. Their formulations offer adequate rules to transform reality, but these rules are partial cases: it is impossible to define in relation to what purpose this takes place, without completely redefining the 'meaning' of science. Thus they [these formulations] seem to be opposed to humans – whose aims they spring from in reality – as inert matter, and as such they dominate them. The question posed at the beginning is essentially resolved.[63]

63 Ibid., p. 71.

This criticism can be extended to the problem of 'pure science'.[64] The idea of *science pour la science* is an expression of academic corporatism in the framework of a division of intellectual labor that obscures the functions of science.[65]

The theme of the non-neutrality of science finds its most strenuous proponents today among feminist epistemologists, who argue for the relevance of one's standpoint in the wake of Sandra Harding arguments about positioned "stronger objectivity".[66] The argument of *The Bee and the Architect* is relevant insofar as it leads us to reconsider – in addition to the gender basis of scientific partiality – the class component, which is mostly neglected today. Rereading this book can help us to reconnect the epistemological chain science-consciousness-alienation-standpoint to economic analysis and labor struggles. In this respect, what is also in order is a reassessment of György Lukács' trajectory from his early theses on class consciousness to their later integration as part of a labor ontology.[67] Moreover, criticism of the purity of science, which today is mostly discussed in the context of practical knowledge and the practical roots of science,[68] can be broadened to include socio-economic and cultural-political aspects. Most of the dominant approaches rely on premises stemming from pragmatism, which are mostly individual-oriented or partial as they isolate scientific practices from broader societal contexts. *The Bee*

64 Ibid., p. 105.
65 See Michael Polanyi, *Science, Faith and Society* (Oxford: Oxford University Press, 1946), p. 8.
66 See Sandra Harding, *The Science Question in Feminism* (Pittsburgh: Cornell University Press, 1986), and "Rethinking Standpoint Epistemology: What Is 'Strong Objectivity'?" in *Feminist Epistemologies*, ed. by Linda Alcoff and Elizabeth Potter (New York: Routledge, 1993), pp. 49–82.
67 Ciccotti et al., *L'Ape e l'architetto*, pp. 211-223.
68 See Pamela Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: The University of Chicago Press, 2004) and Pamela O. Long, *Artisan/Practitioners and the Rise of the New Sciences, 1400–1600* (Corvallis: Oregon State University Press, 2011).

and the Architect can help reactivate a praxeological dimension that goes beyond practice, to include collective social and political agency.

II. The non-separability of facts and values: The authors of *The Bee and the Architect* also argue that judgments of fact and judgments of value cannot be separated.[69] This is a consequence of the goal-oriented character of science. Indeed, it is connected with the thesis of scientific non-neutrality. The authors of the book also express this idea as the context-dependency of "dati" (i.e., data, empirical facts) and "fatti" (i.e., deeds, facts in Vico's sense of historical constructions). It would make sense to connect such a thesis with the theme of the 'epistemic values' of science.[70] At this point, however, it is necessary to stress the main difference with respect to the current debate on values in science. It should be remarked that *The Bee and the Architect* is distant from the postmodern spirit that is often ascribed to the concept of epistemic values. In this work from the Seventies, the problem of the values that enter science via epistemology is presented as a historical-materialist thesis, which is to say that it directly descends from Marxist historicism. Thus, unlike postmodern relativism, this approach has the advantage of keeping together the cultural (praxeological) origin of values and the materiality of social structures.[71]

The thesis of the inseparability of scientific facts and values also implies a strong anti-reductionist stance. Societal facts cannot be deterministically deduced from natural, biological, or physiological data or theories, taken in isolation and without an epistemological-historical critique of their origin, validity, and goals. No facts are value-free.

69 Ciccotti et al., *L'Ape e l'architetto*, p. 26.

70 This is a major theme in Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007).

71 Omodeo, "Soggettività, strutture, egemonie: Questioni politico-culturali in epistemologia storica," in *Studi Culturali* 15/2 (2018): pp. 211-234.

Indeed, no political decisions can be considered to be necessitated by scientific or technological objectivity. This implies that technological transitions should never be implemented without political transitions, as if they were politically neutral: all techno-scientific solutions depend on the society that they envisage.

III. The inseparability of science and ideology: science is embedded in mentalities – what historians and philosophers of science variously refer to as "Denkstile", "styles of thinking", or "historical *a priori*", depending on the reference authors (Fleck, Hacking, or Foucault). The basic idea on which the styles-of-thought problem or the ideological-embedment thesis rests, is that science is a cultural phenomenon. However, culture should not be regarded as a spiritual endeavor. Neither culture nor science can be seen as purely intellectual constructions, contrary to what the most radical social-constructivist views, post-modernism, and post-truth epistemologies suggest. As the authors of *The Bee and the Architect* emphasize, "social origin and arbitrariness are by no means synonyms".[72] A new paradigm should be achieved which is neither idealistic nor reductionistic. We might call it a historical-natural paradigm, one that incorporates an awareness of the cultural conditioning of science.[73] For the authors of *The Bee and the Architect*, historical materialism – and Marx's own path to science, as exemplified by his political and economic theories – could be considered the missing paradigm. In other words, Marxism offers the paradigm of the 'natural history' to come, as it were, not because its scientificity is rooted in the method of the natural sciences at their present stage, but rather – on the contrary – because it questions the imperialism of the method of the natural sciences from a historicist

72 Ciccotti et al., *L'Ape e l'architetto*, p. 63.
73 Ibid., p. 67.

and praxeological perspective. By pointing in this direction, this intellectual project runs counter to the view championed by supporters of 'scientific' Marxism such as Bukharin, Louis Althusser, and Colletti.

IV. The critical overcoming of the ideological either/or alternative between obscurantism and scientism: *The Bee and the Architect* argues that science should not be reduced either to bare facts or to pure ideology. In opposition to the view that it is necessary to choose between two opposite and irreconcilable camps (obscurantism or scientism, irrationalism or positivism),[74] the authors argue that science ought to be seen as the dynamic entwinement of cultural factors and material constraints. It is neither empirically given nor an arbitrary construction. Such an argument has not lost its relevance, as current academic and public debates on science and scientific facts tend to be polarized between radical populist skepticism and technocratic scientism.[75]

The tension between the image and the reality of science[76] appears most clearly, and tends to erupt, in times of crisis:

> In times of crisis, the conflict surrounding the goals of science, and therefore its better abstractions, will become sharper, and the assumed mixture between knowledge and interests will become particularly evident through the contrast between different scientific alternatives.[77]

74 Ibid., p. 50.

75 Omodeo and Lukas Meisner, "L'aut aut di fatticità scientista e relativismo postmoderno quale semplificazione ideologica del problema epistemologico di expertise e populismo post-veritativo," in *Expertise ed epistemologia politica*, ed. by Ienna, D'Abramo, and Badino (Milano: Meltemi, 2022), pp. 37-69

76 On the images of science, see Yehuda Elkana, "A Programmatic Attempt at an Anthropology of Science," in *Sciences and Cultures: Anthropological and Historical Studies of the Sciences*, ed. Everett Mendelsohn, and Elkana (Dordrecht: Springer, 1981), pp. 1-76.

77 Ciccotti et al., p. 65.

Crises and paradigm shifts are as epistemological as they are political. A truly emancipatory leap forward should be fostered through an epistemology from below – the product of a radical science movement linking the rights of science workers to the desire for freedom and justice of society at large.[78]

V. The solution of the dichotomy between nature and history: In the book, the need to overcome the dualism of nature and history[79] is expressed in terms of a task: to bring together 'causes' and 'goals',[80] materialism and historicism. The authors' declared intention is to overcome the disciplinary rift between those dealing with nature and those investigating the human spirit, based on the canonical neo-Kantian separation between *Naturwissenschaften* and *Geisteswissenschaften*.[81] This issue certainly carries methodological and epistemological significance, but it is also ontologically meaningful. It can be related to present-day criticisms of dichotomies ranging from the Anthropocene debate (epistemic history as the history of the Earth system) to eco-politics, as well as new materialism and the post-human condition.[82] The approach of *The Bee and the Architect* embraces a materialist perspective that connects Marx to Gramsci and even Lukács in

78 On the general project of observing modes of knowledge formation "from below", see the following special issue: Gerardo Ienna and Charles Wolfe (eds), "Knowledge from Below: Case Studies in Historical and Political Epistemology", in *Berichte zur Wissenschaftsgeschichte / History of Science and Humanities,* 45 (2022): 535-650.

79 Ciccotti et al., p. 18.

80 Ibid., p. 45.

81 See also Charles P. Snow, *The Two Cultures and the Scientific Revolution* (Cambridge: Cambridge UP, 1959).

82 Among many others, see Jürgen Renn, *The Evolution of Knowledge: Rethinking Science for the Anthropocene* (Princeton and Oxford: Princeton UP, 2020) and Donna Haraway, *Staying with the Trouble: Making Kin in the Chthulucene* (Durham: Duke UP, 2016). For a criticism of the flat ontology of new materialism, see Cat Moir and Charles Wolfe, "Sui fondamenti onto-politici del Nuovo Materialismo: dagli studi scientifici femministi alla metafisica". *In Expertise ed epistemologia politica*, edited by Gerardo Ienna, Flavio D'Abramo, and Massimiliano Badino, (Milano: Meltemi, 2022): pp. 267- 298.

the direction of a historical ontology. Accordingly, the disciplinary rift between natural sciences and the humanities is the expression of a *real* rift, which is social and environmental. This is consonant with current attempts to connect political and ecological struggles in the pursuit of economic and environmental justice.[83]

Concluding Remarks

The relevance of *The Bee and the Architect* for Italian debates on science is beyond dispute, although its legacy is controversial. The publication of the book, back in the Seventies, sparked controversies about science and society, scientific knowledge and ideology, power relations, technology, facts, and values. The echoes of these controversies still loom large over the current perception of science in Italy. They also mark a different path to the Science Wars, which – unlike the path followed in the Anglophone world – rested on materialist premises and Marxist critical theory.[84] Some of the most debated theses of those days have become common assumptions (e.g., the social and political relevance of science and the reflection on this topic), while others have come to the fore in the wake of recent debates about scientific facts and expert-based decisions (e.g., science and ideology). In some cases, themes that did not initially gain prominence have reentered Italian scientific culture via novel currents and trends. However, a full appreciation of the potential of *The Bee and the Architect* is still missing, as is witnessed by some of the most heated polemics that have gained prominence in times of pandemics management, environmental emergency, and war (for instance, the need

83 Foster, above mentioned.

84 On the limits of the Science Wars from a Marxist viewpoint, see Ali C. Gedik, "Back to Engels: A Long Century of the First Fiddle without the Second," in *Marxism and Science: A Journal of Nature, Culture, Human and Society* 1/1 (2022): pp. xiii–xxxix.

for a critical theory that avoids both populism and scientism). The theses and spirit of *The Bee and the Architect* can help us to navigate an epoch that is in dire need of a critical and democratic scientific culture. Moreover, it is time to transcend the national boundaries that have limited the reception of *The Bee and the Architect* thus far. The concepts found in this book, which are centered on a criticism of our societies and stress the relevance of epistemology for politics, ought to be assessed in the context of today's international debates. In particular, *The Bee and the Architect* offers a model of political epistemology that moves beyond postmodernity, post-truth, and novel forms of scientistic reductionism, by offering a cultural yet never arbitrary path – a historical-materialistic praxeological perspective. [85]

85 This text is the result of collaborative work; however, Gerardo Ienna is the author of sections 1, 3, 4.1, Pietro Daniel Omodeo of sections 2, 4.2, 5, 6. For this project Ienna has received funding from the European Union's Horizon 2020 research and innovation programme under Marie Skłodowska-Curie grant agreement no. 101026146. Omodeo would like to acknowledge the UNESCO Chair *Water, Heritage and Sustainable Development*, the FARE project *EarlyGeoPraxis* (funded by the Italian Ministry of University and Research, *cod. R184WNSTWH*), the Max Planck Institute for the History of Science, Berlin, the Max Planck Partner Group *The Water City* (Berlin-Venice), and THE NEW INSTITUTE Center for Environmental Humanities (NICHE), Venice.

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The Bee and the Architect

Giovanni Ciccotti
Marcello Cini
Michelangelo De Maria
Giovanni Jona-Lasinio

> … a bee puts to shame many an architect in the construction of her cells. But what distinguishes the worst architect from the best of bees is this, that the architect raises his structure in imagination before he erects it in reality. At the end of every labour-process, we get a result that already existed in the imagination of the labourer at its commencement. He not only effects a change of form in the material on which he works, but he also realises a purpose of his own that gives the law to his modus operandi, and to which he must subordinate his will.

Karl Marx, *Capital*, trans. S. Moore and E. Aveling, Moscow: Progress Publishers, [1867] 1887, Book 1, Ch.7, p. 127

NOTE

This book contains a series of essays which have a common goal: to understand the function of the [scientific] research system in its most advanced stage, in its historical development in terms of a human social activity which is a theoretical-practical appropriation of nature, so as to appreciate the value of science. This attempt makes use of the tools of a materialistic-historical Marxist approach. However, this book does not pretend, nor aspire to be, an authentic or orthodox interpretation of what Marx meant by science. We would just like to contribute to identifying the appropriate conceptual categories for a correct reconstruction of the role and significance of science in our contemporary capitalist society. In our opinion, such a reconstruction can only be made through a qualitative analysis of the changes which the research system and its values have undergone in the transition from the technical stage of industrial capitalism to the technological stage of monopoly capitalism. However, this analysis must be preceded by the attempt to theoretically study the entanglement of nature and society. Indeed, the interaction between humankind and nature and the social relationships of production, as can be found implicitly or explicitly in Marx's work, in particular from the concrete construction of a science of society, is characterized by an interweaving of subject and object which is, at the same time, an interweaving of causality – i.e., materialism – and goal-orientation – i.e., history.

This is exactly what we have tried to do in the first few essays of this collection.

More specifically, in the second part, the essay about the epistemological debate addresses some general issues which have subsequently been clarified and deepened in the first essay of this collection. However, for the sake of clarity, we have decided not to follow chronological order. As heterogeneous as these essays may appear at first sight, they are actually linked by a common thread represented by the materialistic-historical approach to science, which we try to outline. One will notice that Elisabetta Donini has contributed to one of these essays, but she does not share responsibility for the thesis supported by the book, even though, to some extent, she does share the general ideas. That is why we want to thank her – not only for agreeing to include her article in this collection, but also for contributing with discussions, suggestions and comments on our work.

Finally, we have tried to provide the reader with an interpretive aid for all the material presented with an introduction aimed at reconstructing, through the direct memories of one of the authors, the evolution of ideas and concepts of the role of science, which have changed over time within the Italian left in the last twenty years. In order to document this reconstruction, in the appendix we publish a few old articles which, in some manner, paved the way to the process of collective elaboration and maturation which led us to formulate the theses that we present in this book. This short foreword would be incomplete without our explicit thanks to many friends and companions who listened to us with patience, helped us generously and commented poignantly. Among them, we acknowledge D. Capocaccia and M. Lippi, for having actively contributed to the writing of these essays; A. Baracca, E. Damascelli, A. Gaiano, G. Jacucci, B. Morandi, F. Navach, A. Rossi, G. Suffritti and T. Tonietti for commentaries and suggestions; F. Marchetti for contributing to the initial stage of this work.

Finally, more than an acknowledgement, we would like to express a heartfelt remembrance on the part of the eldest of the group from the oldest of us. Without Raniero Panzieri and the impulse of his acute intelligence, the first essays of the years 1965-66 would not have been written. We dedicate the work produced in the following years to the memory of this revolutionary militant and close friend.

Rome, September 1975
The Authors

Foreword

Marcello Cini

Twenty years ago, the organized workers' movements gave precise marching orders to left-wing scientists. First of all, they were to encourage all initiatives capable of gathering together the most open and modern forces of research so as to demand from the establishment a commitment of resources and a strengthening of structures and functions in favour of scientific institutes.

> The interests of developing the national economy as a whole – we can read for example in the resolution of a meeting of scientific researchers, technicians, economists and parliamentarians belonging to the communist and socialist area held at the Gramsci Institute in the month of September 1955 – required that [....] the exploitation of the new source of energy [nuclear, author's note] and the application of new technologies be aimed at cutting costs and strengthening the whole production system. [...] in the framework of an organic policy coordinating the use of energy sources to serve the public interest. [...] On the other hand, the incipient revolution in the field of production was not exclusively connected to the use of atomic energy, but rather to opening up new opportunities, linked to advanced technologies, such as the use of radioisotopes, electronics and, in general, all auxiliary equipment. [...] Nowadays, it is more than evident that the introduction and development of such technologies has organized scientific research among its prerequisites. This [scientific research] must be updated in all its branches. Indeed,

> **the progress of contemporary scientific research, in most of its sectors, is no longer entrusted to exceptional individual scholars, of which there have been many in the history of Italian science, but rather to the concerted work of hosts of researchers, the resources made available to them according to an overall national programme, and their determination to contribute to the progress and welfare of humankind.**

Secondly, one had to work on an international level for the unification of a scientific community which, over and above a contingent split due to the fact that its members belonged to two different blocs, would find in the neutrality and universality of science a common ground which would guarantee a common humanitarian and pacifist aspiration.

On the other hand, none of these objectives contradicted a more radical political perspective involving an internal social transformation and a strengthening of a "socialist field" on a global scale. On the contrary, they constituted intermediate stages which were indispensable for reaching those goals.

Moreover, such objectives did not only come from the articulation of a contingent policy line dependent on scientific sectors. Rather, they had a theoretical foundation in the Marxist tradition which, even without fully accepting the heavy conditioning of Stalinism, was very dogmatically related to Engels – in particular *Antidühring* and *Dialectics of Nature* – and to Lenin – in particular *Materialism and Empiriocriticism*. Inasmuch as they emphasized the gnoseological meaning of the natural sciences, these books could indeed be taken as a conceptual framework for an idea of the world based on a clear separation between nature and history.

According to this view, codified in "dialectical materialism," in the sphere of nature, a given reality outside of humans can only correspond to one single science, at least within a gnoseological framework. This means that a single source of objective knowledge, as a reflection of reality, is therefore – at the same time – the only tool which can transform and dominate it. On the other hand, within the sphere of history, we address social classes in their relationships which – even through mediations and ruptures – are ultimately determined by the objective framework – i.e., the techniques of the mode of production, in other words, by the level reached in humanity's control over nature.

Hence stems the prime commitment of the Marxist scientist in the specific field of his/her research. Once the Stalinist attempt to base a "socialist" science of nature on the laws of a materialistic dialectics –more valid and insightful than the "bourgeois" one – failed, this commitment could only be reduced – until this dichotomy would be called into question – to the unconditional acceptance of the latter, indeed to its justification. This justification is apparently made *a posteriori*, but is, in fact, *a priori*, both in its methods and purposes, in its rationale and results. Moreover, this commitment was reinforced by the conviction that, by doing so, the Marxist scientist contributed to advancing a secular and rational worldview, thus affirming the superiority of scientific methodology over a traditional, self-styled humanist culture which was, in fact, mainly made up of obscurantism and empty rhetoric.

Please, note that no one wants to bring back Zhdanov. We would simply like to underline that, if one assumes that the process of mankind's appropriation of nature is independent from the social relationships between human beings – or, in other words, if one considers the evolution of the natural sciences as an accumulation of objective data leading to an in-depth and faithful reconstruction of a given natural, although inexhaustible, reality, with the gradual elimination of any socially determined element, there are only two possible choices. Either we use a tool external to science – the "laws of dialectics" – as a key to opening all the chests where the secrets of nature are hidden; or we sanctify every result of science as a step forward for humankind, “from the realm of necessity to the realm of freedom.”

As is the case with all metaphysics, the first choice could not but prove to be fallacious. On the other hand, this was never taken too seriously in Italy. Indeed, the Italian Communist Party never imposed an alignment with the theses of Soviet dialectical materialism (communist biologists refused Sereni’s attempt to officially approve Lysenkoism). On the other hand, open criticism of the official Soviet philosophy could not easily be expressed. Only after the 20th Congress did they start to discuss these problems.

The second alternative is a recurrent illusion, still alive within the left. It was actually reinforced by the failure of dialectical materialism. This reaction is clearly visible, for instance, in my (never published) answer to a questionnaire sent in 1965 by the magazine *Il Creativo* [*The Creative*] to a few communist intellectuals: “To what extent, in your opinion, has the right and necessary relationship between cultural activity and political leadership been realized within the Communist Party?” This was my answer:

> In examining the relationship between cultural activity and political leadership within a Marxist party, we should take into account the fact that the former should not predetermine or circumscribe the latter *a priori*, not to make it sterile and reduce it to a repetition of formulas without any cognitive value. Indeed, a Marxist party draws inspiration for its political action from the analysis of the structure of contemporary society, both in its contradictions and its development, since this party wants to transform society. This action, however, will be successful only if this analysis, free from pre-established hypotheses, reveals facts as they are rather than as someone would like them to be.

> If I speak only about my field of activity, I think we should remember the serious damage done to Soviet science and, indirectly, to the self-confidence of Italian culture by the non-application of the above-mentioned principles. Claiming that a political leadership body can judge the value of a scientific theory in biology, physics or chemistry on the basis of common general principles is a metaphysical and anti-scientific assumption. It is as if you built a philosophical system in order to explain reality, *a priori,* in the manner of idealistic philosophers. This is not to say that Marxists should not criticize those scientists – who are often excellent scientists, but bad philosophers – who reach unacceptable theories of the development of society, or idealistic concepts of the world through arbitrary extrapolations in the fields of physics or natural sciences. However, criticism should not be made by mechanically reversing the process. It is equally mechanistic to consider that the relationship between structure and superstructure is so immediate that it determines the automatic superiority of science and culture in a socialist society over those of a capitalist society.
> In order to realize a relationship between political leadership and cultural activity without dogmatism, but rather incentivizing research, I think it is essential not to stop at the contrast of two terms by identifying the two functions in distinct, almost antagonistic categories of communists. On the contrary, you need to stimulate cultural production activities by politicians and ask the specialized intellectuals to enlarge their horizons to the basic problems of the development of society.

It was not just a matter of left-wing scientists, who could finally feel at ease in their environment, free from an embarrassing complicity. The illusion was inherently connected to the official culture of the Italian Communist Party. The entrance of Prof. Della Volpe and a few intellectuals of his school into the editorial board of the magazine *Società* [*Society*], also contributed to a change. On the one hand, this illusion had a positive influence – as Mr. Colletti mentioned in his recent interview – upon the education of many young communist intellectuals – who were directed to seek in Marx and Lenin the sources of Marxism, which had been abundantly adulterated. On the other hand, this illusion reaffirmed the methodological primacy of the natural sciences, inasmuch as it recognized that scientists owned the only correct method for obtaining knowledge of reality since Marx was identified as "the Galilei of the moral world."

To the communist researchers, this acknowledgement was not only an ideological confirmation of the validity of their own professional commitment. It also reinforced the conviction that the whole "corporation" of scientists was intrinsically and objectively progressive, justifying the choice of supporting any initiative which gathered together its most authoritative representatives, regardless of their individual political positions. The climax of this line, in which the left took a prominent part, was the fight of physicists towards the end of 1959 "to achieve a definitive settlement of the organization of research in the field of nuclear science." The fight was successful as it resulted in the granting of – at least for a few years, until the "Ippolito case" in 1963-64 – a relative quantity of resources to nuclear research, in particular to its most expensive sector, so-called fundamental physical science – i.e., "elementary particles." Not by chance, this field, which gathered the most dynamic physicists connected to a particularly strong and prestigious international "corporation," spearheaded the fight. However, their success, which was also the result of consensus and support from outside the research world, represented the first symptom of a focus on science on the part of the establishment: this was an important new development in comparison with the Fifties.

In 1960, the Confederation of Employers (*Confindustria*) organized a meeting in Ischia in which they called for State intervention in support of scientific research whose results could be utilized by industry. One year later, in December 1961, the Christian Democrats (*Democrazia Cristiana*) organized a meeting on the topic: "A Policy for Scientific Research," intended to introduce the programme platform of the new centre-left party in this area, thus acquiring the participation of the most progressive scientists in this new political path. The key element of the new direction was economic planning: in this perspective, scientific research took on a qualitatively important role – at least in its intentions. Among the communists, the problem of the inadequacy of their positions to that point started to emerge. Indeed, in the new political framework, it was no longer sufficient to demand more funds and more staff. The need to face this challenge clearly arose, for instance, in an intervention by Lucio Lombardo Radice at a meeting of the Cultural Commission of the Italian Communist Party:

> A few events have taken place, which are symptoms of a new trend on the part of the most dynamic monopolistic groups and of the majority current of the Catholic Party, relative to scientific development and science teaching in schools. For example, the resources for scientific research have increased; there have been measures for staff increases, particularly in scientific and technical departments; there has been an attempt (although hesitant and, as we shall see later, inorganic) to replace Latin with Elements of Science in lower secondary schools for pupils in the 11 to 14 age range (see the experimental classes of the "Bosco reform"). There is a good chance that we will go ahead in this direction in any case.
> The "modernization plan" of the bourgeois economic and political leadership groups, which also seems to be emerging in the field of science and scientific culture, will not only run

into the resistance of conservative and obscurantist forces (in the traditional sense), such as weaker capitalist groups and traditionalist clerics (resistance to "disinterested" investments in scientific research, an all-out defence of the old classical lyceum). It is also an idealistic, insufficient, contradictory, and limited plan on its own. The dominant internal limitation (or contradiction) of this plan is the claim to develop science as a mere tool, namely the instrumental concept of science (a tool, of course, of capitalist recovery and development).

This "original sin" of the capitalist modernization plan brings as (already observable) consequences the following phenomena:

1. Massive funding for universities and research institutes without an organic, "institutional" reform of academic culture, which could make this funding fruitful;
2. Training of a numerically substantial mass of American-style specialized scientists rather than scientists in the full sense of the word – i.e., men and women of reason, thought and culture; diffusion of corresponding philosophical trends, namely empiricism, empty fundamentalism, and pure methodism;
3. Survival of the traditional gaps between science and culture, science and philosophy;
4. Better "modern" technical training in school, but without the formation of a scientific spirit.

From what has been said so far, the plan for scientific-cultural reform is clear in its general lines. It must be opposed to the plan of simple "modernization" in the context of the economic, political and cultural structures of capitalism. Naturally, the "new path" of the emerging bourgeois ruling group is also determined and affected by democratic and workers' struggles, allowing us to conduct the battle at a higher level, with more advanced objectives, with proposals which, step by step, can represent an alternative to a real, positive reform (rather than the fruit of maximalism) of the measures and goals of a simple "modernization."

This requirement, however, could only be partially translated into a different policy, and with various difficulties. The thesis of the priority of the quantitative development of scientific institutes continued to prevail, even though – on the level of claims – requests for a democratization of research bodies began to arise. The goal was to obtain the participation of a limited number of researchers and junior lecturers in their management. This would have granted entry into the planning mechanism to the youngest and most dynamic components of the research world with their skills and demands for scientific and social progress.

In the following years, this line would prevail and result in draft law 2650 of the university reform of the Communist Party, as opposed to the infamous law 2314. This was the most advanced proposal that could be made without questioning the institutional function of the university as a place of reproduction for the ideological hegemony of the bourgeoisie.

The pure and simple trust in the development of productive forces as the engine of social progress then had to be accompanied by democratic planning in which progressive scientists, aware of their social responsibility, took up an important, rather than exclusive, role. This viewpoint was not new, since it had already been developed by a group of English Marxists and progressive scientists who, immediately after the War, had created the World Federation of Scientific Workers, together with other international representatives of left-wing scientists, such as Joliot-Curie.

The most coherent formulation of this project for the social use of science can be found in the works of J. D. Bernal, translated into Italian by the publisher Editori Riuniti as *Storia della Scienza* [Science in History] in 1956 and *Mondo senza Guerra* [World without War] in 1960, which had a significant influence on the formation of a group of young communist scientists – mainly physicists and biologists – engaged with this policy in those years. To Bernal we owe the most advanced and passionate proposal of an "alternative use" of science for the construction of socialism, which represented the first attempt to take the new trends at a world level into account.

On the one hand, the thesis of the incompatibility between scientific development and capitalist social relations became unsustainable. A glance across the Atlantic was enough to realize that, in the USA, scientists had almost anything they wanted at their disposal. Above all, it could not be denied that the most advanced technology – from computers to chemistry, from electronics to nuclear power – had its engine in America. Only in the field of missiles did the USSR appear to have an advantage. However, as spectacular as this sector was, it was no longer enough to assert the unquestioned scientific primacy of the socialist system. Within the left, they questioned the idea that scientific and technological development was a specific element of the socialist system in comparison with the capitalist society which, having reached its monopolistic stage, would be structurally incapable of it.

At the same time, they began to see that, in the capitalist West, the unceasing flow of technological innovation pouring out rivers of more or less useful commodities to the privileged people often aggravated the conditions of existence of the most deprived by mixing waste and misery in a strident contradiction. In the same manner, advanced technology provided the powerful with the most advanced instruments of domination and always deprived the weakest of every defence. The race for the most destructive weapons of extermination was the most conspicuous and aberrant example of this distorted mechanism of human dominion over nature. In the circles of researchers who gravitated around the Communist Party, a more articulated concept of the relationship between science and social structure slowly set in. Namely, they stated that whether science, which is itself a trigger of progress, is or is not actually used as such, depends on the existing social structure. Thus, they distinguished between science as a neutral tool, which every industrially advanced society tended to push forward, and the capitalist use of science, which could lead to disastrous consequences. It followed, according to this reasoning, that only the socialist system could use this tool in such a way as to grant humankind its greatest possible benefits.

In my opinion, the winding-up remarks of the speech I was asked to make on the occasion of Gagarin's first space flight were most indicative of this attitude:

> However, we must beware of the temptation to consider scientific and technological progress in itself as a source of happiness and well-being for humankind. Nazi Germany had progressed scientifically, but Eichmann's sinister presence was there to remind us of the crimes for which progress had become instrumental. Nor can Japanese people forget how the conquest of the atom was presented to humanity for the first time.
> Even without reaching these extremes, we could simply remember the technological progress which enslaves Charlot in *Modern Times,* the slavery which sometimes makes man subject to machines: this justifies our statement fully.
> A further proof of this reality is given by considering technological progress not only as an instrument for raising the standard of living of even large sections of population, but

also as a means to lock people down in the sphere of their own immediate interests, freeze their human impulses and feelings, extinguish their ability to struggle with others over common ideals that could make them feel like brothers.
When all of this happens, is it not true that, at a glance, we should rather consider certain people as subject to others who use the achievements of technological progress to maintain their dominance, instead of considering them subjects to machines? Should we not blame a given organization of society rather than scientific progress for the alienation of workers?
Only in a society where all people become protagonists of history do technology and science become tools for liberating all individuals, allowing them to fully develop their own personalities rather than becoming instruments of their own alienation.
This is the reason for our trust in socialism, which is also trust in science, but first of all trust in humankind.

We can therefore say that, at the start of the Sixties, there was a shift of emphasis within the organized workers' movement on the fringe of the left regarding the importance of the various factors involved in the process of social transformation. Confidence in creating the most advanced technological and scientific bases first, within capitalist social relations, began to appear illusory. These bases could no longer allow us to replace – easily and painlessly – a by now anachronistic envelope with a social texture suitable to the level of development reached by the productive forces. Attention then turned to the contradictions of social relationships. Not by chance, after all, did this shift take place under the sign of the workers' struggle in the early years of the decade.

2.

At this point, within a couple of years, some comrades were convinced that it was no longer enough to stop at the criticism of the capitalist use of science. It was necessary to go further and examine whether, in the very fabric of science – in its contents and methods, in the choice of problems to solve and priorities to respect – it would be possible to trace the footprints of the social relations of capitalist production within which it was produced in those days. Ten years ago, this thesis was a heresy – and it still is, in part, for more than one reason.

It was a theoretical heresy because it contradicted the theory of science as "reflection" – i.e., an ever-more faithful and detailed reconstruction and reproduction of a given natural reality. It was also a heresy from the point of view of an assessment of socialist societies since, as far as anyone knew, it legitimized the doubt that, after the thaw, Soviet science was very similar to US science in its methods and objectives, and criticism could link some not-so-secondary aspects of the two societies. Moreover, it represented a form of criticism toward the line of scientific development in Italy which was entrusted to the body of scientists or, at most, to its more advanced and dynamic members.

However, several facts in those years helped to demonstrate that none of these taboos were as untouchable as they might have seemed. On a theoretical level, the contribution of Raniero Panzieri was extremely important. He introduced Marx in his essays "Sull'uso capitalistico delle macchine nel neocapitalismo" ["The Capitalist Use of Machinery in Neocapitalism"] (1961 and "Plusvalore e Pianificazione" ["Surplus Value and Planning"] (1964) as a vibrant and hot-blooded author who was finally talking about contemporary capitalism as well as the role of science and technology, and this helped us to understand this better.

We owe to Panzieri the affirmation of a fundamental point which paved the way to a possible left-wing critique of the theses of dialectical materialism on science:

> In the face of the capitalist interweaving of technology and power, the perspective of an alternative (workers') use of machines obviously cannot be based on the pure and simple overturning of production (property) relationships, conceived as an envelope that would break because of the expansion of productive forces. Production relationships are inside productive forces, which have been "shaped" by capital.

As is well known, Chinese communists first desecrated the second taboo. The publication of the "25 points" in 1963, in which the Chinese Communist Party expounded the substance of their disagreement with the Soviet party and motivated their criticism of the revisionist line attributed to the latter. Among other things, they challenged the idea of the link between productive forces and social relationships, which had led the USSR to engage in the "construction of the material bases of communism" as a priority, thus referring to an increasingly mythical future of the construction of communism through social relationships.

In particular, I would like to stress the fact that the call of our Chinese comrades to the need of ensuring – within the process of social transformation – the priority of politics over economics *a fortiori* involved the refusal to make a priority of scientific and technological development carried out by specialists refusing to let politics enter their work. A small episode illustrates this point better than any reasoning. I happened to visit the nuclear research laboratories of Dubna, at the invitation of the Soviet Academy of Sciences, in order to hold some seminars on Particle Physics just after the "25 points" had been made known. In a nutshell, the criticism of the Chinese seemed right to me, but I wanted to understand what my interlocutors thought. Therefore, during my visit, I tried to discuss politics, over and above physics, getting worked up about the former topic rather than the latter. This behaviour was noted with amazement: a physicist, who turned out to be the secretary of the Party organization of one of the laboratories, did not understand why I was so detached when talking about physics and – on the contrary – so involved when talking about politics. "For us" – he said with conviction – "it is exactly the other way around." It was not difficult to conclude that, at least on one point, the Chinese were right. Soviet scientists looked much more like their American "colleagues" than their "comrades" in the rest of the world. Out of the two terms of the binomial "red" and "expert", the first had been lost along the way.

It was much more difficult to face the third obstacle to a critique of science from the inside, aimed at discovering – in our daily research and teaching work – the traces of the capitalist accumulation process and of dominant social relationships. This obstacle was constituted by the invisible, yet strictly ideological and material constraints exerted by a corporate mentality, which was absolutely determined to marginalize anyone trying to question the dogma of separation between judgements of fact and judgements of value, as well as the ethical standards according to which the introduction of policy in science was an act of dishonesty. It was not until 1968 that the demystification of scientism was able to enter into the 'corporation'.

However, the first cracks in this obstacle date back to a few years earlier, at the start of the Vietnam War. For the first time it became clear that the "international community of scientists" had not only failed to play a progressive role, as the left had been arguing for a long time, but had in fact played a precise role in covering capitalist aggression. The substantial connivence of American scientists with their own government, resulting from the essential coherence between scientism and the ideology of the ruling class in an advanced capitalist society, was translated into a conspiracy of silence in the international scientific community through the blackmail of the unity of all its members over and above different individual beliefs. To be openly on the side of Vietnam, therefore, meant introducing a wedge within this community and beginning to wonder whether there was some deep connection between "big science" and the vehemence of the American war machine.

These are, viewed in retrospect, the objective data which led me to write – in the years 1965-1966 – the three articles reprinted in the Appendix. The considerations on the relationship between science and advanced capitalist society which I developed in these articles represent the first attempt to understand – starting from Marx's analysis of capitalist society – how scientific and technological progress had helped the capitalist system not only to survive – overcoming contradictions which Marx had foreseen as explosive – but also to consolidate and develop vigorously. In substance, the thesis I advanced at the time still seems valid. Indeed, I assumed that one of the reasons for this process was that science and technology did not so much help to reduce:

> the working time necessary to produce certain commodities which society needs at a certain stage of its development, but rather to create new needs, whose satisfaction requires more and more technologically complex commodities which can only be produced through a global, ever-growing employment of the labour-force. (Appendix, Chapter 1)

I think this is still valid today. At the time, however, I was not sufficiently clear about the importance of the capitalist production of non-material goods, services and commercialised information within this process of economic expansion. A detailed discussion of this point, fruit of the joint efforts of these last few years with Giovanni Ciccotti and Mimmo De Maria, is presented in Chapter 2 of this collection, "The Production of Science in Advanced Capitalist Society."

The events of this last decade show widely, in my opinion, that it was right to sound the alarm within the workers' movement about the consequences of an uncritical acceptance of US scientific and technological progress, on the part of both the USSR and Western Communist parties. The fundamental thesis, formulated in those articles, is substantially shared by many people today:

> it is clear that technological progress, inasmuch as it is a means for the intensification of the production of commodities, cannot be *a priori* identified with the well-being of society. Moreover, we cannot abstractly consider such progress as a neutral instrument with respect to the social structure, thus neglecting the crucial influence of the latter on the former. (Appendix, Chapter 3)

These statements were not self-evident. To fully appreciate this, it would suffice to compare them with the contents of the other articles published in the same issue of the magazine *Il Contemporaneo*.[1]

I had the first proof that the alarm was not unjustified and that the problem addressed included fundamental aspects of social change, just when the clash between two opposing concepts of the relationship between humans and technology reached its most dramatic stage. In the month of March 1967, during my stay in Vietnam as a member of the Russell Tribunal, I was asked to present and discuss my latest article at the headquarters of the State Committee for

1 L. Geymonat, for instance, stated that "technical progress is one of the most extraordinary conquests of human reason; it's one of the glories of the modern era." This opinion is substantially valid if related to a given economic and social training (bourgeoisie establishing itself as a revolutionary class), but becomes a rhetorical generalisation when it is arbitrarily extended to another period with opposite features (stage of technological capitalism).

Science and Technology. This article had been published in French in Hanoi by the communist magazine *Recherches internationales*, in a single issue about "Techniques nouvelles, sociétés nouvelles." What struck me particularly on that occasion was not only seeing how much my interlocutors were projected into the future, convinced of thinking about the prospects of scientific and technological development of their country after the victorious conclusion of the war (whereas they had to fight for another 8 years!), but above all by their awareness of the dangers of an uncritical acceptance of the model of Soviet industrialization.

The final proof came a year later, with the explosion of 1968.

3.

The occupation of the University of Rome at the end of April 1966 after the death of Paolo Rossi, beaten by Fascists, marked the birth of the students' movement which, less than two years later, would shake the foundations of our country's educational and political institutions.

It is true that the occupation, in its overall management and stated objectives, stayed within the traditional framework of a vindicative movement for the democratic renewal of the university, but in fact it went far beyond this framework. Indeed, the radicality and extension of mass mobilization led to the development of a dialectic between forms of direct democracy and traditional representative bodies. Here was contained, in germ, the dissolution of the latter, and the affirmation of the former, which would characterize the struggles of the following years. Above all, for the first time, politics burst into university classrooms and would remain there as an indispensable conquest.

Although traditional science and culture had not yet been called into question – someone defined it as "the occupation by those with the highest marks," i.e., "the best" students in the traditional meaning of the word – the conditions were created to start calling them into question.

The soil for this maturation was particularly fertile among physicists, due to both objective and subjective conditions. Indeed, first of all, the growing contradiction was already emerging between an increased number of students and a lack of job opportunities. This would quickly lead the student masses to reflect on the class nature of selection and the hierarchical characteristics of labour in a capitalist society.

Secondly, an increasing discomfort and general uncertainty about the aims and meaning of their work were spreading mainly among young researchers as a consequence of a productivity-based frenzy, the fragmentation and proliferation of research fields, the transience of fads and the loss of a single criterion of cognitive validity that had characterized scientific production over the years, mainly in the leading sectors of physics.

Thirdly, a growing collective commitment to the anti-imperialist struggle was developing everywhere. From the autumn of 1966, there had been a swell of demonstrations, teach-ins, and struggles which gave more and more space to the political mobilization of support for the Vietnamese resistance. This clash radicalized positions and began to open tears within the corporate structure of the university world.

The student uprising of the following year did not take either younger researchers and assistants or fellows and recent graduates with precarious employment by surprise. They were already questioning their placement and their future. However, they were abruptly faced with the choice between plunging into the vortex of a movement, which quickly assumed the features of a total refusal of the system, or stand with the narrow elite of the powerful, in defence of the institutions.

In most cases, they chose, perhaps with some hesitation, the first alternative. However, their integration into the movement was not easy. The few years, or months, which separated them from their past as students objectively placed them in a different social condition in comparison with those who experienced the institution as a merely repressive tool, to be attacked frontally. The movement quickly passed from the discovery that "school gives us bourgeois culture" to the statement that "school teaches us nothing but to obey."[2] The experience of "anti-courses" and "critical university" burnt up the chance of joining up these layers on the basis of participation in the growth of an alternative education project. After all, this did not happen at random, since there were no mediation tools or channels with the working class, which may have enabled it to exercise a real hegemony over the students' movement, and also a concrete capacity to fulfil that function, thus providing the movement with the practical and ideal reference to which such a project could only be anchored.

The new contents, expressed by the success of working-class autonomy in its class conflict, would only be proposed once again after the "hot autumn" of 1969, in the subsequent struggles for contracts within the renewed context featuring the crisis of capitalism, which we are experiencing now. They remain there like valid embryos of a culture antagonistic to the culture of the ruling class.

Therefore, some lecturers and numerous fellowship holders and assistants supported this movement and took a more or less active part in it on the basis of a political evaluation of its nature as a left-wing movement, often engaging in radical forms of refusal of the social role they played. The clash was particularly violent around the issue of examinations, as a symbol of the selective function which

2 See R. Rossanda, *L'Anno degli Studenti*, Bari: De Donato, 1968, for a reconstruction of the events immediately after they took place, and a judgement which, even 7 years later, seems correct.

society confers upon academic institutions. This fight, just like any fight against a symbol, was at the same time necessary and abstract. That was exactly why the conquests of the movement were rather scarce on this terrain and, above all, ephemeral from a practical point of view. However, from an ideological viewpoint, the traces of this fight remain: the myths of the objectivity of the criterion of judgement, the neutrality of the knowledge which is handed down, justice based on merit: all these elements were torn to pieces. On the other hand, the drive toward egalitarianism, the rejection of unbridled competitiveness, the aspiration to active participation in the learning process, according to students' needs and interests, were reaffirmed, though in their own way, as potential values of a different society. These values would not take long to come back to the factories a few months later, with much more trenchancy and disruptive force.

In the meantime, the Italian Communist Party, after an initial hostility to a movement that had exploded out of its control and which did not fall within the traditional conflict patterns of social conflict analysis, in mid-February accepted "its legitimacy, without attacking it, but rather recognizing its autonomy and role, until the meeting between the Party secretary and the leaders of the Roman occupation. It is a relationship of respect, neither politics nor hegemony."[3] A few months later, the thrust to the left which followed encouraged the party to resume – among other things – the debate about the perspectives of scientific and technological development, while taking into account the critical consciousness, which had spread within the party itself on these topics. In December 1968, the Cultural Committee organized a meeting at the Gramsci Institute, which should have been preparing for a later meeting about the problems of research. I was given the task of writing the main part of the introductory report.

3 Ibid.

Here I summarized the main topics covered in my articles from previous years, reviewed in the light of the very recent experiences of the student revolt and the French revolt in May. The thesis of the "non-neutrality of science" was clarified and argued:

> This kind of scientific and technological development is closely interconnected with the development of capitalist society and, while it conditions and determines some of its fundamental aspects, opening up new internal contradictions just as it allows other contradictions to be overcome, it is in turn conditioned and subordinate. The concept which considers science and technology as neutral tools of social progress, independent from social relationships, and requires a process of scientific development following its own internal dynamics, subject to its own laws, is entering into crisis. At most, this dynamic may be favoured or hindered by the structure of society, as well as by the rhythms of its development, but it cannot be altered or determined in its own essence. However, it should be clear that the "non-neutrality" of science has nothing to do with Zhdanovian positions, nor does it propose arbitrary extrapolations of law, development trends or interpretative patterns from the area of social sciences to the area of natural and human sciences. It is a matter of recognizing that science is not only a problem-solving process but, above all, a continuous formulation and posing of problems to be solved. Therefore, in this essential stage of scientific development, not only are intrinsic elements involved, but also other elements external to science itself. This feature grows as science becomes a more and more immediate productive force, not only because it is exploited for productive purposes but also because the development of production along a certain direction rather than another provides

> research with certain tools rather than others. Above all, the social pressure to choose which areas to develop and what kind of investments to make, in order to create a list of priorities of value and prestige among the various fields of science, is a direct consequence of the structure of a given society as well as of its superstructure and dominant ideology.

I had cautiously but firmly formulated my criticism of the acceptance of the Western scientific and technological model on the part of socialist countries:

> In these conditions, the fact that the rhythms and modes of current scientific and technological development are largely dictated by the most advanced capitalist country imposes on Marxist critical thought the urgent task of demystifying this model of development, not only by highlighting the features coming from the – more or less mediated – needs of survival, functioning and expansion of the system, but also from its ideological basis, i.e., the thesis of the "neutrality of science." This is all the more important as this model tends to affect in some essential respects the development of research – even in socialist countries – through various mechanisms, from the drive to imitate the private consumption models of capitalist countries to the pressure exerted by the internationalization of science, which pushes competition on the "objective" ground of key sectors.
> This is also all the more important in order to once again place the problem of the role of scientific revolution in the transformation process from a socialist to a communist society at the forefront. This was the society inferred by Marx [in the *Grundrisse*] where working time stops being the measure of wealth – and therefore the exchange value and the measure

> of value; where "the general reduction of the necessary labour of society to a minimum [...] then corresponds to the artistic, scientific etc. development of the individuals in the time set free, and with the means created, for all of them." The basis of this transformation lies in the growing automation of agricultural and industrial production, as well as in services and, at the same time, in the progressive elimination of the traditional division of labour. Only in this perspective may the development of science itself overcome its current limits and biases in order to become a free creative activity of a growing number of society members.

Above all, I was fighting vigorously, although with some naivety, against the illusion that socialism could be reached through the so-called "scientific and technological revolution":

> I stated that it becomes more and more utopian – on the one hand – to trust in an inevitable crisis coming from an insoluble contradiction between scientific-technological development and the relations of production, and on the other hand to assume a transformation resulting from attempts to solve imbalances, contrasts and contradictions with the help of science and technology. All this is utopia unless we challenge the accumulation mechanism and the choices that ensure its continuity.
>
> Nowadays, the answer should be political rather than technocratic. A "research policy" of the revolutionary left is nonsense unless it becomes an aspect and a tool of the political class struggle. The answer to underdevelopment is, first of all, a struggle against imperialism, led – on the one hand – by the populations of the "underdeveloped" countries, accompanied by the active support and solidarity of the socialist

states, and – on the other hand – by the revolutionary forces in advanced capitalist countries. Not by chance, the Vietnam War was the catalyst for a vigorous resumption of the anti-capitalist struggle in these countries. Not by chance, the leading industries for scientific and technological development are – especially in the USA – the ones most committed to scientific war. However, in this way, the class struggle is not a mere answer to underdevelopment; it is also an answer to the contradictions of advanced capitalist society. Not by chance nowadays, in countries such as France and Italy, this answer tends to involve – with revolutionary contents and perspectives – the workers' avant-garde of technologically advanced industries and the students' movement at the same time. These are indeed the social strata most acutely subjected to the contradiction between the oppressive reality of capitalist relations of production and the liberating power of science as a productive force.

This revolutionary awareness-raising can therefore conquer those layers of the "new working class" (technicians, executives, middle managers, etc.) who are more and more subjected to exploitation in the process of valorisation of capital, only if the proposal of a technocratic solution to the problem is demystified. These social layers, for their scientific-technological professional background as well as for their status as privileged workers with higher wages, are still largely dominated by the "scientific rationality" of reform projects aimed at strengthening scientific and technological development within capitalist structure, without affecting – indeed enhancing – their centres of power. The provocative message: "*Soyez raisonnables, demandez l'impossible*" [Be reasonable, demand the impossible] means, in political terms, realizing that not only so-called "economic rationality" but also the

> presumed "scientific rationality" nowadays are identified with the irrational logic of capitalism.
> The chance of conquering these social strata to an alternative strategic perspective – as shown, for instance, by the events of May 1968 in France – depends to a large extent on the workers' movement's ability to indicate times and modes for the bonding between the socialist revolution and the scientific revolution. It is, however, clear that such times and modes cannot be planned beforehand. This would mean replacing one technocracy with another technocracy, unless we consider the general lines of the contestation of a development which reaffirms at all levels the alienation of man as a producer and as a consumer. Times and modes should arise from the active struggle of the masses who rebel against this condition and through this action propose a new scale of human values and new forms of social relations, thus laying the concrete foundations for a revolutionary process marking a transition stage "from the reign of necessity to the reign of freedom."

The text was approved and presented on behalf of the Cultural Section of the Cultural Committee. During the debate,[4] several presentations grasped the novelty of my approach, while underlining the need to encourage better analysis of the relationship among research, technological development and capitalist structure within the party. On the whole, however, the absence of representatives of the human and social sciences or well-known political leaders (apart from Rossana Rossanda) from the meeting marked a substantial disinterest on the part of the party's traditional leadership. This was the result of a decades-long theoretical vacuum of the whole workers'

4 See *Bollettino CESPE*, n. 25, December 1968.

movement on this specific topic. This vacuum may perhaps explain some confusion in the attempt to fill it. Nowadays – for instance – it seems to us indefensible to identify “scientific rationality” *tout court* with the “irrational logic of capitalism” typical of 1968 and included in the above-mentioned speech. It explains, but does not justify, the stance of the party in this area, featuring on the one hand the persistence of traditional positions, which appear totally inadequate for a reality check, and on the other hand a protean eclecticism prone to day-to-day politics.

The consequences of this stance soon came to light in clamorous circumstances. Indeed, in July 1969, while commenting on the American Moon landing, Sereni’s editorial in the newspaper *L’Unità* exalted “the scientific-technological revolution in progress, of which space industries are [...] an integral part, indeed, *one of its most characteristic aspects*” – and even demanded:

> **a growing commitment to such investments [...] in order to acquire a huge mass of scientific and technological knowledge, new means of production and new productive forces, indispensable in order to quickly overcome the backwardness and misery of entire continents and of many advanced countries as well.**

A few days later, *L’Unità* published my controversial letter about the attitude of the party’s mouthpiece on that occasion. A lively debate cropped up and was concluded – *ex officio* – by Napolitano. Rejecting any doubt about the progressive character of the Moon enterprise, they reaffirmed that the development of productive forces could not fail to contradict social relationships and make them fall apart. This inflexible conclusion, typical of the Second International, neither solved the problem, nor responded to the needs which the range of the debate had revealed. For that reason, it is no wonder that

– once the theoretical question had been circumvented – the policy line remained empirical and, in practice, undefined, linked as it was to the pressures of everyday politics. My answer, having no right of reply on that occasion, appeared in the newly-established magazine *Il Manifesto* and largely summarized the topic of the report which had been approved months earlier. It is probably one of the most relevant essays collected in this book. However, those who remember the atmosphere of uncritical exultation of that period cannot fail to agree on the need for a drastic demystification of that orgy of rhetoric.

The predicted meeting was held in April 1970 in a changed political climate after the dialectic between the left-wing and leadership had been solved by the ejection of the comrades of *Il Manifesto*. In the country, the working-class experienced the historical events of the "hot" autumn of 1969. Two opposing lines collided in the meeting. On the one side, there was the line reasserted by Sereni in his editorial, where he provided the workers' movement with the goal of obtaining investments in the factories of the technologically advanced sectors, as well as the development of research in related areas. On the other hand, there was the policy line pursued by the workers' representatives in research institutes, CNEN [Comitato Nazionale per l'Energia Nucleare, i.e., National Committee for Atomic Energy] in particular, who had been engaged in the struggles of the previous two years.

> **In fact, the only question the working class should ask itself with regard to research is finding in it reasons and grounds for class struggle.**

Thus spoke the secretary of the Nuclear Institute Union, continuing:

> **The working class should no longer regard as essential the battleground opened up by the contradictions between State**

> capitalism and private capitalism, between monopoly capital and small enterprises, national capitalism and foreign imperialism.

The comrades of the ENEA Research Centre at “La Casaccia” further added:

> We think it should be said, without hesitation, that the State, public research institutes, schools, are all deeply ingrained in the capitalist system, so that we cannot talk about a different usage of this term, a “new patronage,” unless – at the same time – we pursue the target of the conquest of power on the part of the working class.

A mediation between these two policies was offered by Giovanni Berlinguer, whose proposal was actually called “new patronage”:

> The indications related to development [...] should not come from capital, i.e., from the demands of profit – as you can read in the introductory report – but rather from the huge mass of Italian workers: therefore science should have a different social destination and a different management.

And again:

> The themes of the connection [between working class masses and research centres] are the immediate conditions of workers, social reforms, the trend of both production and research, general economic and cultural development [...]. The vindictive movement is connected to social reforms, which – in turn – are connected to the fight against monopolies, economic planning, scientific development. We are talking about

> **planning and development which do not respond to abstract models nor simply affect terminal phenomena, but rather are rooted in the concrete conditions of workers and take shape in unified mass movements.**

However, in the following years, the real novelty did not come from the formula of the "new commission" which, as we can see, was still very general. The workers' struggles, with steelworkers at the forefront, would continue – for the defence of health in factories, against the capitalist organization of work, for the affirmation of the workers' hegemony at school, through the tool of the 150 hours, in the midst of class confrontation – the build-up of a "new scientificity" which could express a project of knowledge and control of nature, permeated by alternative social purposes with respect to the science of capitalist society.

The Communist Party took this urge on board in a contradictory way. On the one hand, it identified in the relation between science and work organization a major issue for the strategy of the workers' movement in an advanced capitalist country. The meeting organized at the Gramsci Institute in Turin in June 1973 on this topic therefore marked an important turning point in policy, not only because it contributed to "socializing" – within the party and outside – some of the most significant experiences of the class conflict in the factory, but also because it acknowledged its decisive role in the direction of the process of scientific and technological development. On the other hand, however, the party refused to push this line up to the level of Marxist theory, reaffirming the proxy of academic "specialists" in this field. The supplement of *Critica Marxista*,[5] with the title "About Marxism and Sciences," is the result of this fusion of scientists and

5 I feel I should mention the contribution of Bruno Cermignani, one of the few who tried to face the real problems.

metaphysical philosophers belonging to another respectable, ageless world.

4.

The first opportunity for discussing conflicting stances on science in the community of physicists, between those who had been engaged or involved in the movement and those who had fought against it, was a meeting in Florence in 1970, organized by the Italian Physics Association [SIF: *Società Italiana di Fisica*], on the topic "Science in Contemporary Society."[6] Two talks presented the point of view which had grown out of the "area of 1968," one by Silvio Bergia and my own.[7] The first talk – "The Social and Cultural Function of Scientific Research" contained, among other things, some new ideas for reflection and debate which would be explored and enriched later on by Bergia himself and by Angelo Baracca.[8] In particular, there was a critical analysis of the aims and methods of cutting-edge research, which in the area of physics was characterized by the ever-growing race to the energy accelerator. This analysis made physicists face a reality which many of them would have preferred to ignore since they considered it an inevitable product of "progress." It also traced the main features of the research work back to "the dominant production relationships in society," namely the fact that "experimentation is more often focused upon the routine collection of data than on top-level experiments," giving "yes" or "no" as an answer; "increases in paper

6 The proceedings of this meeting were published by De Donato (Bari, 1968), with the title *La scienza nella società capitalistica*.

7 It is interesting to notice the consensus gained by some of the theses about the connections between research and capitalist development, on the part of another participant, the economist Sirio Lombardini, foreign to that area and rather on the Government's side. The obtuseness of traditional "scientists," who denied such connections, stood out particularly in comparison.

8 See his book *La spirale delle alte Energie,* Milan: Bompiani, 1975.

production, which does not correspond to a real increase of information"; the transience of trends in theoretical physics. Since this discipline cannot make "true predictions," it simply builds new "interpretative schemes suitable to a reality of ever-changing data"; finally, the aspiration to find something new becomes a race to find something before someone else.

In my contribution, reproduced here in the Appendix, we find the expression of the concept of the "non-neutrality" of science, alternatively welcomed by some authors[9] and bitterly criticized by others[10]:

> we are led to challenge the dogma of the neutrality of science, so deeply rooted in the mind and consciousness of many of us, to the extent that we become aware that it is no longer possible to separate the object of our act of knowledge from the reasons for this act; nor to distinguish the moment of investigating reality from the moment of that reality's formation; nor to isolate the problem-solving process without identifying the mechanism, which proposes the problems to be solved. In other words, to the extent that we become aware that reality is not an unspoiled nature that we stand before like Robinson Crusoe, but rather a product of human history, and how, on the one hand, people were led to establish certain social relationships among themselves in order to dominate and thus understand nature and, on the other hand, they were able to take possession of nature and transform it in a

9 See G. Jona-Lasinio, "Mutamenti della prassi scientifica nella società tecnologica" ["Changes in Scientific Practice in a Technological Society," here in the Appendix, Chapter 6]; G.A. Maccacaro in *Scienza e Potere*, Milan: Feltrinelli, 1975, p. 30.

10 See S. Petruccioli and C. Tarsitani, *Critica Marxista*, n. 6, 1972; L. Geymonat, *Scientia*, July-August 1973.

certain way, as a consequence of the social relationships they had established.

The statement "reality is not an unspoiled nature [...] but rather a product of human history," taken literally, was a poor choice of words inasmuch as it seemed to imply that reality is only a product of history. I should have added "also." However, in the following phrase it is clear that it should not be taken literally since I underline the intertwining between the human-nature relation and social relationships, duly implied by a correct materialistic-historical concept of science. The first essay of this anthology examines this concept in depth, coming from a longer work that I carried out with other comrades, such as Giovanni Ciccotti. Therefore, I will not anticipate the details. On the other hand, it seems to me more useful to reconstruct some stages of the process of maturation of the current political positions held by – apart from the individual freedom regarding formulations not explicitly signed – the group of comrades who contributed to the present collection of essays.

The first stage was the development of an interest in the history of physics. Giovanni Jona-Lasinio recognized the need to submit the emerging concept of "non-neutrality of science" to a confrontation with history, testing its usefulness as an interpretative tool for the past and enabling a validation of the analyses of the present, based on it.

In 1971, Jona gave a presentation[11] at the SIF meeting in L'Aquila, in which he set out his programme and the theoretical reasons justifying it, resulting from the experience of a three-year course in the history of physics, held from 1968 onwards, and his collaboration with Giovanni Ciccotti during this period. His presentation was quite successful: the corporation [of scientists], troubled by a deep crisis, was

11 The text reproduced in the present Appendix is a later re-working (1972) of this presentation, but it offers its essential mood and contents.

still willing to accept external criteria to verify its identity. However, only a few years later, this crisis was exorcised and replaced by the triumphalism of the self-justification of science as an absolute cultural value (SIF Meeting in Ferrara, 1975).

The ideal starting point for Jona's talk essentially was the 1857 Introduction by Marx to his *Contribution to the Critique of Political Economy* [first published in 1859][12]:

> We should return the scientific production of natural sciences to the historical totality. Indeed, scientific production is a human activity and, as such, we expect it to be historically determined and feasible in terms of relations, causes and effects. Moreover, since it is a particular and specific human activity, it is not understandable in itself, but only in association with the other similar human activities in other historical periods. In other words, science can only be understood with reference to the totality of human works and actions. Only if we distinguish it from other human activities and capture its peculiar features, without introducing *a priori* elements, we can define science in a concrete, rather than abstract, way. *In other words, science in its concrete reality is not given to us immediately, but rather after a long and accurate analysis.* At this point, it is appropriate to recall Marx: The concrete concept is concrete because it is a synthesis of many definitions, thus representing the unity of diverse aspects. It appears therefore in reasoning as a summing-up, a result, and not as the starting point, although it is the real point of origin, and thus also the point of origin of perception and imagination."

12 Marx, *A Contribution to the Critique of Political Economy*, trans. S.W. Ryazanskaya, London: Lawrence & Wishart, [1859] 1971, available online at: www.marxists.org/archive/marx/works/1859/critique-pol-economy/appx1.htm.

Thus the focus is the identification of the process of concept creation, which allows us to understand science as a human activity and, therefore, as a social activity. The category of "science," according to the dominant bourgeois ideology, is a broad cognitive activity deprived of all the peculiarities which characterized it in different historical periods. Thus its evolution, once we have deleted all its specific features, is reconstructed – according to Hegel – as "the result of the thought which encompasses and deepens itself." On the other hand, according to Marx's "method of political economy," an economic category "cannot exist except as an abstract, unilateral relation of an already existing concrete organic whole." Therefore, "even the most abstract categories, despite their validity in all epochs – precisely because they are abstractions – are equally a product of historical conditions even in the specific form of abstractions, and they retain their full validity only for and within the framework of these conditions." Thereby, "science," as a determinate abstraction, represents the theoretical and cognitive aspect of the man-nature relation, within a certain economic and social framework.

This does not mean that we reduce science to a mere economic factor. Rather, we refuse to consider science as a purely spiritual activity, as an eternal philosophical problem. This is a historical portrait of the epistemological aim of science, from time to time as a specific aspect of the relations of a certain society. "The analysis of the man-nature relation" – Jona continues – "is first referred to the aims inherent in any scientific project, and then to an understanding of the relations of social production."

Jona's policy guidelines were soon translated into an initiative which represented a crucial stage of collective ripeness for the generation of 1968. In 1972, SIF entrusted him with the organization of the Physics Summer School in Varenna. The topic was: "The History of 20th-Century Physics."

This was a broad enough topic to allow the intertwining of vastly different issues: from the stories of some protagonists of quantum mechanics, or of the development of "big science," to the introduction of professional science historians to the contemporary epistemological debate. There was not yet a coherent and articulate Marxist presence; however, most participants deeply felt the need for such a presence and promised an ever-increasing individual and collective commitment on this terrain.

The Varenna Meeting actually spurred a multiplication of contributions on the history of science in the following years by physicists and mathematicians who, though mostly committed to fundamental research, felt the need to critically analyse the contents and methods of their discipline, in their historical context, from within.[13]

The chance to analyse science production in terms of social and historical categories, capturing those specific features that make it a particular, historically determined human activity was a slow and difficult conquest for many militants of the Italian left. A number of slogans from 1968 went in this direction, but the construction of an adequate conceptual apparatus was an undertaking of very different dimensions. These difficulties were particularly serious because it was – as I tried to show in detail – a line of thought which found very little support in the Marxist theory known in the Western world.

Through a British reissue of the talks of the Soviet delegation to the Congress of the History of Science and Technology, held in London in 1931, we actually discovered a current of dialectical materialism – apparently very much alive until the beginning of the Stalinist era – which explicitly and eloquently supported a viewpoint which is very similar to the ones discussed in the present collection of essays.

13 We may simply mention the research of Braccesi, Baracca and Rossi, who shed light on the origin, historically attributable to the social context, of a few concepts which are assumed as axiomatic definitions in physics work in particular. See also the proceedings Donini Elisabetta, Rossi Arcangelo, Tonietti Tito, 1977. *Matematica e fisica. Struttura e ideologia*, Bari, De Donato.

This was very important for us. The volume was entitled *Science at the Crossroads* and was published in 1971; but we only discovered it less than one year ago. In an essay by Nikolai Bukharin, "Theory and Practice from the Standpoint of Dialectical Materialism,"[14] we find the following statement:

> The idea of the self-sufficient character of science ("science for science's sake") is naive: it confuses the *subjective passions* of the professional scientist, working in a system of profound division of labour, in conditions of a disjointed society, in which individual social functions are crystallised in a diversity of types, psychologies, passions [...] with the objective *social role* of this kind of activity, as an activity of vast *practical* importance. The fetishizing of science, as of other phenomena of social life, and the deification of the corresponding categories is a perverted ideological reflex of a society in which the division of labour has destroyed the visible connection between social function, separating them out in the consciousness of their agents as absolute and sovereign values.

He goes on to say, regarding the cognitive value of science:

> The 'class subjectivism' of the *forms of cognition* in no way excludes the objective 'significance' of cognition: in a certain measure cognition of the external world and social laws is possessed by every class, but the specific methods of conception, in their historical progress, *variously* condition the process of the development of the adequateness of cognition,

14 N. I. Bukharin in N. I. Bukharin et al., *Science at the Crossroads*, London: Cass & Co., 1931, available online at: https://www.marxists.org/archive/bukharin/works/1931/diamat/index.htm.

> **and the advance of history may lead to such a 'method of conception' as will become a fetter upon cognition itself. This occurs on the eve of the destruction of the given mode of production and its class promoters.**

About one year after the Varenna Summer School, Ciccotti and Jona participated in a debate about "Science, Culture and Society" promoted by the journal *Scientia*, with an article, reproduced in the present anthology, in which they started an explicit and concrete analysis of the socially-conditioned nature of science at the level of the basic epistemological and methodological choices.

As proof of the fruitfulness of the viewpoint developed therein, a specific example of a historical analysis carried out in the light of this point of view can be found in this volume. The essay on the relationship between Boltzmann and Planck shows, in practice, how one can finally answer a few questions which had not even been formulated yet by enlarging the traditional research field of the history of science in order to include cultural and productive dimensions, typical of a certain socio-economic reality.

If the first of the thematic strands of our maturation can be retraced – as we noticed above – to Marx's 1857 Introduction [1859], the second one is rooted in the Marxist theory of fetishism, which I personally focused my attention on between 1970 and 1972. This is indeed an unsolved knot which one has to deal with in attempting an analysis of capitalism in its technological stage through Marxist categories. Indeed, on the one hand, advanced capitalist society seems to be characterized by a generalized "process of alienation of labour" (according to Marx) in all labour spheres. This is a process of inversion between subject and object in which "commodities, which become a means of domination (of capital upon the workers) are, in turn, mere results of the production process, therefore its *products*." More in general, people, not only as producers but also as consumers, appear increasingly dominated by objects, which in turn seem endowed with "natural social properties." In Marxist terms, people seem to be dominated by "commodity fetishism." On the other hand, however, the concept of the form of value on which – in my opinion[15] – the concept of the alienation of producers could be based, with a precise reference to the social structure rather than a mere philosophical notion, has been a moot point for a hundred years. Its use appears problematic, to say the least, in order to analyse a socio-economic body in which many Marxist abstractions have lost their precise meaning.

Indeed, unproductive work seems to be assuming an increasing importance (growth of the tertiary sector); in the area of the production of material and non-material commodities, the prevalence of simple work over complex work has disappeared. Monopoly and oligopoly have replaced market competition among capitalists, not to mention the problem of exchange between imperialist countries (technological producers) and satellite countries (raw-material producers). I believe that this contradiction between the crisis of the concept of value and the validity of the idea of fetishism must be addressed. My contribution to the debate on the link between Marx and Sraffa, reproduced in the present anthology, should be considered in this light.[16]

Its heterogeneity with reference to the other essays is, therefore, more apparent than real, for two reasons.

First of all, indeed, it provides support for the analysis of the process by which science is produced, carried out in Chapter 2, inasmuch as one suggests that in any place of capitalist production of commodity one can notice the presence of all those aspects of the

15 However, there have been attempts to break up the connection between the will for the concept of fetish and the form of value. See, for example, M. Lippi, "Lavoro produttivo, costo sociale reale e sostanza del valore nel *Capitale*," *Problemi del Socialismo*, vol. 16, n. 21-22, 1974.

16 The ideas expressed in this essay, naturally, represent only me, since there is still no agreement amongst all of us.

production process of capital, highlighted by Marx on the basis of his analysis in terms of value and added value, even though the organic composition of capital in different productive areas is not constant. In particular, we want to stress that the notion of the alienation of work and commodity fetishism is materialistically based upon the social relations of production, existing also in a real economy, in which prices differ from exchange values.

In the second place, this essay is directly connected to the general topics handled in Chapter 1 since it discusses the precise usage of the concept of "non-neutrality of science," in particular of economic science:

> the process leading to scientific knowledge is a formulation of "determined abstractions" which must, first of all, be adapted to the real object; they must capture its essential and specific elements at a certain level and at a certain stage of its development, but are at the same time an expression of the socially-conditioned viewpoint of the subject. Namely, this is an expression of his/her theoretical and practical horizon, past experiences, and the project of transforming nature and society to which he/she – implicitly or explicitly – adheres.

The introduction could end here. Its main goal, indeed, consists in showing the reader the genetic and conceptual relations among the various essays collected in this anthology, while underlining their common matrix and aim: the development of a framework and a method, based on some of the cornerstones of Marx's thought, so as to facilitate a materialist analysis of science, inasmuch as it is a human social activity. However, we will not have completed the reconstruction of events and contributions which affected this drafting process unless I explicitly recognize my huge debt to and at the same declare my clear dissent from Lucio Colletti.

As far as I am concerned – even though I think that, more or less, this is true also of the other contributors of this anthology – I believe that Colletti provided the key for understanding the cornerstones of Marx's thought upon which our work is based: i.e., historical materialism and the theory of fetishism. As a proof, it seems important to me to quote a few passages from his work "*Bernstein e il marxismo della Seconda Internazionale*" [*Bernstein andl Marxism in the Secona Internazional*], so as to make it clear how much our interpretation of Marx's thought draws inspiration from Colletti. He quotes a particularly significant phrase by Marx:[17]

> In production, men not only act on nature but also on one another. They produce only by co-operation in a certain way and by mutually exchanging their activities. In order to produce, they enter into definite relations with one another and only within these relations does their action on nature, does production, take place.

The interweaving of these two processes – Colletti continues – is "the key to *historical* materialism":

> Traditional materialism, which sees men as products of their environment, forgets, according to Marx, that men in turn change their circumstances and that "it is essential to educate the educator himself." It forgets that it is not enough to consider practical-material circumstances as the *cause* and man as their *effect* – the inverse must also be taken into

17 L. Colletti, "Bernstein and the Marxism of the Second International," trans. J. Merrington and J. White, in *From Rousseau to Lenin: Studies in Idelogy and Society*, New York and London: Monthly Review Press, 1974, available online at: http://www.marx2mao.com/Other/BMSI68.html.

> account. Just as man, the effect, is also the cause of his cause, so the latter is also the effect of its own effect.
> In other words, as a product of objective material causation, man is also and simultaneously the beginning of a new causal process, opposite to the first, in which the point of departure is no longer the natural environment but the concept, the *idea of man*, his mental project. [...].
> Now the simultaneity of these two processes [...] is the secret of and key to *historical materialism* in its double aspect, of causation (materialism) and finality (history). But it also permits an explanation of that crucial point in Marx's work: his concept of 'production' or 'labour' as at once production of *things* and production (objectification) of *ideas*, as production and intersubjective communication, as material production and production of social relations.

From these premises, Colletti derives the refusal of "an opposition between *factual judgements and value judgments,* between science and ideology." On the other hand, he underlines:

> value judgements are inevitably present in scientific research [...]. This is precisely the link between science and politics, between knowledge and transformation of the world, that Marx accomplished in the historical-moral field. [...] This in turn allows us to understand that what Bernstein and so many others saw as a defect or weakness of Capital – the co-presence within it of science and ideology – on the contrary represents its most profound originality and its strongest element.

However – and here I dissent – this apparent concordance of general formulations produces, in practice, rather different conclusions.

According to Colletti – who expresses his thesis with great clarity and honesty in *Intervista politico-filosofica* [A Political and Philosophical Interview] (1974) – what was already implicit in his preceding works, in the statements reported above, are not related to the science of nature or "science" by definition, as an ideal of "true" science. It seems that this idealized science is not part of the relationship between humankind and nature – inextricably intertwined, as Colletti himself writes, with human social relations.

It would seem that, for science, what Colletti had said in 1959 does not apply: namely, that the only way in which the nature-society relation can be outlined is by "assuming the priority of nature in the historical-concrete condition where the problem arises. This is evidently a condition in which, over and above nature, humans are already there, questioning nature, and therefore society itself is there, so that the simply natural relation has already overturned into a historical-natural relation."

In other words, Colletti refuses, in the case of the science of nature, to ask himself the question of the way in which – according to Marx's Introduction of 1857 – the concrete appears "in reasoning as a summing-up, a result, and not as the starting point, although it is the real point of origin, and thus also the point of origin of perception and imagination." It is as if there were a biunivocal correspondence between real and ideal concreteness; as if the categories of science *only* represented elements of a given objective reality in thought. As a consequence, there is no space for "the inevitable presence of judgments of value in the scientific investigation," which – in fact – seemed a relevant acquisition within a historical-materialistic definition of science. Once we assume that natural science is nothing but a faithful – though approximate – reproduction of an objective reality, the *freedom from contradictions* of this reality, descending by definition from its pre-categorial being – "origin of perception and imagination" – *ipso facto* becomes *freedom from contradictions* of concrete thought, which becomes "synthesis of many definitions, thus representing the unity of diverse aspects."

If we follow Galvano Della Volpe, and assume this (false) image of natural science as a paradigm of any science and try to lead Marxism back to the science of society, in the real (!) sense of the word, i.e., science, like any natural science, no wonder that Colletti is in front of two versions of Marx.

Let's have no misunderstanding. I think – but I am by no means sure – that Colletti is right when he states that there is, *in nuce*, an ambiguity in Marx between the Kant-inspired concept of natural science and his reconstruction of a science of society, characterized by an entanglement between the objective and subjective, and therefore incompatible with the former concept. But it does not follow in any way that the latter should be thrown overboard in favour of the former.

Instead of taking from Kant (i.e., from Newton) a model of "true" science and noting, with disappointment, that it is not suitable for Marx's work – nor, to be sure, for current natural sciences – we believe it is much better to take the latter as a paradigm of science, "in its double aspect, of causation (materialism) and goal-orientation (history)." We should then verify whether it allows us to better understand – in its historical development and in its concrete reality – the meaning and value of human social activity consisting in the theoretical and practical appropriation of nature. In this way, we would understand the value of science. We have tried to do this, through trial and error, in the following pages.

Part 1

The Historical Rationality of Scientific Practice

Scientific Planning versus Scientism

Giovanni Ciccotti, Marcello Cini, Michelangelo De Maria

Introduction

> The current industrial revolution – N. Wiener said – should devalue the human brain, at least as far as its basic, regular functions are concerned. Naturally, just as a carpenter, a mechanic and a qualified tailor survived – one way or another – the first industrial revolution, in the same manner a scientist and a qualified administrator can survive the second industrial revolution. Let us suppose that this second revolution has already taken place. In that case, the average man, endowed with average – or indeed inferior – skills, will not be able to sell anything worth buying.
> The only solution consists in building up a society based upon human values, other than buying-selling. A great preparation and a demanding struggle are necessary in order to build such a society.

In the meantime, this struggle has not yet been won, and the process mentioned by Wiener has been enlarged and deepened, also involving science which has actually become, if we paraphrase a well-known saying, a huge collection of "puzzles." Hence, a crisis of mistrust in the usefulness and meaning of science has emerged, both in the general population and in the scientific community involved in a fight for the transformation of society. This crisis has often been idly countered with a trial against science, which is unsatisfactory because is is too superficial and solipsistically irrational to be useful.[18]

However, the crisis is there, whatever the value of its formulations, which at least has the merit of showing that the value of science and its social function is more complex, more interesting and more charged with consequences than the superficial certainty of scientism and its easy solutions, stated through commonplaces, would have us suppose.

Much more serious is the responsibility of those who,[19] by relying on the weakness and mystical character of the claims of irrational critics, propose a false dilemma: either obscurantist or scientist. In fact, this is not the right way to face a crisis of values, aims and comprehension, but only a way to exorcise it. Moreover, it helps to prop up the old false and damaging idea that only the purely technical aspects of the problem of science are important, no matter whether they are epistemological or historical.

Anyone – whether a technician, scientist or just a responsible citizen – experiences the conditions of crisis every day but has no sympathy for irrational attitudes, knows how pointless the long and learned academic dissertations are when they evoke science in order

18 This is certainly the case of H. Marcuse, throughout his works. More recently, we may find similar insights in J. Habermas and other, less prominent authors. For a clear and inspirational review, see: P. Casini, "Eclissi della Scienza," *Rivista di Filosofia*, vol. 61, 1970, p. 239. See also P. Rossi, "Processo a Galileo nel 20° secolo," *Aspetti della Rivoluzione Scientifica*, Naples: Morano, 1971, p. 13.

19 The whole traditional academic culture roughly shares this stand. It is sad that more or less explicitly Marxist authors have aligned with this position without trying to avoid false dilemmas. See, for instance, the easy winding-up – with H. Marcuse and the young G. Lukács – of the problems in the chapter related to this in L. Colletti, *Il Marxismo ed Hegel*, Bari: Laterza, 1969; the mannerist neo-Enlightenment of P. Rossi in his recent works; the inconclusiveness of L. Geymonat's pupils – E. Bellone, G. Giorello, S. Tagliagambe take to the field in order to propose yet another alliance between dialectical materialism and scientism in the recent book *Attualità del materialismo dialettico*, Rome: Editori Riuniti, 1973. In our opinion, the position of L. Geymonat himself is different and more sensible in his essay, contained in the above-mentioned book. Even more interesting is P. Casini, "Eclissi," and in his Introduction to the *Storia della Scienza*, by Maurice Daumas, Bari: Laterza, 1979, p. ix [*History of Technology and Inventions,* trans. E.B. Hennessey, New York: Crown Publishers, 1969].

to defend it from its denigrators and represent it in a manner that has very little in common with its real nature. People know that, as long as there are no *positive* answers to the questions raised over time, and only *formal*, superstructural solutions are provided, it will be impossible to start a real process of subjective and objective reappropriation of the power of dominion over nature, a power which is objectivated both in the means of production and in science.

In order to make the meaning of our research clear, we should make a few points – which we will discuss more in-depth further on – so as to single out the real problems we start from and the method we want to use.

The results of productive activity can be obtained by applying either technique or technology. Indeed, we mean to distinguish between a production based on empirical procedures – without a systemic use of a pre-established natural knowledge – and a production whose theoretical conditions are provided by natural sciences. We can rephrase the latter case by saying that technological production is ideally subsumed by natural sciences, so that it comes from the application of a pre-existing plan of activity. In this sense, Newton's construction of a reflecting telescope is a typical example of technological activity.

On the other hand, the *technological stage* – which is only taking place now [in the twentieth century], is a condition in which the sciences constitute a fundamental ingredient of *all* production sectors. We notice that, although it does not seem necessary, this situation emerged together with large-scale production in all sectors, so it was realized thanks to the economic interdependence of all producers.[20] It is therefore clear that only in the technological stage do

20 In principle, it is not absurd that technological production coexists with the greatest economic independence. This was actually the idea of Francis Bacon as he proposed, in *Instauratio magna*, a society made up of independent artisans and farmers who would be

sciences reach their greatest socialization. It is also clear that it is important to understand the value, meaning and social function of science if one wants to reconstruct the general movement of society, perhaps in order to transform it. Hardly anyone can deny this problem. However, we want to underline the fact that this problem cannot be solved through the dichotomies provided by academic culture. It is generally assumed that, if one wants to understand the use and function of science in society, one should ask a sociologist, or even seek an economic analysis of modern society. On the other hand, if one wants to define the value of science, one should refer to epistemology, or – even better – do good science. Finally, if one faces general problems, such as the meaning of science in culture and civilisation, one has to refer to practical philosophy and examine informative historical examples. We believe that these distinctions, though useful for defining one's object of research and identifying levels of analysis, do not have a rigorous foundation. Indeed, we think that it is impossible to reconstruct the social aspects of science without giving a definition of science suitable to that society. Conversely, we cannot build up a definition of science within scientific activity that is enough articulated to allow us to explain the features of its impact upon society.

In this regard, we agree with the Soviet scholar Bonifaty Kedrov, whom our culture can hardly consider to be irrational. Here is what Kedrov wrote about "the laws of development of Science":

> *In actual fact, the material and the spiritual* (in this case, the logical) *factors never operate separately* in historical development. They are intertwined and interact, leaving a profound

helped by a centralized science suited for their purposes. However, it is difficult to understand what kind of real mechanism (i.e., not based only on good intentions) could socialize a society born of the basic needs of many small independent monads. On this matter, see: B. Farrington, *Philosopher of Industrial Science* (London: Lawrence and Wishart, 1949); P. Rossi, *F. Bacone dalla magia alla scienza,* Bari: Laterza, 1957.

> impress on each other. It is only in the abstract that we can conventionally separate one aspect from the other, and speak either of the material causes of some historico-scientific event or of the logical continuity in its link with other events. Material practice cannot itself create a sufficiently advanced stage of cognition unless the necessary cognitive premises have arisen for the achievement of that stage [...]. Conversely, a logical stage, which has matured in the development of science cannot be realised without the incentive provided by practice. This pattern of dependence (the interconditionality of the two aspect of the question of the fundamental law of the development of science) can only be seen and understood if the study of the material and the logical aspects of the development of science is conducted, not separately but in their unity, through the use of a single scientific method. It is to be regretted that we are as yet practically unskilled in studying the spiritual and the material factors of contemporary historical development (including the natural sciences) in their connectedness and inter-conditionality.[21]

We do not think that this interdependence of various phenomena prevents the problems posed from being solved rigorously. In this sense, we have no inclination to mysticism, nor any sympathy for confused ideas. Rather, we think that the moment has come to try and arrive at a suitable viewpoint, which is appropriate to the problems under discussion.

In another context,[22] we have analysed the efforts and difficulties

21 B. Kedrov, "Regarding the Laws of Development of Science," *Social Science*, USSR Academy of Science, vol. 5, 1974, p. 34.

22 G. Ciccotti, G. Jona-Lasinio, "Il dibattito epistemologico moderno e la socializzazione delle scienze," *Scientia*, vol. 108, 1973, p. 481 ("Modern Epistemological Debate and the 'Socialization' of Science," Chapter 3 in this volume).

of modern epistemology in disconnecting the necessarily present link between the validity of cognitive thought and its function in the process of transforming reality. We also realized that this attitude does not provide an accurate definition of science, and does not explain how scientific knowledge grows. Thus, it actually constituted the reason why it cannot answer the questions raised by the socialization of science in technological capitalism. It also prevents the detection and analysis of possible alternatives. Everything becomes clearer and simpler – as we will show in detail later on – if we choose the viewpoint of materialism because then the link immediately follows the viewpoint, and we can find suitable tools for a global analysis of science in society, today and in historical perspective. Let us try to clear this up and introduce our research programme.

We define materialism as "the tendency to include both the law and time-limit of any transformation in the thing that is being transformed, so that the latter is the condition, and the former the function."[23] It is therefore clear that the term 'nature' indicates everything which exists, not only what pre-exists, i.e., the material on which we work – as is typical of any materialism that ever existed in history – but also the person who makes transformations possible, the law that allows it, and the product of these transformations. We can now outline this definition as follows: nature is inseparably *data* [dato] and *deed* [fatto, i.e., fact], and neither can be omitted in any rigorous definition. On the other hand, the only meaning we can attribute to a definition such as Ernst Cassirer's, according to whom "in strict physical terminology 'nature' is nothing but an aggregate of relations, of laws [...] such a set is a 'form',"[24] which rigidly separates reality and its

23 B. Cermignani, Introduction to A. Einstein, *Relatività; Esposizione Divulgativa*, Turin: Boringhieri, 1967, p. 19.
24 E. Cassirer, *Determinism and Indeterminism in Modern Physics*, trans. O.T. Benfey, New Haven: Yale U.P., 1956, p. 119 [This quote has been slightly altered by the authors. We reproduce here a translation of how it appears in Italian]

evolution from nature, which is considered as a spiritual and subjective synthesis of what one knows, largely unrelated to reality. Thus, he introduces the harmful dichotomies we mentioned above in the definition itself. On the other hand, we want to underline that our viewpoint has been clearly expressed by Marx as a materialistic-historical instance.

Let us go back to our main problem. The materialist hypothesis directly provides a basic homogeneity among nature, society and their laws, namely the various sciences. However, this hypothesis also allows us to relate the various ways of making science that succeeded one another more closely, as well as the social and productive framework within which they have become well-established. Indeed, from this point of view, science does not represent, nor can actually represent, anything but the law-based quality of nature, which provides the ideal basis for social production or, in mature capitalism, the suitable tools for a series of transformations leading from one historically determined level of existence to another. Therefore, among the modes of production, i.e., the ways of appropriating nature, social relations and, more generally, the organization of society and organized human knowledge – namely science – there must be a well-defined relation which can be called the *coherence* of science with society. We anticipate that this coherence is not only expressed in the contents of science, obviously tied to the development of techniques, but also in the methods and goals of scientific activity. Moreover, we can say that the lawfulness of nature is determined in view of the transformations we want to realize (or prevent, but we will go back to this). Therefore, the fact that science is related to society does not affect its validity. Indeed, its validity depends only on its ability to subordinate itself to – and thus dominate – the natural and social conditions which constitute the starting point of the transformations we are looking for.

Now, the more advanced the socialization process of scientific research is, the more important and enlightening the result of the analysis which we are proposing here is for the reconstruction of society's fundamental structures and development trends. It should be remarked that, among these trends, one can find the revolutionary one aiming at a radical change in both production and life.

Furthermore, in the technological stage of capitalism, these integration processes have reached their highest level so that there is a very pressing need to rebuild the links of coherence mentioned above. However, we cannot directly use Marx's theory to this aim, even though we think that the theoretical basis and research method we propose are already there in his work. Indeed, although the reconstruction of society's developmental trends was the main goal of his work, his analysis essentially focused upon the historical forms of production (nature as a *deed/fact* of its time) as well as their related social relations, but it only marginally addressed the question of science. After all, he could not actually address that question since, in a technical stage, science could systematize progress but rarely get ahead of it.

It should be clear that, at this point, the first thing we should do is provide the fundamental reference points so as to start unravelling the set of issues bound to the particular nature and role of sciences in advanced capitalist society.

Thus our research, which is frankly preliminary, will take place along the following lines. First of all, we will give a materialistic definition of science which allows us to explain the processes of socialization and integration typical of contemporary science. We will also make sure that this definition includes the key data of past scientific developments (this is an important test for the validity of our definition). Then, in light of this definition, we will examine the links between science and ideology, and, on this basis, we will attempt a first classification of ideologies which may allow us to single out the value and meaning of science.

This will show the wide range of interventions within the perspective of the process of the construction of socialism. Therefore, we will have to discuss the method of investigation most suitable to these goals at length. On the one hand, we shall realize the shortcomings of the usual scientific abstraction which proceeds, without taking history into account, in a hypothetical-deductive way, without discussing the reasons for its hypotheses or implicit choices. On the other hand, we will introduce a method which is, at the same time, hypothetical-deductive and historical and which is typical of materialism. We will show that this method can detect the implicit goals of traditional scientific abstractions and the historical reasons for their origin, rise to prominence and disappearance. Moreover, it can suggest suitable scientific areas and modes for pursuing an alternative on the basis of society's contradictions and implicit alternatives. If we were presumptuous, we could say that this is an attempt to enlarge the field of application of scientific socialism.

A remark is necessary at this point. In the course of our work we shall use – as broadly as possible – the materialist-historical concept of Marx (and Engels) and its insights about science and scientific development within society. However, we emphasize that we have no philological claim, nor do we claim to represent some Marxist orthodoxy. We are only interested in offering food for thought about an exceptionally pressing and actual issue.

Science and Ideology

The first consequence of the materialist point of view[25] is contained in the request to give priority to the natural basis in any rigorous definition of phenomena. This request comes from the homogeneity

25 We would like to stress the fact that, although we consider the materialist viewpoint a fundamental hypothesis, full of important effects, we believe that it makes no sense to put ourselves in the perspective of a demonstration of materialism, at least until it is clear what the demonstration is and at what level of language it is made.

of reality in its various forms (natural, social, spiritual) and from the real (ontological) priority of the whole on the parts. Thus, for instance, since society can neither exist nor develop without producing, i.e. without certain relations with nature, the analysis of the social relations of production should be the starting point for trying to understand society and its laws of development.

The situation is not different if we refer to spiritual manifestations in general, and to cognitive thought in particular. The only difference is that, on this occasion, not only nature, but also society constitutes a *prius* with respect to them:

> From the start the 'spirit' is afflicted with the curse of being 'burdened' with matter, which here makes its appearance in the form of agitated layers of air, sounds, in short, of language. Language is as old as consciousness, language *is* practical consciousness that exists also for other men, and for that reason alone it really exists for me personally as well; language, like consciousness, only arises from the need, the necessity, of intercourse with other men [...]. Consciousness is, therefore, from the very beginning a social product. [26]

Therefore, in order to understand the nature and development of legal and political arrangements of society, as well as to single out the reasons for particular forms of social consciousness (i.e., culture) which are active in any historical moment, we should refer to their real initial basis, which is constituted by the productive forces and their related lifestyles. Indeed, as Marx says:

26 K. Marx, F. Engels, *The German Ideology*, Ed. by C.J. Arthur, New York: International Publishers, 1970, pp. 50-1, available online at: www.marxists.org.

> The mode of production of material life conditions the general process of social, political and intellectual life. It is not the consciousness of men that determines their existence, but their social existence that determines their consciousness.[27]

The evolution of cosmological ideas probably represents the most explicit example of this thesis. Let us refer, for instance, to Egyptian cosmology:

> the Earth was pictured as an elongated platter. The platter's long dimension paralleled the Nile. [...] Clearly several of the main structural features of this universe were suggested by the world that the Egyptian knew: he did live in an elongated platter bounded by water in the only direction in which he had explored it.[28]

If productive activity is not a simple restoration of consumerism – i.e., if human life is not strictly cyclical along the generations – clearly there will be either a development or a decline of productive forces. The second case involves a shrinking of resources available to society and thus represents an unstable and destructive solution which, although possible, is not interesting in the present context, so we shall not discuss it. On the other hand, the first case can render the existing social relations of production unsatisfactory. These are the historical preconditions of social revolutions. When they actually take place, social relations (and their legal forms) along with forms of social consciousness and ways of approaching reality change radically.

27 K. Marx, *A Contribution to the Critique of Political Economy*, Moscow: Progress Publishers [1859] 1977, available online at: www.marxists.org/archive/marx/works/1859/critique-pol-economy/preface.htm.

28 Thomas. S. Kuhn, *The Copernican Revolution*, Cambridge: Harvard U.P., 1957, p. 5.

Referring once again to the development of cosmological theories in order to clear up our thesis, suffice it to think of the Ptolemaic universe of the Middle Ages, which was finite and hierarchically ordered, as compared to the infinite universe of Newton, without a pre-established order of time. We should think about the similarities between the implicit values of these two ideas of the world, as between the explicit values of social relations in those societies (feudalism and capitalism) which expressed those concepts.[29]

Naturally, during transitional periods, the same alternatives come up in social consciousness, which may be singled out in the oppositions of material life. So, although in these periods the dominant ideas still belong to the ruling class within the social relations of production, social consciousness also expresses points of view that are antithetical to those ideas and which express a different relationship with reality which people want to establish, and which was already there *in nuce* in the ongoing conflict between productive forces and social relations of production. In order to fix ideas, we refer to Giordano Bruno's concept of the infinite and of infinitely inhabited worlds (a concept which will be soon become dominant). Just think of their contrast with the finite and geocentric consciousness prevailing at the time, which still expresses values tied up with the feudal organization of society, which was a dominant rather than universal concept.

29 At this point, it is worth underlining that conceptual transformations take place in science not only when whole economic-social groups change, but also when successive stages are developing within a certain group. What characterizes the two cases is the different depth of the conceptual transformation that is taking place. Of quite another order, for instance, was the rupture wrought by the scientific revolution of the 16th century, as compared to Aristotelian science, than the one emerging from a comparison between contemporary physics and Newton's science. In this case, indeed, it is more a leap of level within an already consolidated experimental and theoretical practice (whatever the supporters of the centrality of human life in the philosophical adventures of modern physics may say), than a real contrast between cosmological attitudes and related ways of life.

So far, we have tried to show that, as a consequence of the materialist standpoint, mankind does not create history on the basis of either a single or collective will, which simply express values. Indeed, the history produced by mankind is the result of objective relations which men entertain among themselves and with nature, independently from human ideas about them. However, as is evident, *humankind itself makes history* (with all the idiosyncrasies humans are capable of), and we are interested in reconstructing the real – and probably chaotic – manners, in which history (which certainly is not chaotic) is produced, so we should address the individual agent of this process (who is always likely to fade into background like an extra), the common people in society, and try to characterize their activity.

Human history differs from natural history essentially because it is basically a continuous alteration of the natural cycle.[30] This is possible because human work is, in general, the implementation of a *plan*, a *project*, and therefore an activity aiming at a goal rather than a simple instinctive action.[31] Needless to say, the realization of a purpose is not automatically guaranteed. Indeed, the goal is subordinated to the law of the phenomenon that must be dominated. However, this is not a problem inasmuch as humans, in the course of history,

30 "The materialist doctrine" – Marx says in his *Third Thesis on Feuerbach* – "concerning the changing of circumstances and upbringing forgets that circumstances are changed by men and that it is essential to educate the educator himself. This doctrine must, therefore, divide society into two parts, one of which is superior to society. The coincidence of the changing of circumstances and of human activity or self-changing can be conceived and rationally understood only as *revolutionary practice*." The English translation was first published in the Lawrence and Wishart edition of *The German Ideology* in 1938. The most widely known version of the *Theses* is the one based on Engels's edited version, published as an appendix to his *Ludwig Feuerbach* in 1888, where he gave it the title *Theses on Feuerbach.* You can find an online version, translated by W. Lough in 1969, available online at: www.marxists.org/archive/marx/works/1845/theses/theses.htm.

31 For a discussion of the concept of *project*, see: G. Ciccotti, Jona-Lasinio, "Modern Epistemological." See also T. Maldonado, *La Speranza progettuale*, Turin: Einaudi, 1969: English version, *Design, Nature, and Revolution: Toward a Critical Ecology*, trans. M. Domandi, Minneapolis: U. of Minnesota Press, [1972] 2019.

have shown that they know how to take that into account. This characterization of human work has been vigorously expressed by Marx in *Capital:*

> A spider conducts operations that resemble those of a weaver, and a bee puts to shame many an architect in the construction of her cells. But what distinguishes the worst architect from the best of bees is this, that the architect raises his structure in *imagination* before he erects it in reality.

And shortly after, he confirms:

> At the end of every labour-process, we get a result that already existed in the imagination of the *labourer* at its commencement. He not only *effects* a change of form in the material on which he works, but he also *realises* a purpose of his own that gives the law to his modus operandi, and to which he must subordinate his will.[32]

Therefore, what distinguishes human activity is its designed character, the presence of ideal elements and end-oriented thoughts. Now, only the relation between the individual and the collective level eliminates the arbitrariness inherent in the abstract thought considered in itself. Therefore the *integration*[33] of all thoughts and

32 Karl Marx, *Capital*, trans. S. Moore and E. Aveling, Moscow: Progress Publishers, [1867] 1887, Book 1, Ch.7 , p. 127, available at: https://www.marxists.org/archive/marx/works/1867-c1/ch07.htm.

33 We should notice that this integration, which gives coherence to the elements composing a culture, is by no means a retrospective operation of historical reconstruction. Of course, it is also this. At least partially, it is always provided by a synthetic representation and operating rules that some people manage to provide for their own time. Suffice it to think, for example, of Aristotle for the richness with which he represented ancient culture, Newton for the reformulation of science in the 18th century, and Marx for the unification of the socialist urges of

behaviours expressed by the members of a society is what we can define as *culture*. On the other hand, culture is what can be rationally understood in terms of historical materialism. It is culture, rather than thought, which plans the production of every single labourer and, as a manifestation of social conscience, defines a project for society.

Naturally, since the historical conditions expressed by a culture are intimately contradictory and transitional, the integration of all thoughts into a single *project* may appear impossible. Thus, within one culture, we may find different projects interpreting the same natural and social reality, aiming at – usually – alternative interventions upon it. From what has been said so far, it is clear that the differences among the various projects can be traced back to (alternative) class structural contrasts within a certain socio-economic group.[34]

Let us try to clarify this thesis with an example. Let us refer to the failure to develop techniques in ancient times. Not that there

our time into one single theory. Incidentally, this is also the meaning we manage to attribute to the concept of genius.

34 The awareness that there are various possible projects for the transformation of reality, and of nature in particular, has not always existed. Rather, the supporters of scientism state that, even nowadays, there cannot be more sciences at the same time which are alternative in their methods and aims and opposed in the examination of contents. However, others express more mature and aware opinions. For instance, they say that the very coexistence of different visions of the world permits the search for external, historical and social reasons for scientific opinions. In this regard, R.K. Merton says: "With increasing social conflict, differences in the values, attitudes and modes of thought of groups develop to the point where the orientation which these groups previously had in common is overshadowed by incompatible differences. Not only do there develop distinct universes of discourse, but the existence of any one universe challenges the validity and legitimacy of the others. The co-existence of these conflicting perspectives and interpretations within the same society leads to an active and reciprocal distrust between groups. Within a context of distrust, one no longer inquires into the content of beliefs and assertions to determine whether they are valid or not, one no longer confronts the assertions with relevant evidence, but introduces an entirely new question: how does it happen that these views are maintained? Thought becomes functionalized; it is interpreted in terms of its psychological or economic or social or racial sources and functions," *Social Theory and Social Structure*, New York: The Free Press, 1968, p. 511. Naturally, even though posing ourselves this question represents a step forward (in comparison with scientism), if we stop here, we reach the eclectic empiricism of modern sociology.

were no discoveries in antiquity: discoveries were made, forgotten and made once again. The point is that, in the process of integration mentioned above, they represent nothing. Indeed, either they were made explicitly, in a game context and therefore were not understood as technical discoveries, or they were understood as such, but no social group ever offered them as an alternative to the subordination (typical of antiquity) of *art (technē)* to *nature*, so that no alternative project was ever born around them.[35] It is therefore no surprise that the science of classical antiquity is naturalistic and anti-machinery. This corresponds not only to the state of the productive forces and social relations at the time, but also to the *idea* that the dominant social forces proposed for the *development* of those forces and those relations. Nor can we simply remove that idea for a comparison with a better idea. As long as there are no alternative social forces behind another conception, a crisis of adaptation to the dominant conception is always resolved with an internal rearrangement of the conception itself (Karl Popper would use the term "conventional stratagems"). Suffice it to think of the rigour of medieval criticism of Aristotle's concept of motion, and their systematic conclusion with a rediscovery of its complex validity. We should then compare this attitude with the subjectively equivalent, but *objectively* much more revolutionary, one of Renaissance critics.[36]

Let us try to take stock of the situation.

We have already referred to science in our examples, and we do hope it is clear in what sense we meant it. However, on a general

35 See the essays by Alexandre Koyré and P.M. Schuhl in A. Koyré, *From the Closed World to the Infinite Universe,* Baltimore: Johns Hopkins U.P., 1957; Shmuel Sambursky, *The Physical World of the Greeks,* Princeton: Princeton U.P., 1956; Benjamin Farrington, *Head and Hand in Ancient Greece: Four Studies in the Social Relations of Thought*, London: Watts, 1947; *Greek Science: Its Meaning for Us*, London: Penguin, [1949] 1961; *Science and Politics in the Ancient World*, London: Allen & Unwin, 1939.

36 See G. Ferilli, *Il Problema delle Origini della Meccanica moderna: il tardo Medioevo*, unpublished thesis, Physics Dept., University of Lecce, academic year 1972/73.

theoretical level, we have not yet articulated the concept of culture that we introduced, nor have we established whether there is only one concept of truth or more than one, as related to the various articulations of that concept. This will allow us to single out, in relation to the different forms of cognitive thought, the challenges of a strictly materialist definition of science.

If we try to separate the various forms of organized thought which contribute to forming a culture and leave aside – because of our limits – the analysis of artistic forms, we immediately come across the very widespread contrast between the various forms of thought, valid because functional to practice, or universally and absolutely valid. While the former are ideological, the latter are scientific. It is not difficult to prove that this distinction is not very convincing when put in historical context. Take, for example, the concept of force in Kepler's mechanics and try to distinguish any animistic and magical elements from what is empirically so well-founded that it can be considered as scientific. As has already happened with historians who have tried this reconstruction, a confusion beyond words arises, and it is rather difficult to decide whether Kepler was an astrologer, a saint or a scientist.[37] Well, we think that the difficulties referred to derive from a misplaced question. Indeed, at least from the materialist point of view, the *contradiction* between science and ideology has no basis. According to Marx:

> **The question whether objective truth can be attributed to human thinking is not a question of theory but is a practical question. Man must prove the truth – i.e. the reality and**

37 For a paradigmatic example of a distorted reconstruction, see Max Jammer, *Concepts of Force: A Study in the Foundations of Dynamics,* Cambridge: Harvard U.P., 1957. On the other hand, for a rigorous reconstruction, out of the scientific box, see Alexandre Koyré, *The Astronomical Revolution: Copernicus, Kepler, Borelli*, trans. R.E.W. Maddison, London: Routledge, 1973.

> power, the this-sidedness of his thinking in practice. The dispute over the reality or non-reality of thinking that is isolated from practice is a purely *scholastic* question.[38]

We would like to point out that this criterion should not be considered pragmatic, nor has it much to do with empiricist scepticism. On the level of abstraction we are moving in, practice does not belong to an isolated individual but rather to a social individual. Therefore, the objectivity at issue cannot be reached through the practice of an isolated human being; rather, it is bound up with the coherence of the real activity of humankind and its possible contradictions and (more or less consciously) related ways of thinking. According to Marx: "The human essence is no abstraction inherent in each single individual. In its reality, it is the ensemble of the social relations."[39] Ilyenkov, a Soviet philosopher of the new generation, expressed this point with remarkable effectiveness:

> The links between the concept – a theoretical abstraction expressing the objective essence of the thing – and practice [are] much broader, deeper, and more complicated. In the concept, the object is comprehended *from the standpoint of mankind's practice in its entire volume throughout the history of world development*, rather than from the standpoint of the particular, narrow pragmatic objective and need.[40]

These details should, among other things, serve to dispel

38 Marx, *Theses on Feuerbach*.

39 Ibid.

40 E. V. Ilyenkov, *La dialettica dell'astratto e del concreto nel Capitale di Marx*, Milan: Feltrinelli, 1961, p. 21, our italics: English edition: *The Dialectics of the Abstract and the Concrete in Marx's Capital*, trans. S. Kuzyakov, Moscow: Progress Publishers, 1982, available at www.marxists.org.

possible misunderstandings coming from a naive comparison between the above-mentioned criterion and the ones active *within* formalized linguistic systems.

Therefore, a single criterion of validity for any type of cognitive thought eliminates any opposition between science and ideology. Moreover, it removes any foundation of an allegedly universal and absolute validity, neither affected by history, nor related to it.[41] As a consequence, we discover that there is only one type of cognitive thought, which includes science. Besides, if we just compare the usual definition of ideology with this criterion of validity we realize that this genre is *ideology*, and *science* is just one of its particular specifications.[42]

At this point, we should make two remarks. First, we should underline that while we establish the generic identity of science and ideology, we certainly do not want to cancel their differences, but rather to define them for what they are, as essential specific differences which have a particular defining sense only because all the rest is common. For instance, nothing is more misleading than defining a human as a mammal. And yet, we must consider this aspect since it is something in common between men and animals and which should be repeated if forgotten. Indeed, specifics are the very essence of the definition since they add something instead of (logically) contradicting something, so that they show their defining character only with reference to their common basis. In the same way, if we say that science is

41 Accurately, Emile Durkheim (quoted in R.K. Merton, *Social Theory,* p. 527), while extending his sociological research to the social genesis of thought categories, relies on three types of evidence: 1) historical variation of logical rules; 2) the linguistic character of concepts – also scientific concepts – is a proof that they are social products; 3) their coherence with a set of beliefs – not only their objective validity – contributes to the acceptance or rejection of concepts.

42 Even Max Scheler stated that this stand is typical of historical materialism (quoted in R.K. Merton, *Social Theory*, p. 521, n. 21): "A specific thesis of the economic conception of history is the subsumption of the laws of development of all knowledge under the laws of development of ideologies."

generically ideology, i.e., we assert the historically determined, therefore relative[43] character of scientific knowledge, this does not teach us much about the validity of its statements. However, this statement is necessary because it fixes the limits within which questions of validity make sense with reference to sciences. Now, on to our second remark.

We think it is implicit, in everything we have said so far, but we think it worth repeating, that there is no contradiction between the social origin of scientific categories and their applicability to nature and society. Indeed, social origin and arbitrariness are by no means synonyms so that, as Robert K. Merton rightly says, scientific categories may be appropriate to their subject in varying degrees. However, since social structures vary (and the classification system also varies), there are inevitable 'subjective' elements in logical constructions which are typical of a society and spread within it.[44] The task of science is not (nor has ever been) the search for the truth. Through

43 Even contemporary bourgeois sociology comes to the conclusion that scientific knowledge is not independent from the social structure. Naturally, such sociology does not relate this dependency to the contrast between classes. Nevertheless, it provides an interesting refusal of the cliché which is on the lips of most bourgeois scientists. Indeed, Merton describes the typical hypothesis of the sociology of knowledge in the following way: "The 'Copernican revolution' in this area of inquiry consisted in the hypothesis that not only error or illusion or unauthenticated belief but also the discovery of truth was socially (historically) conditioned. As long as attention was focused on the social determinants of ideology, illusion, myth, and moral norms, the sociology of knowledge could not emerge. It was abundantly clear that in accounting for error or un-certified opinion, some extra-theoretic factors were involved, that some special explanation was needed, since the reality of the object could not account for error. In the case of confirmed or certified knowledge, however, it was long assumed that it could be adequately accounted for in terms of a direct object-interpreter relation. The sociology of knowledge came into being with the signal hypothesis that even truths were to be held socially accountable, were to be related to the historical society in which they emerged," R.K. Merton, *Social Theory*, p. 513-14.

44 "The 'class subjectivism' of the *forms of cognition* in no way excludes the objective 'significance' of cognition: in a certain measure cognition of the external world and social laws is possessed by every class, but the specific methods of conception, in their historical progress, *variously* condition the process of the development of the adequateness of cognition, and the advance of history may lead to such a 'method of conception' as will become a fetter upon cognition itself," N. I. Bukharin, "Theory and Practice."

its categories, science "seeks to establish order and attempts to construct a world of abstract relationships in harmony not only with observations and techniques, but also with current practices, values and interpretations."[45]

Once we have brought science back to the genre of ideology, it makes sense to attempt a classification of the fundamental *ideological forms*. We believe there are three forms: *false consciousness, appropriate consciousness* (even though in a mystified form), *scientific consciousness*, adequate for an end, without a mystifying form.

Let us now try to clarify the nature of these three ideological forms. The first has been introduced by taking into account the existence of ideologies which do not conform to the interests of their class, which assumes they are true, nor do they correspond adequately to the situation[46] they want to explain and, in any case, manage to assert themselves socially as 'true' theories. This false consciousness, generally introduced by the dominant class and functional to its purposes, constitutes one of its instruments for stabilizing the existing social order and reinforcing its own power. It also allows us to understand the disorientation of the subordinate class in relation to its real interests.[47] Thus, for instance, it allows us to understand why the small-holding peasant, whose interests would lead him to the side of the proletariat, actually thinks he has nothing in common with them. Nowadays we can find documents of this ideological form in the so-called scientific diffusion, in the poorer achievements of academic culture and, finally, in all forms of eschatological propaganda still

45 François Jacob, *La logique du Vivant: une histoire de l'Hérédité*, Paris: Gallimard, 1970. English edition: *The Logic of Life: A History of Heredity*, trans. B.E. Spillmann, Princeton: Princeton U.P., 1993, p. 11.

46 R.K. Merton, *Social Theory*, p. 532 ff.

47 It should be noted that, in general, this kind of false consciousness is built so as to reproduce the would-be eternal character of *everything that is* (a state of fact that should instead be represented in theory) so effectively that it fully satisfies the "cognitive" needs of the dominant class which introduces it.

widespread today.

The second form represents all those situations in which we use concepts with an operational value, i.e., capable of coordinating an effort of understanding and intervention in society and nature. However, the reasons for this introduction have been concealed behind generic and mystifying flags, such as truth, good and so on. Then, in these conditions, the search for limits (and conditions) of validity and purposes implied in these theories turns out to be impossible in terms of theory because limits and (ideological) purposes are excluded in principle. Let us try and clear this up with an example.

The best example of a consciousness fit for the purpose, but in a mystified form, is given by Engels as he discusses the meaning of the Protestant Reformation:

> **The ineradicability of the Protestant heresy *corresponded* to the invincibility of the rising bourgeoisie [...]. Here Calvinism justified itself as the true religious *disguise* [our italics] of the interests of the bourgeoisie at that time.**[48]

However, we would like to emphasize the fact that scientific analyses often belong to this category. Let us consider, for instance, Galileo's physics. We can consider his complete lack of understanding of the *meaning* of the unification of terrestrial physics and celestial physics, which he in fact proposed, as an expression of a different attitude toward the knowledge of 'natural reality', from having glimpsed the possibility of a different relation to a paradigmatic 'social reality'. This stands out even more if we compare it with the precise consciousness of the social effects of Galileo's scientific revolution, as

48 F. Engels, *Ludwig Feuerbach and the Outcome of Classical German Philosophy*, ed. C.P. Dutt, New York: International Publishers, [1886] 1941, pp. 57-58.

shown by Cardinal Bellarmino.[49] Indeed, he was willing to accept any change to the cosmology of Aristotle and Ptolemy provided it explained phenomena while the static, hierarchical and finite vision of the cosmos was not affected. This vision of Galileo fitted with his aims of preserving the dominant social order at the time.

Therefore, the limit of this ideological form is confusing *one* schematization of reality with *the only possible one*, while omitting the historical (and sometimes empirical too, such as Calvinism!) circumstances in which it was made and, therefore, functions and retains a value.[50] The mistake, according to the materialist viewpoint, consists in thinking that, in the analysis and build-up of a body of knowledge about society and nature, there is *the* best way regardless, as Ilyenkov would say, of the purposes implied in 'human practice', or at least in some parts of it, during a stage of transition. Indeed, for a materialist,

> the nature of the idealizations permissible in the analysis of a problem is determined by *the problem in its entirety* and therefore depends not only on the properties of the system considered but also on just which questions we want to answer by our analysis.[51]

Naturally, the quasi-stationary periods of social development provide few chances for conflicts provoked by implicit viewpoints on

49 Interesting, in this regard, is Giorgio De Santillana, *The Crime of Galileo*, Chicago: Chicago U.P., 1955.

50 The inability to provide these specifications is particularly obvious and striking, after the Second World War, in the case of nuclear physicists and their megalomaniac projects. See D.S. Greenberg, *The Politics of American Science,* Harmondsworth: Penguin Books, 1969. Thus the way of presenting the construction of their machinery as a fact of practical interest too, when in fact in the community of physicists, they cannot, or will not, explain the meaning of that "too," appears all the more disgusting.

51 A.A. Andronov, A.A. Vitt, S. E. Khaikin, *Theory of Oscillators*, trans. F. Immirzi, London: Pergamon Press: 1966, p. xvi.

science. The situation is quite different in a time of crisis. Indeed, in times of crisis, the conflict regarding the goals of science and, therefore, its better abstractions, becomes sharper, and the assumed mixture of knowledge and interest is particularly evident in the contrast among various scientific alternatives.[52] At this point, a remark is necessary. In fact, from a materialist point of view, there is no difficulty in admitting that there is no form of knowledge in which we can separate judgments of fact from judgments of value. However, it is a scientific community-based view that this could and should happen in science. In order to help debunk this prejudice, which – we repeat – is meaningless in materialist terms, we must make the following epistemological digression.

While discussing the problem of human mental development, in order to clear up a few epistemological questions, the physicist Leon Rosenfeld rightly remarked that the possibility of scientific thought is connected with the possession of 'formal operations', i.e., the tools of logic. In this formal stage, the language "pursues an autonomous

52 Here we intentionally paraphrased the epistemological comparison which Popper established between conventionalism and his stand, as he controversially required that epistemology make available and, indeed, prompt deep transformations in basic scientific theories. See K. Popper, *The Logic of Scientific Discovery*, London/New York: Routledge, [1934] 1992. For a global estimate, see also G. Ciccotti, G. Jona-Lasinio, "Modern Epistemological." We would like to report here, for those interested in these topics, the description given by A. Banfi in his 1920 Foreword to Georg Simmel's *Die Probleme der Geschichtphilosophie*, Leipzig: Duncker & Humblot. [1892] 2nd ed., 1905 (English edition: *The Problems of the Philosophy of History*, trans. G. Oakes, New York: Free Press, 1977), of the crisis induced in culture by a radical social transformation: "This crisis is usually accompanied by two typical phenomena. Namely, the break-up of a technical-practical arrangement, which in periods of balance, dominates not only individual empirical practice, but also social, moral, esthetic and religious practices. In a fixed value-system, which is objectively guaranteed, the individual freely deploys its energies and recognizes the world, framed in its categories, as a world of free will, where ends and means are explicitly separated and distanced. However, where this arrangement is disconnected, the clear teleology of will is obscured, the clear distinction between means of action and will fluctuates, and a blind will seems to be dominating the world and the souls, sweeping them away towards contents, and also new modes of evaluations, which are devoid of universality [...] Therefore this is not only an introduction of new contents to the category of purposes, but also an overturning of the very teleological concept of life."

development by purely abstract derivations of new concepts without immediate correspondence in the sensorimotor field" of facts. In this condition of separation between formal and concrete, the "ever recurring problem of the adequacy of conceptual constructions whose link with sensorimotor experience is only an *indirect* one" [our Italics].[53] Since, in fact, "between theory and experience, theory always has the first word, it determines the form of the question and thus sets limits to the answer." We can thus conclude, against scientism, that "'those who seek God, find him,' said Pascal – but they only find the God they are looking for."[54]

In this situation, while taking into account these remarks, the problem of the third ideological form makes sense. We shall now define it.

Let us note, first of all, that the historically-conditioned value of any form of cognitive thought is based upon two essentially distinct constraints. The first one – more properly a limitation – is that each period is characterized by a certain range of possibilities, which is defined not only by current theories or beliefs, but also by the nature itself of the objects available for analysis, by the existing equipment, which allows us to study them and construct a discourse on it. "It is only within this range that reason can manoeuvre. It is within these fixed limits that that ideas operate, are tested and come into conflict."[55] On the other hand, the second, which represents the active moment of making history, is based on the following fact. No socially-widespread knowledge, no cultural level (as defined above), has a merely reproductive, mirroring character. In each representation of the world there is an idea of transformation, the wish to reorganize

53 L. Rosenfeld, "Unphilosophical Considerations on Causality in Physics," in *Selected Papers of Léon Rosenfeld*, ed. R.S. Cohen & J.J. Stachel, Boston: Springer, 1979, pp. 678-679.
54 F. Jacob, *The Logic*, p. 15-14.
55 Ibid., p. 11.

and change reality (maybe reduced to identical reproduction, as we shall soon see), which constitutes the goal for the construction of that (valid!) representation.[56]

Thus, the third form of logic is composed of all those analyses of reality, of all those theories which are scientific because they are empirically founded and therefore operational, aware of the point of view and purpose they are functional to.

Since this ideological form is bound to humankind's capacity to control (rather than create!) its own destiny, and this end is very far from its realization, it does not really make sense to look for examples. However, Marx's work remains our paradigm, both for its ability to assert itself socially as a revolutionary ideology and for its being a science, namely a conscious analysis of reality from the point of view of the possible: i.e., the viewpoint of the working class. Moreover, as a first approximation, our examples are all the rare cases of historical *awareness* of culture. Let us mention one of them.

We know that, for Aristotle, scientific investigation must explain things as they are. Therefore, accordingly:

> **Nature is presented as an ideal which it is the task of art to realize or re-establish, and as a *norm* whose precepts and indications art must follow in order to achieve its aims.**[57]

56 In this regard, Marx says: "Feuerbach speaks in particular of the perception of natural science; he mentions secrets which are disclosed only to the eye of the physicist and chemist; but where would natural science be without industry and commerce? Even this pure natural science is provided with an aim, as with its material, only through trade and industry, through the sensuous activity of men," K. Marx-F. Engels, *The German Ideology* , Moscow: Progress Publishers, [1845-6] 1968, available online at www.marxists.org, . See also K. Marx, *Theses on Feuerbach*.

57 Paolo Rossi, *I filosofi e le macchine*, Milan: Feltrinelli, 1962, p. 139: English edition: *Philosophy, Technology and the Arts in the Modern Era (1470-1700)*, trans. S. Attanasio, New York: Harper & Row, 1970, p. 137.

Conversely, the Greek *technē* can only bring to completion the work of nature or imitate it in its productions. Upon this basis, Aristotle's science provides a "*theory* [our italics] which, starting naturally from the data of common sense, subjects them to an extremely coherent and systematic treatment."[58] Moreover, as "Paul Tannery and Pierre Duhem recognized, Aristotelian science agrees much better with common experience than that of Galileo and Descartes."[59] This is not the place to document the previous statements, which are – however – very convincing. All we care about here is that, upon these premises, Aristotle can *prove* the impossibility of the existence of automata, that is, of machines capable of replacing human beings.

Indeed, Aristotle first argues that slavery would cease to be necessary, if inanimate instruments could come to life: "We can imagine a situation in which each instrument could do its own work, at the word of command or by intelligent anticipation."[60] He then shows "in the light of reason," and "on the basis of actual facts,"[61] that slavery is by *nature*, i.e., not only does exist, but contains in itself the principle of its existence, therefore it *must be*. Finally, he concludes that automata cannot exist. Thus Aristotle's concept of nature is such that it allows him to explain the multitude of phenomena that occur as problems in his age, while at the same time *justifying* the institutions of society which he considers essential, e.g., slavery.

It is well-known that the disappearance of the ancient economic and legal relations characterized by slavery involved not only the falsification of the *natural existence* of slavery, but also a deep transformation of the concepts of nature, ending up in the scientific revolution of the 17th century. Therefore, at the basis of Aristotle's position,

58 A. Koyré, *Etudes d'histoire de la pensée scientifique,* Paris: Presses Universitaires de France, 1966, p. 154.

59 Ibid., p. 254.

60 Aristotle, *Politics*, trans. E. Barker, Oxford: Oxford World's Classics, 2013, p. 14.

61 Ibid., p. 15; these are the two sources of Aristotle's demonstration.

there is undoubtedly an a-critical attitude of conservation and sanctification of the existent. However, the deep consistency between the arrangement of scientific data and the historical purposes of ancient society make it a meaningful realization of the concept of historical awareness (if not quite self-awareness, pertaining only to scientific socialism) of the sort we wanted to represent here.

Marxism and Natural Science

The classification of cognitive forms, which we have identified, provides an overview of the various possibilities that can arise – from the materialist point of view – for those who are engaged in contributing to the development of knowledge in a given time and in a given society. However, we have not presented the relationships between the cognitive forms that we have listed and the ones which actually existed, yet, although we have hinted at it in the above examples. In particular, we mean natural science, in the usual meaning of the term. The problem, as we will try to show, is far from irrelevant since its clarification is the solution of the matter, which is much debated within Marxism, of the relation between science and materialism – with the latter meant as the *critical theory of reappropriation*. As we will discuss further, the individuation of certain tasks and development potential of a militant materialist standpoint in the framework of the problems posed by scientific research in the exact and natural sciences depends on its solution. Everything that we have said in the preceding pages entitles us to claim that scientific theories, in their specific contents, inevitably bear all the 'ideological' consequences of the social relations of production from which they arise, alongside their positive understanding of objects in the sense of forming the effective ideal level of human practice. Moreover, as we mentioned above, inasmuch as historical aims – implicitly but necessarily present in any scientific body – refer to an intrinsically contradictory social and historical situation, subjects may state reasons which are completely devoid of universality – i.e., express particular interests of a particular social layer. Some examples may be appropriate, so as not to misunderstand the last statement and reduce it to a mere empty defence of the necessary freedom to seek the 'truth', typical of science, against obtuse and short-sighted political power. The high scientific value of the research carried out by Antoine Lavoisier at the end of the 18th century is well known. His 'Newtonian' programme for the reduction of chemistry to the laws of mechanics was very important for the progress of science. It is also well known that the systematic application of Newton's principle that all matter is positively heavy, led him to enunciate the fundamental law of the conservation of mass. However, science historians well know how Lavoisier strongly and coherently (both from his scientific and political stances) opposed – from his aristocratic and rigid reductivist programme – the broadening of the definition of science required at the time by the lush growth of peculiar research not immediately attributable to the Newtonian model.[62] On the other hand, such research was definitely not reducible to pure fantasies of dreamers, since they gave origin, soon after the French Revolution, to various disciplines related to modern physics (thermology, electrology, optics, etc.), thus removing the absurd claim that reduced all physics, inasmuch as science, to mechanics. It is useful to mention, in this case, the importance of a political power – perhaps crude, but certainly far-sighted – capable of stopping the intolerable claims of such a prestigious figure with such an exemplary sentence.

On the other hand – here we want to get back to the general question – it is not difficult to show through examples how the changed social relations of production call for an alteration of the

62 See G. Israel, P. Negrini, "La rivoluzione francese e la scienza," *Scientia*, vol. 108, 1973, p. 41.

fundamental points of view present in scientific research, thus imposing on scientists an ideological (and thus productive!) re-vision of structures and fundamental operational concepts governing the interpretation of nature. In fact, it is certainly not for transcendental reasons that Kant, in his 1786 work *Metaphysical Foundations of Natural Science*, defined chemistry as a "systematic art" rather than as a science. He came back to this problem in his *Opus postumum* by addressing once again all the questions connected with the structure of matter, making full use of the possibilities implicit in the concept of caloric and trying to provide a transcendental basis to justify the scientific character of all those peculiar sciences which, just like chemistry, must use experience to learn their own 'laws'.[63] In fact, if you consider the huge, accelerated development of *physica specialis* – according to Kant's definition – in those years due to the Industrial Revolution and, even more, to its political theorization implied in the profound transformations wrought by the French Revolution, we can see that the change in Kant's focus does not come from an inner development of his speculative thought but rather from the theoretical need to provide a firm foundation and encompass those great technical and scientific developments which were taking place all around him in a rational design. Indeed, it should be stressed that – abstractly considering things, from a purely speculative viewpoint –, nothing prevented Kant from leaving that 'empirical' research on a sub-philosophical level once the field had been identified and defined as *physica specialis*. The example of Lavoisier teaches us this as well.

In the same spirit and with the same motivations, you can understand the urgent need that Comte felt to prepare a *new* classification of sciences, which could give sense, meaning and location to each of them, especially since Comte knew the value of a systematization

63 See Vittorio Mathieu, Introduction to I. Kant, *Opus postumum*, Bologna: Zanichelli, 1963.

of knowledge very well, as offered by the encyclopaedists with D'Alembert's *Discours préliminaire à l'Encyclopédie* of 1751. After all, it is not at all a matter of taste, completeness or aesthetics that separates Comte from the Enlightenment.

Finally, just to bring up one example among many possibilities, theoretical physicist Leon Goldberger, while talking at the 12th Solvay Physics Meeting in Brussels in 1961, introduced the "dispersive philosophy"[64] which split the physicist community in two, i.e., into theorists of dispersion and those out of fashion.[65] We believe that this was not an internal discussion within the scientific community but rather a proposal, in a particular case, for an organic adaptation of physics to the new times, when it has become usual to leave out of the reach of science – for complex reasons which we will try to explain – the difficult choice of theories, the traceability of facts to easily-inferred entities and qualities, and the awareness of the social relevance of this choice. However, these burning and difficult issues involve us at present. We will return to them further on, at least to start a preliminary discussion. Therefore, in order to express what we have gone so far arguing as a formula, science is not neutral, but rather has ideological overtones, not only because of its social implications but also for its more specifically technical contents and concepts. However, as a general rule, the awareness of the non-neutrality of science is not operational in the modern scientific community. In a little while, we will try to discover why. In the meantime, let us note that the scientific theories which present themselves as neutral in both methods and

64 We have no interest here in discussing the meaning of this term. We just want to emphasize the fact that "philosophy" does not retain here its usual meaning. Rather, it is a literal translation from English and indicates a global attitude within a particular research area. In Italian, this sounds (rightly according to us) a little bit ironic.

65 See M.L. Goldberger, "Theory and Applications of Single Variable Dispersion Relations," in *Douzième Conseil de Physique Solvay, La Théorie quantique des Champs,* New York: Interscience Publishers, 1961, p. 179.

results suffer from substantial mystification. Their formulations offer adequate rules for transforming reality, but these rules are partial cases: it is impossible to define within what purpose this takes place without a whole reconstruction of the "meaning" of science. Thus, they seem to be opposed to man – whose aims they come from in reality – as inert matter, and as such they dominate him. The question posed at the beginning is essentially resolved. All sciences aspiring to neutrality must be classified in the second ideological category. This is generally the case for natural sciences.

Some further remarks may help clear up the conclusion we have just reached.

As is well known, within the field of research activities there have been, and still are, forms of 'biased science', which have no real cognitive contents but are rather disguised forms of propaganda, clearly intended to produce false knowledge and thus falling into the first ideological category we have analysed. A typical example is constituted by racist theories that have been proposed from time to time. Apparently, they were adapted to the latest scientific results, as is the case of recently devised methods to measure the hereditary bases of intelligence. However, even in physics and mathematics, which seem more sheltered from these distortions, mystical and Platonic interpretations have been made of the results obtained for the express purpose of increasing the power of the scientific corporation. This induces in the non-competent a reverential respect for science, as well as an unmotivated and hateful cognitive despair, which should cause the most uncritical and supine acceptance of the 'scientific' management of society. These interpretations clearly come from an aristocratic and priestly conception of science, as well as from illegitimate extrapolations. A proof of what has been said – impressive for the source from which it comes, which is anything but common – was offered by theoretical physicist Richard P. Feynman in 1964 during some lectures addressed to students who were not studying Physics:

> For those who do not know mathematics, it is difficult to get across a real feeling as to the beauty, the deepest beauty, of nature [...]. It is too bad that it has to be mathematics, and that mathematics is so hard for some people [...]. Physicists cannot make a conversion to any other language. If you want to learn about nature, to appreciate nature, it is necessary to understand the language she speaks in. She offers her information only in one form; we are not be so unhumble as to demand that she change before we pay any attention.
> All the intellectual arguments that you can make will not communicate to deaf ears what the experience of music really is [...]. I am trying to describe her. But it is not getting across because it is impossible. Perhaps it is because their horizons are limited in this way that some people are able to imagine that the centre of the universe is man.[66]

To these words its does not seem out of place to oppose – in Descartes's words:

> The power of judging well and of telling the true from the false – which is what we properly call good sense or reason – is naturally equal in all men [...] our opinions differ not because some of us are more reasonable than others, but solely because we take our thoughts along different paths and don't attend to the same things.[67]

The abuse of results obtained in the 1920s and 1930s – in the

66 R. P. Feynman, *The Character of Physical Law*, Boston: MIT Press, 1967, p. 58.
67 Descartes, *Discourse on the Method of Rightly Conducting One's Reason and Seeking Truth in the Sciences*, trans. J. Bennett, available online at: https://www.earlymoderntexts.com/assets/pdfs/descartes1637.pdf.

race for the development of quantum ideas in physics – is best known and most widely treated in the literature. The goal at the time was to expunge from science some guiding ideas with a materialist background, including – not least – causality.[68] But it is not worth insisting on this matter here.

Finally, we should examine the case of those scientific theories which do not pretend to be neutral and contain statements aware of their foundation in historical and sociological relativism, and thus analyse their objects in view of an overall social process. Obviously, these theories should fall into the third ideological category. However, the attempts which were made in this direction in the last few decades, mainly in the area of humanities[69] – are generally either eclectic, and therefore poorly productive, or essentially alternative to the overall system of Marx's theory. On the other hand, only in historical materialism – sometimes designated as 'philosophy of praxis' –the relationship between valid theories, aware of their own ends (within the historically possible ones), and the overall social practice is expressed in rigorous terms. That is why we think that this is the only completely satisfying model of the third ideological form. It should, however, be clear that the matter cannot be resolved with the purely methodological approach we are using now.

68 In this regard, see the many interesting conclusions reached by Mario Bunge, *La causalità*, Turin: Boringhieri, 1970: English edition: Mario Bunge, *Causality and Modern Science*, London: Routledge, 2009.

69 We refer, for instance, to the efforts of Gunnar Myrdal to include finalistic viewpoints in the construction of an economic theory. However, instead of developing the consequences of this viewpoint, Myrdal falls almost immediately back into a position of scientist empiricism. Indeed, in his postscript to the new edition of his works, under the title *Value in Social Theory*, he writes: "In defending the method, I would base myself on the fundamental thesis that value premises are necessary in research and that no study and no book can be *wertfrei*, free from valuations." But, he adds: "Indeed, both the choice of the set of value premises [...] and their more specific definition ideally can, and should, be made on the basis of a realistic study of people's actual valuations. They can then by empirical research be tested for relevance and significance." G. Myrdal, *Value in Social Theory: A Selection of Essays on Methodology*, ed. Paul Streeten, London/New York: Harper, 1958, p. 261-62.

In any case, this situation should not be surprising. In the absence of a conflictual social reality, such as capitalist society which is divided into classes, the growth of scientific knowledge can only take place in divergent directions. Indeed, these directions correspond to different social ends: on the one hand, the maintenance of current social structures; on the other hand, universal empowerment. Here, then, the basic problem is a choice, and it is clear to us, which choice should be made: "The standpoint of the old materialism" – Marx briefly concludes – "is civil society; the standpoint of the new is human society, or social humanity."[70]

The conclusion we have reached, i.e., the essential non-neutrality of science, is in radical contrast with the neutralist belief – deeply rooted in the scientific community – at least as regards questions of the *validity* of knowledge. Indeed, a certain historical dynamic is admitted in the development of knowledge by acknowledging, in particular, that scientific discovery, whether theoretical or experimental, may require – in order to be understood and rationally explained – the introduction of (social) elements which are foreign to research itself. However, they believe that *all* matters relating to the validity of any research under examination may be completely solved, independently from the overall social practice. More to the point, they say that the question of the adequacy of a theory to its empirical context may be solved without any 'ideological' elements. This position is untenable, not only on a general methodological and historical level – as we have seen so far – but also inasmuch as one can show that an epistemological criterion of validity involves a hypothesis for the organization of the research activity.[71]

70 Marx, *Theses on Feuerbach*.

71 See the enlightening conclusions reached by G. F. Azzone, who starts from an opposite point of view, in his article "Riforma dell'Università e autonomia della Scienza," *Il Mulino*, 6, 1973, pp. 917-44.

However, the point we are eager to highlight is not this one. In fact, we wanted to explain, on a historical basis, why a wrong opinion is so widely spread and deeply rooted among both scientists – who, at least, gain by it – and non-scientists – who do not profit from it. Indeed, we do not believe that people are stupid, nor that individuals may succeed in socially imposing such a diabolically misleading point of view. We are thus led to seek a social explanation of the phenomenon:

> The idea of the self-sufficient character of science ("science for science's sake") is naive: it confuses the *subjective passions* of the professional scientist, working in a system of profound division of labour, in conditions of a disjointed society, in which individual social functions are crystallised in a diversity of types, psychologies, passions [...] with the objective *social role* of this kind of activity, as an activity of vast *practical* importance. The fetishizing of science, as of other phenomena of social life, and the deification of the corresponding categories is a perverted ideological reflex of a society in which the division of labour has destroyed the visible connection between social function, separating them out in the consciousness of their agents as absolute and sovereign values.[72]

Therefore, the lack of social self-consciousness of science is the expression of a feature of capitalist society. However – and this is an important point – the capitalist division of labour is not only a redistribution of functions within the social body (in that case, one could rightly consider the division of labour as a historically irreversible process). It shows instead, to the maximum degree, the essential

72 Bukharin, "Theory and Practice."

features of capitalism which are clearly summed up by Bukharin:

> The capitalist economic order is a system of unorganised elementally developing, and *as a whole* irrational economic life ('anarchy of production', competition, crises, etc.) [...]. In relation to the actions of individual persons this regularity is irrational, even though every one of them should act according to all the rules of rational calculation. This irrational current of life is the consequence of the anarchic character of the capitalist structure.
> The regularity of capitalism is an *elemental regularity,* coming into existence irrespective of (and sometimes against) the will of man (typical examples are the regularity of the industrial cycle, of crisis, etc.). This regularity shows itself in the shape of a compulsory law, "like the law of gravity when a house falls on your head."[73]

What makes it possible to survive in this situation is that, "In the economic life of capitalism the elementary social necessity of definite proportions between the branches of production is achieved by means of an elemental fluctuation of prices, in which the law of value expresses itself as the elemental regulator of socio-productive life."[74] But here is the central issue: the exchangeability of objects, which in capitalism is inherent in things, is in fact a relationship between people hidden in the shell of a relationship between things.[75] This reversal, significantly suprasensible, inasmuch as it takes place at the level of the building blocks of society, establishes itself as its natural law.

73 Ibid.
74 Ibid.
75 Marx, *Capital*, Book 1, Ch. 2, available online at: https://www.marxists.org/archive/marx/works/1867-c1/ch02.htm.

Thus, the fetishist character of all aspects of life within the capitalist production mode. But there's more. The discovery of this mystification does not allow us to overcome the difficulties since it does not only concern people's consciousness but also, more importantly, the reality of their relationships, involving in them a systematic exchange of nature and history.[76]

Therefore, the *real* demystification of the non-neutrality of science and its socially conscious reappropriation are not simple readjustments of human consciousness within the system of relationships provided by capitalist society. They require the removal of the latter, and the radical overcoming of the limits of capitalism.[77] In our opinion, this is the political and social process we are experiencing, and

76 Thus, Marx explains (*Capital*, Book 1., Ch. 1) the impossibility of using the discovery of the law of value to rationalize capitalist society: "Hence, when we bring the products of our labour into relation with each other as values, it is not because we see in these articles the material receptacles of homogeneous human labour. Quite the contrary: whenever, by an exchange, we equate as values our different products, by that very act, we also equate, as human labour, the different kinds of labour expended upon them. We are not aware of this, nevertheless we do it. Value, therefore, does not stalk about with a label describing what it is. It is value, rather, that converts every product into a social hieroglyphic. Later on, we try to decipher the hieroglyphic, to get behind the secret of our own social products; for to stamp an object of utility as a value, is just as much a social product as language. The recent scientific discovery, that the products of labour, so far as they are values, are but material expressions of the human labour spent in their production, marks, indeed, an epoch in the history of the development of the human race, but, by no means, dissipates the mist through which the social character of labour appears to us to be an objective character of the products themselves. The fact, that in the particular form of production with which we are dealing, viz., the production of commodities, the specific social character of private labour carried on independently, consists in the equality of every kind of that labour, by virtue of its being human labour, which character, therefore, assumes in the product the form of value – this fact appears to the producers, notwithstanding the discovery above referred to, to be just as real and final, as the fact, that, after the discovery by science of the component gases of air, the atmosphere itself remained unaltered."

77 Thus the groundlessness of all attempts to achieve an "alternative science" within capitalism and also the radically non-socialist character – because idealistic and individualistically solipsistic – of those proposing a refusal of science and a return to nature in order to solve society's problems. Indeed, it is not the scientific enterprise *as such* which is responsible for the fetishization of science.

with a view to contributing to the process of transition to socialism, we should understand the meaning, and maybe the interest, of the following remarks.

Conclusion

Let us conclude by clarifying what has been said so far and developing its consequences.

The consideration of the close bond of dependence between the historical affirmation of the capitalist mode of production, the rise of large-scale industry and the development of modern natural sciences belongs to the best tradition of materialism. One of the features of capitalist production – Marx says, is the "Organisation of labour itself into social labour: through co-operation, division of labour, and the uniting of labour with the natural sciences."[78]

This is well-known in Marxism, and no doubt universally shared. However, we are arguing for something more, and here we do not think there is sufficient clarity, and certainly not agreement. Indeed, we traced back dependency, or better still coherence between theory and practice of a certain society to the relative autonomy of theories in comparison with facts. Thus science is not "the concept of the world *par excellence*, which lifts the veil formed by ideological illusion and leaves humanity face to face with reality as it actually is," but, "in concrete terms, science is the union of the objective fact with a hypothesis or system of hypothesis which go beyond the mere objective fact."[79] Therefore, hypotheses, which are the starting point for the

78 Marx, *Capital*, Book III, Ch. 15, available online at: https://www.marxists.org/archive/marx/works/1894-c3/ch15.htm.

79 Antonio Gramsci, *Further Selections from the Prison Notebooks*, ed. and trans. D. Boothman, London: Lawrence & Wishart, 1995, p. 293. This was clear to Marx as he wrote: "But all science would be superfluous if the outward appearance and the essence of things directly

build-up of a scientific theory, are not an unambiguously determined expression of reality but rather express it objectively and coherently from the point of view which is implicitly there in the social practice of a given time and a given society.[80]

At this point, two clarifications are required: one conceptual, the other philological. Let us start from the first one. It is evident that, if the society we are talking about is in transition, since it has within it irremediable contrasts which push towards a transformation of the social relations of production, the meaning of the crisis will also spread to the levels of values, implicit in scientific – and more generally cultural – work, thus producing instability. This emotional strain will be resolved as contrasts are resolved, typically resulting in a revolution in ways of life and language, but also in a scientific revolution. We may refer again, for clarity, to the controversy between the Encyclopaedists and the French Academy of Science, and consider the hardships that the new viewpoints had to endure in order to become principles of the new re-organization of knowledge within the scientific framework prevailing before the French Revolution,

coincided," *Capital*, Book III, Ch. 48. We may note, however that, within a historical, and thus dynamic perspective on the issue, there is no single essence of a thing, but rather as many essences as there are viewpoints, and they cannot be organized in a hierarchy towards a better definable Truth.

80 Since the development of capitalism has more or less standardized both modes of production and social knowledge at the world level, nowadays the latter is much less necessary, at least within the developed capitalist area. In the past, however, it was easy to identify in the form of various national sciences. The scientific transformations which made them gradually disappear have been studied by historians of science. They clearly corresponded with the stages of supranational unification realized by capitalism. For instance, the disappearance of the concept of electromagnetic aether from physics, and the introduction of the abstract concept of field allowed them to merge in the early 20th century, thus marking the end of their opposition. See G. Battimelli, *Teoria dell'elettrone e teoria della relatività – uno studio sulla causa della scomparsa dalla prassi scientifica del concetto di etere elettromagnetico*, unpublished thesis at the Physics Institute, University of Rome; see also, by the same author: "Etere e relatività," *Sapere*, Vol. 75, Nov. 1974, pp. 46 ff.

and compare it with the features of the post-revolutionary scientific flowering.[81]

As regards the second question, when passing from one kind of social organization of production to another, the social group which becomes dominant must use all the material and theoretical conditions bequeathed to them by the preceding stage, provided they are compatible with the overall social objectives pursued by this group in this new stage. The problem is whether science belongs to the set of compatible conditions. We believe that the necessary elements for answering this question are implicitly contained in the preceding pages. However, we consider it useful to recall the essential elements.

A social transformation immediately changes the human-nature relation but cannot change nature as an active force. However, the change of the overall social goals pursued in the new situation is based on the chance of fully developing forms of production which were embryonic in the preceding stage, or else totally different ("more human" in socialism). This moves the focal points of interest within the scientific consideration of problems which produces a representation of nature adapted to new needs. The result of this process is nothing more and nothing less than a Copernican Revolution. Bearing this in mind, clearly what we have to do, at a scientific level, now, just as in every transitional stage as defined above, is become involved in determining the implicit scope of available theories and problematize them by comparing them to previous ones. Indeed, only if we realize the necessary historical element in them can we grasp its limits and acquire that detachment which allows potential alternatives to be seen. This was shown by the humanists of the 15th century with their

81 G. Israel, P. Negrini, "La rivoluzione"; Arcangelo Baracca, Angelo Rossi, "Scienza e Rivoluzione Borghese- 1789: prassi e organizzazione della scienza," *Sapere*, vol. 75, Oct., 1974, p. 46.

theoretical inventiveness, born from the analysis of medieval theories and based upon a detached historical comparison with the purest formulations of classical antiquity.[82]

But we will return to this shortly. Here we just want to add that Gramsci's statement, according to which "one social group can appropriate the science of another social group without accepting its ideology,"[83] seems to us a confirmation of our solution to the problem. Out of historical and cultural reasons, according to Gramsci, the term 'science' designates its practical-factual aspect rather than its theoretical aspect, whereas the term 'ideology' is used not only to designate more or less misleading concepts of the world, but also valid theoretical structures, in particular the finalistic element inherent in the hypothetical nature of scientific theory. However, we are not sufficiently hardened philologists so as to be able to fully support this stance. Nor is it essential for us to do so, so we give up.

On the other hand, let us go on with the discussion of the general question.

Marxism generally accepts the fact that the coherence between overall knowledge and society is not a merely external connection, but rather involves science up to its abstract peaks. However, this is bound up with science in the pre-capitalist stages of societal development. On the other hand, positions are diversified and may have very profound oscillations as we face the same challenge in the capitalist stage, as related to the reappropriation of sciences in the transition to socialism. We believe that these oscillations can be explained, though not justified, by the dualistic character of capitalism. We will try to make this point clearer.

82 See the enlightening and challenging remarks by Eugenio Garin, *Medioevo e Rinascimento*, Bari: Laterza, 1973. In particular, the first and fourth essay of the first part, and the second and fifth of the second part. For an English edition, see E. Garin, *History of Italian Philosophy*, vol.1, ed. and trans. G. Pinton, Amsterdam & New York: Rodopi, 2008.

83 Gramsci, *Further Selections*, p. 293.

Inasmuch as capitalism had to create, for its own survival, the minimum material bases for the socialization of the means of production, it appears as a progressive historical force in comparison with the goal of socialism. Since this result has been achieved thanks to the development of modern natural sciences, they were attributed the merit of this as well as a progressive character. On the other hand, all the faults implicit in that way of creating the minimum material bases were attributed to capitalism, as the bare fabric of economic relations. This is actually a misunderstanding typical of scientism, as Gramsci noted: "In actual fact, since too much is expected from science, it is conceived of as a superior form of witchcraft, and because of this one cannot realistically evaluate what science has to offer of a concrete nature."[84]

On the other hand, we have tried to demonstrate how the deep estrangement of nature from humanity, which is implicit in capitalism since it is, in itself, an estrangement of the means of production from the material producers and, in general, the social power of dominion over nature, profoundly affects the social way of conceiving nature itself. That is, in the last resort, because natural sciences are autonomous articulations of the social division of labour, their results appear – fetishistically – as completely separate from social production. Once we have singled out the origin of such forms of estrangement, the construction of socialism can only be a process in which the formal reappropriation of the means of production on the part of the workers corresponds to the beginning of a real reappropriation of the whole power of dominion over nature, which is partially objectified both in science and in the means of production. By saying this, we do not want to join positions of easy extremism which identify the destruction of capitalism with the suppression of the social division

84 Ibid., p. 295.

of labour. Rather, we want to emphasize the need for a radical transformation of the relation between material production and the production of scientific knowledge. Nor can the acritical promotion of all research activities, nor the dissemination of its results as widely as possible, be sufficient to this aim. Indeed in this case, the difficulties of acquisition make any hope for improvement, let alone transformation, fade. We are thus brought back to the tasks incumbent on organic intellectuals (scientists in particular) with good memories.

In this regard, Gramsci said:

> The philosophy of praxis had two tasks to perform: to combat modern ideologies in their most refined form, in order to be able to constitute its own group of independent intellectuals ; and to educate the popular masses, whose culture was medieval. This second task, which was fundamental, given the character of the new philosophy, has absorbed all its strength, not only in quantitative but also in qualitative terms. For "didactic" reasons, the new philosophy was combined into a form of culture which was a little higher than the popular average (which was very low) but was absolutely inadequate to combat the ideologies of the educated classes. And yet the new philosophy was born precisely [...] to create a group of intellectuals specific to the new social group whose conception of the world it was.[85]

If you take into account the above linguistic remarks without arbitrary distinctions between science and ideology, clearly Gramsci is talking about the topics we have been discussing so far. Therefore,

85 Gramsci, *Selections from the Prison Notebooks*, ed. and trans. Q. Hoare and G.N. Smith, New York: International Publishers, 1971, pp. 392-393.

there are two levels on which the materialist (practical and intellectual) initiative on science should be committed: the first concerns the mass culture which should accompany and make fruitful the ongoing process of transformation; the second regards the scientific (not scientistic) comparison of the adequacy of fundamental theories of current research with the contemporary demands of social practice.

As far as the first level is concerned, we do not think it will be possible to develop the conclusion (which we have hinted at as a method) within a coherent proposal. We would simply like to emphasize that, in our approach, there is no Enlightenment illusion. We simply want to point out the need, on the part of those who want to transform society, to question the values expressed by the culture they want to transmit.[86] We would like to linger somewhat longer on the second level, since this is the area where we have been most engaged.

We have seen that the development of scientific knowledge does not take place with continuity, nor merely thanks to its own internal logic. Rather, it is characterized by periodic revolutions which give substance – at the level of thought – to radical transformations of social practice. However, this process, which has always existed, has remained an undeniably truth but an uncontrollable historical process. On the other hand, we believe it is possible to coordinate human practice and theory and reach a higher form of self-awareness through the third, ideological form which explicitly introduces the entire human practice in explaining both development and the limits of the theory's validity.

Let us see how this happens.

Now, in order to control the social and scientific development leading to radical transformations of the forms of knowledge, two complementary levels must be followed. The first one consists in

86 See the remarks by Pierre Guidoni, "L'insegnamento scientifico come Ricerca," *Il Giornale di Fisica*, vol. 13, 1972, p. 240.

mastering, in various areas, scientific activity *as such*, in order to assess the theoretical, experimental and practical relevance of available theories. One has to possess the linguistic and experimental skills that are to be found in the current scientific production. On this basis, one should single out – through historical comparison – the overall social goals and the active choices in the contemporary scientific context. It is to be noticed that one must have a good grasp of the current scientific issues in order to proceed in this way, since only then does a historical *comparison* make sense. For example, Piero Sraffa states that, only when his research in political economy led him to make a conceptual distinction did the interpretation of a fundamental, though obscure, statement contained in David Ricardo's book *On the Principles of Political Economy and Taxation* appear natural.[87] We add that this made the sense of his own research clearer. It would be easy to quote other examples, but we believe that the problem has already been sufficiently clarified.

If, at this point – i.e., the second level that we were discussing above – we manage to give a scientific formulation of the possible alternative aims of social practice, we will be able to evaluate the inadequacies of all the disciplines within the area of science. On this basis, it would make sense to start a conscious process of adapting research to the most progressive demands of human practice. Such as, for instance, health problems inside a factory, but also, at the level of mass culture, the reduction of very abstract physical-mathematical propositions to an intuitive, although rigorous language. Let us note, however, so as not to give rise to misunderstandings, that in a situation of

87 Sraffa states that the conclusion reached by Ricardo, according to whom the profits of agriculture regulate the profits from all other industries, may here equal the statement according to which wheat is the only basic product in the economic system under examination: "If the interpretation given our introduction to his *Principles* is accepted [...] (It should perhaps be stated that it was only when the Standard-system and the distinction between basics and non-basics had emerged in the course of the present investigation that the above interpretation of Ricardo's theory suggested itself as a natural consequence)," Piero Sraffa, *Production of Commodities by Means of Commodities*, Cambridge: Cambridge U.P., 1960, p. 93

transition, the adaptation we mentioned aims at a *homogeneous social group* rather than to an entire, often contradictory, society.[88]

Let us give a historical example which will serve as an ideal model so as to disentangle the various elements of the problem, which we have set forth here little by little, in an abstract way.

Science historians know well that in the period between 1820 and 1842 various areas of physics and chemistry (mechanics, thermology, magnetism, electrology, acoustics, etc.) had developed so powerfully that they deserved an accurate examination of their achievements, field by field, on the part of an observer outside the discipline – Auguste Comte, the founder of positivism.

It is also well known that, in those years, the production of many totally identical objects had been helped by the scientific affirmation of concepts related to accurate measurements. These concepts, which came from industrial production,[89] allowed it to develop on a large scale. However, both production and precision techniques had difficulty in establishing themselves universally because – in fact – the only sector which enabled an improvement of measurement procedures was mechanics; in particular, the only type of 'force' which could really be controlled was mechanical force. On the other hand, as each sector of physics remained independent from the others, the progress made in one field could not be generalized. The dominant

88 From a retrospective view, the question we are discussing becomes simpler – since it is reduced to finding out the reasons which can explain the emergence of the key problems of science, the turning points of its development. Here we totally agree with Kedrov who, in his article on the laws of the development of science, quoted above, solves the issue as follows: "When the same scientific problem, or research area, *or the same scientific trend face a given science, from the viewpoint of technical, practical, and technological requisites, and – at the same time – from the viewpoint of the internal logic of development of science itself, such problems become crucial.* In them, two aspects (or 'lines') of scientific development – the material-industrial and the logical-cognitive – converge, establish a contact, or intersect," B. Kedrov, "Regarding the Laws," p. 37.

89 Maurice Daumas, "Precision of Measurements and Physical and Chemical Research in the Eighteenth Century," in *Scientific Change*, ed. A.C. Crombie, London: Heineman, 1967, pp. 418-30.

explanatory structures at the time were based on the assumption that, behind individual phenomena, there were material fluids, real and proper stored substances, that conceptually prevented the passage from one phenomenon to the other. Meanwhile, at a completely different level of social practice, the use of thermal machines was generalized, and people from all walks of life (among them also scientists, of course, but *not only*) were discovering and collecting the most different conversions from one phenomenal order to the other. In these conditions, a description of the phenomenon as "manifesting but a single 'force,' one which could appear in thermal, electrical, dynamical, and many other forms, but which could never, in all its transformations, be created or destroyed."[90] It must be admitted that this principle was often presented in the darkest metaphysical form.

In these conditions, the most prestigious scientists of the time derided these efforts, considering them to be, frankly, untenable. For example, we know very well the obstacles which Johann Christian Poggendorff – editor of the *Annalen der Physik* – put in the way of the publication of papers by Julius von Mayer and Hermann von Helmholtz. As a result of the clash between the old and new scientific generations, not on questions inherent and internal to theory, as they unconsciously believed, but rather on the much more complex problem of the adequacy of scientific thought to the social practice in place, the principle of energy conservation was enunciated by many scientists independently in the years 1842 to 1847. As a result, "the means was offered to immediately introduce, in any physical process, the possibility of exact measurements, let's say to correct it with accuracy, and thus to dominate it experimentally, according to a common measure and number." As a consequence of the energy conservation

90 Thomas S. Kuhn, "Energy Conservation as an Example of Simultaneous Discovery," in Marshall Clagett, ed., *Critical Problems in the History of Science*, Madison: Univ. of Wisconsin Press, [1959] 1969, p. 321.

principle, “a quantity of exact measuring devices in all branches of physics was manufactured.”[91] The further development of large-scale industry would be very much based upon this scientific statement. Within its intrinsic and extrinsic limits, the principle of energy conservation refers in any case to the fetishist character of science in capitalism. We have already discussed this point. What we would like to emphasize is that, as the process of scientific transformation does not depend on the realization of an internal logic that is absolutely beyond human practice, it can be controlled, at least in conflictual situations, which are critically predictable. The problem of science, examined in a scientific way– with all due respect for scientists, who do not tolerate being examined by their own methods – is nothing mystical or radically different from the problem of society. Through its development, science shows that it is a well-defined function of social practice.

The problem, as usual, is not to contemplate the world, but rather to transform it. Incidentally, the mode we have been describing – if we are not mistaken – is essentially Marx’s logical-historical method of certain abstractions:

> **Mathematicians and mechanicians, and in this they are followed by a few English economists, call a tool a simple machine, and a machine a complex tool. They see no essential difference between them, and even give the name of machine to the simple mechanical powers, the lever, the inclined plane, the screw, the wedge, etc. As a matter of fact, every machine is a combination of those simple powers, no matter how they may be disguised. From the economic standpoint, this explanation is worth nothing, because the historical element is**

91 Hugo Dingler, *Storia filosofica della Scienza,* Milan: Longanesi, 1949, p. 190: Original German edition: *Geschichte der Naturphylosophie*, Berlin: Junker & Dünnhaupt, 1933.

wanting. Another explanation of the difference between tool and machine is that in the case of a tool, man is the motive power, while the motive power of a machine is something different from man, as, for instance, an animal, water, wind, and so on. According to this, a plough drawn by oxen, which is a contrivance common to the most different epochs, would be a machine, while Claussen's circular loom, which, worked by a single labourer, weaves 96,000 picks per minute, would be a mere tool. Nay, this very loom, though a tool when worked by hand would, if worked by steam, be a machine.[92]

92 Marx, *Capital*, Book I, Ch. 15.

The Production of Science in Advanced Capitalist Society

Giovanni Ciccotti, Marcello Cini, Michelangelo De Maria

1.

The feeling is widespread that the trust in the automatically progressive character of scientific work which prevailed until the end of the Sixties has been lost in large sectors of society, and partially in the scientific community itself, thus leaving space for a growing scepticism about the liberating power of science as well as its cognitive power.

This attitude is undoubtedly connected with the distrust in the possibility of leading the huge development of productive forces back to human ends after the so-called scientific and technological revolution. This mistrust originated once the rationale for such development was identified, on the basis of empirical evidence, with the ongoing process of the integration of science into the productive structures of the industrial society of mature capitalism.

Indeed, even though scientific and technological research goes on as before, though perhaps with internal adjustments, as an engine of development it is becoming increasingly clear that this is a particular development that produces advantages for a few and increasingly heavy costs for many. As a consequence, the crisis of technocratic and rationalizing optimism, on the one hand, leads to gusts of antiscientific pessimism, while on the other hand, the distinction between natural and social sphere is reaffirmed, circumscribing within the latter a criticism of how knowledge – and the instruments acquired little by little – are used.

We believe that both strands are inadequate and incapable of facing the real core of the problem. Dangerous confusions are implied in attributing responsibility for the dehumanizing forms of modern technological society to science. However, it is not enough simply to stress this danger, even though it is useful to point out the fact that the proposals against science, instead of looking for the social root of problems, often retrace themes and suggestions already there in the irrational late-Romantic decay.

A pure and simple reaffirmation of the validity of science does not get us very far on a cognitive level. In fact, it simply tries to exorcise the spectre of a widespread crisis rather than challenging it on its real grounds. In other words, if we refuse the thesis which traces dehumanization back to the technical-scientific reification of reason, rather than to social relationships within a capitalist society, this does not exempt us from the task of investigating to what extent – conversely – the reification of such social relationships within the universe of commodities is mirrored in the contents and methods of scientific production.

The problem is there, and it is useless to deny it. Namely, we should undertake the search for links between science – as a peculiar human social activity – and the social relations of production which, in general, rule people's working activity in *this* society. This means that it is necessary to pass from a generic judgement – now widely accepted – of the 'non-neutrality' of science to a more precise identification of the various levels of mutual interaction among these activities, of the mechanisms through which this interaction takes place, and of the possible lines of intervention for a transformation of the social role of science through the explicit acknowledgement of social goals to be affirmed as an alternative to the ones effectively pursued – even though in a mystified and occult way – by science in contemporary capitalist society. Therefore, only if we acknowledge the crisis which calls into question the meaning, goals and value of science can we overcome the impasse between the antiscientific pessimism of irrationalism and the scientistic optimism of an abstract rationalism. Just starting from the awareness of this situation of crisis, it seems to us important to try and find once again – within Marx's concept of nature and of the scientific method – the tools for an analysis and a reconstruction of the natural, historical and ideological totality which coincides with our present society. Our conviction appears clear, from what we have briefly mentioned, that only within a correct – although schematic – reconstruction of the links between science and the other structural and superstructural components of our society can we give concrete, non-subjective answers to the questions arising from this crisis.

2.

First of all, we should mention the first two aspects of Marx's thought we want to hold on to in this analysis. The first is the refusal to separate the object of our enquiry into two strictly distinct and non-communicating spheres: humankind on one side, and human-nature relations on the other. Those who accept this separation, more or less consciously, accept in fact a premise that is in contrast with the formulation of the problem, and therefore precludes any fruitful exploration. That also includes those who, though denying this separation in the abstract, assume nature and history to be two different 'domains' of dialectical materialism, thus risking to fall into a more or less revised version of Stalin's Diamat, namely an 'ontological transformation' of dialectics which, thus, becomes "a positive principle of the world, something it most definitely was not for Marx."[93]

On the contrary, a correct use of Marx's dialectical thought

93 Alfred Schmidt, *The Concept of Nature in Marx*, London: Verso Books, 2014, p. 57.

allows us to avoid a second danger implied in another widespread interpretation of this human-history relation. Indeed, if one tends to interpret the mutual interaction between these two spheres as a one-way correspondence between the 'development of productive forces', in the sense of an autonomous process of growing dominion of man over nature, and social relations which by and by adapt – maybe with tremors and breakups – to the level of this development, one falls into a mechanistic conception of history and society that one cannot claim to attribute to Marx, even though it has obtained a large space in the Marxist tradition. Although in this brief introduction we do not want to further discuss this with supporters of this position, it seems to us necessary to stress – at the cost of having to disagree with a statement of Lenin – that we cannot say that Marx, "while proving the necessity of the present order of things [...] at the same time proves the necessity of another order which must inevitably grow out of the preceding one regardless of whether men believe in it or not, whether they are conscious of it or not."[94] Nor can we say that "Marx treats the social movement as a process of natural history, governed by laws not only independent of human will, consciousness and intentions, but, rather, on the contrary, determining the will, consciousness and intentions of men."[95] In order to show that this mechanistic interpretation of Marx's thought is unacceptable, we should simply set it against Marx's own criticism "of all hitherto existing materialism" in the *Theses on Feuerbach*. This criticism underlines that it is just the objectification of any real human activity, and its reduction to a natural phenomenon, namely the inability to conceive it subjectively as a "sensuous human activity," a "*practice*," and let the "active" side be

94 V.I. Lenin, *Collected Works,* vol I, Moscow: Progress Publishers, 1960, p. 166, available online at: www.marxists.org/archive/lenin/works/cw/pdf/lenin-cw-vol-01.pdf.
95 Ibid.

developed abstractly by idealism, as opposed to materialism.[96] In fact, this criticism underlines that "the materialist doctrine [in the sense of the old Feuerbach's materialism, which echoes in Lenin's words, which few contemporary dialectical materialists like so much,[97] *Authors' note*] concerning the changing of circumstances and upbringing forgets that circumstances are changed by men and that it is essential to educate the educator himself,"[98] i.e., completely forgets the existence of historically determined alternatives. It has been said,[99] paradoxically (but not so much!), that if historical events were equally and necessarily determined and independent from human will and consciousness, like natural phenomena, a revolutionary party would be as meaningless as a party aiming at realizing a lunar eclipse.

The second aspect of the Marxist dialectic and materialist concept to which we refer (an aspect very closely related to the previous one) consists in underlining that we cannot separate the moment of knowledge from the moment of practice, without reducing the former to a mere passive reflection of a given object, and the latter to an active manifestation of a subjective thought. On the other hand, if we maintain the dialectical unit of perception and activity, this implies the refusal to distinguish statements of fact (passive reflection of the object) from statements of value (subjective practical activity), therefore, the refusal to separate science and ideology as irreducible. In our opinion, it is essential to single out the ideological form to which any cognitive thought can be traced, including what is commonly intended as scientific knowledge inasmuch as it allows us to catch the project of practical activity which, more or less mystified, is always

96 Marx, *Theses on Feuerbach*.
97 Silvano Tagliagambe, in *Attualità del Materialismo Dialettico*, Rome: Editori Riuniti: 1974, p. 142.
98 Marx, *Theses on Feuerbach*.
99 Helmut Fleischer, *Marxism and History*, trans. E. Mosbacher, New York: Harper & Row, 1973, p. 107.

there. In this sense, the features of Marx's concept, summarily outlined, make it a perfect example of scientific knowledge – but we have talked about this elsewhere.[100] Therefore, in principle, it allows us to recompose the unity between ideology and structure, thus enabling us to demystify the apparent autonomy of consciousness from the process of material production. In this way, we can account for the implicit meaning and purpose of modern science. One of the goals of the analysis sketched in this paper is actually to try and do so.

3.

Moreover, it is important in our opinion to explicitly refer to what Marx defined as "the scientifically correct method" to "reproduce what is concrete along the historical method of determinate abstractions, expounded in the 1857 introduction to *A Contribution to the Critique of Political Economy*. On this point too, there are contrasting positions and interpretations in the context of Marxism, which reflect, together with different positions of principle, also different estimates of the main contradictions of contemporary capitalist society. In the above-cited book, Marx states:

> Bourgeois society is the most advanced and complex historical organisation of production. The categories which express its relations, and an understanding of its structure, therefore, provide an insight into the structure and the relations of production of all formerly existing social formations the ruins and component elements of which were used in the creation of bourgeois society. Some of these unassimilated remains are still carried on within bourgeois society, others,

100 G. Ciccotti, M. Cini, M. de Maria, "La Progettualità scientifica contro lo Scientismo" ("Scientific Planning against Scientism," Chapter 1 in this volume).

> **however, which previously existed only in rudimentary form, have been further developed [...]. The anatomy of man is a key to the anatomy of the ape.** [101]

Therefore, the consequence of the "scientifically correct method" is a refusal to consider the present as the end point of a chronological sequence of successive stages that prepared the way for its onset. Thus, we must start from the analysis of "the most complex and developed historical organisation of production" if we want to address the problem of the value of science and the social function of research. On the other hand, if we assume "science" in the abstract as our object of analysis, as a general human activity that has always engaged humans regardless of a particular, historically determined form of socio-economic organization, this ultimately means that "we conceive reality as a thought that embraces and deepens itself."

Indeed the carelessness towards this fundamental aspect of Marx's method of analysing reality condemns to sterility the reproposal[102] of "Engels's programme towards science" as a once-and-for-all solution to the "gnoseological problem": a solution which should provide a permanently valid frame of reference, sufficient to ensure an ever deeper and more correct relationship between humans and nature, once the field is cleared of the contingent and changing vicissitudes of human social relationships. Let's have no misunderstandings: we are not interested in discussing whether, and to what extent, Engels was a "good Marxist" in his analysis of the dialectics of nature. What we reject is the attempt to elevate the analysis of the open problems within science led by Engels, at *that* level of social development,

101 Marx, *Contribution to the Critique of Political Economy, 1857 Preface*, translated by S.W. Ryazanskaya, London: Lawrence & Wishart, 1971, available online at: https://www.marxists.org/archive/marx/works/1859/critique-pol-economy/appx1.htm.

102 Tagliagambe, *Attualità*, p. 179.

to an unchangeable paradigm. It should be explicitly recognized that this analysis allowed him to intervene in the *substance* of the scientific debate on the right side, since he grasped the specific, historically determined character of *that* science.

In fact, it was a science which was not very incorporated into the productive process and which was strongly affected by philosophical thought, as well by the dominant ideas and cultural traditions, so much so that it was divided up into national "schools" corresponding to the different levels of social organization. Thus, through a correct identification of the ideological figures that permeate the various positions and scientific theories, from a materialistic and dialectical point of view, Engels could take a stand in support of Darwin, the atomists, the organicists, and so on. However, Engels himself realized very well the transience of that particular historical situation, which he did not hesitate to affirm: "the advance of theoretical natural science may possibly make my work to a great extent or even altogether superfluous."[103] Therefore, while assuming we would once again encounter the same problem, it is not by chance that we revive the same debate and propose the same interpretative scheme within contemporary science. This is indeed a science which, as a concrete human activity, is qualitatively different from that of the last century since its social goals, mode of production and the ideology that permeates it are different. We risk – without even realizing it – falling back into social evolutionism, painted over with scientism. On the one hand, indeed, it has been theorized that "since man can expand his horizon by extending his knowledge and dominion to that part of nature which he does not yet control from the theoretical – and consequently

103 Engels, *Anti-Dühring: Herr Eugene Dühring's Revolution in Science,* trans. E. Burns, Moscow: Progress Publishers, [1878] 1947, p. 8, available online at: https://www.marxists.org/archive/marx/works/download/pdf/anti_duhring.pdf.

practical – point of view, *there lies the root of humankind's progress*."[104] On the other hand, Stalin's condemnation of Mendelian genetics and quantum mechanics in the name of the Diamat, trying to turn the situation upside down by enthusiastically buying into modern physics and make it the prop of 'true' dialectic materialism, was quickly dismissed as an unpleasant accident. In this way, however, we find ourselves with an instrument that no longer serves any purpose. It is indeed difficult to acknowledge that the problems posed to humanity by the development of science in contemporary capitalist society can be reduced to the debate between those "who, on the basis of a general reference to evidence and intuition, condemn the use of new mathematical and logical methods, with which physicists – and scientists in general – try to deepen more and more the knowledge of reality," and those who "consider the use of such instruments not only useful, but also indispensable."[105]

4.

On the basis of these instruments, Marx's analysis carries out its fundamental work of demystification which consists in bringing to the surface the social character of the seemingly objective, natural properties of things.

The most general case is represented by commodity:

> A commodity is therefore a mysterious thing, simply because in it the social character of men's labour appears to them as an objective character stamped upon the product of that labour; because the relation of the producers to the sum total of their own labour is presented to them as a social relation,

104 Tagliagambe, *Attualità*, p. 186.
105 Ibid., p. 188.

> existing not between themselves, but between the products of their labour.[106]

This happens because, in a capitalist society,

> since the producers do not come into social contact with each other until they exchange their products, the specific social character of each producer's labour does not show itself except in the act of exchange. [...] To the latter, therefore, the relations connecting the labour of one individual with that of the rest *appear* not as direct social relations between individuals at work, but as what they really *are*, *material relations* between persons and social relations between things.[107]

In particular, these commodities happen to become capital: namely, they acquire the property of transforming the means of production into tools to submit live work to the goal of producing new capital. Thus these objects – machines and raw material, first of all, but also, as we will see later on, non-material commodities, such as inventions, patents, *know-how,* and so on – seem to acquire the mysterious property of producing new value themselves. In fact, the property attributed to them actually belongs to the social relations they mediate. Means of production and occupational goods, which the class of capitalists possess – are the means through which they force the class of people who only have their own hands for working to accept a social relation subject to conditions laid out by the capitalists themselves. The constraint thus resulting from the direct relation of subordination of the worker to the capitalist appears as a consequence of the labour process, as an objective need – not only of machines and

106 Marx, *Capital*, Book I, Ch. 1.
107 Ibid. (emphasis added).

materials, but also of technology and science. Indeed, Marx clearly states:

> The productive powers of social labour, thus developed, appear as *productive powers of capital*. As such social forces they are *capitalised* vis-à-vis labour [...] the same thing of course takes place for the forces of nature and science, the product of general historical development in its abstract quintessence: they confront the workers as *powers* of capital. They become in fact separated from the skill and knowledge of the individual worker, and although – if we look at them from the point of view of their source – they are in turn the product of labour, they appear as *incorporated* into capital wherever they enter the labour process.[108]

From this remark, we will take the cue – this is the second objective which we set ourselves for the following pages – to try and single out the character of 'fetish' (in the sense given by Marx to this term) which science and technology assume in our contemporary capitalist society.

5.

What we said above should clear up our goal: arriving at a formulation of the concept of science which may represent an abstraction, more adequate to an understanding of an advanced capitalist society than a mere identification as a productive force. Indeed, this identification is only one aspect of reality – an aspect which, if unilaterally assumed to represent all of reality, would attribute to science an

108 Karl Marx, *Capital*, Book I, unpublished Sixth Chapter, [1864], trans. B. Fowkes, available online at: https://www.marxists.org/archive/marx/works/1864/economic/ch02b.htm.

objectivity which rejects out of hand any social conditioning. That is why we will not go into depth regarding a few – actually fundamental – questions on the concrete way in which science functions as a productive force in contemporary capitalist society. Such questions could concern, for instance, the mechanism through which research stimulates economic development in various countries of the capitalist area, in relation also to their location with respect to the imperialist metropolis, or the role of multinational companies, in particular their interaction with the various domains of pure and applied science. Nor will we address the question of the role played by the capitalist state in organizing and financing research and its relation with private capital.

Indeed, it seems to us that – apart from a personal lack of tools and skills to handle this issue – it is more important and urgent, even at the cost of lapsing into schematism, to investigate the main features of the 'social properties' acquired by science inasmuch as it is the science of the current stage of development of capitalism, rather than try to enrich and deepen a one-sided representation of this fundamental human social activity.

In our attempt, we shall extensively use Marx's category of *commodity*. However, we are perfectly aware of the fact that the role played by a commodity in a mercantile society is rather different from the one in a capitalist society, in the two stages analysed by Marx (manufacturing and large industry). Even the meaning of the category – commodity – is different as an object, a piece of 'merchandise', and also from a socio-economic point of view in the stage of imperialism – characterized by the concentration of certain sectors of production in multinational companies with a dizzying expansion of the service sector and, in general, by what Marx defined as "non-material production" and – this is particularly relevant for the subject we are interested in – by the planned production of technological innovation under the control of capital. We would like to underline that – despite the lack of an update of Marx's analytical theory, which may satisfyingly represent the dynamics of the contemporary capitalist system in its essential stages, we consider it correct – and therefore fruitful for a deeper understanding of reality – to hold to the assumption that the essential feature of all commodities is their dual nature – use value and exchange value. The latter can be traced back – in a more immediate way than it would seem if we follow Marx's theory of value literally[109] – ultimately to abstract labour delivered by manpower, turned into merchandise. Clearly, this essential feature of any commodity does not exhaust all its properties and functions. From the economic point of view, an ideal market under competitive conditions where simple commodities – destined for immediate consumption – are exchanged is one thing, and a market under an oligopolistic regime, where many commodities are destined to enter the production process of other commodities through a complex chain of mediations, is another thing. However, we think that only by referring to those conceptual coordinates, which allow us to recognize existing production relations as capitalist relations, and therefore merge the stage of imperialism in the concept of capitalist economic-social education with the preceding ones, can we try to make a scientifically correct – although schematic – reconstruction of contemporary society.

6.

The full development of capitalist society is characterized, according to Marx, by the fact that "the entire production process appears as not subsumed under the direct skilfulness of the worker, but

109 For an extensive discussion of the theory of *value* as scientific category, see Marcello Cini, in *Problemi del Socialismo*, n. 21-22, 1974 ("Labour-Value as a Scientific Category," Chapter 5 in this volume), and "Lo sfruttamento capitalistico: apparenza o realtà?" *Sapere*, December 1974.

rather as the technological application of science.[110] However, the most advanced stage of such development requires the extension of a qualitatively new condition, namely it

> occurs only when large industry has already reached a higher stage, and all the sciences have been pressed into the service of capital; and when, secondly, the available machinery itself already provides great capabilities. *Invention then becomes a business*, and the application of science to direct production itself becomes a prospect which determines and solicits it.[111]

Therefore the production of inventions becomes an economic activity; inventions become a particular form of *commodity*. This point provides the key to one of the most characteristic aspects of contemporary capitalist society.

As Marx was writing *Capital,* he could have imagined that "all spheres of material production" were "subject (both formally and actually) to the capitalist mode of production." However, he added:

> Non-material production, even when it is carried on purely for exchange, that is, when it produces *commodities* [...] All these manifestations of capitalist production in this sphere are so insignificant compared with the totality of production that they can be left entirely out of account.[112]

110 Marx, *Grundrisse: Foundations of the Critique of Political Economy*, trans. M. Nicolaus, Penguin Books/New Left Review, [written 1857-61, published 1939] 1973, p. 618, available online at: https://www.marxists.org/archive/marx/works/ 1857/grundrisse/.

111 Ibid*.,* p. 623 (emphasis added).

112 Marx, *Theories of Surplus Value (vol. IV of Capital)* , ed. S. Ryazanskaya, trans. E. Burns, Moscow: Progress Publishers, [1863] 1963, available online at: https://www.marxists.org/archive/marx/works/1863/theories-surplus-value/.

On the other hand, in our contemporary capitalist society, the capitalist production of intangible assets in the form of commodities has achieved a remarkable importance. Not only are inventions produced in the form of commodity, but also a significant quantity of other *information* related to the productive process (know-how, industrial organization, management) or to consumption (marketing, advertisements, etc.) is produced in a capitalist way or, in Marxist terms, by workers who produce surplus-value.[113]

Moreover, the information produced as commodity immediately 'consumed', has grown immensely, from mass-media communications (radio, TV, newspapers, magazines, records, tapes, etc.) to individual communications (phones), education (partially)[114] and shows. Most of these spheres of production are still subject to the capitalist mode of production. This means that the proportion of capital invested in this sphere of production becomes significant, resulting in the absorption of a relevant number of salaried workers. Unlike what happened at the time of Marx, their salary is a capital investment

113 In a recent study entitled "La Divisione del Lavoro in Fabbrica," *Il Manifesto*, n.5-6, 1969, p. 28, you can read: "A relevant part of the productive process is made 'tertiary,' i.e., in order to produce a high volume of products at a low cost, you must produce (with the help of machines too) a resource as important as the others, namely: information. [...] The employees are thus transformed from vicars into manufacturers of intangible assets endowed with value."

114 As far as education is concerned, Marx had already clearly said: "If we may take an example from outside the sphere of production of material objects, a schoolmaster is a productive labourer when, in addition to belabouring the heads of his scholars, he works like a horse to enrich the school proprietor. That the latter has laid out his capital in a teaching factory, instead of in a sausage factory, does not alter the relation," *Capital*, Book I, Ch. 16. However, he added: "In this sphere for the most part a *transitional form* to *capitalist production* remains in existence, in which the various scientific or artistic producers, handicraftsmen or experts work for the collective trading capital of the book-trade—a relation that has nothing to do with the capitalist mode of production proper and even formally has not yet been brought under its sway," *Theories of Surplus Value*. Later on, especially in the United Kingdom and the USA, entrepreneurs of the knowledge factory multiplied until, because of the spread of demand for education on the one side, and capital's interest in better qualified manpower on the other, general basic education was delegated to the State because it was no longer remunerative. However, a large number of educational institutions in certain sectors (night schools, vocational training schools) remained in the hands of private capitalists.

rather than an income for consumption. Indeed, their production is destined for the market.

Even without examining in detail the modes of the production process of *information* as a commodity, it is clear that certain aspects of the submission of work to capital at this stage imitate well-known aspects of the capitalist production of material commodities – namely the division of labour and the resulting fragmentation and repetitiveness of work, the hierarchy of tasks, the alienation of labour production from the worker, the contrast of the means of employment, which present themselves to the worker, as capital, as 'foreign powers'. In a word, it is the submission of the work process to the process of valorising capital.

A confirmation of the trend toward the commodification of information is provided by a study on the system of transfer of technological information, namely the distribution and consumption of this commodity in the United States.[115] According to the author, Director of the National Technical Information Service, this system does not guarantee the transfer to users of a production of technological information, whose volume has increased about 16 times from 1930 to 1970.

Moreover, the demand for speed in the transfer of information from the producer to the consumer has grown. "Competition is a partial cause of the demand for speed, as is a general cultural change that emphasizes the value of time." The inefficiency of the current system depends, among other factors, on the fact that users are faced with a price mechanism which has little or no correlation to the fulfilment of their needs. However, in the services "offered by commercial enterprises [...] higher prices usually result in better system response and greater user satisfaction." That is why, the author concludes that,

115 William T. Knox, "Systems for Information Technology Transfer," *Science*, vol. 181, 1973, pp. 415-19.

among the measures for the improvement of this transfer, it is necessary to have "much greater standardization of components of the information system," and "greater reliance on pricing for full cost recovery in order to render higher quality service." A distribution system should be created, in which the enhanced management capacity of the private sector should be accompanied by a higher effort on the part of federal authorities to encourage coordination and integration of all the different parts. There is no need to insist on the characteristics of the process of reduction of information as commodity, revealed by this analysis.

We should emphasize that what we have said so far does not at all imply that the reduction process of *information* takes place within the sphere of the private sector. Rather, parallel to the development of this process, the intervention of the state in all productive activity, in particular of non-material goods, has continued. As we said earlier, it is not our task to address such a challenging issue as the role of the state in advanced capitalist society; however, we would like to mention that, when the state intervenes in a productive sector with direct or indirect investments, together with private capital, this does not change the capitalist character of the production relations at all. The fact that a relevant part of technological information is produced by public institutes, or by private companies, often subsidized by the State, does not essentially change the conclusions we can draw from considering information as being produced like any other commodity.

7.

However, there are some specific differences between the production of information and the production of material commodities. In particular, the difficulty of concentrating its production in a single place, like the factory, with its disciplinary and supervisory regime, makes this commodity more difficult to subject to the intensification of rhythms, constant increases in productivity, and growing exploitation which characterize the production of material commodities. Not by chance, productivity in the tertiary sector increases much less than in either industry or agriculture.[116]

Moreover, at first sight, information seems to be a very different commodity in comparison with others. From the viewpoint of use value, it can be consumed indifferently by many or few people, without each having to give up a greater or lesser part of what they receive.[117] In some cases, also in the past, in order to reduce information to a commodity, namely in order to give it an exchange value, they had to prevent – by various devices – its use by others besides the buyer. Thus legal protections obliging those who come in possession of certain information to pay a certain price to the producer, or restrictions, which physically prevent those who have not paid the corresponding price from accessing the tools providing information. In these cases, therefore, 'exchange value' seems less linked to the time needed to produce it than to the number of consumers. However, in the current stage of the development of capitalism, characterized by an increased degree of differentiation of consumption ranges, the difference between information as a non-material commodity and material commodities has become much smaller than it seems if you compare it with the production of commodities in a capitalist society, as analyzed by Marx. In fact, we can say that information becomes a

116 Victor R. Fuchs, *The Service Economy*, New York: Columbia University Press, 1968, p. 109.

117 Some friends – economists – made us aware that there are commodities endowed with an economic value which does not become the property of a single individual, but rather are enjoyed by a certain number of people independently (for example, a lighthouse, which nobody buys but many use, even though it is expensive to build). This form, which cannot properly be considered a commodity because there is no market for it, can probably be traced back the production of information in a stage preceding the technological stage of capitalism. However, we think that in this stage – as we will see – we can talk of large-scale production of information, in the form of real commodity.

large-scale commodity only when accumulation takes place predominantly through the production of use values. Indeed, this stage is distinguished by a social mechanism of earlier distribution of use values in comparison with the natural process which makes objects unusable due to physical deterioration, both for consumable goods and the means of production. The conditions are therefore created to make information quantitative and its consumption measurable (a necessary condition in order to transform it into a commodity).

As happens for any material commodity at this stage of development, the rapid obsolescence of information restricts its usability so that the systematic production of new information is more and more necessary. The free availability of information to all interested parties, which more or less maintains its value in use over time, has been replaced by a private consumption of information, which cannot be used unless it is consumed as soon as it is produced. Therefore, the conditions for the exchange on the market of this commodity are created: information has become a commodity.

Moreover, one can notice that the mechanism of pricing seems the same both for material and non-material commodities – although this is not the methodologically appropriate place to advance or discuss hypotheses for revising Marx's theory on the mechanism of pricing and profit in a non-competitive capitalism (besides, we do not possess any). This further element confirms the successful commodification of most information produced in a mature capitalist society.

8.

The substantial uniqueness of the form of commodity – regardless of its material or immaterial nature – clearly appears, after all, as regards all the means of production. A patent, for example, is an invention which took the form of a commodity.[118] This commodity is bought by the capitalist, so as to be used in the production cycle in the same way as machinery.

A new technology – from its origin inside a research lab, to its usage in relations of production – must first of all have a use value for capital. It has no direct use value for all members of society: as happens for any machine employed in the production process of a capitalist regime, in order to become a commodity, it must first of all be useful for the valorisation of capital. The plan of an assembly line – similarly to the machines which physically constitute the line itself – is a commodity destined for a twofold function, namely as a working medium for the work process, and as a tool for the production of surplus value.

These are, therefore, commodities whose use value requires the commodification of the labour-force. At this point, it is worth underlining that we can maintain a scientific meaning of exploitation as 'appropriation of unpaid work time' as the foundation of the formation of profit, even though we question Marx's identification between the mass of surplus value and the total profit of capitalists.[119]

Therefore, as it happens for any commodity, not only social relations among producers are mirrored in the exchange value of the products of their work and appear like natural social properties of these products. In the means of production of a large capitalist

118 From a historical point of view, the patent has not always been a commodity. At the start, it was a way to prevent competitors from using an invention which was being exploited by the inventor himself who, either on his own or in partnership with others, had the necessary capital. This was the case, to give a well-known example, of Watt. Later on, the patent became, in a stage which we could define as artisanal, a commodity which the inventor, an autonomous producer, sold to a capitalist who wanted to exploit it. Edison represented this stage. Finally, in the technological stage of capitalism, the patent is no longer a commodity produced by independent workers, but rather by salaried workers. The process of production of innovations is subsumed into capitalism.

119 Marcello Cini, "Lavoro, plusvalore e profitto," presentation at the meeting on the issue of Transformation in Marx, Siena, 1971. See also the papers quoted above.

industry, advanced technology included – the basic social relation of this society is mirrored, namely the relation between capitalists and workers.

This does not mean that we give up the distinction between 'productive forces' and 'relations of production' – two concepts that Marx places in a dialectical relationship – "whose limits should be defined, and which does not cancel the real difference." Rather, this means refusing the hypostatization of an impenetrable barrier between the social sphere and the natural sphere. In fact, the development of productive forces is a process in which objective elements of human control over nature are intertwined with historically determined elements coming from social relations. Productive forces are manifested in reality as *productive forces of capital.*

Indeed, we should not forget that Marx's concept of productive forces includes, first of all, humans themselves, namely the workers of capitalist society. It is thus a peculiar, socially determined development of productive forces, characterized by technical innovations and scientific discoveries, destined to stretch the surplus work of the masses to its natural limits and thus prevent

> the free development of individualities, and hence not the reduction of necessary labour time so as to posit surplus labour, but rather the general reduction of the necessary labour of society to a minimum, which then corresponds to the artistic, scientific development of the individuals in the time set free, and with the means created, for all of them.[120]

From what we have said so far, any theory of the neutrality of technology is untenable. Indeed, the concept of neutrality is nothing

120 Marx, *Grundrisse*, p. 625.

but a specific form of fetishism, which attributes to intrinsic objective properties of this product of the intellectual and manual activity of men what follows from the social relations among them. After all, even a purely phenomenological analysis, like the one carried out by Barry Commoner[121] on the correlation between certain consequences of modern technology and its specific function for the valorisation of capital, is enough to demystify the theory of its neutrality:

> The crucial link between pollution and profits appears to be modern technology, which is both the main source of recent increases in productivity – and therefore of profits – and of recent assaults on the environment. Driven by an inherent tendency to maximize profits, modern private enterprise has seized upon those massive technological innovations that promise to maximize this need, usually unaware that these same innovations are often also instruments of environmental destruction. Nor is this surprising, for, as shown earlier, technologies tend to be designed at present as single-purpose instruments [...] the desire to enhance productivity, and therefore profit.

9.

We traditionally distinguish applied science, which can be directly traced back to the form of commodity, from 'pure' science, generally defined as a disinterested activity based on the investigation of reality. That such a distinction seems to exist, in fact, is a datum of the current organization of scientific work. However, this organization is

121 Barry Commoner, *The Closing Circle: Nature, Man and Technology,* New York: Alfred A. Knopf, 1972, pp. 267-268.

quite recent, just as – for that matter – the emergence of this dichotomy in the body of science. Despite the evident historical origin of this distinction, we generally accept a relatively blurry characterization of pure science, aimed at avoiding the search for the historical significance of this activity. Indeed, its origin is identified in a generally 'spiritual', 'meta-historical' feature of human beings. Our purpose is exactly the opposite, according to the methodological indication that we have followed. It is trivial, or even misleading to affirm that, at the root of pure research, there is – nowadays as well as in the past – the innate curiosity of humans for the reality which surrounds them, their thirst to know and investigate the unknown, their 'natural' capacity to rationally interpret the links between the phenomena that are perceived by their senses: "Hunger is hunger; but the hunger that is satisfied by cooked meat eaten with knife and fork differs from hunger that devours raw meat with the help of hands, nails and teeth."[122]

Even 'human nature' can only be explained as an historical process. Galileo's curiosity is not the same curiosity of a modern physicist who studies elementary particles with an accelerator because, on the one hand, there are different solicitations of the two subjects from the social context, and, on the other hand, they play different roles in such a context.

Therefore, if we try to examine the functions which 'pure science' fulfils nowadays, we must first of all distinguish the use – in other areas – of results, techniques and methods of 'pure' scientific activity from the superstructural role that the production of pure science plays as a specific form of culture. While we shall discuss this second point later, as regards the first point, we think we should critically discuss a thesis[123] according to which, as far as the productive

122 Marx, *Contribution to the Critique of Political Economy*.

123 In the past this thesis was partly supported by one of us, Marcello Cini, but nowadays its validity should be strongly questioned.

process is concerned, the dominant interest is not so much the immediate interest of capital in the development of science in view of possible technological application but rather an interest of the producers of advanced technology for the consumption of such commodities on the part of the producers of science. In this sense, the case of space science is often referred to, since it is often a 'commissioner' of advanced technology. In fact, we do not think one can say that 'pure' scientific research mainly represents a form of unproductive consumption of advanced technology, necessary to maintain a high demand for these goods on the market. Even though, under particular economic conditions, the increase (or decrease) of investment in scientific research can be used by the capitalist state as a 'boost' for the economy, this can only concern the fluctuations of expenditure around an average value, but it does not help us to understand the relevance which scientific research has acquired, nor its links with both technology and production.

Apparently, there does not seem to be a direct interest of capital in the production of pure science, in terms of the possibility of a short-term use of the results it produces since it has been observed that the time interval between a scientific discovery and its technical application has not decreased in the last few decades, but has in fact increased.[124] In fact, in our opinion, this remark retains its value only with reference to the introduction of a completely new technology following an important scientific discovery; on the other hand, if you look at its impact in terms of intermediate technologies, you will find a much quicker rhythm than in the past.

However, an indication of the connection between scientific research and economic development can be derived, in our opinion, from the interpretation of some data reported in a well-known book

124 H.B.G. Casimir, "The Ominous Spiral," *Studium Generale*, 24, 1971.

by D. J. De Solla Price.[125] Here, the author shows that the normal rate of growth of science and technology has been exponential in recent centuries. This trend is confirmed for a whole series of variables, which the author considers significant (number of universities, number of PhDs in scientific disciplines, number of engineers, number of scientific publications, extracts, important discoveries, number of kwh of electric energy produced, etc.). The most important outcome of the graphs developed[126] by De Solla Price consists in the fact that the *doubling time* – both of the number of noteworthy scientific discoveries and of remarkable physicists (i.e., 20 years) – corresponds to the doubling time of the Gross National Product. Even if this correlation does not necessarily imply a cause-and-effect relationship between scientific development and productive development, it seems to us difficult to explain this quantitative coincidence without acknowledging that science, nowadays – *on average* – has a greater impact on productivity growth *than in the past*.

In the first place, in terms of 'pure' research, a real testing of technological products takes place. This enables the mass release of *already tested* advanced technology in the production of commodities (consider, for example, computers or miniaturized circuits). In this sense, 'pure' research plays a very important role in stimulating the consumption of goods with a high content of advanced technology in

125 D.J. De Solla Price, *Little Science, Big Science*, New York: Columbia Univ. Press, [1963] 1971, Ch. 1.

126 We would like to underline the fact that he uses graphs and data to support a thesis we do not share. To this regard, it is instructive to note that, in order to single out the laws which regulate the growth of science and technology and their correlation with the development of society, De Solla Price relies on methods of statistical mechanics usually reserved for gases. In his Preface, the author says that the original meaning of the word "gas" is "chaos," and states that the plausibility of the techniques he has used consists precisely in the fact that *disorder* represents, as in the case of a gas, the salient data which distinguishes the variability of the parameters he considers significant in the analysis of the development of science, technology and society. It is interesting to mention the well-known remark by Marx – i.e., that *anarchy* is an essential feature of the capitalist mode of production.

all cutting-edge sectors of the economy. Therefore, 'pure' science appears nowadays, first of all, as a process of creating languages, through which we proceed to lab tests and trials of technologies, using nature as a lab rat. Thus, this activity appears as a giant 'test circuit', or more accurately, as a 'control lab' for the whole of applied science. Thus the more such activity falls under the social controls typical of bourgeois society, the more it is interested in ensuring their taking place.

In the second place, the creation of new languages has a considerable importance in order to provide a framework within which new information-commodities can be produced. In other words, it is not so much the specialist content specific to 'pure' research activity, which can be used in the short-term in producing information for the market, as methods, formalism and algorithms, which are transplanted in the production process of 'applied' science. Suffice it to think of computer languages and operator calculations and, more in general, to the extension of advanced mathematical methods, originally introduced in the study of physics, to other sectors, from economics to the organization of the productive process.

In this sense, a significant role is played by a restricted layer of scientific leaders who, above the mass of average scientists (simple "creative officials of the programme"[127]), indicate important 'fashion' changes in the various areas of research, driving mass work towards new formalism and new experimental techniques.

In the third place, large laboratories – as we shall see later on – represent an ideal testing ground for the introduction of new methods of control and management of complex integrated productive organization employing highly skilled and highly technical labour.

An authoritative confirmation of the substantial correctness

127 G. Jona-Lasinio, "Changes." We note that the number of average scientists is growing – according to the statistics of De Solla Price – more quickly than the Gross National Product. On the other hand, the number of scientific leaders grows as much as the GNP.

of this analysis comes from the Public Relations Department of the highest European Organization for Fundamental Research, CERN (Centre Européen des Recherches Nucléaires) in Geneva. In a brochure illustrating the Institute's activities, they state, among other things, that "CERN has doubtless favoured the development of production techniques through direct participation." Indeed, the realization of new instrumentation "underpins the progress realized in certain fields of technology." They cite, as examples of techniques "developed in collaboration with industry": "very high tensions" (hundreds of thousands of volts); "very short response times" (billionths of a second); "very low pressures, comparable to those found on the Moon's surface"; low temperatures and superconductors. Still, from the same source, we learn that CERN "actively contributes to the development of systems capable of ensuring the best exploitation of computer networks connected to a large number of entry and exit terminals." Finally, we are reminded that, at CERN, they have tested "the most modern planning and control methods of all its activities, since it is well-known that cutting-edge research requires cutting-edge technology, and in turn cutting-edge technology requires strict management."

On the other hand, the substantial homogeneity between a large research centre and a productive structure is explicitly recognized in many official documents of CERN itself. In a report of the staff policy working group, they state: "We should once again emphasize that CERN is an industrial employer rather than an academic institution."[128]

Ultimately, in order to understand the importance and the role assumed by 'pure' science in advanced capitalist society, we should underline that, if on the one hand science cannot be directly identified

128 *Working Group on Appointment Policy Report*, CERN, 31 August 1972.

with the production of commodities (and therefore with a purely economic activity), in any case it performs two distinct functions: 'the body of science', i.e., a set of dominant 'paradigms' in various research fields – provides the framework and constitutes the support and ineradicable basis upon which the production of information is developed; on the other hand, the production of science has increasingly acquired the function of a 'test circuit' for advanced technology and labour organization, and therefore represents an encouragement to the technological and management progress of the production of commodities.[129]

10.

Inasmuch as it is a social activity not directly aimed at the production of commodities, science appears as a method for the generation of ideas through ideas, within an autonomous process which only accidentally and casually receives demands and stimuli from the rest of society. These demands and stimuli, in any case, would not change either the structure or contents of science. At most, they could affect rhythms and modes of its development.

We should emphasize that this viewpoint is common both in those who consider science as the mirror of a given objective reality within human consciousness and those who consider it as a purely rational construction which aims at connecting, in the simplest and most economic manner, the largest number of empirical procedures. The former groups thinks that it is a matter of discovering and bringing to light something which was already there, complete in all its

129 These considerations broadly agree with the thesis put forward by Jona-Lasinio, "Changes," according to which the change introduced into the overall attitude of society towards science would be strictly connected to the transformation induced in modern capitalism by the mass-production of consumer goods and the breakthrough of the New Deal.

parts and links. The latter group thinks that it is a matter of constructing the most rational and effective scheme for the proposed purposes. In fact, these points of view have something in common, namely they are both 'philosophical', in the sense that they both consider science as the result of the activity of the human mind, as an abstract intellect, in the face of an uncontaminated nature which is always equal to itself. Thus, they eliminate the social, economic and historical context as irrelevant in comparison with the gnoseological problem, hypostatized into an eternal and unchangeable problem.

According to what we have proposed in the preceding pages, on the one side, we should try to understand how the relations of production of advanced capitalist society affect the ways individuals represent their relationship with nature and, on the other side, how the representation of a certain relationship with nature is mirrored in their representation of their social relations. In the first case, one should retrace the reflection of a material mode of production in the production of science. In the second case, one should detect which contributions to the production of ideology are intertwined with the processes of scientific production.

These goals are well illustrated by a remark of Marx in the first book of *Capital*:

> Technology discloses man's mode of dealing with nature, the process of production by which he sustains his life, and thereby also lays bare the mode of formation of his social relations, and of the mental conceptions that flow from them. Every history of religion, even, that fails to take account of this material basis, is uncritical. It is, in reality, much easier to discover by analysis the earthly core of the misty creations of religion, than, conversely, it is, to develop from the actual relations of life the corresponding celestialised forms of those relations. The latter method is the only materialistic,

> and therefore the only scientific one. The weak points in the abstract materialism of natural science, a materialism that excludes history and its process, are at once evident from the abstract and ideological conceptions of its spokesmen, whenever they venture beyond the bounds of their own speciality.[130]

11.

Entering into the details of the relation between the dominant material production and the production of science, it seems appropriate to mention what Marx stated in general about the relationship among the various branches of the economy:

> There is in every social formation a particular branch of production which determines the position and importance of all the others, and the relations obtaining in this branch accordingly determine the relations of all other branches as well. It is as though light of a particular hue were cast upon everything, tingeing all other colours and modifying their specific features.[131]

In light of this premise, we want to prove the validity of the hypothesis according to which the production of information as a commodity is the dominant form of production, even within the sphere of the production of science, which is not directly a commodity, and characterizes both the relations among producers and between the producers and the products of their work. Indeed, in the preceding paragraphs, we have tried to explain how the production of 'pure'

130 Marx, *Capital*, Book I, Ch. 15.
131 Marx, *Contribution to the Critique of Political Economy*.

science represents the necessary basis for the production of information and how, on the other hand, the production of information in advanced capitalist society has assumed the features of the capitalist production of material goods, i.e., has become itself production of commodities. If a mode of production of technology and information has affirmed itself on an industrial basis, 'pure' science could not continue being produced with the 'artisanal' features, which had characterized its operation until the period before the First World War. This explains how, in the last few decades, national and international 'large laboratories'[132] have become the primary loci for scientific research whereas, in fact, the role of 'small laboratories', decentralised in single universities, has become secondary. Indeed, the 'large laboratory' has the characteristic of a 'multiplier' of the productive efficiency of science (higher concentration of scientists, faster exchange of information, possibility – on the part of a research group – to use different machines, and the potential simultaneous use of facilities by several research teams, etc.) and therefore ensures that the production of "pure" science keeps pace with the production of information.

Note that, even though – historically – the prototype of the large laboratory (The Manhattan Project, Los Alamos) was born *before* the onset of the domination of the capitalist mode of production of information, the logical issue which determines the consolidation of the large laboratory in scientific research consists in the fact that, in the following years, applied science, and information in particular, has become a commodity.

Once the existing connections have been clarified between the emergence of the large laboratory and the production of information as a commodity, the mechanism which is established becomes clear:

132 Note that the material conditions necessary for the existence of large laboratories is large monopoly capital, i.e., the concentration of capital in such masses which enable the financing of these enterprises.

making the process of scientific production homogeneous to the capitalist one.

The most advanced 'management' methods of labour organization are invoked and applied in order to maximise the 'productivity' of research. According to Harvey Brooks, one of the main authorities of American science policy, "the first question is how to organize, staff, and direct the search for knowledge so as to obtain the greatest rate of scientific progress for a given investment of human and material resources."[133] The consequences of this trend are not difficult to discover.

First of all, the organization of research work tends to become independent of the aims of research itself, so that it is essentially based on the instrumentation used. Since the latter is often very similar to that used in the production of technology, ultimately the capitalist use of instruments tends to decide the division of work and the organization of science production. In this sense, specialization is also a decomposition of labour into increasingly simple acts: in every research team, the various members are dedicated to different tasks; the separation between researchers of different levels and skills is created, along with executive technicians. Hierarchical relationships are created within the research group. In this regard, it can be noted that there is an increase in the number of researchers whose work is linked to a certain technique, with a reversal of the traditional subordination of the technique used to the problem which should be solved, which is transformed into a subordination of the problem to the technique which has become, by now, compulsory.

As a consequence – says R. I. Yaes in his ruthless description of research conditions in elementary particle physics – "as it happens for the rest of the workforce – hundreds of physicists are now

133 Harvey Brooks, " Knowledge and Action: The Dilemma of Science Policy in the '70s," *Daedalus*, vol. 102, 1973, p. 125.

condemned to life to do a boring, senseless and alienating job."[134] In these conditions – the author continues – "the members of the *establishment* of physics assume the same attitude towards their younger colleagues as those industry managers, who have always considered their employees more as means of production than as human beings."

In the second place, as in the production of commodities, time becomes a crucial factor so that work may produce a useful result. Hence the acceleration of research rhythms, the fierce competition between researchers to make the first discovery, the tendency to discard projects that take too long so as to obtain a tangible result sooner. All this provokes a rapid obsolescence of the information produced, which is in perfect harmony with the general features of any commodity at this stage of capitalism. At the same time, there is a stratification of consumption within a restricted élite, which has quick access to first-hand information and can therefore directly exploit the "most innovative" techniques, and a mass of consumers who receive a product which, by now, can only be used for the production of routine. Not by chance, in most research fields this subdivision coincides – as shown by a most enlightening study by G. Morandi, F. Napoli and C. Ratto[135] – with the division of the world according to the geography

134 R. I. Yaes, *Physics from Another Perspective. A Cynical Overview* (unpublished manuscript), Memorial University of Newfoundland, St. John's, Canada.

135 G. Morandi, F. Napoli, C. Ratto, *Un'indagine sociologica sulla ricerca in fisica dello stato solido* (unpublished typescript). The authors draw the following conclusions from their analysis: "capitalism and imperialism export their features, their way of living and producing, within the scientific 'production mode' and precisely through: (i) a strict separation of international labour, which mirrors the division of the world into areas producing advanced technologies, mature technologies, and a third underdeveloped world; (ii) a way of 'making science' (within each single area) based on maximum productivity (this brings, for example, a progressive breach between theoretical and experimental work), and on the characterization of scientific work more as an 'exchange value' than as a 'use value.' In other words, all that matters is not the abstract progress of 'knowledge,' which the work can produce, but rather its novelty, and therefore its 'saleability' on the market, even though this implies – as we mentioned earlier – they are only used until they are 'innovative,' and then abandoned when they are 'mature' (abandoned means handed over to areas for their exploitation at this stage), before they have

of imperialism: the metropolis, which produces advanced technologies, the satellite areas, which produce mature technologies, and the underdeveloped areas.

In the third place, a quantitative criterion is established, as for any other commodities, for the purpose of determining production efficiency, which becomes the socially recognized yardstick of success. This is a consequence both of the need to justify the productivity of investments – in means of production and salaries – in comparison with investments in sectors producing commodities, and the need for the production of ‘pure’ science to keep pace with the industrial production of information, inasmuch as – as we explained earlier – this represents an indispensable condition for the productive development of information as a commodity. It does not matter so much that information is useful: it only matters that it is produced. In the field of high-energy physics alone, the list of preprints[136] received by the library of a large laboratory (in this case, SLAC: Stanford Linear Accelerator Center) includes more or less a hundred articles a week, about 5,000 per year. No one is able to digest such a large amount of information, and not even to select useful contributions for a certain goal. You have to rely on another value criterion in order to choose. This is provided by productivity. The need to establish a quantitative criterion for measuring scientific production leads, indeed, to a qualitative scale of values which privileges those contributions which are capable of ensuring the subsequent production of as many further publications as possible. Therefore, the measure of success of a

produced appreciable results.” In our opinion, it is very interesting that these conclusions come from an accurate analysis of a homogeneous sample of about 300 articles published on a very specialized subject of solid-state physics, thus providing precise “experimental” data supporting our general argument.

136 Preprints are the fastest form of communication of research results before they are published in a journal. Those who do not receive preprints and only read journals come into possession of information that is already aged, practically unusable. Journals are practically an archive.

paper is determined by the number of citations, just as the measure of the efficiency of an institution is measured by the number of publications it produces.

Two sociologists, Jonathan Cole and Steven Cole,[137] have elevated the criterion of the citation count to the absolute measure of the value of a paper. As Yaes notes:

> This technique will appear particularly attractive to 'scientific administrators' for various reasons. First of all, it appears objective, because it does not require a subjective assessment by the administrator in question. Moreover, counting quotations is easier and less time-consuming than a subjective assessment, which, in any case, requires a degree of technical sophistication on the part of the administrator equal to the one of the scientist. But, most important of all, this technique allows to show what they want to show. The already well-known scientists will be quoted more often just because they are high-profile, therefore people pay more attention to what they say.[138]

Just as young researchers are pushed – unless they want to be eliminated quickly – to publish a lot, without pauses for reflection, following the fashion of the moment, in the same way scientific institutions (centres, laboratories, research teams) tend to focus both means and efforts along directions of sure success, according to canons accepted and defined by the *establishment*: a typical example is given by the construction of more powerful particle accelerators. We witness, therefore, the same concentration process which characterizes large capitalist enterprises. Those research centres, which already

137 J.R. Cole and S. Cole, "Citation Analysis," *Science*, vol. 183, 1974, pp. 32-33.
138 Yaes, *Physics from Another*.

receive the most funds, will tend to absorb more and more funds, thus eliminating smaller laboratories. The National Accelerator Laboratory of Batavia, which cost 250 million dollars, absorbs 60 million dollars for operating costs each year. Nevertheless – or, better still – for this very reason, scientific results are disappointing. “In the absence of sensational discoveries” – we read in *Science* – “more extensive quantitative measures are planned.”

It is worth underlining that the mechanisms we have discussed are not circumscribed, as it may appear from the examples we have chosen, within the field of physics, even though this science probably represents an exemplary case. The evidence of the biologist S. E. Luria seems to us indicative in this regard:

> The production of scientific research varies depending on external circumstances, with regard not only to the contents of research but to the way it is carried out – its style. The charming snootiness of the physicists as intellectuals, for example, did not survive the pressure to associate with the military crowd during the 1940s. […] A medium-big scale, not quite that of physics, but relatively substantial all the same, has overtaken biology. […]
> But the entrepreneurial system does lend itself to opportunism. […] A subtle change in ethical standards follows: not necessarily a loss of integrity, but a shift of responsibility from the scholar to the entrepreneur. One sees signs of such a change taking place in biology, in which substantial research support dates only from two decades ago. For example, if someone published some good work, other scientists used to allow him to develop it alone at least for a few years. Now eager researchers rush back from professional meetings to perform the obvious experiments that a speaker had not

> **yet had time to do. Nothing strictly unethical, of course – not according to the ethics of competitive enterprise.**[139]

12.

Besides the mechanisms we have illustrated, which work directly on the organization and division of research work, in particular inside large laboratories, on the form of the product, and on its social value, there are more mediated relationships at the superstructural level among dominant social relations in society and the form which science assumes as a social product.

This is due, first of all, to the fact that scientists belong, as a group, to the ruling class, and their elite is part of the executive leadership. Through the education they have received, their social contacts, their concrete interests of collaboration with productive structures, educational institutions, and mass-media, they transmit values and behaviours inside the corporation.

In particular, the subordination of the latter to the rules given by the establishment is ensured by a dense network of advisory boards at all levels of public institutions. A recently published[140] sociological analysis of technical-scientific advisory boards in the USA shows how this network not only binds a very large number of scientists and engineers (about 20,000) directly to power, but also indirectly affects the behaviour of the vast majority of the members of the scientific community. Indeed, the fact of belonging to the advisory board provides social prestige and professional advantages, which function as an incentive for younger and lesser-known researchers. Moreover, the

139 S.E. Luria, "Research Style and the Entrepreneur," *Science*, vol. 180, 1973, p. 164.
140 M.L. Perl, "The Scientific Advisory System: Some Observations," *Science*, vol. 173, 1211, 1971.

author says – "it is commonly believed that the members of this consulting body are the most professionally qualified experts, whereas those who are outside are considered amateurs." That is why scientists are so cautious towards their administrations and tend "not to oppose their scientific and technological attitude with too much vigour or publicity."

We would like to briefly mention a second aspect of the link between the production of commodities and the production of science at a superstructural level. It has been noted[141] that, in physics, the strictly reductive explanatory mechanisms used in the first decades of the 20th century ("the idea was to reduce the problem to the determination of the fundamental or elementary components and of the forces to which they are subject") have disappeared in the elementary-particle physics developed in the last twenty years. This transformation consists in replacing the previous method of analysis with a global description, unrelated to the traditional concept of dynamic evolution. This transformation could be put in relation with the transition from mechanization to automation of the production process. A situation in which the use of systems in the behaviour of individual components determined the behaviour of the resulting system, has been replaced by a use of systems in which the global behaviour of the overall system is determined by the mutual *feedback* of all components. In other words, we could here find an example of the relationship between the work practice, through which people actively intervene upon nature in order to transform it, and the conceptual tools, which they use to understand nature in the course of the acquisition of knowledge. The consequence of the change that we described, which implies a real redefinition of the concept of the 'scientific explanation' of a process, is that – as Jona-Lasinio says in

141 G. Jona-Lasinio, "Changes" [TN: as in the original, this internal reference has no corresponding passage.]

the above-mentioned article – "truth criteria no longer exist in the strict sense of the word." In these conditions, "the average theoretical physicist is a program officer (creative at best). Theoretical physics no longer explains anything."

In this regard, we would like to underline the fact that, in correspondence with the two functions carried out mainly by scientific research (indispensable framework and support of the production of the information and technology 'testing circuit'), besides the above-mentioned role played by the *average* scientist, there is a minority of scientists, generally placed at the top of the hierarchical scale within the scientific community, who possess the "privilege" of establishing the programmes and deciding the paradigms according to which average officials complete their tasks. We remember, in this regard, Thomas Kuhn's[142] considerations on the activity of the scientific community in periods of normal science, marked by the articulation of the accepted paradigm and 'puzzle'-solving within the paradigm itself. However, a substantial difference, as compared to the model proposed by Kuhn, consists in the fact that, in the mode of science production characteristic of advanced capitalist society, different paradigms can 'coexist' without necessarily opening a period of *crisis* (in Kuhn's sense) within the scientific community. Indeed, such production can be subdivided into different, but not mutually exclusive, programmes, essentially equivalent from the point of view of knowledge.

13.

Insofar as the science production process – as the production of something which, although not an immediate commodity, is socially useful – is increasingly subsumed by the capitalist mode of production

142 Thomas S. Kuhn, *The Structure of Scientific Revolutions*, Chicago: The University of Chicago Press, 1962.

of information as a commodity, its products are increasingly distinguished by social properties which, although apparently intrinsic and objective, in actual reality mirror relations of production.

As in the production of material commodities, it is the concreteness of the products and of the means employed to produce them – their use value – which blends in as a material and objective support "with the specific social features they possess at a certain stage of the historical development." In the same way as in science production, it is the real objectivity of the human-nature relation, established through it, which blends in with the special social character conferred on this relationship by the dominant mode of production. In other words, the science produced in an advanced capitalist society, precisely because it represents our objective relationship with nature, returns to this society scales of values, patterns of behaviour, forms of organization and social goals, which *appear* equally objective and natural. And it is actually this ideological content which contributes, to a large extent, to what is considered contemporary 'scientific culture'. Let us quickly examine some of its main features.

First of all, science provides a model of development based on production as an end in itself. Indeed, it is proud not to have any aim. Its 'purity' rejects any 'instrumentalization'. Thus, science ennobles and represents as an autonomous intrinsic value nothing but the law – typical of the capitalist mode of production – according to which "the scale of production is not determined according to given needs but rather the reverse: the number of products is determined by the constantly increasing scale of production, which is prescribed by the mode of production itself."[143]

In the second place, science is presented as a corporation closed to non-experts. As a consequence, on the one side it refuses to submit

143 Marx, *Capital*, Book I, unpublished Sixth Chapter, available online at: https://www.marxists.org/archive/marx/works/1864/economic/ch02a.htm.

its aims and its social role to society's control and discussion; on the other hand, it proposes a social model, in which "the competent people" of a certain sphere of activity form a separate body which stands above ordinary people. It is clear that such a form of organization appears as a necessary condition for the correct functioning of science as an institution, and therefore as an objectively sound proposal for all the other institutions. *Inter alia*, it follows that, since only recognized institutions have the power to define who is competent, people who challenge recognized institutions are, by definition, ineligible and must be outcasts. But it is now clear that the opposite is also true: the form which the institutions of a capitalist society take on as a function of the reproduction of existing social relations also characterizes science as one of the institutions of this society.

In the third place, science is presented as pure objectivity. The result is a model of society where relationships among human beings are determined by objective laws. A society where common people must accept that their lives are decided by a 'scientific' organization of work, that their skills are assessed in a 'scientific' manner, and that their place within society is fixed by an 'objective' scale of values.

Finally, science points the way to success in specialization. As a consequence, this is a society where everyone aims at engaging exclusively in an increasingly restricted field of activity, giving up any participation in collective life, delegating the solution of social problems to the mechanisms of the system.

It is perhaps unnecessary to say that this model of society is the image reflected, 'as in a mirror', of advanced capitalist society.

The Modern Epistemological Debate and the ‘Socialization’ of Science[144]

Giovanni Ciccotti and Giovanni Jona-Lasinio

Non-Neutrality of Science

Towards the end of his book on the philosophy of science, Mario Bunge, a decidedly realistist epistemologist who had very little sympathy for sceptics, summarized the challenges that he had to face in the course of his work:

> **If the preceding analysis is substantially correct, we must abandon the widespread belief that every theory *single-handedly* faces its empirical jury. Firstly because, in order to describe specific observable facts, a theory must be adjoined some information, a definite model, and a bunch of hypotheses linking that which is observable with that which is not observable. Secondly, because the empirical jury is itself backed up by a body of theory, it needs a further model (of the empirical set-up) and some bridge hypotheses.**

If that is the case – Bunge continues – “there can hardly be any *conclusive* evidence for or against a scientific theory.”[145]

We are here faced with the explicit recognition that there is no direct and unambiguous relation between scientific theories and the

144 Published in *Scientia*, July-August 1973, pp. 1 ff.
145 M. Bunge, *Philosophy of Physics*, Dordrecht, Boston: D. Reidel Publishing Company, 1973, p. 235-36.

facts that they must explain. On the other hand, this is not a merely technical problem of epistemology; if we acknowledge the non-absolute character of scientific knowledge, i.e., we realize its fully human – finite, rather than ultrahuman – validity, this may lead us to a regressive, anti-scientific scepticism, but may also open – without erroneous mythologies – a constructive discussion on the value of science and on the social function of scientific research. That is what is at stake, more or less consciously, in the debate about the neutrality of science which has been so lively in the last few years. So now we are going to look at the implications of the relative non-verifiability of scientific theories, as mentioned above, so as to state – in the widest and most satisfactory way possible – the thesis of the non-neutrality of science.

In order to proceed in the best way, it is better to refer to those areas of epistemology, which have best interpreted the growth of scientific knowledge in the last century. In fact, further on we will explicitly refer to epistemological attitudes in the field of physics, but we do not believe that this will affect the general character of the topics we are addressing.

At the start of the century, once the confidence in passing from facts to laws in a unique way through scientific induction was lost, conventionalism faced the challenge of the validity of scientific statements by saying that it is based upon a "*methodological decision*" taken by the scientists.[146] If a theory, as in the case of Newton's mechanics illustrated by Henri Poincaré, has achieved remarkable empirical success, scientists can *decide* not to let that theory be disproved. Any anomaly that occurs may be overcome with the help of auxiliary hypotheses and "conventional ploys," as defined by Karl Popper.

146 I. Lakatos, "Falsification and the Methodology of Scientific Research Programmes," in *Criticism and the Growth of Knowledge*, ed. by I. Lakatos and A. Musgrave, Cambridge: Cambridge University Press, 1970, p. 104.

According to Poincaré, the defender of conventionalism who was most active in science, we should "abandon the principles only after having made a loyal effort to save them."[147] On the other hand, "if a principle cease to be useful to us," this means that "experience, without directly contradicting it, will yet have condemned it.[148]

Even in this case, there would be no reason for excessive regret. According to Poincaré, however, who was writing in 1904, "we are not yet there."[149]

In any case, even if the principles of science changed, this would not alter the truth, which is given by the ability to determine increasingly precise and rich relations among phenomena.

In this way conventionalism, though acknowledging the possibility of there being more than one theory explaining the same facts – based on the fruitfulness, convenience and simplicity of theories – gave criteria *within* scientific research in order to choose the best theory and could present, once again, a vision of science as essentially neutral. Indeed, its development appeared purely cumulative, and there seemed to be no important relationships between this development and the history of society.

However, if one just considers the deep transformations that science has undergone throughout the twentieth century, one can realize the inadequacy of the conventionalist stand set out above.

An attempt to overcome the limits of classic conventionalism was made by Popper's methodological falsificationism. He proposed a theory of the growth of scientific knowledge that is more suitable to the developments of contemporary science, which has endured frequent revolutions in its fundamental theories. It is not worth dwelling

147 Henri Poincaré, *La valeur de la science*, Paris: Flammarion, [1905] 1970, p. 142. English version: *The Foundations of Science*, trans. G.B. Halsted, New York: The Science Press, 1913, p. 315, available online at: https://www.gutenberg.org/files/39713/39713-h/39713-h.htm.

148 Ibid., p. 144.

149 Ibid., p. 320.

here on the building blocks of methodological falsificationism. Suffice it to say that, on the basis of methodological, thus conventional, decisions, it makes use of the asymmetry between the logical impossibility of *testing* an inference and the possibility of *falsifying* a theory in order to provide criteria for choosing when one needs to replace an old theory with a new one:

> According to my proposal – Popper writes – what characterizes the empirical method is its manner of exposing to falsification, in every conceivable way, the system to be tested. Its aim is not to save the lives of untenable systems but, on the contrary, to select the one which is by comparison the fittest, by exposing them all to the fiercest struggle for survival.[150]

The controversy with classic conventionalism makes this stance even clearer. While the former thinks that the development of science is "only possible in a research pursuing the aim of absolute security, with a rigour without concessions,"[151] Popper requires no definitive certainty from science (and, as a consequence, he does not obtain it). Thus, while

> periods when science develops slowly will give little occasion for conflict [...] to arise between scientists inclined towards conventionalism and others who may favour a view like the one I advocate. It will be quite otherwise in a time of crisis. [...] In such times of crisis this conflict over the aims of science will become acute. We, and those who share our attitude,

150 Karl R. Popper, *The Logic of Scientific Discovery*, London/New York: Routledge, [1935] 2002, p. 20.

151 Hugo Dingler, *Die Methode der Physik*, Munich: Ernst Reinhardt, 1938. For an English extract, see: "Method Instead of Epistemology and Philosophy of Science," trans. Peter McLaughlin, *Science in Context* vol. 2, no. 2, 1988, pp. 369–408.

> will hope to make new discoveries; and we shall hope to be helped in this by a newly erected scientific system.[...] But the newly rising structure, the boldness of which we admire, is seen by the conventionalist as a monument to the "total collapse of science" [...] In the eyes of the conventionalist one principle only can help us to select a system as the chosen one from among all other possible systems: it is the principle of selecting the simplest system – the simplest system of implicit definitions; which of course means in practice the "classical" system of the day.[152]

Indeed, as Popper argues, scientists do not usually proceed in this manner. Therefore:

> *Only with reference to the methods applied* to a theoretical system is it at all possible to ask whether we are dealing with a conventionalist or an empirical theory. The only way to avoid conventionalism is by taking a *decision*: the decision not to apply its methods. We decide that if our system is threatened we will never save it by any kind of *conventionalist stratagem*. Thus we shall guard against exploiting the ever open possibility just mentioned of [...] attaining for any chosen [. . .] system what is called its "*correspondence with reality*."[153]

Therefore, while conventionalism managed to save a wholly internal vision of the development of science, Popper's falsificationalism, in order to get closer to the developments of contemporary science, seems to acknowledge an element of non-neutrality in scientific research, namely the researcher's subjective sensitivity in identifying

152 Karl R. Popper, *The Logic of Scientific*, pp. 59-60.
153 Ibid., p. 61.

the best theory to choose from among the infinite number of possibilities. This would open up the possibility of determining a non-trivial relation between the mechanisms of society's historical development and the ones of scientific growth. Popper thinks this should not happen. So he tries to come to terms with the difficulty through the interesting distinction between the logic and psychology of scientific discovery. Indeed, even admitting that "scientific discovery is impossible without faith in ideas which are of a purely speculative kind, and sometimes even quite hazy,"[154] Popper considers the way, in which a person formulates a new idea, as "irrelevant to the logical analysis of scientific knowledge." The method used for a scientific test of a new idea "is concerned not with *questions of fact* (Kant's quid facti?), but only with questions of justification or validity (Kant's quid juris?)."[155] According to him, it is possible to fulfil the latter task – the ultimate aim of epistemology – through "a '*rational reconstruction*' of the steps that have led the scientist to a discovery – to the finding of some new truth."[156] This can be obtained through his theory which he defines as a "*deductive method of controls*," which was briefly mentioned above. Thus, the historical development of science which, once again, would turn out to be internal, would be constituted by great scientific discoveries – which are falsifiable – *falsified* by large crucial negative experiments. This is the result of the application of objective standards and Popper's criteria of rationality to history. However, as Imre Lakatos (an epistemologist of Popper's school) rightly remarks in a recent article:[157]

154 Ibid., p. 16.
155 Ibid., p. 7.
156 Ibid., p. 8.
157 Lakatos, "Falsification," pp. 114–15.

> If we look at history of science, if we try to see how some of the most celebrated falsifications happened, we have to come to the conclusion that either some of them are plainly irrational, or that they rest on rationality principles which are radically different from the ones [Popper's] we just discussed. First of all, our falsificationist must deplore the fact that stubborn theorists frequently challenge experimental verdicts and have them reversed. In the falsificationist conception of scientific "law and order" we have described there is no place for such successful appeals. Further difficulties arise from the falsification of theories [...] Their falsification, as it occurs in actual history, is *prima facie* irrational by the standard of our falsificationist. According to his standards, scientists frequently seem to be irrationally slow: for instance, eighty-five years elapsed between the acceptance of the perihelion of Mercury as an anomaly and its acceptance as a falsification of Newton's theory [...] On the other hand, scientists frequently seem to be irrationally rash: for instance, Galileo and his disciples accepted Copernican heliocentric celestial mechanics, in spite of the abundant evidence against the rotation of the Earth.

Thus, the history of science does not support Popper's theory of scientific rationality. Consequently, the distinction between psychology and the logic of scientific discovery is lost, in the sense that it is no longer only the way in which a scientific discovery is made that depends on the social-historical context. Indeed, external history affects the very possibility of establishing oneself, and therefore – as we shall explain better later on – the very validity of scientific discoveries, i.e., of scientific theories and laws.

Of course, they tried to provide evaluation criteria for scientific theories so as to save the intellectual value of science and ensure a growth dynamic of scientific knowledge based upon internal reasons. However, the salient point of these criteria is to accept that scientific audits are always comparisons that require three elements: two or more rival theories, and the experiment.[158] So no comparison is *decisive* for the choice or abandonment of a theory. The resulting arbitrary choice is easily verifiable, for instance, if we look at recent developments in theoretical physics. Moreover, it opens up prospects of considerable interest for the issue of the neutrality of science which we want to examine here. In fact, it is now a firmly established opinion in the area of epistemologists, who are more sensitive to the effective development of science, that

> **observation and experience can and must drastically restrict the range of admissible scientific belief, else there would be no science. But they cannot *alone* determine a particular body of such belief. An apparently arbitrary[159] element, compounded of personal and historical accident, is always a formative ingredient of the beliefs espoused by a given scientific community at a given time.**[160]

However, if epistemology cannot provide normative criteria that are able to rationally evaluate – i.e., from within science – theories and modes of scientific progress, then there is no alternative other than trying to *explain* changes in 'paradigms' – a term used by Kuhn – in sociological terms, by reconstructing the structural and therefore social causes of those choices. If one puts oneself in this order of ideas, and tries to understand the development of science and

158 Lakatos, "Falsification," p. 115.

159 Arbitrary in the sense of "non determinable" within a particular set of eligible scientific beliefs. Indeed, from a general historical point of view, such an element is perfectly determinable.

160 T.S. Kuhn, *The Structure of Scientific Revolutions*, p. 4 (emphasis added).

society together, the ancient and deep-rooted image of scientific progress, which considers it as a linear, continued accretional process of knowledge (in short, a cumulative process), is expected to fade away. Indeed, in the history of science and of scientific thought we find – besides relatively stable and cumulative stages of development – other stages of radical transformation and discontinuity with the past, which we cannot simply refer back to the refinement and multiplication of observations, measurements and experiments. This comes from the fact – mentioned above – that no 'empirical basis' is sufficient on its own to decide the fate of a scientific theory. The meaning of these 'scientific revolutions' has been very well described by Kuhn:

> Each of them necessitated the community's rejection of one time-honoured scientific theory in favour of another incompatible with it. Each produced a consequent shift in the problems available for scientific scrutiny and in the standards by which the profession determined what should count as an admissible problem or as a legitimate problem-solution. And each transformed the scientific imagination in ways that we shall ultimately need to describe as a transformation of the world within which scientific work was done.[161]

Therefore, scientific revolutions undermine that image of science that wants to guarantee for its theories a validity superior to society and its historical forms of development. To this regard, we consider the following remark by John Von Neumann quite interesting:

> It is only proper to realize that language is largely a historical accident. The basic human languages are traditionally

161 Ibid., p. 6.

> **transmitted to us in various forms, but their very multiplicity proves that there is nothing absolute and necessary about them. Just as languages like Greek or Sanskrit are historical facts and not absolute logical necessities, it is only reasonable to assume that logics and mathematics are similarly historical, accidental forms of expression.**[162]

The idea of the autonomy of scientific theories with respect to society, even if not supported for apologetic reasons, has no foundation in reality. Rather, it arises from that premise of the extraneousness of nature from society, which is so deeply-rooted in the conceptual representation of nature in modern sciences. This premise, far from being the necessary element of scientific research, i.e., in the partition of reality into various levels of knowledge, is fuelled today by the capitalist estrangement of producers from their product. We can now attempt to enunciate the thesis of the non-neutrality of science in its full extent.

Not only is the relation between scientific theories and the facts, on which they are based, not one-sided, but the very statements of scientific laws, far from having a validity of their own within the historical and social context of the discovery, have a value *related* to the historical and social framework, in which they arose and established themselves. Naturally, there is also the psychological context of the discovery: however, if it represents the more properly subjective element of the discovery – which we certainly do not want to deny here – it is undoubtedly irrelevant for an objective and historical estimate of the discovery, which society as a whole provides.

Another important point, which we should clear up is the use of the term *correlation* – rather than *dependency* – in order to indicate

162 John Von Neumann, *The Computer and the Brain*, New Haven: Yale University Press, 1958, p. 93.

the relation between the justification of a theory, the acknowledgment of its value, and the social context in which this takes place. In this way, we want to underline the fact that the various sciences do not simply mirror some level of society, but rather actively contribute to reconstructing it. Therefore, science provides information on reality, elaborating a partition of it into various levels of knowledge, building conceptual categories and experimental techniques, so as to define these levels more and more accurately. Thus it takes a mediating grip on reality. People cannot overcome this mediation because, as natural, finite creatures, they can only produce and reproduce in a finite way. Naturally, since the process is open, no limit is set *a priori* to the power of building and controlling the wealth of reality.

However, within a given society and a given time, we need a particular mediation of reality. This mediation – as we saw beforehand – is not uniquely determined (nor can it be) by reference to the needs, interests and expectations of people from that time and society. In this case too, in the presence of social contradictions, there can be more than one way to look at reality where several coexisting 'paradigms' are in conflict with one another. We will come back to this later: we now want to explain that, when using the term correlation, we have in mind the fact that science does not only mirror nature and society, and their historically determined interaction, but it is also a *project* for society.

Let us try to clarify the issue by focusing on the concept of project.

Scientific work features the creative formulation of interpretative hypotheses in order to single out modes of intervention on nature which are most suitable to reality and to the peculiar values of a specific social formation. If the social body is not homogeneous, but instead has essentially distinct social strata within it, with conflicting historical perspectives, for example the bourgeois and feudal aristocracy in France by the end of the 18th century,[163] then there is not only one suitable way, but rather a number of conflicting scientific concepts and practices. However, we should stress that, in so far as they coexist, very different scientific concepts and practices actually coincide from the point of view of empirical predictions. To this regard, we may mention the classic example of the competition among astronomical systems – those of Ptolemy, Tycho and Copernicus[164] – which around 1600 were largely equivalent from an empirical point of view. Therefore, the idealization of reality, a feature of the build-up of scientific theories, cannot take place without intentionality, which is indicative of a human goal. On the other hand, it is appropriate to explicitly stress here that this goal does not coincide with what the subjective consciousness that the individual scientist imagines, but is rather identified by the overall meaning and by the social function of scientific thought in a certain moment in history. This is the result of the objective mediation, made between the original, creative scientific work and the historical circumstances in which the scientific development is determined. Consequently, as such, it is objectively to be found.

The Social Integration of Science

Non-neutrality is a formally negative concept.

However, that formulation implies articulation and enrichment in the idea of science and scientificity. The use of a formally negative concept comes only from historical reasons and echoes the controversies of recent debates. In order to develop our discourse in all its

163 See G. Israel, P. Negrini, "La rivoluzione francese e la scienza," Part I, *Scientia*, vol. 108, 1973, p. 41; Part II in *Scientia*, p. 357.

164 On the social meaning of these contrasts, see A. Rossi, "Copernico nella realtà del suo tempo," *Critica marxista*, vol. 11, n. 3-4, 1973, p. 291. On this issue, see also T.S. Kuhn, *The Copernican Revolution*.

breadth, we must abandon that formulation, which has no logical reason to exist, and try to transform it into a new definition of science and scientificity.

We have described the disintegration of the purely epistemological – inner and absolute – concept of science and the consequent referral to the social. Such referral could lead to the accusation of irrational relativism against our analysis. Conversely, as we will explain, it allows us to satisfactorily give an account of what science is on a methodological plane. Indeed, owing to the element of planning which we identified, science tends to express an ideal plan of human activity, whose meaning and uniqueness cannot be determined except with reference to the possible integration of scientific data in a wider theoretical, practical and ideological context. These terms refer to the importance, within this process of integration, respectively, of cultural tradition, material production, form and values of social organization.

Thus, we can define as scientific all those procedures, which determine a lawful regularity [*legalità*] in accordance with the above-mentioned condition of integrability.

Technique and technology are related to this definition and complementary to it. We define as technical all those successful and acquired productive procedures, which are not necessarily understandable in scientific terms, i.e., in terms of the lawfulness of known reality. In this sense, technique is one of those *external* elements which can precede science – and often do so. Science should be able to integrate them. The other way around, productive procedures based upon the lawfulness of a historically determined reality define the technological context.

Therefore, there is no *a priori* way to decide the lawful regularity of reality, either diachronically or synchronically. Different historical entities – such as countries or social classes – can propose scientific contents and thus notions of a scientific nature – corresponding to different levels of interventions upon nature. Moreover, when integration in a wider context is difficult, our criterion of scientificity predicts alternative plans and, in perspective, the emergence of scientific revolutions. On the other hand, there is no cumulative development of science enabling us to extrapolate a future *form* from its current *form* on the basis of entirely internal reasons. For example, there seems to be no conclusive *internal* reason for the disappearance of the concept of electromagnetic aether from science. Conversely, the higher adequacy to the social request of speeding up scientific practice, of a "mathematistic" interpretation of scientific concepts in comparison with an ontological one, seems to provide the leitmotif of that conceptual transformation.

At this point, it is better to examine a frequent objection raised against our argument.

The difference has often been noted between the scientific developments of France, Germany and England in the 19th century, and their merging into a more homogeneous tradition in the first half of the 20th century. This event is usually interpreted by the supporters of the neutrality of science as proof of the universal and ahistorical nature of the scientific method, as perceived nowadays by the community of specialists. However, it simply shows the higher material, social and cultural homogeneity, which historical development has produced in Europe in the 20th century.

A further proof of our thesis is that – though as a trend – we may notice remarkable differences between scientific practice in the USA and the prevailing one in the Soviet Union, both in contents and approach. In this regard, we may notice the rapid development of non-linear analysis in the Soviet Union, connected to problems of control and programming, and the immediate feedback in the epistemological attitude, relying on the overall setup implied in the problems of Soviet planning. This clearly appears in the typically materialist preface to the monograph *Theory of Oscillators*,[165] written by Aleksandr Andronov and others in 1937. Andronov, together with Lev Pontryagin, invented structural stability, a key concept of non-linear analysis. In connection with this, it would be interesting to carefully compare manuals of science in the Western world and in the Soviet Union.

It would also be interesting to notice the great resumption of studies of classical mechanics in the USSR, which is difficult to understand outside a materialist-dialectical cultural tradition.

We should now explain how the essential role attributed to the historical-social context does not dismiss every foundation of the idea of scientific progress. Usually, we understand human actions insofar as we succeed in connecting them to existing traditions or, in case, they manifest as dissent, to the extent that we realize the reasons leading to the denial of such traditions. This also applies to the sciences, whose progress we perceive through increasing levels of articulation and inclusion of their former selves they propose. This very chance of understanding and continually reconstructing one's own history, a starting point for any subsequent planning activity, allows us to talk about an increasing degree of truth, or approximation of nature, reached by human knowledge. In the moments of knowledge crisis, the explosion of contradictions at various levels of society drives such a wedge between the present and experienced history that it makes comprehension – and consequently a linear and continuous growth of knowledge – impossible. The state of crisis does not end until a new project and a new ability to control the present are established. This shows, among other things, that the responsible management of the present and an understanding of the past to a large extent imply each other in social life.

165 A.A. Andronov, A.A. Vitt, S.E. Khaikin, *Theory of Oscillators*.

Finally, to conclude this short review of the social character of science, we would like to examine in detail that aspect of our definition of scientificity which we considered as a characteristic and qualifying feature: namely, the trend towards integration in a wider context. Starting from recent history, we want to try and more accurately develop the meaning of this tension towards integration, which scientific data must possess in order to be considered as such. Naturally, the possibility must be left open that – subjectively – alternative notions of scientificity are of relevance within a particular choice of individual scientists. However, what we are interested in saying is that a multi-level integration is typical of what is objectively established as science in the course of history.

The criterion we adopted, in line with our previous argument, is that the most developed forms of a historical process, if adequately interpreted, offer the necessary categories for an understanding of the preceding forms of the process itself.

Now, the idea of sciences as an integrated system of knowledge is certainly not new. However, we want to emphasize a new breadth and a new role of this integration that make it a defining feature.

Integration into a conceptual system has certainly been a common property of statements which have been considered scientific in any time and place. However, in modern scientific development, we can single out new and specific levels of integration which increasingly determine what is meant by science. If we follow a distinction made by two Polish authors,[166] we can currently divide the integrative processes into two fundamental types: vertical integration and horizontal integration. The former considers the approximation of scientific research to social practice, and as a consequence an approximation among basic, applied and oriented research. If we understand this

166 I. Malecki, E. Olszewski, "Regularities in the Development of Contemporary Science," in *Sociology of Science*, ed. B. Barnes, London: Penguin Books, 1972, p. 147.

process, we have the key to identifying the social function of science.

On the other hand, the latter process consists in interpreting and overlapping traditional disciplines and focusing research projects upon complex problems.

In the interdisciplinary phenomena falling into this second category, the socially mediated character is often quite evident, namely the connection between the identification of a new level of analysis of reality and the resulting methodological choices.

Consequences

Understanding a process of development is the first step toward exercising control over it and directing it to conscious human ends. Scientific communities, nowadays organized in strictly specialist groups engaged in increasingly esoteric activities, show obvious symptoms of crisis. The break-up of activities and the failed perspective of a unitary scientific system, which would allow a continuous confrontation and a 'reconciliation' of scientific theories with reality, prevent that very process of recapturing which – as we saw earlier on – is a necessary condition for the progress of any kind of knowledge. Thus, the estrangement with which the development of science presents itself to the common people and to the very producers of science.

It is necessary to break this structure, not only to enable a general control of scientific development, but also to guarantee the continuation of this development. The permanence of current structures does not seem – in perspective – to promise anything other than a decay into a turbulent regime, in which we can discern no overall coherence.

Many levels of integration of historically established science obviously require multiple interventions, so as to enable structural changes. At a more general level, this poses a problem of global planning of scientific research. This is a difficult and controversial issue. Planning partial sectors is, by now, a common practice even in basic research, when, for example, particle physics reaches the levels of organization required. However, once the general objectives of a scientific organization are set, the idea is still supported that, within the organization, work is divided ‘naturally’, giving rise to a balance, which is the result of spontaneous interactions among individual researchers, or relatively small groups of researchers. In other words, *laissez faire* and individual initiative as key factors in promoting research are canons now largely accepted by the scientific community. In this way, science increasingly tends to behave like a homeostatic system, with subsequent adjustments produced by individual actions or ideas. The result of this trend is an essentially conservative science, which is unable to predict radical and revolutionary changes. On the other hand, the idea of a global planning of science states the principle that, at the current stage of scientific maturity, we can renew scientific forms in a conscious and fundamental way so that interventions upon nature are more appropriate to social needs. The current system of partial planning in capitalist societies cannot rationalize these radical choices, so that – apart from exceptional circumstances outside social consciousness – they are not realized. In fact, returning to the image of the homeostatic system, the existing structures do not allow small fluctuations to produce radical innovations.

On the basis of the general considerations we have developed so far, we would like to suggest a few specific points of scientific and cultural policy by taking into account the levels of intervention of the members of scientific communities.

Indeed, even though we know very well the inherent limitations of planning activity in our society, and we realize that planning is not an alternative to revolution, we think it makes sense to try and identify the possibility of a relation with nature, which is coherent with a perspective of socialist transformation, namely making an interesting use of the autonomy implied in planning activity.

In his recent essay, Mulkay[167] clearly showed that changes in scientific paradigms and the fertilization of new fields, or the stimulation of other branches that seem to have reached a natural limit, are often connected to the migration of specialists from one sector to the other. A similar process, which nowadays takes place in a completely random way, is strongly discouraged by strict scientific training, and – above all – by the specialistic conservatism of individual research organizations, which are only willing to grow their own area. And yet, in our opinion, it provides guidance for new possible models of scientific education and research organization. Indeed, a politics that gives maximum encouragement – obviously within the limits of specific situations – to the movement of researchers among different disciplines might quickly lead to a wholly new synthesis in scientific practice. Naturally, the development of new tools of knowledge is unthinkable without a linguistic unification, expressing a new level of synthesis of human action, in which global interventions upon nature are possible and can be included in global, conscious projects, which may be controlled by society. In this regard, in the development of non-linear analysis we mentioned above while talking of Soviet scientists, we seem to glimpse linguistically unifying ideas, which have actually already assumed an important role in problems of economic planning as well as in different disciplines such as statistical mechanics, information and control theory, and the emerging theoretical biology.

However, there are levels of integration, which include much larger social layers in comparison with the scientific community. There is, in no sense, a critical popular scientific culture:

167 M. Mulkay, “Cultural Growth in Science,” in *Sociology of Science*, ed. by B. Barnes, London: Penguin Books, 1972, p. 126. See also Mulkay’s *The Social Process of Innovation*, London: MacMillan, 1972.

> Production relations and ways of life have changed more quickly than reflections about them; a theory of the world [...] has been replaced by an eclectic collection of proposals and languages. In daily life, there is bewilderment, crisis, or the old habit of surviving the day. Women who had gossiped all their lives of girls wearing skirts showing their ankles (and had gone on gossiping when they were showing calves and knees) suddenly collapsed and accepted, without objection, skirts showing their upper thighs. They simply no longer had a reference system. People who had never seen a steam-powered machine or used a telephone watched the Apollo project on television. They would welcome in the same way, without blinking, perpetual motion, remote transmission of matter, a shift of the Moon from its orbit and colour TV. So many things are incomprehensible and, at the same time, possible.[168]

Nor has current educational literature remedied this situation. Indeed, it spreads results which always refer to something else in order to be fully understood, thus confirming the division of labour instead of denying it. But there is more to it. Scientific outreach passed from a mad exaltation of futuristic perspectives – a projection of current realizations – to tragic visions of ecological disasters. To a large extent, they are both cases of mystifications which sanctify people's estrangement from scientific development. On the other hand, the main problem consists in building up a mass scientific culture. The matter is explained very clearly by F. Ciafaloni in his intervention:

> Building a scientific culture does not mean teaching everyone the general principles of mechanics, as if they knew nothing

168 F. Ciafaloni, "Proposta di un Programma per una nuova serie della rivista *Sapere*," unpublished manuscript [my translation].

of mechanics only because they were never taught a specific principle of mechanics, or had never experienced its construction. Rather, it means providing the tools and ideas in order to reconstruct, from a distorted and partial use and an alienated participation in the construction, the theoretical and practical possession of the products of a technique, namely understanding how to produce them, why they are produced, and the general principles on which they are based and used. Only then can reappropriation become possible. Only then does a possible reappropriation become operative.

In other words, through education, we should make citizens capable of 'experimenting', and thus of consciously enjoying what nature offers. Now, since the nature we are part of is deeply imbued with the social dimension and, far from being a mere external immediacy, it is also a result of science, we should qualify common sense as scientific. In order to do so, we will have to overturn the traditional 'theoretical' form of education and proceed in the direction of a mass 'technological' education.

One last remark. In order to realize this programme, knowledge of science is not enough. The argument we have developed so far should clearly indicate that, in our opinion, a 'technical skill' represents the lowest form of self-awareness. In fact, it often happens nowadays that one may be true specialist, but they are incapable of conscious planning. The attempt to exercise control over present needs, as we saw earlier, is a reconsideration of the past in the light of the present and its demands. We should therefore promote an empirical effort of historicizing the development of the sciences, not only capable of detecting the social function of science but also of estimating its nature and its consistency with the needs of the present.

Part 2

Materials from the History of Theories

The Development and Crisis of Mechanicism: From Boltzmann to Planck

Giovanni Ciccotti and Elisabetta Donini

1.

The issue we are going to address here can be considered as part of a programme aimed at understanding why and how ideas change in science. The *inner history*, in all its forms, is certainly insufficient to explain the transformations of scientific theory and practice, so we would like to typify, in a particular case, the building blocks of the clash of cultures, ideals and politics hidden behind any radical change of scientific thought and reconstruct it through historical analysis. Thus we will see how – in a selected environment – the scientific community, by collecting external stimuli, can translate them into a scientific proposal of knowledge about nature, according to the needs of the dominant production relations of society.

This programme is not very interesting on its own, but it becomes more interesting if we consider it as one of the steps that can help clear up the problem of the *social function of science.* By breaking down the issue, we discover two more basic steps, namely the relations between organization and research institutes and the social institutions of reference; the policy of science, i.e., the formulation of a project and the solution to the problem of its management (with what social forces, at which institutional levels, etc.). The latter element is only meaningful in the present, but the ability to base the historical interpretation of the past can give it consistency. Conversely, the other two steps acquire meaning only in relation to the present, and provide a condensing nucleus of a theory of reappropriation of scientific research and of its results for precise class purposes.

2.

Going back to the step which we consider essential, we would like to examine a remarkable *historical case* which can help us understand the inner dynamics of the growth of scientific knowledge. This is the problem of the origin of quantum mechanics; it is, after all, almost trivial to stress that the issue of the relations between classical mechanics and quantum mechanics still presents itself today, so that the overall integration of the three steps mentioned above is quite clear here.

More explicitly, we think that the very relevance, in the present, of the problems connected to quantum mechanics can attribute the right meaning to the effort of defining its historical character. If we look at the formal framework of contemporary science (physics in particular), we realize that it has apparently reabsorbed the tension of the debate about the epistemological attitudes peculiar to quantum mechanics. In the first half of the twentieth century, both philosophers and scientists themselves had deeply squabbled about a range of issues, from causality to the possibility of a strict determinism, to the irreducible presence of chance in physical relationships. On the other hand, the current situation highlights an almost total sanctification of scientific paradigms, the undisputed basis of the current formulation of physics. Thus there is a double order of problems: on the one hand, we should understand why the features determined by this historical age are projected into the domain of an objective and neutral science, which has mostly removed, as marginal, the problems of reflection upon its own epistemological basis. On the other hand, it is necessary to know how to finalize the same debate on science so as to bring it within a total project of reversal of current class relationships.

We do not want to address these issues directly here; but we do think they should constitute the explicit reference point in order to understand the meaning of the discussion of the origin of quantum mechanics, which we are going to start. It is not a question of engaging with a particular historical period so as to confirm the inadequacy of an analysis led only within science, as we said above. Rather, we should enrich the instruments with which to orient ourselves about the social and ideological assumptions of contemporary theoretical physics and about the meaning of its trends.

In order to clarify the current relevance of the problem, we should remember that, besides the role of undisputed dominance exercised in Western physics, quantum mechanics has established itself as the backbone in the Soviet Union as well.[169] A long and fierce debate with dialectical materialism about its foundations has been resolved in a quiet reconciliation, which – though in practice since in the 1930s and 1940s, as many Soviet theoretical physicists used quantum mechanics, often refraining from engaging in ideological choices – has now become an official, orthodox theorization. On the other hand, even in the Western world and in Italy in particular, there are different stances on the problem of science, though all of them refer in various ways to Marxism. The central issue, relaunched with force from the new levels of anti-capitalist autonomy expressed in the class-struggle of recent years,[170] expands from projects of reappropriation to the hypothesis of alternative science and the simplistic refusal of capitalist science. Compared to all this, it becomes crucial

169 See M.E. Omelianovskij, V.A. Fock, *L'interpretazione materialistica della meccanica quantistica – Fisica e filosofia in URSS*, Milan: Feltrinelli, 1972; S. Tagliagambe, "L'interpretazione della meccanica quantistica in URSS alla luce del materialismo dialettico," in L. Geymonat et al., *Storia del pensiero filosofico e scientifico*, vol. VI, Milan: Garzanti, 1973.

170 Just think of all the debates about the function of science as related to the capitalist organization of labour, where workers are protagonists. We can mention, for example, a few papers published in *Sapere* in 1974, in particular: "Lavoro e nocività: il sapere operaio (discussione tra sette consigli di fabbrica)."

to discuss whether science developed – and still develops – within an objectively progressive enrichment of knowledge – though subservient to distorted ends – or if the latter arrangements are essentially connected to ideological choices induced by historical and social goals, and therefore carry upon them signs of class.

3.

Let us see how the problem of the birth of quantum mechanics arose. By the end of the 19th century, within the framework of physics, two problems stood out: on the one side, the relation between thermodynamics and statistical mechanics; on the other side, compared to the completion of electromagnetism with the formulation of Maxwell's theory, the issue of the existence of aether, and, in general, of the relation between wave phenomena and mechanics.[171]

The problem we are going to examine is linked in some ways to both aspects: indeed, Planck's hypothesis of the need to acknowledge that the energy of certain systems does not vary in a continuous way but only assumes discrete values, multiples of a fundamental unit (i.e., the 'quantum'), is derived from the study of the so-called 'black body' f: in a nutshell, it is a matter of analysing electromagnetic radiation, stuck in a hole, and detecting valid properties in conditions of thermodynamic equilibrium of the system.

Now, there is a vast literature – actually with a rather apologetic flavour – which considers Max Planck's works from 1899-1900 about the problem of the black body as revolutionary, mainly because remarkable quantities of energy appear in them.[172] This is a historically false consideration because Ludwig Boltzmann, since 1872 (and then

171 In this regard, see: G. Battimelli, "Etere e relatività," *Sapere*, November 1974.
172 See the wealth of literature quoted by E. Bellone, *Aspetti dell'approccio statistico alla meccanica: 1849-1905*, Florence: Barbera, 1972, p. 3.

in an essay of 1877), had already handled energy as the sum of a finite number of units, multiples of a basic quantity ε. This had been, for Boltzmann, a very useful calculation tool whose applicability was, however, limited by the condition that it was possible to send ε to zero without changing the results already obtained. In other words, the results should not depend on what was assumed as a mere calculating device. This was actually the condition dropped by Planck.

If there is innovation in Planck – and we think this is undeniable – it does not lie in the introduction of a new logarithm, but rather in the concept of the relation between physical theory and the calculation tools allowed. The 'revolution' does not consist in the formal reduction of energy to discrete quantities, as it does in the different use of such a breakdown. Indeed, Boltzmann underlined that his reduction acts only at the level of mathematical technique, allowing greater clarity in calculations, without being essential to the result. In fact, he writes: "I certainly do not need to remark that for the moment we are not concerned with a real physical problem."[173] Indeed, he explains that it would be very difficult to imagine a situation in which molecules of gas undergoing shocks could only exchange a certain quantity of energy. Clearly, according to Boltzmann, the purely instrumental character of the device is tied to the impossibility of giving a physical interpretation of it in mechanical-molecular terms.

Quite differently, Planck, in his works of 1899-1900, totally ignores the problem of interpretation: what interests him is developing a compact and simple formulation. After all, just to clear the field of the endless misunderstandings that might arise from the philosophical turmoil of the old Planck, we emphasize that it might be

173 L. Boltzmann, "Further Studies on the Thermal Equilibrium of Gas Molecules," in S.G Brush, *History of Modern Physical Sciences,* vol. 1, *The Kinetic Theory of Gases: An Anthology of Classic Papers with Historical Commentary,* N.S. Hall, ed., Singapore: World Scientific, [1872] 2003, p. 293, available at: https://gilles.montambaux.com/files/histoire-physique/Boltzmann-1872-anglais.pdf.

misleading to want to measure the depth of innovation in the attitude towards science only in terms of the subjective awareness of the scientist. We refer – for instance – to the stance expressed by Planck on the occasion of the proposal of Einstein's admission to the Preussischen Akademie der Wissenschaften. Here, Planck showed his inability to positively solve his intimate contrast between ideological demands and his (implicitly acknowledged) concept of the nature of scientific progress. This emerged very clearly from the only doubt he expressed with regard to that admission:

> **His [Einstein's] speculations had pushed him too far sometimes, for instance with regard to his hypothesis on photons [which Planck still denied]. However, we should not give too much importance to this fact. Indeed, exact sciences would progress very little, if no one dared take risks.**[174]

However, let us go back to our problem and try to see the question more in detail.

It is well-known that Boltzmann knew about the problem of the black body, and had even worked on it, so much so that he demonstrated that the total density of energy from the radiation is proportional to T^4 (T= absolute temperature). On the other hand, we have just seen that the technique which would have solved the problem of determining the spectral distribution of energy in the black body had been introduced by Boltzmann himself as he had 'quantized' energy in order to facilitate the solution of a series of problems of statistical mechanics. In particular, he had used this technique so as to measure the probability of a status. Well then – the question arises

174 Quoted in A. Einstein, *La teoria dei quanti di luce*, introduction by A. Hennann, Rome: Newton Compton, 1972, p. 19 [my translation]. Cf. English edition: *Quantum Theory of Light*, London: Newton Compton, [1906] 1992.

– why did Boltzmann not address the problem of the black body, which remained unsolved, and lose interest in it, at least as far as we know? Moreover, mind you, Boltzmann had great confidence in statistical methods, whereas Planck, as he said himself and as can be inferred from his works, had a distinct liking for 'absolute thermodynamics' rather than for statistical thermodynamics. Only after a few years of work did he acknowledge the importance of the statistical hypothesis.[175]

4.

The problem is less obvious than it seems: we can reasonably suppose that there was something more than a mere clash of opportunities.

If we consider the state of physics at the end of the 19th century, and we decide to give priority to the problem of the black body – a decision that is clearly far from necessary – it is quite unlikely that a solution different from Planck's can be found, with the subsequent proposal to abandon classical physics and build a quantum theory. But nothing prevents you from bypassing the obstacle and assigning a different *priority* to the problems to be solved. One could decide, for example, to develop and refine the formalism of classical statistical mechanics, thus making it a more flexible tool of interpretation in various physical situations. It would not be right to consider this alternative as impossible, or as just too complex and brainy. In order to be convinced of this, suffice it to think of the current development of studies on the so-called 'ergodic theory' in classical mechanics, and of the many unexpected results, so as to formulate the idea (still

175 See what Planck himself wrote to this regard in *Scienza, filosofia e religione*, Milan: Fabbri, 1973, pp. 17-8. See also M.J. Klein, "Thermodynamics and Quanta in Planck's Work," *Physics Today*, vol. 19, n. 11, 1966, p. 23.

not fully founded) that the quantum hypothesis is not independent, but can originate – in particular conditions – from classical statistical formalism.

This salvage operation also makes this discussion about the start of the 20th century significant for the present. Indeed, why did a series of scholars – often motivated by dissatisfaction with the non-deterministic or non-casual character of quantum mechanics – try to replace it not with a theory endowed with different predictive contents, but rather with a different substructure of physical models? With respect to this situation, a concrete proof that classical mechanics can be used to explain certain 'facts', generally considered as irrefutable clues of an indispensable quantum hypothesis, means every interpretation of the necessary and progressive development of a change in scientific concepts becomes even more fleeting. Even more so, we should try to understand that some potential explanations, for which tools are ready, are not put into practice because the criterion of what is relevant or significant for science changes.

In fact, from this point of view, it is possible, and easy, to answer the question of why Boltzmann did not deal with the problem of the black body to its full extent. Boltzmann evidently chose the latter of the above-mentioned alternatives, whereas Planck chose the former. Thus, of course, the problem was not solved; it was simply moved to another terrain, that of decision-making. One must wonder for what historical reasons both Boltzmann and Planck decided to give priority to such different research problems, what their confrontation meant, and why Boltzmann lost.

Clearly, from the above considerations, an answer to these questions cannot be found inside the scientific problem area (which actually offers a range of open possibilities). Rather, it is necessary to compare the different social aims which different scientific programmes can fulfil.

In order to achieve this, we should refer to the German scientific environment, in which both Boltzmann and Planck were working, and its main trends.

5.

At the end of the 19th century, three main positions contended for supremacy. The first was the statistical mechanics of J.C. Maxwell and L. Boltzmann, the second is the so-called energetic school, which attempted to base all physics on the principle of energy conservation, removing the intuitive foundation of mechanics (W. Ostwald, G. Helm, etc.). The third was the emerging theoretical physics, of which Planck can be considered a significant exponent, at least according to his works more than to his subjective opinions, at the level of historical reconstruction.

First of all, we notice that this partition is really experienced as a battle on different fronts of physics at the time: Planck himself, for instance, refers to it in the preface to the first and second editions of his book on thermodynamics.[176]

The main ground of the clash between mechanicism (with all its internal diversifications) and energetics was not a juxtaposition of different theories, but rather of different interpretations of the function and task of science. Let us quote a significant excerpt of one of the champions of energetics, Georg Helm, while referring to a particularly harsh moment of the debate:

> in the controversy kindled in 1895 at Lübeck, [it is not] really a question of atomism or of matter continuously filling space, not a matter of the inequality sign in thermodynamics, or of the energetic foundations of mechanics. All of these

176 M. Planck, *Treatise on Thermodynamics*, trans. A. Ogg, New York: Dover, 1945, pp. viii-x.

> **are only details. In the final analysis, what is at stake are the principles of our knowledge of nature. [...] If the field of energetics is comprehended in this breadth, in which alone justice can be done to its efforts, then the decision is very simple: Here scholasticism – here energetics – that is the choice!**[177]

Indeed, the effort of energetics, which is welded to a positivist vein, responds to an overall philosophical project by pursuing the attempt of reducing the task of scientific theory to the classification of phenomena (or, with a more mystifying term, 'the data of experience') so as to arrange them according to the relationships that connect them.

Thus, the energetics school imposes on science a unity of principles, inasmuch as the spirit is unitary, and the abolition of any explicatory structure based on materialism (hence the controversy on atomism). Therefore, according to the energetics school, in the construction of theories, the mystical-aesthetic aspect is more important than an efficient explanation[178] (even though the principle of energy conservation does not seem sufficient – on its own – to explain irreversible processes, there is no hurry in *complicating* the theory by assuming a second thermodynamic principle independent of the first one – thus the controversy with Planck). As is obvious, as a consequence, this was a conservative trend which, in order to save an old idea of science, was willing to bring it to a sclerosis while leaving unexplained a huge quantity of phenomena and problems that had already been identified in those same years by experimental research and rapid technological developments.

177 Georg Helm, *The Historical Development of Energetics*, trans. R.J. Deltete, Dordrecht: Springer, [1898] 2000, p. 36.

178 In this regard, see the pages devoted to Ostwald and Helm by E. Meyerson in *Identité et réalité*, Paris: Librairie Philosophique J. Vrin, 1951, in particular, pp. 397-401. See also the opinion of Max Planck in *Scienza, filosofia e religione*, note 7, pp. 15-8.

On the other hand, Boltzmann's attitude was quite different. Statistical mechanics was a very ambitious attempt to save the mechanical explanation by enlarging its application domain by introducing statistical statements. In this way, a richer reference theory could be obtained, a theory which considered even the explanations obtained through the description of the statistical behaviour of mechanical systems to be endowed with physical significance.

More accurately, a work of historical reconstruction allows us to describe this project in the following terms: Boltzmann was convinced that problems had to be faced and solved, but was also convinced that the result needed to be obtained without making a radical break with tradition. He thought that new tools should be invented and introduced in physics, but not so as to break the unitary conceptual framework of physics: rather, they had to be uniformly and universally dominated by an elite, the restricted scientific community of which he was a member. Thus the choice of Boltzmann, who could be considered as a representative of the progressive wing of the conservatives, was wide-ranging. He wanted to save the mechanical explanation, and thus the fundamental unity of explanation in physics, while at the same time adapting the theory to the growing need to explain a myriad of special phenomena and effects.

Planck's position was quite different, and can be mainly inferred from his scientific work more than from any conscious reflection upon it. If we take, for instance, the preface to his above-mentioned book on thermodynamics, we can see very clearly the emergence of his position on the opposite front in comparison with both attitudes. Indeed, he explicitly showed his impatience with both kinetic-statistical methods and the attempt to establish thermodynamics on the first principle only.

In fact, Planck clearly stated his 'possibilistic' concept of scientific work:

> A third treatment of Thermodynamics has hitherto proved the most fruitful. This method [...] does not advance the mechanical theory of heat, but, keeping aloof from definite assumptions as to its nature, starts direct from a few very general empirical facts [...] This last, more inductive, treatment [...] corresponds best to the present state of the science. It cannot be considered as final, however, but may have in time to yield to a mechanical, or perhaps an electro-magnetic theory.[179]
>
> We should underline the fact that the incompleteness of his viewpoint did not prevent Planck from making a systematic use of it. Rather, he would have no scruple about using Boltzmann's statistical method when it was useful to him.

Within this 'possibilism', we find the core of Planck's innovative action. Indeed, whether he tries to explain and articulate the second law of thermodynamics, in particular the concept of irreversibility, on the basis of an assumed validity of the laws of thermodynamics against the approach of energetists, or he refers to Boltzmann's statistical interpretation in addressing the problem of the black body, going beyond the application limit demanded by Boltzmann, his programme is simple. He wanted to maximize the explanatory efficiency of the theory at the cost of breaking it up into a myriad of independent – or even contradictory – partial constructs or theories. Each mathematical model, each rewording of the language capable of theoretically interpreting an unexplained set of empirical results was worth consideration and was assumed as a theory, or at least as a draft. This was not contradicted by his huge philosophical-critical production on the building blocks of physics, nor by his conviction – operating only on

179 Planck, *Treatise on Thermodynamics*, pp. viii-ix.

the level of subjective satisfaction – i.e., that scientific activity was a quest for the absolute. In fact, according to Planck, this was a request outside active research, whose standards he never questioned.

In order to explain this distinction better, let us compare the positions of Boltzmann and Planck on simplicity as a methodological criterion of physics. Indeed, while – according to Boltzmann – simplicity is a building block of physical *theory*, and functions as a selective criterion between opposing *theories*, in Planck's opinion, simplicity provides an important topic in the choice between *formulae*, introduced to *explain* experimental data.[180]

Now, it us not difficult to guess the leitmotif of Planck's scientific choices. He came from a changed situation. The school in which he studied was broadening its recruiting and opening up to technical education; the new culture was created under the pressure to drop general theoretical controversies (like the one between Boltzmann and the energetists) and address, as a matter of priority, all outstanding issues produced by technical and scientific developments, even though such questions were very peculiar from a theoretical point of view.

The historical context that gives meaning to this clash of ideologies and scientific concepts is Germany between the 19th and the 20th centuries, with its powerful process of industrialization in which there was the spread of a sufficiently ductile education which guaranteed

180 Boltzmann, in his *Lessons on the Methods of Theoretical Physics* from 1899, says: "it cannot be our task to find an absolutely correct theory, but rather a picture that is as simple as possible, and that represents phenomena as accurately as possible" (quoted in E. Broda, "Philosophical Biography of L. Boltzmann," *Acta Physica Austriaca*, Suppl. X, 26, 1973). Planck, in one of his well-known articles of 1900 on the problem of the black body, wrote: "I mentioned already then that in my opinion the usefulness of this equation was not based only on the apparently close agreement […] with the available experimental data, but mainly on the simple structure of the formula and especially on the fact that it gave a very simple logarithmic expression." M. Planck, *On the Theory of the Energy Distribution Law of the Normal Spectrum*, 1900, in Planck's original papers in quantum physics, edited by H. Kangro, London, 1972.

the integration of science and technology. Significantly, in the last decades of the 19th century, England had also faced the problem of the decline of its industrial dominance. Indeed, if Germany had exceeded English levels in the production of steel, in the chemical industry and in the diffusion of electrification, this was largely due to its education system which was managed by the State and had a strong technical-professional component. Here is an 1884 report of the Royal Committee for technical education:

> Many German chemists were, and still are, trained in German universities. Your commissioners believe that the success achieved on the Continent with the foundation of huge industrial plants, mechanical workshops and other installations would not have been realized in all its extension, notwithstanding many delaying influences, without the superior system of technical education in such schools, without the means for original scientific research and the general appreciation of the value of such instruction and original research, which is widespread in those countries.[181]

Therefore, what German society asked of science was the ability to intervene in a wide range of sectors: thus, scientists were not interested in a 'concept of the world' but rather in the formation of research areas autonomous enough to be dominated even by partial constructs, provided there were fruitful developments. The more strictly reductionist ideals succumbed to the greater flexibility and richness of theoretical physics – which, once broken into languages which were no longer necessarily unitary – managed to fit, in a

181 Quoted in C. Singer et al., *Storia della tecnologia*, vol. 5, Turin: Boringhieri, 1968, p. 799.

mathematical formulation that was easy to master, the widest range of problems.[182]

6.

In conclusion, we can say that the revolution of the fundamental concept of physics was not imposed by the internal difficulties of the development of statistical mechanics. Rather, this revolution was favoured by the widespread social need for the simplification and fragmentation of scientific activity. This implied an increase in the predictive power of theory. Therefore, the scientific community had to make a choice – which was not subjective, but rather historical – between two lines. These lines are perfectly identifiable by historical analysis even if they were not consciously pursued by the scientists who chose them, and can be summed up as follows: 1) favour the process of the socialization of science, at the risk of having to give up the mastery of social construction as a whole (Planck); 2) try to obtain a satisfying compromise between the request for the closer integration of scientific research with the consequently greater role to play, and the need to guarantee to the scientific community unitary control over the development of research activity, as based on a mechanical explanation (Boltzmann); 3) reject the ongoing historical process outright, at the cost of identifying science and ideology.

It is by now clear that the last alternative had no chance to assert itself. And so it was. But it is also clear that Boltzmann's choice,

182 To further confirm this, we can mention the parallel process of attention to the transformation of scientific attitudes which took place in the USA, which also witnessed massive productive development in the same period (let us mention the case of J.W. Gibbs and his "axiomatized thermodynamics," in many ways close to Planck's formalization of theoretical physics). See also G. Battimelli, "Etere e relatività," on how the same features of this period in Germany are mirrored by the origin of the theory of relativity.

much more challenging than Planck's, was destined to failure, at least as an isolated position. If it had been organically inserted within a programme of scientific activity, it could have hoped to respond to the social demand which had provoked the crisis. On the other hand, we know that this was not the case.[183]

However, it is worth underlining some interesting cues in Boltzmann's position. First of all, the lucidity with which he realized that, in order to overcome the crisis – a crisis of the institutional task and of the explanation technique of scientific research – a mediation between old and new was necessary in order to fill the gap between a rich and articulate tradition and contemporary needs. On the other hand, we should say that Boltzmann only saw the cultural data of the problem. In the second place, we should emphasize his refusal to accept, without any criticism (as Planck does), a state of need. Thus he consciously attempted to put an entire scientific heritage at the service of society, holding on to the subjective need for the control of this process on the part of the scientific community. Admittedly, this is still a generic functionalization which refers to society as a whole, without taking into account its class contradictions which produce opposing goals. After all, these problems – more specific to the present time – were not mature at the time of Boltzmann, and the 'case' we have handled can tell us nothing about them, at least not directly. In fact, the features of science in advanced capitalist society give the correct reading keys for understanding their evolution. Comparison with the present is the real focus of interest since it is involved in the responsibility of political projects. In this sense, the historical analysis

183 It seems to us significant in this regard to recall that Lenin, in his book *Materialism and Empirio-criticism* (1909), recuperates the positivity of Boltzmann's theory as "essentially materialist." The re-evaluation Boltzmann on the part of Soviet scientists is also illuminating, since it shows their interest in this attempt of – subjective – control of science in a regime of social and scientific planning. See also, for example, N.N. Bogolyubov, Y.V. Sanochkin, "L. Boltzmann," in *Usp. Fiz. Nauk*, vol. 61, n. 7, 1957.

can be neither the example of a method, nor the crystallization of the objectivity of what happened, as a necessary occurrence. In order to move to the present, we are interested in thoroughly discussing which forces dominated, and what aims have shaped certain turning points which are still active.

Labour-Value as a Scientific Category[184]

Marcello Cini

The long-running controversy about the 'transformation problem' in Marx, regarding the limits of the validity of Marx's procedures for obtaining the production prices of commodities starting from their exchange value, has been – and is still generally considered, even within Marxist culture – a very specialized, academic question. But is it really? A few recent developments seem to indicate that this is not so.

Even though at first sight it may not seem to be the case, Joan Robinson's article,[185] which opened up a recent debate, provides an example. The Cambridge economist explained that 'the second crisis of economic theory' was caused by the inability of theory to provide the appropriate tools to intervene in the *contents* of employment once Keynes had contributed to overcoming 'the first crisis', showing how to act on the *level* of employment itself. In other words, this was theory's inability to question the social aims of the activity of workers employed in production: "So it has come about that Keynes's pleasant daydream was turned into a nightmare of terror."

Is this not – in Marxist terms – just the manifestation of a profound contradiction between concrete work, which creates use value, and abstract labour, which creates exchange value? Thus the ghost so often exorcised – *value* – reappears as a fundamental category of a

184 published in *Problemi del Socialismo*, n. 21-22, 1974.

185 J. Robinson, "The Second Crisis of Economic Theory – Richard T. Ely Lecture," published in *The American Economic Review*, vol. 62, n. 1/2, March 1972, pp. 1-10, published by the American Economic Association.

critical analysis of capitalist society and its contradictions. Therefore, I agree with Michael Lebowitz[186] when he writes that, "To question what production is for and who should receive the fruits of that production is to question production for surplus-value."

However, the tendency to state that *value* as a scientific category is a useless or ineffective tool nowadays enjoys increasing credit, even among Marxists. This position follows, as is well-known, from two observations. The first is the long-standing admission that the procedure proposed by Marx in the third Book of *Capital* of obtaining the price of commodities and the rate of profit in terms of value and surplus value is not correct. The second, more recent one, takes note of the solution suggested by Sraffa to the problem of price decisions and inferring the uselessness of the long path Marx followed to get to prices through exchange value – even assuming the problem of processing has been solved or can be solved. In particular, they say that Sraffa actually solved the problem left open by Marx and that, as a consequence, his work should be considered the final contribution to that critique of political economy which had been started with *Capital*.

The crux of the dispute between the supporters of this thesis and 'orthodox' Marxists is reduced, at first sight, to the question of whether Sraffa's model, as an objective contribution to the scientific knowledge about capitalist society, should be included in the analysis of Marx, replacing a missing or defective part, even at the cost of a radical readjustment of the analysis itself. Or, conversely, whether Marx's theory should be kept intact, even at the risk of causing a rejection of Sraffa's results. In my opinion, the question – in these terms – is misplaced. Indeed, it assumes a unique process of reappropriating reality through scientific thought which is foreign to Marx's concept

186 M. Lebowitz, *Following Marx: Method, Critique and Crisis*, Leiden/Boston: Brill, 2009, pp. 17-18.

of scientificity as reconstructed from his methodological writings[187] but, above all, from his complete works.

Indeed, if we reject – like Marx – the concept of the knowledge process as a passive reflection of the object to affirm a concept based on the dialectical unity between perception and activity, we also refuse a concept of science as neutral, objective and non-judgmental. In other words, we refuse a net distinction between science and ideology. On the other hand, any act of knowledge which represents a concrete enrichment of the intervention capacities of a historically determined subject upon reality implies his/her formulation of an ideal plan and the assumption of a social aim.[188]

This aspect distinguishes Marx's materialism from any other kind of materialism since it does not make the distinction between subject and object absolute, but considers it as a relative and temporary separation since the subject, and its relationship with the object, *are parts of the objective reality* and of its changes. Marx underlines that this is the only way to explain the process of transformation of society from within:

> **The materialist doctrine concerning the changing of circumstances and upbringing forgets that circumstances are changed by men and that it is essential to educate the educator himself. This doctrine must, therefore, divides society into two parts, one of which is superior to society. The coincidence of the changing of circumstances and of human**

187 Marx, *Theses on Feuerbach*; Marx, *Grundrisse*.

188 See the well-known passage from *Capital*: "But what distinguishes the worst architect from the best of bees is this, that the architect raises his structure in imagination before he erects it in reality. At the end of every labour-process, we get a result that already existed in the imagination of the labourer at its commencement. He not only effects a change of form in the material on which he works, but he also realises a purpose of his own that gives the law to his modus operandi, and to which he must subordinate his will," Book I, Ch. 7, available online at: https://www.marxists.org/archive/marx/works/1867-c1/ch07.htm.

> **activity or self-changing can be conceived and rationally understood only as *revolutionary practice*.**[189]

Therefore, the process leading to scientific knowledge is a formulation of 'determined abstractions' which must, first of all, be adapted to the real object; they must capture its essential and specific elements at a certain level and at a certain stage of its development, but are at the same time an expression of the socially-conditioned viewpoint of the subject. Namely, this is an expression of his/her theoretical and practical horizon, past experiences, and the project of transforming nature and society to which he/she – implicitly or explicitly – adheres.

That is why the crux of the dispute between those who think that "Sraffa's theoretical results must be fully vindicated in the Marxist tradition,"[190] and those who, conversely, think that "a critique of political economy which leaves aside Marx's theory of value turns into a crippled and also partially apologetic vision of capitalism,"[191] should be traced back – in my opinion – to a comparison between theories based on different ideological assumptions which come from socially different subjects. If we want to take sides in this controversy, this does not mean simply choosing between more or less satisfying alternatives on the basis of a quantitative judgment of greater or lesser scientificity, with an absolute criterion. Rather, this means examining the results of comparative analyses in light of the aims expressed by the interests of the corresponding social classes or strata.

From this examination, it clearly appears that, the more a social subject is interested in making deep transformations in the texture of

189 Marx, *Theses on Feuerbach*.

190 A. Ginzburg, F. Vianello, "Il fascino discreto della teoria economica," *Rinascita*, vol. 30, n. 31, 1973, p. 19.

191 M. D'Antonio, C. Napoleoni, M. Bianchi, "Per la ripresa di una critica dell'economia politica," *Rinascita*, vol. 30, n. 43, 1973, p. 19.

society, the more necessary it is to assume a critical viewpoint as a basis for the analysis being expressed. Conversely, the more a social subject is interested in not changing reality, the more 'neutral' his/her analysis will be, or at least apologetic. In the same way, the analysis expressing the viewpoint of the revolutionary class is – so to speak – more scientific than the analysis mirroring the viewpoint of other classes, in the sense that it brings to light those deep connections among social subjects which need to be broken in order to reach the goal of this class.

On the basis of these considerations, I will try to make a contribution in support of the need to hold onto Marx's analysis so as to guarantee a level of scientific knowledge on the part of society which may become, at the same time, a tool for its revolutionary transformation on the part of the working class.

2.

There are essentially three arguments – and I think this is right – which are formulated against the thesis according to which abandoning the categories of 'value' and 'surplus value', and maintaining only the categories 'price' and 'profit', would leave the core of Marx's analysis of capitalist society intact.

First of all, we underline that the form commodity 'price' (and correspondingly, salary and profit) is a category appropriate only for the description and detection of both apparent and superficial links of capitalist society. Let's make it clear: this does not mean an erroneous or ineffective description and detection of such links. Rather, it means undertaking this analysis *from the ideological point of view of a capitalist*, for whom there is *no* distinction between capital invested in the means of production and capital invested in salaries. Thus, in this sense, the analysis is superficial and limited: if, as a starting point, we accept capital as an undifferentiated and primitive form – to which everything relates – the problem of explaining its genesis and structure is eliminated, not resolved.

Once we assume this point of view – which, as we underlined above, represents the theoretical and practical horizon of the capitalist class – capital becomes a group of objects which are apparently endowed with the mysterious property of producing a surplus. The formation of a net product becomes a merely technical process if we do not seek the origin of the process of accumulation at the level of social relations among producers underlying the relations among objects and – in particular – if we ignore the relationship which allows the owner of the means of production to use, at his/her discretion, the workforce he/she has bought on the market. As Lebowitz says: "Such a theory is simply a theory of alienated economics."[192]

The second kind of argument emphasizes the conceptually inseparable link between the theory of fetishism and the shape of value which commodities assume when production relations are capitalist relations:

> A notion of fetishism which is not based upon the concept of the form of value – Lorenzo Calabi writes – not only cannot give rise to the materialist notion of producers' alienation, but is also transformed into a generic idea of estrangement which cannot be overcome by a theoretical support of a certain class antagonism, but only [...] an external discovery of a conflict it cannot infer.[193]

The same thesis is supported by Camillo Daneo:

192 Lebowitz, *Following Marx*, p. 27.

193 L. Calabi, "Il fascino indiscreto del proletariato," *Rinascita*, vol. 30, n.. 34, 1973, p. 20.

> from the analysis of commodities it emerges that any exchange of objects is actually an exchange of quantities of human work (mediated by money): therefore a relationship between human beings – who, in the same exchange, reproduce their condition as social individuals – expressed and 'twisted' into a relation between objects. This is indeed 'commodity fetishism'. However, this fetishism implied in the *form of value* cannot be taken as a separate concept, detached from the related concept of the value contained (inherently) in commodities, including labour force, as commodity. In other words, it is a value *given* before the exchange, even though it is expressed and realized in the exchange.

He adds:

> [with Sraffa], any definition of work-value and even the faintest reminder of value form disappear. All that is left is an interesting and rigorous simultaneous determination of price, profit and salary, on an *ideological* level, of apparent links.[194]

Here too, we should underline the contrast between the social goals, implied in the two viewpoints. Indeed, Marx's analysis aims at revealing 'the mysterious character of the commodity-form' because only when we discover how commodities, "reflects the social characteristics of men's own labour as objective characteristics of the products of labour themselves, as the socio-natural properties of these things," does it seem possible to demystify the 'supernatural' properties of the fetish and provide the exploited class with a weapon to shoot it down.[195]

194 C. Daneo, "Ricardo rivisitato," *Quaderni Piacentini*, vol 13, n. 51, 1974, pp. 74, 83.
195 K. Marx, *Capital. Critique of Political Economy (Vol. 1).* London: Penguin, 1992, p. 92

Conversely, in Sraffa's analysis, it is assumed, although implicitly, that the natural, objective properties of things decide the way men work. Indeed, by leaving out any reference to the work necessary to produce commodities, the social cause of the mechanism controlling working conditions is lacking: i.e., the exploitation of the labour force. The labour absorbed during the work process becomes technical data, originating in the technical features of the means of production which have been used. Therefore, this analysis no longer provides a conceptual tool for indicating the goals of a social transformation aimed at eliminating exploitation.

Thirdly, we notice that the formal equivalence between profit and salary – both shares of a surplus, whose origin has been lost – moves "to a sphere outside the economy the more immediate the antagonism between wage labour and capital." Salary becomes "a rate of national income, unrelated to a surplus value *prior to distribution*."[196] Thus the scientific explanation of exploitation disappears, which was one of the most important results of Marx's analysis. It is now reduced to the trivial affirmation that, if the rate of profit increases, the rate of salary decreases.

Therefore, Sraffa's model implies a clear separation between production, on one side, considered as the domain of a technique resulting from a human-nature relation without any connection to society, and distribution, on the other side, seen as the only arena of history and of human relations. Accordingly, it is difficult to state that such consequences can be 'integrated' into Marx's theory, to which – with a little goodwill – many things can be attributed, though doubtless we cannot attribute hesitations about the estrangement of the productive process from the clash between social classes.

196 Ibid, p. 82.

3.

While it is true that these arguments in defence of the concept of value are correct – and I fully agree with them – it is also true that, on the specific terrain of the passage from the fundamental level of the social relations of production to the superficial level of distribution, Marx's analysis is – at least formally – inadequate. In other words, the contradiction between the qualitative, social meaning and the quantitative, technical aspect of value appears unresolved.

Some say that the solution lies not in the correction of Marx's calculations but rather in checking whether the passage from value form to price form can explicitly be expressed in mathematical terms. Daneo, for example, writes:

> we cannot help agreeing with those who remark that 'placing' the category of the general rate of profit, and then the one of production prices, implies a *redefinition* of all rates constituting capital advances in terms of production prices. What is, once again, denied here is that such a redefinition can be expressed through some mathematical or algebraic 'retransformation'.[197]

I agree with this statement, but only to a certain extent. In fact, it is correct if we want to underline the inadequacy of mathematical language as compared to the complexity of social relations, and the fallacy of a procedure that delegates the deduction of conclusions, which can only be reached after an in-depth conceptual analysis, to the automatism of a mathematical logarithm. It is true, for example, that a mathematical relation between different quantities can always be read in different ways, i.e., it is indifferent to the relationship of

197 Ibid., p. 78.

cause and effect – indeed you can indifferently express a quantity in function of another, and vice versa. But such a reversal risks leading us to absurd conclusions if we try to use it as an interpretation of reality. On the other hand, this statement is probably too opinionated if it implies an incompatible irreducibility of a certain knowledge form – adequate, not mystified – of reality with a formalization which allows us also to infer relations between measurable quantities.

In this sense, I propose to show that many things can still be said in order to claim for Marx's procedure – a transition from the analysis of reality in terms of value to its description in terms of price – a rigour not substantially obscured by the well-known inaccuracy of the findings set out in the third book of *Capital*, a rigour which has so far not been acknowledged, even on the Marxist side.

The starting point of this order of considerations is the reaffirmation that Marx's choice to carry out the analysis of the first book of *Capital*, as if commodities were exchanged at their value, far from descending from an arbitrary simplification of reality, represents, on the contrary, the most correct choice – in terms of method – of the best conditions in order to reveal in its essence *the fundamental phenomenon Marx wants to explain* – the origin of capital accumulation, thus freeing it from all that might modify its appearances. Indeed, this choice amounts to a representation of the real economy through an abstract model created so as to cancel secondary complications arising from the organic composition of the different sectors and maintain the substantial distinction between capital invested in means of production and capital invested in salaries, by assuming a constant relation, common to all sectors.

If you hold to this viewpoint, the problem of the "transformation of values into prices" should be considered as the problem of calculating the corrections to be made to exchange values, which effectively represent the relations in which commodities are exchanged within an economy characterized by an organic composition of the capital in all sectors, as such conditions are no longer valid. On the other hand, it is clear that, depending on whether the conditions of the composition of capital in the real economy differ a little or a lot from those of an ideal economy with a constant composition, we can think of making this correction through a greater or smaller number of successive stages of approximation. For instance, this procedure is common in the natural sciences since it allows the level of approximation to be adapted to the needs of precision of the case at hand and to the extent of disruptive effects.

Now the point we want to underline is that, in this perspective, Marx's procedure – so greatly discussed and criticized, inasmuch as it was considered a method claiming to provide an exact result without succeeding – reveals itself for what it really wants to be, namely an essentially correct method for assessing how far prices deviate from values at the first term of approximation, in terms of the parameter measuring how far the real economy is from the abstract model. After all, we can see that this was Marx's essential – though implicit – intention when we read the well-known paragraph from the third book in which he writes that he is aware that his procedure does not give the correct result, but he considers that the error is negligible for the purposes of his analysis. Here is what Marx says:

> We had originally assumed that the cost-price of a commodity equalled the value of the commodities consumed in its production. But for the buyer the price of production of a specific commodity is its cost-price, and may thus pass as cost-price into the prices of other commodities.[...] It is necessary to remember this modified significance of the cost-price, and to bear in mind that there is always the possibility of an error if the cost-price of a commodity in any particular sphere is identified with the value of the means of production

> **consumed by it. Our present analysis does not necessitate a closer examination of this point.**[198]

However, the fundamental point is that you can go much further along the way shown by Marx by directly formalizing the above indication, 'iterating' the procedure, so as to take into account – through successive approximations – the difference between value and price, even for commodities which make up invested capital.

In other words, while the *prices* of produced commodities are obtained – in a *first approximation* – from the *values* of commodities (means of production and salary-goods) which are consumed during the production process, while taking into account profit at a constant rate in all sectors, in the same way the prices of produced commodities are obtained *in a second approximation* from the prices of commodities consumed during the production process, already obtained in the first approximation in the preceding stage, and so on. Thus it is shown that, by extending the iterative process to a limit of an infinite number of successive stages, we can obtain[199] the correct results for both prices and profit rates, i.e., the same results achieved through a system of self-consistent equations for prices and profit rates deriving from the equations of Sraffa's model. These equations are appropriately corrected so as to replace a variable salary, considered as labour price, with a certain living wage, considered as the price of the labour-force. This shows that prices, within a real economy, can be achieved through successive corrections, starting from those values which represent – *in the corresponding abstract economy, with a constant organic composition* – commodities exchange relationships.

198 Marx, *Capital*, Book III, Ch. 9, available online at: www.marxists.org/archive/marx/works/1894-c3/ch09.htm.

199 M. Cini, "Valore e prezzo: Marx aveva ragione?" in *Valori e prezzi nella teoria di Marx*, ed. by R. Panizza and S. Vicarelli, Turin: Einaudi, 1981, pp. 265-284.

We would like to draw attention to the fact that, in the interpretation of Marx's procedure that we have proposed here, the starting point for obtaining prices is *not* represented by the values of commodities in the real economy, *but rather by the values of the commodities in the abstract economy, with a constant composition*. Indeed, in the values of the real economy, we find the disruptive effect of inequality between sectors; therefore, the transformation of values into prices cannot be considered as a consequence of a non-homogeneous organic composition among the sectors themselves. On the other hand, if we consider values as applicable exchange relationships within the abstraction representing reality reduced to the bare essentials, purified of all elements unrelated to the main phenomenon, it feels natural to attribute to the non-homogeneity among the various fields the *cause* for the transformation of values into prices, and consequently build up the successive stages of this transformation in terms of the parameter (or parameters, in a more general case) that measures how far the real economy deviates from the underlying ideal model.

In other words, this interpretation of Marx's analysis underlines, according to the method which Marx himself explained in his 1857 introduction to his *Contribution to the Critique of Political Economy*, that only by abstracting a simpler conceptual model from the class of all possible economies, with a different organic composition in various sectors but featuring common quantities of means of production and consumed wage-goods, can you draw on an in-depth model of scientific understanding of reality as compared to an empirical examination of individual cases, which would not catch the shared foundation. In this sense, the abstract model really represents, removing fortuities, the common properties of a class of phenomena precisely by virtue of simplification (i.e., reduction in the number of independent variables) resulting from a selection of common features which should be considered essential.

In this regard, I would like to emphasize once again what we said at the start about the intertwining of objectivity and subjectivity in the process of the scientific understanding of reality. In particular, in the concrete case of the analysis of value, if you accept the interpretation of Marx's analysis described so far, clearly the process of abstraction implies a choice that also contains a subjective element. Here, subjectivity does not mean arbitrariness but rather assuming a socially defined viewpoint. In other words, from the perspective of capital, the difference between variable and constant capital is considered inessential, therefore the unique profit rate decides the choice of variables – i.e., prices – which characterize the process of production. On the other hand, from the perspective of wage labour, the abstraction revealing the essence of social relations of production – as we said beforehand – considers differences in the organic composition of capital to be inessential, and therefore leads to the identification of exchange relations with values, as a consequence of this choice.

At this point, it becomes more evident why the course chosen by Marx to get to prices and profit is not unnecessarily long and complicated, as compared to the shortcut represented by Sraffa's system of equations for deciding prices. A simple moment of reflection is enough to realize that, in fact, the longer road not only allows us to obtain to the formal results of the empirical theory, but it also brings with it all the substantial findings of the theory of value which would otherwise be irretrievably lost. We should now examine, in detail, the meaning of this statement.

First of all, we can now follow – step-by-step – the process of transformation of surplus value into profit, even though the former no longer coincides in quantity – as Marx believed – with the latter. Within such a framework, this difference in quantity, which is one of the main arguments of the opponents of Marx's value theory, is explained by the need to level-down profit rates in all sectors through a repeated redefinition of exchange relations, but does not lead to breaking the genetic link between surplus value and profit. The known, but not sufficiently emphasized, fact that only if the surplus value is positive there is also a positive profit rate, is explained only by this genetic link.

On the other hand, it is not surprising that the transformation does not preserve the absolute quantities since the abstract work itself, which is a measure of value, is not an invariable and absolute unit of measurement. In the same way, the work individually performed in excess or defect as compared to the standard of socially necessary work does not add or detract from the value of a commodity. Likewise, the surplus value in excess or defect in a certain sector, as compared to the one compatible with an equal profit rate, is not found in the profit itself. In short, once unravelled, the origin of profit from surplus value in conditions of a particular conceptual simplicity, namely at a more abstract and yet deeper level, this origin can still be traced under the appearances of more complex conditions, at the level of a more empirical and superficial explanation, once we find the correspondence between these two levels, which features a precise law of transformation.

All of this allows us, secondly, to save the scientific concept of exploitation, since the labour contained in the goods composing the daily wage is always lower than the worker's labour during one day. Clearly, from the outside, from the viewpoint of capitalist ideology, it makes no sense to compare such amounts of work since only prices show up on the surface. The comparison between the work which is socially necessary for the reproduction of the worker's labour-force and the work he/she has done – on the contrary – is essential, if you assume the worker as a subject, because this comparison is crucial in order to characterize lifestyles and working conditions, as well as to understand the real relationships between workers and capitalists, and the mechanism by which these relationships are reproduced.

Again, once we have discovered, at the most abstract level, the mechanism which allows capitalists to dictate the terms in which the workers' labour-force is used so as to produce the highest possible value, we can retrace such a mechanism, even beneath the veils that cover it at the level of empirical manifestations. Here is what Marx writes in this regard:

> By increase in the productiveness of labour, we mean, generally, an alteration in the labour-process, of such a kind as to shorten the labour-time socially necessary for the production of a commodity, and to endow a given quantity of labour with the power of producing a greater quantity of use-value.[...] it by no means suffices for capital to take over the labour-process in the form under which it has been historically handed down, and then simply to prolong the duration of that process. The technical and social conditions of the process, and consequently the very mode of production must be revolutionised, before the productiveness of labour can be increased. By that means alone can the value of labour-power be made to sink, and the portion of the working day necessary for the reproduction of that value, be shortened.
> The surplus-value produced by prolongation of the working day, I call *absolute surplus-value*. On the other hand, the surplus-value arising from the curtailment of the necessary labour-time, and from the corresponding alteration in the respective lengths of the two components of the working day, I call *relative surplus-value*.[200]

Now, clearly, only if this analysis in terms of value has been made beforehand is it possible to point out that, even in the real

200 Marx, *Capital*, Book I, Ch. 12, available online at: www.marxists.org/archive/marx/works/1867-c1/ch12.htm.

economy, the mechanism that capital keeps operating for the purpose of profit is the constant increase of labour productivity. Only if, in the apparently neutral relationships connecting the quantities which characterize production – in which physical quantities of commodities and hours of labour all appear as 'technical' quantities on the same level – that relation of cause and effect is introduced, which only the analysis of value can single out. In this way, they can let the results show through, which Marx had already discovered:

> **Hence there is immanent in capital an inclination and constant tendency, to heighten the productiveness of labour, in order to cheapen commodities, and by such cheapening to cheapen the labourer himself.**[201]

Indeed, only from the direct comparison between the labour contained in the goods-wage and the worker's labour during the productive process, namely from the substantial difference between exchange value and value-in-use of the labour force, can we infer the variables – i.e., duration of the working day and intensity of labour – on which the capitalist can exercise effective control *within the factory*. We can fill the formal schemes with meaning while granting the compatibility between a single profit rate and the exchange relationships not starting from the category of price – useful within distribution, but secondary within production – but rather from value, the only category which can lay bare the social relations of production.

Only in this way can we reaffirm that the substantial antagonism between workers and capitalists is not the result of a dispute over the distribution of the surplus product, but corresponds rather to the appropriation of a portion of the worker's labour time on the part of the

201 Ibid.

capitalist. If we forget that workers are important for capitalist accumulation, first of all, because they work, we assume an attitude which is not consistent with a scientific analysis of reality.

Appendix

Science, Technological Progress, Capitalism and Class Struggle[1]

Marcello Cini

Within the workers' movement, discussions about the role of scientific and technological research in the development process planned for the Italian economy should be aimed not only – and not so much – at reaching immediate conclusions but rather at clarifying the strategic perspectives of such a process. In this sense, it may be useful to refer to one of the main issues of Marx's analysis, the relationship between the development of productive forces and the structure of society. Obviously, we rule out any automatic connection between scientific and technological progress and the transformation of society, but it seems interesting to us to repeat the question of whether – and to what extent – this progress, regardless of its concrete modes and directions, contributes to creating the conditions for overcoming capitalist society.

Leaving aside, for the moment, the problem of the need, for the construction of a socialist society, to have sufficiently developed productive structures providing for the survival of all its members and satisfying their desires through their individual labour, we would like to focus our attention upon the mutual interaction between technological evolution and the mode of production in a capitalist society.

According to Marx, in the capitalist mode of production, a contradiction arises when, to the degree that large industry develops,

1 Published in *La Città futura*, February 1965.

> the creation of real wealth comes to depend less on labour time and on the amount of labour employed than on the power of the agencies set in motion during labour time, whose 'powerful effectiveness' is itself in turn out of all proportion to the direct labour time spent on their production, but depends rather on the general state of science and on the progress of technology, or on the application of this science to production.[2]

In short, such contradiction consists in the fact that:

> Capital itself is the moving contradiction, [in] that it presses to reduce labour time to a minimum, while it posits labour time, on the other side, as sole measure and source of wealth. [...] Forces of production and social relations appear to capital as mere means [....] however, they are the material conditions to blow this foundation sky-high.[3]

The history of the last century has taught us that, in fact, these conditions have not been sufficient in order to blow up the base of the capitalist system in the most technologically advanced countries. Among the many causes which have allowed the system not only to survive, but also to develop vigorously, we would point out the most interesting one in terms of our question. Indeed, apparently the contradiction underlined by Marx has been overcome – among other things – through the use of scientific discoveries, not so much for the reduction of the working time necessary to produce certain commodities which society needs at a certain stage of its development, but rather to create new needs, whose satisfaction requires more and

2 Marx, *Grundrisse*, p. 624.
3 Ibid., p. 625.

more technologically complex commodities which can only be produced through a global, ever-growing employment of the labour-force. With decreased direct participation of human work in the production process, the base for the appropriation of surplus-value on the part of capital has not failed. Rather, the mechanism for creating capitalist profit is reinforced, through the growing subordination of workers. Ultimately, scientific progress provides capitalism with the means to dig itself out of the pit into which that same progress had driven it.

It is well-known that the invention of ever new durable consumer goods, and their rapid, artificially triggered obsolescence, is one of the main mechanisms behind the expansion and stability of the modern capitalist system.[4] What we want to emphasize is that the development of research, which nowadays is increasingly concentrated in the USA because of a growing process of consolidation and labour division at an international level, tends to be determined much more by the structural needs of capitalist society than by the drive to satisfy human aspirations for well-being, equality and freedom. Clearly, for instance, each individual does not need their own helicopter; on the other hand, capitalist society, at a certain stage of its development, may necessitate the creation of the 'need' to acquire a helicopter each.

The close interdependence which this establishes between the goals of the capitalist system and research choices and programmes deserves more in-depth study than has been done so far. This interdependence goes far beyond the traditional subordination of certain research areas to military purposes, which is still the primary, and best-known, form of conditioning. For instance, it cannot be ruled out that an intensification of the already massive unproductive investment of economic surplus in extremely expensive fields of research

4 See, for example, Paul A. Baran in *Has Capitalism Changed?* ed. S. Tsuru, Tokyo: Iwanami Shoten, 1961; *The Political Economy of Growth*, New York: Monthly Review Press, 1957, pp. 22-23; 41-42.

(space exploration, high-energy physics) could – in order to stabilise the capitalist economy – replace a part of military budget allocations should future disarmament agreements, albeit partial, be made, thus providing a new way of overcoming the contradictions of the system.

At this point, we should say explicitly that the argument made so far is undoubtedly one-sided. The emphasis has been deliberately placed on the relationship between science and technology, neglecting all considerations of science as a matter of culture and on the social role it plays as such. It is not possible here to extend our discussion to this topic, but it would be naive and schematic to presume to reach concrete choices on research programming without taking due account of the moment of science's autonomy. However, it seems reasonable, based on what has been said, to arrive at observations of principle regarding some general problems. When English labour proposed to solve the problem of the elimination of millions of workers as a result of automation, foreseeing the emergence of new industries which utilized the results and products of scientific research, not only did they not contest the capitalist system, but they even encouraged its reassessment on a new balance. This new balance merely recreated the conditions, discontinued due to automation in conventional industries, for the accumulation of profit through the appropriation of surplus value produced by the labour force as it was reinserted into the production process.

This state of affairs does not change even if the State takes control of the new industries arising from State-funded research. This spiral only breaks down if the working class fights for a different distribution of the benefits coming from the introduction of automation in the production process, i.e., the reduction of working hours, and manages to force capitalism to renounce the particular type of development that allows it to overcome the contradiction underlying the formation of profit. This result cannot be the outcome of bitter class struggles during which the scale of values of various consumer goods is altered so that, ultimately, the development of research only in certain directions is encouraged. In the same way, the problem arises of using science and technology for the progress of underdeveloped countries. To this regard, Harold Wilson rightly said:

> In a system of society beset by the delirium of advertising and the ceaseless drive to produce new and different variants of existing consumer goods and services, there is no thought being given to the research that is needed to find the means of increasing food production for those millions in Asia and Africa who are living on the poverty line and below the poverty line.[5]

Once again, it is a matter of forcing the most industrially advanced capitalist countries to renounce a kind of development which consolidates the system so as to release research from the heavy conditioning exerted by this type of development. In this case, too, class struggle, both at the national and international level, can decide this turn.

In this perspective on the close connection of working class struggle and the socialist transformation of society, we think it is important to look at the problems of scientific and technological development in our own country as well. Otherwise, under the illusion of making forward progress, we risk contributing to the strengthening of those very structures we would like to transform.

5 H. Wilson, from the opening speech of the debate on science in *Labour's Plan for Science*, London: Victoria House, 1963, p. 5, available online at: https://nottspolitics.org/wp-content/uploads/2013/06/Labours-Plan-for-science.pdf. See also *The Labour Government 1964-1970: A Personal Record*, London: Weidenfeld & Nichols, Joseph, 1971.

Human Progress and Productive Slavery[6]

Marcello Cini

It is by now a commonplace to say that the world is being transformed every day before our very eyes because of the continuous innovations brought by scientific development to the technological foundation and economic structures of the productive process. However, the modes and forms of these changes depend on those very structures and forms of social organization so much that any attempt to directly relate the development of science and social progress seems, at the very least, superficial, if not without any foundation whatsoever. The concept itself of 'social progress' certainly needs to be called into question in a world where, together with the most intensive pace of industrial production ever known, the most dramatic contradictions ever witnessed by history are developing. If, on the one hand, mankind's effective dominion over nature and the exploitation of its resources is increasing, on the other hand the danger of the total destruction of civilization looms larger and larger. While the means available to fight disease and prolong life become more and more effective, an imbalance is developing between the part of humankind that does not have enough to eat and the part that does not sleep because they fear a rebellion of the first group, according to an effective definition of Josué de Castro.

Within industrially advanced countries, the contrast between

6 Published in *Il Contemporaneo*, June 1965.

the development of productive forces and the inability to effectively ensure well-being for all becomes increasingly striking. The fact that this contrast, though particularly evident in capitalist countries, also exists, in different forms, in countries where the private ownership of the means of production was eliminated or greatly reduced, shows that solutions to problems arising as a consequence of scientific and technological progress cannot be mechanically or schematically traced back to the nature of the means of production, even though they are clearly related to it.

It is therefore important for the workers' movement of advanced capitalist countries to start discussing these problems in order to at least begin to identify them clearly before trying to analyse them in the light of the tools of interpretation of society developed by Marxist thought.

With the following remarks, we will try to make a contribution to this stage of the discussion.

2.

For a long time, it has been argued that one of the most harmful consequences of the capitalist organization of society, at least in the stage of oligopolistic and monopolistic capitalism, would be the restriction and distortion of scientific development as well as the slowing down and hampering of the process of exploiting its discoveries for the production of commodities. In such terms, this statement is too general not to be easily contested. As for the first issue, one might point out the extraordinary development of biology in the USA contrasted to the very serious standstill in the Soviet Union after thirty years of Lysenkoism. As to the second issue, it would suffice to compare the growth of the chemical industry in general, and of plastics in particular, in both countries.

A more detailed analysis is therefore required if we want to clearly define the consequences of the capitalist use of scientific discoveries upon society.

If we focus our attention on the most advanced capitalist country, we can see that, in the USA, scientific research – as a whole – develops at a quicker pace than in any other country in the world. The number of Nobel prizes being awarded every year to American citizens is one of the signs – and not even perhaps the most indicative – of this state of affairs. Moreover, a growing process of labour division at the international level, among the various capitalist countries, has led to a concentration of research in American labs, due to both the direct emigration of many researchers from their countries of origin and the impossibility of these countries to keep up with the investments in manpower and means necessary to support competition. For example, it is fairly well known that the global volume of US government spending on research in 1962 exceeded the entire budget of the Italian State. Perhaps it is less well known that, for every miner, there are three university lecturers and scientific researchers, or that in the industry of calculating machines, one in two people has university-level training.[7]

Just browse a magazine like *Scientific American* and you can find dozens of announcements offering jobs with exclusively research tasks to physicists, mathematicians, chemists, biologists and engineers in both industry and private laboratories.

This correlation between research development and economic development within the capitalist area allows us to assign to scientific research one of the most important roles in the mechanism of self-regulation and expansion of a system aiming at the creation of profit though the productive process. Since the creation of profit takes place through the appropriation of surplus value on the part

7 *Informazione scientifica*, n. 474 (IS/4), p. 15.

of capital, the role of scientific and technological progress must be sought in its ability to increase the employment of the workforce in the production of goods. In this regard, it has been underlined that the main change brought about by modern capitalism, as opposed to the time of Marx, consists in the increasing weight which the second sector of economy, the manufacture of consumer goods, has gained within the process of accumulation.[8]

In this regard, it is important to notice that the organic composition of capital in industries producing consumer goods is, in general, lower than in those producing capital goods. However, the main role played by the development of research in overcoming the internal contradictions of the capitalist system is probably the creation of more and more new needs for society. The satisfaction of these needs requires the production of more and more technologically complex consumer goods. A typical example of an artificially imposed need is the colour TV: if you think that, in this case, in our country alone we are talking about an investment of about 100 billion Italian liras in two years, the absurdity of this sort of use of scientific progress becomes obvious.

However, it is clear that the only way to counter the downward trend of profit, arising from the phasing out of the labour force in conventional areas due to technological developments and automation, is to recreate the conditions for the capitalist appropriation of surplus value by reintegrating the workforce in new sectors of the productive process. When L. T. Rader, a US industrial senior manager, says that "from a purely technical point of view, we have sufficient knowledge to produce food in such quantity as to feed all those who are hungry, and turn seawater into fresh water to irrigate the deserts," but that "all this nowadays is not economically feasible," he is actually only saying

8 Dario Lanzardo, "Produzione, consumi e lotta di classe," *Quaderni rossi*, n. 4, 1964.

that this is not compatible with the survival of the capitalist regime.

If what is 'economically feasible' implies, on the one side, hunger for two-thirds of humanity, on the other side it opens the other third to perspectives which should be a cause for concern. A generally recognized consequence of the type of development characteristic of American society is the increasing replacement of human relationships with relations between individuals and objects. This process of isolation and subordination to machines has been widely described, for example, in Bruno Bettelheim's essay on mass society.[9] He points out, for instance, that with the extended tendency to leave the task of making decisions directly affecting men to machines, workers tend to consider themselves numbers rather than people. "The punch card – he says – with the sorting machine which makes it useful, seems to turn each of us into a mere conglomeration of useful characteristics. Singly, or in certain combinations, these traits allow persons in control to use us first and foremost as owners of such traits, and only incidentally (if at all) as total persons."

In this way, "many manipulations of men which would ordinarily arouse great resistance in the manipulator, if not open refusal, are carried out without qualms, because all the manipulator has to do is feed anonymous cards into a pre-set sorting machine."

There is no need to underline the essentially authoritarian nature of a social structure in which men are not only considered numbers, but are themselves convinced of being mere numbers. Suffice it to mention, as a symptom of this state of affairs, the vast power of opinion-making tools and the rigid mass conformity deriving from it. This process of dissolving real relations among human beings deprives the members of this society of any possibility of exerting an effective power of choice and decision-making on crucial aspects of

9 Bruno Bettelheim, *The Informed Heart: Autonomy in a Mass Age*, Glencoe, IL: The Free Press, 1962, p. 54, 55-6.

their lives through ordinary conscious and autonomous activities.

Even one of the most positive sides of the 'affluent society' – the reduction of working time due to technological progress – seems to be, in fact, more apparent than real. Apart from the lengthening of the time necessary to go from home to work, which partly forfeits the benefits of working-time reductions, the phenomenon of having a second job is also extending to economically developed countries. According to Georges Friedmann,[10] the search for a second job in order to supplement one's primary income corresponds to new needs, "aroused not so much by economic need as by the desire to continually participate in new lifestyles, themselves in constant transformation." The existence and extension of this phenomenon – Friedmann concludes – would even undermine

> the economic system itself, in so far as it involves an uncontrolled race between production and consumption and gives rise to more and more artificial needs, manifested in material equipment and growingly complex and refined gadgets. The man of the 'affluent society' would, therefore, be condemned to be a modern Sisyphus who exhausts himself relentlessly pushing a burden which keeps rolling backward.

3.

If these considerations on capitalist society are essentially valid, we find it natural to advance a few hypotheses on the perspectives connected to the build-up of an industrially developed socialist society. It seems to us, for instance, that Khrushchev's formulation of

10 Georges Friedmann, "Le loisir dans le monde de l'automation," *Civiltà delle macchine*, XI, 6, 1963, p. 75.

the problem of competition between the two systems, based upon the challenge of the production of consumer goods, makes the mistake of leaving the choice of a more favourable terrain to the opponent, namely accepting that the mechanism of social development, which leads to the strengthening of the base of the capitalist system instead of blowing it up. Moreover, if you accept the hypothesis of the development of a socialist society, typified by the production of the same kinds of commodities as the capitalist society, the goals of the two kinds of society and the roles played by human beings in them cannot be very different. Indeed, if investments tied to a certain type of consumption tend – in a capitalist society – to maintain the creation of profit as the main feature of the productive process, similar choices on the productive level should lead to similar consequences on the level of the alienation of human labour, even within a society where the economy is planned by the government rather than private groups.

Finally, accepting the challenge of matching and surpassing the USA on the level of artificial needs and imposed consumption cannot help but reproduce, within the socialist area, the clash between underdeveloped countries and countries which pursue the goals of the affluent society.

Therefore, in this moment, it is particularly important that the workers' movements in industrially developed capitalist countries take a stance toward these problems. It is, first of all, a matter of reaffirming – as Antonio Labriola used to say[11] – that:

> **it is better to use the expression 'the democratic socialization of the means of production' than that of 'collective property' because [...] in the mind of more than one it is confused**

11 Antonio Labriola, *Saggi sul materialismo storico*, Rome: Editori Riuniti, 1964, p. 18: English edition: *Essays on the Materialistic Conception of History*, trans. Charles H. Kerr, 2010, p. 91, footnote 2, available online at: https://www.gutenberg.org/files/32644/32644-h/32644-h.htm.

> with the increase of monopolies, with the increasing *statization* of public utilities and with all the other fantasmagoria [*sic*] of the ever recurring State socialism, the whole effect of which is to increase the economic means of oppression in the hands of the oppressing class.

We should also refuse the thesis according to which the superiority of the socialist system would only consist in eliminating productive anarchy through planning, thus promoting the fast-paced development of the economy, and reassert that the main goal of a socialist society is to reintegrate individuals as the subjects of productive activity, freeing them from their current condition as instruments of the machines, as producers and consumers within the framework of a planned production process based upon the need to maximize accumulation.

The idea is to put the egalitarian demands of communist ideals in the foreground as opposed to the hierarchization of tasks and, consequently, the economic and prestige differences resulting from the subordination of humans to the needs of productivity.

Only in the perspective of a society in which working time ceases to be the measure of wealth and exchange value ceases to be the measure of value, in which the goal is "not the reduction of necessary labour time so as to posit surplus labour, but rather the general reduction of the necessary labour of society to a minimum, which then corresponds to the artistic, scientific etc. development of the individuals in the time set free, and with the means created, for all of them,"[12] can science truly become, once again, one of the highest and freest forms of creative human imagination.

12 Marx, *Grundrisse*, p. 625.

The Social Function of Science[13]

Marcello Cini

1.

The chapter “Machinery and Modern Industry” of Book I of Marx’s *Capital,* starts with the following words:

> **John Stuart Mill says in his *Principles of Political Economy*: “It is questionable if all the mechanical inventions yet made have lightened the day's toil of any human being.” That is, however, by no means the aim of the capitalistic application of machinery. Like every other increase in the productiveness of labour, machinery is intended to cheapen commodities, and, by shortening that portion of the working day, in which the labourer works for himself, to lengthen the other portion that he gives, without an equivalent, to the capitalist. In short, it is a means for producing surplus-value.**[14]

Since then, many transformations in the modes and relations of production have taken place. The impetuous development of technology and the ever faster use of scientific discoveries have opened up, on the one side, the possibility of a more or less total automation of the productive process and, on the other side, dramatic contradictions. Having accepted the assumptions of Marx’s theory of value, we need to check to what extent its analysis and consequent predictions – based upon the technological level of Marx’s time – must be

13 Published in *Il Contemporaneo*, October 1966.
14 Marx, *Capital*, Book I, Ch. 15.

examined critically in light of recent changes.

An in-depth analysis of the capitalist use of technological and scientific progress, as well as of its role in opening up or resolving contradictions within the system is – nowadays more than in the past – one of the urgent tasks for a workers' movement searching for a path that could lead to the construction of socialism in developed capitalist countries. It is all the more urgent because – today, just as in Marx's age – it is clear that technological progress, inasmuch as it is a means for the intensification of the production of commodities, cannot be *a priori* identified with the well-being of society. Moreover, we cannot abstractly consider such progress as a neutral instrument with respect to the social structure, thus neglecting the crucial influence of the latter on the former.

2.

The first order of problems regards the analysis of the role played by scientific and technological progress in the expansion and stabilisation of the capitalist system. In my opinion, the main point is that innovations and discoveries do not only allow commodities to be made more cheaply and produce surplus value, thus extending that part of the working day which the worker freely gives to the capitalist; they also create new sources of surplus value through the establishment of industries which produce lasting commodities, which become technologically more and more complex.[15] The resulting positive effects for the system are manifold. First of all, there is the possibility of increasing the total quantity of surplus value, not only by re-absorbing the labour force made redundant by traditional industries within the new industries where machines have replaced part

15 A few remarks concerning this topic were made in an earlier article, published in *Il Contemporaneo*, 1965, n. 6 (in this volume, Appendix, Chapter 2).

of the workers, but also by absorbing additional labour force as well. Secondly, a way out – through the almost unlimited expansion of the secondary sector of the economy (manufacture of consumer goods) – of the most dangerous contradiction of the system, i.e., the contradiction between production capacity and consumption potential, is created. Thirdly, an element arises which opposes the trend toward falling profit rates, a consequence of the lower organic composition of capital in the industries producing consumer goods. This element is added to the effects provoking a higher intensity of labour and an increased value of constant capital in all sectors of the economy – both consequences of technological progress. Fourthly, new chances of unproductive expenditures are opened up which are capable of absorbing excess production (in addition to traditional military expenses) resulting from the increase of services and mass-media, which are already substantial today, with spending on *big science,* i.e., missiles, satellites, particle accelerators, etc.

At this point, it is interesting to underline that the only economic sector producing goods whose consumption cannot expand unlimitedly (at least within one country), is agriculture which, in capitalist countries, tends to have a lesser importance the higher its productivity is. This confirms that, if the consequences of scientific and technological progress only affected labour productivity rather than kept creating new products, and thus new needs, the contradiction between the need to shorten working time and the use of working time as the measure and source of wealth would become irreconcilable, thus putting a strain on capitalist society.

We should emphasize, still in this order of problems, that while the monopolistic structure of capitalist society in its most advanced stage can often hinder or delay the application or introduction of new methods and procedures making ‘commodities cheaper’ and delay their obsolescence and rapid decay, it does not thwart the creation of new types of industries – rather, it favours them.[16] This is clearly shown by the extraordinary flourishing of new American scientific industries (electronics, aerospace, nuclear and computers) as opposed to the relative stagnation of the methods and products of the traditional automotive industry.

These trends of the advanced capitalist economy stand out in a recent study in which the shape of the American economy in the years 1947 and 1958 was compared.[17] The variations of production in certain branches, absorbed by industries in order to satisfy consumer demand for goods, are quite significant. To highlight a few data points: the economic weight of electronic components increased by 82%, plastic and synthetic materials by 41%, chemical products by 31%, office services by 42% and communications by 33%. On the contrary, the economic weight of traditional mechanical components decreased by 23%, ferrous raw materials by 27%, timber by 26%, and coal by 40%. Overall, there was a tendency to replace products absorbed by industries with others of lesser value: the proliferation of new materials tended to make the various industries more and more interdependent. In the labour market, the shift from strictly productive functions to the roles of coordination and integration required by a larger and more complex system was the main feature, together with the relocation of the work force from industries producing commodities, whose demand was in decline, towards new industries.

3.

A point we should explore – related to the above considerations

16 See Paolo Sylos Labini, *Oligopolio e Progresso tecnico*, Turin: Einaudi, 1964, p. 187: English edition: *Oligopoly and Technical Progress*, trans. Elizabeth Henderson, Cambridge: Harvard U. P., 1962, rev. edition 1969.

17 Anne Carter, “The Economics of Technological Change,” *Scientific American*, vol. 214, 1966, p. 25.

– the bias exerted by the demands of the economic system's development upon scientific and technological progress. I will merely indicate some facts, without attempting a complete analysis.

An examination of the allocation of US research spending reveals how much the selection of priorities is tied to these broader needs of the economic system. In 1966, total expenditures for defence, NASA (space), and AEC (atomic energy) absorbed 10 billion dollars, applied research 4 billion dollars and basic research 2 billion dollars.[18] As a percentage, one can calculate that 35% went to aeronautics and missiles, 24% to electronics and 10% to chemistry. Recent news has indicated that President Johnson wants to shift the research budget towards investments which can provide short-term practical results.[19] If someone thinks that these choices might be caused by military interests more than by a true survival necessity of the system, we could answer that military interests, in turn, represent a remarkable portion of the economy and are thus indispensable for the stability of the system itself.[20] In any case, it would be wrong to think that the natural development of science and technology must happen in the way that it is occurring nowadays in the USA and assume, as a consequence, that each country should conform to this model or compete with it.

A proposal showing how important it is for the USA to try and make the most of research to solve the most urgent internal social problems is contained in an article by Alvin M. Weinberg, Director

18 *Scientific Research*, vol. 1, n. 1, 1966, p. 20.

19 "President Johnson officially announced for the first time that he has nothing against research, while he has almost had enough of 'research for its own sake.' He has ordered research planners – in biology in particular and implicitly in other fields – to try and obtain useful results. The injunction will further shift the balance of funding in favour of applied research in all fields." *Scientific Research*, vol. 1, n. 1, 1966.

20 An in-depth study of the connection between militarism and industry can be found in Victor Perlo, *Militarism and Industry*, New York: International Publishers, 1963.

of the Oak Ridge National Laboratories.[21] He thinks that technological remedies can help solve these problems without resorting to the most difficult way of verifying its causes.

It is likely that some of his suggestions, like the development of cheap electric cars to eliminate smog, the use of cheap calculators and other remote communication systems for education, the construction of nuclear energy desalination plants, could be adopted to the advantage of the American economy. However, it is interesting to notice that this pragmatic approach does not prevent Weinberg from seeing that "the technological solutions to social problems tend to be meta-stable, namely they replace a social problem with another one. The most typical example of this instability – he continued – is "the peace imposed on humankind by the H bomb."

4.

The prospects of extensive development of automation in the production and distribution of goods and its implications for the stability and development of the capitalist system merit some observations which shall then be deepened and enlarged. One of the most important points concerns the question of planning within many capitalist countries. For a long time, complete and total anarchy in the social division of labour was considered a central feature of this kind of economy.

In the last few years, the need to eliminate the harmful effects of this anarchy has led to the introduction of planning in many capitalist countries.[22] A lucid analysis of these trends in light of a critical re-reading of Marx's texts has been made by Raniero Panzieri:

21 *Scientific Research*, vol. 1, n. 7, 1966, p. 32.
22 Silvio Leonardi, *Democrazia di Piano*, Turin: Einaudi, 1966.

> Marx's analysis of the factory, of direct production in capitalism has very rich elements for the formulation of a socialist perspective which does not rest on the illusory and mystified basis of its identification with planning, as such, detached from the social relationship that can be expressed in it. In this analysis, Marx destroys the misunderstanding of the capitalist impossibility of planning. On the contrary, the system tends to react to any contradiction and limitation to its maintenance and development with a growing degree of planning: this is essentially the law of surplus value.[23]

The point I would like to emphasize is the essential role played in this evolution by the adoption of automated processes both in production and in control and decision-making tasks thanks to the progress of science and technology in electronic calculators. Peter Drucker, a US industrial organization expert, very clearly explained the reasons behind and consequences of these transformations.[24] While referring to a further discussion of the consequences, it would be interesting to find his reasons a confirmation of the thesis that planning becomes increasingly necessary – as a consequence of technological progress – in order to guarantee a stable system:

> In the traditional systems of production, the major risk, that of economic fluctuation, is absorbed by production. Production is cut down when business falls off; it is stepped up when business improves. Our entire economic theory, as far as that goes, is based on this risk-absorbing function of production. Under automation, however, production can no longer absorb

23 Raniero Panzieri, *Plusvalore e pianificazione*, in *Quaderni rossi*, n. 4, 1964, p. 283.
24 Peter Drucker in "The Promise of Automation," in *Automation, Implications for the Future*, ed. Morris Philipson, New York: Vintage Books, 1962, pp. 218-19, 226.

> the risk of economic fluctuation, or only to a very limited degree.
> Automation requires continuous production at a set level of output for a considerable amount of time [....]
> For automation, as an absolute first condition, requires the establishment of a fairly predictable, stable, and expanding market. [...] It certainly requires deliberate planning for technological change – that is, directed efforts to make products systematically obsolete by bringing out better ones on a preset schedule.

In these conditions, "capital spending will be increasingly carried out independently of the business cycle, and this in turn will stabilize the cycle."

5.

At this point, the most interesting issue for us is the social cost of this development of capitalist society and its consequences for the social structure and the conditions of workers.

Doubtlessly, for example, Marx's prediction of a trend toward the lengthening of the working day did not actually take place, even though the conspicuous shortening of the working day in the statistics is probably overstated since it does not take into account the time needed for commuting and the phenomenon of second jobs.[25]

Without any claim to completeness, it is useful to put the subject into context by listing a few of the more important consequences. First of all, the undoubted increase in *per capita* income is accompanied by increasing income inequality and greater social stratification.

25 Friedmann, "Le loisir," p. 75.

From the study "Poverty and Deprivation in the US," carried out on data from the US Department of Labour, it turns out that, in 1960, one fifth of the US population lived in poverty and another fifth in slightly better conditions, still lower than a "modest but sufficient model."[26] In England, in 1960, 5% of the population owned 75% of the country's wealth. The worsening trend of lower-income groups compared to higher-income groups has been recognized by many sociologists.[27] Therefore, this trend has led to worsening conditions for the lower-income strata of the population which is made all the more serious by the greater incentive to meet new needs which the necessary expansion of the system imposes on all potential consumers.

This increased inequality becomes even more dramatic if you compare industrially advanced countries with less developed countries. Two examples are sufficient to provide a picture of the problem. It is well-known that, in Western countries, *per capita* investment far exceeds the entire *per capita* income of non-industrialized countries in Asia. It is probably less well known that the total expense of the English population for tobacco is higher than the total income of the same number of Indian people.[28]

The second order of consequences comes from the increasing differentiation and hierarchization of work in the productive process. It has been said that automation is eliminating, and will do so even more in the future, not only the most tiring and boring of manual jobs, but also routine executive jobs, both in offices and workshops (accounting, control and testing), shifting labour to more skilled occupations:

26 Harry Magdoff, "Problems of United States Capitalism," in *Socialist Register*, London: Merlin Press, 1965, p. 62.

27 Dorothy Wedderburn, "Facts and Theories of the Welfare State," in *Socialist Register*, London: Merlin Press, 1965, p. 127.

28 P.M.S. Blackett, "The Scientist and Underdeveloped Countries," in *The Science of Science*, London: Souvenir Press, 1964, p. 45.

> There may actually be no workers on the production floor of tomorrow's push-button factory [.... But ...] incredibly large numbers of men will be required behind the scenes in new, highly skilled jobs as machine builders, machine installers, repair men, controllers of the machinery and of its performance, and programmers to prepare information into the machine. In addition, large numbers of highly educated men will be needed for new jobs as designers of machinery, draftsmen, system engineers, mathematicians or logicians. Finally, large numbers will be needed for new managerial jobs requiring a high ability to think, to analyze, to make decision, and to assume risks.[29]

Here too, the main question is the relative location of the individual within society. First of all, it is true that, on average, the qualification required for the workforce increases with technological progress. This is accompanied, on the one side, by a growing intensity of work and, on the other, by an increased inequality in the required skill level for different tasks in a certain industry and among different industries. Moreover, as a consequence, in the higher complexity of production technology and the increased networking among the various industries, individual work tends to lose importance in comparison to the final product. Essentially, there is a growing estrangement of workers from the product of their work. Even this work is much more qualified and demanding than it used to be ten or twenty years earlier. A typical example of the relative debasement of work, despite its requirement of increased qualifications, is provided by the growing use of graduates in complex executive tasks, such as programming for electronic computers. Therefore, workers are more and more subject

29 Drucker, "The Promise," p. 222

to production requirements which completely escape their possibilities of understanding and control. This is combined with a more rigid hierarchization and a reduced chance of rising on the social scale.

The third type of consequences follows precisely from these findings and refers to the decreasing participation of workers (at all levels) in the sphere of decision-making, including indirect and representative forms. The apparent rationality and scientificity of the authoritarian planning imposed by the interests of the strongest economic groups leaves no room for alternative democratic initiatives. Here too, the use of electronic computers tends to extraordinarily facilitate this process:

> Computers are especially useful for dealing with social situations that pertain to people in the mass [...]. They are so useful in these areas that they undoubtedly will hep to seduce planners into inventing a society with goals that can be dealt with in the mass rather than in terms of the individual. In fact, the whole trend toward cybernation can be seen as an effort to remove the variabilities in man's on-the-job behavior and off-the-job needs, which, because of their nonstatistical nature, complicate production and consumption.[30]

Finally, we should mention the problem, which deserves an in-depth study, of the depletion of representative democratic institutions that follows from the heightened power of the government over citizens, made possible by the extensive introduction of computers in the state apparatus. Outright uncontrolled abuses can result from the easy filing and accumulation of confidential information on individuals. Moreover, the possibility of solving more and more complex

30 D.N. Michael, in M. Philipson, ed., *Automation, Implications for the Future*, p. 115.

problems concerning the community by processing a huge amount of data, outside of any possibility of control, can make the relationship between leadership and citizens more and more authoritarian, wrapped in the guise of scientific rationality.

6.

The consequences of the capitalist use of technological and scientific advances, which have been summarily illustrated, can be summed up in the traditional terms of inequality, alienation, and class dictatorship. It is, however, necessary for the workers' movement to recognize these ancient evils in their modern forms so as to avoid the mistake – in developing its strategy for developing a society in which they can be abolished – of being deceived by the technical-scientific mystifications which conceal its substance.

Now, more than ever, the goals of socialism are equality, people's reconquest of the products of their own work, with the disappearance of alienated work, the conscious and responsible participation of all citizens in the management and control of society, the disappearance of classes. Undoubtedly, a society of this kind can only arise on the basis of the development of productive forces in such a way to guarantee the abundance of goods necessary for the satisfaction of everyone's needs, but the crucial issue is that this stage of economic development must be reached – while fighting for the construction of socialism – without renouncing a gradual approach to its basic objectives. On the other hand, nowadays the main feature of social-democratic policy is the acceptance of the economic development goals of the capitalist system as tools for reaching 'social justice'. It is probably useful to underline, in this regard, the perfect coherence between the position of Harold Wilson, head of the Labour opposition, on the perspectives of scientific and technological development in England, and the wage-freeze laws enacted by Harold Wilson as head of the government.

We cannot say that the workers' movement in advanced capitalist countries has developed a clearly alternative policy rejecting the blackmail of a false sense of well-being and proposing improved conditions for workers by solving the most serious contradictions of contemporary society. I am sure that, as this elaboration becomes more precise, several myths about the inevitable character and objective value of the development of science and technology will have to fall.

The Satellite of the Moon[31]

Marcello Cini

The most explicit exposition of the declared purposes of the Apollo project was made in 1967 by NASA's official spokesmen:[32]

> while the single, simple goal of placing an American on the Moon and bringing him back before 1970 served to catalyze and focus the entire space program, that single goal could not justify the program's huge expense. It is therefore claimed that the program is justified in addition by: 1) the spinoff of fundamental technology that might be important for future military applications; 2) the experience gained in the management of vast scientific and technological enterprises, in particular with regard to enforcing standards of reliability; 3) fallout in terms of applications for communications, weather forecasting, surveillance, and so on; 4) fallout in terms of economic advantage to a segment of US industry whose maintenance has become a national obligation; 5) basic research in space sciences, yielding important information about the Sun, Moon, planets, particles and fields of space, at modest additional cost; and finally 6) assuming that nations inevitably compete with one another, competition with the Soviets in the race to the Moon is a benign substitute for war.

We will come back on these points later. Now, we simply report

31 Published in *Il Manifesto*, 4 September 1969

32 Robert Haselkorn, Editorial Introduction, *Bulletin of Atomic Scientists*, March 1967, p. 3.

the criticisms raised by important areas of the US scientific community to this approach. The editorial itself in the *Bulletin of Atomic Scientists*, which reported this statement, goes on in this way:

> the critics claim that many of these arguments could be advanced equally in favour of a large federal investment in ground-based problems such as environmental pollution, high speed ground transportation, or mass education, whose solutions do not simultaneously advance the threat of war by developing of quasi-weapons.

In 1964, Alvin Weinberg, Director of the Oak Ridge Laboratories, wrote[33]:

> The main objection to spending so much manpower, not to say money, on manned-space exploration is its remoteness from human affairs, not to say the rest of science. [...] There are some who argue that the great adventure of man into space is not be judged as science, but rather as a quasi-scientific enterprise, justified on the same grounds as those on which we justify other non-scientific national efforts. The weakness of this argument is that space requires many, many scientists and engineers, and these are badly needed for such matters as clarifying our civilian defence posture or, for that matter, working out the technical details of arm control and foreign aid. If space is ruled to be non-scientific, then it must be balanced against other non-scientific expenditures like highways, schools, or civil defence. If we do space-research because of prestige, then we should ask whether we get more

33 *Physics Today*, March 1964, p. 42.

> prestige from a man on the Moon than from successful control of the waterlogging problem in Pakistan's Indus Valley Basin. If we do space-research because of its military implications, we ought to say so – and perhaps the military justification, at least for developing big boosters, is plausible, as the Soviet experience with rockets makes clear.

In November 1966, one could read in the editorial of the journal *Scientific Research* that:[34]

> So far our space program has been essentially an engineering effort addressed to Moon landing, mostly dictated by political considerations as a reaction to a Soviet initiative. Now that the achievement of this first national major objective is in sight, we finally get the chance, in the name of science, to put the extraordinary human and instrumental potential which we have built up over the last decade to good use.

We could go on, but what we have reported is more than enough to highlight certain things. First of all, the purely scientific interest of the space programme is less relevant than it looks. Secondly, the political and military objectives are dominant, at least in the current stage. Thirdly, as far as the usefulness and applications of indirect results are concerned, doubts have been raised by significant parts of the scientific community. Let us examine these claims more closely.

Cost and Waste

Basic science financed by NASA is valued (1966 budget) at an

34 *Scientific Research*, November 1966, p. 5 [my translation].

estimated 650 million dollars, out of a total of 5.1 billion dollars per year.[35] However, up to 90% of this expense covers the costs of instruments which are launched into space and used only once: "It is like building a huge laboratory with a giant 200GeV accelerator, and then throwing it away," as D.D. Wyatt, NASA Programs Chief, used to say. Clearly, this is the most expensive research possible. What about its results? Discussing the value of a scientific result *per se*, within a certain research sector, does not take us very far if one has to choose a priority referring to investments with such a relevant social cost in means and personnel. From this point of view, while evaluating the importance of one discipline as compared to others for the purpose of investment choices, we cannot dismiss the criterion that "we must give the highest priority to those scientific endeavours that have the most bearing on the rest of science."[36] What makes a discovery scientifically relevant – indeed – is its ability to unify different phenomena in a coherent scheme, to highlight new phenomena, which provoke the critical revision of a set of knowledge, in particular to connect one scientific area to other areas, leading to a more general and unified understanding of reality. According to this criterion, it is the opinion of leading scientists[37] that the scientific interest of space research is far lower than other disciplines, such as biology, behavioural science and even nuclear physics. Therefore, these brief remarks confirm the first impression of the above-quoted list, where only 5) mentions scientific research, in terms that make us think of an advertisement, offering a bright ornament with a 'modest additional cost' rather than an essential component of the programme.

The final aim is clear after a short examination of NASA's other

35 *Scientific Research*, May 1966, n. 12 [my translation].

36 A. Weinberg, in *Physics Today*, March 1964, p. 42.

37 See, for example, the letter of the Nobel Prize winner Max Born in the *Bulletin of Atomic Scientists*, October 1966, p. 12.

points. The first one explicitly mentions interest in the development of new weapons. The second has major implications in the military field as well: if one thinks about how huge a scientific and technological enterprise is constituted by the developed and continued renewal of the most powerful army in the world, not to mention the organization of a possible nuclear war. The third point concerns areas of significant military relevance (communication, weather forecasting), or even only aimed at the military ('surveillance' means espionage across the Earth's entire surface). The fourth point regards the leading industry, which is essential for US military power. Finally, the sixth point concerns the affirmation of US prestige and hegemony in the whole world. Clearly, military build-up and its exploitation on a level of power policy are the main reasons for the space race.

However, the function of economic support in leading sectors, such as aircraft, missiles and electronics, is far from negligible – it is, in fact, a decisive element. Here, of course, different factors intertwine, varying from the close interconnections among the Pentagon's higher echelons and the leaders of these industries, to the corporate pressure of labour unions. Undoubtedly, one of the main stabilization and development mechanisms of the US is at stake here.

Stabilization of the System

It is well known that the safety valve of military spending, as non-productive investment, is essential for counteracting the trend towards overproduction. There was a period in which serious Marxist economists were predicting that such spending – in a time of peace – should not exceed a certain ceiling,[38] arguing that, at this point, the US economy would be in crisis. These predictions were refuted, not

38 Shigeto Tsuru, in *Has Capitalism Changed?* In 1958, they predicted that in 1968 the US military budget would not exceed 56 billion dollars. In fact, it was close to 90 billion.

only because the Vietnam War provided the opportunity for increased production destined to military use, but also – maybe above all – because the scientific and technological progress in this area, of which space research is one of the main driving forces, brought about a relentless, qualitative improvement of weapons, making them more and more expensive. Suffice it to think, for example, of the use of missile remote-guidance computers and the possibilities opened by the rapid progress in miniaturized circuits[39] to extend the use of remote control systems to even smaller projectiles.

Therefore, spending on space research is not only a non-negligible direct factor of support to the capitalist economy, but also contributes to enlarging the budget for military costs as a stabilizing element of the system.

Moreover, space research offers the only possible alternative for industries engaged in war production in the case of a possible reduction of armaments, without having to face serious problems of reconversion. In this case, the stabilizing function might be gradually moved from military expense to space exploration, where it is not difficult to think of putting projects in the pipeline which may absorb tens of billions of dollars[40] in the same unproductive way as weapons – and this is the main point.

We should discuss this last issue, namely the relevance of ideological and superstructural components even in the Moon adventure. From the atavistic drive to get to the heart of the sky, to the will to dominate nature, the spirit of adventure, the love of country, the race to fame, the race for money, the desire to escape and sports passion – all of these elements certainly intervene and push both the immediate

39 We are on the verge of being able to place 10,000 to 100,000 transistors in a square cm of a silicon sheet.

40 As is known, the Apollo project cost 23 billion dollars (more or less half of the Italian national income).

protagonists and the public toward the space race.

However, it would be wrong for Marxists to forget the class nature of ideologies. Even the best of these values derives, in a more or less mediated way, from the practical needs of human societies, and in modern civilization from the interests of the ruling classes. However, it would be naive to believe that ideological motivations can prevail over structural motivations.

We should now discuss a series of questions related to the use of the innovations and knowledge acquired in the course of the space programme (fallout) and possible alternative programmes.

However, a preliminary consideration is useful, which may seem obvious but which is not so for many people. Any collective action or large-scale human enterprise involves consequences which are often unpredictable, sometimes exceptional, but in any case different from its main goal. This action generates reactions which may even obscure the effects which were proposed at the start. However, if one justifies an action through its possible indirect effects, when one considers its main goals useless or even harmful, this is not only logically incoherence but also a mystification. In this way, one would get, if not the Nazi's exaltation of the war as the selection of the strongest, then at least its justification as a fundamental factor behind scientific and technological progress.

Having said that, let us briefly examine applications in the fields of communication, technology of materials and instruments, weather and medicine, which constitute the fallout of space exploration.

The use of artificial satellites not only extends the reception of TV programmes, broadcast from any part of the globe, across the entire Earth's surface, but also increases the transmission of all kinds of radio messages at a remarkable rate. In the same way, the solution to the problems of miniaturisation of on-board equipment enabled the production of compact and light-weight instruments and computers, just as the solution of the problems of spacecraft resistance to extreme conditions of temperature and dynamic stress enabled the development of materials endowed with exceptional features. Some of these innovations are already widely used (satellite communication), whereas others have entered production, even though generally only for very expensive and specialized products or tools.

As far as meteorology is concerned, its practical effects are probably more limited. It is true that satellites allow us to obtain a complete and simultaneous picture of the atmospheric conditions of any part of the globe. This can be useful for civil and military air transport, which need to know the situation very quickly, especially when it comes to flying over uninhabited regions. However, long-term forecasts, which might be useful for agriculture or preventive defence against climatic disasters, are not possible at the moment, as shown by the fact that hurricanes regularly devastate whole regions of the USA, nor do we see how they can become possible in the near future. In the current state of meteorology as a science, inadequate in relation to the great complexity of the phenomena at stake, the wealth of data gathered by growingly complex satellite networks probably represents a waste given the poor chances of their interpretation. Not to mention the possibility of any planned control of the climate, which certainly belongs to the realm of science fiction.

Finally, in the field of medicine, apart from a series of data on the functioning of the human organism in the absence of gravity or under high acceleration, along with the possibility of remote diagnosis of the conditions of the human body, no relevant new knowledge seems to have emerged so far.

Hunger in the World

Overall, it seems possible to say – first of all – that the space programme has not developed a sub-product representing the solution to an open problem of contemporary society. Secondly, the applications which have been used, or will be used in the near future, generally tend to further develop high-tech sectors, potentially exacerbating existing imbalances between advanced and developing countries, while at the same time opening the chances of producing new expensive goods rather than the large-scale production of commodities needed to meet the primary needs of vast numbers of people. In this regard, the private use of helicopters and computers will doubtlessly increase following the application of innovations coming from space programme fallout. It is easy to imagine the benefit to mankind. Thirdly, and finally, as far as sectors of more general interest are concerned, such as medicine, a planned and direct effort would reach much more relevant results. In front of increasingly urgent health problems – even in the USA – mental illness, cancer and heart disease are nightmares which burden tens of millions of Americans; who could deny that investments in personnel and equipment comparable to those destined for space research[41] would lead to far more important steps forward than those obtained by the Apollo programme?

The question of alternatives appears quite stark. In 1966, Weinberg[42] wrote:

> **Our country will soon have to decide whether to continue spending 4 billion dollars a year after having landed on the Moon. Is it too scandalous to suggest that this money (which, as they say, must be spent in order to support our economy) be used to build huge nuclear sea-water desalination plants in arid areas on the edge of the oceans? If these plants work with breeder reactors, the operating costs should be low enough to allow the development of large-scale agriculture in these**

41 In 1967, the budget of the National Institutes of Health was 1.3 billion dollars, as compared to 5.1 billion for NASA.

42 *Scientific Research*, July 1966, p. 32 [My translation].

areas. I calculated that, with 4 billion dollars, we could supply water to feed over 10 million new-borns every year.

The problem of world hunger is often used as a pretext to show off one's good intentions. In fact, the practical measure adopted by the great powers to face this shame of mankind goes far beyond pupils' collections. Suffice it to remember that, at the New Delhi conference organized in March by the United Nations Agency for Trade and Development, it was announced that the 'assistance' of rich countries to poor countries slightly decreased in the decade from 1958 to 1968, from 0.64% to 0.57% of their national incomes.[43] It is well known that this aid is totally insufficient to meet the basic needs of low-income countries. However, what is immediately striking is that the NASA budget amounts to 0.6% of US national income, i.e., on its own it is slightly higher than the current aid level. Therefore, not even from a quantitative point of view can it be argued that space spending is irrelevant, not only compared to effective needs but even compared to what is currently done to meet the needs of millions of starving people.

Moreover, the matter should be examined from a qualitative point of view. It is true that, if the money spent on space research were used for food or basic necessities, the result would be little more than a drop in the ocean. However, as Weinberg suggests, if investments were made in water production plants for agriculture, the results would be much more substantial. Finally, if the money spent on space research was instead supporting programmes addressing the problem of nutrition – from protein synthesis to the transformation of inedible proteins, from irrigation to fertilizers, etc. – it is safe to assume that the problem could be solved, or at least the

43 See, for example, *Le Monde*, March 19, 1968.

most catastrophic predictions might be averted and appalling famines might be prevented by the end of the next decade.

So, it is not mere rhetoric to affirm that those who decided to send two men up to the Moon sentenced millions of other men to death with that choice.

Many other goals of planned research could be identified which, owing to their social ends, should have priority over space research. But that is not the point I want to develop. Instead, I will try to examine, in light of what I have argued so far, the real meaning of the scientific and technological progress driven mainly by the USA and, on the other hand, the limits and dangers of the USSR's acceptance of this arena of competition.

However, in order to reach this stage of our discussion, I should first mention some basic issues related to the social function of science in contemporary society.

The Capitalist Use of Science

For some 'Marxists', the issue is simple. As Marx taught us – they say – we should distinguish between productive forces and production relations. Productive forces (science is certainly one of them) do not bear any sign of the ownership relationship under which they arise. Therefore, they are always useful – and their development constitutes an absolute progress for humanity.

On the other hand, in a capitalist regime, production relations generate exploitation, so class struggle should be directed against them in order to transform them and build up a society which inherits and employs the productive forces developed within an old social order in a different way. Moreover – they argue – capitalism ceaselessly tends – in order to maintain the mechanism of profit accumulation – to develop productive forces until, as Marx wrote in *Capital*, "they reach a point of incompatibility with their capitalist casing. Then the bond is broken." Therefore, the task of revolutionary forces in their struggle to reach their objective of social transformation would be to stimulate productive forces and concretely challenge all obstacles to this development coming from capitalist production relations. A corollary of this argument is that those who mistake candles for lanterns, i.e., productive forces for production relations, and attribute to the former the damage caused by the latter, are Luddites.

Two axioms underlie this reasoning – which, in its elementary mechanism, flattens the complex articulation of Marx's thought. The first consists in the rigid distinction between productive forces and production relations. In this regard, it should be specified that faith in this incompatibility does not lead – at least in its less crude formulations – to believing that the development of productive forces automatically brings about the collapse of the capitalist system. On the contrary, the prevailing thesis sees development as necessary but not sufficient, in the sense that is represents a condition for the sharpening of the class struggle by acknowledging its role in the revolutionary process. However, even in this form, this theoretical scheme does not explain one of the most macroscopic facts of the last fifty years. Namely, it does not explain why the break-up of capitalist social relations, with the abolition of the private ownership of the means of production, has always taken place in countries with levels of productive forces much more backward than the most advanced capitalist countries at the time.

Secondly, this argument does not pose a fundamental question: when capitalist property relations are abolished in a given country, does the development of productive forces assume different or similar features, rhythms and forms? If there are differences, do they concern quality or merely quantity?

How is it possible to reconcile, within the narrow outline of this analysis, on the one hand the affirmation of the cultural value of science assumed to be neutral in terms of production relations, and – on the other hand – the acknowledgement of the class character of culture in a society where the bourgeoisie holds power?

Finally, is it really enough to repeat the words of *The Communist Manifesto*, waiting for the day in which we will witness "the revolt of modern productive forces against modern conditions of production, against the property relations that are the conditions for the existence of the bourgeois and of its rule,"[44] without wondering whether the concrete analysis on which this prediction was based, 120 years ago, can be applied today, unchanged, to the stage of monopoly capitalism?

Certainly, nobody nowadays would have the ambition to give a comprehensive and correct answer to these questions. But it is at least possible and necessary to make an effort in this direction.

Productive Forces and Monopoly Capital

It has often been remarked[45] that there are essentially two consequences of a 'conscious technical use of science'. The first is increased work productivity, i.e., a decrease in the socially necessary work time for producing the commodities which a society needs in a given stage of its development. The second consists in the 'multiplication of the use value of labour', i.e., of production branches. As Marx[46] says, "the production of capital constantly and necessarily creates, on one side, the *development of the intensity of the productive power of labour,* on the other side, the *unlimited diversity of the branches of labour*." Now, these two effects operate very differently within the evolution of the capitalist system.

44 Marx and Engels, *The Communist Manifesto*, trans. S. Moore, Moscow: Progress Publishers, [1848] 1969, available online at: www.marxists.org/archive/marx/works/1848/communist-manifesto/.

45 See, for example, *Bollettino CESPE*, n. 25, December 1968, p. 5.

46 Marx, *Grundrisse*, p. 688.

The former enters into direct and irreconcilable contradiction with the principle of capital valorisation, based on the identification between exchange value and work time, and on the consequent capitalist appropriation of surplus value produced by the use of the labour force; in this sense, "Capital itself is the moving contradiction, [in] that it presses to reduce labour time to a minimum, while it posits labour time, on the other side, as sole measure and source of wealth."[47]

However, the latter effect acts in the opposite direction. Through the continuous development of the possibility of creating new commodities, new workforce can be incessantly absorbed in new productive branches and maintained in the conditions of commodity. The use values of the workforce are also multiplied, thus provoking an ever-increasing differentiation, from manual labour up to the highest forms of intellectual labour. In other words, the second effect of scientific and technological development tends to strengthen and enlarge the capitalist relations of production to all levels of the social structure.

If we now consider how these contrasting effects operate in different stages of development of the capitalist system, we realize that, in the competition-based stage, the first one far exceeds the second one, and it cannot be controlled by individuals as a consequence of the anarchy dominating the exchange process. Not by chance, in the analysis of *Capital*, which mainly chooses a competitive system as its object, the capitalist use of technology is essentially identified with the introduction of machinery in order to increase work productivity.[48] Two essential points underlie Marx's synthetic formulation of the incurable contradiction between the development of productive forces and capitalist production relations: the prevalence of increased labour productivity as a consequence of the applications of science

47 Ibid., p. 625.
48 Marx, *Capital*, Book I, Section IV.

to the productive process, and anarchy in the exchange process. At the level of monopoly capitalism, however, not only do the great opportunities provided by promoted and planned scientific production enable the creation of new outlets for consumption; it also becomes possible to control and regulate – to some degree – the effects of increased work productivity as a consequence of the attenuation of the competitive mechanism, or at least of its transformation.[49]

Therefore, the identification between the development of productive forces – as a factor which comes into conflict with capitalist production relations – and the development of science and technology within a mature capitalist society, loses most of its theoretical justification and therefore its effective cognitive value.

The extension of capitalist planning from the factory to increasingly large areas of society represents the form, which mature monopoly capitalism elaborates in order to react to the contradictions limiting its development and to guarantee continuity in the process of appropriating surplus value. As Panzieri wrote a few years ago:

> In front of the capitalist intertwining of technology and power, the perspective of an alternative (workers') use of machinery cannot evidently be based upon the plain and simple overturning of (property) production relations, considered as a shell which, at a certain degree of expansion of productive forces, would be destined to simply break because it is too thin. Production relations are *within* productive forces, which have been shaped by capital.[50]

49 On this point, see the analysis made by Paul A. Baran and Paul M. Sweezy, *Monopoly Capital: An Essay on the American Economic and Social Order*, New York/London: Monthly Review of Books, 1966.

50 Raniero Panzieri, "Plusvalore e pianificazione," *Quaderni rossi*, n. 4, 1963, p. 271.

One of the most characteristic and important facts of this 'intertwining of technology and power', between productive forces and production relations, has been the assumption – on the part of the capitalist state – of the task of planning scientific research as its own vital interest. In particular, planning space research – as we have seen in detail – is the clearest example of a capitalist development of science, namely of a process, in which productive forces are 'shaped' by the capital, and not simply 'used' as a naive mechanist view would demand, as if they were shovels or potter's wheels.

Science is not only the solution to problems one accidentally encounters on the street. It is a process, in which the posing and formulation of new problems go hand in hand with their solution. At the stage of locating and selecting problems, capitalist relations of production play a role which is all the more crucial the greater the investment in necessary people and means, and the more important the objectives for the development and strengthening of the system. How could one deny that, nowadays, we would be facing a different science, as far as contents, methods and the importance of the various disciplines are concerned, if research in the USA had not been so largely conditioned by the economic, political and military expansionist needs of capitalism?

The Soviet Thesis

At this point, it should be clear that the remarks set out here not only do not resemble Luddism, but they also want to indicate a process of science's degeneration which increasingly degrades its cultural value and distort its growth, stifling its potential, as well as new and unpredictable perspectives which might only originate and flourish in a climate of new relationships among people freed from exploitation.

The Soviet thesis[51] – on the contrary – argued that the underlying reasons for space research were the needs of science and the desire to bring future benefits to humanity. The argument in Blagonranov's paper does not address the central issue – i.e., the priority of choices – as if this problem did not even exist. "The development of science – he says – is far from being stimulated by utilitarian purposes [...] It may seem, in the beginning, that the knowledge acquired in a new field serves only to satisfy the 'curiosity' of the scientists working on it. The practical consequences of this knowledge are not entirely clear, neither to society, nor to the scientist himself." There is a truth in this statement. However, what is puzzling is that he resorts to examples, such as Zhukovsky, one of the founders of aerodynamics, and Hertz, who discovered electromagnetic waves, both great late nineteenth-century scientists, for whom it is very difficult to find an analogy with contemporary scientists. It is funny how one of the top Soviet science planners places a scientist of the last century, who practically built the modest tools with which he investigated the secrets of nature with his own hands, on the same level with the coordinated efforts of a hundred thousand scientists involved in space programmes, in which the Soviet Union invests more than 1% of its national income. The list of the results in the paper (Blagonranov acknowledges that those of meteorology "may seem modest, but we cannot underestimate them") does not go beyond the scope of a speech about research and therefore does not even touch on the concrete problem of the priorities of science as related to goals and social utility, an issue which was raised by a part of the US scientific community.

How can we explain this stance? Doubtlessly, at the roots of

51 This thesis is contained in a paper by A. Blagonranov, in *Literaturnaya Gazeta* (trans. in *Bulletin of Atomic Scientists*, October 1966) as a commentary to a letter by Max Born, quoted above.. Given the position of Blagonranov, this article can be considered as representative of official opinion.

the Soviet space effort there has been the need to develop sufficiently powerful and precise missiles so as to achieve a military balance with the USA. It would be absurd to deny that it was a valid goal. Considerable efforts had to be made for the development of carriers which could make American cities feel the same threat which US bases on the borders of the USSR exerted upon Soviet towns. In other words, once the USA had chosen this ground of military build-up, the USSR had to reshape its own defence system in response. Certainly, we could open up here a whole argument about the nature, features and possibilities of self-defence for a socialist power. A self-defence which may consist not only in becoming a militarily unconquerable stronghold, being feared for its retaliatory capabilities, but also in enlarging a global 'political' system of solidarity and *political* relations of force so as to keep the aggressiveness of the opponent in check. In sum, the best defence for the socialist field is the spread of revolutions and the blindsiding of imperialism in what is still its field. After all, the USSR made extensive use of the instrument of political mobilization until it was certain of its capability of military deterrence. What else were the huge 'peace' campaigns of the Fifties if not this? Not by chance, the first flight of *Sputnik* also marked its decay.

However, the Soviet stand also mirrors the trend – neither recent nor justified – of considering their own strategic, state and military power as the main guarantee of the affirmation of socialism and the number one priority for the whole socialist world. Hence the pursuit of ever-increasing prestige. "These successes – Blagonranov says – raise the prestige of Soviet science and technology and, more generally, in the eyes of the world." After all, we cannot forget that the *Sputnik* launch in 1957 healed the blow inflicted by the 1956 crisis of the socialist area. In the face of those who were talking about the crisis of socialist society, about the Polish October and Budapest, or – like the politician Pietro Nenni – were predicting the rapid decline of Soviet influence, its military and technological force was flaunted and thus the inherent validity of a system that enabled a country, which had started out as very backward, to reach scientific and productive summits until then unknown to humankind. How many communists were not comforted by this? It was understandable, but it already had introduced a criterion of judgement, as if a *productive* result could compensate for a *political* crisis. This was profoundly dangerous.

Blurring Social Goals

However, having recognized certain needs and historical heritage, it is unjustifiable that this choice is not accompanied by a minimum of in-depth discussion on the costs, priorities and meanings related to the development of both Soviet research and society. Indeed, the USSR also suffered the same dystopia as the USA owing to this choice. First of all, there was the huge expenditure as compared to other investments that, therefore, required the renunciation of other fields of intervention; the priority of a certain technology led to the creation of a lobby of superscientists who became a privileged social group; there was the renunciation, or deliberate delay, of healing internal imbalances; aid to the Third World was withdrawn, delayed or decreased. Why do not they talk about it in the USSR at least as much as they talk about it in the USA?

The meaning of this silence is glaring, since it mirrors the absence of a real debate on the leadership's choices, on the meaning and purposes of Soviet society – behind 'material conquests', social goals are blurred, as well as the serious problems of the transformation of human relationships, the passage to communism, now postponed *sine die* after Khrushchev's promises. Clearly the space race, in the USSR just as in the USA, assumes the value of a replacement for patriotic self-satisfaction and evasion. Doubtlessly, the 'first Soviet man on the Moon' will be used, for the purpose of the unification of public opinion, not unlike 'the first American on the Moon' was used in the

USA. On the one hand, they want to prove the superiority of a system, and vice versa. The alternation of successes and delays between the two superpowers proves that this kind of victory reveals nothing but the greater or lesser efficiency of investments and uses in this field. Therefore the adoption of this model turns out to be simultaneously a result of and a tool for depoliticization.

Thus it is not surprising that, in order to cover all this, they adhere fully and uncritically to the thesis of 'neutrality' and of the absolute, aseptic value of science and technology, free from any social compromise. It is a way of abandoning the responsibility for choosing scientific and technological priorities which – instead – would draw nourishment from the needs of human societies, from their material contradictions, from the aim of building new equal, free relationships, not only between men of the same nation. This is accompanied by the mechanical faith – or rather the declaration of faith – in the inevitable contradiction between scientific development and capitalist relations of production.

Similar Models

In fact, few things prove the contrary with such surprising evidence as the space race. So far, it has not led to conflict between, but rather to a kind of reciprocal modelling of the two systems – socialist and capitalist – on the same pattern, which is necessarily the one of the stronger industrial power, the USA. This type of scientific and technological 'revolution' forces socialist society to compete on the terrain chosen by the opponent, introduces into its social dynamics requirements and needs, and bears the mark of inequality and waste. In an increasing spiral of induced consumption and investments, it forces this society to suffer from the choice of the leading sectors of the economy which, the more they strengthen the system, the more they distort the social relationships of socialism, postponing its prospects for progressing to a further stage of development.

Nor – obviously – is this penetration limited to the economic area. The acceptance of the priorities of investment implies the acceptance of a scale of values regarding the relative importance of commodities, productive sectors, different branches of science, in the evaluation of work and, therefore, of people, opening the door to the entry of a series of behavioural models, social prestige and moral values which make up the very fabric of bourgeois ideology.

This is a serious statement, but it is difficult not to be alarmed by the ray of light it casts upon this process of decaying ideals. Indeed, in space enterprises, we see an exaltation of values such as courage and the spirit of conquest, the worship of technical efficiency, the supremacy of superhumans with nerves of steel. Such values, considered in themselves, are the basis of antithetical conceptions of the world compared to the values of those who fight for human equality. We cannot deny the fact that the 'values' of Soviet astronauts are similar to those of US astronauts. On the other hand, there is a gulf between the values of a Vietnamese peasant and a US marine. "Unhappy is the land that needs a hero" – said Brecht in *Life of Galileo*. Unfortunately, the world still needs heroes. But for what purpose, for what battle? For us, communists, we do not need the heroes which power a machine which, on the one hand, lands on the Moon, and on the other hand crushes the exploited and the oppressed in a condition of inequality. On the contrary, our 'hero' is someone who measures everything according to the needs of the most deprived of his brothers and sisters, in science as well as in life.

The Myth and Reality of Science as a Source of Well-being[52]

Marcello Cini

1.

In the 26 May 1969 issue of *Scientific Research*, Richard Hamming of Bell Labs Computer Science Research Department, warned us that "if we allow computers to be used to decrease man's possible choices, or in other words his sphere of freedom, in the next few years the world will be transformed into a real hellhole. On the other hand, if we use these machines to increase possible choices, the world will almost become a paradise." How can we take the second road without being dragged down by the first one? According to Hamming, the main reason which prompts a programmer to decrease the number of significant options – i.e., to roll down the dangerous descent – is the push to use computers as efficiently as possible. The elimination of one or two choices available to those who use the program saves a few microseconds or milliseconds of time for the mainframe. Thus, there is a tendency to always use the machine at maximum efficiency, at the expense of its users.

I wanted to immediately get to the heart of the topic with this example because, in it, we can identify, without many preliminaries, some of the most important and general nodes regarding the relationship between science and society. First of all, we find a denial of the automatic identification of scientific-technological progress

52 Published in the collection *La Scienza nella società capitalista*, Bari: De Donato, 1971

with well-being, while acknowledging that every step forward opens up alternative pathways. Each of these ways corresponds to a choice between – as our computer expert said – 'hell' or 'paradise'. Some may observe that this is not a great discovery. However, I am not sure that the potential polyvalence of science is so widespread. Of course, everyone agrees that nuclear fission enables us to make both bombs and power plants, but they say this problem only concerns a few people and is – after all – an extreme case. However, allow me to underline that these choices clearly concern all of us, every day. An artificial divide falls between the intrinsically good scientist and the intrinsically bad politician, and the problem of the social responsibility of the researcher presents itself in its immediacy. Thus we find the starting point for concretely analysing the underlying mechanism behind the choices – and which often determines them – within this process which leads people to interact more and more closely with the products of science: the machine's efficiency as a time-saving machine, the minimization of costs and maximization of benefits on the part of the machine's owner, at the expense of the machine's user.

Here too, we can make a general consideration, noting how artificial it is to isolate the human-nature relation from social relationships between human beings. Clearly, the process of appropriation and use of nature on the part of humans is strictly tied up with the way people relate to each other in order to produce everything that is necessary for social life.

Thirdly, and finally, we are led to question the development dynamics themselves of the various branches of science. Indeed, no one can reasonably claim that – referring directly to our example – information science and data processing will develop, as far as their scientific contents and features are concerned, like a body of knowledge and theories, like a structure of machines and instruments, in their forms of software and hardware, regardless of the road taken – heaven or hell – for their social use. In other words, we are led to challenge the dogma of the neutrality of science, so deeply rooted in the mind and consciousness of many of us, to the extent that we become aware that it is no longer possible to separate the object of our act of knowledge from the reasons for this act; nor to distinguish the moment of investigating reality from the moment of that reality's formation; nor to isolate the problem-solving process without identifying the mechanism which proposes the problems to be solved. In other words, to the extent that we become aware that reality is not an unspoiled nature that we stand before like Robinson Crusoe, but rather a product of human history, and how, on the one hand, people were led to establish certain social relationships among themselves in order to dominate and thus understand nature, and on the other hand they were able to take possession of nature and transform it in a certain way, as a consequence of the social relationships they had established.

As I said before, these are some of the knots we are going to deal with. How should we deal with them? We need to go beyond general declarations of goodwill, exhortations to reason, appeals to moral firmness. "It's your world. Don't leave it to the experts!" – American students urge. The experts, if they want to retain their right to speak, must get their hands dirty with the facts of people's lives. That's what we are trying to do today, even at the cost of someone being scandalized, believing that we stray too far from the sterilized test tubes of scientific laboratories.

2.

In order to talk about 'well-being', we should first of all know what we are talking about. But there is no need to sit down and invent some intelligent definition or look for an absolute reference system in abstract ideals; rather, we can start from an analysis of real conditions of *lack* of well-being experienced by most of the three billion people living on the Earth with us at this moment.

From the viewpoint of a phenomenological snapshot, we would be neglecting a basic necessity for the survival of the human species itself if we only considered the problems posed by scientific and technological development in that part of the world where this development is taking place. In this sense, we can all agree that the most basic example of the lack of well-being is hunger. We know that a substantial percentage of humankind – 10 to 20% – is doomed to hunger. If we want more quantifiable data, we can recall that, according to the UN's 1965 statistical yearbook, countries with pre-industrial economies, with about 50% of the world's population, contribute about 10% of the world's gross product, whereas the one-fifth of the global population who belongs to the advanced capitalist countries contributes around 60%.

This results in a 13-fold difference in average *per capita* income. If we take into account the fact that income in countries in Asia, Africa and South America, which constitute the former group, are as unevenly distributed as those of the latter group – Japan, the USA and Europe – these averages do not really help us. It is more significant to recall, for example, that the *annual* increase of the assets and services available to the average American is more than double the *total* assets and services available to the average Asian. Considering some of the more characteristic indices of economic and social development, the UN data for 1964 shows a 20-fold factor in the average results of energy and steel production for each inhabitant, with peaks of 200 and more for Nigeria and the USA, a 20-fold difference in the number of inhabitants per doctor, and about 30-fold for inhabitants per radio receiver. Now the most dramatic aspect of this picture – in almost unanimous opinion – is represented not so much by the absolute figures we have mentioned, but rather by the gap between developed countries and the countries euphemistically defined as developing, which increases every year instead of decreasing. Gross growth-rates per capita were, respectively, 2.8 and 2.7% in the years 1950-60; they became 3.5 and 2% in the years 1960-64.

Let us now examine how the developed capitalist countries, which are notoriously opposed – to the point of war – to any revolutionary change in this state of affairs, work to transform the situation gradually and peacefully. The total aid to the countries of the so-called Third World on the part of the DAC[53] member countries (OECD data) grew from 7 billion dollars in 1960 to 10 billion dollars in 1965 (we recall, by way of comparison, that the cost of the Apollo programme amounted to over 20 billion dollars). By taking into account the increase of the gross national income of developed countries, the aid has decreased from 1.19% to 0.97%. However, if we examine the question a little more closely, we realize that things are actually worse. First of all, the 10 billion dollars are reduced to 8 if we take into account the fact that this amount includes credits to exporters (which essentially concern the competition among developed countries) and the reinvestment of profits which could hardly qualify as aid. But – above all – we should consider that the capital invested by developed countries in third-world countries that returns home amounts to a reverse flow valued at 4.9 billion. If we add interest on loans (1.1 billion), sea freight for the transport of products (1.35 billion) and the constant transfer of currency due to the degradation of trading terms (constant depreciation of exported raw materials and constant increase in the prices of imported industrial products) (4.5 billion), compared to 8 billion in aid there are 12 billion in bloodshed. I will refrain from making further remarks and merely observe that it would be difficult to dispute the claim that the current socio-economic system not only is incapable of solving the most serious contradiction afflicting humanity nowadays, but that it also tends to exacerbate it even further.

53 United States, Canada, Austria, Belgium, Denmark, France, Federal Republic of Germany, Italy, Netherlands, Norway, Portugal, Sweden, England, Japan and Australia. See Pierre Jalée, *Le tiers monde dans l'économie mondiale*, Paris: Maspero, 1968, p. 99.

In this regard, I would like to mention a recent analysis by the Latin American economist André Gunder Frank, *Capitalismo y Subdesarrollo en América Latina* [*Capitalism and Underdevelopment in Latin America*], which explicitly reveals how the subordination of peripheral areas to the metropolis – a subordination based at first on industrial monopolies and more recently on manufactured goods and advanced technology – brought about underdevelopment. Frank shows how the satellite regions less connected to the metropolis (for example, São Paulo and Minas Gerais in Brazil) have had greater opportunities for autonomous development. In the same way, in the periods in which the links between the satellite areas and the metropolis were weaker (during the First and Second World Wars and the Depression of the Thirties), greater development took place.

Moreover, the phenomenology of the lack of well-being in the areas which were defined as 'the countryside of the world' would be seriously reticent, if we did not recall that here, more than elsewhere, wars, whether declared or not, often reduce the value of life to zero. In 1953, President Eisenhower said:

> **We know [...] that we are linked to all free peoples not merely by a noble idea but by a simple need. [...] For all our own material might, even we need markets in the world for the surpluses of our farms and our factories. Equally, we need for these same farms and factories vital materials and products of distant lands.**[54]

Therefore, it is not a free inference to retrace in these needs the prime causes of wars, such as the one which is devastating Indochina

54 President Dwight Eisenhower's inaugural address, January 20, 1953, p. 3, available online at: https://www.eisenhowerlibrary.gov/sites/default/files/research/online-documents/inauguration-1953/1953-01-20-inaugural-address.pdf.

and is growing wider and wider, or of mass exterminations like the ones in Indonesia and Santo Domingo. But I will not insist on the more purely political aspects of these conflicts while reserving the right to come back later to the relation between science and the military-industrial complex in developed countries, the USA in particular.

Let us now look briefly at us, the privileged of the Earth. At first glance, the standard of living in the countries of welfare, an affluent society and the economic miracle provides, almost by definition, the standard of well-being. Doubtless in these countries starvation is no longer an acute social problem. *Per capita* production grows at a satisfactory rate on average. Durable consumer goods – cars, household appliances, tv sets – are now widespread in a high percentage of the population. Social assistance in various forms has been expanded to cover sickness and old age. The average length of human life has grown longer. The general level of education is increasing, and the limit of compulsory schooling has been raised. The number of people who engage in intellectual activities is increasing, and manual work is becoming less strenuous. However, there is a downside to each of these advances.

This economic development is taking place while exacerbating regional imbalances. The industrialized areas are becoming congested, whereas the most backward areas are depopulating and decaying. The same mechanism which stifles rural areas in favour of a metropolis works inside the metropolis itself, aggravating the contrast between the centre and periphery, the city and the countryside, large and small industry. The same applies to individual incomes. From the official data reported in a detailed study by Gabriel Kolko,[55] the share of income available to the poorest half of the population decreased from 27% in 1910 to 23% in 1959. Moreover, in the decade between

55 Kolko, *Wealth and Power in America: An Analysis of Social Class and Income Distribution*, New York: Prager, 1962, p. 102, 126.

1947 and 1957, half of the families had such a low income that they could not guarantee a subsistence standard of living, and a third of families had an even smaller income, which could not even guarantee an emergency standard of living. This means that, Kolko underlines, "the gains of relatively full employment and a normally ascending real income have been largely offset by the rise of new causes of poverty and by the perpetuation of an important segment of the traditional causes." The fact that, still ten years later, President Johnson had to point out to the nation that the War on Poverty was one of his most urgent tasks means that the problem is far from being solved.

The stratification of income corresponds to the stratification of consumption: "Even though the total consumption of goods of each income class may rise as its real income grows – Kolko remarks – the consumption gap between income classes will remain very great." After all, John Kenneth Galbraith had already remarked in his well-known book *The Affluent Society*:

> **it can no longer be assumed that welfare is greater at an all-round higher level of production than at a lower one. It may be the same. The higher level of production has, merely, a higher level of want creation necessitating a higher level of want satisfaction.**[56]

I will not dwell on the most striking aspects of consumer society, widely disseminated by an infinite number of books, movies and magazines at all levels. I would simply like to underline how transient the ability to satisfy certain needs is on the part of those same commodities which encouraged their growth, not only because of their rapid obsolescence – more or less by design – but also as a consequence of

56 Galbraith, *The Affluent Society*, New York: Houghton Mifflin, 1958, p. 158.

the chain reaction that the mechanism sets in motion. The example of the car is trivial, but no less relevant. Paul Baran and Paul M. Sweezy in their book *Monopoly Capital* write: "Having appeared as harbinger of a new freedom – the freedom of movement – it is reducing mobility within cities and rendering life in the suburbs a traumatic experience for all who must commute to and from their work."[57]

The other example which immediately comes to mind is environmental pollution, though I will not dwell on it because after President Nixon attracted America's attention to the seriousness of the problem in his message to the Congress, it is superfluous to insist, at least in the context of phenomenology.

The problem of the transformation of the environment immediately leads us to talk about health. Nobody can undervalue the extraordinary success of medicine in certain fields. The increase in life expectancy is the spectacular proof of this. In developed countries, people can live on average twenty, even thirty years longer than those living in Third World countries. However, if doctors manage to lengthen people's lives, how does the social system permit them to live? A research project on the mental health of adults New York City residents between 20 and 59 years of age, known as the *Midtown Manhattan Study*,[58] showed that only 18.5% of the sample studied could be defined as healthy, whereas 36.3% and 21.8% showed symptoms of a medium or moderate grade mental disorder, respectively. Finally, 13.2, 7.5 and 2.7% showed symptoms of pronounced, severe and maximum degree, respectively. In this regard, it is also worth recalling that the well-known study by August B. Hollinsghead[59] pointed out the correlations between mental health and class

57 Baran and Sweezy, *Monopoly Capital*, p. 305.

58 See Leo Srole et al., *Mental Health in the Metropolis: The Midtown Manhattan Study*, New York: McGraw-Hill, 1962; see also Baran and Sweezy, *Monopoly Capital*, p. 364 and note 20.

59 Hollingshead and Fredrick C. Redlich, *Social Classes and Mental Illness,* New York: John Wiley & Sons, 1958.

stratification. However, apart from research and statistics, were any of us not impressed by reading posters that invited us to behave kindly to foreigners, recalling that one out of five Americans suffers from serious mental disorders?

Finally, allow me to hint at the conditions of an individual who is a worker within the complex production cycle at different levels. Firstly, there is the question of working time. Doubtless, since the time of Marx's *Capital*, the working day has passed from twelve to seven or eight hours. This is certainly a fundamental victory, though a more realistic assessment should take into account the increased duration of commuting time and the rising phenomenon of second jobs which, according to George Friedmann,[60] is also extending to economically advanced countries to the point that "the man of the 'affluent society' would, therefore, be condemned to be a modern Sisyphus who exhausts himself relentlessly pushing a burden which keeps rolling backward."

Anyone with any knowledge of the working world knows what a nightmare both time cuts and pace increases represent for those working on machines or assembly lines. Each transformation of the production process, each retrofitting of machinery, each technological innovation, results in an intensified exploitation of the worker's labour. In an article published in the newspaper *Il Giorno* on March 5, 1968, entitled "Gli operai italiani di fronte al male oscuro" [Italian Workers Facing Evil], Giorgio Bocca began with these words: "A modern, rational, organized company, that wears out the mind and nerves of its workers is an impersonal, powerful and enigmatic enemy," concluding, after a long analysis of the different forms of workers' neurosis and company reactions to it: "and yet, there are still good – actually bad – reasons to believe that the more and more intensive

60 Friedmann, : "Le loisir," p. 75.

exploitation of workers will not cease as long as there are workers to exploit."

With the intensification of work rates, accidents increase. In Italy, occupational injuries claim one victim per hour, one accident every 6 seconds. In 1967, accidents increased by 9% and the number of victims by 8% compared to the preceding year. As for the decrease of fatigue, let us listen to the workers of the most modern Italian factory, Fiat[61]: "The two people responsible for shredding the bottoms of the Fiat 124 pass 61,000 kg to each other in 8 hours, over 30 tons per head; 44,000 in the area of the Fiat 850 model, 30,000 on the flanks of the Fiat 500 model. Furnace workers must bake 3,500 pieces in 8 hours, weighing 7 to 9 kg, every 8 seconds." What about intellectual work? And the technicians? In a document approved by the assembly of the occupants of Snam Progetti, October 1968, we read:

> Many technicians are attracted by the company's propaganda, which promises a creative job, adapted to their intellectual aspirations, capable not only of giving them satisfaction but also of opening up career opportunities. The reality is quite different. [...] But even when the technician realizes that his job is purely executive, this does not mean renouncing his career prospects. At first, he thinks naively that he can command by proving to be more capable than others. He will try to specialize, to study in his limited free time, to perform better. Then he realizes that the company does not care if he is better, if he can speak more foreign languages, if he works outside normal hours. The boss must, above all, be a scoundrel.[62]

61 *L'ambiente di lavoro*, Rome: Fiom-Cgil, 1969.
62 "Lotte dei tecnici," *Linea di Massa*, n. 2, 1969.

This is certainly a one-sided synthesis, but it is indicative of a widespread condition, different from the one described in richly illustrated magazines published by the PR agents of large companies.

At this point, in this quick and fragmentary review, it is necessary to mention, albeit briefly, a few countries from the socialist area. On the whole, it is estimated that, with 30% of the world population, they produce 30% of its gross product. It would, however, be wrong to consider them as a homogeneous block. As is well known, there is clearly a great disparity – and not only an economic one – between China and the USSR. Indeed, the USSR seems to be edging towards the same kinds of problems which are typical of industrially advanced countries. The recent call for greater organisational efficiency and intensified production, the tendency to model certain forms of consumption on Western examples and, above all, the increasing coincidence between Soviet and Western scientific and technological research programmes indicate that this opinion is not groundless. Beyond subjective assessments of the ideological contrast with the USSR, we do know for sure that China, although it started twenty years ago at the same time as India and other underdeveloped countries, has long erased hunger from its countryside and is constantly raising its population's extremely egalitarian standard of living.

3.

This year's meeting of the American Association for the Advancement of Science, as compared to the past few years, featured greater attention – on the part of American scientists – to the consequences of technological innovations and a greater commitment to finding the most appropriate ways to use science to solve the problems of humanity.

From the February 1970 issue of *Scientific American* we discover that the topics of the main session concerned: the relationship between the production of energy and the environment, military funding of academic research, arms control and disarmament, technological planning, hunger and malnutrition, the future of the space programme, chemical and bacteriological welfare, environmental planning, optimal population levels and the effects of medical and bacteriological intervention on human identity and dignity.

At the same time, we also learn that in a special programme entitled "The Sad State of Science," a group of graduate students indicted the entire scientific establishment for its subordination to industry and the military at the expense of general welfare. The final resolution, approved by the Association Board, commits the organization to focussing its main activities over the next decade, in direction of "the main contemporary problems related to mutual relationships between science, technology and social transformations, including the use of science and technology in promoting human well-being."

Some isolated voices had been raised for some years in America, calling for a different orientation of the priority tasks of scientific research in order to take into account the most urgent social problems and find technological solutions to them. In *Physics Today* (1964) and *Scientific Research* (1966), Alvin Weinberg, Director of the Oak Ridge Laboratories, explicitly proposed the choice between continuing to spend 5 billion dollars a year after the Moon landing or using this money (which must be spent to sustain the economy) to build nuclear desalinisation plants in arid areas on the edge of the oceans?[63]

A few of his suggestions, such as the development of electric cars and the use of a vast network of computers for education, are going to be realized. The rapid worsening of the problem of environmental pollution, for example, has highlighted, as we learnt from Nixon's message, the realization of the first prototypes of electric cars.

63 *Scientific American*, July 1966, p. 32.

However, Weinberg does not ignore the fact that "technological solutions to social problems tend to be meta-stable, namely, they replace a social problem with another one."

However, the key point which needs to be examined before giving an opinion on the real scope of the philosophy underlying Weinberg's proposals is the mechanism governing their implementation. John Kenneth Galbraith, an economist who knew the laws of economics very well, used to say about his colleagues: "Nothing in economics so quickly marks an individual as incompetently trained, as a disposition to remark on the legitimacy of the desire for more food and the frivolity of the desire for an elaborate automobile."[64] In other words, as long as the hungry have no money to buy food, and the sated have money to buy a Cadillac, the laws of economics 'force' society to produce Cadillacs and restrict the quantity of food. You may object that this is a schematic and outdated picture of the capitalist economy, which was probably all right before the 1929 crisis and before the Keynesian revolution, but no longer nowadays. Doubtless, even after Keynes, it is still true that the only goal of a company – no matter what it sells – is to produce in order to earn good profits. What has changed, if anything, is that the State learned, in the interest of the economy – namely, the holders of the means of production – to promote the growth of consumer purchasing power in times of recession, through suitable measures of investments and credits, so as to allow the resumption of production and thus the accumulation of profit.

Harvey Brooks and Raymond Bowers, members of the National Academy of Sciences for technology planning, can confirm that the main trigger of technological innovation is profit:

64 Galbraith, *The Affluent Society*, p. 120.

> It has been admitted so far that the use of a given technology should be allowed as long as it can give profits to those who exploit it, and that any harmful consequence would not be serious enough to justify the decision of interfering with this process.[65]

A concrete example of this mechanism is reported by the *Liberated Guardian* of May 17, 1970:

> The Mellon Group in Pittsburgh deals with air pollution. Mellon checks steelworks, has extensive building properties in the centre of Pittsburgh. The value of these properties was decreasing because of the pollution provoked by the steelworks. Thus they hired a few economists in order to discover whether it would be convenient to install ventilation devices in blast furnaces, in order to raise the value of buildings in the city. They replied in the affirmative. Therefore they took action, not because people were breathing poisoned air, but because it was convenient to clean the air.

Therefore, what may happen is that, when certain social contradictions become so acute that they threaten or provoke a loss of profit, someone intervenes – either the affected capitalists or the State, which guarantees the interests of the ruling class as a whole – to introduce or favour the introduction of a new technology which may remove the cause of loss and allow, while used, the accumulation of new profit. Clearly, the technological solution to a social problem sooner or later leads – as Weinberg says – to the outbreak of a new social problem, since the purpose of the adopted innovation is not

65 *Scientific American*, February 1970, p. 13.

to provide well-being or relieve people's malaise, but rather to merely open up new sources of profit for some resourceful entrepreneur.

Thus the cycle starts again: a new technology will temporarily eliminate those consequences which are more harmful than those it has supplanted or modified, and in its growth will open up new contradictions, provoke ever higher social costs, make workers more and more prisoners of a hostile technological universe that they will be less and less able to dominate. Perhaps the poor scientists, sincerely tormented by guilt, witnessing the flowering of their genius bear poisoned fruit, will continue to look for technological solutions to social problems.

4.

The recognition of the inability of both science and technology – in the context of this economic and social system – to find solutions to the most serious contradictions that afflict humanity can lead to two possible choices. On the one side, there is evasion: whether this entails romantic-irrational solutions, such as the escape from the city, the dream of an impossible return to an idealized state of nature, the denial of reason, or even an evasion through abstract thought and isolation in the company of the philosophy of nature or the spirit.

On the other side, there is commitment and action in order to act at the only level where the root causes of so much human suffering can be attacked: the level of social classes.

The complexity of contradictions, the intertwining of the most radical features of development and underdevelopment, heightened social tensions at all levels, the explosion of violence in its most brutal forms, these are all manifestations of a profound inadequacy of a system based on the reduction of labour to commodity and of the production means to capital to organize society so as to make the lives of its people worth living.

Any attempt to place people at the centre of social life smashes against the iron law which makes human social relations in capitalist society result from the exchange of the products of labour, considered as commodities. Thus, individuals relating through things are dominated by them, as well as by the objective laws of exchange, namely the market.

Giuseppe Bedeschi writes that:

> **social objectivity, and the products which constitute social objectivity and which were created by people, are set against them as hostile, independent entities: objects which dominate people, instead of being owned and dominated by them [...] from being real subjects, humans have been downgraded to a predicate of other predicates, which have actually become real subjects.**[66]

In *Capital,* Marx wrote: "By means of its conversion into an automaton, the instrument of labour confronts the labourer, during the labour-process, in the shape of capital, of dead labour, that dominates, and pumps dry, living labour-power."[67]

Here we find the core which our brief analysis of contemporary society had already highlighted: to the extent that science becomes a means of production, it becomes capital, and as such is opposed to workers as an external power and crushes them, making them instruments for goals they do not share. This estrangement from the producer of working conditions and the products is a feature of the capitalist process of production, both in its individual aspects and in its entirety.

It is therefore necessary to go back to Marx, and to the great

66 Bedeschi, *Alienazione e feticismo nel pensiero di Marx*, Bari: Laterza, 1968, p. 147.

67 Marx, *Capital*, Book I, Ch. 15.

revolutionary tradition of the working class that originated in Marx. This does not mean looking for codified rules and dogmas to honour, but rather rediscovering a spring whose waters, flowing through the course of history, have become so muddy that it is difficult to recognize them. We should go back to Marx, not so much to find in his analysis of capitalist society those conceptual tools which, in their extraordinary capacity to anticipate, sometimes turn out to be more penetrating today than 100 years ago, but also to find that global, passionate scientific commitment to addressing those problems of society which are precluded by so many modern social sciences, deliberately, and with academic detachment. We want, finally, to rediscover a scientific method which refuses to be empirical, without rejecting the objective data of reality, which turns down *a priori* schematism but accepts conceptual abstraction, and which sets as a criterion for verifying the knowledge of reality the ability to transform it. In this regard, we should underline the distance between Marx's method and that travesty of Marxism which consists in representing social processes in ways that are so deformed as to force them into pre-constituted dogmas. It is worth recalling with what intellectual vigour Marx, on the one side, recognized in capital the function of an objective progress along the difficult road which can lead humans from necessity to freedom, and on the other side, shed light on the limits that the very nature of capital continually creates, thus making this goal unreachable within the system.

Marx states in the *Grundrisse*:

> Hence exploration of all of nature in order to discover new, useful qualities in things; universal exchange of the products of all alien climates and lands; new (artificial) preparation of natural objects, by which they are given new use values [...] This creation of new branches of production, i.e. of qualitatively new surplus time, is not merely the division of labour,

> but is rather the creation, separate from a given production, of labour with a new use value [...] Thus, just as production founded on capital creates universal industriousness on one side [...] so does it create on the other side a system of general exploitation of the natural and human qualities, a system of general utility, utilizing science itself just as much as all the physical and mental qualities [...] Thus capital creates [...] the universal appropriation of nature as well as of the social bond itself by the members of society. Hence the great civilizing influence of capital.[68]

However, on the other hand:

> But from the fact that capital posits every such limit as a barrier and hence gets ideally beyond it, it does not by any means follow that it has really overcome it, and, since every such barrier contradicts its character, its production moves in contradictions which are constantly overcome but just as constantly posited. Furthermore. The universality towards which it irresistibly strives encounters barriers in its own nature, which will, at a certain stage of its development, allow it to be recognized as being itself the greatest barrier to this tendency, and hence will drive towards its own suspension.[69]

It is time to reach a conclusion: let us go back to the starting point: the development of computers. We cannot (unfortunately, I'd like to add) entrust our future to the moral sense and goodwill of programmers or designers, or to a scientific objectivity which does not exist. Behind them, far more powerful forces are acting. No one

68 Marx, *Grundrisse*, pp. 335-36.
69 Ibid., p. 336.

alone can prevent the system from making sure that each of us, in a more or less near future, can do without our own personal computer, which we'll have to throw away every year to buy the latest model. No one alone can prevent the system from making sure that each of us – with our own history, success and failure, aspirations and tastes, is condensed into a number of punched cards that can allow someone, in the supreme interest of efficiency, to frame us in the right moment, in the right role, at the right level of an increasingly stratified social scale. It is only to the extent that a revolutionary force grows that places the construction of a society as its strategic perspective, where the production of goods for a market acting on the basis of value is replaced by a productive process including the phasing-out of the social division of labour, the reduction of work to commodity and human subordination to the products of their own labour, whereas science and technology may acquire – as it is really possible – alternative contents and purposes, as compared to those attributed by the dominant ubiquitous capital.

It is illusory to separate this search for alternative aims from the growth of a process of struggle against the authoritarian hierarchy of the factory and of society, for the creation of a new kind of producer and the formation of new collective power centres. In this perspective, the needs to satisfy become different from the needs which nowadays, in this divided and hierarchical society, stimulate the individual, alienated both as producer and as consumer. We can, for example, imagine that a different use and development of information science and data processing can be stimulated by the need to enable worker's councils and collectives, representative bodies and workers' assemblies, to play an informed role in the social management of productive processes, make real and significant choices, organize the social fabric on new bases. We can also imagine a possible revolution in psychiatry due to the repudiation of the legitimacy of giving people a price on the basis of their alienated work.

Only in the perspective of a society in which working time ceases to be the measure of wealth and exchange value ceases to be the measure of value, in which the goal is "not the reduction of necessary labour time so as to posit surplus labour, but rather the general reduction of the necessary labour of society to a minimum, which then corresponds to the artistic, scientific etc. development of the individuals in the time set free, and with the means created, for all of them,"[70] can science truly become, once again, one of the highest and freest forms of creative human imagination.

70 Marx, *Grundrisse*, p. 625.

Changes in Scientific Practice in a Technological Society[71]

Giovanni Jona-Lasinio

Totality

In his essay, "What Is Orthodox Marxism?" Georg Lukács states[72]:

> **When the ideal of scientific knowledge is applied to nature it simply furthers the progress of science. But when it is applied to society it turns out to be an ideological weapon of the bourgeoisie. For the latter it is a matter of life and death to understand its own system of production in terms of eternally valid categories: it must think of capitalism as being predestined to eternal survival by the eternal laws of nature and reason. Conversely, contradictions that cannot be ignored must be shown to be purely surface phenomena, unrelated to this mode of production.**

While we agree with the second part of the statement, nowadays there are serious doubts on the validity of the initial premise. Indeed, this premise seems to be referring to an ideal of an essentially ahistorical scientific knowledge which, when applied to nature, only

71 Seminar held on March 3, 1972 at the Faculty of Philosophy of the State University of Milan.

72 Georg Lukács, in *History and Class Consciousness*, trans. R. Livingstone, London: Merlin Press [1919] 1967, available online at: www.marxists.org/archive/lukacs/works/history/orthodox.htm.

serves the progress of science.

However, let us go back to Lukács:

> The methodology of the natural sciences which forms the methodological ideal of every fetishistic science and every kind of Revisionism rejects the idea of contradiction and antagonism in its subject matter. If, despite this, contradictions do spring up between particular theories, this only proves that our knowledge is as yet imperfect. Contradictions between theories show that these theories have reached their natural limits; they must therefore be transformed and subsumed under even wider theories in which the contradictions finally disappear.
> But we maintain that in the case of social reality these contradictions are not a sign of the imperfect understanding of society; on the contrary, they belong to *the nature of reality itself, and to the nature of capitalism*.

Elsewhere, in the same essay, he states:

> The 'pure' facts of the natural sciences arise when a phenomenon of the real world is placed (in thought or in reality) into an environment where its laws can be inspected without outside interference. This process is reinforced by reducing the phenomena to their purely quantitative essence, to their expression in numbers and numerical relations.

Therefore, Lukács seems to identify a clear dividing line between natural sciences and social sciences. The same method, the same ideal of knowledge – that of natural science – once extended to social science, becomes an ideological fact.

> The reason behind this idea is that:
> Only in this context which sees the isolated facts of social life as aspects of the historical process and integrates them in a *totality*, can knowledge of the facts hope to become knowledge of *reality*. […] Concrete totality is, therefore, the category that governs reality.

Lukács continues:

> The opposition between the description of an aspect of history and the description of history as a unified process is not just a problem of scope, as in the distinction between particular and universal history. It is rather a conflict of method, of approach. Whatever the epoch or special topic of study, the question of a unified approach to the process of history is inescapable. It is here that the crucial importance of the dialectical view of totality reveals itself.
> I have extensively quoted Lukács because I wanted his position on natural science to be unequivocal. It is doubtlessly ambiguous since it is not clear how natural science can be excluded from historical totality, which is the fundamental category of reality. Through this separation, an essential element of bourgeois ideology, i.e., the so-called neutrality of natural science, has survived for a long time in the Marxist tradition.

As I mentioned above, nowadays this separation appears unacceptable, and the form taken by class struggles in recent years has greatly contributed to making us aware of it. However, we cannot stop at findings. We must demonstrate this in concrete terms. We also want, if possible, to stick to a methodology that overcomes Lukács's dualism from the start.

On this level, a critique of Lukács provides an almost obvious indication: we must return the scientific production of natural science to the historical totality. In fact, scientific production is a human activity and, as such, we expect it to have historically determined causes and effects which can be analysed in terms of relations. Moreover, since it is a specific and particular human activity, it is not understandable in itself. It can only be understood when analysed together with all other human activities in a certain historical period and compared to similar activities of other periods. That is to say, science can be understood only by referring to the totality of human work. Science can be concretely – rather than abstractly – defined only by differentiating it from other human activities and capturing its peculiarities, without introducing aprioristic elements. In other words, science, in its concrete reality, is not given to use immediately but only after a long work of analysis. At this point, it is worth recalling Marx:

> **The concrete concept is concrete because it is a synthesis of many definitions, thus representing the unity of diverse aspects. It appears therefore in reasoning as a summing-up, a result, and not as the starting point, although it is the real point of origin, and thus also the point of origin of perception and imagination.**[73]

This need to retrieve scientific production for the historical totality, so as to make it intelligible, is very clearly expressed by Marcello Cini in his report at the Science and Society conference of 1970[74]:

> **we are led to challenge the dogma of the neutrality of science, so deeply rooted in the mind and consciousness of many of**

73 Marx, *A Contribution to the Critique of Political Economy*.

74 Cini, in *La scienza nella società capitalistica*, Bari: Laterza, 1971 ("The Myth and Reality of Science as a Source of Well-being," in this volume, Appendix Chapter 5).

us, to the extent that we become aware that it is no longer possible to separate the object of our act of knowledge from the reasons for this act; nor to distinguish the moment of investigating reality from the moment of that reality's formation; nor to isolate the problem-solving process without identifying the mechanism which proposes the problems to be solved. In other words, to the extent that we become aware that reality is not an unspoiled nature that we stand before like Robinson Crusoe, but rather a product of human history, and how, on the one hand, people were led to establish certain social relationships among themselves in order to dominate and thus understand nature, and on the other hand they were able to take possession of nature and transform it in a certain way, as a consequence of the social relationships they had established.

Science in Its Social Dimension

Once we have clarified our methodological and programmatic premises, we must get to the heart of the matter.

Since we have recalled the peculiar character of science as a human activity, it is reasonable to try to grasp it first in its social dimension. Human work, and scientific work in particular, is clearly a relationship established between humans and nature. Within this relationship, first of all, humans themselves are nature, matter interacting with matter. However, the relationship is such – and this is true for any kind of work, but to the highest degree for scientific work – that human nature is modified, in the sense that its subjective and objective ability to determine its own needs changes. This is true for immediate needs, those related to the scientific activity itself, and long-term needs related to the general planning of one's own life, within social dynamics.

This simple remark shows that the analysis of the human-nature relationship is first referred to the aims implicit in any scientific project and, therefore, to understanding the social relations of production. Let us try and fix this point, by recalling – though schematically – some fundamental stages in the relationship between science and society.

The scientific revolution of the 16th and 17th centuries originated in the midst of profound social transformations. The dissolution of the old feudal system had come to an end in many European countries. New relations were being established and a new class emerged, the bourgeoisie, which could in turn be divided into commercial and entrepreneurial bourgeoise, arising from the dissolution of corporations. The latter would play a revolutionary role by inventing a new form of production: manufacturing. It would be the bearer of a new ideology that declared mankind the master of its own destiny, and therefore capable of planning it.

The science of the 17th century scientific revolution was not born neutral: rather, it was part of a more general plan as we can find in various statements, for example, by Francis Bacon and René Descartes. The latter would formulate the first technological project of modern times, consistent with the ideals produced by the social and political realities of the 17th century. I say, once again, that the new science was characterized by a conscious design of activity towards nature at all levels. This is consistent with the fact that, with the advent of the first capitalist forms, there arose, for the first time in human history, a situation in which a few individuals, new entrepreneurs or capitalists, planned the activity of other people, the wage earners.

As I said earlier, manufacturing represents the discovery of the division of labour as a basis of productive efficiency. However, the division of labour implies a new structure for the relationship between humans and nature. It implies that a complex work has been analysed and broken down into simpler elements. Then the same work is reassembled at the social level, in the sense that now different workers perform those simpler jobs which previously were the work of a single person. Therefore, a new relation between humans and nature resulted from the new relations of production. Indeed, decomposition and recomposition was also the essential canon of the new science. This combination was not arbitrary. Anyone who needs convincing of this should listen to the testimony of contemporaries. Adam Smith, the first theorist of the division of labour, wrote *The Wealth of Nations*[75] in the mid-eighteenth century as manufacturing and new science had already been considerably consolidated. This is what he wrote about technological progress:

> **The invention of all those machines by which labour is so much facilitated and abridged, seems to have been originally owing to the division of labour. Men are much more likely to discover easier and readier methods of attaining any object, when the whole attention of their minds is directed towards that single object, than when it is dissipated among a great variety of things.**

Therefore, in the mind of Adam Smith, social relations and relations with nature imply one another.

These short hints already bring us beyond bourgeois historiography which considers the birth of the new scientific method as a purely cultural phenomenon, which is completely explained by the opposition between the dominant Aristotelianism-Platonism, on the one side, and Galileo on the other. The traditional history of science, which chronologically reconstructs the appearance of individual

75 Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations*, ed. E. Cannan, Chicago: University of Chicago Press, [1776] 1977, p. 13.

scientific statements, is based – here we refer to Antonio Labriola, quoted by Paolo Rossi in his book *Storia e Filosofia*[76] [*History and Philosophy*] – on the premise that the development and progress of reason lies behind the chronology. This method has a small drawback: it allows us "to understand how existing science logically gives origin to new science," enables us to see how "the work of abstraction, inference and combination" continues with a "science started, and partially matured in the circle of the indoctrinated," but does not allow us to understand which concrete conditions push people towards science. To ensure the existence of a history of science – Labriola concluded – you need to find and determine the origin of scientific necessities, which are then related to other human needs.

We have therefore identified in the degree of division of labour an element which defines the degree of scientific development. This idea was briefly touched upon by Marx in the *Grundrisse*, thus overcoming the dichotomy between science and the capitalist use of sciences, which sometimes seems to dominate his analysis. The production relation Marx refers to is not the manufacturing one of our preceding example, but rather the one originating in the Industrial Revolution:

> In machinery, the appropriation of living labour by capital achieves a direct reality in this respect as well: It is, firstly, the analysis and application of mechanical and chemical laws, arising directly out of science, which enables the machine to perform the same labour as that previously performed by the worker. However, the development of machinery along this path occurs only when large industry has already reached a higher stage, and all the sciences have been pressed into the

76 Rossi, *Storia e filosofia*, Turin: Einaudi, 1969.

> service of capital; and when, secondly, the available machinery itself already provides great capabilities. Invention then becomes a business, and the application of science to direct production itself becomes a prospect which determines and solicits it. But this is not the road along which machinery, by and large, arose, and even less the road on which it progresses in detail. This road is, rather, dissection – through the division of labour, which gradually transforms the workers' operations into more and more mechanical ones, so that at a certain point a mechanism can step into their places.[77]

This passage is part of a broader discourse by Marx on machinery:

> The starting point of Marx's reflection is the thesis that, when a tool is transformed into a machine, the following circumstances occur: 1) the machine incorporates the technical application of a knowledge of nature, which is foreign and extraneous to the worker, into its own structure; this means that its functioning no longer depends – like that of the simple tool – on the worker's personal skill, but rather on the natural laws incorporated within the machine itself, so that – contrary to what happened before – now the worker's labour is a function of the tool (machine), and not the other way around. In this way, the relationship between the individual, nature and tool changes: at first, the tool is the mediating term which establishes the relationship between man and nature. With machines, the poles of the relationship are, on the one side, the tool, i.e., the machine itself, and on the other

77 Marx, *Grundrisse*, p. 623.

> side nature, whereas the worker is now simply an element of mediation; 2) With machines, capital reaches its own perfection in the sense that the subordination of labour to capital is no longer only legal and social, but begins in the very environment of the productive process, where a material submission of labour to capital also takes place. In this sense, it is confirmed that the presence of science within the tool is also a separation of science itself from the worker. In general terms, it is the separation of science from the community.[78]

Science, born in the context of a social separation, namely from the division of labour and the rise of a new class – the bourgeoisie – as a separate social body, turns out to be a dynamic and essential factor for the perpetuation of the separation process itself. In this way, the deep social contradiction of scientific production emerges.

The Meaning of the Current Evaluation of Science

This aspect, rich in ideological implications, can be analysed further. In fact, we may wonder: Why in the recent social ideologies of the Western world does such a contradiction emerge only rarely, whereas a positive evaluation of science in black-and-white terms usually prevails at all levels?

Let us do some social phenomenology. For this topic, it is appropriate to briefly refer to the history of economic thought. From its beginnings, namely from the 18th century to the early 20th century, economics has been defined by J. K. Galbraith as 'the tradition of

78 Claudio Napoleoni, *Smith, Ricardo, Marx*, Turin: Boringhieri, 1970, p. 200 [my translation], English version: *Smith, Ricardo, Marx,* trans. J.M.A. Gee, New York: John Wiley & Sons, 1975.

despair'.[79] A fundamental premise is the misery of the masses and of great inequality.

The economic outlook for the average person was remarkably dark. People's typical fate was live a life on the brink of hunger, and any better conditions were to be considered abnormal. Progress would increase the wealth of those who, generally speaking, were already well-off, and would not, instead, favour the masses. This pessimism dominated the so-called central economic tradition until the great economic crisis of the 1930s.

If we believe, as it seems correct to me, that these ideas mirrored the general level of awareness of society's development and perspectives, clearly the positive view of science we have referred to could not constitute a universally accepted idea but could, logically, only be found in the image of society and the ideology of a privileged elite. To understand this, we recall the words which Henri Poincaré wrote at the beginning of the 20th century[80]:

> the search for truth should be the goal of our activities; it is the sole end worthy of them. Doubtless we should first bend our efforts to assuage human suffering, but why? Not to suffer is a negative ideal more surely attained by the annihilation of the world. If we wish more and more to free man from material cares, it is so that he may be able to employ the liberty obtained in the study and contemplation of truth.

As you can see, the idea of well-being that emerges belongs to a privileged class which can cultivate wisdom as an end in itself. However, a new idea, a new theory of society imposed itself starting from the 1930s in the most advanced countries, in particular in the USA,

79 Galbraith, *The Affluent Society*, p. 18.
80 Poincaré, *The Foundations*, p. 205.

with the New Deal. The idea was that increased production constituted an alternative to the redistribution of income and would reduce social tension caused by inequality. Increasing production was a programme on which both the rich and poor could agree since it was mutually beneficial. The history of recent decades, at least from the local point of view, seems to confirm this thesis. The great material progress and the increased well-being of the average person in the last few decades indeed come from increased production rather than a redistribution of income. As a consequence, the purpose of an economic expansion, of increased productivity, ended up taking root deeply in the mentality of larger and larger masses of people. This is the origin of the consumer society, and thus of technological civilization. In this society, both scientists and technicians acquired a new role, insofar as they were recognized as being endowed with an explicit skill for social innovation through their work. Social innovation typically consisted in the creation of suitable ideas and means for advancing the economic expansion.

American Science after the Crisis

Even though brief, the previous discussion clearly shows that science, as a particular human activity, lives and grows within a deep dialectical relationship with the development of society as a whole. This cannot help but provoke profound and immediate reflections regarding scientific methods, contents and conceptualizations.

We will deal with the development of physics, above all in the USA, in the period following the 1930s which, in the above analysis, we identified with a productivity-based society.

The economic crisis of 1929 deeply affected the scientific structures of the USA.[81] We cannot enter into detail, but we will mention some facts.

At the close of the 1932 election campaign, President Hoover's speeches made frequent references to science, which was described with the well-known metaphor – the new frontier. This metaphor was not new, but in Hoover's campaign it had a special connotation. Indeed, he apparently identified scientific research with prosperity, and therefore science itself as the long-term remedy to the fall in productivity which had accompanied the Great Depression.

Hoover's electoral defeat cast a heavy shadow over this outlook and seemed to open the way to the opposite idea, i.e., that research was responsible for overproduction and thus the Depression. However, Hoover's viewpoint was subsumed within a larger vision, in a new ideology typical of the New Deal. The idea was an integration of social sciences and natural sciences, aiming – through planned interventions – at the solution to the socio-economic crisis. The Roosevelt administration led the scientific apparatus to an unprecedented level of development, with its efficiency greatly improved by the pairing of research with planning.

I will try to locate some aspects of American theoretical physics of the last 30 years within the framework of this ideological and social background, which would remain a constant of American scientific policy. The choice of theoretical physics is not motivated only by the fact that I have direct experience in it. Indeed, in theoretical physics, I think that one can more easily recognize the dominant ideologies in a given moment of the development of physics in general.

In order to highlight the points we are interested in, it is helpful to refer briefly to the situation of this discipline between the end of the 19th century and the start of the 20th century.

81 See A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities to 1940*, Cambridge, MA: Belknap/Harvard U.P., 1957.

We were in a period of deep crisis of mechanicism, with a proliferation of electromagnetic theories. Faced with the difficulty of unifying the description of the world, Poincaré had proposed a theoretical physics which was largely autonomous in terms of empirical data and descriptions which are eventually valid in particular sectors. It was a physics of general principles, and its main topics were, for example, the main laws of conservation and the variational principles of classical physics.

The relationship of a theory – thus conceived – to reality was very peculiar. It is interesting to read Poincaré's words once again:

> These principles have a very high value; they were obtained in seeking what there was in common in the enunciation of numerous physical laws; they represent therefore, as it were, the quintessence of innumerable observations. [...] The application of these five or six general principles to the different physical phenomena is sufficient for our learning all that we could reasonably hope to know of them.[82]

In this speech, the possibility of having to settle for a qualitative description of the world seems implicit. It is also clear that these principles cannot be directly invalidated. You may therefore wonder when you must abandon a general principle if it cannot be directly contradicted.

Poincaré answers in this way: "Just simply when it shall cease to be useful to us, that is, to make us correctly foresee new phenomena. We shall be sure in such a case that the relation affirmed is no longer real; for otherwise it would be fruitful."[83]

The only criterion of invalidation seems to be a criterion of

82 Poincaré, *The Foundations*, pp. 143, 301.
83 Ibid., p. 144.

productive efficiency. Theoretical activity largely becomes a planning of the theoretical description, and thus, above all, the invention of new languages.

I have quoted Poincaré because his proposal is deeply connected to a world in which production through machines was fully developed. However, his proposal is still within classical physics, and its full meaning only appears in its mature realization within contemporary theoretical physics. This is the point I would like to develop now. The dominant problem of physics in the last century is certainly the problem of the structure of matter. For a very long time, the explanatory mechanisms – commonly accepted by the scientific community dealing with these matters, as is well-known – have been strictly reductive. The idea was to reduce the problem to the determination of the fundamental or elementary components and of the forces to which they are subject. Therefore, they accepted an *a priori* hierarchical structure of matter (in which the large was explained in terms of the small). This explanatory mechanism, as we know, has been very successfully applied and has led to the recognition of a series of elementary constituents and a hierarchy of forces. But the landscape has completely changed in the last 25 years.

In elementary particle physics, completely reductive explanatory mechanisms of a mechanistic type have essentially disappeared. Let us reconstruct some stages of this process. In an article of 1932, Paul Dirac introduced a Lagrangian formulation of quantum mechanics in terms of a principle of action. As in classical mechanics, the principle of quantum action no longer referred to an evolutionary – and therefore causal – description, which yet had survived in the formalization of quantum mechanics. Dirac's idea was taken up at the beginning of the 1940s by the American physicist Richard Feynman, through what he defines as a 'space-time approach' to quantum mechanics and to field theory. In this approach, there is a global description of physical processes and there is no longer a need for explanations like causal sequences. What is required is, essentially, only the self-consistency of the procedure. Past and future become somehow equivalent, and the temporal sequence of events loses importance. Let us leave it to Feynman[84] himself:

> In many problems, for example, the close collisions of particles, we are not interested in the precise temporal sequence of events. It is not of interest to be able to say how the situation would look at each instant of time during a collision and how it progresses from instant to instant. Such ideas are only useful for events taking a long time and for which we can readily obtain information during the intervening period. For collisions it is much easier to treat the process as a whole.

However, if we stopped at Feynman, the process would still not be completed. Feynman globally describes processes which could still be reduced to the traditional formulation. Nonetheless, between 1955 and 1960, the position radicalized. The global description, free from any dynamic traditional preconditions, was declared to be the only possible one and theoretical physics was structured into a series of research programmes competing with each other and presenting new features. Let us list some of them and try to find some common ground: 1) the S-matrix; 2) axiomatic theory in its various branches; 3) algebra of the currents.

Is there common ground among these different attitudes? I think so.

1. None of these topics is focussed upon traditional reductive mechanisms.
2. Each tries to describe and 'globally' reconstruct the physical

84 R.P. Feynman, *Quantum Electrodynamics*, New York: W.A. Benjamin, 1961, p. 180.

world.

3. They share the principle that it does not matter where you start in the description and reconstruction of the physical world.

In order to realize the significance of these statements, it is interesting to read the words of Geoffrey F. Chew (paraphrasing Feynman)[85]: "*The correct theory should be such that it does not allow one to say which particles are elementary*." The theory of the S-matrix of strong interactions aims "to predict – given certain symmetries – all the observed particles and their mutual interactions in terms of a single constant with the dimensions length."[86]

How, then, do you set up a dynamical calculation without any one particle being more elementary than another? To this question, Chew responds: "I believe the answer to be: it doesn't matter; one may begin anywhere, taking an arbitrary singularity as a starting point and attempting to reach as much of the S matrix from this point as computational ability allows."[87]

Some observations can be made. The *a priori*, programmatic nature of this approach is evident. Where the theory proposes the reduction of complex particle phenomena to simple and essential elements, these are purely conceptual and abstract in nature. Indeed, they are properties of symmetry, coupling constants, singularities and properties of analyticity.

Obviously, my description is overly schematic, but this last point seems to me particularly important and significant. In those years, theoretical physicists who adhered to a particular programme were endowed with a series of general concepts, guiding principles which they applied to a problem or a set of particular problems. Their principles, such as, for instance, the ones of the S-matrix, were compatible

85 G.F. Chew, *S-Matrix Theory of Strong Interactions*, New York: W.A. Benjamin, 1961, p. 4.
86 Ibid., p. 1.
87 Ibid., p. 5.

with a number of specific theories and since, the aim was to globally reconstruct the world, the failure of the programme in any particular sector did not invalidate the programme as a whole. It could always be said that the rest of the world, which had not yet been taken into account, would be capable of eliminating the contradiction. Therefore, the idea of the *experimentum crucis* with the ability to invalidate the entire theory disappeared. A programme only stopped if its productive efficiency reached a deadlock, or if it was surpassed by another programme in its ability to provide partial qualitative reconstructions of the physical world, even though not in detail, in accordance with experimental facts.

The similarity of these patterns of reasoning with an idea of planning appeared several times. These are *de facto*, short-term sectoral planning approaches that ignore the whole. If we want to make an analogy, they are typical of advanced capitalism. Therefore, local rationality can coexist with global irrationality. However, just as we cannot undervalue the locally revolutionary character of capitalism, so often emphasized by Marx, in the same way we cannot ignore the intellectual dynamism of that kind of physics. Perhaps, just like capitalism, this physics also seems destined to create new contradictions. Indeed, the disappearance of explanatory reductivism destined elementary – i.e., essential – particle physics to having to declare the non-fundamentalism of its objects and lock itself into an abstract explanatory cycle in which particles only generate more particles.

In support of the particular nature of theoretical physics, I can cite a few other specific examples: Tullio Regge's theory of poles, and Shoichi Sakata's model. In the former case, it was a strictly demonstrable mathematical property of the solution to Schoenberg's equation. It originated in Italy, but it did not go beyond the strict context in which it was inferred. However, once absorbed by American physicists, it lost any semblance of rigour and became the main heuristic frame for the theory of the S matrix – namely, a programme.

A similar destiny awaited Sakata's model. It is a reductive model of the structure of elementary particles and was the product of a school of Japanese Marxist physicists. Once this idea moved to the USA in the 1960s, it lost its reductive character and became the starting point of the algebra of currents. Thus, the social context seems to be at the root of these choices of principle.

So, if we want to negatively characterize the dynamism of this physics, we could perhaps adopt the slogan: "Produce in order to overcome contradictions – or – efficiency and a headlong rush."

I think the time has come to draw some conclusions.

I started my argument with Lukács: perhaps it is not inappropriate to return to Lukács now. The relevant chapter of *History and Class Consciousness* bears the title "The Standpoint of View of the Proletariat." I would like to say something about this point of view. Marx writes that: "When the proletariat announces the dissolution of the existing order of things it merely declares the secret of its own existence, for it *is* the *de facto* dissolution of this order of things."[88] However, this dissolution and thus liberation can only be a product of its action. Science is, to this day, the tool with which the bourgeoisie plans its own destiny. Therefore, there can be no liberation of the proletariat unless it appropriates science, transforms it and makes it a tool of its own empowerment, of its own planning capacity. Only in this way will it be possible to break the process of endless rationalization with which capitalist society has proven so capable of overcoming its own contradictions. If this does not happen, even a successful revolution might still fail, having to finally settle with the old classes, the custodians of the rules of the game.

88 Marx, *Critique of Hegel's "Philosophy of Right"*, trans. A. Jolin and J. O'Malley, Cambridge: Cambridge U.P., 1970, p. 142.

Critical essays

What Is Alive and What is Dead in *The Bee and the Architect*

Giovanni Ciccotti and Michelangelo De Maria

Introduction

The chance to publish *The Bee and the Architect* once again, after almost forty years, pushes us to reconstruct the climate of hope which characterized the years immediately after 1968 as we attempt to make a critical examination of it. This is not only meant on the level of criticism of science, which was the specific object of the book, but also on the more general level of the meaning of that social transformation which 1968 was, for better or worse. We have never seen a failure, or better still, a more total discrepancy between what its meaning should have been for the protagonists of the movement – i.e., a deep, essentially socialist transformation – and what it actually was: a radical transformation of customs and manners. Indeed, we passed from a narrow-minded, obtuse respectability (typical of the post-war period in Europe, and even more in the USA, engaged in a state of almost continuous war in the name of an essentially imperialistic defence of "American Freedom" at risk of being undermined by Communism) to an openness to informality, sometimes beneficial, but often also abused. We will mention two symbolic examples (and their assessment) in order to describe the situation: in a matter of months, if not weeks, the hats and umbrellas of the employees of the City of London disappeared, which had been a sort of compulsory uniform for the unfortunate. In just a few years, poorly managed union struggles extended to Italy (and other countries as well), resulting in the corruption of public hospital personnel from department heads down to the most anonymous porter, with a real collapse of the quality of services provided. In the great melting pot of 1968, each intellectually or socially engaged person tried to find a reason for their own life choices. A generation of libertarian and frustrated idealists emerged, as well as slick, corruptible, and corrupted politicians with few ideas, followers of Machiavellianism more than of Machiavelli. Of course, there were also serious and decent citizens, who – unfortunately – were no longer willing to think and act politically. The motto "everything is politics" of those years had generated its righteous antibodies.

However, as often happens, the excessively radical cure had thrown the baby out with the bath water! Now the "misdeeds" of the 1968 leadership and subsequent generations, who had settled for the worst of those values, have led us into a dark forest from which nobody knows how to get out: neither politicians, who are very mediocre, often disqualified figures, nor professionals, often locked in power games without ideals, nor the rest of society, which fails to make itself heard or is badly represented by unions which lack any ethical sense not to mention – as a general rule – any strategies. Everything suggests that the train has gone off the tracks and that the crisis will not be solved from within (by the awareness of the need, according to Hegel) but rather by some great, largely unanticipated event. In the meantime, we enjoy our charismatic, often fake leaders (Berlusconi, high church authorities, etc.) and witness the resumption of all the darkest forms of irrationalism (a return to religiosity, the mystical "green" attempt to make Nature friendly, you name it).

Obviously, in this climate of crisis and uncertainty, people are trying to rediscover – through the reflections of others who have experienced a period of crisis – some positive and unifying idea which might help us break the deadlock by using our intelligence. As far as science is concerned, which nowadays has been devastated by innumerable ideological superstructures conveyed by strange channels, advertising included, we have gone back to *The Bee and the Architect*.

The question is: can a new reading be useful?

Let us first make a necessary, if unpleasant remark: today, *The Bee and the Architect* is an almost unreadable book. It is written in a doctrinal style and is full of Marx quotes (nowadays this distinction makes us smile, since very few people care for either Marx or Marxism, but at the time the dividing line was essential). Moreover, the authors were not professional philosophers, but rather physicists (some of us were experienced, others were at the start of their careers, we had read history and philosophy texts but were still amateurs in the field into which we ventured, but – mind you – we were not "weekend warriors" of epistemology, as some inexperienced humanists wanted to define us). We were not very accustomed to the humanistic style and we were straightforward enough not to worry too much about formal elegance. The fact that the book is full of quotes from Marx and Marxist authors (Marx, Gramsci, Bukharin, etc.) should not come as a surprise. It is, indeed, a true sign of the times and deserves an explanation for those who were not there. Everything else is just a lot of criticism from sloppy scientists, illiterates for "literati," and requires no further comment.

The year 1968 marked a deep discontinuity in post-War culture which was more easily manifested in Italy than elsewhere given the limited cultural forces in the field because of the strong provincialism resulting from the poverty of the reconstruction period

Before 1968, people were either Catholic or Marxist. The two choices coexisted, as is typical of eclecticism, but this was somehow irrelevant. The "mysterious" convergence of the two options produced – for instance – on lay-communist minds by the impact of the arguments typical of the Barbiana School, is a classic product of the chaos of 1968. There were a few "third way" intellectuals, but this was a silent minority. The concept of secular status, in particular, was universally absent. Therefore, it was difficult to think outside the box. In order to think freely, you could only start from there.

The exaggeratedly anarchistic freedom of post-1968 culture (partly due to the historical weakness of academic traditions which could – and should – have fixed standards) was the result of a partial "coming to terms" with it (*si bien que mal*, as the French say). Within a few years, the very parochial language – which used to be habitual – disappeared, leaving room for a much freer search for the "truth" which, however, does not seem to have flourished. This is one of the reasons for our contemporary problems.

The two kinds of parochialism mentioned above (needless to say, Marxism seemed like pure spring water compared to the closed, stale and provincial theories of the official Catholic culture) were not able interpret or lead social development, neither as theories of society nor as ideologies. Therefore, everyone was forced to find their own way, with despairing and transient dogmatisms (it is difficult to say how many studies on the fetishism of Marx appeared in those years...) that opened the way to more satisfying interpretations of reality. However, that "*itineriarium in mente dei*," could not help but start from the first principles chosen up to then. For us, authors of the *Bee*, these principles could only be the ones which you can find in Marx's works since Marxism, with its dogmatism, had started showing its theoretical weak points. Looked at in retrospect, this narrow way does not hide the actuality and truth of the problems in question; the validity and utility of knowledge, scientific knowledge in particular; trust in human capacity and possibility of transforming society according to human – and not inhuman – purposes; the chance create a non-ideological ethics grounded in humanity (rather than mysticism like religion) and universal enough to be convincing and, somehow, limit, enlighten, and guide action. In order to achieve all this, the *Bee* was not enough, but the idea was to create the conditions for such a work and to write the *prolegomena* for an integrated science of this type. In this sense, the *Bee* laid the foundations for tackling the problem today, so that it is worth reading and thinking about it again. When the book appeared, it was very successful but more controversial than constructive, full as it was of misunderstandings, and it generated nothing concrete. Perhaps this is why it deserves to be taken up again. Let us see in detail what followed the publication of the *Bee*, in the presence of an inadequate academic structure, as the Italian university system was – and still is. From the academic and humanistic branches (Lucio Colletti, Paolo Rossi) and from the political orthodoxy (the Gramsci Institute, as represented by its Director at the time, Valentino Gerratana) the book was condemned to the final judgement of God, without even being read. This sparked curiosity and was probably at the root of the success of a book that was so difficult to read. At the same time, such a brutal liquidation did not help understanding the work at all, but only created sides. In those weeks of harsh controversies, we recall just one review which fully grasped the spirit of the book, written by a physicist from Milan (Antonello Sparzani) and published in the *Quotidiano dei Lavoratori*, the newspaper of the Avanguardia Operaia. From the more "progressive" academic-sociological side, the book was hailed as messianic. Students were sent to us – the authors – in order to write dissertations *on* the book, rather than *developing* its possibly useful ideas. This exposed a huge void of ideas which, later on, Sokal's hoax brilliantly highlighted.

Finally, the reaction of the scientific academy was sympathetic, but that's all. In the period after 1968, all "progressive" faculties had equipped themselves with science history groups and teaching initiatives. However, in pure Italian style, very little was done to make these positions competitive and cutting-edge, and the enthusiasm soon subsided.

On the other hand, politics soon forgot the complexity of the message and moved in different ways. The historical left lost all interest in the question. The new left, born from 1968, developed and enhanced the anti-rationalistic impulses that had had run freely throughout the 1968 rebellions. The rather agitated and emotional issues of ecology took the place of the discussion started off by the *Bee* about the role, the possibilities and the limits of scientific and technological knowledge in a democratic society.

Under these – not particularly promising – conditions, we think it is right to try and single out what is still alive and what is dead in this book published in 1976.

We will start from the issue of the validity of scientific knowledge and then move on to the issue of the non-neutrality of science and the problem of democratic control of the development of knowledge.

We will only briefly mention the attempt at a political, economic and sociological reflection on society and science in capitalist society. In our opinion, this theme proved to be less challenging. Not only it did not lead to developments, but it was also shown to be superficially descriptive and very little normative. It left fundamentally untouched all the issues that we wanted, if not to solve, at least let mature.

The Epistemological Question of the Non-Neutrality of Science

How it arose

The first question which it seems appropriate to ask when you put take the *Bee* in your hand is where did its central problem come from, i.e. the non-neutrality of science? Then, what exactly is the problem? Finally, is the solution given in the book still valid and of interest?

Shortly before 1968, let's say in 1966, when our story begins – as we will see – our rather composite group, actually still unaware of being a group – was composed of an established physicist (Marcello Cini), another physicist close to having completed the first, most important, part of his career (Giovanni Jona-Lasinio), and two "sorcerer's apprentices" (Giovanni Ciccotti and Michelangelo de Maria). We were all operating, more or less, under the banner of Marxism. More correctly, we were all proponents of secular and radical culture, and we were looking with interest at political and social processes, having a generally socialist perspective (at the time, it would have been defined as "social-communist"). The eldest of us, who was also the pole star of the young ones, had a solid scientific-engineering training, was rather agnostic in philosophy, quietly positivistic and little problematic on the foundations and intrinsic value of science. On the other hand, he lived his ideological commitment with radicalism and had already expressed strong criticism of the capitalist (ab)use of science. In those years, the second most senior was what is usually defined as a man of culture: he had rather extensive scientific and philosophical interests. Of both Catholic and Jewish background, he also flirted with religion. At the time, he was anything but a radical. On the other hand, we younger ones were experiencing a strange contradiction: as sorcerer's apprentices, we had a deep trust in science: not for nothing we had chosen to become physicists. However, because of the times, we had many doubts about the soundness of the foundations of science and a great longing for clarity. Therefore, over and above scientific training and politics, we kept a keen eye on philosophical discussions, whether Marxist or not.

In these years, among positivism, conventionalism and operationism on the one hand, and historical, dialectical and structuralist materialism on the other hand, European culture (Italian and French in particular, whereas Anglo-Saxon culture had not been much affected by the revival of Marxism) seemed to be looking for solid foundations of knowledge, *including* in the most trusted bases, namely natural sciences. The fundamental philosophical problems started mixing with political and ideological problems regarding knowledge. In the Marxist version, these are class problems (however, remaining vague, this knowledge became the knowledge of exact sciences). Thereby, the issue of the objective value of scientific knowledge (known at the time as the issue of the non-neutrality of science) became less marginal and moved to the centre of attention.

This was an age in which one passed with continuity from cultured speech in politics – including peripheral reasoning on the value of scientific knowledge – to the rediscovery of the critical fathers of science (Poincaré, Bachelard, Bernard, among others), as well as to modern historians of science and epistemologists (Koyré, Farrington, P. Rossi, Kuhn, Lakatos, and so on). All this without forgetting the political theme of planned social development, which typically involved a judgement on the nature of science (Lysenko is a magnificent example of how mental short-circuits, supported by political power, can produce disasters).

At this point the situation was quite clear. As for us young people, the contradiction we had vaguely felt was now evident and could be clearly expressed. Are natural sciences a non-ideological form with an ahistorical validity (apart from the obvious and trivial increase of knowledge, and the possibility of making mistakes which, later on, historical developments may eventually correct), or do they take part in ideology – whether dominant or alternative – as suggested by Marx? In the extremist circles of 1968, people opted for the latter alternative. On the other hand, we thought that the question deserved to be examined in more detail in order to obtain a more convincing answer.

How it can be defined

Therefore, we used accurate historical analyses, made a large use of Aristotelian distinctions, but employed very little dialectics (mainly Marxist dialectics, which we happily declare, *apertis verbis*, not to have understood as yet; in particular, we totally missed everything that even vaguely referred to Hegel's philosophy of nature) to arrive at conclusions which we still consider valid and which we will sum up here in a justifiable (rather than demonstrable), but apodictic manner.

1. There is no evidence for living entities transcending the sensible world. Even thought, the most impalpable thing we know, has a material basis. From what we can understand, we would say this is an electro-chemical basis.
2. Humans, symbolical animal *par excellence*, create these entities by deciding that they existence, with an evident abuse of power. With them, people make conjectures and create systems of thought which may help them in acting (surviving and extending their "zone of influence") and in building their own environment. These "systems of thought" also include logic and are necessarily conjectural and conventional. This does not detract from their validity, which actually becomes a problem: namely, how to distinguish between valid thought/knowledge and pure fantasy.
3. All systems of thought have in common an "ideological" nature (symbolic entities of reason), but that does not mean that they are all true/valid or, vice versa, all false. In the *Bee*, we used a typical Aristotelian argument to drive this point home. Generally speaking, all systems of thought are ideological, but ideology as such includes many different "species," such as religion, myth, science, etc., which have every right to be different from each other. The fact of belonging to a certain type, however, introduces an essential constraint: namely, they cannot be in contradiction with the characteristics of the genre. In the *Bee*, we illustrated this with the concept of a mammal: a monotreme, a cow, and a human are all mammals, and yet the specific differences are such that it is difficult to recognize the relationship. Sciences can boast of being the most guaranteed, verified and

stable “ideologies” that can be imagined. In fact, other known forms (myths, religions, political ideals) seem more strictly related to human imagination and symbolic capacity than to a universal intersubjective confrontation. Hence, the concept of a law of nature has a much stronger validity than the legal concept of law.

4. However, the fact that exact sciences are also “ideological” allowed us to understand why, beyond the banality of their temporal growth, all sciences – hard sciences included – have a not so trivial evolution and therefore a historical character which is similar (in the *Bee* we used the definition “coherent with”) to the one of the society within which they developed. Here, too, we basically agree with the arguments of that time, even though further developments (for instance the discovery of Alexandrian science, which is very far from Aristotelian science) and the blurring of the concept of class, typical of Marxism, led us to better define the concept.

Let us see what it was and what it is, with a few examples, and then enunciate the problem in general.

How was the matter sorted out? Where do we stand?

As has been wisely demonstrated by professional science historians, Aristotle’s physics was not wrong. In it, we find the perfect description/prediction of well-known physical behaviours which are considered to be significant and successful, sometimes in circumstantial approximation. However, for the way it is put together, that physics does not intend to go *beyond* nature, as is typical of modern physics, but simply describes it correctly and determines “natural” limits of behaviour (i.e., describe a being, inasmuch as being was Aristotle’s “motto”). Among other things, it is significant that machines (which he defines as *automata*) cannot exist. If they existed, they would do the work of slaves by themselves so that slaves would no longer be needed. However, Aristotle argues, slaves exist by nature, therefore machines cannot exist! It is useless to underline that what we define as modern science was actually born in order to build machines, even though, at least "*in nuce,*" that kind of science was already there in the Alexandrian era.

In the second example, Aristotle enunciates in his physics the correct law according to which all bodies fall in fluids with a speed which is inversely proportional to the density of the medium (nowadays, we say "limit speed" because we have the concept of instant speed, and the law is only valid for the speed reached asymptotically). Then the conclusion immediately follows that the void does not exist. Indeed, Aristotle says, since in the void the (limit) speed would be infinite, i.e., it should move the body across an infinite space in a finite time, whereas we *know* that the Universe is finite – thus there is no void.

Finally, as reported on purpose by Thomas Kuhn in his fundamental book *The Structure of Scientific Revolutions* (1962), the satisfaction of Aristotle is well-known when he ascertained that, after a certain amount of time, the pendulum stops at the bottom (the "natural" place for bodies, according to Aristotle), whereas for Galileo that is a monstrosity (energy should be conserved and the pendulum should continue to go up and down indefinitely), which requires an explanation. There is agreement on the fact, but conflict over the reasons.

In all these cases, the hallmark is that Aristotle works in a perfectly reasonable way from the scientific point of view but includes in his reasoning more markedly "ideological" elements, related to the times he lived in, and coherent with the structural features of his society, whereas "modern" scientists, though working in the same way, start from a more open and active worldview, enjoy greater freedom and reach more universal formulations. Indeed, it is impossible the ignore the “consistency” between the two kinds of physics and the societies they were born in. Ancient society was based on wars and slaves, whereas modern society is based on bourgeoisie and development. Therefore, there isn’t a bourgeois and a proletarian science, but rather a legitimate, better still, a necessary discussion within and outside science, which is immersed in its own world, on the most satisfying way to grow and how to accomplish it. The nature and intricacy of this discussion are more than worthy of study and would deserve a chapter in itself. For example, Bacon had perfectly understood the inadequacy of Aristotle’s science for achieving the goals of transforming and controlling Nature, which it had set for itself, while being unable to contribute anything lasting to modern science. Thus, nothing moved in the old Aristotelian theory, even though there had been strong pressure on scientists to change point of view. Conversely, Galileo hd made a significant contribution to change without being aware (somehow against what is suggested by Bertolt Brecht) of the role of his scientific creativity in this shift of paradigm (as Kuhn would say) and society.

Not that a “modern” approach was impossible even in ancient times (as “modern” Alexandrian scientists seem to prove), but it is not without significance that an “incoherent” proposal was conquered militarily and politically by the Romans and then forgotten, since the Romans, though appreciating possible technological results, could not understand their origins, being utterly incapable in maths and scientific reasoning in the modern sense of the word.

Which is to say that, regarding the issue of the “non-neutrality” of science, the validity of scientific knowledge is not up for discussion (as far as possible, it is guaranteed and verifiable at any time in history). Unlike the most elementary symbolic forms (myths, religions, political ideologies, etc.), which are deeply rooted in subjectivity, exact sciences have a high degree of objectivity which manifests itself both in space and time. Logic and maths, coming from our "inner sense," are more universal (if you accept principles and rules, everything follows *necessarily*): natural sciences, which are descriptive, are less "neutral," but possess a standard of objectivity which cannot be reached by other symbolical forms.

What is in question, instead, is the nature of scientific growth, which seems to proceed more through trial and error, where the choice of "coherence," without being fundamental, has a certain weight. Here we see the intervention of the concept of planning conscious choices as well as the modern concept of "research system," but we are opening up a new problem and going beyond the *Bee*, where there is only an explicit invitation to address this challenge. So far, we are still *toto corde* with the *Bee*. However, going into the details of this position, I think that a further explanation would have saved us from possible sociological misinterpretations which did not help to correctly understand the book.

After Koyré, who had helped us understand the revolutionary nature of the passage from classical ancient science (we say this in order to keep the Alexandrian scientists out of antiquity) to modern science, we encountered Kuhn and his idea of growth of knowledge through revolutionary ruptures. Once again, this concept of Kuhn has nothing to do with the validity of scientific theories going under, but rather with the way in which new theories originate. It is not a matter of "paradigmatic" developments, but rather of new concepts and worldviews. The plurality of revolutions identified by Kuhn, which went far beyond the simple contrast between ancient and modern science, convinced us that "coherence" with social development could (and should) be sought also in these – so to speak – "minor" conceptual transformations (at least if compared to the broad opposition between ancient and modern).

Not that this is illegitimate or senseless, but the ground is slippery, and one must beware of platitudes. Sustained by the chronological placement of history – of Marxist origin – (in some sense it was teleological, because it foresaw the end of history), which considers four social structures – slavery, bourgeoisie, aristocracy and proletariat – to be fundamental, in the *Bee* we strongly supported this search for coherence between the development of conceptualization and society. In the historical chapters, we also discovered some interesting correspondences. However, we are now convinced that the concept of coherence has a certain meaning in major transformations but is meaningless as you move towards microevolutions (incidentally, this is also true of Kuhn's scientific revolutions). Conversely, if you do not look so much at *scientific concepts* individually taken, but rather at the whole set of concepts and methods of the *research system*, then coherence becomes a strong concept which opens up – studying its mechanism in detail – the possibility of political intervention, driven together by reason and purpose. This is the area in which we would like to see scientists work. We will gladly leave sociologisms to those who have time to waste.

We would like to finish off these brief remarks with a joke. We started to grapple with the problems of the book, spurred by the 1968 chaos, since we are (neo)Kantian in epistemology and ethics ("practical reason"), but Marxists in the theory of history and politics (science and practice of goals, respectively). About forty years later, having discovered in Kant the science of ends in his *Critique of Judgement*, we can say that, though respectful of and interested in Marx, we are now (neo) Kantian only.

Relevance of the Bee's Contribution to a Sociological Analysis of Science

In a non-academic, ideological battlefield book such as the *Bee*, you should not look for a systematic structure. However, it is clear even to a superficial reader that the book presents two major issues: namely, understanding the value of science in itself and within society (the design of science and the poverty of scientism), which includes chapters 1, 3 and 4, and the first work of the appendix, and the political wish to give a sociological definition of science, which includes chapter 2 and 5, and the rest of the appendix. In our opinion, the latter part has emerged as much more null and void. It has two key-concepts: in modern capitalism, science – as information – is a commodity and its essential function (for which you cannot do without, as the ancient Romans tried) is the test circuit of technological innovation, a tangible and intangible asset to bring into the commercial circuit of the developing capitalist society. We will keep this brief, since the past few years have helped us to clarify our ideas. Considered in the abstract, the above-mentioned concepts are not wrong. However, in light of the facts, they have proven useless both in politics and in theory. In politics, they are descriptive rather than normative – concepts, so they do not help to define a functional practice for progressive purposes. In theory, they did not manage to put much order to such an important matter as the social function of science. They remain a useful document of the exhausting search for truth in the troubled climate of the years following 1968.

Conclusion

In these years, science has largely demonstrated its validity and liveliness over and above its great capacity for technological innovation. Our generation could laugh at our parents who, in their youth, had not known the phone, the plane, or the radio, not to speak of television, and in some cases, even home electricity.

We were at ease in all this; we had no idea, not only of GPS, but also of fax machines (nowadays already wholly superseded), of the possibility of mobile phones or consultable databases on the Internet. In less than a generation, the Internet and online information have largely supplanted paper information (books, magazines and so on). The very concept of Diderot's Encyclopaedia is dead and buried. In this situation, science and the research system should be more and more at the centre of attention. This happens in the rest of the world, but not in Italy, where the most ambitious expectations have been replaced by a state of melancholy resignation on the left, often led by superficial – if not false – ideals. In all this, we consider Sokal's battle an amazing example of well-made resistance.

In this context, the themes of the *Bee*, within the precise limits outlined above, possess an unsuspected truth and actuality, and are still absolutely interesting, important and worthy of being (re)discovered and used as a structured motivation for research. There is only the regret of forty years which were somehow lost. In particular, the study of the evolution of scientific ideas, in terms of their internal logic and coherence (or incoherence) with the surrounding society, and the search for the aims implicit in the development of the research system constitute the core issues of the *Bee*, and they are still waiting for their Newton. That is all the more important as science, in order to become an element of social progress, should first of all become culture, and therefore be understood in its meaning, beyond the circle of its "wise" practitioners. Afterwards, once valued by the majority of people, it can become a useful political element that is potentially progressive in terms of human development. As it is now, science only serves those who take possession of it and use it for themselves, without regard to the general interest, and without taking into account the possible contraindications of its use. In other words, in most people, the idea of science for science's sake can only generate either a resigned acceptance of its benefits or a suspicion and fear of this esoteric activity, endowed with sorcery and/or religious power, whatever the intellectual pleasure associated with this beautiful and interesting knowledge, which is motivating for those who engage it with creativity. May this reprint help us to go in the right direction.

A last, dutiful, observation, by way of an acknowledgement. For one of us, GC, the maturation in these issue in the last thirty years is the product of cultural and ideological "quarrels" – always constructive – with his wife, Nicoletta Bosisio. In particular, this happened during the work on the present text. At first, we wanted to include her in our notes, but since she declined the invitation as she was not among the authors of *The Bee and the Architect*, GC considers it his duty – and pleasure – to admit his intellectual debt and her important contribution to the ideas expressed in these pages. On the other hand, all of us would like to remember the various friends to whom we submitted our texts, who gave us useful suggestions which we hopefully understood and used well. In particular: Giovanni Battimelli, Arianna Borrelli, Marco Lippi, Anna Tramontano, all of whom we are delighted to thank.

The Bee and the Architect: Thirty-five Years Later

Marcello Cini

1.

When the book was published in 1976, a very lively debate was immediately sparked by Lucio Colletti's hatchet job of in *L'Espresso*. His "critique" was based on a series of obvious banalities, such as "bodies fall in the same way under the action of gravity, both in socialist and in capitalist countries," or "there is a fundamental difference between scientific truths, the sermon by a parish priest, or the report of a party secretary." The conclusion was that science is objective knowledge *tout court*, and therefore saying that the social context affects scientific parameters is complete nonsense.

The weekly magazine correctly asked us to reply to his criticisms, and we followed suit. This exchange of words was enough, in a period of heated polemic over everything to do with Marxism, to enlarge the discussion, thus creating an unexpected advertisement for our theses, upon which everyone wanted to express their opinion, if only to say something bad about them.

A storm of criticism followed this exchange. Criticism came from representatives of the most varied disciplinary areas and political-cultural affiliations. Philosophers accused us of field invasion: Marcello Pera invited us to study Popper and defined us as "amateur epistemologists." Ludovico Geymonat claimed the validity of Engels's "dialectical materialism" as opposed to our reference to Marx's "historical materialism." Our physicist colleagues were – obviously – even more severe. They had not liked Thomas Kuhn's book *The Structure* *of Scientific Revolutions*, which highlighted the historical character of the evolution of scientific concepts and categories, since they saw – in the subtitle – the concept of paradigm juxtaposed to "historical materialism."

In fact, the subtitle immediately placed Kuhn's theses in the political and cultural context of the time. The term "paradigm," which subsequently entered common use for historians, sociologists of science and, more generally, in the cultural vocabulary, well represented for us – and still represents for me – the form taken at a given historical moment by a body of knowledge shared by a given disciplinary community dedicated to deepening and articulating this knowledge in different directions, without questioning its conceptual core.

On the other hand, the second reference in the subtitle, i.e., historical materialism, is very old and, nowadays, almost incomprehensible. This is certainly not the place to discuss it. I just wanted to remind you that our purpose was twofold. First of all, our approach enabled us to argue with the official philosophy of the Soviet regime – dialectical materialism – which had led to the aberrations of Lysenkoism in genetics and the excommunications hurled by Zhdanov, Stalin's Minister of Culture, against other scientific theories: from Copenhagen's interpretation of quantum mechanics in physics to the concept of molecular orbitals in organic chemistry.

On the other hand, this approach also allowed us to criticize the supporters of the absolute character of the categories adopted by science in order to describe the world, as well as the supporters of the universal, ahistorical validity of a scientific method taken as a criterion of demarcation between scientific knowledge and – more or less – subjective beliefs.

Doubtlessly, the interpretative categories of the developmental dynamics of capitalist society we used in order to analyse the connections between the social fabric and the growth process of knowledge were typical of the Marxist tradition in which we were immersed. It is also true that the Marxist references we adopted enabled us to give shape to our basic thesis, according to which the truths of science have, at the same time, an objective content, rooted in the concrete reality of the surrounding world, and a subjective form – of course, a collective subjectivity – exercised in accordance with precise rules by socially recognized scientific institutions. This subjectivity comes from the categories which, in a given socio-historical context, scientists adopt in order to represent them.

We can obviously discuss to what extent and by what means this categorization process may draw inspiration and impulse – over and above the internal problems of a given discipline – also from the wide variety of phenomena, conflicts, interests and values that crisscrossed and animated the social fabric in the historical period taken into consideration. I can even admit that our analysis, in the political context of the decade between the 1960s and the 1970s, over-simplified the relationship between "science" and "capital," thus skipping significant mediations and laying out exaggerated generalizations.

But the fact remains that this analysis allowed us to accurately foresee the essential phenomenon of this century: namely, the growing tendency of capital to shift the qualitative and quantitative weight of the production of commodities from the sphere of material goods to the sphere of immaterial goods.

2.

As for me, a few years before the publication of this book I had already entertained the notion that a radical transformation of capitalist production was looming on the horizon, caused by the change of the role played by science in the production process. My first article about the relationship between science and capitalism, entitled "Science, Technological Progress, Capitalism, and Class Struggle," (in this volume) dates back to 1965 and was published in *La città futura*, the magazine of young communists.

In December 1968, we held a preparatory meeting at the Gramsci Institute in order to organize a conference on the problems of research. I was entrusted with the task of witing the general part of the foreword. In it, I took up topics which had already been introduced in some articles published in the preceding years in the theoretical magazine of the Italian Communist Party, *Il Contemporaneo*, reread in the light of the recent experiences of the French May and the student revolts. The thesis of the non-neutrality of science was formulated and argued in them.

I wrote that the concept of science and technology as neutral instruments for the progress of society – regardless of social relations – was suffering a crisis. This concept assumes a process of scientific development that follows its own internal dynamic, subject to its own laws. At most, this dynamic can be favoured or hindered by the structure of society, but it cannot be altered or determined in its substance.

However, it should be clear that the affirmation of the non-neutrality of science has nothing to do with positions close to Zhdanov, nor does it propose arbitrary extrapolations of laws, development trends and interpretative patterns from the social sciences to the humanities and natural sciences. One should recognize that science is not only a process of problem-solving which can be used for problems posed by external reality to individuals and society, but above all a continuous formulation and proposition of problems to be solved, so that at this essential stage of scientific development, not only intrinsic factors are included but also factors which are external to science itself.

This kind of analysis allowed me not only to grasp the existence of a close connection between the newly born computer *science* and the future computer *industry* that would ensure their mass diffusion, but also the crucial role which the latter would play in the development of capitalism as a world system. During the discussion following the presentation of the foreword, I added:

> I am quite convinced that, in the next twenty to thirty years, we will witness the development of the computer industry resulting from the increased private use of computers, similar to the private use of cars [...]. This development will introduce forms of further selection, enslavement and competition, and to people's imprisonment in an increasingly inexorable logic, mainly due to private consumption. Clearly, this industry – from the economic point of view – can enhance the development of the economic system, just as the auto industry did, but it also lends itself to providing individuals with a type of consumption which enslaves them like a drug.[1]

Certainly, nowadays I consider this prediction as exceedingly catastrophist. However, if you think that thirty years ago Bill Gates was a mere boy and computers were only very expensive giant mainframes, which only institutions like the Pentagon and the Atomic Energy Commission could afford, my prediction for the future was quite correct. Irrespective of the assessment of this phenomenon, nobody can deny that, without the network of personal computers, there would not have been the globalization of markets and products of the last few years, without which capitalism would be very different.

3.

In 1972, a few years after the meeting at the Gramsci Institute, I started to reflect, together with Giovanni Ciccotti, Michelangelo de Maria and Giovanni Jona-Lasinio, on the nature of science, on *big*

1 In *Bollettino CESPE*, Proceedings of the Conference "Problemi della ricerca scientifica e tecnologica," n. 25, December 1968.

science in particular. By that expression, at the time, we indicated the typical form of scientific production in advanced capitalist societies based on the investment of huge sums of capital and on the division of labour and production as an end in itself. That was a form which was markedly differentiated from the form which science had assumed until the mid-20th century: i.e., individual and artisanal, investigating natural phenomena and their properties.

Indeed, we wanted to understand how such a radical change in scientific production had affected the epistemological status of objectivity and certainty led to belief in a pure and disinterested science.

The drafting of the results of our research took almost two years and was published in two essays – "La Progettualità scientifica contro lo Scientismo" [Scientific Planning against Scientism] and "La Produzione della Scienza nella società capitalistica avanzata" [The Production of Science in Advanced Capitalist Society] (both in this volume). In the former, whose merit must be fully attributed to Giovanni Ciccotti, who was also the driving force behind this joint effort, we laid the groundwork for our reasoning.

In short – having realized the crisis of trust in the meaning and usefulness of science – both on a mass level and within the scientific communities engaged in the transformation of society, the purpose was to fight against the false dilemma between obscurantism and scientism proposed by the traditional academic culture. On the second page we can already read that:

> Anyone – whether a technician, scientist or just a responsible citizen – experiences the conditions of crisis every day but has no sympathy for irrational attitudes, knows how pointless the long and learned academic dissertations are when they evoke science in order to defend it from its denigrators and represent it in a way that has very little in common with its real nature. People know that, as long as there are no *positive*

> answers to the questions raised over time, and only *formal*, superstructural solutions are provided, it will be impossible to start a real process of subjective and objective reappropriation of the power of dominion over Nature, a power which is currently objective both in the means of production and in science.

I will not dwell on the development of the arguments at the time, also because I think Giovanni will do so in another parallel essay. I shall only quote one of our final statements, which I think is still valid – better still – is more valid now than before:

> What we would like to emphasize is that, as the process of scientific transformation does not depend on the realization of an internal logic that is absolutely beyond human practice, it can be controlled, at least in conflictual situations, which are critically predictable. The problem of science, examined in a scientific way– with all due respect for scientists, who do not tolerate being examined by their own methods – is nothing mystical or radically different from the problem of society. Through its development, science shows that it is a well-defined function of social practice.

On the other hand, the goal I set for myself in these introductory remarks was to mainly refer to the essay "The Production of Science in Advanced Capitalist Society." The main reason for this choice is that its contents were linked – on the one hand – to the reflections about the relationship between science and capitalism which I had been developing for a few years, and on the other hand, they represent the bases for the development of my thought in the books which I published in the following years, up to the latest one, written together with Sergio Bellucci and entitled *Lo Spettro del Capital* [*The*

Spectre of the Capital].[2] Therefore I resume the thread of the speech, starting from this explicit acknowledgement of the partiality of the viewpoint adopted.

The key to analysing the typical aspects of contemporary capitalist society was offered by a sentence in the *Grundrisse* – a real precursor. According to Marx, the most advanced stage of development of capitalist society is only reached:

> when large industry has already reached a higher stage, and all the sciences have been pressed into the service of capital; and when, secondly, the available machinery itself already provides great capabilities. Invention then becomes a business, and the application of science to direct production itself becomes a prospect which determines and solicits it.[3]

Therefore, the production of inventions would become, at that stage, an economic activity, and therefore inventions would be a particular form of *intangible commodities*. However, it was clear that Marx was not talking about the capitalist society of his time. Indeed, he recognized elsewhere that "with non-material production [...] All the phenomena of capitalist production in this area are so insignificant in comparison with production as a whole that they can be disregarded entirely."[4] The most advanced stage of capitalist society Marx was talking about was a future one, namely ours. Therefore, we had to start from here in order to find an answer to our questions.

Then we realized that the highest stage of capitalism predicted

2 S. Bellucci, M. Cini, *Lo spettro del capitale. Per una critica dell'economia della conoscenza*, Turin: Codice, 2009.

3 Marx, *Grundrisse*, p. 623.

4 Marx, *Economic Manuscripts of 1861-63*, in *Marx & Engels Collected Works*, vol. 34, trans. B. Fowkes, London: Lawrence & Wishart, [1863] 1989, available online at: https://marxists.architexturez.net/archive/marx/works/1861/economic/ch38.htm.

by Marx had started in the second half of the 20th century, with the appearance of a larger and larger production of non-material commodities. It was a real qualitative leap. In the preceding stage, until the Second World War, capitalist society had been based on, as it is written in the first few lines of Marx's *Capital*, "an immense accumulation of commodities." However, he was talking about things, objects, material goods and hand-made products, coming from raw materials, in definite places – factories and fields – and carried elsewhere to be used and consumed individually by those who came into their possession, within an overall localized market. He was not talking about words, images, sounds and symbols.

However, starting already from the 1930s, but more massively after the Second World War, the production of material commodities ceased to be the only source of profit for capital. Not only was there a growth of investment in the tertiary sector for the production of services for the market, but there was also a huge investment in the production of *information*.

Ever-increasing capital is invested for the production of new information destined, in turn, to produce other commodities (innovation of both product and process, know-how, labour organization, but also marketing and advertisement, and above all software of all kinds) and for the production of information which is directly "consumed" from mass media (radio, TV, newspapers, shows, tapes and records, databases and wire network services).

In this case, too, as it was for computers, now that everyone is talking about "information society," these statements appear trivial. However, thirty-five years ago, as we were writing that the reduction of information to commodity was a turning point in the development of capitalist society, no one on the left understood what we were talking about. Neither orthodox Marxists, who considered our argument to be not fully anchored to the principles of dialectical materialism, nor the reformers, who did not tolerate that the essentially progressive role of science be questioned.

On the one hand, indeed, we were explaining that capital tends to submit information to the same economic laws as material commodities:

> in our contemporary capitalist society, the capitalist production of intangible commodities in the form of goods has achieved a remarkable importance. Not only are inventions produced in the form of commodities, but also a significant quantity of other *information* related to the productive process (know-how, industrial organization, management) or to consumption (marketing, advertisements, etc.) is produced in a capitalist way or, in Marxist terms, by workers who produce surplus-value.
> Moreover, the information produced as commodities immediately "consumed," has grown immensely, from mass-media communications (radio, TV, newspapers, magazines, records, tapes, etc.) to individual communications (phones), from education (partially) to shows. Most of these spheres of production are still subject to the capitalist mode of production. This means that the proportion of capital invested in this sphere of production becomes significant, resulting in the absorption of a relevant number of salaried workers. Unlike what happened at the time of Marx, their salary is a capital investment rather than an income for consumption. Indeed, their production is destined for the market.

Therefore, in this way, "The free availability of information to all interested parties, which more or less maintains its value in use over time, has been replaced by a private consumption of information which cannot be used unless it is consumed as soon as it is produced."

However, on the other hand, we remarked that information is also quite different from material goods:

> From the viewpoint of use value, it can be consumed indifferently by many or few people, without each having to give up a greater or lesser part of what they receive. In some cases, also in the past, in order to reduce information to a commodity, namely in order to give it an exchange value, they had to prevent – by various devices – its use by others besides the buyer. Thus legal protections obliging those who come into possession of certain information to pay a certain price to the producer, or restrictions which physically prevent those who have not paid the corresponding price from accessing the tools providing information. In these cases, therefore, "exchange value" seems less linked to the time needed to produce it than to the number of consumers.

4.

The production of science has traditionally been considered – and still is, from a certain point of view – a disinterested activity aimed at searching for objective relations between elements of reality, only driven by the curiosity, or thirst for knowledge, of certain individuals without utilitarian motives. In this sense, we tend to underline the distinction between the moment of learning, typical of science, and the practical moment of the application and use of its discoveries.

However, as we have already broadly discussed, this distinction has never been absolute, not even in the past. Nowadays, the narrow link between "pure" research, which is only conducted in order to discover nature in a selfless way, and technological innovation, stimulated by interest in continuously inventing new tools to satisfy the demands of an increasingly demanding and sophisticated market, has become a tangle that is difficult to unravel.

In sum, we said that scientific knowledge, even when it is not immediately destined for the market, could not help being produced – not to be left behind – in the same way as information which is bought and sold. The mechanisms of this integration of the production process of scientific knowledge into the social tissue were analysed and discussed in the *Bee* by Gianni Jona-Lasinio in an important essay entitled "Changes in Scientific Practice in a Technological Society." In particular, he highlighted – with concrete examples – how, in the last century, the different contexts of the USA, European countries, Japan and the USSR affected the modes and purposes of research programmes, even in the so-called fundamental sciences.

In any case, I leave it to him to develop and eventually go deeper into the topic, and I would simply underline that our common conviction that science could not have remained stuck at the crafts stage in front of the massive transformation in the production of information as commodities due to the entry of the capital in this production area. I would, however, like to stress that we have never said that science and technology are responsible for the injustices of capitalist society. We have never been Luddites, nor have we ever sympathized with them, although we have often been accused of this.

We stated in the book, and I think this statement is still right, that there is a close link between the trends and growth of science with everything that characterizes the surrounding social fabric in a given historical moment: from cultural traditions to economic interests, from dominant ideas to ideological conflicts.

I personally believe that those professionally involved in science should engage in continuous criticism within their institutes regarding the choices, priorities and trends in the overall panorama of science so as to bring to light the more or less hidden ties between those choices and the process of capital accumulation which is entering into all areas of individual and collective life in contemporary society.

5.

Thus the essential differences between the production of tangible and intangible commodities were already clear to us at the time, both in the sphere of production and consumption. Nowadays, these differences are forcefully denied from the viewpoint of capital so as to justify the appropriation of an asset which is public in nature.

For example, Thomas A. Stewart, Editor of the well-known US magazine *Fortune*, clearly explains in his book *Intellectual Capital: The New Wealth of Organizations*[5] that, from the point of view of capital, they are no different from the production of material commodities. Capital invents infinite different ways to ensure that the fundamental fact – the production of commodities – does not change:

> *Intellectual capital is intellectual material – knowledge, information, intellectual property, experience – that can be put to use to create wealth.* It is collective brainpower. [...] Once you find it and exploit it, you win.
> You win because today's economy is fundamentally different from yesterday's. We grew up in the Industrial Age. It is gone, supplanted by the Information Age. The economic world we are leaving whose main sources of wealth were physical. [...]
> In this new era, wealth is the product of knowledge. Knowledge and information – not just scientific knowledge, but news, advice, entertainment, communication, service – have become the economy's primary raw materials and its most important products. Knowledge is what we buy and sell. [...] The capital assets that are needed to create wealth today are [...] knowledge assets.

5 Stewart, *Intellectual Capital: The New Wealth of Organizations*, New York: Doubleday, 1997, p. x.

Therefore, knowledge is compelled by capital – against its common good nature, whose use increases the individual wealth of knowledge without depriving others – to become a rare asset, available only to those who can afford to buy it.

On the other hand, from the point of view of work, much has changed. In the stage of producing material commodities in the capitalist factories of the 20th century, labour was parcelled and sizeable as the sum of time necessary for a series of successive, pre-established basic actions performed by an unskilled worker (Taylorism). In the capitalist production of intangible commodities, on the other hand, work cannot be reduced to pure quantity. Even in the simplest form of production of *signs* endowed with *meaning*, there is a *qualitatively* essential individual component that is not quantifiable in terms of time. In the factory of *objects*, the source of profit lies in the *quantity* of salaried work, whereas in the factory of *signs*, it lies in its *quality*.

6.

In our 2009 book,[6] Sergio Bellucci and myself analysed the nature and consequences of the transformation of the capitalism from the 20th to the 21st century, based on the production of material commodities, into today's capitalism producing non-material commodities. Non-material production, and in general all the production of the Information Age, is characterized by a totally different cycle compared to that of material commodities in the Fordist Industrial Age. There are many differences. First of all, it has neither *time* nor *place*. Many of its component reside in a ubiquitous way in all the places of the known worlds, and are configured temporally in a state of permanent accumulation, concerning any interaction with information and

6 S. Bellucci, M. Cini, *Lo spettro del capitale*, Turin: Codice, 2009.

any conscious elaboration taking place in vital processes. In addition, the non-material production cycle is innovative in major points and escapes from classical schemes.

At the same time, it represents the birth of an economic circuit of a new type and the construction of a circulation grid of the "possible," of ideas, beliefs and mass information present within society. The cognitive cycle, which is bound up with the functioning of the structures of the meaning-producing industry is constantly immersed in the vast immensity of the subjective "interpretation" of messages on the part of both individuals and social bodies, and in the self-production of "raw materials" on the part of individuals submitted to *input* represented by communication and information pressures. Not by chance, nowadays behaviours, tastes, choices and lifestyles are monitored moment to moment and are transformed into information to be sold on the market, to be analysed by producers of both material and non-material commodities.

At the level of the use value of knowledge, the change is, if possible, even more substantial. The nature of the "common good" of knowledge dates back even to Thomas Jefferson, one of the founders of the USA, who – paradoxically – is nowadays the strongest bulwark in defence of Intellectual Property Rights[7]:

> If there is one thing, wrote the author of the Declaration of Independence, which Nature has made less subject than others to exclusive ownership – it is the possibility of thought, i.e., the idea, which an individual can possess in an exclusive way so long as he/she reserves it for him/herself. As soon as the idea is disclosed, it inevitably makes its way to everyone, and those who receive it cannot discard it [...] Apparently, it

7 E. Grazzini, *L'economia della conoscenza oltre il capitalismo*, Turin: Codice, 2008.

> **was purposely and benevolently disposed by nature that ideas should spread freely from one to the others throughout the world for their moral and mutual education and improvement of their conditions […]. Therefore, invention in nature cannot be subject to ownership.**

The definition of non-material commodities is, therefore, self-contradictory. It is the only commodity that, at the time of its consumption, not only does not "deteriorate," end and become waste, but produces further *raw material*, connected to the preceding one, which multiplies the raw material available to the industry of meaning-production and the overall cognitive sphere of humankind. The processes of globalization are offering new forms of cultural contamination, interweavings of meanings and signifiers, and developing imaginary frontiers in the structures of sense.

The dimensions of this planetary network produces a multiplication factor which was unthinkable up to a few years ago, a factor which hints at a new capacity which seems to be emerging as an adaptive factor of a new species. Cultural sedimentation (all the knowledge accumulated by humanity throughout history and available to humankind) and the process of understanding and disseminating ideas themselves, which people receive of these accumulated notions, represent a huge *background* which is placed into production through new economic models based upon information. All possible details, all conceivable interpretations, all experimented practices, and the interactions among them, represent a large melting pot from which emerge products, innovations, ideas for services and new acquisitions through a permanent and irreversible process.

The private appropriation of this potentially huge common good – currently running at an increasingly rapid pace – through patents, trademarks and licences – and the spreading like wildfire of intellectual property rights reproduces, with a strong analogy, the transformation of public lands into private plots which took place in England between the 16th and 18th centuries. However, there is a substantial difference compared to the *enclosure* of communal lands four centuries ago, and this opens up new perspectives on the chance of preventing the current private appropriation of intangible common goods produced by the mind. Indeed, while, according to the recurrent cliché of economists, communal material goods were destined to inexorably degrade inasmuch as they were "victims" of the so-called *tragedy of commons* – i.e., the over-exploitation of sources (land, water, wildlife, etc.), which everyone used regardless of their possible exhaustion, without investment to restore its production capacity, because no one took this responsibility. Clearly common knowledge, unlike the common use of land, does not suffer from deterioration. Rather, as we saw earlier, it is self-perpetuating though a mechanism of positive feedback.

The question, then, is whether we can reverse this trend by initiating processes for the construction, management and use of these non-material commodities, gradually removing them, according to local situations and urgent needs, from their reduction to commodities on the part of contemporary capitalism. It is not a question of pursuing an ideological plan but rather of realistically acknowledging the contradictions which trouble contemporary capitalism which, on the one side, is swept by uncontrollable financial storms which create and destroy vast quantities of paper wealth but also overwhelm the lives of billions of real men and women, and on the other side, is dominated by a handful of multinationals which control a large majority of activities in key areas of world economy: from food to energy, health to transport, guns to leisure time.

I am convinced that the essential contradiction which has characterized the process of capital accumulation in the age of producing material commodities – the contradiction between the need to promote the unlimited growth of production of commodities and the push to the private appropriation of most of the wealth produced – now assumes a new and potentially disruptive role with the arrival of the age of producing non-material commodities. As the example of the current world of software privatization shows, the privatization of knowledge is now entering, and will enter even more so in the future, into contradiction with its intrinsic nature as a common good, suffocating and distorting its development, producing the opposite effect compared to the one proposed by the – more or less *bona fide* - market apologists.

Perhaps our anticipations at the time were not all just fantasies.

Looking Back at *The Bee and the Architect*

Giovanni Jona-Lasinio

1.

The following considerations are, to a certain extent, complementary to the essays by Giovanni Ciccotti, Michelangelo de Maria and Marcello Cini. What we are writing today reflects our different evolutions during the thirty-five years since the book was published, with varying experiences both in scientific research and in our reflections on the topics of the book.

The publication of *The Bee and the Architect* in 1976 is a fact of Italian micro-history which – however – is rightly linked by the other authors to the general history of the period in order to understand its origin and aims, and then give a judgement of its merit. Here, I will try to introduce elements and facts related to the physics of the last few decades which I consider useful for assessing the present relevance of the book, and emphasize the interest today of its main claims. On the other hand, I shall not dwell on the most dated aspects which have already been effectively analysed by Ciccotti and De Maria, when distinguishing what is dead from what is still alive in *The Bee and the Architect.*

I will start by describing my way to the topics of the book. This helps me get to the heart of the problems. Before 1968, unlike Marcello Cini and my younger colleagues, I was not politically engaged, although I considered myself generically as belonging to the left. I was certainly not a radical, just as they underlined. The year 1968 represented my political initiation, as I had the chance to explain in a recent interview.[1] In addition, in that period the Science Faculty entrusted me with a course on the History of Physics, which I taught for two years in Rome, and four years in Padua. In the whole period of the course, from 1968 to 1974, I was discussing intensely with Giovanni Ciccotti, which allowed us to find a common thread. The history of science is one of the recurrent themes of *The Bee and the Architect* where it constitutes a channel for an understanding of this peculiar human activity, namely scientific research. This is not the story of a series of successes marking the stages of a triumphal march, nor a story of values and merits, but rather a story rooted in the general history of human activity.

The first reference author was Alexandre Koyré, who was suggested by Thomas Kuhn, one of our later mentors, during a seminar. I think that an effective way to describe Koyré's work is by quoting a passage from a well-known book by Paul Veyne, *Comment on ecrit l'histoire*, published in France in 1971, which I discovered much later[2]:

> Before him [Koyré], the history of science was mainly a history of great discoveries and inventions, a history of established truths and how they were arrived at; Koyré has put in place a history of errors and truths, a history of the too human progression of eternal truths (Kepler discovering one of his laws on the basis of Pythagorean lucubrations and at the cost of two mistakes in calculation which cancel each other out; Galileo, feeling obliged to define his position between Platonists and Aristotelians, believing he must reclaim the thought of Plato, and imagining, perhaps, that he is inspired

1 F. Socrate (ed.), *Un altro sessantotto*, Rome: Biblink Editori, 2008, p. 375.
2 Paul Veyne, *Comment on ecrit l'Histoire*, Seuil: Paris, 1971. English translation: *Writing History*, trans. Mina Moore-Rinvolucri, Middletown, CT: Wesleyan U.P., 1984, pp. 68-69; p. 20.

by that philosophy, just like a contemporary physicist thinking he owes his discoveries to Marxism).

In another part of the same book, Veyne states*: "for a reader of Koyré, the idea that the birth of physics in the seventeenth century might be explained by the technical needs of the rising middle class was not inconsistent or even absurd."*

This is actually the starting point we adopted together with my younger colleagues, and from this it was only a short step to extending Marxist analysis to scientific production.

The drive towards the history of science – of physics in particular – in my case did not come only from an intellectual curiosity or from political motivations, but rather from questions arising within my research activity for which I could not find a satisfactory answer, and which caused me some discomfort. I had started my activity as a theoretical physicist with the more or less explicit conviction that, in physics, a clear distinction between true and false statements was possible and that this would decide the destiny of theories, ideas and everything else. However, what I could see and feel within my scientific community was quite different. I realized that scientific communities – especially in the case of theoretical physicists – were not all the same. For example, the theoretical activity of the Rome community, located at the time in a single university, was dedicated to the phenomenology of elementary particles, while my leanings went towards more *fundamental* theories, with a marked use of mathematics. In other words, theoretical physics was not a monolithic discipline with which all researchers identified. I realized my natural habitat when I went to work in the USA, together with a Japanese physicist who was, in some sense, an *irregular* as compared to the community to which he belonged. In sum, in 1968, in the depths of my consciousness there was the idea that the acceptance and evolution of a scientific practice depended on very complex inner dynamics which were also affected by the historical and sociological features of the societies involved.

All of this became more explicit after reading Koyré's books, in particular his essays on Galileo in which the science's dependence on more general cultural schemes was clearly highlighted. The next step was constituted by reading the works of Marx, as shown by the numerous quotations – with some display of neophyte erudition – in "Changes in Scientific Practice in a Technological Society," which appeared as the last appendix of *The Bee and the Architect.*

This text – a re-elaboration of a presentation given at a meeting of the Italian Physical Society in 1971 – and a basis for a later seminar at the State University of Milan – over and above its ideological charge, a clear sign of the times, attempted to relate the specific contents of the leading areas of scientific research to social and political facts, in particular in the USA and USSR, the two countries where there was a social programme for sciences, though in different forms. A similar analysis of physics between the 19th and the 20th centuries can be found in the chapter "The Development and Crisis of Mechanicism," by Ciccotti and Elisabetta Donini.

This was the fundamental and most interesting aspect, beyond the relatively obvious issue of the good or evil usage of scientific discoveries, of the emerging thesis of the non-neutrality of science. A more mature formula less ideological was discussed in a later article, written with Giovanni Ciccotti, also included in the book. I admit that the term *non-neutrality of science*, in this general sense, does not appear to me the best possible, but to date a more effective one has not turned up.

It is well known in scientific research that a problem can remain invisible for a long time, until the language to formulate it is created, and this often happens, as Planck remarked, after some solution to the problem has been found. For us, the effort of synthesis in *The Bee and the Architect* provided a new perspective for the scientific research in which we were all engaged. In particular, it opened up the possibility of building a real phenomenology of scientific research and its stronger links to society. The facts I will now describe are somewhat unrelated elements which will hopefully be useful for a later analysis of basic physics research in recent years.

2.

I will start from a traumatic episode for the community of particle physicists – the US Congress's cancellation of the construction of the SSC, the Superconducting Super Collider, in the early 1990s. Here are the facts: the SSC particle accelerator was planned in the 1980s when Ronald Reagan was President, and its construction started in 1991. In October 1993, after millions of dollars had already been spent, the programme was abandoned, notwithstanding the formal endorsement of President Clinton. In the meantime, the costs of realizing its construction had been soaring (it was a much larger machine compared to the LHC, the Large Hadron Collider, currently in operation at CERN). The sum could only be compared to the costs of space flights, and the critics of the project were saying that the USA could not afford two projects of that size. In fact, the debate was much more complex, and two communities faced each other before Congress: those engaged in the physics of condensed matter, led by Philip Anderson, who were against the project, and those engaged in particle physics, led by Steven Weinberg, who were in favour. Both scientists had won the Nobel Prize. Anderson in the end won, and the arguments of each leader were mirrored in two general papers published in 1995 in the book *Physics of the Twentieth Century*.[3] While Weinberg expresses a strictly scientific viewpoint, belonging to his community, Anderson makes a comprehensive analysis of the structure and social

3 L. Brown, B. Pippard, A. Pais (eds.), *Twentieth Century Physics*, New York: Institute of Physics Publishing and American Institute of Physics Press, 1995.

relevance of the physics represented by his community, devoting a large space to the distinction between *Big Science* and *Small Science*.

One month after the cancellation of the SSC, an article by Silvan Schweber was published in the November 1993 issue of *Physics Today*, with the title "Physics, Community and the Crisis in Physical Theory."[4] The crisis was, to a large extent, identified with a crisis of reductionism. This paper was very much appreciated by Anderson, in the above-mentioned essay, where he says that: *"this can be considered as an important contribution to the great philosophical debate on the SSC and other large scientific projects, which dominated the last decade of the century."*

This complex matter could not help but attract the interest of historians and philosophers of science. I will quote a recent article, published in 2009 in the important journal *Studies in History and Philosophy of Science* with the peculiar title "Kuhn, Popper and the Superconducting Super Collider."[5] This article is part of an ongoing debate in the USA on the possible role of the epistemological attitudes of scientists in the decisions leading to the cancellation of the SSC. Some of them do not believe that the failure to carry out the project was only due to economic and political reasons. In particular, some think that, in this matter, two different views of science collided: an idea of a science which evolves for internal reasons, following Kuhn's vision in *The Structure of Scientific Revolutions*, against an idea of science as part of an *open society*, in Popper's sense of the term, from which epistemology also derives. The author of the article, Andrew T. Domondon, of the University of Chicago, argues that Kuhn's vision does not imply an inner evolution of scientific activity which is

4 Schweber, "Physics, Community and the Crisis in Physical Theory," *Physics Today*, November 1993.
5 Domondon, "Kuhn, Popper and the Superconducting Supercollider," *Studies in History and Philosophy of Science*, vol. 40, 2009.

in contrast with a Popperian concept of a science open to society. In particular, he writes: "I noticed how elements from both Kuhn and Popper emerged in the debate about the SSC, and I said that it was wrong to assume that the cancellation of the program was due to an excessive adherence to Kuhn." The author thinks this is an exaggeration, just like considering the adversaries as exemplary followers of Popper. He also remarks that Kuhn correctly underlines the importance of social, political and technological concerns in trying to understand scientific practice, as well as the role of the scientific community in handling matters of epistemological relevance.

This debate may appear unusual in the traditional scientific historiography, but certainly not to the authors of *The Bee and the Architect*, as for them the question of the SSC is exemplary: the different scientific visions, epistemology, social and political dynamics explicitly meet and fight. All this happened outside Marxist visions of the relationship between Science and Society. I would like to underline that this debate appears natural in the USA, where the social role of science is largely recognized, beyond its declared aims, which may not be shared. To this regard, *The Physicists* by D.J. Kevles is an interesting book covering the story of the US community of physicists at the end of the 1970s.[6] In Italy this is an almost unthinkable debate, after the abandonment of the nuclear energy development programme in the 1960s. The government has never promoted a wide-ranging and socially relevant scientific policy.

6 D.J. Kevles, *The Physicists*, New York: Vintage Books, 1979.

3.

In the 1990s, as I mentioned earlier, the USA choose to abandon large particle colliders but decided to continue space missions, though with reduced funding since they no longer need to compete with the USSR. The choice of the USA – in my opinion – was dense with consequences. It favoured a discipline, now considered state-of-the-art and essential – i.e., astrophysics, together with cosmology. There is an important link between astrophysics and space missions: suffice it to think of space telescopes. There is also an ever-closer bond between particle physics and astrophysics, which I would like to briefly illustrate.

There is a general understanding[7] in the particle physics community that, because of the costs, there will not be another particle accelerator after the LHC at CERN. Therefore, one may wonder about the future of this branch of physics, which has claimed a leading role precisely for the object of its research. Before the invention of accelerators, the source of particles was the Universe, the well-known cosmic rays, and it seems to me that, in a different way, we are going back to the Universe. The discovery of the CMB – *Cosmic Microwave Background* – in the 1960s was – and still is – considered the major support of the Big-Bang theory, the explosive, datable origin of our Universe. In this perspective, the world of particles which we can observe, whose phenomenology is well described by the Standard Model, has its own history and is the result of the evolution of the Universe. Astrophysics allows us to reconstruct, though with a number of uncertainties, the stages of this evolution on the basis of various hypotheses. First of all, the assumption that the physical laws we know have stayed the same during the whole evolution. The possibility that the particle coupling constants among particles depend on time is a topic

7 This was the opinion of several physicists at the time but the perspective has changed in the last decade. See e.g. https://home.cern/science/accelerators/future-circular-collider

which originated in an article published by Dirac in the second half of the 1930s and is still controversial. The description of nature and the laws of particles must, therefore, be compatible with the history of the Universe. For example, nowadays we can notice a prevalence of matter over anti-matter: it is the problem of baryogenesis, which does not yet have a fully satisfactory explanation. Moreover, the origin and nature of dark matter and dark energy are still well beyond our understanding. These problems might require a substantial revision of our basic theories.

The epistemological novelty of all this is that, with the impossibility of conducting experiments at ever higher energies, our knowledge of particles will be indirect and will be acquired while studying the Universe as a whole. A possible parallel with biology comes to mind, considering the constant cross-references between evolution, which brought about the existence of life, and the search for its microscopic bases. A research logic is therefore emerging which is much more complex than the traditional *hypothesis-experiment-confirmation.*

4.

There are further signs of change in scientific practice and epistemology. In these last few years, physics has become increasingly differentiated in areas facing different levels of reality, between microscopic and macroscopic, and each area requires a different specialization on the part of the researcher. The use of various incomplete theories, often including *ad hoc* elements which allow an interpretation of empirical data, is by now a rule. Usually, physicists define these theories as models: we live in an era of a great shortage of so-called "fundamental" theories. Even the famous standard model of elementary particles is by now considered a mere phenomenological description. The success of a model is, first of all, a practical success. Suffice it to think of the several models used in nuclear and chemical physics. At the root of all models there is quantum mechanics, but models are used as independent theories for different aspects of a complex physical reality. In the above-quoted article, Schweber talks about a decoupling between research sectors, which he considers as a clear sign of the crisis of reductionism and of the unity of science. It should be recalled that theories are also guides for acting upon nature, and theoretical physics in general is not only a search for truth and fundamental laws, but also establishes the basis for rules with which you can plan new experiments and new machines. Theory therefore also responds to requests of a utilitarian nature. The terms to "verify" or "falsify" a theory can hide the planning aspect and induce us to forget that technology, outside of labs, provides an important validation for basic theories.

5.

In the 1973 article with Ciccotti, we stated: "Integration into a conceptual system has certainly been a common property of statements which have been considered scientific in any time and place. However, in modern scientific development, we can single out new and specific levels of integration which increasingly determine what is meant by science." I think that the examples considered here show that there is no pre-defined path for science and that the creativity of the scientific community as a whole, and of each individual scientist, is included in a larger dynamics which involves society, encouraging and affecting it at the same time. This is the meaning of the non-neutrality of science, one of the common threads of *The Bee and the Architect*, which I still share.

There is also the planning aspect of science, another feature of the book, which determines its social impact and cannot do without a global concept of society and values – namely, of ethics. Ethics was not explicitly the focus of our attention when the book was published, but I do think that, nowadays, for a lay scientist, the important challenges are the construction of the cognitive and social value of science without false mythologies (I'm still using a term of the 1973 article), and the establishment of an ethics upon a non-metaphysical basis. In our age, these actions are closely linked; this correlation cannot be disregarded, either today or in the future, on either an individual or a collective level.

I do hope that readers of good will, belonging to the younger generations, will take up again, in a creative way — and overcoming their ideological burdens — the messages contained in the tentative analysis of science presented in our book.

The Relationship Between Science and Society in the Historiography of Science and in *The Bee and the Architect*

Arianna Borrelli

Modern Science as a Historical Phenomenon

Around the year 1800, a series of elements within European culture slowly formed a new combination which, towards the middle of the 19th century, began to describe itself as "science" ("*Naturwissenschaft*").[1] The methods of mathematical analysis and instrumental quantification had already been developed in the 17th century. The standardization of the units of measurement followed a few decades later. A fundamental contribution to the process of the formation of science was given by French culture in the revolutionary and Napoleonic period, whose philosophy of nature was dominated by the school of Pierre-Simon Laplace. In this context, most science historians locate the origins of the so-called "hypothetical-deductive" method, based on the search for a comparison and numerical agreement between theory (intended as a mathematical structure) and experiment (intended as standardized, repeatable experience, thus universal in theory, just like a mathematical formula). Further essential

1 For general references on the history and historiography of science, see: *Storia della scienza moderna e contemporanea*, ed. P. Rossi, Turin: Utet, 1988; R.C. Olby et al. (eds.), *Companion to the History of Modern Science*, London: Routledge, 1990; R. Maiocchi, *Storia della scienza in Occidente dalle origini alla bomba atomica*, Florence: La Nuova Italia, 1997.

contributions arrived during the 19th century from the Anglo-Saxon, North American and Central-European areas, especially regarding the development of ideals of precision and the institutionalisation of the various scientific disciplines.

The German *Naturwissenschaft* created its own identity in contrast to the idealistic and romantic currents of thought which had dominated the first half of the 19th century and, although multiform, were summarized under the general label *Naturphilosophie*. The contribution of these schools of thought to the formation of modern science has been discussed by various scholars, notably Thomas Kuhn, but it still is a commonplace to indicate "romanticism" as a symbol of "anti-scientific" trends.[2] The 19th century also witnessed the emergence of ideals of "rationality" and "objectivity" which would become the cornerstones of the self-definition of modern science.[3] Despite being a localized historical phenomenon, modern European science shares several elements with the theories and practices of the philosophy of nature and technique of past ages and from non-European cultures, and it is therefore legitimate to analyse the latter with the use of categories such as "scientificity" or "rationality," provided that a clear definition of such terms is given. If we discuss the works of Isaac Newton or Galileo Galilei as part of the "history of science," this is justifiable, inasmuch as both the works and the iconic figures of these authors became, in the course of subsequent historical developments, an integral part of modern science. At the same time, it is a problem to talk about Galileo or Newton as modern scientists, when you consider them in their respective historical context.

If we acknowledge that modern science is a phenomenon which is socially, economically and culturally located, this in no way implies that we question its validity. Rather, it means that we undermine the

2 T. Kuhn, "Energy Conservation as an Example of Simultaneous Discovery."
3 L. Daston and P. Galison, *Objectivity*, Cambridge MA: MIT Press, 2007.

basis of those principles of rationality and objectivity which, in the opinion of many people, whether scientists or not, constitute science itself. The emergence of this narrative can be traced back to the Age of Enlightenment which witnessed the *a posteriori* construction of the 17th century "scientific revolution." The work of constructing the historical identity of modern science went on in the 19th century, in works by authors such as William Whewell and Ernst Mach, to mention only the most prominent ones. From the start of the 20th century at the latest, however, a certain number of thinkers started successfully to call into question the concept of scientific methodology as a series of theoretical predictions and experimental confirmations which, errors excepted, invariably leads to an accumulation of notions about a nature which is, more or less naively, considered as a "thing in itself." This research led, on the one side, especially in the context of analytical philosophy, to more and more refined attempts to offer a basis for the validity of science by defining "reality" in such terms as to guarantee a certain correspondence with scientific knowledge. On the other side, however, they also gave rise to research aimed at analysing scientific practices more carefully so as to offer a characterisation closer to reality than to the rhetoric of rationality and linear progress.

The Relationship between Science and Society in Historiography

For philosophers, the question of the validity of contemporary science has been the focus of discussion, for example in the works of Karl Popper, Imre Lakatos, or Paul Feyerabend, but historical examples were often used to argue in one direction or the other. Lakatos's work distinguished itself for the introduction of "rational reconstructions" of episodes from the history of science. In this approach a reconstruction as complete as possible of the history of events from the historical point of view was left aside in favour of a narrative which represented scientific activity in its ideal form, defined as starting from methodological premises chosen by the historian himself.[4] Lakatos stated that such an "internal" history of science was independent from any external factor. Conversely, Feyerabend used historical examples to call into doubt the claims of science to offer high-quality knowledge, different from that of other branches of human knowledge, and to show how the definition of "rational" behaviour could not be given, regardless of its historical and social context.[5] On the side of history and sociology, which we want to deal with more widely here, the situation appeared more complex.[6]

The history of science, as written by scientists, had been useful at the end of the 18th century for the creation of a basic narrative in which rationality and individual genius played a central role. Historians active in the early 20th century, who had often received scientific training, were therefore faced with the problem of whether and how to call into question the ideals of science while trying to analyse its development (also) as a historical phenomenon. The first and most influential works of Anglo-Saxon historians of science on the relationship between science and society date back to the impulse received at the Second International Congress of the History of Science and

4 I. Lakatos, "History of Science and Its Rational Reconstructions," *PSA Proceedings*, 1970, pp. 91-136.

5 Feyerabend, *Against Method: Outline of an Anarchistic Theory of Knowledge*, London: New Left Books, 1975.

6 For a review of the historiography of science, in particular on the relationship between science and society, see : M. Hagner, "Ansichten der Wissenschaftsgeschichte," in M. Hagner (ed.), *Ansichten der Wissenschaftsgeschichte*, Frankfurt: Fischer, 2001, pp. 7-36; H. Kragh, *An Introduction to the Historiography of Science*, Cambridge: Cambridge U.P., 1987; the following articles found in R.C. Olby et al. (eds.), *Companion to the History of Modern Science*, London: Routledge, 1990: J.R.R. Christie, "The Development of the Historiography of Science," pp. 5-22; R. Porter, "The History of Science and the History of Society," pp. 32-46; B. Barnes, "Sociological Theories of Scientific Knowledge," pp. 66-73; R.M. Young, "Marxism and the History of Science," pp. 77-86; T. Pinch, "The sociology of the Scientific Community," pp. 87-99.

Technology, which took place in London in 1931, at which a delegation from the USSR, led by Nikolai Bukharin, participated. In the reports of the Soviet scholars, whose texts were published in the conference proceedings, the key developments in the history of science were explained in terms of social and technological factors, whereas the role of the "big name" was downplayed.

The direction indicated by the Soviet delegation was welcomed in the Anglo-Saxon area among authors of Marxist leanings, such as John Bernal, who conceived science as a means to realize social progress and interpreted its history in terms of an almost immediate correspondence between society and science. The analyses of the relationships between science and proposals from bourgeois scholars were more sophisticated and historically relevant, but had a more limited horizon. The best known among these scholars was Robert K. Merton. If, on the one side, Merton fully accepted the idea that the path of scientific development was determined not only by objective observation and rational reflection, but also by socio-economic and technological factors, on the other side he set clear limits on the role of the latter and expressed the conviction that scientific knowledge has a validity that transcends any "external" value, and exclusively derives from developments "internal" to the discipline. This distinction between an internalist and an externalist approach would dominate the historiography of science for decades. In his PhD thesis (1938), Merton stated, in a broad argument well supported by historical evidence, that transformations in the approach to the study of nature in 17th century England were also due to external factors, the most important of which were technological developments and the emergence of a Puritan ethic.[7] The "Merton thesis" provoked a large discussion in the following decades, but the roles of religious and

7 Merton, "Science, Technology and Society in Seventeenth Century England," *Osiris*, 4, 1938, pp. 360-632.

technological factors in the development of science were still scarcely considered, and the historiography of science was dominated by narratives focussed on theories and ideas, for instance in the work of Alexandre Koyré and Alistair Crombie, as well as in the work of Ludovico Geymonat, whose philosophical background was Marxist. The results of this research provided an essential impulse to research, but at the same time contributed to reinforcing the impression that, in order to understand the development of science, it would be enough to concentrate on theoretical aspects without taking into account the dynamics of experiments, or the contribution of technicians and techniques, not to mention economic, political, and social elements.

The work of Ludwik Fleck, and in particular his 1935 book *Entstehung und Entwicklung einer wissenschaftlichen Tatsache* [*Genesis and Development of a Scientific Fact*], went beyond the distinction between internal and external history, but remained uninfluential for several decades.[8] Fleck highlighted the notion of "thought collective" (*Denkkollektiv):* i.e., a structure which could be formed both by scientists and non-scientists from which – through social interactions – new scientific "facts" emerged and were consolidated. Fleck's work was neglected for decades and later re-discovered by Thomas Kuhn, who introduced it as one of the starting points for the reflections of his book, *The Structure of Scientific Revolutions*. It is difficult to overvalue the relevance of Kuhn's work for the history and philosophy of science, both for the influence he exerted upon scholars from the humanities and for reactions among scientists. Kuhn's idea was that the development of science is mostly constituted by long stages of "normality" in which scientists work within a paradigm which the community cannot question, as if by construction. In such stages, all

8 L. Fleck, *Entstehung und Entwicklung einer wissenschaftlichen Tatsache*, Frankfurt: Suhrkamp, [1935] 1980; English version: *Genesis and Development of a Scientific Fact*, trans. F. Bradley and T.J. Trenn, Chicago: University of Chicago Press, 1979.

the experimental data are explained in terms of the dominant paradigm, and only when an empirical result of particular relevance does not find its place within the paradigm ("anomaly"), the latter suffers a crisis and, in a short stage of "revolution," is replaced by a new one. Kuhn talks of the "incommensurability" between different paradigms, thus casting doubts on the idea that scientific knowledge, once in existence, is valid forever. Both this idea, and the apparent "irrationality" of an uncritical devotion to a paradigm were interpreted by many people – scientists and non-scientists – as anti-scientific criticism, even though Kuhn kept emphasizing that his argument was in no way intended to criticize the validity of scientific knowledge, but rather to provide a realistic representation of the way scientists are more or less convinced of having reached it.

Both critical reactions to Kuhn's work and the general trend of the historiography of science from the 1950s onward should be understood by taking into account the particular historical context: i.e., the Cold War. Between the 1950s and the 1970s, the development of scientific knowledge and technology in the countries of the Western Bloc was often instrumentalized to show its superiority on a political and social level. In particular, the impact of technological innovations upon daily life, interpreted as an improvement of the quality of life, provided an effective argument in favour of the values of Western democracy in general, and of the USA in particular.

Although in that period in the West there were critical voices about the equation of technological innovation and social progress – for example Martin Heidegger and the Frankfurt School – not only scientists, but also philosophers and historians of science often felt compelled to uphold positions which were politically aligned with those of the majority, and therefore to underline the rationality of science and its essential character as a "pure" activity, subject to social, religious or economic influence only in cases of erroneous assessments. Both history and philosophy of science tended to ignore technology and the problem of the historically contingent character of scientific practices and theories, but there were in the 1960s highly original and influential thinkers, such as Marshall McLuhan, Edgar Morin and Vilém Flusser who, starting from very different cultural backgrounds, offered in-depth reflections on the impact of technology, not only upon society in general but also in the way in which the individual perceives and conceives the world. Starting from the end of the 1970s, these and other innovative trends placed the notion of "techno-science" at the focus of discussions about science and society.

From the 1970s onwards, the topic of the relationship between scientific knowledge and the society in which it emerges was the focus of a growing number of essays of sociological, historical and philosophical character, including *The Bee and the Architect*. These works were placed in the context of various trends of philosophy, history and cultural anthropology that had originated between the 1960s and the 1970s. These were authors and works that had very different backgrounds and interests, but – at least looking back – they all shared the idea that scientific knowledge could and should be studied with the same methods and the same premises with which we investigate any other human activity. Questions related to the assumed "truth," "rationality" or "objectivity" of science were thus posed – if at all – only in terms of a reconstruction of the meaning attributed to those terms in a particular historical and social context.

From the mid-1980s onwards, there was the so-called "practical turn" in which scholars realized the need for greater attention to the practical aspects of science (experimental apparatus and method, informal practices, implicit knowledge, methods of representation) and to the fact that scientific activity is always a collective activity rather than the product of isolated individuals, whether great thinkers or not. In this context, Fleck was re-discovered as a forerunner of a new approach. At the same time, there was a reassessment of the idea of "personal knowledge" developed by Michael Polanyi in the 1950s.[9]

We cannot discuss here the contributions of the numerous authors who took part in the construction of "science and technology studies" and the creation of the sociology of scientific knowledge. In the following, we will simply list a few names and titles based on personal choice: Paul Forman, "Weimar Culture, Causality, and Quantum Theory: Adaptation by German Physicists and Mathematicians to a Hostile Environment," *Historical Studies in the Physical Sciences*, 3, 1971, pp. 1-115; David Bloor, *Knowledge and Social Imagery* (London: Routledge Kegan, 1976); Bruno Latour and Steve Woolgar, *Laboratory Life: The Social Construction of Scientific Facts* (London: Sage, 1979); Andrew Pickering, *Constructing Quarks: A Sociological History of Particle Physics* (Edinburgh: Edinburgh U.P., 1984); Steven Shapin and Simon Scheffer, *Leviathan and the Air Pump* (Princeton: Princeton U.P., 1985); Donna Haraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspectives," *Feminist Studies*, 14, 1988, pp. 575-599; Norton Wise and Crosbie Smith, *Energy and Empire: A Biographical Study of Lord Kelvin* (Cambridge: Cambridge U.P., 1989); Harry Collins and Trevor Pinch, *The Golem: What You Should Know about Science* (Cambridge: Cambridge U.P., 1993); Michel Serres, *Les origines de la géométrie* (Paris: Flammarion, 1993); Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: University of Chicago Press, 1997); Hans-Jörg Rheinberger, *Toward a History of Epistemic Things. Synthesizing Proteins in the Test Tube* (Stanford: Stanford U.P., 1997); Evelyn Fox Keller, *The Century of the Gene* (Cambridge MA: Harvard U.P., 2000). It is important to underline that these and other works had very different approaches and purposes, and that mutual criticism was not spared among the various authors.

9 M. Polanyi, *Personal Knowledge*, London: Routledge and Kegan, 1958.

From the start of this new kind of interest on the part of human sciences for natural sciences, most of the (natural) scientific community saw these trends as a threat to its own fundamental values. At the beginning of the 1990s, the situation was further exacerbated, especially in the USA, where scientists in those years suffered dramatic budget cuts, such as the one in 1994 which put an end to the construction of the Superconducting Supercollider (SSC). Among scientists, the impression spread that such measures were at least partially due to an "antiscientific" climate linked to the works mentioned above, and to books by authors such as Jacques Derrida, Gilles Deleuze, Félix Guattari, Luce Irigaray and Paul Virilio who, even though they had not been typically engaged with scientific knowledge in a narrow sense, had often used (or abused, according to scientists) scientific terminology. The 1990s therefore witnessed the outbreak of the so-called "science wars," starting with a series of isolated discussions in which scientists criticised certain historical or philosophical works. For instance, Steven Weinberg lashed out with great vehemence at Pickering's *Constructing Quarks*, stating that "no one would give a book about mountain climbing the title *Constructing Everest*."[10] In a short time, there were general attacks against "the enemies of science" which threw everyone together in the same pot and criticised authors without confronting their ideas. The best-known product of the "science wars" was probably the book *Impostures intellectuelles*, by Alan Sokal and Jean Bricmont (Paris: Odile Jacob, 1997) [UK title: *Intellectual Impostures*, London: Profile books, 1998; American title: *Fashionable Nonsense*, New York: Picador, 1998] in whose passages the "enemies of science" were discussed by taking them out of context and criticising them on the basis of literal interpretations. At the same time, renowned scientists did not hesitate to exploit their academic

10 S. Weinberg, "Against Philosophy," in S. Weinberg, *Dreams of a Final Theory*, New York: Pantheon Books, 1992, p. 188.

influence in order to act on an institutional level against "the enemy."

Apparently, the "science wars" did not improve the budget of scientific research, and certainly they did not prevent the continuation of high-quality works of sociology of science, even though – unfortunately – they often ended up convincing the scientists that there is no reason to be interested in such topics. In the meantime, studies of the history of knowledge have partially lost interest in physics and other exact sciences and rather focussed on new technologies and on the life sciences, which in the last few years have started to play an increasingly relevant role within society.

We should finish this short and certainly incomplete overview noting that the question of the non-neutrality of science, although it has a central relevance for the collective identity of scientists, is important far beyond that restricted horizon and has implications also in the economic and political areas. I'm here referring not so much to the role of technology within modern society, but rather to the figure of the scientist – preferably a physicist – as an "expert," a point of reference in order to establish what is "scientifically proven" or not. Suffice it to think of recent debates on the reliability of well-grounded scientific knowledge which is politically and economically unpopular, such as the effects of tobacco on public health or the human origins of climate change.[11]

The Bee and the Architect: A Plurality of Voices, a Plurality of Paths

The Bee and the Architect, published in 1976 on the basis of reflections which had already begun in the first half of the 1970s, fits well into the picture of the literature of those years which was

11 N. Oresko and E. Conway, *Merchants of Doubt: How a Group of Scientists Obscured Truth on Issues from Tobacco Smoke to Global Warming*, New York: Bloomsbury Press, 2010.

addressing the study of scientific knowledge with great enthusiasm, from very innovative viewpoints, with a diffused background impression of a "crisis of science" which was experienced in different ways according to one's intellectual environment.

Whereas the first impression that a contemporary reader would likely receive from the book would doubtlessly be linked to the language and Marxist premises of the volume, the second impression is much more difficult to describe. This would be a sense of disorientation due to the fact that the arguments developed in the text are difficult to understand in terms of the categories of today's discourse on history and society. As discussed in the preceding paragraph, the "science wars" have accustomed us to think either in the reductionist terms of "science" and its "enemies" or in the almost excessively refined categories of "science and technology studies." None of the schemes, however, fully fits the argument developed by the authors of *The Bee and the Architect*, even though it is easy to find expressions and topics in the text which might lead towards either one direction or the other. What is happening?

Evidently, we are in the 1970s. The "crisis of science" of that period was an unquestionable presence, different from the contemporary age which is characterized by the perception of climate changes due to technology, the negative effects of industrial globalization, the threatening economic growth of certain "developing" countries. On the other hand, in the 1970s, most citizens of Western industrialized countries identified science with the technology of cars, TV sets and house appliances. However, according to left-leaning intellectuals and – more generally – those interested in improving society not only in terms of the quality of material life, but also its intellectual and cultural level, these changes were also threatening.

At the same time, for "pure" science and, in particular, high-energy physics, in which some of the authors of *The Bee and the Architect* were engaged, the 1960s and 1970s were a period of great transformations linked to the emergence of new theories of weak and strong interactions of elementary particles. If physicists in general had much to be proud of in those days, Italian physicists could feel involved in those successes without at the same time having to suffer the “publish or perish” pressure characteristic of other Western academic communities, most of all the American one. The authors of *The Bee and the Architect*, for instance, were at the time already inside the Italian university system, free to choose their own the topics on which to work. Over and above the political-intellectual background, this was certainly a very important factor in provoking a historical-philosophical reflection on the non-neutrality of science and the negative influence of the “industrialization” of research.

However, back to the point: the positions of the authors of *The Bee and the Architect* cannot be traced back to either side of the “science wars” but contain elements of both, which combine and intertwine in various ways in the course of the book. In the *Denkkollektiv* of *The Bee and the Architect*, there are two souls which cannot be attributed to any of its components and are, at a first approximation, respectively political and historical-philosophical. From the political point of view, the problem arises of how to understand and combat the negative effects of science (and technology, but the authors identify the two elements, as we will see) upon contemporary society. On the other hand, from the historical-philosophical point of view, the question of the non-neutrality of scientific knowledge is discussed with respect to the socio-economic forces of the historical context from which it emerges.

The two strands of ideas are closely connected, inasmuch as the crisis of science is explained by affirming its non-neutrality and tracing its contemporary negative effects back to the dominant capitalism. However, the historical-philosophical discussion is not intended solely to demonstrate the interdependence of science and society but is also meant to guarantee some sort of “objective” validity to the former. This need is already expressed in Marcello Cini's Introduction, even though it focusses mainly upon the political theme. Cini emphasizes the dehumanising effects of technological innovations, linking it with the negative influences of capitalism and poses the question of whether, even in the "fabric of science [...] it would be possible to trace the footprints of the social relations of capitalist production." Further on, while discussing a quote from a preceding work, Cini corrects and blurs some of his positions, explaining that, although he had written that "reality is not an unspoiled nature [...] but rather a product of human history," he points out that "I should have added 'also'." Shortly afterwards, he mentions "the need to submit the emerging concept of 'non-neutrality of science' to a confrontation with history, testing its usefulness as an interpretative tool of the past and enabling a validation of the analyses of the present based on it." Therefore, the idea of the non-neutrality of science appears here not only as a thesis to use as a basis for one's own programme of research policy, but also as a viewpoint to explore with interest – although with a certain distrust.

This second soul of *The Bee and the Architect,* which takes care to avoid putting science on the same level of other forms of human knowledge, clearly emerges in the first essay of the main part of the book: "Scientific Planning Against Scientism," by Giovanni Ciccotti, Marcello Cini and Michelangelo de Maria. Reading its first paragraphs, we are struck by the sudden appearance of a Marxist-tinged vocabulary, but also by the tones of the "science wars": they want to solve the crisis, without exorcising it "with a process to science, unsatisfactory because too superficial and solipsistically irrational to be useful." And behold the great enemy appears on the horizon: irrationality coming from the left wing, as the authors inform us in the notes referring to Herbert Marcuse and Jürgen Habermas without, however, discussing their theses, apart from the charge of irrationalism. And yet, from this the authors somehow move in this "irrational" direction, arguing in favour of the non-neutrality of science with respect to the society in which it was born. Before taking this route, it is however necessary to find an absolute reference for the validity of scientific knowledge. As we said earlier on, scholars such as Merton, Kuhn and Geymonat had already raised this issue and had offered solutions, which – however – the authors of *The Bee and the Architect* did not deem acceptable and did not even dwell upon (Chapter 1). Merton is often quoted with approval upon specific topics, but at the same time the authors associate him with the "eclectic empiricism of modern sociology" (Chapter 1). Further on in the book, they draw on the work of Derek De Solla Price, pointing out that he uses charts and reported data in order to "support a thesis we do not share" (Chapter 2). It is not difficult to identify in this attitude with regard to quotations the typical approach of natural sciences, and it is no wonder that, at the time, there were angry reactions on the part of both historians and philosophers.

Let us leave aside these formal aspects and move to the content: can we call into question the neutrality of science without falling into irrationalism? The authors think this is possible and, courageously accepting this "third path," they demonstrate that they are no mere scientists. Further proof will come in the following pages where they use Marxist philosophy in order to give the ideal answer to their problem: the development of science should be associated with the progress of society, whose objective character cannot be denied in the ideological context the authors are working in.

In order to support this thesis, which is possibly dated, but anything but trivial or banal, the authors of *The Bee and the Architect* relate some analyses of historical events in order to recover – in a few selected episodes of the history of science – similarities (better still: "coherences") with contemporary social upheavals. However, apart from discussions about the present, such arguments do not offer a detailed analysis of the historical context and of the social and economic forces acting in it: assuming as a premise the Marxist concept of history, the authors take for granted the existence of social forces acting along a linear and necessary process, mirrored in the actions of both the masses and individuals, even though the latter are not aware of it.

In this way, the scientific opinions of Antoine-Laurent Lavoisier, Ludwig Boltzmann and Max Planck are interpreted as expressions of the various trends at work in the society of their time, without feeling the need for some specific material or cultural link as the basis for such an interpretation. In the essay "The Development and Crisis of Mechanicism: from Boltzmann to Planck," by Ciccotti and Elisabetta Donini, the different use – on the part of both Boltzmann and Planck – of the hypothesis of the discretization of energy in a system with many degrees of freedom becomes, in this approach, the basis for identifying these historical characters with the representatives of conservative socio-economic trends (Boltzmann) or of innovative trends (Planck), regardless of their actual political views or social position. This kind of argument is clearly difficult to accept for a historian who does not share their philosophical premises. However, from a purely philosophical viewpoint, this is certainly an original position worthy of further development. In particular, this approach becomes intriguing when applied to the study of contemporary science, as in Giovanni Jona-Lasinio's discussion of the analogies between the particle theory of the 1960s and the capitalist system (Appendix, Chapter 6).

The following passage is much more suggestive, but more difficult to agree with:

> science historians well know how Lavoisier strongly and coherently (both from his scientific and political stances) opposed – from his aristocratic and rigid reductivist programme – the broadening of the definition of science required at the time by the lush growth of peculiar research not immediately attributable to the Newtonian model. [...] It is useful to mention, in this case, the importance of a political

> **power – perhaps crude, but certainly far-sighted – capable of stopping the intolerable claims of such a prestigious figure. (Chapter 1)**

These lines imply that the execution of Lavoisier during the Terror was somehow due to the elitist character of his scientific opinions and not only to his privileged social status at the time and in particular to the fact that, by family tradition, he also held the role of tax collector.

At this point, it is interesting to notice how, though the authors of *The Bee and the Architect* do largely use Marxist theories in their analyses, they do not touch on the Marxist principles of the history of science in which collectives and practice dominate the development of science rather than great thinkers and theory. In particular, technique is absent as an independent factor at the basis of scientific and social development. Indeed, it is meant as a purely practical activity, devoid of an abstract reflective level and opposed to technology, which is instead defined as an application of the principles of science (Chapter 1). At this point, when describing the contemporary period as a technological age, the whole argument about technique is reduced to a discussion of the assumed scientific principles whose application technique is supposed to be. Nowadays, this point of view appears extremely distorted – suffice it to think of how the progress of nanotechnology has transformed society without the development of a real theory (meant as a coherent physical-mathematical structure) associated with it. In any case, this viewpoint allows the authors of the second essay of the book ("The Production of Science in Advanced Capitalist Society" by Ciccotti, Cini and de Maria) to characterize pure science as commercialized information, relevant to the production process inasmuch as it is a "test track" for applied science (Chapter 2). This thesis is confirmed by a public relations text of the CERN (Centre Européen des Recherches Nucléaires), the largest research centre for nuclear physics, in which CERN's technological spin-offs are emphasized. Perhaps contemporary readers tend not to see in this text so much the confirmation of the productivity of pure science and its equivalence to technology, but rather an attempt on the part of pure scientists to present themselves as a valuable commodity, assimilating their work to a kind of information which is actually quite different, and much more interesting for the market. On this basis, the authors continue with the political register, proposing an analysis of the effects of the commercialization of science which is characterized by deep insights, in particular regarding the public image of science.

As evidence of the composite character of the text, we should notice that, in this second essay, there is no invective against the "irrational" tendencies of those who exploit the crisis of science in order to criticize it beyond measure, and the authors make no effort to save its validity. On the contrary, they insist on its non-neutrality and its fetishistic character. The following remark seems particularly noteworthy in this regard:

> science is presented as pure objectivity. The result is a model of society where relationships among human beings are determined by objective laws. A society where common people must accept that their lives are decided by a "scientific" organization of work, that their skills are assessed in a "scientific" way, and that their place within society is fixed by an "objective" scale of values. (Chapter 2)

In the final essay of the main part of the book ("Modern Epistemological Debate and the 'Socialization' of Science," by Ciccotti and Jona-Lasinio), there is a new, unsettling change of register: indeed, the problem of the non-neutrality of science is here introduced as an abstract question of the philosophy of science through a critique of modern epistemology carried out in a competent and articulated manner, illustrating the theories of the various authors before criticizing them. In this essay, the authors remark once again that the thesis supported could be seen as "irrational relativism" and try to downsize their own position, pointing out that they are proposing a "correlation" rather than a "dependency" between science and society (Chapter 3). While the Marxist arguments binding science and society do not make an appearance, the political issue turns up – what can we do against the crisis of science? – and a solution is offered in the form of a "global planning of scientific research" (Chapter 3) and an education policy addressed to "making citizens capable of 'experimenting,' and thus enjoy, in a conscious way, what nature offers" (Chapter 3).

In conclusion, we can say that the two souls of *The Bee and the Architect* are both interested in taking note of the crisis of science and proposing solutions, but from two different points of view: on the one side, they feel the need to stem and change the course of the transformations which science and technology impose on contemporary society; on the other hand, they want to solve the tension between the perception of science as a dehumanizing factor and the idea that it is actually the highest form of human intellectual activity, at least partially endowed with absolute value.

From a certain viewpoint, the plurality of voices, the complex process of writing and rewriting the text, the interweaving of Marxist arguments in favour of such mutually distant theses as the non-neutrality of science and the objective validity of scientific knowledge, make *The Bee and the Architect* a labyrinth which can probably be best appreciated only if you read it without following a pre-established order. We may well hope that the contemporary public – scientists in particular – will take advantage of the new publication of this book to reflect on topics related to the history and sociology of science, which should be addressed with an open mind and the courage to innovate: qualities clearly demonstrated by these authors.

The Bee and the Architect Between Scientism and Irrationalism in the 1970s

Marco Lippi

1.

When re-reading this book from 1976, I am struck by its density. In its opening, the text gives a report of the discussions and the clashes which stirred the intellectual environment, in particular among scientific researchers, in or near the Italian Communist Party between the 1960s and 1970s. The report comes from Marcello Cini, one of the protagonists of those episodes. Its central part discusses the epistemological search by authors such as Popper, Lakatos, Kuhn, and makes use of their results in order to reject the thesis of the neutrality of natural sciences which was dominant among Marxists at the time. At the same time, it proposes the Marxist point of view, freed from scientism, as a superior tool of analysis of the development of sciences in capitalist societies, and as a basis for the construction of an alternative scientific project in coherence with the interests of the working class.

The book also contains two historical essays which illustrate the above-mentioned central thesis, one by Ciccotti and Donini, and the other by Jona-Lasinio; there is an essay by Cini on the theory of labour-value as well as a few others on the consequences of scientific development upon technology, on society as a whole and on working conditions.

2.

My first consideration concerns the whole book. Nowadays, the certainty with which the authors quote passages from Das *Capital* and other classic Marxist works is very impressive. It is as if the reader, whether a member of the general public, scientist, or left-wing activist, were supposed to know, at least in broad terms, Marx's thought and the problems discussed by the left. Here you get a measure of the importance – or even of the hegemony – of the Marxist left for the culture (even academic culture) at the time in our country. In those same years, studies of theoretical economics, both in Italy and – to a large extent – in Europe and elsewhere (England in particular, and even in the USA) were strongly affected by Marxism, by Piero Sraffa and by the attempt to unify the theories of Marx and Keynes.

Reading this book, someone who did not live in those years will get the impression of a relic of a time gone forever. But that would be wrong: the central problems exposed in the book are still present. The book asks whether it is possible to say that natural sciences develop independently from the social and historical context. The answer is negative, and is partly supported by the direct reference to Marx, and partly by historians of scientific thought and epistemologists who do not proceed from Marx's thought. The central thesis is that the development of science is open and cannot be reduced to a continuous enlargement of our knowledge of the laws of nature. This does not necessarily mean that you can decide between rival theories and explanations only on the basis of an experiment. As a consequence, one can pose the question of the choices of the scientific community. Here I am not thinking of the applications of science, but rather of the deeper question of the directions taken by basic sciences.

3.

In my opinion, the authors' arguments against the neutrality of science are developed most clearly in the third chapter, "Modern Epistemological Debate and the 'Socialization' of Science," as well as in the two historical essays by Ciccotti and Donnini and by Jona-Lasinio. In the third chapter, the authors lean on works from the history of science and epistemology (Lakatos and Kuhn, in particular) in order to state that the refined version of the neutrality of science proposed by Popper – i.e., a scientific development passing through crucial experiments and falsifications – does not hold.

I think it may be useful to give the contemporary reader a scheme of the positions prevailing at the time regarding the question of the neutrality of the natural sciences. The scientistic position, which I have already mentioned, dominated the academic environment, whether right-wing or left-wing. The idea that basic natural sciences develop neutrally with respect to the social and historical context, was quietly accepted. The left was rather characterized by the criticism of the use of science, war applications, and the corresponding lack of development of socially useful applications.

We can define as scientistic the position of Lucio Lombardo Radice, mathematician and Communist, who at the time was an influential character in left-wing culture. He wrote about science as well as classic topics of Marxism, such as the dialectic of nature, differences in the development of science in the Soviet Union and in capitalist countries. As young university students of scientific faculties, we were also quietly scientistic. An exception among us was Giovanni Ciccotti who was already working – as a student – on themes which would become central in *The Bee and the Architect*, in particular on the non-neutrality of science in a deeper, epistemological sense, which goes beyond the question of the use of scientific results. The first part of the book, "The Historical Rationality of Scientific Practice," contains most of the ideas which Ciccotti supported, in his dashing style, in the course of many discussions with me and with many others, both students and teachers, of the Roman university left.

A harshly critical position towards science came from the Frankfurt School, from authors such as Horkheimer, Adorno and Marcuse. However, it did not concern epistemology, the internal development of natural science. In works such as *Dialectic of Enlightenment* (1947) and *One-Dimensional Man* (1964), they stated that the Enlightenment and science contain the seed of capitalist exploitation of both humans and nature, but nothing regarding the central problems of *The Bee and the Architect.*

In sum, the question of the neutrality of science had different meanings in the discussion at the time: not neutral because bent to the ends of capitalism and imperialism – a popular expression at the time – not neutral because it was one with capitalism – as the Frankfurt School said. However, it could also be non-neutral in a more refined sense, as maintained by various authors, including Lakatos, Kuhn and those of *The Bee and the Architect.*

Critical positions such as that of the Frankfurt School were claimed by small minorities before 1968. If we leave aside, for a moment, the link with the Soviet Union, the politics of Italian communists hardly distinguished itself from a quiet reformism: democracy, workers' rights, fairer distribution of income, economic planning; natural science at the service of economic and civil progress (the above-mentioned position of Lucio Lombardo Radice). This was a position which was quite distant from the Frankfurt School's criticism of the Enlightenment and science, and of their development in mass society, subservient to capital, first in the workplace, and then in induced consumption, dazed by the media's cultural surrogate.

With 1968, the situation underwent a complete reversal. The majority position of the new left – the academic left in particular – rejected reformism as a renunciation of a radical modification of social relationships and, with it, trust in the progressive role of sciences.

The denunciation of the capitalist use of research results was transformed into a denunciation of scientific research in general. The

Frankfurt School's themes exerted a great charm, just as many other positions of radical criticism at the time. For many years to come, the left would talk of a crisis of capitalism, crisis of a science, crisis of reason. The criticism of reformism, of progressivism and of science would rapidly affect school, university, research and daily life. Once the dam broke, nothing was saved in those years for those who tried to stay sober in this disaster of the left: weak thought, hermeneutics, the return of Heidegger, down to the anti-nuclear triumph, and then Eastern wisdom, horoscopes and tarot cards. In our country, the criticism of the Enlightenment and scientific thought found fertile ground in a diffused ignorance of the building blocks of science, encouraged by our best philosophers, by whom the structure of our school was inspired. To this day, almost everyone in Italy would acknowledge without embarrassment that they do not know Giuseppe Peano or Tullio Levi-Civita. However, those who did not know something about Benedetto Croce would hardly have been invited twice to an elegant salon. Not to mention those who refused to enthusiastically adhere to the statement – rather frequent even among cultured people – that melodrama doubtlessly is Italy's greatest contribution to the world in the last few centuries.

In 1976, when *The Bee and the Architect* was published, the political movement of 1968 had partly degenerated, was partly exhausted. However, the above-mentioned cultural movement, the critique of science and the Enlightenment was alive and in full development. The task which the authors of *The Bee and the Architect* faced was therefore very delicate. On the one side, they wanted to distance themselves – with great determination – from naïve and refined scientism. But they also wanted to distinguish themselves clearly from the criticism of science from idealistic and anti-enlightenment positions, and therefore from the penetration of the theses of the Frankfurt School. In this regard, at the very start of the first chapter, they talk about a "process to science, unsatisfactory because too superficial and solipsistically irrational to be useful," with reference to Marcuse and Habermas.

Immediately afterwards, however, this judgement is weakened: these formulations:

> at least [have] the merit of showing that the problem of the value of science and its social function is more complex, more interesting and more charged with consequences than the superficial certainty of scientism and its easy solutions, stated though commonplaces, would let us suppose.

And again: "Much more serious is the responsibility of those who, by relying on the weakness and mystical character of the claims of irrational critics, propose a false dilemma: either obscurantist or scientist" (in a footnote, the authors to whom this polemical passage is address are named: Lucio Colletti and Ludovico Geymonat).

Now as then, I appreciate the arguments of the book for their attempt to develop a position that is distinct from both scientism and irrationalist criticism of science (moreover, I learned a lot from the book and its authors). However, I still do not share their indulgence towards authors such as Marcuse or Habermas, in light of the post-modernist plague which struck the left in the 1970s and which shares the anti-enlightenment roots of the Frankfurt School.

The point is that Marxism, and the left in general, attracted a large number of intellectuals with an exclusively philosophical-literary background, without any knowledge of the basics of modern science. They sometimes use words because of their etymology, other times according to their evocative power, as in poetry. When they talk about science or epistemology, they are fascinated by terms such as chaos, catastrophe, complexity, non-linear, imaginary, infinite, infinitely small, and they place them together by ear so as to produce pages and pages of delirium. See, in this regard, A. Sokal and

J. Bricmont's *Intellectual Impostures* [US title: *Fashionable Nonsense*] (1998) which contains an exhilarating collection of texts by Lacan, Kristeva, Irigaray, Deleuze, Guattari and others, in which sciences are evaluated, criticised and even used.

On the other hand, it is also true that the same defect, a total ignorance of the basic rudiments of science, can be found in Lucio Colletti, one of the champions of the scientist camp during the controversy of those years (I'm mentioning Colletti again also because the Introduction's author dwells on his "debt to and dissent from" him). Colletti, too, had an exclusively philosophical background and this made it impossible for him to understand the delicate epistemological questions which the book discussed. Having said that, I believe we should give Colletti credit for indicating, with determination, the need to isolate Marx "the scientist," of *Capital* in particular, from the rest of the production of Marx and Engels, from dialectical materialism, from the Frankfurt School's idealistic revival. However, Colletti stopped here. The Marxist science of capitalist society, according to him, was modelled upon natural sciences. Colletti does not go beyond any philosophy textbook in defining the meaning of natural sciences. However, for a young Marxist activist with mathematical training like myself, Colletti's books were very important. Thanks to him, I avoided breaking my head with the dialectics of nature and with dialectics in general. I often joked: if it wasn't for Colletti, perhaps I would have spent time reading the two gigantic tomes of Jean-Paul Sartre's *Critique de la raison dialectique* (1960).

4.

In sum, between the two "enemies" challenged in this book, the irrationalist critics of science and the left-wing scientists, I think that the former were by far more dangerous.

In this regard, it is worth mentioning an episode which has many similarities with the attempt made by *The Bee and the Architect*. It took place in the same period, between the 1970s and the 1980s when a group of economists, concentrated in the Faculty of Economics of the University of Modena, tried to diffuse among the left some results which had been obtained out of the classic Marxist tradition. In particular, as I mentioned above, this was the theory of prices by Piero Sraffa and Keynes's general theory. As far as Sraffa's theory is concerned, it was necessary to overcome the conviction, crystallized in Marxism, that all the important conclusions of *Capital* came from the theory of labour-value.

We faced a fierce resistance, mainly on the part of those who had no idea of the problem, namely that prices differ from labour-values. Marx was aware of this, and the solution he proposed, the well-known "transformation of values into prices," is not at all obvious. I still remember the settlement of the whole problem on the part of a philosopher: of course, there is a contradiction between values and prices in Marx's theory, but this simply mirrors a contradiction of capitalist society. A charming thesis: one can say any nonsense, and then attribute its responsibility to the surrounding world.

It is almost useless to warn readers that the essay by Marcello Cini, "Labour-Value as a Scientific Category," in the book, is totally different. Cini expresses his total dissent from Sraffa's position; however, his arguments are based on a solution which he thinks he has given to the problem of transformation.[1]

5.

Starting from the 1980s, the dominant position in economic theory attributes to the market the capacity for self-regulation and

1 See the last part of the essay, in which Cini provides an interpretation of the procedure of transformation, left unfinished by Marx, and proposes a way to complete it.

recommends keeping public intervention to a minimum – a real counter-revolution in comparison with the Keynesian period. Nowadays, faced with the disaster caused, among other things, by financial deregulation, many economists are starting to wonder about the functioning of complex systems, such as capitalist economies, and to have doubts about the existence of an “invisible hand” which guarantees optimal development. However, natural sciences are complex systems too. This book strongly supports that idea, even though an optimal dynamic is not only not assured, but does not even exist. Therefore, there is ample room for evaluation and criticism of the directions taken by the natural sciences.

The Spectre of Science and the Ghosts of Irrationalism

Dario Narducci

1.

It is perhaps a welcome sign of the changing times that a significant number of initiatives in the last few years have taken up themes and problems which were among the best fruits of the lively intellectual life of the 1970s. These initiatives, apart from the obvious criticism of those who would have preferred to cancel that period of Italian and World history altogether by applying the mediaeval condemnation of *damnatio memoriae* (in the name of modernity, of course), are in no way marked by nostalgia – rather, they are made urgent by the need to revive issues which appear to have been set aside rather than overcome: from the women's question to the relationship between culture and society, from the modes of production of knowledge to its fruition, just to mention a few. In this sense, an essay commenting on *The Bee and the Architect* thirty-five years after its first edition can serenely take the freedom to write about the neutrality of science and its relationship, on one side, with the methodological status of science[1] and, on the other side, with historical contingency,

1 In these pages we will often use the term *science*, which is used with different meanings in different contexts. Unless otherwise indicated, the word will be employed according to the conventional and extensional definition of *Naturwissenschaft* – knowledge of the physical (natural) world.

starting from *The Bee and the Architect.* Out of the many declinations of such a hub, in this short essay we will focus upon one single aspect which, however, we consider very relevant for the way in which it characterized the dialogue between the scientific community and civil society: namely, the status of science. More explicitly: is there, here and now, the possibility of thinking of ways of producing scientific knowledge beyond the classical opposition between scientism and irrationalism? In other words: can science get rid of its claim of being a form of ahistorical and absolute knowledge without transforming itself into a mere scientific doxology, one among an infinity of possible opinions regarding nature and the rules which control it?

The idea that science has its own status, different from other modes of knowledge production, is known to be the basis of neo-positivist thought:

> In such a way logical analysis overcomes not only metaphysics in the proper, classical sense of the word, especially scholastic metaphysics and that of the systems of German idealism, but also the hidden metaphysics of Kantian and modern *apriorism*. The scientific world-conception knows no unconditionally valid knowledge derived from pure reason, no 'synthetic judgments *a priori*' of the kind that lie at the basis of Kantian epistemology and even more of all pre- and post-Kantian ontology and metaphysics. The judgments of arithmetic, geometry, and certain fundamental principles of physics, that Kant took as examples of *a priori* knowledge will be discussed later. It is precisely in the rejection of the possibility of synthetic knowledge *a priori* that the basic thesis of modern empiricism lies. The scientific world-conception

> knows only empirical statements about things of all kinds, and analytic statements of logic and mathematics.[2]

The separation of science from the historical context in which scientific thought is created appears to be a strong methodological need, based upon the criticism of natural language.[3] Indeed, if science were a historical event, its results would be subjective, and thus relative. On the contrary, because it is a necessary discourse upon physical reality, unchangeable and traditionally independent of the observer, an authentic knowledge of nature must eject all subjects – be they individual or collective – from speech by singling out the scientist as an instrumental, inessential bearer of knowledge. In his *Postscript to the Logic of Scientific Discovery,* Karl Popper remarks that:

> Although objective knowledge always results directly or indirectly from human actions, from steps taken in the light of subjective *and* objective knowledge, objective knowledge often emerges without having been previously known subjectively. This is invariably the case in all calculations (as far as the man who makes them is concerned): here we wait for the result to emerge in some physical shape before we form the corresponding subjective conviction [...].
> It will be seen from what I have said, that we can consider objective knowledge – science – as a *social institution*, or a set or structure of social institutions. Like other social institutions, it is the result of human actions, largely unintended, and almost entirely unforeseen [...]. To be sure, it lives and grows

2 H. Hahn, O. Neurath and R. Carnap, *Wissenschaftliche Weltauffassung: Der Wiener Kreis*, Vienna: Artur Wolf, 1929. English version: "The Scientific Conception of the World: The Vienna Circle," in M. Neurath and R. Cohen (eds.), *Empiricism and Sociology*, Dordrecht: Reidel, 1973, p. 308.
3 Ibid., p. 307.

> largely through the institutionalized cooperation and competition of scientists who are not only inspired by curiosity [...] but even more so by the wish *to contribute to the growth of knowledge* – that is, of objective knowledge.[4]

Therefore, even though the scientific enterprise is inevitably *social* and historically placed, the consequent scientific production maintains an objective character. This is an essential persistence since its deletion would undermine not so much the role of the scientist as the meaning of scientific research itself, which finds its reason to be in its being produced outside and beyond the subject. However, the point is: how and when does the act of knowledge lose its initially subjective character? In the methodological language, the place of the experiment transforms the scientific product from subject to object. Among the different opinions which individual scientists rightly form about a series of phenomena, the experiment cancels the erroneous ones, falsifying them. This process of selection of concepts continues in order to allow the identification of a single symbolical representation (i.e., a theory) coherent with all experimental observations – which, as such, is objective (only related to the object).

Of course, this is a terribly naïve mechanistic hypothesis which, however, is largely shared within the scientific community. This *reduction ad unum* of scientific opinions can be attacked from many points. First of all, the presumption of the uniqueness of the theory, which is difficult to demonstrate – as well as its presumption of existence, by the way, even though this problem falls into another area. Secondly, the incompleteness of testing, which makes necessarily subjective the selection of *experimenta crucis* with respect to which the theory is objectified. Thirdly, there is the neutrality of the

4 Popper, *Realism and the Aim of Science*, vol. 1, *Postscript to the Logic of Scientific Discovery*, ed. W.W. Bartley, III, London & New York: Routledge,1992, pp. 95-96.

experiment, whose intrinsically theoretical nature (oriented to testing theories, i.e. statements having the status of opinions) has been well and extensively described.[5] Conversely, the scientific method, in its historical dynamics as well as in its conceptual stability, has clearly shown the capacity to generate extraordinarily solid theoretical constructs which evolve in time into more general theories and, in any case, can always include a wide range of phenomena. This fact justifies, to some extent, the sensation that science has its own capacity of advancing and correcting itself, which hardly occurs in other areas of human thought.

2.

Therefore, if on the one side scientism has a questionable foundation, but also reasons for being understood, on the other side, the refusal of the scientific method as a privileged means of understanding the natural world has its rights – and its wrongs. Save for pure irrationalism, which challenges the objectivity of science as a sin in itself (and therefore, ironically, ends up with an involuntary partnership with acritical scientism), epistemological criticism *sensu lato* believes it can deny *tout court* any chance of an objective knowledge of nature, disputing even the methodological primacy of science and thus placing any discourse on the natural world on the same level. According to Feyerabend, for instance,

> **science is much closer to myth than a scientific philosophy is prepared to admit. It is one of the many forms of thought that have been developed by man, and not necessarily the best. It is conspicuous, noisy, and impudent, but it is inherently**

5 Feyerabend, *Against Method*.

> superior only for those who have already decided in favour of a certain ideology, or who have accepted it without having ever examined its advantages and its limits. And as the accepting and rejecting of ideologies should be left to the individual it follows that the separation of state and *church* must be supplemented by the separation of state and *science*, that most recent, most aggressive, and most dogmatic religious institution.[6]

In the same tradition, J.-F. Lyotard writes:

> 1. Scientific knowledge requires that one language game, denotation, be retained and all the others excluded. A statement's truth-value is the criterion determining its acceptability. [...] In this context, then, one is "learned" if one can produce a true statement about a referent, and one is a scientist if one can produce verifiable or falsifiable statements about referents accessible to the experts.
> 2. Scientific knowledge is in this way set apart from the language games that combine to form the social bond.[7]

As we have written elsewhere,[8] the relativization of scientific knowledge *sic et simpliciter* is an arbitrary practice, unnecessary with respect to a knowledge which, undeniably, has its own internal skills for self-correction, typically absent from other forms of production

6 Ibid., p.295.

7 Jean-François Lyotard, *La Condition Postmoderne: rapport sur le savoir*, Paris: Editions de minuit, 1979. English version: *The Postmodern Condition: A Report on Knowledge*, trans. G. Bennington and B. Massumi, Minneapolis: University of Minnesota Press, 1984, p. 25.

8 D. Narducci, "Sul ruolo politico e morale della scienza: Renato Treves e il Relativismo scientifico," in R. Treves, *Spirito critico e spirito dogmatico*, Milan: FrancoAngeli, 2009, pp. 105-121.

of knowledge. Any reduction of scientific knowledge to naturalistic doxology throws out the baby with the bath water. Or, rather, it only throws out the baby and retains the dirty water, since it seems impossible to ignore science, the technologies it has created, and the effects of these technologies upon our *modus vivendi* – both for our social life and for our strictly personal life. The result is that a *negative* criticism of science, while renouncing precise critiques, makes us defenceless in front of the impact that science has upon the social context in which we all inevitably live and act.

However, there is some dirty water which scientists, most of all, should want to get rid of. As Ciccotti and Jona-Lasinio poignantly remarked thirty-five years ago,[9] it is clear to whoever has even an amateur knowledge of scientific history that the idea that there might be an engine totally internal to science, only linked to the possibility of the experiment, to distinguish between "true" and "false" theories is entirely illusory. The limits of the neo-positivist paradigm, well beyond the problem of verifiable theories, consisted in a reading of the history of science that, once again, deliberately ignored (or pretended to ignore) the mechanisms of adaptation of theories to experimental evidence found in contrast with current theories. The conventionalist approach was created precisely to account for this historically determined need – and, conversely, for the impossibility of science to give up falsified paradigms where no better theories were available. As Lakatos points out[10]: "by [its] standards, scientists frequently seem to be irrationally slow: for instance, eighty-five years elapsed between the acceptance of the perihelion of Mercury as an anomaly and its acceptance as a falsification of Newton's theory." However,

9 G. Ciccotti and G. Jona-Lasinio, "Modern Epistemological," originally "Il dibattito epistemologico moderno e la socializzazione delle scienze," in *L'Ape e l'Architetto*, Milan: FrancoAngeli, 2011, chapter 3.

10 Lakatos, "Falsification," p. 115.

epistemological conventionalism, despite having the merit of taking charge of history (no small thing, really!), provides an interpretation of the theoretical evolution of science – and of their founding status – which is largely insufficient. The above-quoted considerations by Popper which try to single out a way to escape narrow conventionalism are a clear proof of this. Popper agrees on the social connotation of the act of generation of the theoretical construct, even going so far as to grant the scientist a psyche which determines preferences of both style and model – but then he takes a step back when, from the chaos of the first intuition, one moves to formulate a theory, which loses any historical influence in front of the validating power of the experiment.

3.

However, the question arises as to whether science really needs this objectivist *allure* to guarantee its own status and specificity. In other words, would the more than doxological character of science really be at risk if science abandoned the idea of being a kind of knowledge produced outside the subject? Before trying to answer this question, a digression on the possible historical origin of scientific objectivism would be useful. The separation between science and philosophy is a long and complex process that started in the Renaissance and was completed (if at all) only in the 20th century.[11] In Plato, the unity of the Universe ensures the need for the laws of nature, since they come from the metaphysical harmony of the One. In the same way, Aristotle's physics obtains its own *auctoritas* from a

11 Massimo Cacciari took up this theme (in *Micromega*, vol. 5, 2002), showing the opportunity of once again articulating a link between science and the philosophy of nature. See also G. Boniolo, P. Vidali, *Introduzione alla filosofia della scienza*, Milan: Bruno Mondadori, 2003, chapter 9.

complete representation of the world. Aristotle's organisms are *entelechies* which possess the principle of life and whose cause-effect laws are only a marginal reflection. The breakdown of the bond between physics and metaphysics was consummated slowly, evolving in Spinoza's immanentism (*Natura naturans, Natura naturata*), passing from Leibniz's criticism of the naturalistic mechanicism of Descartes and the sceptical realism of Hume. Only at the beginning of the 20th century did science establish a complete autonomy with respect to the philosophy of nature by dissolving its old alliance through the criticism of its foundational clauses carried out by the Vienna Circle. Up to the first few years of the 20th century, the nomologic principle stands on legs external to science – still on largely metaphysical bases. The breakdown of this difficult balance between physics and metaphysics wholly left to science the duty of its foundation, which would be too fragile if it were still connected to the *res extensa* – and exceedingly arbitrary if entrusted to an unidentified actor. Descartes's *res cogitans*, reduced to the status of natural observer, seems a too transient entity to provide science with a sufficiently solid constitution. Thus, the need arises for an objectivation of the mechanism of constructing scientific knowledge, basically a neo-Spinozan plan enshrining the *auctoritas* of the scientific representation of the natural world in *Natura naturans*, a God-Nature representing itself through the only apparently human enterprise of scientific investigation.

If we want to give even marginal credit to this simplified – and probably very approximate – tale of the history of natural philosophy, it may appear reasonable to consider the neutrality of science as the last backlash of the denied metaphysical tradition. It is certainly true that it also assumes social connotations and is exploitable for political uses of science as an instrument for the creation of neutral and compelling truths – but this is not the point we want to analyse. On the level of its foundations, the need for an objectification of scientific products appears to be the almost inevitable outcome of a half-finished transition from the philosophy of nature to a naturalism without any transcendence. We can rephrase the question we were posing in different – but possibly equivalent – terms: would the more than doxological character of scientific knowledge be at risk if science admitted being the product of a sentient and thinking subject rather than of an entity external to the subject itself? Of course, the answer would be negative, insofar as we can distinguish between subject and individual. Because the founding and distinctive feature of science does not consist in being a product alienated from its producer, but rather in being a collective product of a plural subject which expresses its own plurality through the exercise of stringent rules allowing it to falsify wrong theories, not on the basis of opinions or the mere consent of the community but rather through strict protocols of invalidation – or through methods of re-definition, enlargement and overcoming of theories. This is where the specific essence of scientific knowledge lies: neither in its rigour (which is an attitude largely shared with many other branches of human knowledge) nor in its universalism (which simply exists only in the *a posteriori* reconstruction of its historical occurrence), nor in its extraordinary capacity to explain and predict phenomena – but rather in its ability to correct itself through procedures which are only based upon a methodological consent (the so-called "Galilean method," however unlikely this label may be). Therefore, scientists may often make mistakes and often (almost always in new and interesting topics) disagree with one another. They also maintain theories that are evidently falsified – whereas sometimes they choose among theories with similar predictive capabilities on the basis of considerations which cannot be traced back to recognizable methodological principles. However, they do possess tools which help them overcome the limits of opinion, and of arbitrary preference – tools which are primarily linked to the possibility of experimenting (because science only handles reproducible phenomena, unlike almost any other area of human thought) and quantifying observed phenomena (and thus comparing theories based upon their quantitative capabilities of predicting phenomena).

Therefore, we may be entitled to conclude that the recognition of the non-neutrality of science does not imply a decay of the authority of science itself. For the sake of paradox, we would almost be tempted to conclude that the claim of the non-neutrality of science constitutes the historical completion of the neo-positivist project to free scientific thought of all metaphysical superstructure. This certainly does not imply reducing science to no matter what opinion, which may be valid as much as oriental-style syncretism, astrology or other irrationalistic mumbo-jumbo. Just as such forms of irrationalism assume they can overthrow the Moloch of science, they actually strengthen its worst possible use – namely its authoritative use. Placed on the same level as any other *magic* (in the etymological sense of *maha*, feast) and because of its predictive capabilities and its technological products, science would not struggle to confirm itself as the greatest magic – at least in its practical outcomes, even when not in its public acceptance or in its explicit consent.

4.

Indeed we must note how science, in the last few years, because of its alleged neutrality, is running the paradoxical risk of becoming a source of truth. The scientist is often considered in political and economic debate a sort of reference person who "knows the truth." If this were not enough, science, as a source of truth, is called to ally itself with dogmatic forms of thought in an increasingly frequent and alarming way. Indeed, the increasing frequency with which religion asks science for a curious legitimacy is alarming since religious ethics covers issues related to the natural world. Suffice it to think of what happened in the Italian debate about artificial insemination, aggressive medical treatments, or the so-called "living will" – or about the recurring topic of the voluntary termination of pregnancy. The Catholic Church has often relied on the authority of science to answer scientifically nonsensical – but theologically fundamental – questions regarding the beginning and ending of individual life, causing a drift of both sense and role between religion and scientific knowledge. It marks an exchange of roles and meaning which produced – or tried to produce – a crossed legitimacy for the production of absolute, indisputable knowledge between politics and science, where politics looked for an ally in science so as to support or take decisions in the medical and technological area, which affected – and still affects – civil society first on the political, then on a technical level (energy issues, ethical questions, environmental problems, etc.). In this case, too, science is asked to generate truths which cannot be criticized, effectively validating an uncritical approach to complex problems.

However, at the same time, science has also faced the challenge of relativistic extremisms for which any theory of nature equals any other. The confrontation, born in the USA and later imported to Europe and Italy, between Darwinism and Creationism is a good example of this. Possibly all this appears contradictory at first sight, but it actually mirrors, in our opinion, a conceptual *vulnus* behind a certain mechanical practice of relativization. In its dogmatic interpretation, science generates truth. Therefore, since there is only one truth, science must agree in its conclusions with all other *machinae cogitandi* (religion, political ideologies, etc.) capable of generating truths.

Therefore, even without demonstrating the possible denial of scientist neutrality, which must not necessarily reach an extreme relativism, it would be in any case appropriate to wonder about the political expediency of a complete relativization of scientific knowledge that, instead of *freeing humanity* , would leave people even further under the control of dominant powers. A society which, on the threshold of the new millennium, would consider the scientific method as a leftover from the past would be a society devoid of essential critical tools as compared to the possibility of applications of science – i.e., technologies. On the other hand, we can assume that a critique of the alleged neutrality of science, instead of a simple denial of its status, would refine the focus of the criticism of science as *criticism of its products* more than *of its procedures*. The (material and non-material) products of science, *inasmuch as objects of interpretation or usage*, are indeed primarily historicized and subject also to political criticism. The distinction between *procedures* and *products* of science, even if expressed in different terms, is not new.[12] The interpretation of a theory is an individual act, both historically and economically set, just as the use of a device. Therefore, unlike science itself (which is not neutral but is not even a mechanical consequence of the dominant economic modes of production[13]), the material and non-material products of science not only are non-neutral but, just like any other product, are anchored to the productive and economic system in which they are conceptualized, produced and consumed. Cini's prophesy (in the year 1968, six years before the construction of the Apple I, the first PC of the Cupertino company) is still inspiring:

> I am quite convinced that, in the next twenty to thirty years, we will witness the development of the computer industry resulting from the increased private use of computers, similar to the private use of cars [...]. This development will introduce forms of further selection, enslavement and competition, and to people's imprisonment in an increasingly inexorable logic, mainly due to private consumption. Clearly, this industry – from the economic point of view – can enhance the

12 See the criticism of instrumentalism in Popper, as exposed both in his *Postscript* and in *Conjectures and Confutations: The Growth of Scientific Knowledge*, London: Routledge, [1962] 2022.

13 On the (even Italian) misadventures of Lysenkoism, see A. Guerraggio, "Il '68 italiano e la scienza: premesse e contesti," *Pristem/Storia*, 27-28, 2010, pp. 3-25.

> **development of the economic system, just as the auto industry did, but it also lends itself to providing individuals with a type of consumption which enslaves them like a drug.**[14]

In conclusion, the new publication of *The Bee and the Architect* seems an excellent chance not only for the scientific community but also for those who, outside the scientific and technological world, have to confront the *conspicuous, noisy, and impudent* machine of science to discuss, once again, in a straightforward and critical way the twofold role of science in our late modernity: in culture, of which science is an integral, not a minor, part; and in economics as well, since it draws vital sustenance from science. It could also be an occasion (or, more modestly, an encouragement) to bring political debate again to places which should be familiar to it, where ideology, culture and philosophy are not bulky or embarrassing guests, but rather strong tools in the analysis of reality and in planning its transformation.

14 M. Cini, in *Bollettino CESPE*.

The Fight against Orthodoxy

Giorgio Parisi

When I was asked to write an essay for the long-awaited reprint of *the Bee and the Architect,* I thought to myself: “Easy: it’s a book which I know perfectly well and have read many times. It should suffice to look at it quickly, find some quote, and I’ll know what to say.” Easier said than done. I wrote down my first draft rather quickly, starting with: “I remember when I read this book for the first time: it was 1973 and I was in my office in New York at Columbia University…” However, in a later dash of lucidity, I had the scruple to check the date of publication, and to my amazement I discovered that *The Bee and the Architect* had been first printed in 1976. I wonder what I had read in New York in 1973: perhaps an essay by one of the authors, which at the time was circulating separately as a preprint. In any case, I threw away what I had written and read the book again very carefully (as if this were the first time), trying not to superimpose my memories onto what I was reading, to understand what its message is now and what kind of impression it may give to the reader.

Perhaps the first feeling you get now is displacement. When a book is written – and this is particularly true of essays – the authors have very well in mind the audience which they are addressing. One of the evident concerns, especially in the first part of some of the essays which make up *The Bee and the Architect*, is to show that the authors’ theses are completely in line with the original texts of Marx and are their natural consequence, and that, if the giants of Marxism (in one case even Lenin) state contrary arguments, well, they are heading off the right road. The origin of this concern could be well understood in 1976: a Marxist orthodoxy had been built according to which there were indisputable truths; to this ideological rigidity corresponded Communist parties which, in their huge variety of political practice, were often characterized by a strong repression of internal dissent: the opponents of the dominant line were typically accused of being deviant (generally to the right) from the correct line. The great prestige obtained by the Soviet Union for its decisive contribution to the defeat of Nazi-Fascism, the Cold War which divided the world into two parts, and the consequent need to take sides, had largely contributed to this crystallization. The Italian left had long been dominated by the Communist Party, and its cultural hegemony was felt heavily in the whole area of the progressive left.

In the 1960s, the situation started to change. In Italy, many intellectuals began to think outside the traditional patterns, and tried to open spaces for themselves to the left. The year 1968 impetuously broke the dam, and in 1969 a group of intellectuals and political leaders of the Italian Communist Party (among whom was one of the authors of *The Bee and the Architect)* started a magazine (which later became a daily paper), *Il Manifesto*, coherent with their political positions: as was perhaps inevitable, the promoters were expelled from the Party. However, even outside *Il Manifesto*, the heterodoxy towards the "vulgate" was spreading. The "galaxy" of the extra-parliamentary left was born. In the 1970s, this process was well under way, but there was an area which the critical wave had not yet touched since it was protected by a universally recognized "*super partes*" status: science. I can speak of this with first-hand knowledge since I know its inner workings: our authors, professional scientists and physicists, and Marxists at the same time, decided that it was time to reconsider the traditional positions on the role of science in society.

As regards science, one of the fundamental theses of Marxist orthodoxy was that "an ideal of an essentially ahistorical scientific knowledge which, when applied to nature, only serves the progress of science" (see Chapter 6 of the Appendix). On the contrary, the authors thought that, since scientific production:

> is a specific and particular human activity, it is not understandable in itself. It can only be understood when analysed together with all other human activities in a certain historical period and compared to similar activities in other periods. That is to say, science can only be understood by referring to the totality of human work [...] science, in its concrete reality is not given to us immediately but only after a long work of analysis.

In stating this, the authors were aware of being twice heretical: not only were most of them placed in various positions on the left of the Communist Party, but they were also strongly in contrary to one of the key points of that orthodoxy. The authors' theses were not politically neutral: given the ever-growing importance of science and technology in modern society, the risk was far from marginal that an illusory vision of science might induce a wrong interpretation of the changes in progress and workers' struggles. For this very reason, it was crucial for the authors of this book that their argument had all the ideological justifications and necessary critical apparatus in order to be politically acceptable to the Marxist left and might, therefore, affect left-wing politics.

Why was I talking of a sense of displacement when re-reading this book? Marxist orthodoxy has gradually disappeared, together with its defenders, with the collapse and mutation of the Communist parties in power. Therefore, nowadays, there is no longer the need for dialogue with them, even if in often polemical form, nor of justifying one's own position when recalling the origin of Marx's thought and the pre-Stalin Marxist tradition, as the authors of this breakthrough book had done. For those who did not experience that period, it seems incomprehensible to focus so much effort on establishing

Marx's original vision on the topic.

The Marxist Background

The recourse to Marx's original thought, however, does not only have a defensive role towards Marxist orthodoxy; it is also useful in order to understand the genesis of the authors' positions, which are extremely original. Even the scientific community at the time was essentially and wholly convinced of the absolute objectivity of science: according to the contemporary opinion among scientists, there had certainly been influences of society upon science, but they had only contributed to speeding up or slowing down scientific developments which, on their own, would have evolved towards an objectively (rather than historically) determined final construction.

I remember that the essay of the book, which I read first left me, frankly, puzzled. It was "The Satellite of the Moon," by Marcello Cini, published in *Il Manifesto* in the month of September 1969 (reproduced in this volume). In that article, Cini analysed the Apollo programme, emphasizing that the scientific spin-offs of space programmes were absolutely accepted as real motivations, and that similar considerations could also be made for the usefulness of applications and for indirect results; on the contrary, political and military objectives of space missions were out front and dominant. Cini then went on to include these considerations within a more general argument about the capitalist use of science and the relationship between productive forces and monopoly capital, and he concluded by saying:

> How could one deny that, nowadays, we would be facing a different science, as far as contents, methods and the importance of the various disciplines are concerned, if research in the USA had not been so largely conditioned by the economic, political and military expansionist needs of capitalism?

Obviously, at the time, within the left they had to confront their Soviet comrades who candidly claimed that "the underlying reasons for space research were the needs of science and the desire to bring future benefits to humanity." For Cini, it was easy to prove, logically, how these statements really masked deeper political and military reasons, but in doing so he was on a collision course with the Communist Party, of which he was one of the leaders.

At the time I was twenty-one, and just like many young people of my generation, I had read many science-fiction novels in the "Urania" series: the landing of a man on the Moon seemed to us the start of a new stage of exploration and colonization, first of the Moon, then of other planets, in which the Earthmen finally started to take their first steps in the Universe. Cini's criticism certainly contained some truth, but it implied, to our eyes, only that the major powers – for their short-sighted and wrong reasons – were doing something that, from the viewpoint of the general evolution of humankind was meaningful and necessary, but also absolutely not to be postponed. We thought that Cini did not realize that we were facing the dawn of the Space Age and that he was focussing on contingent details without appreciating its great novelty. His argument actually seemed to us rather limited.

Forty years later, it is quite clear that he was right and we were wrong. The Space Age and the colonization of the Moon never really started. Apart from a large number of Moon rocks and some spectacular pictures, there is nothing left in our hands of those trips. In fact, it is as if no one had been on the Moon at all. The drastic closure of the programmes for the human exploration of the Moon, without any window for reopening, and the marginality of current space exploration programmes, speak volumes about the crucial importance of contingent political-military reasons at the time of Moon landing. However, back then, almost all scientists did not see (or did not want to see) these connections. Therefore, the authors were also heretical in the restricted environment of the scientific community, and the development of their ideas would have been impossible in a purely scientific area. We can understand the genesis of their positions only if we consider the influence of the Marxist tradition. Indeed, Marx had stated that: “The mode of production of material life conditions the general process of social, political and intellectual life. It is not the consciousness of men that determines their existence, but their social existence that determines their consciousness.” For his part, Lukács had stepped up, by saying that, for the bourgeoisie: “it is a matter of life and death to understand its own system of production in terms of eternally valid categories: it must think of capitalism as being predestined to eternal survival by the eternal laws of nature and reason,” and that “only in [a] context which sees the isolated facts of social life as aspects of the historical process and integrates them in a *totality*, can knowledge of the facts hope to become knowledge of *reality*.”[1] In other words, the inconsistent claim of capitalism to be the end of history was a crucial point of Marxist criticism. Starting from these premises, for Jona-Lasinio (Chapter 6 of the Appendix) it was “almost obvious” that “we must return the scientific production of natural science to the historical totality,” even though Lukács himself had stopped short of this step by arguing the contrary, namely, that his considerations did not apply to natural laws.

It is very interesting to notice the convergence our authors’ thought with the thought of the Soviet delegation to the Congress of the History of Science and Technology held in London in 1931. Nikolai Bukharin (a top-level political figure, extremely popular in the USSR, who was one of the most illustrious victims of Stalinist purges) wrote that:

1 Lukács, *History*.

> The idea of the self-sufficient character of science ("science for science's sake") is naive: it confuses the *subjective passions* of the professional scientist, working in a system of profound division of labour [...] with the objective *social role* of this kind of activity, as an activity of vast *practical* importance. The fetishising of science [...] is a perverted ideological reflex of a society in which the division of labour has destroyed the visible connection between social function, separating them out in the consciousness of their agents as absolute and sovereign values.[2]

Cini, at the 1970 "Science and Society" meeting, was unconsciously influenced by these words of Bukharin – who at the time he did not even know – as he stated that:

> we are led to challenge the dogma of the neutrality of science, so deeply rooted in the mind and consciousness of many of us, to the extent that we become aware that it is no longer possible to separate the object of our act of knowledge from the reasons for this act [...] nor to isolate the problem-solving process without identifying the mechanism which proposes the problems to be solved. (in this volume, Chapter 5 of the Appendix)

Scientific Planning

In those years, class struggles in the factories, workers' struggles for their health and better working conditions certainly influenced

2 Bukharin, "Theory and Practice."

the authors as they themselves recognize. In the moment in which the methods of production were introduced by capital as objectively necessary and scientifically deducible, discussions about the production of science in an advanced capitalist society, particularly on the role of information which was becoming a commodity, were becoming questions of great political relevance, and the authors aspired to discuss them at this level. From the theoretical point of view, this was not easy: they wanted to refuse scientism, without refusing science *tout court*, without falling into a new "Luddism." The method which was followed in *The Bee and the Architect* consisted in taking scientific planning as a guide and analysing science while taking its social goals and its objective social role into account; somehow, bee-scientists – who carried out their research work without reflecting on the context – were opposed to architect-scientists, whose concrete actions and research were destined for a project which preceded their works. Modern science acquired a clear meaning only when it was considered within the framework of the ascent of the bourgeoisie and of the development of modern capitalism.

It was therefore necessary to analyse the social role of science, determine on the one side the effects of science upon society, and on the other side how social needs affect science. Obviously, the two problems are closely connected, and it is impossible to get to grips with the one without analysing the other. However, even at the risk of separating what is not separable, I prefer to discuss them one at a time. Indeed, the considerations of this book concerning the influence of society upon science at the time aroused the most controversy and public debate.

The Non-Neutrality of Science and Angry Disputes about the Book

In order to understand the influence of society upon science, the authors sustain that we should examine past history in detail, "to understand which concrete conditions push people towards science [...], you need to find and determine the origin of scientific necessities, which are then related to other human needs" (Chapter 6 of the Appendix). This is the key issue of the book, which the authors address with great balance, aware of the risk of falling into two great, and opposed, dangers: denying the objective building blocks of science or believing that the objective knowledge of nature is only determined by a logic internal to science itself. While proceeding on this path, the authors show a great knowledge of the history of science. The sense of their positions can be better understood if we take into account the examples they studied. Here, I list some of these examples, trying to catch a few crucial points:

The discovery of the principle of energy conservation, from 1842 to 1847, was harshly criticized and opposed by many scholars who wanted to give scientific dignity to mechanics only, leaving aside the new disciplines of thermology, electrology, magnetism, acoustics. The battle was decided in favour of the new disciplines, also because of the crucial role they played in industrial production and of the need for precision measures in order to achieve standardization of the goods produced.

Boltzmann and Planck had both studied the problem of the thermal radiation emitted by a black body, but with very different attitudes: the origins of this difference of perspective could be understood only after a reconstruction of the German scientific environment and the violent clash among the various trends.

In the 20th century, in the aftermath of the Second World War, there had been a rapid development of large laboratories, both national and international, in which research was concentrated; the prototype was the Manhattan Project at Los Alamos during the War, aimed at planning and building the atomic bomb. The success of these large laboratories was due to their functioning as multipliers of the efficiency of the process of scientific production, also to the aim of ensuring that the development of pure science could keep up with industrial production.

The professional ethics of scientists was increasingly changing towards the morale of competitive enterprise. Once, "if someone published some good work, other scientists used to allow him to develop it alone at least for a few years. Now eager researchers rush back from professional meetings to perform the obvious experiments that a speaker had not yet had time to do."[3]

The scientific practice of both the USA and USSR had remarkable differences in their trends. For instance, in the Soviet Union there was a rapid development of non-linear analysis, which could be related to problems of Soviet planning, whereas "the great resumption of studies of classical mechanics in the USSR [...] is difficult to understand outside a materialist-dialectic cultural tradition" (Chapter 3 in this volume).

These are factual remarks, which can be fully endorsed. However, a completely new picture emerged of it: science was a social activity like any other (apart from the fact that, perhaps, it required a much greater commitment) and its choices were also made for irrational, extra-scientific reasons, which were sometimes openly social and political: it was no longer an objective, neutral superstar whose choices were totally rational and, therefore, only understandable through an internal logic reserved for specialists. Nowadays, the thesis seems to us wholly natural, almost trivial, that, although the current success of science cannot be denied, it has been influenced by society and its needs all along its historical process. Another history, another society would have produced a different science, also capable of explaining the phenomena which were considered essential in that society.

3 S.E. Luria, "Research Style."

However, at the time, that was not the case at all: most of the academic establishment were furious: the most famous and authoritative Italian commentators (Lucio Colletti, Giorgio Bocca) considered the thesis of the non-neutrality of science completely intolerable and tried to take it down with a series of striking platitudes, such as: "the bodies fall in the same way under the action of gravity both in socialist countries and in capitalist countries," which obviously did not grasp the point. Even though Giuseppe Barletta in *Marxismo e Teoria della Scienze* (1978) [*Marxism and the Theory of Science*] ludicrously and incomprehensibly accused the authors of being Stalinists ("to the reductive and syllogistic Zhdanovism of Cini and his équipe," Colletti seemed almost forced to oppose the thesis of the *neutrality* of science, which was no longer supported even by any wise neo-positivist), the main charge was wounding the *prestige* of science: the authors were accused of being Luddites, and Marcello Cini was placed by Giorgio Bocca in the list of "bad teachers" who were ultimately responsible for nefarious anti-scientific and irrational trends.

In fact, so many years later, the opposite seems true: there are strong anti-scientific trends in contemporary society, the prestige and trust in science are quickly decreasing, astrological, homeopathic and anti-scientific practices are spreading widely, together with a ravenous technological consumerism and faith in technology. However, this mass distrust is also due to the fact that science still presents itself as superior to a party game, and in a sense as an absolute wisdom, in comparison to other questionable skills when, in fact, it is not at all. Just the stubborn refusal to accept one's own non-neutrality weakens the prestige of scientists who flaunt an untrue objectivity before the public which somehow feels its partiality and its limits. The risk of scientism, as we read in *The Bee and the Architect*, is "since we expect too much from science, it is conceived as a superior witchcraft, so that it is not possible to realistically evaluate what science concretely offers."[4] As a result, non-scientists place themselves in an irrational position in front of a science, understood as inaccessible magic, destined to be disappointed, and therefore prefer other irrational hopes (a topic addressed by Marco d'Eramo in his book *Lo Sciamano in Elicottero* [The *Shaman in a Helicopter*]).

The Social Role of Science

As we said beforehand, over and above considering the influence of social and economic relationships on scientific work, on the other side we should also take into account the role of science in both society and the economy. In other words, it was necessary to clear up the links between science and the social relations of production, as well as the relationships between pure science, applied science, and the production system. *The Bee and the Architect* addresses this task in detail, underlining that all these partially conventional distinctions are part of the same process. Pure science – the authors warn – not only provides applied science with the necessary knowledge to grow (languages, metaphors, conceptual frames), but also has a more hidden – but not less important – role. Scientific activities indeed also function as a giant testing ground for technological products and constitute an encouragement to consume technologically advanced products; moreover, large laboratories are "an ideal testing ground for the introduction of new methods of control and management of a complex integrated productive organization employing highly skilled and highly technical labour" (Chapter 2).

These remarks at the time caused a furore and seemed biased, ideological, even though nowadays they appear rather indisputable, almost obvious: suffice it to think of the large number of products

4 Gramsci, *Further Selections*, p. 57.

which have been first tested in advanced research, sold in order to offset the costs of research and development, then passed to production and mass consumption (for example, camera sensors, initially used by astronomers). Large research centres (CERN in Geneva at the world level, the National Laboratories of Frascati at a national level) played a decisive role in creating computer networks, the Internet and HTML language which is at the root of the World Wide Web. Indeed, as has been said countless times in the press, HTML was born at CERN in order to fulfil the needs of the scientific community.

Re-reading these pages after a long time, I am struck by the courage of the authors since, supporting themselves with facts, they destroyed the prejudice of scientific neutrality and found themselves fighting on two fronts with the most powerful trends of the *intelligentsia* of the time, attracting the charge of anti-scientism on the part of both anti-Marxists – for obvious reasons – and orthodox Marxists. The latter were concerned about the alleged "scientific" character of their dogmatic materialism being questioned. I am also impressed by the authors' ability to take early notice of a few general trends which at the time were only *in nuce*; indeed, they attributed a certain relevance to a phenomenon which was then only starting but glaringly obvious today: i.e., the progressive transformation of information into a commodity – better still – into the most important of commodities. Information, just like knowledge, is very different from other commodities. In order to block its free dissemination and increase its exchange value, patents, licences and copyright have been established. The central role of information is so relevant in the economy of contemporary society that it is actually called the Information Society (several pages of the recent book by Balducci and Cini, *Lo Spettro del Capital* (2009) [*The Spectre of Capital*], are devoted to a study which enlarges and develops a few topics already contained in *The Bee and the Architect*).

Therefore, so many years after its publication, *The Bee and the*

Architect has clearly opened a new path for studies of the philosophy and history of science. In many ways, history has given reason to this book, so much so that many disruptive comments have now entered into common sense. Just like all the books which have made an era, it allows us to rediscover, even in its outdated parts which nowadays would be useless but were crucial at the time, the taste of a period and its intellectual tensions. From this point of view, it has become a classic, which in order to be fully understood needs to be put in context and placed, once again, in its own time.

On the other hand, even today this book opens up to us a series of discoveries: the quotes from Marx and Marxist authors no longer have the function of denouncing a body of guardians of orthodoxy in favour of "authentic" Marxism but produce the effect of exposing readers to forgotten pages which reveal a surprising openness, modernity and lucidity of a thought that nowadays is marginalized and ignored by the dominant culture.

Above all, *The Bee and the Architect* communicates – and this is also a discovery – the actuality and validity of a critical method – in this case a method of science criticism – which in its determination to stick to a rigorous analysis of the facts is at the same time scientific and Marxist, in the best sense of both terms: it is faithful to the scientific method as much as possible in human science, where observable phenomena are not subject to mathematics, and Marxist in its attention to the social and economic basis of each human action, and in the awareness that no human construction, including science, can be subtracted from history.

It is a method which still teaches a lot to those who – now as then – as scientists or historians – or both – work with the tools of critical analysis in order to understand their own times and demolish all prejudices which, from time to time, hinder its cogence.

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The *Bee and the Architect* can be regarded as a manifesto and an important document of the Italian radical science movement of the 1970s and 1980s. First published in 1976, it was written by a group of physicists from the University of Rome – La Sapienza who were not content with producing important works in their discipline, but wanted to reflect their role as scientists and the role of science in society. In particular they focused on the critique of models and paradigms, which obscured the socio-economic and political motivations as well as contexts of science. The authors claimed that the objectives implicit in scientific abstractions are thus made invisible and as consequence abstractions become mystified and perceived as inescapable forces. This focus also gave the book its title, referring to the famous quote by Marx:

> … a bee puts to shame many an architect in the construction of her cells. But what distinguishes the worst architect from the best of bees is this, that the architect raises his structure in imagination before he erects it in reality. At the end of every labour-process, we get a result that already existed in the imagination of the labourer at its commencement. He not only effects a change of form in the material on which he works, but he also realises a purpose of his own that gives the law to his modus operandi, and to which he must subordinate his will.

From these premises the authors analysed how fact and value, as well as knowledge and ideology, intersect in the tasks of scientific labour. In this way they debunked the myth of neutrality in science.

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