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Snapshots from the Development of the Natural Sciences

Gérard Toulouse

Introduction

When, in early 2006 at the plenary meeting of the French National Commission of UNESCO (CNFU), Maurice Aymard talked about the initial plans for this conference, I found his choice of theme a stroke of genius, and I do not use this expression lightly. A stroke of genius in its relevance, taking in both the present day and the long term. A stroke of genius as well with its promise of riches, an opportunity for many openings.

Through my experience in institutions comprising a wide diversity of competences (Ecole de la rue d'Ulm, Centre National de la Recherche Scientifique, Institut de France), I can say that none of them could have provided a context suitable for this meeting, and that only this one, the CNFU, was able to do so. And once again I am pleased to pay tribute to the Comité des Sciences Humaines et Sociales and its chair, André Bourgey, for the intelligence and quality of their influence.

My suggestion that, in addition to the programme, two contributions should be included that offered clarification regarding developments specific to the exact and natural sciences, was not made without ulterior motive. I knew that the French school of mathematics was heir to a long and instructive history, and that over the centuries it had managed to reconcile intensive international exchange with the lively maintenance of a specific cultural tradition, in particular a linguistic one. The panorama painted by Pierre Cartier was brilliant and masterly, clear and precise: how I would have wished, when I was a student, that our teachers could sometimes have taken the trouble to provide a similar overview capable of triggering many questions!

Since the natural science field is clearly too broad for a similar exercise, I am going to play the complementarity card for all it is worth. The above-mentioned snapshots will thus be chosen with a direct connection to this conference's theme. And the issue

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that constantly underlies them will be: why and how, among the practitioners of the exact and natural sciences, can some of them make a contribution (modest and considered) to the vast current project of the social sciences whose goal is to break free of a reductive Eurocentrism in order to achieve a renewed universalism?

My *historical periodicity* will focus, on the one hand, on the last 50 years in particular, and on the other hand on the four centuries of western modernity.

Before that we should remember in what vivid terms our predecessors, both scientific and literary, were together named and placed in the dock as offenders or accomplices (or at least suspects) after the disasters of the 20th century (wars and totalitarian regimes).

> We saw with our own eyes conscientious work, the most solid teaching, the most serious discipline and application, taken over for horrific intentions. [. . .] There is the lost illusion of a European culture and demonstration of the impotence of knowledge to save anything whatsoever; there is science, fatally wounded in its moral ambitions, and dishonoured, as it were, by the cruelty of its applications. [. . .] The pitching of the boat was so ferocious that the best-hung lamps were finally overturned. (Valéry, 1957)

> I maintain that some germs of inhumanity, some causes of the contemporary crisis that forces us to redefine culture, [. . .] are hidden in the complex web of civilization. [. . .] Art, intellectual concerns, the sciences of nature, many forms of erudition flourished very close in time and space to massacre sites and death camps. It is the nature and significance of that proximity that we need to examine. Why were the humanist traditions and models of conduct so bad at resisting political savagery? Did they really act as a brake, or is it wiser to recognize in humanistic culture pressing appeals to authoritarianism and cruelty? [. . .] I cannot think how a debate about the definition of culture and the survival of the concept of moral value can neglect these issues. (George Steiner, 1971)

Let us step back to the start of the modern era. Since then the development of the natural sciences can be usefully analysed in terms of *scientific revolutions* (Kuhn, 1962), of which we can identify around 20. Those revolutions are predominantly conceptual or instrumental (the latter being most frequent, about twice as many). Among disciplines we can see phenomena of divergence (by branching) or convergence (by coming together). Two examples will suffice to illustrate these ideas.

The Newtonian revolution concerning the dynamic nature of matter made it possible to unify sublunar mechanics (of the earth) and supralunar mechanics (of the heavens), thus bringing together two previously distinct disciplines. A strong model of scientific theory (quantitative, mathematical, deterministic, predictive) was developed. The solidity of the theoretical demonstrations and the robustness of the practical predictions helped to embolden contemporaries, who were encouraged to release their hold on the handrail of earlier convictions (revealed truths, holy scriptures) and grasp a different guiding framework offering a new form of reliable knowledge.

However, the paradigm of classical mechanics became so dominant that many physicists were subsequently led to reject other types of scientific theory, and in particular to turn their backs on Darwinian theory as to the evolution of living things. In fact that theory had features (lack of predictive power, absence of maths) that were likely to make heads swim. For beyond formal appearances it was basically a

question of giving eternal orders (heavenly bodies or life cycles) to irreversible processes, and not only on earth but soon even as far as the whole cosmos (expansion of the universe, big bang, birth and death of stars). Henceforth we need to reconcile this strange duality of the world we live in: the universality of the basic laws of matter, the historical contingencies of a universe evolving irreversibly.

If the concept of scientific revolution turned out to be valuable for apprehending the development of the natural sciences over the long term, its use seems rather more marginal in the social science arena because of the stronger emphasis on the specificity of individual contributions, and less stress placed on coherent increment within disciplines, even though a number of social sciences (economics, demography, linguistics, archaeology, etc.) pursue strategies of emulation or symbiosis with various exact and natural sciences.

Later on I shall emphasize two other kinds of relationship, first by analogy/contrast between scientific revolutions and moral revaluations, and secondly by continuity of circular, pluralist method, from exact and natural to moral and political sciences.

Around 1955–60 a sort of turning point can be perceived in techno-scientific development and its relationship with society:

- a technological take-off: conquest of space (Sputnik 1957), the start of miniaturization processes (Feynman, 1960);
- signals and awareness: Russell-Einstein manifesto (1955), John von Neumann (1955), Hannah Arendt (1958), C. P. Snow (1959), Eisenhower (January 1961).

In an article entitled 'Can we survive technology?' von Neumann lays out this diagnosis: 'For progress there is no cure. Any attempt to find automatically safe channels for the present explosive variety of progress must lead to frustration. The only safety possible is relative, and it lies in an intelligent exercise of day-to-day judgment'.

Arendt (1958) asks the question: 'In what circumstances is a non-totalitarian world possible?' and gives incisive answers:

> [. . .] the first boomerang effects of science's great triumphs have made themselves felt in a crisis within the natural sciences themselves. The trouble concerns the fact that the 'truths' of the modern scientific world, though they can be demonstrated in mathematical formulas and proved technologically, will no longer lend themselves to normal expression in speech and thought.
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> [. . .] It could be that we, who are earth-bound creatures and have begun to act as though we were dwellers in the universe, will forever be unable to understand, that is, to think and speak about the things which nevertheless we are able to do.
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> The reason why it may be wise to distrust the political judgment of scientists qua scientists is not primarily their lack of 'character' – that they did not refuse to develop atomic weapons – or their naïveté – that they did not understand that once these weapons were developed they would be the last to be consulted about their use – but precisely the fact that they move in a world where speech has lost its power. And whatever men do or know or experience can make sense only to the extent that it can be spoken about. [. . .] Men in the plural, that is, men in so far as they live and move and act in this world can experience meaningfulness only because they can talk and make sense to each other and to themselves.

Technical developments can be analysed in two modes: *gigantism and miniaturization* (elephants and fleas). Continuing an old trend (Eiffel Tower, Titanic, etc.), gigantism soared between the wars with the construction of powerful states (contrary to Marxist or liberal ideology: withering away of the state or minimal state) intent on waging war, dominating, controlling. The cold war gave fresh stimulus to the gigantism of artefacts and major projects (dams, steel mills, h-bombs, space rockets), but at the same time there began a long process of miniaturization (transistors, lasers, components) that has continued ceaselessly since then, and for which the market demonstrated its efficiency (innovation and investment stimulated by consumption) and its superiority in economic competition (even in the end in the space and military areas). And this led to the fall of the Soviet Union, which was suited to producing elephants, granted, but not fleas.[1]

And if hopes for the pacification of the world after the cold war have been disappointed it is largely because of the increased precision of weapons (laser targeting, GPS), which has made it possible for the USA to strike anywhere on the planet, more cheaply, using a professional army (abolition of the draft). In this way the dominant nation has managed, because of technical advances, to overcome the two internal causes of its earlier failure in Vietnam.

With the hindsight provided by over a century's historical experience we can now proceed to evaluate Marx's two main ideas, one of which has been disproved and the other confirmed. According to the first, common ownership of the means of production would make it possible to maximize development of productive strengths; this long-criticized theory no longer finds favour. According to the second, the political system likely to win out would be the one that maximizes development of productive strengths: up to now everything seems to point in that direction, because the winning formula in the race appears to be the combination of powerful state and commercial sectors associated in a many-tentacled military-industrial-scientific complex.

For those who hold to Marxism this result might be perceived as justifying Marx's claims to scienticity; indeed, contrary to Popper's objection, Marxism was quite refutable because it has been in large part refuted. For the rest the hope remains that the second theory will be disproved in the future before the rush to the (demographic and ecological) precipice runs its full course.

We can mention in passing that, in the current heated debates around intellectual property, the arguments put forward on both sides (whether for or against patents) claim to have the same goal: maximizing the rate of production of knowledge. All things considered, is that really an absolute priority?

A final remark related to phenomena of divergence/convergence among disciplines: over the last half century the process of miniaturization has offered two remarkable instances of convergence. First there was the convergence of microelectronics, informatics and telecommunications, a source of major geo-strategic and social upheaval. And then the more recent convergence of nanotechnologies, bringing together physics, chemistry and biology on scales of size where distinctions between inert and living, man and machine, are eliminated, thus opening up a field of possibility far broader than the field of the desirable.

It was with the intention of explaining and putting into perspective 'the ethical

movement in the sciences' (Toulouse, 2004), particularly for the benefit of my colleagues in the natural sciences, that the idea of *moral revaluation* was defined in relation to similarity-contrast with the older and now well-accepted concept of scientific revolution (Toulouse, 2006). The simplest and most direct introduction to the category of moral revaluations (note the original spelling)[2] consists of a list of examples: the abolition of slavery, women's liberation, decolonization, replacement of war by law, the ethical movement in science.

Since Hiroshima signs of a collective raising of consciousness have appeared among participants in science. The Pugwash conferences for science and world affairs, founded in 1957 (two years after the Russell-Einstein manifesto) with the aspiration of embodying the social and moral consciousness of scientists, acquired a well-deserved visibility when they won the 1995 Nobel peace prize. Furthermore, in the declaration for the Nobel centenary in 2001, around a hundred signatories (winners of various prizes) solemnly reaffirmed the goal of replacing war with law (Koch-Miramond and Toulouse, 2003). So it cannot be denied that many scholars are involved in the movement, which also includes other actors (diplomats, politicians, journalists, lawyers, etc.).

The ethical movement in the sciences, understood in the broad sense, has many components, among which it is possible to distinguish three major strands:

- science and war, mentioned above as part of the movement to replace war with law;
- the future of the planet (sustainable development);
- bioethics (biomedical practices and appropriate respect for life).

Over the past decades UNESCO has played a pre-eminent pioneering role in giving these last two strands coherence and prestige via its environmental programmes as well as the activities of the International Committee on Bioethics and the World Commission on the Ethics of Scientific Knowledge and Technology.

In general, within the scientific community, varied and contrasting responses are observable to the growing social protests around topics such as: nuclear installations, health crises, genetically modified organisms, nanotechnologies, etc. So much so that it often becomes inappropriate, and even sometimes counterproductive, to use globalizing assimilations about 'scientists'. Hence the attempt here to sketch a typology in the form of a scale consisting of four levels, *four attitudes* from arrogance to fairness.

The first level (the upper one by convention) is massive arrogance: such social protest movements are basically illegitimate and should be denounced for what they are, obscurantism and irrationality; those who are not with us are against us; scientists must close ranks to combat the threat of anti-science and save modern civilization from its critics.

The second level is evasion: these protests are one nuisance among others; let us hope they disappear as they came; in the meantime we continue our activities as usual, it would be a waste of time to worry about them; after all it is the duty of politicians to protect us against social agitation; if the situation deteriorates we shall go and work in a more hospitable country.

The third level is tolerance: these protests raise genuine problems of the social acceptability of new technologies; the various professions involved need to make an effort to win back people's confidence, and researchers in particular must contribute a necessary minimum to this end; if the discontent subsides we can return to our previous behaviour till there is a further alarm.

The fourth level (last by convention) is fairness: these cases of social protest are more significant than attacks of hotheadedness; the formidable march of technology and the race for economic growth and competition are reasons for everyone to be concerned; to avoid predictable disasters (crashing into the wall of physical barriers because of the earth's finite nature) scientists should engage sincerely, *in good faith*, in processes of social co-construction, allowing serious deliberations about options and choices.

In relation to successive and diverse attitudes observed within the community of political commentators as regards the specificities of democracy in India (ideas of equality and secular society) our colleague Balveer Aurora has drawn up a similar table that is in fact so comparable that it encouraged me to recount my own intuitions as to my professional environment. According to our colleague's comments what can be seen here is a list of the various modes of reaction from an orthodoxy faced with anomalies that disturb it. And his exposé persuaded me to add in the future the oriental word 'harmony' to 'fairness' in the description of the fourth level.

It is the group of scientists on this level (fairness, harmony) who can be counted among the promoters of the moral revaluation, called 'ethical movement in the sciences' earlier.

Several important past studies (Quine, Rawls, Føllesdal) have pointed up the generality (through logic and empiricism) of the hypothetico-deductive, circular method and advocated its extension to the moral and political sciences. This *continuity of method* relies on the plurality employed in the practices of scientific publication and communication.

Science is built on foundations of trust. We may even think that the successes of the scientific enterprise depend on a 'right to error in good faith' within communities of peers.

Beyond the context of exact and natural science practice can be seen a very widespread aspiration, both inside and outside the scientific community, which aims to *open up spaces of good faith* in order to develop reliable knowledge obtained through achieving a reflexive equilibrium (an equilibrium that can be improved by new facts or arguments). A similar aspiration is manifested in several innovative practices introduced within parts of the ethical movement in the sciences: ethics committees, ethical spaces, areas for 'candour and mutual respect' (Pugwash), etc. Just as in the many forms of participatory democracy (public debates, citizens' conferences, orientation councils) designed to deliberate and co-construct techno-scientific choices.[3]

The further we step away from the firm handrail provided by mathematical demonstrations and experimental tests, the more recourse to the advantages and resources of plurality increases. And this increased recourse brings greater demands on good faith. This is where paths open up for exploration in order to invent innovative practices able to give more efficiency to John Rawls's theory of justice and its basic criterion, which is to optimize the lot of the least well-off.

Finally relevant mention should be made of the link between *cultural and biological diversity*. For that purpose Claude Lévi-Strauss's eloquent words are required here, part of his inaugural speech at the celebrations of UNESCO's 60th anniversary (16 November 2005):

> Cultural diversity and biodiversity are therefore not just phenomena of the same type. They are intrinsically linked and we are made constantly more aware that, on a human scale, the problem of cultural diversity reflects a much broader problem whose solution is still more urgent, that of the relations between humans and other living species; and we realize that it would be no use seeking to overcome it in the first instance without also addressing it in the other, given that the respect we wish to obtain from individual human beings towards cultures different from theirs is but one particular case of the respect they should feel for all forms of life. By isolating humans from the rest of creation and defining too narrowly the limits of that separation, western humanism inherited from antiquity and the Renaissance has resulted in the rejection, outside arbitrarily drawn borders, of ever more neighbouring fractions of a humanity to whom it was particularly easy to refuse the same dignity as the rest enjoyed, since it had been forgotten that the human individual is primarily to be respected as a living being rather than as lord and master of creation: an initial recognition that would have compelled humans to show respect for all living beings (Lévi-Strauss, 2007: 10).

And on that note we reach the conclusion of this brief overview which has aimed to identify several convergent paths, open routes and trails to be explored, allowing us to hope that some of the devotees of the natural sciences will act not only as attentive spectators and well-wishers, but also sometimes even as constructive partners, with regard to your project of profound renewal in the social sciences, which may be seen as an original mixture of scientific revolution and moral revaluation.

Gérard Toulouse
Ecole Normale Supérieure, Paris
Translated from the French by Jean Burrell

Notes

1. The French word puce means both 'flea' and 'microchip' (translator's note).
2. This spelling of the word revaluation, which has been used for several years, has a twofold advantage: stressing the analogy with the word revolution and avoiding any confusion with revaluations (in French ré-évaluations – translator's note) of currencies.
3. At the end of this conference our colleague Bénédicte Fauvarque-Cosson obligingly requested an interview with me which appeared shortly afterwards in a law journal (Toulouse, 2007: 1856).

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