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Postnormal Science and the maturing of the structural contradictions of modern European science

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ABSTRACT

To analyze the sometimes paradoxical features of contemporary science, I use the concept of 'contradiction', namely a problem that cannot be solved within the confines of the system in which it is set. I study such contradictions as knowledge and power, knowledge and ignorance, the True and the Good, innovation and property, elitism/democracy, and reality and safety. I then sketch the reactions that have occurred so far, both official and popular, and advance some ideas of my own, including awareness and non-violence.

1. Introduction – the problem

Although the scientific press is still full of exciting new discoveries, there is a widespread sense that all is not well in the world of science (including science-based technology) of modern European civilisation. The most obvious symptoms are a continuing shortfall in recruitment, along with continued public distrust (notably in the U.K. and the U.S.A.), scandals in both commercialised science (pharmaceuticals) and high-prestige research, confusion over the key issue of carbon-based anthropogenic global warming, and now steadily increasing competition from Asia in many important areas. To the extent that global pollution and climate change are the results of our science-based industrial system, then the pragmatic argument that 'science is good and true because it is successful' is weakened. None of these symptoms marks the end of science as we have known it; there are very many talented and dedicated scientists whose work still contributes to human betterment. But these problems show no sign of going away, and they require serious attention. Making sense of these scattered phenomena is not easy. To some extent as an experiment, I have chosen to use an historical approach, going through some key issues, most of which have been present in modern European science since its creation some four hundred years ago.

In my earlier work *Scientific Knowledge and its Social Problems* [1] I identified several pathologies of what I then called 'industrialised science'. These were of science that is entrepreneurial, shoddy, reckless or dirty; and also runaway technology. Although these were then barely over the horizon, they have since become recognised as serious issues. In the intervening thirty-five years, it has become possible to discern the structural features of the scientific enterprise in which those pathologies have flourished, and new ones emerged. I analyse these in terms of 'contradictions', here meaning a tension whose resolution, or a problem whose solution, is impossible in the terms of the currently accepted frameworks. The tension will usually, but not always, be expressed in terms of opposites. Contradictions evolve with the system they affect. They can be less salient at the outset, and can indeed be suppressed for a long time. But they can eventually 'mature' and require resolution lest they damage or destroy the whole system. A good example of a contradiction in the political sphere is

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slavery in the early U.S.A.; it needed a civil war to resolve the constitutional issue, and then it festered as a social issue for nearly another century before any resolution was attempted. Slavery is a good example of a structural contradiction, as it was built into the written Constitution as well as in the social life of the nation.

Here I will sketch a set of structural contradictions in European science, as a preliminary to the achievement of a theoretical understanding of how they have arisen and how they might be resolved. This is very much 'work in progress', subject to revision at all degrees of depth at any time.

2. The contradictions

Listed roughly (but not exactly) in the order of their appearance in the development of science, the contradictions are: knowledge and power; knowledge and ignorance; the True and the Good; consequences; quality; innovation and property; elitism/democracy; corruption in research; image and audience; societal context; reality; and safety. Many of these contradictions were present at the origins of modern science and were suppressed in the intervening centuries. They have now matured and become urgent.

2.1. Knowledge and power

The relation of natural knowledge with state power was acknowledged as a problematic issue by both Bacon and Descartes, but then forgotten. In recent times it was believed that 'pure science' would produce a 'fountain of facts', thereby claiming credit for the good applications while blaming 'society' for the bad. The possibility of corruption of the knowledge-creation process by entanglement with institutional power was gradually recognised again with the emergence of 'big science' after World War II. Now the dominant industrialisation and militarisation of research produces urgent issues of ethics, quality and morale. These are compounded by the involvement of science in what many see as the global exploitation of the world's vulnerable peoples and species (as in biopiracy and 'terminator' seeds). What Francis Bacon envisioned as a uniting of human knowledge and power [2] is instead becoming a merger, between very unequal partners [3]; therein lies the matured contradiction of knowledge and power.

2.2. Knowledge and ignorance

The relegation and denial of ignorance was central to the programme of the 'new philosophy' of the seventeenth century. This, rather than atomism, was the core of its 'metaphysical barbarism', as it ruptured the tradition of philosophical wisdom extending back to Socrates [4,5]. Ever since then, this 'ignorance of ignorance' has been maintained by all teachers and by most philosophers. Education in science is now far more dogmatic than in theology. Students learn by example that for every problem there is just one correct solution, usually expressed to three significant digits. In natural science this is a disaster, in the social sciences it is a catastrophe. One consequence has been a general incompetence in the management of uncertainty in scientific information, resulting in the widespread occurrence of misleadingly precise numerical expressions. The NUSAP system and its descendants attempt to rectify this defect and to supply craft skills for the management of uncertainty [6]; but as yet few scientists appreciate the need.

Debates on policy issues are distorted by a general incomprehension of how competent scientists can disagree. In the 'Climategate' affair, much damage was done by the refusal of mainstream scientists to admit that there could be reasonable doubts about the dominant paradigm. Now, with the growing recognition of policy-critical uncertainties and 'unknown unknowns' of all sorts, ignorance has come back with a vengeance, its awareness being promoted with all possible motives from best to worst [7]. Thus the contradiction between unreflective knowledge and ignored ignorance harms the search for knowledge itself, and its applications to policy as well.

2.3. The True and the Good

In its long struggle against the institutions of religion, their rationale based on theology, Science claimed for itself the unique path to the achievement of the True and the Good in this world. Among philosophers the True has been in retreat for more than a century, although science teaching has not yet caught up with the change. We have only just now learning how our knowledge and our ignorance are shaped by values; this results from the necessary choice between 'sensitivity' and 'selectivity' in all statistical tests. The chosen balance will determine which results are 'not-significant' and hence rejected and forgotten. Thus our ignorance as well as our knowledge is influenced by the values that shape research. As to the Good, it is compromised, not merely in the applications of science, but also in its very activities. What I previously called entrepreneurial, shoddy, reckless and dirty science (along with runaway technology) [5] can no longer be ignored. The sufferings of sentient beings (non-human and human alike) in research need to be justified, requiring the creation of a very new ethic of compassion in science. The loss of conviction that science is essentially involved with the True and the Good cannot but affect morale, on which recruitment and quality-assurance critically depend. The contradiction between the old absolutist vision of science and the new realities of this human institution will require considerable maturity for its resolution.

2.4. Consequences

The possibility of adverse, usually 'unintended' consequences of the applications of science was also recognised by Francis Bacon, but suppressed thereafter [8]. Not until the use of poison gas in World War I was it even imagined that science could do evil. Now the examples of what we might call 'Muddle and Malevolence' crowd in. There is still the overriding threat of annihilation in nuclear warfare along with science-based weapons of destruction as yet unnamed; and in the civil sector we have the corresponding threats of global climate change, computer malware and science-based pollutants of all sorts (personal and environmental), to say nothing of the disruptions soon to be produced by the nascent 'converging' technologies of mind, information and matter. The current President of the Royal Society now questions whether we will survive this current science-based century [9]. At the policy level, we can ask under what conditions could there be an effective official reassurance that a proposed new technology is 'safe' or 'safe enough'? If the prospect of a successful reassurance is doubtful, then the politics of innovation takes on a new form. The genuine traditional positive claims for the benefits of science are now in contradiction with its unintended, and perhaps uncontrollable, negative consequences.

2.5. Quality

Francis Bacon descried the very low quality of scholarship and invention of his time, and believed that he could remedy it by an administrative and moral reform [10]. Quality assurance in research science has always depended on the high quality (technical and moral) of its leadership, as there can be no external body of expert critics and quality-assessors for highly technical research. But the informal system of self-regulation is now under increasing strain under the conditions of 'mega-science'. Research and technology development, both civil and military, are increasingly affected by hype and fantasy ('Star Wars', stem-cells, GM crops, drones for killing 'terrorists'), as scientific discovery must promise immediate commercial profit or military advantage to justify its investment. Information Technology is being used an important engine of corruption, as in electoral systems in the U.S.A. and in public-sector IT systems in the U.K. [11]. Extending considerations of quality to science-based industry, we find a very dangerous situation, where the pillaging of the planet (fisheries, rainforests, aquifers) seems to be beyond the ability of anyone to control. Low quality provides the link between the credit crunch, partly caused by abysmally poor mathematics and statistics, and the BP oil spill, the result of old-fashioned cost-cutting and lax regulation. Quality assurance of science, developed over generations of 'little science', has now come into contradiction with the contemporary social processes of the industrialised production and utilisation of knowledge.

2.6. Innovation and property

Reconciling the needs of scientific innovation and personal intellectual property was first accomplished by such devices as challenges (on mathematical problems already solved by the challenger), anagrams, and sealed notes claiming priority. Then the two-stream system emerged: patents ensured that the market would reimburse inventors, and peer-reviewed journals ensured that prestige-rent in the form of citations would accrue to discoverers. Each world had its appropriate etiquette and ethics appropriate to the special characteristics of knowledge as produced in each case, and their overlaps could be managed. Now, with the increasing commodification of knowledge and the blending of discovery and invention in the new life sciences, the boundary has become indistinct.

In the research factories of mega-science, researchers lose the intellectual property of their discoveries, and their status is less that of scholar and more that of proletarian. Even the nominally independent academic researchers become outworkers, marginalized craftsmen like the handloom weavers in the Industrial Revolution. The contradiction between the inherited structural requirement of distinct streams of discovery and invention, and the inevitable blurring of just that distinction in the current management of innovation and property, can easily lead to corruption and paralysis in research.

2.7. Elitism and democracy

The demand for 'science for the people' was raised unsuccessfully in earlier revolutions (English, French); then under Stalin the populist charlatan Lysenko destroyed Soviet biology. In spite of professions of democratic sentiment, science is part of elite culture. The very language of science, explicit, logical, formalised, and technically esoteric, requires a style of thinking that is almost totally restricted to those with a lengthy (and expensive) education. It contrasts with the informal, partly tacit, situated and anecdotal knowledge used by those less favoured people who actually keep our system running (as in the 'Murphy's Law' literature). When particular philosophical doctrines, purveyed in the scientific style, collide with deeply held popular beliefs, there arises a dangerous reaction, most notably in the case of Creationism. On the political side, the contradiction between the essential integrity and impartiality of the research community, and its involvement with vested interests of the State and commerce on policy issues, threatens to destroy public trust, with potentially grave consequences.

2.8. Corruption in research

Science has never been immune from human frailty. Battles over 'priority' (securing intellectual property) have been fierce and vicious. Sir Isaac Newton himself secretly masterminded a report by the Royal Society on the invention of the

calculus in which his rival Leibniz was traduced. But generally science has required, and achieved, exceptional integrity in its work. This includes the intellectual integrity of researchers not yielding to the temptations of quick and easy answers, and the ethical integrity of referees and assessors, giving fair judgements and respecting the property of colleagues. Under the conditions of mega-science, 'entrepreneurial science' is the enforced norm, and there are many new perils of corruption. The prospects and rewards of instant success, combined with the hype, uncertainty and even fantasy of so many technoscience projects, create new stresses on the ethical standards of scientists. The widespread manipulation of research and of published results by commercial sponsors (notably but not exclusively drug companies), and the complicity of regulatory agencies, can no longer be ignored or denied. The integrity that had previously been assumed to define the scientific endeavour is now in contradiction with the new harsh realities.

2.9. Image and audience

By its very nature, scientific research cannot guarantee to produce an immediate return, and so it has always needed the promise of eventual reward to its patrons, either individuals, institutions or the state. Maintaining a sympathetic audience, for securing resources, recruits and protection, has depended on a sincerely projected image of Science as the unique provider of the means to human happiness in this world. That image has been increasingly compromised by the involvement of science with power and its mixed consequences, as well as by the discredited hype for civil nuclear power and by the recent scandals of science-based consumer industries (BSE, harmful pharmaceuticals, junk-food). The repeated official exhortations to scientists to "tell the public about their work" display both a pathetic misconception about what interests the public, and also a serious error about the conditions of work of scientists, most of whom have employers (State or business) or contractors who forbid just such communications. The portraits of science in the best-selling novels of the late Michael Crichton are strongly at variance with the image projected in the children's events and science cafés. Thus science is caught in the contradiction between the need for an accepted positive image, and the reactions of an increasingly skeptical and informed public that is all too aware of its negative aspects.

2.10. Societal context

Historically, the context of the growth of European science was the successive phases of the expansion of the European empires, from the Renaissance onwards to the present. Through its expertise in the means of production and of conquest, science was fully engaged in the process of empire, and shared its ideologies (including racism and sexism). Now that economic power is moving Eastwards, Euro-American science, especially in its industrial aspects, displays senescence. The ebbing of local recruitment (and the increasing dependence on Asia) is one obvious sign of this condition. Euro-American science could be in a process of hollowing-out analogous to that of its manufacturing industry and information technology. Given the crucial role of science in the modern knowledge economy, the contradiction between inherited imperial power and imminent decline is very serious indeed.

2.11. Reality

Perhaps the deepest contradiction in modern European science derives from the drastically reductionist 'atomistic' reality imposed by the 'new philosophy' of the seventeenth century. In a remarkable transformation, this ancient heresy quite suddenly became the accepted educated common sense in North-West Europe. This Epicurean metaphysics rigorously excluded both the Aristotelian 'final causes' and the enhanced realities of the Stoic craft-magical tradition. This revived cosmology was later claimed to be a truth deduced from science, although many of the greatest early modern scientists inhabited a much richer reality. After centuries of dominance, it is now being challenged. Its truncated reality is rejected by Western Biblical commitments and Eastern philosophies alike, sometimes within science ('Gaia') and sometimes among its consumers (Creationism, Complementary Medicine). Traditionalist scientists feel themselves engulfed in a rising tide of 'irrationalism'. But the world-view of contemporary physics is quite other than the billiard-ball universe of its predecessors. Until that is assimilated, we will experience the contradiction between the inherited metaphysical framework of modern science and the rapidly changing common-sense of its publics. Schumacher's 'flat cosmology'

2.12. Safety

Although this is the most recent contradiction, more than any other it expresses the predicament of modern European science. Thanks largely to science, life is (at least for the time being) more safe (at least for the rich minority) than ever before in history. 'The Safe' is now an absolute for public policy, along with 'The Just'. But the manifold contradictions in 'The Safe' cannot be kept concealed. For the practical policy question becomes 'How safe is safe enough?', and since safety cannot be measured, it is a conundrum. Safety cannot be reduced to risk, for it is pragmatic, contextual and ethical; the question is not whether a quantity measuring a risk is zero or 'acceptable', but whether the institutions managing the hazard are competent and trustworthy. Governments are caught in a policy contradiction: they need to demonstrate a commitment to safety for their electorate, while economic progress, or indeed national economic survival, demands high-tech innovation, which is

inescapably dangerous. Some of the recent loss of public trust in governments and their scientists is a result of the failure to resolve this contradiction of governance in the scientific age.

3. Reactions

Some of these contradictions are now presenting urgent challenges. What are we to make of them? Doing more science along the present lines will not resolve them. Indeed, the 'converging' science-technologies that are described by the acronym GRAINN (Genomics, Robotics, Artificial Intelligence, Nanotechnology and Neuroscience), laudable as they are in their own terms, can serve as case studies in the aggravation of the maturing structural contradictions of science rather than as a means to their resolution. The problem is not one of the failings of individual scientists, either in their motivation or their probity; we can assume that they are doing their best to bring new knowledge and power to humanity. The problem is at the systemic level, where these inherited structural contradictions have matured, independently of the wills and even of the awareness of the individuals who are caught up on them.

Contradictions need not have a destructive outcome; the success of non-violence in places like South Africa and Northern Ireland shows that creative resolutions can be achieved. The contradictions of modern European science have not yet raised up a coherent movement of reform or protest. Thus even the ETC Group, militantly opposing a wide range of abuses and sponsoring its 'Captain Hook Awards' for biopiracy by leading multinationals and governments, focuses entirely on the guilty institutions and does not yet broaden the scope of its critique. The theory of Post-Normal Science, highlighting uncertainty and value-loading in policy-related science, and calling for an extension of the peer-community beyond its traditional elite base, has cut through the inherited false-consciousness of science and has provided an initial basis for systematic criticism. How long this theory will continue to be illuminating for the cutting edge of critical reflection and action, is impossible to predict.

3.1. Official responses

It is also impossible for me to predict how these multiple, systemic contradictions will sort out. There are already some encouraging responses. On the issues of safety of new technologies, notably nano but with others following, the established scientific authorities have recognized new risks and have called for appropriate regulatory regimes. The message, if not the title, of Post-Normal Science is now the accepted common sense of management of problems involving new science. In all sorts of areas, the involvement of citizens in decision-making has been developed. Of course, all such exercises have a multiplicity of goals, and on occasion the 'citizens' or activist side has complained of manipulation. But even that represents progress from the earlier state of affairs when appointed experts met in private to sort things out. On the other contradictions, however, there is little sign of recognition or response at the official level. Even when an eminent person discusses the deep problems facing our science-based civilisation, as Lord Rees, the implicit assumption about science is that what made the problem can also make the solution.

3.2. Societal responses

Complementary to these developments on the 'established' side, there are growing movements of opposition to the abuses of science that are made for the advancement of profit, power and privilege. The previous mass campaigns against GM crops in Europe still cause governments to proceed with caution in promoting innovation. Other pressure-group campaigns expose pollutants and poisons, be they gender-bending chemicals, artificial sweeteners or just plain junk-food. The fear that citizens would all turn into consumers has not materialised. Rather, citizen-consumers show a healthy skepticism about all the established institutions and their claims of safety, and they know how to use their power. In consumerist commerce, 'organic' (bred largely by popular distrust of industry and the regulatory authorities) and 'sustainable' are increasingly powerful labels. The message of Post-Normal Science has been put into creative practice, notably in Tasmania, in a methodology of community-based assessments [12].

Without being overtly political about the conduct of science in general, the various 'open' movements in software and in science now start to bring huge changes to the socio-political structures of science. The 'Wiki' movement and the online publication of sources of every sort breach the silent barriers to access to scientific knowledge, which have hitherto excluded all those who lack the support of rich institutions. Combined with the new conversational technologies of communication and a new socio-political awareness, we could be at the birth of a process of 'democratisation of knowledge' of the sort that reformers of science of past generations strove vainly to achieve. I have argued that the blogosphere, which was so important in transforming the debate on Anthropogenic Carbon-based Global Warming [13] is now developing to the point where it can become a basis for a matured and influential Post-Normal Science [14].

For the new industries of information, we can apply a classic Marxist analysis, and see how the new means of production, involving information rather than matter and energy, produce new 'social relations of production' with workers who are not inferior in knowledge and sophistication to their bosses, and who can innovate in the social sphere (as with the varieties of 'shareware') as well as in the technical. There are already examples of 'citizen science' where amateurs make a real contribution to 'new natural history' research programmes, as astronomy [15], and where they will soon set agendas for projects closer to home. Thanks to the low and rapidly reducing cost of bio-information, 'garage biology' [16] now becomes a

practical reality. In some ways the social life of science is returning to the age of philosophers and amateurs, before the professionals took over in mid-Victorian times.

And on the issue of reality, the 'common sense' of Victorian physics and neo-classical economics becomes rather antique in the face of the paradoxes of contemporary physics, cosmic-scale speculation, micro-scale engineering, and systems thinking. The dialogue between orthodox and Complementary and Alternative medicine, with all its implications for society and reality, continues and deepens. It is even possible now to get Healing on the UK National Health Service. A group of 'deep green' thinkers has made a start on a philosophy of science that combines holistic, traditionalist and anti-corporatist themes [17]. This fundamental transformation requires patience; after all, it took most of a century before any scientists except for cranks and rebels accepted that the Earth is spinning like a top and also floating through the heavens.

3.3. Awareness

Having got so far, I must offer a speculation on which dimension of the complex social system of science could provide the crucial element for the process of resolution of these structural contradictions of European science. At the moment I favour 'awareness' as the starting point. This is partly from my post-normal background, recognising Thomas Kuhn as the philosopher who, however confusedly, identified the anti-human tendencies of 'normal science'. Kuhn's myopic puzzle-solving 'normal' scientist is strongly reminiscent of the captive children of the contemporary popular novel by John Hersey, The Child-Buyer [18], who were kept manacled and blinded so that they could more efficiently solve mathematical problems for Defense. The 'objective' and 'value-free' character of science, so lauded by its apologists over the generations, justified a teaching style that produced puzzle-solvers who described their actions in the third-person passive voice. Needless to say, many teachers performed this indoctrination in the sincere belief that it was liberating men's minds from theology and superstition; and perhaps, in its early days, it did. But the world moves on. I have done my bit for awareness in science, providing students with a list of questions of what science means for them, in my little book A No-Nonsense Guide to Science [19].

I should say that 'awareness' also characterises the new radical political movements, starting with feminism and including Zapatistas and 'alternative' social change campaigns. Their strong base in the ex-colonial 'majority world' provides them with a keen awareness of the contradictions of European science, as they are not sheltered from their consequences by the diffused material affluence that we have enjoyed. The contrast of these new movements with old-style Marxism, doomed by its belief in itself as 'The Science of Society', should never be forgotten. And an enhanced self-awareness of science, with all its inherited contradictions, could help embattled scientists (as in the U.S.A.) defend its integrity more effectively against the demagogues and kleptocrats, more effectively than an invocation of the vanished world of 'little science'.

3.4. Non-violence

However, awareness on its own can become sickly, leading to recursive levels of irony and introspection that rise beyond the restraining bonds of common sense and sanity. It needs a guide and a control, and for that I suggest the moral element, non-violence. The most redemptive feature of the history of the century gone by is the rise of non-violence as a political and cultural force. In that I include the rise of compassion extended to ever widening sets of beings outside the upper-class white males who had dominated consciousness for so long previously. The great heroes of that century, Gandhi, Martin Luther King and Nelson Mandela, showed that non-violence can truly transform politics in a way that ordinary methods cannot. Rather than discuss non-violence at length here, I might just remark that during all this period there was no discernible connection between science and non-violence. Of course, in historical perspective, we can say that science helped to create our powerful means of production, enabling 'the human use of human beings' [20] rather than the dehumanisation of the many by the few which seems to have been the story of civilization so far. If we ask, what would a non-violent science now look like, the guideposts are few. Gandhi, Schumacher and Vandana Shiva have spoken of it, but noone has yet articulated the vision in relation to the situation and powers of Euro-American science today. Of course, when one contemplates the role of science in the 'war on terror', it would seem that non-violence is very far away indeed. But if that be the case, let us face the prospect and draw our conclusions.

3.5. Valedictory

Do not expect a smooth ride! If the cultural hegemony of Science is suddenly shattered, we can expect turmoil, confusion and excesses of all sorts. Contradictory tendencies would struggle for supremacy, and their internecine battles could be more intense and vicious than those against the common opponent; this is the lesson of reformations and revolutions in the past. Both Creationism and aromatherapy reject reductionist science, but their differences are deep indeed. Indeed, the main reason for my analysing these contradictions in European science, is to help us become more effective in making their resolution creative and not destructive. This essay, preliminary and tentative, is intended as a contribution to that endeavour.

Acknowledgements

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