THE GOOD, THE TRUE AND THE POST-MODERN

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The post-modernist scheme for understanding and interpreting cultural phenomena in terms of three 'ideal-types'—classical, modern and post-modern—has been deployed to interpreting many areas of human activity. The post-modernist thesis is interpreted and combined with work on uncertainty and quality to show how post-modern themes can be applied to the understanding of developments in science-based technology and societal aspects that relate to them.

The concept of 'post-modernism' has been discussed in English-language milieux widely for more than a decade, and by now it has permeated popular discourse about culture and society. It provides an attractive evolutionary scheme for understanding and interpreting cultural phenomena in terms of three characteristic ideal-type styles—'classical', 'modern' and 'post-modern'. Although the concept was first deployed analytically in connection with literary, artistic and architectural criticism,[1] it has now been extended so widely as to be applicable to any human activity, and its meaning has been correspondingly diluted and confused. Combining post-modernist themes with our own work on uncertainty and quality,[2] we show how these can be applied to the understanding of developments in science-based technology and those aspects of society that relate to them.

The role of science-based technology in the creation of 'hyper-reality', by means of simulations and simulacra, is implicit in the discussions of Jean Baudrillard.[3] With copies possessing the superb perceptual quality that can now be achieved by technology, the original exemplar is either devalued by replication, or rendered quite irrelevant by being indistinguishable from its copies. In this hyper-reality, a world of self-referential signs in which 'fiction' or 'lie' have no meaning, history, or indeed any other sort of independently existing reality, is evaporated. Baudrillard uses American popular culture for examples, particularly Disneyland, which is largely a material re-creation of a film fantasy, and at the same time the representation of the American Dream. Post-modernity is exquisitely expressed by the title of a recent article in *Time* magazine, 'Fantasy's Reality // Orlando, the

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boomtown of the US South, is growing on the model of Disney World: a community that imitates an imitation of a community'.[4]

Our analysis of post-modernity in the technological system is complementary to that of Baudrillard. He concentrates on culture, and argues that the application of the technologies of spectacle and simulation have caused the degeneration of popular consciousness. We start by focusing on post-modernity as it reflects the leading contradiction of our global industrial civilization. This can be described as the opposition between the universal drive for individual material welfare and the technical means for its achievement. The one is realized as personal health, safety, comfort and convenience; but the resulting activities of consumption will collectively degrade and destroy the global natural and social environments. The motor car (already possessed by the world's rich) and the refrigerator (now actively desired by many of the world's poor) are important examples of this contradiction. The age-old contradiction between the rich and the poor, now realized ever more acutely on a global scale, cannot be resolved on the material plane alone, for that would sharpen the leading contradiction to the point of total destructiveness: the planet cannot sustain 3 billion private automobiles.

Whereas Baudrillard focused on the dissolving of reality into a hyper-state, our analysis rests on the threat to quality in human activity and experience. In the cultural sphere, he saw post-modernism as destroying the traditional philosophical ideal of the True; in the technological sphere, we show how post-modernity also confuses and corrupts the Good. When any innovation (such as nuclear power, genetic and biomedical engineering or computers) has the potential of producing evil in forms that cannot be predicted, it becomes impossible to apply simple ethical principles for the evaluation or control of the activities. The response to such dilemmas can either be a collapse into a nihilism that encompasses reality and ethics alike, or a reconstruction of philosophy on lines that are more robust and resilient against the contradictory experiences of our times.

Quality

The quality of any human production has internal and external components; the different levels of internal quality correspond to the different levels of skill required for the activity. At the minimum level there is dexterity, the equivalent of playing scales on a musical instrument or doing set exercises in an arithmetic textbook. Above this (and including it) is craftsmanship, which does not necessarily require originality, but involves a personal knowledge of the material, the tools, their limits, and their potential, so that they become an extension of oneself.[5] Finally, there is creativity, which includes craftsmanship, but where a new interpretation is achieved; this enhances the potential of the material and tools while still respecting their limits.

All these levels of internal quality can be assessed by criteria developed within the field of practice, and similar criteria are developed for the degrees of quality within each level. External quality, which is defined by a relationship with a broader community of users, has its own criteria and modes of assessment. It is conceived in such terms as fitness for purpose, reliability and economy. The processes of quality assurance in industry govern this sort of quality. Clearly, good external quality starts with an adequate level of internal quality; but in general the relation between the two can vary enormously. In our book *Uncertainty and Quality in*

Science for Policy[6] we analyse quality of scientific information, mainly in relation to its external aspects.[7]

We start our analysis of quality with the classical style. There it is easy to distinguish the different levels of quality, in terms of their characteristic levels of skill. The pupil learns dexterity, the student achieves craftsmanship, and the mature artist is then capable of genuine creativity. It is essential to the classical style that creativity presupposes craftsmanship, and craftsmanship dexterity. In earlier times, practitioners in the visual arts were craftsmen, who had learned their trade as apprentices in a master's workshop; a few of them rose to the heights of being independent creative artists who are still remembered. Even today, classical pianists, however much natural talent they may possess, must have gone through an initial lengthy apprenticeship with tedious routine exercises for training the hands and mind to a total dexterity. Craftsmanship is not necessarily attained that way, but requires a further quality of 'musicianship' which cannot be learned by drill. Genuine creativity (in this case, of interpretation) comes only to those who can eventually press against the limits of the total system that consists of materials and tools, and self and teacher. In this way, progress occurs; none of the elements are the same again; but this achievement is not easy or safe to attempt.

Although the product in the classical style may appear as quite straightforward to the naive spectator, those with a deeper understanding will perceive those subtle features which distinguish achievements of high quality and creativity from those that are merely competent. This is why 'connoisseurship' among performers and critics is so essential for the maintenance of standards for the highest levels of quality. But the immediacy of the reality being represented makes possible a wider participation in the enterprise of appreciation and evaluation. Differing levels of dexterity and craftsmanship are transparent even to those outside the circle of practitioners and connoisseurs, such as a concert audience. They become educated in their own skills of appreciation; and they share the commitment to the reality being represented, to the certainty in the message being conveyed, and also to the quality that is essential to the creative production.

Thus, in the classical style, reality and quality interact fruitfully. In the modern style there is an unresolved tension between the two. In spite of their depth and articulation, the abstract structures which constitute reality in the modern style can never achieve full contact with 'appearance', that complex and subtle texture of the world as perceived and worked. The form becomes the core of the message. Hence such productions lack that immediacy of lively personal contact which enables practice at continuously ascending levels, from exercises for dexterity, through problems for craftsmanship, to challenges for creativity. Of course, it is possible for any of these levels of skilled practice to be achieved in a modern style; it is the continuous progression between them, dependent on a deepening interaction with the world of practice as well as with the lessons of past masters, that is problematic.

Within the modern style the tasks of teaching become extremely difficult. The pupil's initial learning of technique for the achievement of dexterity cannot be motivated by a promised continuous progression up to the higher levels of creativity. Artistic expression becomes alienated from technical mastery. This may explain why in the creative arts we have had manifestoes and movements rather than schools of masters and pupils in the classical sense. Whereas previously it was quite respectable for an artist to belong 'to the workshop of' a master in the classical style, masters in the modern style have only imitators. Although in its

formal elements the modern style relates more to the strictly classical rather than to its 'romantic' variant, in its social practice it produces the same sort of heroic individualism as old-fashioned romanticism.

As a result of these aspects of the modern style, the tasks of quality evaluation become difficult. For example, when people see a late Picasso sketch, some may say that their young child could have done the same; they are not aware that such apparent naivete was achieved through decades of well documented development of inspired work, starting with outstanding classical achievements. Thus the quality is not always apparent to the naive spectator, but will need to be mediated through critical expertise . Moreover, the inaccessibility of modernist productions deprives the creative community of a lay audience which, whatever its limitations, serves to keep the work grounded in its own living experience of the world. In the modern style, the community of those who are engaged in criticism and evaluation shrinks down to the producers and experts, and eventually becomes esoteric.

We can use the concept of 'audience' to illustrate the relations between cultural productions and their societal context. In the classical style, the audience, inexpert but educated, is an essential part of the production; performer and audience share the same reality. In the modern style, the effective audience is restricted to experts, either colleagues or professional critics. In the post-modern style, the audience is fragmented, and exists as those individuals who happen to be able to have an experience. The way that the message operates depends on the style: classically, it shows; in the modern style it demonstrates; and (as Baudrillard puts it) in the post-modern it seduces.[8]

The external quality of productions is defined and evaluated by some relevant community. The community may be large and diverse, as in the classical style, or restricted as in the modern. But quality is not necessarily purely subjective or even merely intersubjective on that account. This community has a commitment to its particular shared reality and values; and it possesses examples of excellence ('classics') which serve as models for the maintenance of standards. Of course, there is always a tension between the private purposes of those who are engaged in the activity and the public functions of their work; thus even the greatest of artists must survive in the material world, regardless of the spiritual excellence of their creative work. But there must be a harmony between the private and the public; and if in any creative product the private or covert purposes dominate over the public or advertised ones, quality is betrayed.

In the post-modern style, the message is no longer distinctly announced as in the classical style, nor implicit in the form as in the modern style; but it exists only in the experiences of the separate spectators. The locus of quality of production is shifted away from the message, and is concentrated on the technical achievements that enable the total confusion of that hyper-reality which is created for spectators. These technical achievements can reach great excellence, and indeed must do so if hyper-reality is to be maintained. But the expertise is purely technical, and is alienated from the experience (be it aesthetic or psychedelic) that is being purveyed to the spectators.

We can further illustrate the three styles in terms of the education of the participants in the experience. As we saw, in the classical style an educated inexpert audience is presupposed; in the modern style it becomes problematic but still fundamental in principle; while in post-modernity it is irrelevant. Spectators at classical or modern productions (such as sports, with examples of team games and field events respectively) will gain an enhanced appreciation from their education

in the special skills involved; such spectators can discuss fine points of performance or strategy as ardently as do opera-goers. By contrast, those spectators at post-modern happenings need only to be recognizable as belonging, through special attire or other insignia. The quality of the performers and of the audience's discrimination are less important, respectively, than that of the technicians who enable and mediate the performance, and the designers of the T-shirts sold to the audience.

Post-modernity as a mass phenomenon

If post-modernity concerned only some writers and critics who were gripped by scepticism or nostalgia, it could be dismissed as yet another fashion or intellectual game. But the post-modernists work on a larger canvas; they claim that all of contemporary society is affected by post-modernity. To the extent that this is true, and (for us) to the extent that the technological system is also involved in the post-modern phenomenon, its study is of very great significance. For it is an essentially parasitic, not to say cancerous, social development. This can be seen in the fate of its most consistent and profound exponent, Baudrillard, who in the 1960s became disillusioned with both Marx and Freud, and after decades of study sees our present civilization as one of impending metaphysical catastrophe.

On the larger scale, we can say that (in Western culture at least), it is hard to imagine how a new generation that has been totally immersed in hyper-reality could still be able to master the classic sort of dexterity that is required for operating its special technological substructure, as well as for keeping society running. In that way, a mass post-modernity would be an affair of not much more than one generation, leading either to some sort of puritanical reaction, or to a rapid and total degradation of the technological system and much besides. Even before World War I, E. M. Forster had a vision of a hyper-technical society experiencing a gradual but accelerating decline of maintenance and quality-control until 'The Machine Stops'.[9] With post-modernity in command, this would be realized suddenly and soon.

Baudrillard and others see post-modernity as an essential feature of the current version of the mass popular culture that has grown up in the 20th century. Indeed, some hostile critics of post-modernism interpret their analyses in terms of the nostalgia of a cultural elite that has lost its previous hegemony over society's cultural production. In one sense, post-modernity represents the end of hypocrisy, in that the less educated masses can now enjoy the cultural products that they want and pay for without being made to feel guilty or inferior. By the same token, they can freely refuse to support the elite high-culture productions which seem to benefit only a snobbish minority.

The mass 'permissive' society of the 20th century has brought a new freedom from an earlier repressive, hierarchical system of culture; but many will argue that it has been accompanied by a general flattening of quality. In earlier hierarchical societies, self-discipline and a commitment to quality were generally fostered for the elite (more rigorously for the arrived than for the hereditary). The lengthy training periods of classical cultural productions (like those in classical educational systems), depended on the young learner's acceptance of a lengthy and rigorous training, which was natural in such a cultural context. The sharpened critical awareness and powers of abstraction characteristic of the creators of the modern

style depended on their previous immersion in classical culture, and so it was less of a revolution than was then imagined.

One might say that one of the greatest tragedies of socialism was the implicit belief that a general commitment to quality could be carried over and diffused throughout society, when the old social and ideological structures were replaced. The system did succeed in maintaining quality in some classic elitist fields of arts, scholarship and sports, and also in some areas of military production. However, as standards of expected quality in the civilian sector rose, the system could not deliver. Finally, the bureaucracy drifted into its own hyper-reality of socialist clichés. Thus the failed coup of 1991, complete with worldwide live TV coverage and total bungling by the conspirators, could be considered the first major post-modern political happening.

The historic occurrence of such a collapse of quality (and with it the corresponding socioeconomic structures) is indisputable evidence that it can happen; now the strategic question is how its recurrence might be prevented elsewhere. The development of mass society in the market economies did not lead to such a catastrophic decline in quality in the civilian sector; the exigencies of competition ensured that quality (at least as perceived by consumers) would in general be maintained and even enhanced. But there are several tendencies which remind us that quality is internally complex, socially mediated and perhaps even sometimes contradictory. One is the decline of quality in the traditional skills imparted by formal education; whether this is occurring is still a subject of debate in the UK, but it is beyond doubt in the USA. Another is the phenomenon, already mentioned, is the alienation of technical quality from the message of post-modern cultural productions.

The maintenance of quality in even the most basic social institutions can no longer be taken for granted. Capital itself can be fruitfully analysed in terms of the three styles. In the classical style, it functions as the facilitator for an independently real manufacturing sector, providing the means whereby the material forces of production can be deployed. We have a modern style with finance capital, which directs the industrial sector to its own advantage; the basic elements of reality in this style are the abstracted units of money, and quality is assessed primarily in financial terms, with the manufacturing activity as subsidiary. In the post-modern style, finance becomes free-floating, serving only its own immediate ends; the realities of manufacture (and even of national industrial survival) are irrelevant to its activities. In post-modern junk-bond finance, what had previously been private and covert (the manipulation of industries and the resources and jobs invested in them) now becomes public and manifest, though in this case with little sense of irony. When units of money eventually lose their reference even to an intersubjective reality, the reality of finance becomes brittle; for a fable about this contingency, see Kurt Vonnegut's novel *Galapagos*.[10] A foretaste of this, a sequel to the post-modern spectacular failed Soviet coup, was provided by the European monetary crisis of September 1992, when British financial and economic policy unravelled live on TV.

Finally, there is the recently appreciated environmental aspect of quality, in the danger that our industrial civilization will destroy its natural habitat. The ruling ideology of economics deems the environment to be 'external' to the market; and so the preservation of its quality will always be peripheral to the main business of society. This induces a hyper-real state in commentaries on the problem from a conventional economics approach. Thus one influential economist recommends

the consideration of 'climatic engineering' such as shooting particulate matter into the stratosphere. The only criterion of quality he imagines is cost-effectiveness; unpredictable or uncontrollable planetary ecological effects of such interventions are not in his profession's scheme of things. Another of his options is adaptation to a warmer climate; he assumes that the necessary mass migrations would take place gradually and automatically, in an orderly fashion, as sea-levels rose.[11] Thus the market system and its theorists exhibit post-modernity in their own characteristic ways.

Post-modernity in mathematics

It is a significant historical coincidence that modernism emerged simultaneously in mathematics and in art, at the very beginning of the 20th century. Formalism and cubism are expressions of the same quest in two widely different fields of creativity. As Baudrillard says, 'Cubists still searched for the "essence" of space, attempting to unveil its secret geometry'.[12] Post-modernity has recently come to both fields through a merger, accomplished by computers. Although 'computer art' had been cultivated by some enthusiasts for some time previously, it was the invention of 'fractals' that brought serious mathematics and popular art together. The interaction has taken a variety of forms, including the generation of artefactual simulations of landscapes and other natural features to be used in films and television. The most striking examples are the films and videos of the 'Mandelbrot sets', which bring the spectator down through infinitely repeating curved patterns on ever finer grids, producing a nearly psychedelic experience. It must be remarked that the vivid colour that contributes so much to the effect is not a part of the mathematical structures, but is simply a coding for the local refinement of the computational grid.

With the Mandelbrot sets, that part of mathematics becomes a spectacle in the Baudrillardian sense. Spectators feel themselves being enveloped in the microscopic world, as if the infinitesimally small quantities of 'the calculus' can at last be seen directly, and in glorious Technicolor. The sets are widely used to display the attractions of mathematics to prospective students; this would seem to be their main application so far to mathematical practice. Their philosophical influence, as part of computer methods, should not be underestimated. For some two and a half millenia, mathematics was considered to be essentially a science of proof and demonstration, with reckoning an inferior relative; this was the accomplishment of the 'Greek miracle' in comparison to the computational mathematics of all other civilizations. With the popular appeal of fractals, even pure mathematics once again becomes (in part) an empirical study of a special sort.[13]

With fractals, the entities of mathematics change from being conceptual structures (as the circles and lines of Euclidean geometry or the abstract concepts of modern mathematics) and becomes the outcomes of computations with determinate numbers. In that sense, mathematical reality returns to its pre-Greek base in computation, but now mediated through computers whose rapid calculations cannot be grasped by human skills or intuition. Along with reality, mathematical certainty is also being transformed. The 'proof', with all its known foundational problems, is now supplanted by the computer program. This is essentially opaque to comprehensive review by humans, so that the outcome of a computation will always be in doubt. But if it seems to work, it will of course be accepted, until such time as 'bugs' are discovered. Thus here too empiricism re-enters mathematics

after its long exile. Criteria of quality must also be revised to accommodate this radically new sort of mathematics; in the absence of connection with traditional ways of doing and conceiving mathematics, excellence in this field relates to the soundness of the underlying information technology, but also to the attractiveness of the display.

Such developments bring post-modernity to mathematics in several ways. On the one hand, the modernist image of mathematics is now in danger of crumbling to a post-modernist assault. The paradoxical situation is well described by Mary Tiles:[14]

> . . . the flight to a post-modern proliferation, its restriction of analyses to the fragmentary and the perspectival, through abandonment of standards of coherence and consistency and the demand for rational order, is itself a continuance of the quest for security, for a defence against the possibility of a radical critique, the kind of critique which is a force for change and development. In this way the postmodern position readily slides into the conservative strategy of liberal pluralism which, by allowing a place for all, needs to listen to the claims of none.[15]

As the collapse of modernism in the philosophy of mathematics engenders a Feyerabendian mood of 'anything goes', so the intrusion of computers into the practice of teaching and learning can render mathematical skills apparently obsolete, with eventual consequences that could be catastrophic. After all, if cheap computers can do algebra better than the students, why should they bother learning? It is distinctly old-fashioned to claim that there are some basic skills and insights which cannot be computerized; and after nearly a century of modernism it is impossible to advance arguments in favour of the empirical, craft element in mathematics at all levels. So it is likely that students will generally know only sufficient mathematics to program their hand-held computers; and they will then be utterly incapable of assessing the quality of what their computers produce. We would then have a post-modernity analogous to that we have already discussed in connection with hyper-reality, but this time in the most basic of the arts whereby we survive.

Chaos and computer models

An analogous and closely related development is 'chaos theory'. This brings uncertainty closer to the heart of science, for it treats of systems which are completely deterministic in their causality, but which are nonetheless unpredictable in detail. Thus uncertainty moves inwards from its classical base in 'randomness', and also moves upwards in scale from its modern physical base in quantum phenomena. In philosophical terms, it represents an uncertainty that is epistemological, and therefore deeper than either technical or methodological, as described in our notational system NUSAP.[16] The prospect is now real, that any physical system (other than the trivially simple ones) will possess this deepest sort of uncertainty and defy exact prediction of its future states. However, whether an indeterminate system is genuinely 'chaotic' (rather than merely complicated or truly random) can be known only by whether its behaviour ultimately settles down to a quasi-periodic state; and 'ultimately' may be beyond experiment or even computation.

The methodological problems of 'chaos theory' do not stop there, for the basic mathematical measures of the defining 'fractal' properties of chaotic systems seem peculiarly artefactual. The numbers that emerge from the mathematical constructions and computations depend not merely on the choice of the defined

'fractal' measure, but also quite strongly (and indeed non-linearly), on the scaling of the sets being measured. The absence of effective criticism of these fractal measures on the grounds of their variability makes them a novelty in mathematics. In classical or modern terms, they would be dismissed as merely gadgets.[17]

On the other hand, there is much debate among scientists about the status of chaos theory as applied to physical phenomena, such as the weather and geological processes. For the computation of the fractal dimension of a chaotic system to be genuine and not artefactual, a sufficient number of empirical data-points must be available, and this number increases very rapidly for higher fractal dimensions. The production of extra points by interpolation does not really satisfy the requirement. Because of such problems, some authors have queried whether the subject is about chaos or simply about confusion.[18] It is as yet uncertain whether chaos theory will become a more significant and permanent addition to science than its predecessors in mathematical fashion, as 'catastrophic theory'. But to the extent that it establishes itself in its present form, its combination of deep uncertainty, ambiguous reality, and confused criteria of quality, will identify it as belonging to the post-modern style.

Because the basic mathematical phenomena of chaos theory (shown by quite simple computer programs) are so striking and unexpected, and because the approach seems to explain the practical difficulties of predicting the behaviour of complex systems, there is a tendency among practitioners to consider a 'chaotic' model as being the reality which it purports to represent. This fallacy of misplaced reality is a very common one in the whole field of modelling; it is all the more prevalent because of the absence of effective tests for demonstrating what sort of correspondence, if any, there is between models and reality. Unlike the counter-intuitive elements of contemporary physical theory (which is modern in its style) the components of the chaotic models, devoid of certainty, quality and reality, are post-modern.

The widespread use of computer simulations have brought post-modernity on a mass scale to many branches of the technological system. We need only quote an early essay by Baudrillard:

> An immense process of simulation has taken place throughout all of everyday life, in the image of those 'simulation models' on which operational and computer science are based. One 'fabricates' a model by combining characteristics or elements of the real; and by making them 'act out' a future event, structure or situation, tactical conclusions can be drawn and applied to reality. It can be used as an analytical tool under controlled scientific conditions. In mass communications, this procedure assumes the force of reality, abolishing and volatilizing the latter in favour of that neo-reality of a model materialized by the medium itself.[19]

About this process, he comments

> We should be careful not to interpret this immense enterprise for producing artefacts, make-up, pseudo-objects and pseudo-events that invades our everyday existence as the denaturation or falsification of authentic 'content' ... It is in form that everything has changed: everywhere there is, in lieu and in place of the real, its substitution by a 'neo-real' entirely produced by a combination of coded elements.[20]

Thus Baudrillard saw models as a key medium whereby questions of reality become impossible; the model cannot be falsified, the (uninterpretable) code replaces the message, and all is hyper-reality.

It does not require the culturally apocalyptic vision of a Baudrillard to produce

such an analysis of the invasion of the technological system by simulation models. In a recent discussion of the application of computer modelling to global environmental problems, the distinguished American mathematician S. Mac Lane described 'systems analysis' as,

> the construction of massive imaginary future 'scenarios' with elaborate equations for quantitative "models" which combine to provide predictions or projections (gloomy or otherwise), but which cannot be verified by checking against objective facts. Instead, [such] studies often proceed by combining in series a number of such unverified models, feeding the output of one such model as input into another equally unverified model . . . Such studies as these are speculations without empirical check and so cannot count as science . . .[21]

Replying to a defence of the field, Mac Lane continued to doubt that global problems should be tackled by models 'that in the first instance are not verifiable' and added 'problems are not solved and science is not helped by unfounded speculation about unverifiable models'. His concluding comment was on quality, to the effect that the research institution he was criticizing does not appear to have an adequate critical mechanism, by discipline or by report review.[22]

It is interesting that Baudrillard's analysis mentioned the use of models in policy; and indeed for a couple of sentences he seemed to be slipping back from post-structuralism to an old-fashioned 'realism'. It is for policy purposes that such models are mainly developed; and the difficulties of an empirical test of models are as nothing compared to testing their quality as policy instruments. Hence rationalistic fantasies of the applications of mathematics to statecraft, going back to Leibniz (17th century) and Ramon Lull (14th century), now have a new lease of life in post-modernity. A convenient name for such methods is the acronym GIGO (American for 'garbage in, garbage out'). We can give a strict definition of a GIGO methodology as one depending on computations where the uncertainties in the inputs must be systematically suppressed, lest the outputs become totally indeterminate. In this methodology, theories are replaced by computational models, experiments by computer simulations, and data by experts' guesses. In classical terms GIGO could be considered to be a new sort of pseudo-science, masquerading more successfully as it depends not on magic but on computers. However, in post-modernity, where quality as well as reality and certainty is evaporated, GIGO is simply another aspect of the technological system.

Such scientific developments can be understood in part as a reaction to the leading contradiction of our global industrial civilization. The problems are created by the opposition between the cultural drive for individual material welfare and the adverse social and environmental consequences of the collective technical means for its achievement. One way forward would be to realize that the technological system that has created the problems cannot be simply adapted for achieving their solution. Then there would need to be a radical transformation of the science-based technology that is deployed on such global problems; we have described this as 'post-normal science'.[23] The other, easier way, is to carry on as much as usual in the technological and political systems, and increasingly with GIGO methods boldly to go forward into post-modernity.

Post-modern technology

The phenomenon of post-modernity is most easily seen in technology, the largest sector of the technological system, through computer graphics. These are highly

developed miniature spectacles, designed for salesmanship; they relocate quality from the work itself to the display. Their most effective use in the political system has been in connection with the Strategic Defense Initiative (SDI), post-modernistically named after the 'Star Wars' science-fiction film. Viewers who regularly saw 'our' anti-missile-missiles unerringly homing in on 'theirs' were not misled by the modest legend 'artist's reconstruction; they knew that SDI was being displayed as an impermeable shield against aggression. In such cases, quality is betrayed by an intentional confusion between adequate computer graphics of an excellent technological system, and excellent computer graphics of an imaginary technological system. Thus military technology entered hyper-reality and became yet another post-modern happening, though on a vast scale. Historically, SDI could only happen because of the already existing confusion between hardware and fantasy in nuclear deterrence.[24] Of course, in a relatively open society many people can and will participate in the process of quality assurance, publicly criticizing and demystifying such ventures; the debate on such issues cannot be restricted to hard technicalities, but also involves methodology, politics and ethics, and so becomes a post-normal corrective to post-modern tendencies in technology.

A more enduring post-modern technology is biotechnology; here the problem is not with systems that are illusory, but with the creation of new living things that cause confusion by violating our inherited categories of ethics and reality, the Good and the True. The debate on biotechnology has always been loaded, since at any time up to the present the dangers have been necessarily speculative while the beneficial achievements are relatively modest and quite real. If the burden of proof is on critics, they lose every time. But when proponents promise vast benefits while assuring that 'society' will be able to prevent any harm, the balance of plausibility shifts. Policies for technological development or for regulation can no longer be based on the firm realities discovered or created by classical scientific research; in their place we have uncertainties and ignorance, interpreted through policy considerations. These have been hitherto mainly of national defence or private profit; but now that is challenged by considerations of prudence and even compassion. This situation can be appreciated as part of 'post-normal science' and managed accordingly. But when the fiction of classical 'normality' is maintained, we are truly in post-modernity. Then science-fiction becomes relevant to policy, not as prediction but as parable.

The most notorious ethical problems arise in connection with reproductive technology. Although the normal social processes have been tampered with for a long time (see the Bible for the surrogate-motherhood techniques whereby the Twelve Tribes of Israel were founded), technology has, in this sphere as in others, transformed both practical prospects and ethical problems. It is not merely that we have an array of techniques whereby the reproductive process can be drastically deconstructed, so that 'parenthood' now becomes rather like a set of locations on a factory assembly-line. This analogy becomes directly relevant when we consider the possibility of extending existing cloning techniques from the higher mammals to humanity. At this point, science-fiction and indeed political fantasies become technological possibilities to be costed like any others. What sort of 'human' would it be, if it were a cloned copy, sharing an emotional make-up and even consciousness with its simulacra? Such a 'Brave New World' already happens with cows on a commercial basis, without any ethical outcry. It is well known that there can be no incentive to invest without the prospect of reward, and conversely there is no prospect of reward without a propensity to invest; therefore we need to begin to

imagine what would happen to the sentient products of such a post-modern biotechnology.

Biotechnology also takes us to post-modernity in the regulation of technology; an illustrative example is the planned diffusion of living genetically manipulated organisms, particularly on the microbial scale. In this case the ethical uncertainties derive mainly from our ecological ignorance. On the traditional scientific model, regulation must be based on an anticipation of important unwanted events and of their consequences. But even if microbial ecology were a large and flourishing science, certainty of prediction in this field would be a vain hope. The range of possible interactions between organisms and environment is so vast that it can scarcely be classified let alone quantified. Under these conditions, 'policy numbers' cannot be other than fiat, or fiction.

In the case of genetically manipulated organisms intended to survive in the wild, quality assurance is involved in the regulatory process in a contradictory way; we can describe this in terms of the 'fine-tuning paradox'.[25] An organism intended to survive in the wild must be sufficiently robust to do so; but if it is to be acceptable ecologically, it must be sufficiently delicate not to disrupt existing balances. To engineer such an organism is a task on its own; to construct a scientific proof that these desirable properties are present and stable is at a higher level of difficulty. Yet without a solution of the 'fine-tuning paradox' it is hard to see how there can be an effective science-based regulatory policy. The pretence that such contradictions can be definitively solved by the applications of normal science is a manifestation of post-modernity; only with a recognition of ineradicable uncertainties, and the opening of debate to all stakeholders, can there be a genuine, post-normal policy of regulation.

Malleable realities

The technological system has been in constant evolution throughout its history; and now it is also radically changing the reality in which it operates. Of course, the world of nature was changed by agriculture, and human life transformed by modern industry; but now our experience of physical and conscious realities are being exposed to a deeper confusion. One obvious symptom of this development is that 'science-fiction' is no longer fictional; hyper-reality has no obvious boundaries with the impossible or the unreal. The technological realization of this is the embryonic field of 'virtual realities'. A hyper-real sensory experience at the price of ordinary entertainment is now feasible. Those who engage in it seriously will soon find themselves having tactile as well as visual sensations of a new and unusual kind. What sorts of effects there will be on personalities, and on society, as the equipment becomes ever more accessible and refined, we cannot predict in detail. An effective political will for regulation of new technology occurs only when it raises palpable new fears or violates ancient taboos. Would electronic sex necessarily do either? If not, then the regulation of this technology, with cultural powers beyond our imagining, will be left largely to the marketplace.[26]

Even at this early stage of the evolution of post-modernity, fiction becomes a guide to practice in the understanding and control of the technological system. The influence of the pioneers of science-fiction on the visionaries of space travel is well known. Michael Crichton's *Jurassic Park*[27] is a morality tale about the present, using an imaginary but nearly feasible project for making a really real theme park with genuine dinosaurs. He starts by reminding us of the commercialization of

biological science attendant on the total revolution that biotechnology is effecting in ourselves and our environment. His story is about the essential imperfections in any biological simulacrum, using both the sophistication of chaos theory and the homespun wisdom of Murphy's Law. Because the venture was dominated by pride and greed, things inevitably went wrong, and (as is well known to any computer engineer) inevitably did so in unpredictable ways.

The parable is about sin, and the amoral drive for power regardless of the consequences. The point is similar to that made by Norbert Wiener in his classic *God and Golem Inc.*:[28] that simony and sorcery are still alive, now in the guise of a science that is governed by gadget-worshipping. But one does not need such bad intentions for paving the road; post-modernity is the contemporary outcome of the centuries-old faith that through the modern technological system we can escape from the human condition. In dialectical fashion, the modern technological system has resolved some severe contradictions in the material and moral conditions of the fortunate fraction of humanity, but in doing so has created others, ever more severe and urgent.

Post-modernity is the reaction to these new contradictions as they manifest mainly in the cultural sphere; it can be defined as the wilful adoption of illusion as the really real reality. In this sense the post-modern portion of our culture is a drug. External reality cannot be manipulated at will, nor can we ignore the constraints of a global environment that will either nurture or destroy us, depending on our wisdom. As we have seen both in the societal and environmental spheres, reality will eventually but certainly break through. The task facing us is to bring about a technological system that can resolve the novel contradictions in our global situation, now particularly acute because 'normality' is no longer an option. However artefactual its elaborated forms, quality has a root in reality, called survival.

Conclusion

With the collapse of the Soviet empire, the awareness of a global environmental crisis, and the rapid growth and deployment of the new technologies of life and information, there is no doubt that our civilization is passing into a new age. The transition from old assumed realities to new uncertainties may be as deep as that described by Eco in *The Name of the Rose*.[29] Then the culture of monasteries was ready to go up in flames. No-one could then predict the new structures of society and knowledge; and we cannot foresee them for our own future. But we can speak of the way in which we should move. The collapse of 'normality' and 'modernity', and the triumph of post-modernity may lead us to the twilight of the true and also of the good. But a post-normal science, confronting the leading contradiction of our time, can help in the articulation of a technological system with renewed roots in quality and reality.

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Notes and references

1. J. F. Lyotard, *The Postmodern Condition: A Report on Knowledge* (Manchester, Manchester University Press, 1984); F. Jameson, 'Postmodernism in the cultural logic of late capitalism', *New Left Review,* (146), 1984, pages 53–93; N. Wakefield, *Postmodernism: The Twilight of the Real* (London, Pluto, 1989).
2. S. O. Funtowicz and J. R. Ravetz, 'Global risk, uncertainty, and ignorance', in J. X. Kasperson and R. E. Kasperson (editors), *Global Environmental Risk Analysis and Management* (New York, United Nations University, 1992).
3. J. Baudrillard, 'Mass Media Culture' (1974), in J. Baudrillard, *Revenge of the Crystal* (London, Pluto Press, 1990).
4. *Time,* 27 May 1991.
5. M. Polanyi, *Personal Knowledge* (London, Routledge, 1958).
6. S. O. Funtowicz and J. R. Ravetz, *Uncertainty and Quality in Science for Policy* (Amsterdam, Kluwer, 1990).
7. For an analysis of quality in science, see J. R. Ravetz, *Scientific Knowledge and its Social Problems* (Oxford, Oxford University Press, 1971).
8. J. Baudrillard, *Seduction* (London, Macmillan, 1990).
9. E. M. Forster, 'The Machine Stops', in *Collected Short Stories* (London, Penguin, 1954).
10. K. Vonnegut, *Galapagos* (New York, Bantam, and London, Cape, 1985).
11. W. D. Nordhaus, 'To slow or not to slow: the economics of the greenhouse effect', *The Economic Journal, 101,* 1991, pages 920–937.
12. Baudrillard, *op cit,* reference 3, page 95.
13. M. Tiles, *Mathematics and the Image of Reason* (London, Routledge, 1991).
14. *Ibid,* page 173.
15. D. Donoghue, *The Arts Without Mystery* (London, British Broadcasting Corporation, 1983).
16. Funtowicz and Ravetz, *op cit,* reference 6.
17. Baudrillard, *op cit,* reference 3, page 77.
18. I. Procaccia, 'Complex or just complicated' *Nature, 333,* 1988, pages 498–499; D. Ruelle, 'Deterministic chaos: the science and the fiction', *Proceedings of the Royal Society of London A, 427,* 1990, pages 241–248.
19. Baudrillard, *op cit,* reference 3, page 92.
20. *Ibid.*
21. S. Mac Lane, 'Letters', *Science, 241,* 1988, page 1144, and *242,* 1988, pages 1623–1624.
22. *Ibid,* page 1624.
23. S. O. Funtowicz and J. R. Ravetz, 'A new scientific methodology for global environmental issues', in R. Costanza (editor), *Ecological Economics—The Science and Management of Sustainability* (New York, Columbia University Press, 1991); Funtowicz and Ravetz, *op cit,* reference 2.
24. J. R. Ravetz, 'Hardware and fantasy in military technology', in J. R. Ravetz, *The Merger of Knowledge with Power* (London, Cassell, 1990), pages 100–115.
25. J. R. S. Fincham and J. R. Ravetz, *Genetically Engineered Organisms: Benefits and Risks* (Chichester, John Wiley, 1991) page 136.
26. H. Rheingold, *Virtual Reality* (London, Secker and Warburg, 1991).
27. M. Crichton, *Jurassic Park* (New York, Knopf, 1990).
28. N. Wiener, *God and Golem Inc* (Cambridge, MA, MIT Press, 1964).
29. U. Eco, *The Name of the Rose* (London, Pan Books, 1984).