Values and Science: A Philosophical Examination of Values Suggested by Recent Developments within the Sciences

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1. Prologue: How the problem of science in relation to value first arises.

A recent report that appeared on the BBC website on April 21, 2010 began as follows:

> Scientists from New Zealand's University of Auckland have found that [New Caledonian crows] are able to use three tools in succession to reach some food. The crows, which use tools in the wild, have also shown other problem-solving behaviour, but this find suggests they are more innovative than was thought. The research is published in the Proceedings of the Royal Society B. The team headed to the South Pacific island of New Caledonia, the home of *Corvus moneduloides*. They are the only birds known to craft and use tools in the wild. The discovery that they whittle branches into hooks and tear leaves into barbed probes to extract food from hard-to-reach nooks astounded scientists, who had previously thought that ability to fashion tools was unique to primates. And further research in the laboratory and the field has revealed that New Caledonian crows are also innovative problem solvers, often rivalling primates. Experiments have shown that the birds can craft new tools out of unfamiliar materials, as well as use a number of tools in succession.

The key word in this passage is "astounded". Time and again in recent years, natural scientists out in the field have brought news or, based on experiments carried out in their laboratories, have published articles that have "astounded" many among their peers and audience. There is nothing wrong with careful observation, still less so when this is done in openness to the varieties of animal intelligence and creativity expressed. The problem is that such expressions have been known for thousands of years. It's just that the knowers did not have the modern conception of knowledge that prevails within much of the scientific community and seems to shape much of modern epistemology.

Until fairly recently, knowledge as defined by modern science has been closely linked with whatever happens under conditions within the control of the scientist, quite often bound by the framework of a science that rests on mechanical or quasi-mechanical laws. The model for that kind of science has been the "control experiment." Somehow, what could not be established under such conditions of control came not to count as knowledge. And so, what had long been known could not be known. It was systematically filtered out, made invisible, ignored.

How else can one explain the failure by scientists for so long to acknowledge what anyone who has had a pet or bred animals has known, has been sure of? How else could a man as gifted as Descartes declare unambiguously that animals are just machines? How could this claim remain unquestioned by the Academy until it was turned into an embarrassment by a succession of botanists and zoologists, culminating with Darwin? How indeed could scientists, who believed they had been going about their work with unprecedented intellectual honesty, exclude a phenomenon as basic and pervasive as *heat* simply because it seemed not subject to control experiments?

It is only because Cartesian science remains influential that scientists are repeatedly “surprised”, “astounded”, or “stunned” by the “discoveries” that they are making about animal intelligence and creativity. A science that expects all phenomena to work with the regularity and predictability of machines is not looking for surprises, and certainly not for creativity. This is a fundamental point at which the problem of science in relation to *value* comes up. A science restricted to mechanism must *import* value from elsewhere for the ethical dimension not to fall out altogether. Those who are correctly concerned about the distance between a mechanically minded science and ethics are then obliged to emphasize the obvious *limitations* of such a science and reaffirm the ethical on its own terms.

The ethical compels us on its own terms. But perhaps a more mindful approach by science might help soften the apparently intractable separation between science and *value*. If, in the spirit of pivotal contributors to human life and culture from the ancient mythmakers to unclassifiable individuals such as Da Vinci and Goethe to contemporary naturalists inspired just as much by the Theory of Evolution as by, say, Romantic poetry, the scientist would look with a more open and artistic eye at Nature, then there is *value* there *to be seen*. An accumulation of reliable reports about what Nature brings forth, of the kind with which the present prologue began, at the very least suggests aesthetic and metaphysical value. Value would then no longer be something that must always be *added* to the constantly changing picture of the world offered by science, but it might quite be often suggested or even signified *by the scientific picture itself*.

2. Further steps in the direction of gathering science and value.

Almost forty years ago, Jacques Monod was struck by the radical degree to which the view of Nature and natural history founded on a literal – or at any rate unimaginative – reading of the Bible had been discredited by modern science. The only honest and honourable response, he believed, would have to be unwavering and exclusive commitment to the “ethic of knowledge”.[1] Monod was an excellent example of a Cartesian scientist could between his reductionism and that of Biblical literalism and/or traditionalism. This “primitive bifurcation”[2], still far too prevalent in contemporary disputes between science and religion, prevented Monod from appreciating the implications of his own scientific findings. Much of *Chance and Necessity* is devoted to an elegant and clear argument showing how the chemistry of proteins is just what is needed for them to acquire the perfect three-dimensional geometry that suits them for their biochemical function. It is an argument that would delight those already inclined toward intelligent design. However, there is no need for such inclination to recognize that the chemical composition of proteins dictates a geometry uncannily fit for their living function. This has value *in itself*, irrespective of any grand themes one might wish

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[1] Jacques Monod, *Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology*, trans. A. Wainhouse (New York: Knopf, 1972): 169-180.
[2] We owe this term to Hegel.

to graft on. This in itself suggests some kind of *transcendence*, an extraordinary intelligence at work that produces phenomena whose fit and formation intimate art of the highest order.

The justified celebration of a series of scientific breakthroughs, such as those in biochemistry celebrated by Monod, should not be allowed to go so far as to limit our values to what we learn through science, least of all when it follows a more or less mechanical model. It is true that this model is falling away in part thanks to the science to which Monod contributed in his research, thought, and publications aimed at a broader audience. But it is strange for scientific knowledge to impose, let alone entail, norms and habits of mind that obstruct the acknowledgement of the phenomena it keeps bringing to light at every level. Not only is there the failure to observe significant phenomena that do not require any scientific research at all, such as animal intelligence and creativity, but also those phenomena that would remain invisible *without* the most advanced scientific research yet, once made visible, can themselves be contemplated with the eye of an artist or sage.

On the other hand, to step back from the Cartesian mindset and contemplate the beauty and brilliance of the phenomena brought forth by modern and contemporary science, especially if this be explicitly turned toward Nature, now once more alive and creative, is liable to call up the epithet "pantheism" by some. This is the other side of the primitive bifurcation. Those habituated to monotheistic dualism, in particular the uncompromising, absolute separation between Creator and creature, have found themselves progressively narrowing the scope and meaning of Nature's intelligence and creativity in the name of their faith.[3] To attribute anything of transcendent value to Nature becomes tantamount to idolatry. Monotheistic dualism usually forces those who acknowledge Nature's value well beyond some watered down aesthetic aspect to declare allegiance to a pantheistic monism. Such epithets, all the more when they connote what merits condemnation, reveal a lack of dynamic thinking among certain influential monotheists. It is surely possible to attribute transcendence to Nature while maintaining that not all value comes from Nature, especially in relation to ethics as we shall presently see.

One way to reawaken to value as it arises among the phenomena, even if mediated by cutting edge contemporary science, is through the reconsideration of the perennial tendency to regard the universe as alive in some sense. In our western tradition, this has prevailed from Thales through Aristotle to Leibniz, and again in the thought of Goethe, Hegel, Schelling, Schopenhauer, Dilthey, and Nietzsche, and more recently Bergson and Whitehead. While the ancients did not know our modern science, although they had a solid grasp of mechanism,[4] Leibniz was a contributor to modern science who nevertheless was convinced that Nature was not ultimately a machine[5] and Nietzsche anticipated what might just now be given consideration by a few bold molecular biologists:

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[3] Pierre Hadot, *The Veil of Isis: An Essay on the History of the Idea of Nature*, trans. Michael Chase (Cambridge, Mass and London: Harvard, 2006). See especially Part V.
[4] Hadot, ibid.
[5] See the *Monadology*, Sections 60-69. Section 69 begins thus: "There is, therefore, nothing uncultivated, or sterile, or dead in the universe."

> Is it not permitted to make the experiment and ask the question whether this which is given [namely 'desires and passions'] does not suffice for an understanding even of the so-called mechanical (or 'material') world? [I mean this as a world that possesses] the same degree of reality as our emotions themselves – as a more primitive form of the world of emotions in which everything still lies locked in mighty unity and then branches out and develops in the organic process . . . , as a kind of instinctual life in which all organic functions, together with self-regulation, assimilation, nourishment, excretion, metabolism, are still synthetically bound together – as an *antecedent form* of life?[6]

The cosmic clock as a kind of organism, primitive insofar as it obeys mechanical laws, in short insofar as it is merely a clock? One can see echoes of such thinking in Lovelock. Nietzsche's insight can not be devalued in a cultural atmosphere increasingly dominated by positivism. While the Stoics had already seen the universe as a seed that grows, expands, withers, then starts again, while Aristotle had already implied that the universe acts as some kind of giant organism, there is something distinctly contemporary in Nietzsche's fragment. It is in tune with what has been emerging from the life sciences in recent decades.

A frequently underrated or disregarded philosopher whose work turns out to be even more consonant with contemporary science is Alfred North Whitehead. It is conventional to refer to his thought according to his own phrase, the "philosophy of organism". So deeply embedded is aesthetic value in the universe that to read Whitehead closely is to behold Nature emergent as a work of art in constant progress. The very starting point of knowledge in his philosophy is organic and dynamic. Instead of the routine subject/object distinction, Whitehead begins with *occasions of experience* in which all at once, inseparably, an object (there in some way irrespective of the experience, of course) arouses activity or *concern* within a subject, a concern characterized by its *affective tone*. Everything is coloured with emotion in the most general sense. Our standard model of subjects dispassionately and "neutrally" gathering data turns out, in Whitehead's view, to be an extreme case of "occasions of experience". Physical science is seen by him as an abstraction from a rich and layered process throughout every level of existence in the universe (He extends the notion of "occasion" to every kind of being that exists, whether in our sense organic or inorganic, so that strictly speaking, nothing lacks "life" in this view).[7]

A modern approach that starts with Goethe and passes through Whitehead enriches our view of Nature and acclimatizes us to its profoundest aesthetic dimension. We are invited to partake of natural phenomena in the process of creation, *from within*, as master artists from Leonardo to Cézanne and Kandinsky had aspired for and executed in their painting. We pass from the outer beauty of the phenomena to the inner power that brings them forth and remains present in and with them, to the *sublime*. A science with this in mind, constructed and articulated by scientists with an artist's eye for Nature and the significance of their own work, can then highlight rather than leave out value. In Goethe

[6] Nietzsche, *Beyond Good and Evil: Prelude to a Philosophy of the Future*, trans. R. J. Hollingdale (Penguin, 1973, 1990, 2003), #36.

[7] A wonderfully compressed if extremely difficult presentation of the foregoing can be found in Chapter XI of *Adventures of Ideas* (New York: Free Press, 1967).

and Whitehead, we already have fine role models. Goethe saw himself as a scientist as much as an artist, and while his scientific work and outlook have been conspicuously absent from subsequent scientific or philosophical writing that has appeared in the English-speaking world, intoxicated as it has been with the achievements of one of her most famous native sons[8], numerous works have appeared in French and German that underline the originality, importance, and relevance of Goethe's contributions to science. On the other hand, Whitehead's credentials as one of the greatest mathematicians of the twentieth century and one of the first to comprehend Relativity and Quantum Mechanics need no further comment here.

Nevertheless, one is always tempted to take a good thing too far by giving Nature undue credit. A case in point is several recent attempts to naturalize altruism. A very well researched and argued example is encountered in the work of David Sloan Wilson.[9] There is no reason to dispute the discovery that at the group level, several species act "altruistically" in the sense that individual well-being takes a backseat to the prosperity of the group. We may even accept this as an efficacious "survival strategy". But is it really *altruism*? Whatever one may say of the aggregate effect of altruism in furthering the interest of the group, does this adequately describe the phenomenology of altruism? Is this how a *rational* being would account for his altruism? It seems to take something crucial from the *meaning* of 'altruism' to say that it is the evolutionary by-product of strategies for group-survival. It seems not only to devalue it, but to distort its character altogether. Minimally, one ought to distinguish between sacrifices that in no way are performed in relation to the good of the group and those – like the proverbial example of the mother who hurls herself into rough seas to save her drowning child – that are plausibly built in through an evolutionary process. For these as well, though, how plausible is it to see them thus? Are love and nobility nowhere to be found in a mother's sacrifice for her child? Is it just linguistic embellishment to use such terms?

In the end, the problem becomes a stand-off between those who believe they can naturalize morality and those who affirm that it is of the essence of what is *moral* that it *cannot be naturalized*. A considered and careful look at moral life in the same spirit as the artistic view of Nature - which goes beyond mechanisms and algorithms to the life in things, the contemplation of beauty, and the acknowledgement of intelligence and creativity - may well decide the issue. This is where many believe that Kant, for all the difficulties and controversies surrounding his moral philosophy, has touched on the truth when he insisted that when we are moral, we *transcend* Nature and become *noumenal* beings.[10] Kant indeed conceded too much to the Newtonians in his rather mechanistic and deterministic view of Nature insofar as it becomes known to physical science (keeping in mind his attempt to give Nature her due when he turns, inspirationally, to the artistic viewpoint in the *Critique of Judgment*). But however we enrich and enliven our view of Nature, there is no escape from the problematic ontological status of *ethics*. There is something profoundly dissonant about reducing morality to what is in our interest or some other functional interpretation, something entirely out of character with

[8] Of course, I mean Newton.

[9] See for example Theoretical Foundation of Sociobiology in *The Quarterly Review of Biology*, December 2007, Vol. 82, No. 4: 327-348. A simpler article making the same point is Survival of the Selfless, *New Scientist*, 3 November 2007: 42-46.

[10] See the first part of *Groundwork of the Metaphysics of Morals*, any edition.

the nobility of morality. Philosophers as widely divergent as Kant and Nietzsche, or Aristotle and Wittgenstein, agree on this point.

The spiritual diminution of altruism through the attempt to naturalize and evolutionize it is reinforced when we look beyond the human realm. What is one to say of the recorded and confirmed stories of housecats saving their owners from an upper floor about to collapse onto their beds in the middle of the night (Buenos Aires) or a fire about to engulf the entire home (Australia)? What about dogs that walk hundreds of kilometres to rest by the graves of their masters or who seek rangers in a remote region of Alaska to guide them to the site of trouble? How could this be reasonably linked with the group-welfare of cats or dogs, keeping in mind that cats are hardly animals with a group instinct? Perhaps one would like to argue that somehow cats and dogs "know" – or natural selection "knows" - that they will become more desirable to humans through such acts? What then might we imagine regarding the dolphin who led a woman caught in a riptide off the coast of New Zealand back to safety? A simple application of the "principle of economy" so dear to scientists and those who hold their method in the highest esteem would indicate a rather more direct – and far more persuasive – interpretation of such actions. It is difficult to understand why, among scholars and intellectuals, the recognition of what is good is either denied or granted with a grudge. It would fit the facts far better to regard what animals do under the rubric of a broad nobility, a *moral* value that transcends Nature, of which altruism, sacrifice, and kindness are specific manifestations.

The ontological status of morality, the question whether it is natural or beyond Nature, is not a question that can be settled for all time, and an attempt will most definitely not be made here. Rather, it is far from implausible to regard morality as *transcendent* and this will be the view affirmed from here on. We may in this light point out that however we may come to venerate Nature and behold her significance, the values that she elicits, there is nonetheless a crucial remainder that includes the core of what we call "morality." Faced with the reality of morality, it becomes difficult to label as "pantheistic" those who acknowledge this reality yet in other respects embrace the natural philosophies and metaphysics of thinkers from Goethe to Whitehead (and as stated earlier, the word itself is problematical, a result of the reductionism to which strict monotheists are compelled).

Such subtlety and sophistication were already there in Plato's thought. The *Timaeus* unequivocally presents a living, ensouled, divine universe:

> The god who exists for ever [viz., the creator god or Demiurge] took thought for the god that was to be [viz., the universe], and for these reasons he made for it a body that was smooth, uniform, equal in all directions from its centre, and a complete totality, made up of bodies that were also complete totalities. And once he had set in the centre a soul, which he then stretched throughout the body and with which he also coated the outside, he set the body spinning and made it a single, unique universe, capable, thanks to its perfection, of keeping its own company, of needing nothing and no one else, since it was enough for it that it had familiarity and affinity with itself. This, then, was how he created it to be a blessed god.[11]

[11] This passage occurs at [34b] in all editions. The translation used here is by Robin Waterfield (Oxford, 2008).

Further on, Plato continues through the account narrated by Timaeus:

> The soul, which was interwoven throughout the entire fabric from the centre to the furthest limits of the universe, and coated the outside too, entered as a deity upon a never-ending life of intelligent activity.[12]

Here we have it: A self-sufficient, intelligent, living, divine Nature – and yet who can argue that Plato's was not a philosophy of transcendence *par excellence*? From the early history of western philosophy, in the thought of one of its founders, we see an example of venerating Nature unto divinity without a hint of monism and at great remove from "pantheism." So emphatic was Plato's affirmation of transcendence that in his philosophy, Nature is *twice* removed from Ultimate Reality. There is the Demiurge, who created the universe, and there is an unnameable level of divinity beyond all that we can name or conceive[13], Mystery as present in the great religious traditions of Asia and in God in the modality of Father for Christians.

3. The various approaches to the relationship between science and values.

There are three preliminary ways for us to view the relationship between science and values:

I. The first way has to do with the *limits* of science, both with regard to how far causal explanation must transcend the physical if all kinds of phenomena are properly considered and with science's failure to capture the "inner" side of things. In the *Phaedo*, Socrates explains these limits quite well when on his last night, he narrates how he had been attracted to the natural sciences and the philosophy of Anaxagoras, but then quickly discovered that too much is left unexplained. He provides the specific example of his presence in a prison cell about to ingest the hemlock in compliance with the decision of the Athenian court to execute him. Is he there because his legs and joints moved in a certain way and led him to sit in that chair discussing immortality and other issues with his best friends? Or is he there because the people of Athens condemned him following their evaluation of the accounts of his accuser and Socrates' defence, and because he wished to be a loyal, law-abiding Athenian to the very end?[14]

We are right back with the transcendence of the ethical and the failure of any causal scheme operative within the natural sciences to account for moral action. Had Socrates believed that his own life were prior to all other considerations, he would have accepted Crito's offer to escape and would not be sitting there in jail awaiting the implementation of his death sentence. A modern way to express this problem is by distinguishing between *reductionistic* and *whole-part* causation, as George Ellis does in his James Backhouse Lecture from January 2008. Socrates' decision to accept the verdict of his fellow citizens is a case where human intentionality trumps reductionistic causation. A moral decision affects our conduct as a whole, including the movement of our bodies. A

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[12] Ibid., same translation, at [36e].

[13] Ibid., same translation, at [28c]: "Even if we did find him, it would be impossible to speak of him to everyone."

[14] This argument can be found in any edition of the *Phaedo* at [97b – 99d].

science that includes intentionality is a shift from Newton's world to Goethe's, from Russell's to Whitehead's - and Wittgenstein's:

> In one aspect of the matter, personal experience, far from being the *product* of physical, chemical, physiological processes, seems to be the very *basis* of all that we say with any sense about such processes.[15]

This is perhaps where the limits of mainstream natural science are glaring. Personal experience, *qua personal* and not reduced in turn to some one-dimensional psychological or neurological hypothesis, is almost by definition opaque to a science based on reductionistic causation. This is emphasized in a lecture given by Keith Ward at Gresham College entitled *Science and the Human Person*.[16] The abyss between mainstream natural science and personal experience is shown whenever we try to convert the language of the second into that of the first. Clear, grammatical sentences will be easily identified as absurdities.

II. The second way for viewing the relationship between science and values concentrates on what is *external* to the sciences. It has to do with the *consequences* of scientific thought and research in particular and our scientific culture in general. The importance of this cannot be overestimated after the invention and use of weapons of mass destruction and the application until fairly recently of "scientifically" justified policies that have undermined social and environmental well-being. These and similarly portentous consequences are well known and we need not dwell on them here. It is enough to reassert the need for widely shared values that protect humanity from the darker side of scientific zealotry.[17]

This is where Monod's injunction turns egregious. If we were confined to the "knowledge ethic", what is to prevent, say, the ruthless enforcement of social engineering based on a "soundly scientific sociology"? A cursory glance at the manner in which American public schools were run and designed not so long ago suffices to make any sensible, let alone moral, citizen think with extreme care before ever again giving sociologists a free hand in the conception and planning of the public school system. One is also tempted to add something regarding the "rationalization" of agribusiness so that a once impeccable and utterly reliable food production and delivery system throughout the United States appears to have broken down. In contemporary medicine, one may also consider one or two generations of physicians who have the most advanced scientific knowledge within their respective fields of specialization and the highest technical skills combined with superb diagnostic tools at their disposal yet hardly seem to know what a human being is – as opposed to the long lost and missed family doctor who could diagnose ailments with consummate ease and had a knack for distinguishing physical from psychic ailments. Wanton application of anecdotal "science" to many aspects of modern life may not be as dramatic as the apocalyptic threat of nuclear war, but its

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15 Ludwig Wittgenstein, *The Blue and Brown Books* (New York: Harper, 1965), 48.

16 April 13, 2005, available at http://www.gresham.ac.uk/printtranscript.asp?EventId=272 .

17 See for example Gerald Holton, *The Advancement of Science and Its Burdens: The Jefferson Lecture and other Essays* (Cambridge, 1986).

effects are palpable on a daily basis and have cumulatively led to serious ills and disorders.

III. Meanwhile, within the sciences, there have been several remarkable developments that nobody could have foreseen in the heyday of mechanism and which in their own way compel the (re)consideration of science in relation to value. It is this third way that will be discussed in what follows. The third way for viewing the relationship between science and values is *internal* to the sciences. It has to do with the *content* of what has come to light through scientific thought and research. We began with the example that reports the creativity of New Caledonian crows. In the same spirit, we shall presently be considering a number of examples that cut across various scientific disciplines, all of which show how values emerge through what the most recent scientific developments have been bringing to light. Let us remind ourselves, however, as we look receptively at the various ways that Nature signifies values, that not all value comes to us through Nature, certainly not with regard to what is moral.

4. Values signified by the content of recent scientific thought and research.

Among the most intriguing aspects of the modern scientific adventure are the many surprises it has sprung on us and the ironies with which it has been laden. When scientists began to investigate nature fearlessly, they expected it to be intelligible in transparent fashion and in agreement with mechanical laws. Early successes in medicine, physics and astronomy seemed to confirm their expectations. These were also given much verve by spectacular technical accomplishments, especially after the industrial revolution that enabled the European powers where it unfolded to conquer much of the world. The story of how the mechanistic view unravelled is well known by now and has been in the making, even within the scientific community[18], ever since Michael Faraday decided to see for himself how the different forces were related and began to think in terms of *fields*. Mechanism came under progressively greater pressure with the cumulative effect of discoveries in magnetism and electricity, the theory of evolution and early genetics, the theory of relativity, quantum mechanics, molecular biology and biochemistry, the thermodynamics of non-linear open systems far from equilibrium, astrophysics and others. All of these have by now led to a view of natural phenomena so complex as to defy ordinary formal characterization. The most remarkable thing is that the many-layered complexity has been revealed in the course of single-minded *reductionistic* intent.

Meanwhile, the attempt to formalize mathematics more rigorously has led to its own string of ironies and surprises. The barrier on which this enterprise has run aground is significant for all thought. In a larger work, its features would have to follow our survey of what we have stumbled upon in the relentless modern endeavour to draw forth crystalline, rational structures from nature that we have (falsely) believed would mirror similar structures in our own minds (thought too, not surprisingly, turns out to be far more complicated that can be canvassed by any logical system that supposedly governs

[18] This is significant given that the scientific community routinely ignored the critique of mechanism that had been there all along and grew in force with Hamann, Goethe, Blake, and the Romantics by the beginning of the 19th century.

it). However, here we must limit ourselves to the physical and the biological. We begin with some of the surprises that have been chanced on in the physical sciences, all the while keeping in mind the implications for the relationship between science and values insofar as these are signified by developments *internal* to science.

4.1. Values suggested or signified by recent developments in physics and astronomy:

Among the great many unexpected developments in physics, some of the most consequential pertain to the scientific method itself. To mention but a few: The traditional notion of the thoroughly detached observer turns out to be a fiction from the quantum mechanical standpoint (which has positive implications for the ontological status of the person even in the event of an arguable commitment to science in all areas of interest to human beings); causal interaction at the particle level departs radically from the ordinary conception of causality and, in some of its more exotic forms, appears not to be causal at all (which gives scientific support, should it be needed in the first place, for whole-part causation); certain experiments are too costly or complicated to be repeatable according to the standard scientific criterion and others turn out to be far from repeatable as precisely as scientism imagines (which invalidates the rejection of claims based on "inner experience", such as mysticism, on the ground that they are "unrepeatable"); and certain theoretical claims are not falsifiable because they resist formalization, so that they can never be *demonstratively* shown to be false (which makes the ethical immune to the "accusation" that ethical propositions are not "falsifiable").

The parenthetical remarks in the foregoing paragraph profoundly affect our methodological stance towards what pertains to *value*, notably statements that art, ethics, and religion are on shaky ground because they do not enjoy the theoretical solidity attributable to the physical sciences. It is asserted that their claims are not repeatable or falsifiable, the use of reason within them is causal only in the loose sense, the observer is himself too morally involved to satisfy the criteria for impartiality, and so on. One wonders about the kind of mentality that would even expect reason in art, ethics, and religion to resemble that in the physical sciences, as though there were a simple continuity between the physical world and other realms. In any case, such expectations have now lost whatever scant validity they may once have enjoyed.

However, having made some general assertions regarding the growing philosophical weakness of those who look up to science for the sake of certain *specific* criteria for validity and respectability (criteria that prejudge the issue by ruling out transcendence *in advance*), we must focus in some detail on relevant and factually and conceptually arresting developments that we owe to modern physical science. These developments speak for themselves. Thanks to highly advanced methods of measurement combined with a much enhanced computational capacity, the universe has revealed itself to be almost unbelievably finely tuned. It is true that much of what follows is liable to change (or may have already changed) with regard to the numbers given and even the physical factors involved. No mention is made here of "dark matter" or "neutrinos" as too little is known at this point. Nothing is staked on string theory as fashions change very quickly in physics these days. Finer instruments and the discovery of small errors become hugely amplified when spread across the whole of space-time. There is, however, an essential remainder that provokes much thoughtful consideration regardless of the dizzying instability of contemporary physical science when it comes to specifics. This should not startle anyone who is familiar with Plato's *Timaeus*. For while he certainly got many specifics wrong, his overall sense of the universe, its composition and coherence, is reason for genuine and unreserved astonishment.

The necessary caveats duly given, the following features are noteworthy:

- All regions of the universe must have started out at the same temperature. If this were not so, information would have had to travel across the universe at a speed greater than light.[19]
- Had the universe expanded at a rate smaller by one part in a hundred thousand million million, it would have recollapsed before it ever reached its present size (the "closed" universe).[20] Had the rate been infinitesimally larger, it would have expanded too quickly for any galaxies, stars or planets to form (the "open" universe). Our universe is neither "closed" nor "open"; it is "flat". The probability for a "flat" universe to appear at the outset is virtually zero.[21] That it should have *remained* "flat" over billions of years borders on the miraculous. (The margin of error in this equilibrium is estimated at one part in ten raised to the sixtieth power[22])
- Had there not been tiny differences in density in the early universe, no local irregularities would be possible. This means there would be no galaxies, stars or planets.[23] Moreover, it is because the density of the universe is exactly at the critical level that it has remained "flat" over billions of years, something that a theoretical physicist has compared to a pencil balanced on its point by itself for ages.[24]

All this naturally implies an exceptional degree of order, an intelligence incomprehensible to mere mechanism. Were we to imagine what this means according to the creation paradigm[25], we would need to consider the probability for the selection of such a high degree of order. This can be illustrated by supposing that each model for the universe were the size of a pinhead. The assumed creator would then have to scan a sheet of paper as large as the entire observable universe with a pin in order to select our universe. Considered not as a deliberate act of creation but as the spontaneous emergence of order from a wider state of universal chaos, our universe would (a) take an

[19] In the light of what has been said so far, we must therefore be prepared for a future physics in which the speed of light is no longer a limit – or that all matter is somehow one so that information can be shared potentially instantaneously across its fullest extent, which is itself philosophically laden with significance.
[20] From here on, the tedium of repeating the caveat will be avoided. Obviously, these numbers can change, but the *idea* of an unimaginably narrow zone for the formation of a particular universe such as ours remains valid.
[21] Lindley, *The End of Physics* (New York: Basic Books, 1993): 168-9.
[22] Davies, *God and the New Physics* (Penguin/Pelican, 1984): 179.
[23] Hawking, *A Brief History of Time* (Bantam, 1988): 121-2.
[24] Lindley, op. cit., 168-9.
[25] The same kind of argument can be made were we not to follow the creation paradigm and instead assume something like the Universal Mind, which can be intertwined with Nature at every level. Rather than the absurd precision with which this precise universe is *selected*, the argument is shifted to the awesome *intelligence* behind its *emergence* in this precise form. In other words, intelligent design is by no means compelled by the physics discussed here.

infinitely long time to emerge and (b) would originate from a state that we are unable to observe *in principle*.[26]

Physicists uneasy with what the foregoing suggests have tried to find a way out with what is known as the inflationary model of the universe. However, this involves "an expansion of the universe by a factor of 10^{50} during the first 10^{-35} to 10^{-30} seconds of [its] existence."[27] The inflationary model moreover requires an extremely complicated mechanism to make it work, conceived by Peter Higgs, that at every stage has the character of pure invention. The Higgs mechanism is entirely there not because it is favoured by the evidence, but because the evidence favours reflections that many physicists are desperate to avoid.[28] For all its mathematical brilliance, it has an ad hoc and wanton character quite alien to the canons that, by reputation at least, have governed the midwifery of scientific hypotheses. In contrast, a more intellectually honest pursuit of further clarification and better understanding in the light of those those-provoking findings can only be welcomed.

So this, then, seems to be the option faced by physicists, astronomers and cosmologists at present: Either they remain with facts that suggest a universe so perfectly and deliberately ordered as to invite further metaphysical deliberation on our part, albeit without necessarily rushing to the comforts of "intelligent design" or "creationism", for there is certainly much room for philosophical and artistic imagination as already shown by the likes of the mythmakers and Plato, Aristotle, and Plotinus; or they resort to hypotheses that flagrantly brush aside metaphysically suggestive facts and are left with theories primarily supported by their desire to make them work (which is logically, psychologically, and phenomenologically much weaker than what a native American rainmaker believes about his theories, for the shaman experiences himself as connected with Nature and her magical forces, not as someone willfully devising intellectual contrivances in order to see her in a manner that accords with his desires and assuages his fears).

The hazard of staking too much on the actual numbers given in astrophysical accounts that highlight the order and intelligence embedded within our universe is amplified by a serious obstacle that physical science has come up against. This obstacle pertains to the singularity that marks the initial phase in the emergence of the universe. The physical size of that singularity is limited by the uncertainty principle. General relativity can not be applied to a universe smaller than that permitted by quantum mechanics. The age of the universe when this condition obtains is called "Planck time". But since we have no way, so long as the physical world is defined by the combination of general relativity with quantum mechanics, to go "behind" Planck time, since it is meaningless to speak affirmatively, *as scientists*, of what happened "before" Planck time, no numerical value can be assigned to it. From a logical point of view, given the extent of the laws of physics, the age of the universe at Planck time may just as well be a split-second as be infinite.[29]

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[26]Davies, op. cit., 168-170. But what has just been said in fn 25 supposes that physics in the future may find a way around those limitations.
[27]Arthur Peacocke, *Theology for a Scientific Age* (Minneapolis: Fortress Press, 1993): 69.
[28]Lindley, op. cit., 169-177 and 191-6.
[29]Ibid., 212-3.

When we turn to the subject of matter itself, however, we seem to be on firmer ground. However things may change in the foreseeable future, we cannot ignore the profound ambiguity coming out of the rapidly increasing refinement with which physicists have been able to study matter. The ambiguity consists in the genuine suspension of matter between the physical and the mathematical, and suggestions of its continuity with mind. Let us briefly recapitulate a few milestones along the way to this philosophically open terminus.

Since the days of the ancient Greeks, there has been a tradition in the study of nature that views it as made up entirely of very small particles. These particles are held to be few in kind. The endless variety of the macrophenomena that we experience is due to different combinations of huge numbers of those elementary particles. The image that has often accompanied atomism is that of building blocks in various combinations. However tiny the particles may be, they must be discrete entities that, when combined in sufficiently large numbers, become distinct objects for us.

The definition of a physical thing has changed, however. Physics no longer deals with matter that can be easily visualized in terms of building blocks and what is thus built. It no longer even deals with matter itself exclusively. The world now studied by physics is one composed of matter, energy, and things such as black holes and gravity waves that are non-material by definition.[30] For "hard" matter, it makes sense to presuppose building blocks; for energy, black holes and gravity waves, it does not. In fact, the latter two are beyond the pale of common sense.

Matter itself, the sole component that intuitively lends itself to mechanical analysis, is now interpreted as "locked-up" energy. If matter is unlocked, it becomes energy. If great amounts of energy are concentrated, they become matter. What Einstein captured in his famous and ingeniously simple formula has since been experimentally verified.[31]

To the extent that matter is analyzed as matter in the traditional sense, that is to say as "made up" of elementary particles, the set of particles that physicists have so far established has several strange members. Along with the triad of major subatomic particles, the electron, the proton and the neutron, the positron, anti-proton and anti-neutron have been predicted and then discovered.[32] If the pairs are respectively combined, we are left with nothing “material” in the usual sense. A collision between an electron and a positron, or a proton and an anti-proton, means (“material”) annihilation. Thus the name "anti-matter" has been coined to describe the parts of the universe where there are positrons, anti-protons and anti-neutrons.

What about electrons and other positively material particles? Can we not at least pin them down as such and still regard them as building blocks? No, for two reasons: First, no subatomic particle can be pinned down to a specific motion; it inhabits a world "full of murkiness and chaos".[33] Second, the wave/particle duality has been admitted since the early part of the century as a result of the work and thought of Schrödinger, Heisenberg, and Niels Bohr. Bohr proposed that an electron be considered a particle or a wave *depending on the point of view taken up by the observer*. Moreover, the wave is not a

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[30]Davies, op. cit. , 9.
[31]Ibid., 26.
[32]Ibid., 28.
[33]Ibid., 102-3.

wave *of* a particle (the particle does not itself undulate). Rather, it is a form of *information* about the particle. A particle spreads information as a wave that enables us to know, say, its position or energy levels.[34] It is experimentally an indifferent matter whether a particle exists as such in the absolute sense or whether assuming its existence leads to the correct results under specific conditions. Otherwise, all that is encountered is information. The universe, for all we know, may be a sea of information that is concentrated in certain ways at certain points.[35]

A third complicating factor has unfolded in the effort to analyze the positively material when we turn to protons and neutrons, where mass is mostly concentrated. It was discovered when physicists began to group elementary particles and found that these groupings matched abstract mathematical symmetries. They wondered whether these might not be manifestations of an underlying overall symmetry. Such speculations led to the discovery of quarks, so small that they can only be detected with particles each of which has an energy of billions of electron volts (detection depends on the wavelength of the particle used to that end, and the wavelength is inversely proportional to the particle's energy). They may be metaphorically described as matter's building blocks (protons, for instance, contain three quarks each). But it is more accurate to describe quarks as a mathematically successful way for measuring matter.[36] The arbitrarily chosen qualitative terms used to classify quarks bespeaks indifference to their "real" physical features; for they are said to come in six different "flavours", up, down, strange, charmed, bottom and top - and each "flavour" comes in three "colours", red, green and blue.[37]

At this point, whether we are dealing with physical or mathematical entities becomes experimentally irrelevant. The overall picture is that of matter in conjunction with the non-material and anti-matter, with matter composed in a manner inherently ambiguous, suspended between waves and particles, the particle state itself suspended between the mathematical and the physical. The efficacy of symmetry as a guide for the discovery of hitherto unknown and sometimes inconceivable entities is more suggestive still, turning us in the direction of some trans-subjective intelligence. It seems the better we are able to imagine symmetries, the better we are guided into what some call “the particle zoo.”

The relentless analysis of matter with a rigorously “materialistic” mindset has hence led us ironically to a material landscape far more open-ended than that with which scientists had started out, where the emergent facts themselves have pushed matter to a metaphysical level of indeterminacy relative to its being material or non-material (on top of what quantum mechanics had already brought about pertaining to wave/particle duality, the redefinition of matter at the *physical* level [because of black holes, gravitons, etc..], and the plethora of elementary particles being uncovered). In other words, the breathtaking advances in the quest to unearth matter's building blocks has, in the vertiginous environment of gigantic particle accelerators, finally led matter to "deny" its material quality and dissolve into the mathematical/intellectual.

It almost belabours the obvious to underline the implications for science and values. The bane of modern culture has been the intellectual pressure to reduce reality to its

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[34] Ibid., 107.
[35] This is consistent with emergent quantum field theories, although it is too early to integrate them with metaphysics, i.e. with *durable* thought.
[36] Ibid., 151-2.
[37] Ibid., 154. See also S. Hawking, op. cit., 65-6.

material dimension. One can see how materialism as a way of life flourishes under such conditions, how values are diminished, how art and religion are taken over by commerce and the ethical is disfigured and devalued, reduced to core values such as “honesty” (as though the worst criminal could not also be scrupulously honest!) and “productivity” (the motives for the praise of which are painfully clear in a commercial environment). If, however, physical science itself shows matter and mind to be intertwined, shows deep ambiguity in the concept of matter in harmony with what ancient Greek thinkers since Anaximander had recognized, shows that *the material is metaphysical* – what then?

Next, we turn to the framework in which matter exists, the lineaments of which have also changed drastically. Although the notion of an absolute space had already been questioned by Leibniz (who believed that space existed only insofar as there were *different* things that exist *simultaneously*[38]), and that of an absolute time by Plato, Plotinus, and Saint Augustine (who, following the former two thinkers, pointed out that temporality must be a feature of the created world in contrast with the eternity of the heavens[39]), it is only recently that we have reached the stage where physics itself could go no further were its framework absolute space and time. Today, galaxies are no longer thought of as moving apart through space, but as "stretching" it.[40] Space is an elastic medium opened up according to the movement and energy of the objects creating it (which vindicates Leibniz in his proxy debate with Newton). It is thought to have arisen from an infinitely shrunken, unbounded state from which the universe exploded.[41] Furthermore, the shape into which this elastic medium is wrought is not spherical nor anything similar, but one that allows it to connect up to itself in a variety of ways. Such a shape is called a "hypersphere". In a sphere, we may move from one end to another across its diameter. In a hypersphere, the analogous "ends" may meet at the same point. Finally, there is the abstract suggestion that space and time are components of a more primordial geometry, and that our relatively coherent and organized universe emerged from a correspondingly more primordial state described by that geometry.[42]

Fanciful though this last excursion may be[43], it no longer makes sense to uphold the notion of physical things *in* space and time since physical things *determine* the shape of space and time.

The changes in how we understand the interactions between identifiable concentrations of matter (or "particles") have also been momentous, but we shall pass over them quickly here to save space for some pressing developments in other scientific fields. The traditional conceptions of influence, causality and predictablity are no longer valid across the whole physical domain. In collisions between particles, for instance, the

[38] G. F. v. Leibniz, Letters to Samuel Clarke, in *Selections*, ed. Wiener (Scribner's, 1951): 223, 235.
[39] See any edition of St. Augustine, *Confessions*, Book XI, Chs 11-13.
[40] Davies, op. cit., 13, 17.
[41] Ibid., 14-6.
[42] Ibid., 40.
[43] The idea of a primordial geometry in many dimensions is very much part of mainstream physics, linked as it is to superstring theory, but this can change dramatically soon enough. Again, however, the overall idea of the emergence of our universe from something richer, more layered and complex, remains sound – and agrees with thought as old as ancient Greek mythology and the Hinduism of the Vedanta and the Upanishads.

operative forces are now thought of in terms of an exchange of smaller particles "buzzing" around those approaching one another. Causality recedes as the curvature of space rises to large values, for particles can appear or disappear unpredictably. At other times, particles very far apart have to be thought of as part of a whole to account for the way they simultaneously affect one another (the famous Bell's theorem). And since the probability that a given particle can have some reverberations at *any* point in the universe at any given time is never zero, the interconnectedness of the physical world is such that no system within it can be treated as though it were isolated for an indefinite period of time, an interconnectedness that becomes prohibitively complicated for many situations even over a relatively short period.

Finally, there is the question of how one deals with what appear to be the "pre-cast moulds" that "guide" matter towards galactic structures that are otherwise unaccounted for. In addition to the fine tuning mentioned at the outset, it was discovered that galaxies would not be able to grow to their present size by themselves in the time available. The attempt was then made to suppose that "dark matter" had essentially formed the galaxies to begin with, after which normal matter would fall into an already determined form. But the most recent galaxy survey shows that there definitely is more large-scale structure in the universe than any dark matter theory can account for, however deftly one tries to manipulate and adjust it.[44]

The overall picture we are left with when we canvass the frontiers of contemporary physics, astronomy and cosmology is one that radically departs from the reductionistic, mechanically structured universe that was expected up to a century ago. The universe is now portrayed as either finely tuned to a degree and subtlety never imagined by the mechanists or, to avoid any such acknowledgement, as necessitating contrived and sometimes ridiculous[45] hypotheses; the matter that composes its physical aspect has revealed itself to be a richly layered substrate that defies precise definition in many ways, ambiguous as it is between particles and waves, and even between the physical, the mathematical, and the mental; the space-time that enables matter to come forth in the forms and orders known to us is entirely elastic according to the complex movements, concentrations and interconnections of matter itself; these interconnections are often unpredictable, involve interactions far more intricate and subtle than those implied by traditional notions of how forces interact, and fall outside the province of causality ordinarily understood; and the matter in question is gathered into huge structures (galaxies) in a manner that strongly suggests preformation, a universe that somehow already had the information for the emergence of orders involving very large amounts of matter.

We are faced with an artistic phenomenon on a universal scale. What physical science alone has brought forth can be contemplated as a work of art in progress, unfathomable in its richness and complexity, extravagant in the intelligence displayed, and structured dynamically according to a more fluid and subtle notion of archetypes than intuited by Plato. Aesthetically and metaphysically, the world radiates value and

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[44]Lindley, op. cit., 202-3. See also the recent work of Eric Chaisson.
[45] A parallel universe for *every* quantum bifurcation??

significance through and through. It suggests transcendence even at the humblest "particulate" level, yet the transcendence is thoroughly intertwined with what may be termed "crude matter." The crude matter that has been the benchmark for all materialists is but a mask that now barely conceals metaphysical open-endedness. If the ethical is not explicitly shaped by such art, at the very least it is set on its way by how far materialism is denied by the *physical* universe and how edified we could be through the contemplation of a universe whose creativity becomes ever clearer to eyes enhanced with instruments with a reach beyond the dreams of our ancestors, wrought by our ingenuity and imagination.

4.2. Values suggested by recent developments in the biological sciences.

We may begin with two simple tokens of biological complexity, one experiential, another mathematical. A bee busy drawing nectar from a flower or buzzing annoyingly close in a verdant park are a fairly common sight or sound. Yet what underlies those common activities is uncommonly difficult to analyze or replicate with perfect precision. Human beings are embarrassingly far removed from inventing a machine as small and compact as a bee, but capable of flying. The helicopter is about as close as we have come, and it is rather crude compared to bees. Moreover, the bee plays a pivotal role in the growth cycle of flowers. As bees goes about their business, they have been observed to dance before the hive in order to signify the presence of flowers with the promise of a good haul of nectar and the direction that must be followed to retrieve it. In all that a bee does - recognizing specific flowers, drawing their nectar to produce honey, pollinating them, flying with pinpoint precision, and showing fellow bees the way to the nectar through a dance - there is great complexity, far more than that involved in the design of any flying machine (for that machine would also have to interact with its environment with a sophistication similar to that developed by bees – and it must dance). A fairly unassuming living creature already seems worlds beyond the scope of physics.[46]

Considering the creativity and ingenuity of bees, and the sheer beauty of their activity (which of course includes the hexagonal pattern found in honeycombs), it may seem odd to highlight them by reference to a mathematically translatable criterion such as "complexity". We nevertheless live in a culture that reveres mathematical measure, and if in this way we can show something that expands our view of how Nature signifies value, then why not?

Mannfred Eigen has attempted a mathematical measure of mutational complexity: A rather small gene can be thought of as a sequence having 360 positions each of which can undergo a mutation with the same probability *a priori*. Every position has four different ways that it can be occupied (the four basic constituents of DNA in question, or *bases*, being adenine, cytosine, guanine and thymine, known as A, C, G and T). To evaluate what is involved mathematically, we may construct a sequence space by imagining a point from which it is possible to jump in 360 different directions. In each dimension of this 360-dimensional world, we have a line of four discrete points that represent the four ways that a position within the given genetic sequence may be occupied. The

[46]This example is an elaboration and extension of that given by Cohen and Stewart in their book *The Collapse of Chaos* (New York: Viking, 1994): 56.

mathematical complexity of the space thus formed, because of its hyperdimensionality, is such that it is comparable to the measurement of the whole universe in angstroms (One angstrom [Å] $=10^{-7}$ millimeters).

Mathematically, a mutation may be represented as a jump from one point to another along one of those lines. The mutation occurs in a gene, so its effect is expected throughout the organism (a virus in this case)[47], or the equivalent mathematical space. Thus the space must be extremely complex, even more so than the space already equivalent to the measurement of the entire universe in angstroms, for the routes passing through it have to be intertwined in order for the mutations to take effect. In Nature, such levels of complexity, forbidding when considered purely mathematically, are overcome through the influence of the environment that in the process of selection greatly facilitates the movement triggered by a mutation, indeed guides it. The small distances within that assumed sequence space and the intertwining of the routes within it would then allow the transmission of the characteristics of superior mutants.[48] The environment acts as an "agent" in a dynamic process of formation analogous to what was suggested earlier in the formation of galaxies and stars. This environmental factor shall figure strongly as we later take biological phenomena to yet another level of complexity - or, philosophically, a level of creativity and agency greater than what is manifest at this stage.

Following our brief look at a mathematical translation of the complexity of living phenomena, a shift to a biochemical translation will show more dramatically still how life manifests such levels of co-ordination, synchronization, harmony, ingenuity, co-ordination and creativity that words begin to fail us. Huge textbooks and elaborate research papers contain what is featured below in enormous detail, but one is advised not to lose sight of what it means that so many complex and diverse microactivities gather themselves coherently into a living, growing, viable organism. The more we know, the sharper such (mathematically, logically) incomprehensible coherence is set in relief. Technological advances and the biological and medical research they have made possible have served to enrich our potential appreciation for life (and being) at work through biochemical expressions a sample of which we now survey:

(a) <u>Biochemical manifestations of life's creativity, coherence and complexity:</u> Many features of DNA are striking in the context of our discussion, among them:

- It is not easy to match particular stretches of DNA with genes, because the genetic sequences within DNA are not clearly marked out, but are often surrounded with a lot of inactive DNA material left over from an earlier evolutionary period, called "junk DNA." The difficulty is compounded by the frequency with which a DNA sequence that corresponds to a gene may be in the middle of another such sequence corresponding to a different gene.[49]

- While a lot is now known about how genes produce proteins, there remains the problem of how they get to the right place at the right time in the right amount, so that the same primal cells can develop into different kinds - muscle, nerve, bone marrow, kidney.

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[47] A single mutation in a virus can decide if it lives or dies in its host environment.
[48] Eigen, *Steps Towards Life* (Oxford: 1992), 26-7.
[49] Cohen/Stewart, op. cit., 72.

There is a gap to be bridged between the known chemical processes, and the macroscopic forms that seem to govern the distribution, positioning and transport rate of proteins.[50]

- More intriguing still are *homeoboxes*, DNA sequences contained in all genes that "program crucial switch points in development" (for instance, whether a given part of an organism should be a wing or a limb in a fruit fly). These genes are called "homeotic genes", and they are common to several creatures, among them mice, fish and people (in addition to fruit flies). Of special interest is the possibility that a sequence within the "junk DNA" may be activated by a mutation that affects a homeotic gene, so that an organism may develop features not encountered in many, many generations.[51]

- The complex picture that the foregoing suggests is then compounded when we turn to mutations; for these are equally probable for any base within the DNA molecule (as was mentioned above). Their consequences are fairly elaborate, for they depend on whether protein production is affected either in quantity or in kind, and whatever ripple effects these may in turn have. Moreover, they depend on the kind of DNA sequence in which the mutation occurs, for instance whether this be "junk DNA" (in which case there is no effect unless something long dormant has been accidentally reactivated) or a homeobox (in which case the effect is likely to be dramatic, for instance the appearance of a limb where there ought to be antennae in a fruit fly). In short, we can not study the effect of mutations fruitfully were we to remain confined to the formal level. The *meaning* of the DNA sequence involved (and the processes that issue from it) is crucial, over and above the form.[52] The impingement of meaning on disciplines that hitherto were believed to lend themselves entirely to formalization or quantification is a theme to which we shall return in the next section.

- Most intractable of all are the complex nature and workings of the DNA molecules themselves. In addition to the obvious marks of their complexity, such as their length and superficial composition (they are five feet long and are said to contain around three billion nucleotides, themselves macromolecules each composed from a base, a sugar, and one to three phosphate groups), the cycle that involves DNA requires several kinds of RNA (messenger RNA, transfer RNA, large and small ribosomes) and proteins: some to "read" the instructions given in the DNA "blueprint", some to "carry" them, some to help in the manufacture of proteins, some to gather the necessary amino acids (that compose proteins), some to control the timing and quantity of proteins to be made, and so on, with a number of these processes involving the very member that is supposed to be the end product! Then there are (substantial) instructions on how to read the instructions, instructions on the exact shape of the proteins to be made or used as tools in their own making or the making of others, and so on. The chemistry that the foregoing describes is of such an order of complexity that it would be impossible to translate into exclusively chemical terms, thus necessitating the use of special biological words for the sake of a

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[50]Ibid., 75.

[51]Ibid., 79.

[52]Ibid, 118-9. The complex nature of mutational effects can be further appreciated when one considers the compound origins of a sense organ like the nose. While one ordinarily speaks of someone having inherited her mother's or father's nose, in fact the shape of the nose is governed by some genes, the skin by others, the olfactory charcater by others still, and while in each group the mother's or father's genes may predominate, the composition of all groups put together is random. There is more to a nose than meets the eye. See ibid., 113.

proper description.[53] In short, we have reached a level that demands the treatment of living creatures *on their own terms*, as opposed to reducing the phenomena to chemistry, which we now know would do the phenomena unwarranted and great violence.

(b) Biological and ecological manifestations of life's creativity, coherence and complexity: Here we turn to the influence of the environment on the genetics, anatomy, physiology and development of living creatures, beginning with the egg. The implications for our overall concerns need not be repeated here. No further commentary is needed at this point. What has become increasingly more manifest in the foregoing is made still more manifest in what follows as we witness layer upon layer of greater and greater artistry in Nature:

- A simple consideration of the phases that the mammalian egg undergoes until it becomes a baby is sufficient to manifest the underlying complexity. The human egg, for instance, has a diameter of just 0.1 millimeters, yet it already contains thousands of chemicals and chemical "construction kits"; so instead of merely making copies of itself, it takes chemicals from its surroundings and uses them to *grow* into something very different from an egg: an embryo. The embryo is much better than the egg in taking food and energy from its surroundings, which would be the lining in its mother's womb. It consequently becomes much more complicated, assuming another form, and so on, until the baby appears (at which point, needless to say, development becomes far more complicated as the cultural dimensions begin to take hold in addition to continuing biological growth through adulthood). What matters for us here is another facet of irreducibility, for although chemistry is deeply involved in the growth and transformations of the human egg, it is "so many orders of magnitude more complicated than ordinary chemistry that to call it 'just' chemistry is to beg all of the interesting questions."[54]

- Some other interesting features about the egg that need to be taken into account:
  (i) For the development process to begin in the egg, the genetic code as well as the mother's genes are needed. The latter actually control the initial stages.
  (ii) The "architecture" of the egg is shaped by the mother in a manner that ensures a healthy beginning for its growth.
  (iii) The chemistry of the egg is sensitive to the temperature of its environment, the medium in which the reactions take place, the presence of impurities and other factors. Thus, for instance, the mother's womb has the built-in capacity for carefully controlling temperature and chemical concentrations.[55]

- The timing for anatomical development for its part depends on the combination of physiology with the available food supply. The human heart develops first in the embryo so that nutrients can be transported to the appropriate parts from the lining in the mother's womb. An organism can also develop rapidly or slowly depending on whether it lives off temporarily overabundant food supplies or whether it is to its advantage to develop more

[53]Ibid., 80-2 and 98.
[54]Ibid., 62.
[55]See ibid., 85-7 and 94-5.

slowly - so that puberty may be greatly delayed (a process called "neoteny"), for so long that a creature like the mayfly lives as an adult for but one day.[56]

- The observed features of living creatures are also formed by the environment in which they must survive and perhaps flourish. Thus, the jaws of termites have acquired considerable mechanical efficiency. Carnivores have their eyes at the front to keep prey in sight, whereas herbivores have theirs on the side in order to spot those preying carnivores. We can also speculate on what gave rise to other characteristics: The giraffe may just as well have developed a long neck in order to reach *down* to drink without crouching awkwardly with its long legs (developed for speeding to safety) as to reach *up* for food inaccessible to potential competitors. In all these cases, whether we know exactly why an observed feature has evolved or not, the ethology and evolutionary history of living creatures constrains DNA to the extent that the latter controls protein sequences and cycles that lead the desired features to be there. One can take this further and assert that where social organization demands certain abilities and characteristics, it determines certain DNA sequences accordingly. Moreover, innovative behaviour, if successful, can in the future recast certain parts of DNA in its image.[57]

(c) <u>The wisdom and ascent of living processes:</u> A further sign of life's perplexity comes through a more sophisticated analysis of evolution, in particular how it follows certain channels or paths, among them one that ensures developmental stability, and another that tilts the balance in favour of mutations leading to a superior species and higher levels of organization.

The developmental path followed by living creatures is extremely stable. It can be visualized with the help of a geological metaphor: The setting can be pictured as a landscape with ridges, valleys and mountain ranges, sloping downward if followed from one end to the other. This topography is shaped both by the genes (from "below") and the environment (from "above"). The developmental path would then follow the (imagined) movement of ball bearings rolling downwards. One notices that it would be most unlikely for a such a ball bearing to roll over a ridge or mountain range into another valley. Even then, the valleys may meet further down the sloping terrain. So what is needed for a ball bearing to change course is a sudden upsurge in pressure (caused by a mutation or change in temperature). Should the new course not meet with the former, a developmental change would occur.[58]

To understand the workings of mutations towards greater adaptability, one can then picture the landscape as representing a mutant spectrum that develops towards higher and higher peaks of efficiency. Once a mutation occurs that produces a type more adaptable to the environment, called a "wild type", a "mountain range" is formed around it by mutants akin to the wild type, such that the range towers over the plain of the ordinary mutant population. It is from such ranges that superior mutants are selected, which shows how long term development may be weighted towards rising superiority (which constitutes a microscopic refection of the macroscopic weightedness in favour of ever greater complexity in organization, which will be mentioned briefly below). Experiments have confirmed that the entire ensemble of mutants, and not only the wild type, are

[56]Ibid., 87-8.
[57]See Peacocke, op. cit., 58-9; and Cohen/Stewart, op. cit., 127-8.
[58]Cohen/Stewart, op. cit., 93.

involved in selective evaluation. The target of that selection is called the "quasi-species", which consists of a weighted distribution of mutants centered around one or several "master sequences", or those sequences with the highest selection value among all present. Hence, superior adaptability continues to build up at an accelerated rate (to which thermodynamic and macroscopic structural properties contribute further).[59]

Throughout the build-up, highly complex microscopic and macroscopic factors contribute that are themselves affected by it in an ever more rapidly rising spiral of successively higher levels of organization.

(d) <u>The polyrhythms of life:</u> A separate but no less significant phenomenon for us to consider in this survey is the polyrhythmic nature of the biochemical cycles of life. Far from having reactions that go to completion as we do in conventional chemistry, even the most mundane biochemical cycle proceeds in fits and starts. On a larger scale, endocrinologists now describe the pituitary gland as the "conductor of the endocrine orchestra" in which "all the glands [are] playing music." The biochemical cycles elegantly represented in wall charts actually refer to processes "in a constant state of push-pull-bang-whistle-bleep, with every component varying wildly." There are constant hormonal variations, depending on the time of day or the seasons, among other external factors (the twenty-four hour cycle seems to be particularly important).[60]

With the entire organism subject to polyrhythmic cycles, both with regard to what goes on within itself and in its interaction with its environment, we run straight into the greatest limitation of reductionism: its inability to see that which it reduces in myriad ways *as an integrated whole*. Whether we are considering a trivial cellular reaction, the endocrine system, or the totality of a living creature's biochemical cycles, what seems decisive in the end is the presence of life. Only then is a mechanically intractable integrated web of cycles whose juxtaposed beats form remarkably complex polyrhythms set in motion. Aristotle had something to say here, deceptively simple as it may sound: What finally counts in a living thing is that it is *living*, hence the insurmountable complications from a (lifeless) analytical point of view. It is this living *unity* of organisms that holds systems together that from every other perspective seem amazing for not collapsing into their constituent parts. This utterly simple quality, namely unity, is fundamental to our understanding of the degree to which the phenomena transcend the levels of existence traditionally attributed to them by the reductionistic approach.

(e) <u>Unpredictability:</u> We have already come across physical phenomena that compel us to substantially revise our notion of the concept of causality that applies to natural events. This revision may reach the need to abandon causality altogether when faced with genuinely unpredictable occurrences. Biological phenomena add to nature's repertory of the unpredictable. From the foregoing list of biologically pertinent phenomena, we can appreciate the difficulty involved in predicting the course that a given mutation would take. The difficulty is not only a matter of the mechanical problem of canvassing a miniscule change when its effects are scattered across a vast and thoroughly intertwined molecular structure; but we also do not know how this change is compounded by environmental factors. There is additionally the inherent limit imposed

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[59]Eigen, op. cit., 24-6 and 27-9.
[60]Cohen/Stewart, op. cit., 121.

by the uncertainty principle given that the mutation itself is an event that takes place on a quantum scale.[61] In particular, we are faced with the difficulty of predicting the course that evolution might take when we consider the influence that social organization or innovative behaviour might have on shaping future DNA.[62] Our own study of biological phenomena has consequences that will eventually be a factor in their genetic makeup. At this level, we are no more able to predict what will happen than a poet can divine the exact shape of the polished work at the moment when he is first moved to compose it. The moment he knows its precise form, it is completed, finished. Only it is the natural world in which we as scientists are collectively immersed, a work that is never finished.[63] Nature, as we have asserted frequently, is creative. And creativity by definition means we cannot predict where the process is headed once it starts, other than what can be roughly anticipated in accordance with the changing constraints and channels through which living processes are temporarily guided.

(f) Further evaluation of the foregoing biological phenomena: The remarkable extent of fine tuning encountered in the physical universe, the ontological ambiguity encountered in the nature of matter (physical or mental?), the elasticity of space-time, and the unpredictability of events near the limiting cases of the very large and very small - all of these are taken further when we cross from the physical to the biological domain.[64] For here, *unpredictability* is no longer occasional but a regular feature of life and evolution at both the microscopic and macroscopic levels. The very structure and function of DNA, the way this carries over into genetic instructions, the manner that these are influenced by their environment at the physical, chemical, biological, social and (for us) cultural level - all these make the course of evolution inherently unpredictable and emphatically creative.

As for *fine tuning*, one encounters it all the way, in how (i) protein distribution is precisely allocated so that organs are properly formed with perfect timing during the developmental stage, (ii) the egg is designed, given a jump start, and protected to survive the early stages of its growth, (iii) the parts are developed by plants and animals according to their habitat, (iv) the "topography" of developmental paths ensures long term stability, and so on.

Turning next to *elasticity*, we find that it permeates the entire biological domain. It is there (i) in adaptability to the environment at every stage of development, (ii) in how the

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[61]Peacocke, op. cit., 57.
[62]Ibid., 59.
[63]To say that the world will one day come to an end does not affect this argument, for *we* would then come to an end as well; we would not be there to see the "finished" work. So as long as we have a perspective at all, the work that we explore scientifically is, for all intents and purposes, forever unfinished.
[64] I do not mean to bypass the **chemical** domain, which has immense riches to offer this discussion and without which our account cannot be complete. Such chemical phenomena as the identity and integrity of the elements, the significance of the subtlest isomeric variations, and chemical metamorphoses that, say, in a few simple steps transform a carcinogenic substance (benzene) into one with multiple medicinal benefits (aspirin) can only serve to strengthen what is being argued here. It is only pragmatic considerations of space and time that compel the omission of the chemical and the mathematical. I have written elsewhere about the philosophically significant as it comes to us through chemistry. See Richard K. Khuri, An Organic Framework for a Philosophical Appreciation of Chemical Phenomena, *Annals of the New York Academy of Science*, ed. J. Earley, May 2003: 988: 322-334.

whole organism adjusts in a coordinated manner if it turns out to be larger or smaller than usual (it does not simply burst out of its skin if it becomes bigger), (iii) in the openness of the mutant landscape so that superior efficiency can be rapidly acquired, and (iv) in the organism's ability to eventually integrate successful innovative behaviour into its genetic makeup.

When it comes to *ontological ambiguity*, we find that it affects the biological through and through; for we are unable to say anything that comes even close to doing it justice should be insist on characterizing it as "just chemistry". The biological demands treatment *at its own level*, as something essentially different from the merely physio-chemical. Even this is not necessarily a satisfactory solution to the problem of deciding what living creatures really are. For what does it mean to say that their reality is “biological”, in the sense of *merely* biological? How much does this tell us?

There is so much more one can add in this vein. For instance, in relation to what has already been mentioned regarding the preformation suggested by galactic structures much more elaborate than what the universe would have had time to form by itself consistently with our assumption about the age and laws of the universe, the biological sciences present us with clearer intimations of preformation. Going further still, two new intriguing dimensions present themselves within the biological domain: *meaning* and *unity*. It is crucial to take into account what a given DNA sequence means over and above its chemical form when one is studying the potential effect of mutations. Moreover, all genes must be *interpreted*. They do nothing on their own, taken out of context, the context of life. And one can only make sense of the polyrhythmic biochemical cycles that one encounters in living creatures at every level, from the most trivial to the most comprehensive, and the immense co-ordination demanded by the coherence of those cycles taken singly and all together - a coherence evident in the bare fact that what functions as organisms do has, *mechanically*, no right to hang together! - if one thinks of each such creature as a fully integrated, living whole, as a unity that has life.

(g) <u>Out in the fields: Beauty, spontaneity, care, and intelligence</u>: There is every indication that life itself is intentional, creative, anticipatory, with a coherence that transcends simple logical and all mechanical explanation. Looking at life with our sharpest instruments, with a ruthlessly reductive mindset, has spread out for our contemplation so many ways that value arises, aesthetically and metaphysically. What Goethe believed we can only learn to appreciate about life (and living Nature) without technological enhancements has reappeared through all the clutter of cutting edge research and theoretical abstraction. Whether we look with our five senses just as they are or amplified through many orders of magnitude, what matters is the attitude with which we look – not whether our look is mediated by technology or not.

Nevertheless, an important area of the natural sciences continues to bring in more and more discoveries about the natural world through the simple use of sense-perception, mostly augmented by nothing more than stealthy photography and other detection devices. We therefore conclude with some brief relevant remarks about what biologists and naturalists have brought from the fields.

Meticulously recorder documentary evidence, sometimes gathered painstakingly over many years, has brought to light insights into the lives of wild animals such as leopards and wolves that only native peoples living in the same environments had known before – and were evidently not inclined to translate into detailed accounts that are widely communicable. The awareness of leopards of every little thing that goes on in their surroundings, sometimes over a distance that belies our expectations regarding the range of a perceptual field, and their sensitivity to the subtlest departure from what they have come to expect, indicates a consciousness that, one must admit, is a highly developed form of intelligence. In one incident, a leopard under close study cared for a monkey that had lost its mother.

Over a large territory, wolves learn how to find not the shortest distance, but the path that requires the least amount of energy. In the wilderness of southern Italy, this has been established by tracking devices. A long and winding path through a highly varied topography suddenly made perfect sense when that principle ("least energy") was applied. The improvisational ability of wolves to evade very cleverly set traps is exceptional. They seem able to find them, however carefully they are placed beneath the surface, however the tracks of their placement are covered and the scents annulled, from quite a safe distance. Is it intuition? Among much else that is worth noting, they rear their young in a clearing hidden deep within the woods, where humans are most unlikely to ever come near, and – as photographed by hidden cameras – seem to perform rituals and engage in acts of play in no way reducible to the honing of hunting and defensive skills. And the evasive action they take to be as far away as they can from human beings shows an alertness and ingenuity that has led the Italian locals to state that no other animal matches human beings so well in its gifts.[65]

Bower birds build what look like tunnels of love in the forests of New Guinea and lay out well chosen translucent pieces of glass that play out a symphony of colours that arcs its way across the ground as the sun's position in the sky changes throughout the day. Is it reasonable to file this under the "mating game"?

We all have our favourite stories about cats and dogs, parrots and dolphins, elephants and cheetahs. The more we consider these in relation to value, the more obvious it becomes that we have come a very long way from the abyss that divided a world mechanistically viewed from the transcendent world of art, ethics, and religion. Value comes forth in many ways and with great power as we pause and contemplate what the natural sciences have been bringing to light and take the time ourselves to be out in Nature. While this does not explicitly shape our morals, while morals, as we have noted much earlier, enjoy a measure of autonomy from Nature and are transcendent in their own way, there is much to be gained from a more nuanced view of the relationship between science and values.

Evolutionary theory can also be regarded more carefully. It was once the alleged bane of western religion and traditional morality, and continues to be so for many. It has become the rallying cry for fanatical secularists – and secularists have proven time and again that they can be every bit as fanatical as religious zealots, and more violent still. Yet the theory of evolution has inspired inquiries that have revealed a world of unprecedented colour and beauty, of play and spontaneity, where collaboration is at least

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[65] The accounts about south Italian wolves and an East African leopard called Lakhadima have featured on recent documentaries made and shown by National Geographic. A lot of relevant materials were aired on their television channel during the winter of 2009 to commemorate the bi-centennial of Darwin's birth and the 150th anniversary of the publication of *The Origin of Species.*

as likely as the cold struggle for survival, and with enough purpose to rile those allergic to any hint of teleology.

Properly viewed, evolutionary theory, as anticipated by Bergson almost a century ago and Whitehead a little bit later, has if anything brought before us a far livelier and dynamic display of, for those who believe in it, divine agency, and for those who do not (or who prefer a more implicit approach), a world vividly suggestive of moral, aesthetic, and intellectual *significance*, which it is our privilege to partake of and uncover.

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