

What might logic and methodology have offered the
Dover School Board, had they been willing to
listen?

by

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Would it be constitutional to allow (let alone require) the teaching of either creationism or the theory of ‘intelligent design’ in public schools? At least eleven legal cases have shaped the current debate on this issue; and each of them emphatically supports answering the question in the negative.¹

Such a string of legal defeats should deter any reasonable losing party. But those supporting the teaching of creationism and/or ID-theory are well-organized, heavily funded, and insistent. They will not give up. They want public education to serve narrowly sectarian religious interests. So their

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¹The case are: Epperson v. Arkansas, 1968; Wright v. Houston Independent School District, 1972; Segraves v. State of California, 1981; McLean v. Arkansas Board of Education, 1982; Edwards v. Aguillard, 1987; Webster v. New Lenox School District, 1990; Peloza v. Capistrano School District, 1994; Freiler v. Tangipahoa Parish Board of Education, 1997; Rodney LeVake v. Independent School District 656, et al. 2001; Selman et al. v. Cobb County School District et al., 2005; and Kitzmiller et al. v. Dover Area School District, et al., 2005.

response to each defeat is to morph their doctrines, dissemble their motives, and try yet again.

Former creationists now try to pass themselves off as intelligent-design theorists. The astute Judge John E. Jones III of the United States District Court for the Middle District of Pennsylvania has, mercifully, seen them for what they are. The evidence before his court was overwhelming: ID-theorists are just creationists in disguise. A compelling historical case for this claim, focusing on the notorious ‘Wedge document’, was made in the expert report of Barbara Forrest, an historian and philosopher of science.

Another philosopher of science, Robert Pennock of Michigan State, wrote an incisive and sensible expert report for Kitzmiller et al. in their suit against the Dover School Board. Pennock was trained at the University of Pittsburgh’s Department of History and Philosophy of Science. It is the world’s top-ranked Department in that discipline.

Philosophy, however, is never without its self-embarrassing ironies. Pittsburgh also trained the Warwick sociologist Steve William Fuller, who wrote on behalf of Defendants. In attempting to rebut Pennock’s (and others’) expert reports for Plaintiffs, Fuller filled all of 55-pages. He arrived at the (lucrative and) ‘... considered judgement ... that ID’s religious dimensions are both legally and scientifically benign’, thereby showing a quite singular grasp of First Amendment jurisprudence as well as of scientific method. Fuller’s ‘expert report’ provides ample and alarming evidence in support of the contention that the doctrines of Quine, Kuhn and Feyerabend have made some of their adherents lose sight of the most basic distinctions. (More will be said about the untoward effects of these influential doctrines below.)

So we had the curious spectacle, in the Dover trial, of two experts with diametrically opposed views, and with doctoral training in the philosophy of science *from the same institution*.² How did philosophers get themselves into such an absurd situation? How has it come to pass that a matter of such gravity as the scientific status of a piece of discourse has not reached settled agreement among philosophers *of science*, at least, after careful analysis and criticism of all the options?

Philosophy has drawn many useful distinctions, and therefore has many useful distinctions to draw on. They are distinctions whose appreciation requires some familiarity with the philosophical literature. They are fundamental, important, and indispensable for a proper grasp of the contours of

²Since some readers might over-hastily infer that a Pittsburgh education might be wanting, it is only fair to note that Fuller was trained also at Cambridge University, England.

human language and thought. They are a hard-won reflective achievement. If Philosophy has rendered any service at all to society and human thought in general, it is by formulating and clarifying these distinctions.

The present circumstances call for some of the distinctions to be pressed more urgently, and with greater conviction, by professional philosophers—or at least by the logicians and philosophers of science in their midst. Suppose we had held on to the accumulated wisdom within our own philosophical tradition. Suppose we had accepted and perfected various crucial distinctions it bequeathed us. Would we now be in the helpless mess in which we find ourselves? No. We would be able to confront this religiose anti-scientism head-on.

Science aims to understand the world; and Philosophy aims to understand how science indeed gives us an understanding of the world. Philosophy seeks, if you will, a proper understanding of proper understanding. There are two senses of understanding involved here. First, there is the understanding of language, by means of which we try to represent how things are. Secondly, there is the understanding of how things themselves are, of factual matters—to the extent that we think we can get *at them*, with *us* enabled, but *them* unaffected, by our means of representing them. Understanding aims at truth. We have to inquire whether any purported representation of how things are is understandable—that is, whether it is *meaningful*. If it is meaningful, then our understanding is involved further in assessing whether the representation in question is *true*. Our understanding is at work when we fashion new scientific concepts and put forward new scientific theories involving them. Our understanding is at work when we infer consequences of the scientific hypotheses that we propose. It is the understanding at work when we ‘get to the bottom of things’.

We do so either by distilling elegant and self-evident axioms (in the case of mathematics) or by postulating powerfully unifying laws of nature (often expressed in the language of mathematics). Such laws are usually of wide cosmological scope and great mathematical succinctness. The atomic materials of the understanding are concepts and word-meanings. Its molecular materials are the thoughts expressed by declarative sentences, usually conjectural or assertive. Its organismic materials are whole theories. The connective tissue is logic, mathematics and extensive sets of analytic implications.

Dissecting these materials, in order to appreciate how they fit together, calls for the distinctions that are here asserted to have been woefully neglected or disavowed of late.

Most importantly, we need to distinguish the *cognitively significant* sen-

tences of our language from those that are not cognitively significant. What is cognitive significance? Broadly speaking, it is the significance that a sentence enjoys when its truth-value can be adjudicated by appeal to observation, aided by our exercise of reason (our inferential powers). A cognitively significant sentence is one that aims to represent objective matters of fact. These facts' obtaining or not obtaining can make a difference to how the world appears to us. The truth-values of cognitively significant sentences are constrained only by possible observable evidence and the exercise of our reason and understanding in drawing inferences involving such sentences. By contrast, sentences that are *not* cognitively significant are ones that are not beholden to any possible observable evidence. No exercise of our inferential powers could bring them or their consequences, directly or indirectly, into confrontation with possible observable evidence. For such a sentence, its having one truth-value rather than another could not, in principle, make any difference whatsoever to how we experience the world.

The problem of a criterion of cognitive significance was bequeathed to us by the Logical Positivists and their immediate heirs, the Logical Empiricists. It is also known as the *demarcation problem*: What should count as scientific claims? What are their distinctive grammatical, terminological and logical features? What makes them candidates for the representation of objective matters of fact? Of all the distinctions roughly articulated within twentieth-century philosophy, this is the one that has been the most inadequately articulated by its earlier proponents; the most sorely neglected; the least appreciated; and the most lamentably underdeveloped. Yet it is the key to securing the scientific status of Darwinism and ensuring the lack of such status for ID-theory and its ilk.

There are the following subsidiary distinctions that apply *within* the domain of the cognitively significant: logical v. non-logical; necessary v. contingent; logico-mathematical v. empirical; conceptual v. empirical; analytic v. synthetic; a priori v. a posteriori; and verifiable v. falsifiable. Quine's famous attack on the analytic/synthetic distinction, in his celebrated essay 'Two Dogmas of Empiricism', took place (as a lecture) in 1951. The same year saw publication of Hempel's famous paper 'Problems and Changes in the Empiricist Criterion of Cognitive Significance'. Some of the consequences of these landmark essays will be surveyed here. They are very untoward.

Quine held that the analytic/synthetic distinction could not be independently grounded by any broadly behavioristic theory of meaning. Moreover, thought Quine, the distinction did not deliver any significant benefits for the theory of knowledge. Putnam has since interpreted Quine's attack on

the analytic/synthetic distinction as an attack equally on the other Kantian distinction, that between *a priori* and *a posteriori* truths. The net effect, for many an American philosopher, was that these two Kantian distinctions fell into disrepute. A slide to ‘holistic pragmatism’ took place, with lip-service paid to the tribunal of experience. To continue the juridical metaphor: careless philosophers regarded themselves as entitled to fudge the boundaries among the categories of eye-witness testimony, unfounded speculation by counsel, enacted statute and judicial precedent.

Quine’s doctrine is commonly understood as having arisen from a synthesis of Logical Positivism and American Pragmatism. Quine, as it were, homogenized the language of science, by doing away with the analytic/synthetic distinction, and also the *a priori*/*a posteriori* distinction. What tends to go unremarked, however, is that a wider stage was in effect set by Hempel, for an even more calamitous homogenization—not just of our scientific language and theorizing, but of *all* our discourse, whether would-be scientific, would-be metaphysical, would-be ethical or would-be religious. For Hempel had come to a glum conclusion, and it cast a wide pall. Hempel rehearsed how all the then extant attempts to characterize cognitive significance in a rigorous way had foundered on one kind of difficulty or another. He did *not*, however, venture the conclusion that *no* attempt *could ever* succeed.

From Hempel’s seminal paper, then, we had weary defeatism about the prospects for demarcating science from metaphysics, ethics and religion. From Quine’s seminal paper, we had a kind of argument, *con brio*, for the impossibility and uselessness of the Kantian distinctions. Those persuaded by these homogenizing arguments lost interest in making any further attempts to demarcate science from religion (say). They became reluctant to accord significantly different epistemological statuses to logical laws, mathematical theorems, scientific hypotheses, low-level empirical generalizations, and observation statements.

It was merciful indeed that scientists continued, in the second half of the twentieth century, to test and revise their theories in blithe disregard for a mistaken, but understandably mistaken, interpretation of these Quinean exhortations. The problem lay in the brief slogans that summarized Quine’s views on revisability: “No statement is immune to revision”; and “Every statement can be held on to, provided one makes compensatory adjustments elsewhere”. The latter should really be interpreted more carefully as follows:

For every statement p , there is some possible state E of empirical evidence such that it would be rational to hold p in E , provided one made compensatory adjustments elsewhere.

But unfortunately the slogan lends itself to the looser interpretation

For every (theoretical) statement p , and for every possible state E of empirical evidence, it would be rational to hold p in E , provided one made compensatory adjustments elsewhere.

No scientist can really take seriously the first Quinean claim that *no* statement is immune to revision—not even a basic logical law. An obvious exception to Quine’s claim of non-immunity would be the very logical laws by which one would have to abide in order to be able to carry through a rational process of revision.³

Nor can one take seriously the widespread misinterpretation of the second Quinean claim that any statement can be held on to, no matter what the anomalous evidence, provided only that ‘compensatory adjustments’ are made elsewhere within the system. Quine himself would at most be pointing out a bare logical possibility here, and not claiming that such tenacity in the face of anomalous evidence would be rational. A sober antidote to the philosophical excess of assuming such *carte blanche* came from the bench in *McLean v. Arkansas* (1982). Judge William Overton wrote

While anybody is free to approach a scientific inquiry in any fashion they choose, they cannot properly describe the methodology used as scientific, if they start with a conclusion and refuse to change it regardless of the evidence developed during the course of the investigation.

The judge was saying that creationists are not allowed, by the constraints of scientific method, to do *that*. Yet this is exactly what many readers took Quine to be saying they are free to do, if they so choose. Quine was read as saying that theory revision enjoys no rational guidance.

This misinterpretation of Quine on revisability was reinforced from other quarters. Consider the parallel views about the lack of rationality in scientific change, put forward by Kuhn and Feyerabend. They contributed a

³Intuitionists have given up the law of excluded middle and its intuitionistic equivalents; and relevantists have given up various ‘paradoxes of implication’ and closely related principles that they think are responsible for producing such paradoxes. Far-reaching though such reforms might appear to be, they (necessarily) leave intact a core set of relevant and constructive logical principles. (In the present author’s work—see Tennant (1997)—this intact system is called *IR*, for ‘intuitionistic relevant’ logic; and it is argued that it is *the* correct logic for both mathematics and empirical science.) Also, ‘quantum logic’ has been proposed as a radical alternative to classical logic for the quantum domain. It is a controversial matter, however, whether the word ‘logic’ enjoys its usual sense within the phrase ‘quantum logic’; for no one has yet produced a natural deduction system or sequent calculus for so-called quantum logic.

great deal, in Quine's wake, to the widespread conviction, among the so-called social constructivists, that there was nothing special about scientific 'knowledge'. This so-called knowledge, the constructivists maintained, was the outcome of a highly politicized process, and of social relations having nothing to do with the facts at issue.

But let us return to our focus on Quine. Take his easily misinterpreted claims about revisability. Couple them with his otherwise rigorously analytical approach to philosophical problems. They made for a curious double-whammy. Humanists were put off by what they perceived as the 'scientism' of rigorous philosophizing about truth and method. And the humanists' inclination to relativism now appeared to be licensed by what they took to be Quinean laxity about revision. From the humanists' point of view, the rigorous philosophers (mistakenly thought to be exemplified by Quine, of whom a mistaken interpretation lay all too close to hand) were telling them that 'anything goes'. Why, then, should they bother to acquire the rigorous habits of thought that might lead to a case to the contrary? They therefore felt free to *subjectivize* and *relativize* to their hearts' content. And so the scourge of postmodernism was visited upon the American academy, reaching its pathetic nadir with the Sokal hoax.⁴

Let us not forget, either, that some of the most extreme of these subjectivists and relativists found their way into positions of power in university departments of educational psychology. They placed their duly influenced graduates into positions of responsibility within our high-school system. By the late 1980s and early 1990s the damage was largely done. The present author recalls, shortly after arriving at Ohio State in 1992, receiving an imploring overture from a representative of a parents' group in Southern California. They were looking for support from university philosophers of mathematics who might be willing to write to their school board. We were asked to affirm that a newly proposed textbook was in error. The nature of the error?—it informed students that the right answer to a mathematical problem (to be solved by students in small groups) was the answer with which the majority of the group felt happiest. When juvenile self-esteem trumps logical derivation from first principles as a criterion for mathematical assertability, we know that something is wrong.

It is no wonder that it was at this juncture of our ideological narrative that an extraordinary grass-roots movement took shape among religious fundamentalists. They were able to *get onto the public agenda* the *conceivability* of offering to high school students, *in a science class*, the religious doctrine of

⁴See Editors of *Lingua Franca* (2000).

creationism. To this end the creationists re-labelled their religious doctrine as ‘creation science’. They paid lip-service to the ‘secular’ purpose of protecting students from ‘indoctrination’ in evolutionary theory. They made fraudulent avowals of intent to focus on alleged ‘scientific evidences [sic] for creationism and inferences from those’. With such smoke and mirrors, the Louisiana legislators who passed the “Balanced Treatment for Creation-Science and Evolution-Science Act” (Balanced Treatment Act) were able to elicit the outrageously coddling dissenting opinion of Justice Scalia, with Chief Justice Rehnquist concurring, when the US Supreme Court found that Act unconstitutional (Edwards v. Aguillard, 482 U.S. 578).

One would have thought, after the *débâcles* in Arkansas, Louisiana and elsewhere, that the hordes at the gate would back off. But instead they returned to their mischief in the Pennsylvania town of Dover. Dover is just one jurisdictional district west of one of the sources of *Lemon v. Kurtzman*, 403 U.S. 602 (1971). That was the Supreme Court case that gave rise to the famous three-pronged ‘Lemon test’ for constitutionality under the Establishment Clause of the First Amendment:

First, the statute must have a secular legislative purpose; second, its principal or primary effect must be one that neither advances nor inhibits religion, *Board of Education v. Allen*, 392 U.S. 236, 243 (1968); finally, the statute must not foster “an excessive government entanglement with religion.” *Walz, [v. Tax Comm’n of the City of New York]*, 397 U.S. 664], at 674.

By now the relentless onslaught of the hordes at the gate should have galvanized all educated citizens. By now they should have been deeply concerned about the future quality and integrity of science education in our public school system.

But what was the local response among the American *cognoscenti*? In all the public debate that the author was able to witness in the lead-up to the decision in *Kitzmiller*, there appeared to be not a single opponent of creationism in the classroom who could marshal a proper intellectual case, for the general public, against the claimed scientific status of that doctrine.

This can be blamed on at least four factors (there may be others).

First, public intellectuals in the USA are few and far between, compared to European nations. European nations have higher circulations of high-quality newspapers, and traditions of *wide-ranging* debate on TV, stemming from the days of high-quality, publicly-funded channels devoted to politics, culture and the arts.

Secondly, the philosophy of biology has played poor cousin, or second fiddle, to the philosophy of physics. So there are relatively fewer philosophers both willing and qualified to take up the methodological cudgels against the creationists on the details and scientific status of evolutionary theory. To be sure, leading figures such as Michael Ruse and Daniel Dennett (in the USA) and Richard Dawkins (in the UK) have rendered significant public service through their popularizing publications on Darwinian thought; but the community of philosophers of science concentrate their scholarly efforts much more in the philosophy of physics.

Thirdly, the power of the religious right is a chilling influence on Darwinian demurrals. Like former Soviet dissidents, American academics who privately scoff at creationism seem reluctant to set out a cogent case for doing so, for fear of retribution by the wrathful. This is even chilling the teaching of science in educational facilities in Arkansas. They cannot use the ‘e-word’, for fear of losing outside funding.⁵

The fourth factor comes from the changes in methodological *Zeitgeist* just described. Potential critics of creationism in the classroom have been deprived of communally approved intellectual tools to render the kind of public service that is so badly needed from them. Philosophers are called upon to supply these tools. Among the tools are a firm and clear boundary around the cognitively significant fragment of our language. Within that boundary, and only within it, lies what deserves to be called science.

The First Amendment provisions concerning religion do after all presuppose that one can mark off religious discourse from other kinds of discourse in some sensible way. When Darwinism is mistakenly branded as a religion, and when Intelligent Design theory is mistakenly claimed to be scientific, we know that some serious confusion has set in. The commonsense distinction presupposed in the First Amendment is one that needs to be motivated and further explicated by philosophers, not undermined and disavowed.

Now the reader may wonder why it is proposed that we should resurrect the notion of cognitive significance and apply it in the debate over the status of the theory of Intelligent Design. Why not just meet ID-theory head-on, as it were, in the scientific arena itself, and show it to be false, given the empirical facts? That after all, was what the philosopher of science Larry Laudan recommended one should do with ‘creation science’, back in 1982, shortly after Judge Overton ruled in *Edwards v. Arkansas* that an Act

⁵See The Arkansas Time, ‘Teachers at Arkansas School forbidden to use “E-word” (Evolution)’, <http://www.arktimes.com/Articles/ArticleViewer.aspx?ArticleID=e7a0f0e1-ecfd-4fc8-bca4-b9997c912a91> .

providing for the teaching of creation science in public schools failed all three prongs of the Lemon test.⁶ Laudan, as a good Quinean, naïvely believed that one could just let the two theories, creationism and neo-Darwinism, compete on a level playing-field. He thought that the empirical and pragmatic virtues of the one—presumably, neo-Darwinism—could be expected to win more hearts and minds by the end of the day.

Laudan missed the point that Judge Overton too essayed on the *empirical* inadequacies of creation science. He did so with the shrewd *juridical* objective of establishing that creation science, being devoid of any scientific merit, was being introduced mainly for a religious purpose—thereby failing the first prong of the Lemon test.

But with ID-theory, matters are subtly different. The ID-theorists have strategically retreated from the more outlandish claims of creation science, such as that the Earth is only a few thousand years old. They have pared their theory down to the point where it cannot actually be brought into confrontation with *any* observable facts. It therefore cannot be dismissed as a sub-optimal explanation of what can be observed—because it does not really explain (or predict) anything. Heady with that triumph in avoiding direct refutation, they continue to claim scientific status for ID-theory—thereby not realizing (or refusing to acknowledge) that they have jumped out of the frying pan of outright refutation into the fire of cognitive insignificance.

The methodologist must call ID-theorists on this ploy. Pennock makes a good start when he points out (*loc. cit.*, p. 21)

A god that is all-powerful and whose will is inscrutable can be called upon to “explain” *any* event in any situation, and this is one reason for science’s methodological prohibition against such appeals. Leaving the designer unnamed and undescribed has the same effect. Given this feature, supernatural hypotheses remain immune from disconfirmation or meaningful testing.

Unfortunately, however, Pennock’s positive account of testability, though satisfying to the lay reader, will not pass muster for the logician. He writes (p. 20)

Science operates by empirical principles of observational testing; hypotheses must be confirmed or disconfirmed by reference to intersubjectively assessable data. One supports a hypothesis by showing that certain consequences obtain, which would follow if what is hypothesized were to be so in fact.

⁶See Laudan (1982).

Without any further independent characterization of the logical powers required of hypotheses, this characterization would unfortunately be satisfied by the ‘hypothesis’ that is a mere conjunction of the true observation statements concerned.

How did the rot set in, for the once impressionable young minds now old enough to be drawn in to the campaign for creationism or ID in the classroom? (Note that in *Wright v. Houston Independent School District*, 1972, it was *students* who sued to prevent the teaching of the theory of evolution.) Is it simply a matter of confused allegiances to figures of authority—to preachers in a pulpit, rather than to the clichéd men and women in white coats? Unlikely. A more thoughtful diagnosis would begin with the lamentable neglect of basic logic in our high-school curricula. No high-school graduate is required to understand the concept of logical consequence, or to have internalized the basic rules of inference of modern logic. This is one reason, among others, why we lag behind so many other nations in math test scores. Mathematical proof is the paradigm of logically rigorous reasoning. The vast majority of our high-school students are intimidated by mathematics. They are put off by symbols and rigorous reasoning. At best they can memorize formulae for routine application. But seldom do they learn how to prove, from first principles, why those formulae work. That, at least, is the anecdotal impression gathered after dealing with thousands of students in Philosophy 101 classes over the past fourteen years. These students have never encountered the *proof* that the square root of 2 cannot be a ratio of two whole numbers. The method of *reductio ad absurdum*, so clearly at work in this ancient proof from the school of Pythagoras, is foreign to them. So how could they be expected to understand the crucial notion of the refutability of a scientific theory?

Our high-school graduates are bereft of the concept of consequence or deducibility. They are innocent of the rules of logical reasoning that generate the deducibility relation. Without a grasp of deducibility, they cannot acquire the concepts of consistency and inconsistency. Nor can they attain the notion of logical independence. Still less can they understand the difference between a conservative and a (logically) creative extension of a theory. They are therefore without the intellectual resources that are needed in order to grasp the general features that distinguish scientific theorizing from empirically untestable, theological speculation.

Now it is not being suggested that we could ensure, by means of a little formal logic in the high-school curriculum, that in due course the generally educated college graduate would be apprised of a criterion of cognitive significance! The actual formulation of a provably adequate criterion is a deep

and delicate matter. It involves technical tools not available to those theorists whose failed attempts were surveyed by Hempel back in 1951. More formal logic early in the curriculum would, however, enable the student to appreciate the following claim. It is now possible *rigorously to characterize* what is meant by cognitive significance.⁷ The notion of cognitive significance is available again for the purposes of demarcating scientific discourse from the rest. The notion has a satisfactory logical explication, which can be proved, logically, to be adequate.

The basic idea is as follows. Observational vocabulary is taken as ‘basic’. Any sentence all of whose non-logical vocabulary is basic counts as cognitively significant. But we know that scientific theories characteristically introduce *new* expressions into the language, so-called theoretical terms. Think here of terms such as ‘cell’, ‘germ’, ‘molecule’ and ‘atom’—and, at the other end of the size-scale, ‘black hole’ and ‘galaxy’. How do these terms come to qualify as cognitively significant, alongside the basic ones? The answer, roughly, is as follows. The theory that introduces these new theoretical terms into the discourse embeds them in newly postulated laws of nature. Those laws enable us to make new predictions, to the effect that *if* such-and-such is the case (described in already significant terms), *then* so-and-so will be the case (described in similar terms). Without the new postulated laws, this inferential transition from such-and-such to so-and-so would not be licensed. We can say that the new laws *creatively extend* the reach of our earlier observational reporting and theorizing. They do so, however, in conformity with a crucial constraint. This constraint is that in any situation that would falsify a prediction, any falsifier of the hypothesis giving rise to it *must appeal to some fact expressible in terms already licensed as cognitively significant*.⁸ There is an implicit ordering here. It reflects the way that higher levels of new theorizing accrue, as we peer into the ever smaller and gaze into the ever vaster.

The constraint on creative extension, and creative extension itself, can be spelled out rigorously using the tools of modern logic. The constraint ensures that cognitively significant hypotheses are always answerable to the basic facts. The overall account, then, of cognitively significant sentences is that they are ones whose truth-value, if discoverable, can be determined by the joint operation of our understanding and our sensibility—to put the matter in Kantian terms. In some cases, as with logical laws, the operation

⁷See Tennant (1997), ch. 11.

⁸It follows, then, that a theory that has been falsified, and consequently abandoned, is cognitively significant. Examples would be Aristotelian and Ptolemaic astronomy.

of our understanding suffices. The truth of the sentences in question can be determined from sentential form alone. In the empirical case, however, one is dealing with contingent sentences. If cognitively significant, the truth of these sentences will have a predictable effect on our sensibility. They will make a difference to our anticipation of the course of our future experience.

With that positive picture in hand, the reader is invited to turn to consider and compare the theoretical accounts on offer from the neo-Darwinians and from the ID-theorists. The neo-Darwinian synthesis provides a rich source of materials illustrating how theoretical terms acquire cognitive significance. The central insight of *The Origin of Species* is, ironically, expressed without any theoretical terminology at all. It requires only basic vocabulary. The insight can be laid out as follows.

Within any breeding group of organisms, individuals differ with respect to any number of observable traits. We observe moreover that offspring tend to resemble their parents with respect to these traits. We observe also that some parents have more offspring than other parents. It is now an *a priori* mental exercise to conclude that, over the course of many generations, traits that are responsible for an organism's having more offspring than average will increase, proportionally, within that population. The central implication can be stated thus:

$$\left. \begin{array}{l} \text{Variability} \\ \text{Heritability} \\ \text{Differential reproduction} \end{array} \right\} \Rightarrow \text{Adaptive evolution}$$

The label for this phenomenon is 'natural selection'. It is a blinding statement of the obvious, when one thinks about it—even though it took the genius of Darwin to bring it to our attention. But pause for a moment to consider this: *those people who disavow natural selection are actually rejecting an analytic implication of ordinary language.* They are in the same boat (or on the same raft?) as one who claims that he has in his hands a sphere that is simultaneously both (monochromatically) red all over and (monochromatically) green all over.

Darwin did, of course, bring many more considerations to bear in his long argument for the explanatory adequacy of natural selection. He marshalled a host of taxonomic and distributional facts. He repeatedly contrasted the satisfying naturalistic explanation that the selectionist can provide for those facts, with the lack of any competing explanation from the creationist. He was drawn into coöpting well-confirmed generalizations from animal and plant breeders, and hypotheses from the then-fledgling science of geology.

Geology in Darwin's day modestly postulated that changes had occurred in the earth's crust, but over extraordinarily long periods of time, periods so long that they had not before been contemplated. The hypotheses of geology connected with all manner of observational evidence, concerning rock strata exposed by erosion and discovered by mineral exploration. And they enabled one to reconcile the available facts about the fossil record with the central tenets of Darwin's theory of descent.

The next big theoretical appropriation within the Darwinian synthesis was of Mendelian genetics. Mendel had postulated that organism's gametes consisted of particulate units of heredity, and that the organism's traits were determined by pairwise combinations of these units, one inherited from the mother and the other inherited from the father. Further postulation of dominance and recessiveness enabled the population geneticist to account for important statistical patterns across generations of different types of crosses. So we see theory once again connecting as it should with possible confirming or disconfirming evidence.

Let us consider just one more step in the development of the neo-Darwinian synthesis: the discovery of DNA. Crick and Watson provided the crucial compositional hypothesis concerning Mendelian genes: they were strands of DNA, whose postulated structure could now account for crucial features of reproduction. It could account for meiosis, the process that involves recombination of parental genes in a new sperm or egg. It could account for the fertilization of an egg by a sperm, to produce the zygote. And it could account for mitosis, the subsequent division of cells to produce the organism. From the Crick-Watson model we understand how it is that information flows only from the genotype to the phenotype, and not the other way round. We acquire an understanding of the possible sources of genetic mutations, which account for the reservoir of potential variation within any species. And insights from embryology, concerning the timing of onset of cell-type-differentiation, combine with the DNA-model of the genetic code to furnish fecund materials for the explanation of evolutionary descent. So we see theory yet again connecting as it should with possible confirming or disconfirming evidence.

As more and more specialized sciences are recruited to the Darwinian synthesis, one cannot help but be impressed by what a wonderfully integrative inference to the best explanation it is. The central idea of evolutionary descent of species, via random variation and selective retention, and changing sets of environmental challenges and opportunities, is confirmed from every angle. The synthesis incorporates corroborating theory from quantum mechanics, inorganic chemistry, organic chemistry, molecular biology,

cell biology, organismic biology, population genetics, comparative anatomy, geology, mineralogy, paleontology, histology, embryology, immunology, evolutionary game theory, sociobiology, ethology and ecology. About the only discipline missing is rocket science. Even then we cannot be sure it won't find its way in, through the discovery of evolved extra-terrestrial intelligences.

Two main characteristics of the neo-Darwinian synthesis are worth emphasizing. First, it is clearly cognitively significant in every detail. Secondly, it operates on an extraordinarily fruitful methodological maxim:

Always seek a fully naturalistic explanation for any puzzling or mysterious biological phenomenon.

This is not a mindlessly reductionist maxim, by the way. Naturalism does not entail reductionism. The naturalist is quite prepared to acknowledge that Nature can produce emergent levels of phenomena, which have to be described and explained in their own terms. These emergent terms can defy theoretical reduction to terms used to frame the laws that operate 'lower down' in the layers of material existence (such as the laws of wave and particle physics). That having been said, however, one can still insist that the emergent *facts* are fixed by the lower-level facts. This position on levels of reality and the corresponding levels of theorizing is known as *supervenience without reductionism*.

Now contrast this rich, cognitively significant tapestry of mutually supporting scientific disciplines with the lame and empty doctrine called ID-theory.

ID-theorists' postulation of a vaguely characterized 'design intelligence' is an act of methodological desperation. It is premised on a negative existential of breathtaking hubris: that *there is no* and *there can be no* intellectually satisfying naturalistic explanation of certain biological phenomena.

The most hackneyed of these biological phenomena is the thrashing 'rotor' flagellum of certain bacteria. In the Discovery Institute's unintentionally hilarious animation regularly broadcast on religious cable channels, it is pictured as some kind of ball-bearing housing. The animations also include multicolored Lego-molecules, telling the story of DNA-replication as though it were choreographed in a robotics plant. They provide a broken-backed analogy with a mousetrap, with its five separate components. Each of these components, the terribly scientific-sounding voice-over intones, is absolutely essential to the functioning of the mousetrap. And it took a single intelligence to put it all together, in one act of creative insight, right? ... so ... *that's what must have happened with the marching molecules and with the twirling flagellum!*

These ID-theorists, so ready to allege constitutional shortcomings on the part of evolutionary theory, are stuck in about the 1950s with their reading of the Darwinian literature. They are reprehensibly ignorant of the groundbreaking work of Nobel Laureate Manfred Eigen and his co-worker Egon Schuster on the evolution of the hypercycle, as the origin of DNA. They are likewise ignorant of the theory of exaptation, which Steven Jay Gould did much to popularize before his untimely passing. The exaptationist points to the plausible possibility of there having been a sequence of distinct but overlapping functions that were served by different components, as they became yoked together, componentially, so as to acquire their current function. (This happens, by the way, with both the evolution of organisms and the evolution of artefacts.) Given the (explicable) degree of ignorance about past happenstance in the dim reaches of the phylogenetic tree, the Darwinian naturalist can be forgiven for not being able to produce, on demand, some demonstrably adequate and determinate series of component-specific functions in the evolutionary past of the flagellum's tail. It is an insult to the intelligence of the ordinarily imaginative reader, however, to tell her that *no possible* naturalistic explanation is to be had for this phenomenon. This is the last resort of intellectual scoundrels.

So, uninformed pessimism, ignorance of the literature, and lack of theoretical imagination motivate the ID-theorist to give up on naturalistic, Darwinian explanation. We must resort instead, we are told, to an Intelligent Designer. Note that this is a mere act of existential postulation. Nothing is said about the Intelligent Designer. We learn nothing about its *modus operandi*. We learn nothing of the material mechanisms it can exploit. We are not told that it is a natural thing, in space and time. Indeed, we are told the opposite. We learn nothing about its regularities. We are given no way of predicting, on the basis of this postulation, what might happen next. We are given no way of determining just where, in the order of things, this preternatural agent intruded. If ever there was an invisible hand at work in the universe, this is it. But it is a hand that is said to have poked into matters in the past; while its future interventions in biological affairs on the face of this planet remain completely inscrutable.

This we-know-not-what thing that is postulated by ID-theory miserably fails the test of cognitive significance alluded to earlier.⁹ If lay high-school graduates cannot intuit that immediately, it underscores the crying need for

⁹Note that the claim here is that ID-theory lacks cognitive significance, not that creationism does so. Ironically, by venturing precise apocalyptic predictions based on the Book of Revelations, the creationist may well purchase a degree of cognitive significance, but at the almost certain cost of falsity.

an education devoted to honing the required critical faculties. One fears that a sound conception of what science is, and what the scientific method is, is fast being lost among the younger generation. And we *cannot* run the risk again of having a conservative Supreme Court Justice refer, as Scalia did, to ‘ample uncontradicted testimony that “creation science” is a body of scientific knowledge, rather than revealed belief’. The claim of scientific status for this doctrine is false. Moreover, as the Georgetown theologian John Haught concluded in his expert report for the Dover case, the doctrine is ‘appalling theology’.

The lack of any resounding conclusion to the debate over whether to allow creationism in the classroom reveals the danger inherent in allowing our society to become one for which Putnam’s division of linguistic and theoretical labor becomes more and more entrenched, yet more and more precarious. It used to be that this division worked, because everyone acknowledged who the authorities (in intellectual or lexicographic matters) really were. Also, sufficiently many people were educated to the level where they could *be* authorities, or at least understand and appreciate, in broad terms, what the authorities at times tried to share with them. Our society faces the serious prospect of a dysfunctional system of public schooling. The resulting danger is that the scientific authorities will dwindle in proportion, if not in numbers. They then become vulnerable to being impugned, ignored, vilified or cowed by ignorami who do not have the wherewithal ever to become intellectual authorities themselves. These are today’s hordes at the gate. Look in fear not just at ideologically hostile power-blocs half a world away. Look within.

APPENDIX

The following cases elaborated the principles now governing issues about creationism or ID-theory in public school curricula. These issues are invariably judged in accordance with the Establishment Clause of the First Amendment, which is applicable to States under the Fourteenth Amendment.

1. **Reynolds v. United States, 98 U.S. (1878)**

Held that Mormons have no legal right to practise polygamy.

Referred to Jefferson's 'wall of separation between Church and State.'

2. **Everson v. Board of Education of Ewing Tp., 330 U.S. 1 (1947)**

Justice BLACK for the majority.

New Jersey statute for contributing to costs of transportation to and from schools held to be constitutional.

The 'establishment of religion' clause of the First Amendment means at least this: Neither a state nor the Federal Government can set up a church. Neither can pass laws which aid one religion, aid all religions, or prefer one religion over another. Neither can force nor influence a person to go to or to remain away from church against his will or force him to profess a belief or disbelief in any religion. No person can be punished for entertaining [330 U.S. 1, 16] or professing religious beliefs or disbeliefs, for church attendance or non-attendance. No tax in any amount, large or small, can be levied to support any religious activities or institutions, whatever they may be called, or whatever form they may adopt to teach or practice religion. Neither a state nor the Federal Government can, openly or secretly, participate in the affairs of any religious organizations or groups and vice versa. In the words of Jefferson, the clause against establishment of religion by law was intended to erect 'a wall of separation between Church and State.' Reynolds v. United States, supra, 98 U.S. at page 164. ...

The First Amendment has erected a wall between church and state. That wall must be kept high and impregnable.

3. **Board of Education v. Allen, 392 U.S. 236 (1968)**

Justice WHITE for the majority.

New York's Education Law requiring local public schools authorities to lend textbooks free of charge to *all* students in grades 7 through 12 held to be constitutional.

4. **Walz v. Tax Comm'n of the City of New York, 397 U.S. 664**

Justice BURGER for the majority.

Property tax exemptions to religious organizations for religious properties used solely for religious worship held to be unconstitutional.

It is sufficient to note that, for the men who wrote the Religion Clauses of the First Amendment, the "establishment" of a religion connoted sponsorship, financial support, and active involvement of the sovereign in religious activity. . . . Determining that the legislative purpose of tax exemption is not aimed at establishing, sponsoring, or supporting religion does not end the inquiry, however. We must also be sure that the end result—the effect—is not an excessive government entanglement with religion. The test is inescapably one of degree.

5. **Lemon v. Kurtzman, 403 U.S. 602 (1971)**

Justice BURGER for the majority.

Rhode Island's 1969 Salary Supplement Act and Pennsylvania's Non-public Elementary and Secondary Education Act held to be unconstitutional.

A law may be one "respecting" the forbidden objective while falling short of its total realization. A law "respecting" the proscribed result, that is, the establishment of religion, is not always easily identifiable as one violative of the Clause. A given law might not establish a state religion but nevertheless be one "respecting" that end in the sense of being a step that could lead to such establishment and hence offend the First Amendment.

In the absence of precisely stated constitutional prohibitions, we must draw lines with reference to the three main evils against which the Establishment Clause was intended to afford protection: "sponsorship, financial support, and active involvement of the sovereign in religious activity." *Walz v. Tax Commission*, 397 U.S. 664, 668 (1970).

Every analysis in this area must begin with consideration of the cumulative criteria developed by the Court over many years. Three such tests may be gleaned from our cases. First, the statute must have a secular legislative purpose; second, its principal or primary effect must be one that neither advances nor inhibits religion, *Board of Education v. Allen*, 392 U.S. 236, 243 (1968); finally, the statute must not foster “an excessive government entanglement with religion.” *Walz*, *supra*, at 674.

... we conclude that the cumulative impact of the entire relationship arising under the statutes in each State involves excessive entanglement between government and religion.

6. **McLean v. Arkansas, United States District Court, Eastern District of Arkansas, Western Division, 1982** Opinion of Judge William R. Overton.

The only inference which can be drawn from these circumstances is that the Act was passed with the specific purpose by the General Assembly of advancing religion. ... If the defendants are correct and the Court is limited to an examination of the language of the Act, the evidence is overwhelming that both the purpose and effect of Act 590 is the advancement of religion in the public schools. ... The evidence establishes that the definition of “creation science” contained in 4(a) has as its unmentioned reference the first 11 chapters of the Book of Genesis. ... Both the concepts and wording of Section 4(a) convey an inescapable religiosity. ... The facts that creation science is inspired by the Book of Genesis and that Section 4(a) is consistent with a literal interpretation of Genesis leave no doubt that a major effect of the Act is the advancement of particular religious beliefs. ...

... Section 4(a) lacks legitimate educational value because “creation science” as defined in that section is simply not science. ... Creation science, as defined in Section 4(a), not only fails to follow the canons defining scientific theory, it also fails to fit the more general descriptions of “what scientists think” and “what scientists do”. ... The creationists

have difficulty maintaining among their ranks consistency in the claim that creationism is science. . . .

The methodology employed by creationists is another factor which is indicative that their work is not science. A scientific theory must be tentative and always subject to revision or abandonment in light of facts that are inconsistent with, or falsify, the theory. A theory that is by its own terms dogmatic, absolutist and never subject to revision is not a scientific theory. . . .

The conclusion that creation science has not scientific merit or educational value as science has legal significance in light of the Court's previous conclusion that creation science has, as one major effect, the advancement of religion. The second part of the three-pronged test for establishment reaches only those statutes having as their *primary* effect the advancement of religion. Secondary effects which advance religion are not constitutionally fatal. Since creation science is not science, the conclusion is inescapable that the *only* real effect of Act 590 is the advancement of religion. The Act therefore fails both the first and second portions of the test in *Lemon v. Kurtzman*. . . .

References to the pervasive nature of religious concepts in creation science texts amply demonstrate why State entanglement with religion is inevitable under Act 590. Involvement of the State in screening texts for impermissible religious references will require State officials to make delicate religious judgments. The need to monitor classroom discussion in order to uphold the Act's prohibition against religious instruction will necessarily involve administrators in question concerning religion. These continuing involvements of State officials in questions and issues of religion create an excessive and prohibited entanglement with religion (*Brandon v. Board of Education* at 1230).

7. Edwards v. Aguillard, 482 U.S. 578 (1987)

Justice BRENNAN for the majority.

Louisiana's "Balanced Treatment for Creation-Science and Evolution-Science in Public School Instruction Act", forbidding the teaching of the theory of evolution in public elementary and secondary schools unless accompanied by instruction in the theory of "creation science",

held to be unconstitutional.

Held: 1. The Act is facially invalid as violative of the Establishment Clause of the First Amendment, because it lacks a clear secular purpose. . . . (a) The Act does not further its stated secular purpose of “protecting academic freedom”. . . . (b) The Act impermissibly endorses religion by advancing the religious belief that a supernatural being created humankind. The legislative history demonstrates that the term “creation science”, as contemplated by the state legislature, embraces this religious teaching. . . .

2. The District Court did not err in granting summary judgment upon a finding that appellants had failed to raise a genuine issue of material fact. Appellants relied on the “uncontroverted” affidavits of scientists, theologians, and an education administrator defining creation science as “origin through abrupt appearance in complex form” and alleging that such a viewpoint constitutes a true scientific theory. The District Court, in its discretion, properly concluded that the postenactment testimony of these experts concerning the possible technical meanings of the Act’s terms would not illuminate the contemporaneous purpose of the state legislature when it passed the Act. None of the persons making the affidavits produced by appellants participated in or contributed to the enactment of the law. . . .

. . . because the primary purpose of the Creationism Act is to endorse a particular religious doctrine, the Act furthers religion in violation of the Establishment Clause.

References

The Editors of *Lingua Franca*. *The Sokal hoax : the sham that shook the academy*. University of Nebraska Press, Lincoln, 2000.

Larry Laudan. Commentary: Science at the bar—causes for concern. *Science, Technology, and Human Values*, 71(41):16–19, 1982.

Neil Tennant. *The Taming of The True*. Oxford University Press, 1997.