

WHY THE PANDA PROVIDES NO COMFORT TO THE CREATIONIST

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In the United States, National Public Radio recently featured a contest in which listeners sent in some of their favorite oxymorons (i.e., phrases containing contradictions in terms). My favorites — for example, “friendly fire” for artillery fire that lands one one’s own troops — tended to be somewhat acerbic. Only after the contest was closed did I realize that I had a deserving entry in the oxymoron sweepstakes — scientific creationism. The purpose of this paper is to convince the reader that my belated entry is a legitimate candidate for first prize.

Being a philosopher, I must immediately cover my tracks. I do not mean to suggest that creationism is *necessarily* unscientific. It could have turned out, as it has not, that there was strong evidence for the creation of our world. It could have turned out, as it has not, that the procedures followed by creationists were both scientifically sound and supportive of their views. Indeed, in the first half of the nineteenth century, before some of the evidence now available had been gathered, a number of leading biologists supported a respectable and important form of scientific creationism. My target is the politically potent movement, indigenous to the United States and inspired by Christian fundamentalist beliefs, which has recently masqueraded before school boards, in legislatures, and in court under the *guise* of scientific creationism.

Many of the readers of this essay will already be convinced that this brand of creationism is unscientific. I ask them to read on a bit further for, as I shall argue, the kind of argument one mounts in criticism of creationism is of great importance. I shall try to show that the arguments to this effect most popular among scientists, recently accepted by Judge William Overton in his ruling against requiring the teaching of creationism in Arkansas,¹ are seriously

misguided and that they give the creationist far more leeway than does the alternative style of argument which I will sketch below. The thoughtful reader will note that my claims have important consequences regarding science education, the public's image of science, and, indeed, the very nature of the scientific enterprise.

In order to establish that there is overwhelming evidence against the particular creationist views at the focus of debate and that the relevant creationist arguments are unscientific in character, it will be useful to begin with a brief sketch of some recent debates in evolutionary theory. In the 1950's and 1960's orthodox evolutionary theory was committed to a thoroughly *gradualist* view of evolutionary history.² You have all seen some version of the stately Darwinian tree of life in which each branch represents a lineage and the organisms in each lineage slowly adjust their characteristics to the changing conditions of life (cf. Fig. 1). Standard evolutionary

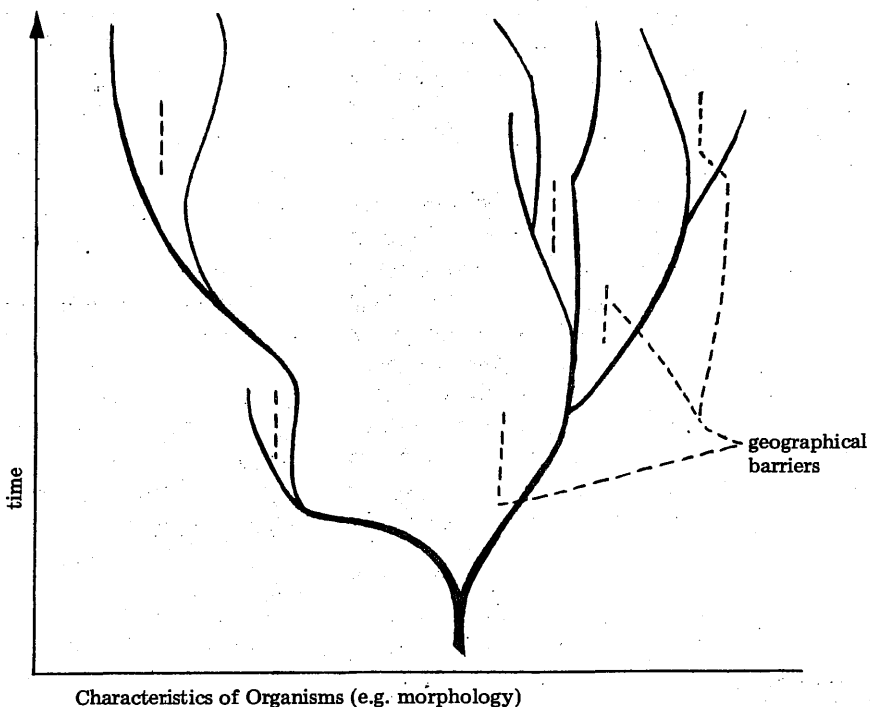


Figure 1.

A schematic version of part of Darwin's tree of life. Note that branching of the tree does not affect the rate of evolutionary change.

theories recognize two fundamental sorts of occurrences in the history of a lineage — branching (e.g., the splitting of one species into two or more independent species) and alteration of organic characteristics. Over time, the distribution of properties such as resistance to certain infections, time from birth to maturation, body size, relative size of organs, overall morphology, instinctive mating behaviors, etc., changes slowly within a population. The accumulation of such changes represents a gradual transformation or modification of the properties of the organisms in the lineage. When sufficient change has accumulated, we recognize a new species. (We also recognize species which are *not* obviously distinct in form when we find populations which, however similar in appearance, do not interbreed when they are in contact in the wild. Assuming common ancestry, the lineage to which such populations belong *must* have branched.) On many accounts, though the matter is somewhat controversial,³ orthodox evolutionary theory held that natural selection keeps organisms at least pretty well adapted to their environment. Accordingly, the rate of organic change is keyed primarily to the rate and character of environmental change so that, by and large, the rate of organic change is independent of the occurrence or rate of occurrence of branching (speciation).

In the early 1970's Niles Eldredge, Stephen Jay Gould, and others revived and developed an alternative schematic account of the history of life, somewhat awkwardly labelled "the theory of punctuated equilibria."⁴ This view, supported by fairly strong paleontological evidence, claims that most organic change occurs around the time of species formation (i.e., lineage branching). According to this view new lineages are typically founded by *extremely* small, isolated, and often aberrant populations. Thus, when a new lineage becomes established, once its organic properties are stabilized they tend to remain fundamentally unchanged (cf. fig. 2). This pertains particularly to the sorts of size and shape properties revealed by the fossil record. For example, given that the typical lifetime of a species of mammals is about three million years, Eldredge and Gould would expect to see virtually no change in the organic characteristics of the members of that species for most of that period (say roughly 2,970,000 years); *if* a complete fossil record were available, they would expect to see the species acquire its distinctive characteristics in a relatively brief period, say no more than 30,000 years. (Note that this is still approximately ten times longer than the period of recorded human history !)

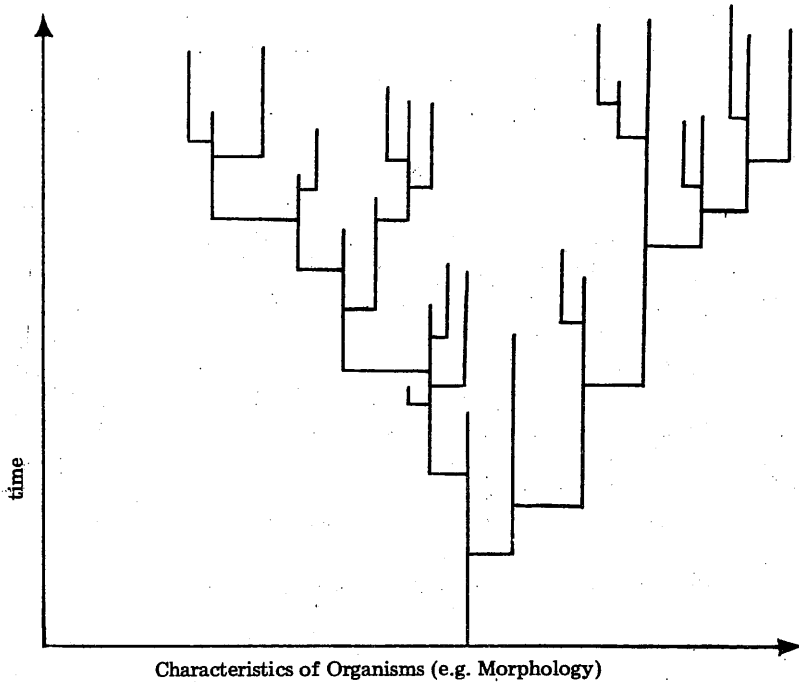


Figure 2.

A schematic version of the punctuational tree of life. Note that all (or most) evolutionary change occurs in connection with the branching of the tree.

For two reasons, however, it is unlikely that anything like a satisfactory fossil record will be available. First, according to the mechanism of species formation which Gould and his colleagues believe to be most common, new species are formed in *very small populations* occupying *marginal habitats*. If this is right (and it fits with views common to many orthodox evolutionists), finding transitional forms will require extraordinary luck. Since a very low proportion of organisms is fossilized and since (according to the theory) *far* fewer than 1% of the organisms which might be fossilized are transitional forms, transitional fossils will be extremely rare. Worse yet, when found they will not be associated with organisms from the parent species since they lived in marginal

habitats, so that it will be difficult to classify them and to establish their precise relationship to the 'parent' species. Second, unambiguous dating of fossils is a tricky business; in most cases it is a considerable accomplishment to establish a date within 50,000 years. But if the punctuatonists are right, this time scale will prove far too crude to allow one to follow the course of organic change within a rapidly evolving population. Thus the fossil record will yield mostly indirect rather than direct tests of the punctuatonist view. Still, that view is clear : on a geological time scale evolutionary history consists largely of punctuaton (rare, relatively dramatic episodes of organic change within small populations, most of which die out) followed, in populations which survive and expand, by long periods of stability in organic form (equilibrium).

This is not the place to follow the ongoing and sometimes bitter controversy over which of the two pictures just described offers a more faithful rendering of evolutionary history.⁵ But it is important to notice that the controversy in no way raises the question *whether* there is evolution. All parties to this dispute agree that there is overwhelming evidence that evolution is a fact; all of the parties subscribe to Darwin's claim that all contemporary species have evolved from previously existing species by "descent with modification." They also agree about the age of the earth (roughly 4.7 billion years), the ancientness of terrestrial life (at least 3 billion years) and of higher organisms (at least 600 million years). What is at stake, rather, are the patterns of evolutionary history (for example, the proportion of organic change occurring in close association with speciation in typical lineages) and the mechanisms by which evolutionary change is triggered and controlled. Although these disputes about tempo, mode, pattern, and mechanism are terribly important — they are the stuff of which science is made — they concern the details, not the actuality of evolution.

How do the pandas of my title enter into the discussion? Pandas are traditionally classified in the order Carnivora, family Ursidae, the same family of species as bears and raccoons. (The German name for raccoons, by the way, reflects their affinities with bears; they are called *Waschbären*, i.e., washing bears.) Not much is known about the evolutionary origins of pandas — for instance there has been considerable dispute about whether they should be considered closer to raccoons or to true bears, or whether they form an independent group derived from an independent ancestor — but the little that is known fits more comfortably with the punctu-

ationist than with the gradualist model. Pandas appear on the scene rather suddenly, clearly distinct from bears and raccoons, with no intermediates known. This is just the sort of picture a punctuationist would expect and just the sort of picture which gives the gradualist trouble. (The latter can, of course, reply that pandas have always lived in regions which have not yet been thoroughly explored for fossils, have always been rare, and are seldom fossilized, so that the appearance of punctuation in this case, like many others, is a consequence of an inadequate fossil record.)

Enter the creationists. They treat the problem of the panda (and many like it) as raising the question whether evolution has occurred. To make their point, they identify *evolution* with *evolution by natural selection* and the latter with *classical Darwinian gradualism*. They then correctly point out that scientists seem to be showing that the classical account of evolution by natural selection is wrong, that Darwinism is in serious trouble. However, instead of treating this as what it is — namely an argument against one version of gradualism within the Darwinian tradition and not an argument against all forms of Darwinism — they treat it as an argument for the distinctness of static natural kinds, *created* kinds with no evolutionary histories.

Although I am picking on a single instance (I'll give one more below), the instance is typical. There are a great many evolutionary problems which have not been solved, a great many difficulties in reconciling data of very different sorts bearing on the age of fossil organisms, the relationship between different fossils or between specific fossils and certain living organisms, the rapidity of genetic change, and similar matters. The typical creationist criticism of evolutionary theory treats these difficulties as refuting the claim that evolution occurred. In all of the cases of which I am aware, the difficulties reveal only that certain subsidiary hypotheses are in trouble — e.g., hypotheses about the age or ancestry of some particular organisms, about specific evolutionary mechanisms, or about the actual patterns of relationships produced in the course of evolution. Difficulties of this character are of no help at all in showing (or trying to show) that evolution has not occurred.

Further information about the panda illustrates the weakness of such creationist interpretations of evolutionary disputes. I am drawing on the opening essay of Stephen Jay Gould's delightful book, *The Panda's Thumb*,⁶ the first three essays of which are devoted to the imperfections and oddities produced in the course of

evolution. These oddities, one of which is the human appendix and another of which is the panda's thumb, often reveal more about the origin of a feature (and hence of the whole organism) than the seemingly perfect adaptations which a superhuman engineer — or God — might have designed. Virtually all mammals have five digits on their limbs, though in some cases the digits are rudimentary and can be found only by careful examination. The panda is unusual in that, in addition to the usual five, it has a sixth, an "extra" digit, an opposable thumb which it uses to strip the bamboo shoots which are the staple of its diet. On close anatomical examination this digit turns out not to be a finger at all, but rather an extraordinary controlled outgrowth of one of the wrist bones. What the "thumb" shows is that a standard feature of mammalian anatomy, a wrist bone, has been modified (more-or-less jury rigged) in a way which helps an organism perform a function — in this case, stripping bamboo. The job which the "thumb" performs happens to be quite important to the panda. But by engineering standards the thumb is a relatively poor tool for the job. Its design is good enough, but its features are best understood by recognizing that it is the product of altered development of a standard part. That is, the "thumb" has been produced by modifying a feature of ancestral organisms, it is an instance of Darwin's "descent with modification." Pandas may, in some sense, constitute a natural kind, but that in no way shows that they arose by special creation rather than speciation.⁷ Citation of work like Gould's in support of creationism without explicitly dealing with this sort of issue is not only poor science — it is also dishonest.

One of the most remarkable features of current creationism is that it almost always proceeds in a wholly negative fashion in scientific matters. That is, instead of starting from a full (or even a partial) theory from which it seeks to derive a positive account of the patterns to be expected in the history of life, it seeks out difficulties like those I have alluded to, turns them into a critique of evolutionary theory and of the claim that large-scale evolution in fact occurred, and seeks to arrive at creation of species by a process of elimination. The obvious difficulty with such a negative argument is that it supposes a false dichotomy: either life evolved in the precise manner in which orthodox evolutionary theory supposes (or is alleged to suppose — creationists don't always have evolutionary theory right), or it didn't evolve at all. The very existence of theory-based disagreements about the patterns to be expected during the

history of life, exemplified in the controversy over punctuatedism, shows the inadequacy of negative arguments like those of the creationists for their larger purposes. Piecemeal negative arguments about single cases cannot show that large-scale evolution of new forms has not taken place.

Am I being fair? Let me illustrate the point briefly by referring to a technical example exploited by the creationists. The example concerns the evolutionary transition from reptiles to mammals. I shall discuss two of Duane Gish's arguments⁸ purporting to show that there was no such transition.⁹ One of the arguments is that all the relevant fossils are distinctly mammals or distinctly reptiles, i.e., that there are no mammal-like reptiles or reptile-like mammals, that what we have here are distinct kinds between which there is no transition. Here the false dichotomy is between being wholly mammalian and wholly reptilian. Paleontologists use certain criteria (bone structure of the middle ear and jaw mechanics for example) in such a way that they can *define* each relevant fossil as belonging to one group (reptiles) or the other (mammals), but whether certain fossils belong to one group or the other depends on which characteristics one takes to be definitional. The various characteristics of the fossils *do* exhibit transitions (though not always smoothly or simultaneously), so that some organisms classed as reptiles are, indeed, highly similar to others classed as mammals. This fact is not altered by human decisions which, once made, require us to classify each organism definitively as a reptile or as a mammal. And the available evidence indicates that similarity and transition are real phenomena. (Cf. Kitcher for references and further details.)

Another of Gish's arguments picks on certain details in the fossil record, attempting to show (wrongly as Kitcher argues) that the transition in question requires a nearly impossible mechanical alteration of the jaw mechanisms of the relevant reptilian organisms, an alteration for which (supposedly) the fossil record provides no evidence.

Without entering into the factual details (about which Gish is straightforwardly wrong),¹⁰ it should be clear that even if this particular argument were sound, it would not in the least undermine the central body of evolutionary theory. Unless it were conjoined with hundreds, no thousands, of similar arguments showing that all (or virtually all) of the well documented fossil transitions are spurious, it would have no general force whatsoever. And even then, without a positive, independently supported alternative to

evolutionary theory, the massed arguments would tend to justify a weak form of scepticism regarding evolution rather than some particular creationist alternative.

The lack of a well-developed creationist theoretical biology is therefore of great importance. I will return to it soon. But first I shall step back from my argument to articulate a moral bearing on my claims that "creation science" requires such a theory if it wishes to be taken seriously and that it is a serious error to treat creation science as unfalsifiable rather than treating it as falsified.¹¹

Judge William Overton's ruling in the so-called Arkansas creationism trial accepted five criteria for a body of claims to be classified as belonging to a science. Two of these, closely related, are of immediate interest : the claims of a science must be testable and falsifiable.¹² *But if falsifiability means 'definitively falsifiable by a single test', no major scientific theory is falsifiable.* Neither Newton's mechanics nor Darwin's theory, nor the current genetical theory of evolution are thus falsifiable. Because the derivation of testable consequences from major theories requires the use of auxiliary hypotheses, additional theories, and so on, no single test can decisively isolate a single theory, no single test can test just one theory by itself. Indeed, since *all* relevant background assumptions can land us in difficulties, no small number of tests, perhaps no finite number of tests can absolutely falsify a major theory. *Testing and falsification of theories are cumulative social processes in which alternative ways of explaining (or explaining away) difficulties are explored at considerable length. And a theory is falsified when, after full and proper consideration by the expert community, it is shown beyond reasonable doubt that it does not fit the facts as well as a developed alternative theory.* (Even then, as in case law, the matter can be reopened on the basis of new findings.) It is not enough to show that a theory is in serious difficulty; one must also show, on grounds of a better supported alternative account, what has gone wrong.

This helps to articulate the importance of putting forward a positive theory. In order to overthrow a major theory, one must show not only that that theory is in trouble, but also that some alternative theory does better in explaining the full panoply of available facts, measurements, hypotheses, and tests — and that it does so in detail. The relevant standard of success requires that the theory, explanations, hypotheses, facts, measurements, and so on *all* withstand the critical scrutiny of those who are trained to scrutinize

such claims, including (but not restricted to) scientists in the immediately relevant disciplines.

Thus claims that creationists are dogmatic or that they are religiously motivated are *not* serious criticisms of the scientific status of their views. What is decisive is their isolation from the life of science, from the gathering, development, and testing of relevant evidence, hypotheses, and theories. As Judge Overton found in his decision, in spite of repeated prodding “no witness [for the defence] produced a scientific article for which publication had been refused” (IV C, p. 939), “not one recognized scientific journal... has published an article espousing... creation science” (IV C, p. 939), and, when challenged to produce scientifically respectable materials suitable for classroom use from the open scientific literature, “the defendants did not produce any text or writing... which they claimed was usable in the public school classroom.” (IV D, p. 941)¹³

Let me return to the interpretation of falsifiability in order to show that, by a reasonable standard, numerous creationist tenets are not only falsifiable, but also thoroughly falsified. On the above account of the process of falsifying a theory, one cannot merely examine a theory (or its logical structure) to determine whether or not it is falsifiable. One must also consider the field of competing theories and the sorts of evidence available, with appropriate investigation by means of which the competitors can be evaluated. Even without a full elaboration of creationist theory, it is not hard to set forth a comparison with evolutionary theory. As the next four paragraphs show, in the absence of dramatic new evidence such comparison reveals that the central tenets of “scientific creationism” are falsified.

What claims are crucial to scientific creationism? I think that we can settle for three, all inspired by a particular reading of the Bible:¹⁴ (1) all species coexisted at one time, (2) life (and indeed the planet earth) is a recent phenomenon as compared with the orthodox geological time scale — say less than 50,000 or 100,000 years of age, and (3) *the* (or at least *a*) major cause of the immense amount of extinction shown by the fossil record was a global flood, the Noachian deluge referred to in the Bible. It is these claims which, I insist, far from being unfalsifiable are thoroughly falsified.

To be clear about my assertion: in terms of logic (1) — (3) are entirely respectable claims. Nor can one logically deduce their falsity from a careful statement of the available evidence. (After all, it is logically possible that the world was created ten minutes ago

with each of us having the memories of an entire lifetime, with rocks already weathered and bearing the scars which provide evidence of the existence of glaciers millions of years ago, in short with all the traces of a pseudo-history. But should we take such a possibility seriously? To do so is to make all evidence irrelevant, to deny that one can use traces and memories to reveal the character of the past. To accept such hypotheses is to give up all pretence of science — and the rational use of evidence as well.) What I assert is that *if the evidence is allowed to speak* (which scientific creationism must allow it to do), it tells overwhelmingly against the truth of claims (1) — (3). There is no reasonable doubt but that they are false.

Obviously I cannot rehearse the full evidence (or even a significant fraction of it) here. The best I can do is to remind the reader how massive and how varied it is and, especially in light of the immense diversity of considerations involved, how uniformly it points to the falsity of all three of the claims in question. To this end I shall mention just a few kinds of evidence, trusting that the reader will be able to supplement appropriately. All three claims are subject to physico-chemical, geological, and biological tests (among others). For example, chemical tests of certain rocks shows that they were formed in the absence of atmospheric oxygen. All indications from investigations of the solar system and its planets support the view that there was no free oxygen on the primordial earth. A careful inventory of the sources of free oxygen supports the claim that free oxygen in the atmosphere derives primarily from the oxygen released in photosynthesis. A careful examination of the maximum rates at which one-celled organisms and plants can release oxygen shows that the process of supplying the atmosphere with oxygen requires millions of years.

Other evidence concerns the thermodynamics of the earth and the solar system, chemical decay process in rocks, radioactive decay processes in rocks, and the sheer magnitude of fossil-bearing strata (which are several thousand feet thick, for example, in extensive sections of South America). Similarly, there is the concordance of geological and biological evidence to show that one-celled (but not many-celled) organisms existed a billion years ago, that first plants, then animals colonized the land, that trilobites were extinct before dinosaurs flourished and that dinosaurs went extinct before there were any large primates. Again, there is massive evidence that birds and mammals are the descendants of different reptilian lineages, that

insects and crustaceans had common ancestors, that bony fish gave rise to amphibians, and so on. Nor is all of the evidence paleontological in character. In addition to the evidence of traditional comparative morphology (cf. the panda's thumb), there is also evidence from molecular biology. For instance, studies of variant forms of proteins common to widely differing organisms (such proteins as the cytochromes) reinforce the picture whose bare bones were sketched above. And in tracing the amount of change a protein has undergone in different lineages, it is often possible to establish independent estimates of the rates of divergence of the molecular structures in question. Once again, these estimates fit very nicely with the evolutionists' picture and differ totally from that of the creationists.

But enough ! The equivalent of a dozen college courses would be required to complete a thorough sketch of the evidence against claims (1) — (3). And this mass of evidence, drawn from many independent sources, is uniform and concordant. (1) — (3) are as thoroughly falsified as anyone could reasonably ask. And any creationist retreat which protects them against this massive evidence (as opposed to a massive confrontation with new evidence or a theoretically-grounded reworking of the total body of evidence, preserving the degree of concordance), while making the claims in question unfalsifiable, also gives up on the scientific enterprise. Given the commitment of would-be scientific creationism to these and allied claims, the verdict must be that "scientific creationism" is a congeries of falsified claims.

But why is it important that the central claims of scientific creationism are falsified rather than unfalsifiable ? Because the difference is the key to showing that creationism, punctuationism, and gradualism are not on a par. The point is particularly important in light of the damage that has been caused by the traditional, overly simple account (or criterion) of falsifiability. (Recall that according to the traditional criterion, a theory is falsifiable if and only if a straightforward evidential test can once and forever refute it, i.e., demonstrate that it is false.) For if this traditional criterion is taken seriously, creationism, punctuationism, gradualism, the entire theory of evolution by natural selection, and Newtonian mechanics are all on a par in that they are all equally unscientific. This is not an argumentative tool which should be handed over lightheartedly to the creationists (or any other obscurantists, for that matter).

But as my sketches of punctuationism, orthodox gradualism,

and creationism have shown, the three are *not* on a par in this respect. Unlike creationists, both punctuationists and gradualists have elaborated their theories in ways which permit and encourage (indirect) tests of those theories. Unlike creationists, punctuationists and gradualists are thoroughly engaged on numerous research fronts — elaborating and testing hypotheses, seeking out new facts and new classes of facts relevant to their expectations, testing the reliability of their results and the concordance of those results with others' results. Unlike the creationists, punctuationists and gradualists are led to open up new research fronts on the basis of particular elaborations of their own positive theories. And finally, unlike creationists, punctuationists and gradualists do not presuppose or maintain the truth of a central body of claims which are massively falsified by carefully developed evidence drawn from hundreds of independent investigations yielding an overwhelming preponderance of concordant evidence.

It has not escaped my notice that the specific weaknesses in the standard arguments against creationism suggest the need for radical improvement in science education and in the public's — and scientists' — understanding of the nature of the scientific enterprise.

ACKNOWLEDGEMENTS

This essay is a revised version of a lecture delivered at Drexel University, Philadelphia, PA, in September, 1982. I am grateful to Lindley Darden for discussion of parts of an earlier draft of this paper and to friends too numerous to mention for sharing their views on this general topic with me.

NOTES

¹The decision, dated 5 January, 1982, is reprinted in its entirety in *Science* 215 (1982): 934–943. Cf. esp. section IV C. Hereafter I will cite Judge Overton's opinion both by section number and by page number in the reprinting in *Science*.

²There are many standard accounts of orthodox evolutionary theory. Among the better are John Maynard Smith, *Evolution*, 3rd ed. (London: Penguin, 1975) and Ernst Mayr, *Animal Species*

and Evolution (Cambridge, Mass.: Harvard University Press, 1963).

³Some of the controversy over the precise content of orthodox evolutionary theory is reflected in S. J. Gould, "Is a New and General Theory of Evolution Emerging?" *Paleobiology* 6 (1980): 119–130, S. H. Orzack, "The Modern Synthesis is Partly Wright," *Ibid* 7 (1981): 128–131, and S. J. Gould, "But not Wright Enough: Reply to Orzack," *Ibid*: 131–134.

⁴First proposed by Eldredge and Gould in 1972, this viewpoint is nicely set forth by Gould in "Punctuated Equilibrium — a Different way of Seeing," *New Scientist*, 94 (1301) (15 April, 1982): 137–141. Cf. also Stephen Stanley, *The New Evolutionary Timetable* (New York: Basic Books, 1981).

⁵I discuss this controversy in a draft manuscript "On Some Recent Controversies Concerning Macroevolution."

⁶New York: Norton, 1980.

⁷Some creationists, in support of their claim that organisms fall into sharply distinct natural kinds, have stressed the importance of punctuationalist arguments. It is true that punctuationalism, if true, tends to make the temporal boundary between one species and another less arbitrary than gradualism. However, this in no way supports the following ideas: that there is a limited number of kinds of organisms, that such natural kinds were created by supernatural means, or that they were created simultaneously. Whether punctuationalism makes species out to be "natural kinds" in any stronger sense than orthodox evolutionary gradualism turns on esoteric biological and philosophical questions which, fortunately, lie beyond the scope of this paper.

⁸Both found at p. 85 of D. T. Gish, *Evolution? The Fossils Say No!* (San Diego: Creation-Life Publishers, 1979).

⁹The case and Gish's arguments are more fully discussed in Philip Kitcher's excellent book, *Abusing Science: The Case Against Creationism* (Cambridge, Mass.: MIT Press, 1982), pp. 106–117.

¹⁰There are, in fact, fossils which show how the transition from a reptilian to a mammalian jaw joint took place, described for example by A. W. Crompton and P. Parker "Evolution of the Mammalian Masticatory Apparatus," *American Scientist* 66 (1978): 19–201. Furthermore, as these authors point out (p. 192), baby kangaroos are born with a reptilian jaw structure and make the transition to the

mammalian structure while living in their mother's pouch. This dramatic instance of the recapitulation of part of the early history of the mammalian lineage, together with the fossils exhibiting transitional jaws, totally undermines Gish's detailed claims about the impossibility of, and the lack of evidence for, such a transition.

¹¹In Section IV C of his opinion, Judge William Overton, reflecting the testimony of the plaintiffs, argues that creationism is unfalsifiable. This appears to be the dominant view of the scientists who have published on this subject.

¹²Much of the remainder of this paper has been influenced by a prepublication draft of Larry Laudan's "Science at the Bar — Causes for Concern," *Science Technology and Human Values* 7 (1982): 16—19. This article, together with the Overton decision and a great deal of useful material has now been reprinted in Marcel C. La Follette (ed.) *Creationism, Science, and The Law* (Cambridge, MA: MIT Press, 1984). Laudan and I arrived at our general views regarding the importance of the falsification of the central tenets of creationism independently of one another.

¹³At this point in his opinion, Judge Overton adds the following footnote: "The passage of Act 590 apparently caught a number of its supporters off guard as much as it did the school district. The Act's author, Paul Ellwanger, stated in a letter to 'Dick' (apparently Dr. Richard Bliss at ICR [the Institute for Creation Research]): 'And finally, if you know of any textbooks at any level and for any subjects that you think are acceptable to you and also constitutionally admissible, these are things that would be of *enormous* [use] to these bewildered folks who may be caught, as Arkansas now has been, by the sudden need to implement a whole new ball game with which they are quite unfamiliar'".

¹⁴There are other central tenets to which creationists adhere strongly which are amenable to similar treatment — for example, the claim that the individuals of a species do not vary enough to allow transformation of organisms from their lineage into organisms belonging to a new species and the claim that man is not descended from non-human primates.