

Critique of “Intelligent Design” (ID)

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Purpose

This paper provides a critique of Intelligent Design (ID)—the claim that evolution is inadequate to explain some of the structures of organisms as well as the phylogenetic patterns of the species that we observe on Earth, and that therefore a designing intelligence was required to produce them. This paper provides a summary of the objectives, tactics, and arguments of ID advocates and responses to their arguments by biologists. I hope that it will provide high school biology teachers, school administrators, and members of the public with information which will be helpful in understanding the fallacies of major ID claims as well as in answering arguments which ID advocates often make.

Outline

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Preamble

Science is concerned exclusively with the natural world; it does not, cannot, and should not deal with any part of a supernatural world. Stephen J. Gould called these two worlds, the natural and the supernatural, “The Two *Non-Overlapping* Magisteria” [my emphasis].

Most people who are now advocating **intelligent design** (ID) claim that only the operation of an intelligence could have brought about the functional complexity which is observed in today's living organisms. Their requirement of an intelligence which is neither observable nor testable, but which nevertheless operates on the natural world, results in the entangling of the natural and the supernatural. Both M. Behe (Ph.D. in biochemistry) and W. A. Dembski (Ph.D. in mathematics and philosophy, and masters degree in theology), who clearly are major leaders in this area, claim a requirement for an intelligent designer (although in slightly different ways). These two men have written books and articles about ID, and participate in active lecture and debate circuits. Along with Behe and Dembski, there are a number of others who also speak and write extensively in support of the overall idea of ID, usually under the umbrella of the Discovery Institute, a west coast organization with considerable financial and other support from the religious right.

They (and others supporting this view) appear to hope that some central aspects of their concept of this supernatural entity will override some of the science that represents the empirically based view of the natural world.

In public, especially in meetings which include people they know to be interested in science education, they refer to an intelligent designer but are willing to specify little about that entity. If pressed, some will admit that although it might be God, it also could be very advanced aliens or Raelians, presuming that, by this dodge, they avoid bringing in the supernatural (religion). Invoking either aliens or Raelians, however, is a smoke screen which simply takes us back a step to ask: Who or what is the intelligent designer who/which designed the aliens or Raelians?

Most religious organizations in our country accept that the up-to-date theory of evolution is a reasonable description of how the variety of organisms that we see on earth got to be the way that they are. They (and this includes many scientists) have a deep and serious belief in the supernatural nature of their God, but they do not find that this interferes with the acceptance of a naturalistic process as the producer of the living plants and animals that we see around us. On the other hand, those committed to ID find that the science expressed by the theory of evolution is particularly distasteful, apparently largely because it ignores any need for a designer. Therefore, they attack it most vigorously.

Because of the requirement in this country that church and state be kept separate in our public schools, these people, the neocreationists, generally will not directly admit that what they are doing is actually an attempt to bring an untestable hypothesis into schools (mostly via textbooks). Instead they take two approaches: 1. To weaken the presentation of evolution in the textbooks, and 2. To (eventually) add some consideration of

intelligent design, while denying its *de facto* religious aspect, into those textbooks (as a parallel and competing theory to that of naturalistic evolution).

In the literature of their own organizations, away from the view of the general public, they say and write that their explicit goal is to introduce religious supernaturalism into our schools. They have made no headway within the scientific community, thus their strategy is to target the public at large and politicians in particular, and to affect high school biology teaching in the process. They are very skillful in public relations and in their use of the media to do this.

In some parts of Texas, addition of ID to the curriculum is already being attempted through public relations, and political and parental pressure by ID activists. Later, this article provides critiques by active research scientists of some of the erroneous arguments that these people are using.

In response to pressures applied by a small group of ID activists (and strongly opposed by the scientific community), in August of 1999, the State Board of Education of Kansas voted to remove consideration of the “big bang”, the age of the Earth, and any reference to descent from common ancestors (which really meant biological evolution to them) from state requirements of subject matter to be covered. They also dictated that future statewide exams in science would not include any questions on biological evolution.

This resulted in major criticisms from most of the press and all of the scientific community; in addition, several large corporations canceled plans to set up some new operations in Kansas. These corporations would not accept an educational system so degraded. This board of education decision was rescinded in 2001, after some of the members who had pushed hardest for it were defeated in the next election.

In Texas, where high school biology textbooks are now being considered for adoption, the short-term goal of the neocreationists is to convince the elected State Board Of Education (some members of which are neocreationists) to provide a more “fair and balanced” presentation of evolution. Some particularly want more consideration of what they call the “weaknesses” of evolution included in the books.

Neocreationists also almost succeeded in getting the Santorum amendment, which supports the teaching of ID, inserted into the federal No Child Left Behind Act of 2001. While removed in conference and not included in the Act, it is nevertheless in the official records of the Senate and is being used by some ID people in their attempts to get ID into schools and textbooks.

In another approach, some neocreationists are encouraging people in local communities to complain about the high school science textbooks that their children are using, and especially about various aspects of the theory of evolution as it is discussed in those books. This produces community pressures on high school teachers and administrators. In some areas, this pressure has produced a measurable reduction in the attention paid to evolution in biology classes. Not only does this short change the students, but it also increases the difficulty they will confront when they attend college. I have seen unmistakable evidence of this in my over 40 years of teaching biology at The University of Texas at Austin.

In addition, these neocreationists work to elect people who share their anti-evolution views, and, in a number of instances, the voting public is unaware of these candidates’ stance (they are

sometimes called stealth candidates).

Neocreationists are aware that most of the textbooks used in science classes in Texas are both pretty good in explaining the theory of evolution and in providing the empirical evidence and the scientific method which supports it. In addition to their attempts to discourage discussion of this theory within local classrooms by encouraging parents and students to complain to teachers and school administrators, they also provide susceptible parents and children with “scientific” questions to ask teachers and administrators. These questions are often worded in rather challenging terms, and if the teacher does not immediately have a really good answer to some “bolt out of the blue” question (which may be timed such that it bears little relationship to what is being discussed in the class), it undercuts the authority of the teacher and the quality of the educational process. This kind of pressure and challenge is especially difficult for the many teachers in this state who have been put into biology classes even though their training in this discipline is limited. Inevitably, it cheats the students and makes teaching more difficult for the teachers.

Jonathan Wells, who has written an error filled book, *The Icons of Evolution*, (parts of which will be critiqued below) has provided a set of ten such “out of the blue” questions. These questions, along with answers developed by biologists, can be seen in the article “Responses to Jonathan Wells’s Ten Questions to Ask your Biology Teacher” by Alan Gishlick of the National Center for Science Education (NCSE); this article is reprinted in the appendix below. It also can be found on the web at: <http://www.ncseweb.org/resources/articles/>

The NCSE is a national organization of scientists and others dedicated to helping to improve science education in America. They perform an exceedingly valuable service, and I urge you to use their outstanding website (www.ncseweb.org). Other articles at the NCSE website provide extremely valuable resources of information about creationist efforts and questions, as well as correct and effective counters to what the neocreationists say.

Neocreationists, in general, do not attempt to convince scientists who study evolution of the reality and value of ID because their attempts in the past have failed so miserably. The primary reason for this failure is that the neocreationists do not use the scientific approach of acquiring empirical evidence about nature, and then proposing logical hypotheses (which are open to falsification) based on these data (along with data and ideas of others).

Biological Evolution

Biological evolution, because of its explanatory, integrative, and predictive powers, is accepted and used by the vast majority of practicing biological scientists today. This theory of evolution adheres to the fundamental requirements of science:

1. It is comprised of a set of logical, explanatory hypotheses which have been constructed using data from observations of the natural world (observations which can be repeated by others), and,

2. It, and its parts are testable and open to falsification through the use of additional or better empirical data (and then may be replaced by better hypotheses based on these additional data and/or better logic). This testing, with the potential for falsification and replacement by a better, data-supported explanation, is another way of pointing out one of science’s strongest characteristics – science is self-correcting.

NeoDarwinism, as I use the term, refers to the entire current contents of modern evolutionary theory, with its important components of geology, chemistry, biology, and other fields. These include many recent pertinent developments, which are now integral parts of this theory, some of which were mostly, if not totally, unknown during Darwin's time. Entire fields have developed since his day, including, the often overlapping areas of cell biology, genetics, genomics, several branches of molecular biology, evolution-development (evo-devo), and so on.

A Summary of the Arguments

A small and excellent set of brief articles which summarize a few of the most important disagreements between neocreationists and neoDarwinists can be found in *Natural History*, the magazine published by the American Museum of Natural History. The April 2002 issue of this magazine provides three short articles, one by each of three major leaders of the ID movement, and a reply to each of these by a scientist who is a major player in the fight against the adoption of ID and the weakening of the coverage of evolution in school textbooks. In addition, there is an introduction by senior editors of *Natural History*, and also a telling final comment by a philosopher-historian. This set of articles can be found at the website: <http://www.actionbioscience.org/evolution/nhmag.html> and also at the website of the National Center for Science Education at <http://www.ncseweb.org/resources>

Intelligent Design (ID) - General

ID is not science because:

- 1. Its core conclusion (a designing intelligence) is not based on empirical data.**
- 2. Its core conclusion (a designing intelligence) is not testable (falsifiable). Therefore, it is not open to the self-correcting mechanisms that must be available within any science.**

It is clear that the proponents of ID want to destroy Darwinism and bring religion into science. They express this in different ways: Dembski writes, "As Christians, we know naturalism is false. Nature is not self-sufficient;" Wells says that he wishes "to devote my life to destroying Darwinism;" and Behe says, "I am hopeful that the scientific community will eventually admit the possibility of intelligent design..." Behe provides only this modest hope in things that he has written (and I have seen), although he has been reported to say that he believes the intelligence of ID to be God.

The three men just quoted are Fellows of the Center for the Renewal of Science and Culture, now sponsored by the Discovery Institute. An early mission statement of these organizations includes the stated goal of "nothing less than the overthrow of materialism and its damning cultural legacies." The political and public relations thrust of this (which they call their "Wedge" strategy) "aims to 'renew' American culture by grounding society's major institutions, especially education, in evangelical religion." (Forrest, 2002)

The Discovery Institute people are smart, well-funded, and have very well-developed political connections. Their activities in Kansas, Michigan, Ohio, Texas, and other states have made headlines. As outlined above, in 1999, they succeeded in getting the Kansas Board of Education to remove references to evolution in the list of required content of textbooks. The activities of these

people pose very serious dangers to the teaching of "naturalistic" science (as if there were any other) in public schools, and could lead to adoption of ID into the curriculum if we are not vigilant, effective, and forceful in opposing them.

Intelligent Design (ID) - Specific

ID people do not do research for data to support their arguments, instead they use, and sometimes abuse, several arguments and probability calculations in attempts to show that evolution can not happen (except in "small and minor" instances such as the evolution of antibiotic resistance in some bacteria). They use these arguments mostly to sway the public (non-scientists); they have been unsuccessful with most scientists, and especially unsuccessful with biologists who know of the immense amount of data which supports neoDarwinism.

In the nearly 200 years since William Paley wrote "Argument from Design," with his conclusion that only a designer (God) could have produced the organisms observed on Earth, other creationists have come up with arguments, some new and some old, to support their claims that neoDarwinian evolution cannot explain the complexity of life now on earth.

Stripped to its essence, the modern claim of the neocreationists comes down to their assertion neoDarwinian evolution could not have produced the organisms that we see. However, because we do see these organisms there must be an alternative, and because it could not be simple chance alone along with the laws of physics, it must be the only possibility that remains – intelligent design.

This kind of claim is contrary to science – science never finds "the *only* alternative model". Instead it is always open to the development of additional evidence that could lead to other possibilities. Science is open-ended in this way, ID is not. In addition, the ID alternative, the theory of an intelligent design(er) is not testable (falsifiable) as no direct empirical evidence can be obtained to provide such a test. ID relies on the supernatural; science relies on natural, empirical evidence.

An older approach, and one some still use, is essentially: "I don't see any way that it could have happened – you've got to show me." Then they say that there are still gaps in the evidence, and sometimes bring up a challenge such as; "You say that whale's ancestors were once terrestrial - show me the transition fossils." The problem with this challenge is that often, and sometimes almost immediately, the requested evidence is discovered and reported on (as it was with the whales – with three different examples). Then there was more evidence supportive of evolution. The still older argument, "I can't imagine how the organisms observed on Earth could be produced by naturalistic processes," is weak enough that it is little used any more.

In 1996, Behe wrote his book, *Darwin's Black Box*, in which he developed his argument concerning what is called "intelligent design" (ID). This idea was derived from earlier writing by P. E. Johnson (see Forrest, 2002, for some of the history). Johnson's idea and claim was that there are lifeforms observed in our world that naturalistic evolution, as described by neoDarwinists, cannot have produced. The core of Behe's particular claim is his concept of what he calls "irreducible complexity".

Irreducible complexity

"Irreducible complexity" is one of the central assertions of ID. It is that some of the complex subsystems observed in organisms, especially at the sub-cellular level, *in principle and in fact* cannot have been produced through any combination of the naturalistic mechanisms of mutation and natural selection. Behe (correctly) claims that these mechanisms are central to the neoDarwinian evolutionary process. He then rightly states that if these mechanisms are shown to be unable to produce evolutionary change in one or more living systems, it would mean failure of the theory of evolution. Darwin himself said this.

Then things begin to go wrong with Behe's claim. He says that, for the evolution of some living systems, a failure of this kind *will* occur because at some necessary stage of the evolutionary chain required to reach the current condition, these systems could not have been functional. And if the system can't work at all, it can't be subject to positive natural selection. In other words, in at least one of the stages required in the evolutionary construction of some system, the system simply will not work. When it does not work, it will be disadvantageous, and therefore, by evolutionary theory, it will be selected against. It follows then, Behe says, that a completed system which has this problem in one or more of the evolutionary stages leading to its present condition *cannot* be constructed by naturalistic evolution. Therefore, it must have had an intelligent designer.

Systems that fit into this category of impossibility of evolution, Behe calls **irreducibly complex**. He chooses several biological systems which he claims fit into this category, and we will return to them after we examine his main introductory selling spiel: It is his mousetrap analogy, which has been quite successful with those who are uninformed in evolutionary dynamics or philosophical argumentation. He claims that a spring mousetrap, as he defines it, could not have been constructed without a plan (intelligence) because it would not work at all until all the proper parts were put together in the proper way. He calls systems with this characteristic "irreducibly complex." He then analogizes this "irreducibly complex" mousetrap to some living systems (especially sub-cellular components), and claims that these living system components are "irreducibly complex" because they also could not have been constructed without the aid of a designer. (This mousetrap has become quite famous in some circles.)

The mousetrap

The mousetrap that Behe delights in talking about has all of the "necessary" parts in the "necessary" relationship with one another. The trap will not work if this is not true. The necessary parts he lists are: A flat wooden platform or base, a metal hammer, a spring which provides power to the hammer, a catch which releases the spring, and a metal bar that connects to the catch which holds the hammer back. He then claims that "[a]ll the pieces have to be in place before you catch any mice." This is true by his *definition*, but as Pennock 1999 (p. 267) points out, "He then switches to an *empirical* conclusion, that any irreducibly complex system that lost a part would be nonfunctional."

Behe is right in that a *superficial* examination of a mousetrap suggests that it is irreducibly complex (Pigliucci, 2002), but recall that it *was* made by an intelligence (a point that Behe emphasizes). In addition, as Pennock (1999) points out, Behe also builds constraints into his mousetrap model that are unwarranted if it is to be a reasonable analog of a biological system: The facts that

the mousetrap is much simpler than biological the systems it is supposed to analogize, that a mousetrap does only one simple thing (and there are other ways of doing that thing), and there is no opportunity for a mousetrap to "try out different variations."

And it gets worse for Behe's analogy than that. For one thing, John H. McDonald of the University of Delaware has suggested a very nice 15 stage model, which by starting with a simple bent wire, can be changed through a series of small increments into a regular hardware store mousetrap. Each stage would be able to catch a mouse, and throughout the series there is a progressive increase in the mouse catching efficiency of the device.

It is a very nice demonstration, and McDonald has it up on his website: <http://udel.edu/~mcdonald/mousetrap.html>. Not only does McDonald provide diagrams of all of the steps from a single simple bent wire up to the "complete" trap, but he also shows neat little animations which illustrate the trapping operation at each of the stages of its "evolution." This is really a site worth visiting. And McDonald makes clear that his exercise is *not* intended as an analogy of how evolution works; its intent he says is "to point out one of the logical flaws in the intelligent design argument."

Behe's weak response to this devastating example is something like "but he didn't go backwards, which is what I was talking about with my mousetrap model." But naturalistic evolution does not usually go backwards either (and does not go very far when it does). Also, in historical reconstruction, absolute certainty down to the finest detail is never possible.

In his discussion of subcellular parts, Behe talks about difficulties in the construction and operation of the flagellum of bacteria (or cilium of eukaryotes), the chemical system which produces clotting in blood, and the Krebs cycle, which is a chemical system central to cellular respiration. He claims that these, as well as many others, represent irreducibly complex systems.

A number of active research biochemists have commented on Behe's claims in these examples. They have pointed to scientific observations showing that there are many "intermediate" parts and stages of each. Also, as mentioned above, it is impossible to know every step of change which has occurred so there will always be gaps in any reconstruction. Creationists have been talking about these kinds of "gaps" for years – there is a never ending supply of them. For one example, if a fossil turns up in a gap between two other fossils in some lineage, they say that now there are two gaps!

When Behe chooses the bacterial flagellum as being "irreducibly complex," Miller points out a number of intermediates between a completed flagellum and other pertinent aspects of the biology of many bacterial cells. He cites many papers in the recent scientific literature having to do with the proteins and genes known to be important to the structure and the function of the flagellum. Surprisingly, it turns out that a number of bacteria have secretory systems which allow them to inject toxins into other cells. And the proteins of this system are "directly homologous to the proteins in the basal portion of the bacterial flagellum." What this illustrates is that this natural system contains a number of subsystems which can take advantage of the "opportunism of evolutionary process (to) mix and match proteins," and, in doing this, to produce protein assemblages which can have "new and novel functions" and perhaps better functions. (See the citation below, and a guide to Miller's website, where you can see a preprint of his paper which will be published in 2004). Miller and others have provided equivalent

discussions and information for other biochemical systems, in which striking chemical homology is observed between the “irreducibly complex” systems chosen by Behe and other systems within the cell.

In one of the more striking examples, Miller points out that “Russell Doolittle has shown how evolution duplicated, retargeted, and modified these proteins [of the digestive system] to produce the vertebrate blood-clotting system.”

We are in the middle of an information and understanding explosion in molecular and genetic biology, with new empirical information being published at ever increasing rates. Simple extrapolation from the kinds and rates of recent scientific discoveries in these areas suggests that there is an inevitability to the rapid extension of this kind of our knowledge and understanding. This clearly will include much more evidence of the kind of cross system provision of building parts and of the development of new and useful functions to which Miller and others allude.

In addition to this, there is fascinating evidence from laboratory work on the construction of subcellular elements. Surrey et al. (2001) report on their results in the development of microtubules and (cellular) motors. They have found that there is considerable self-organization in their very simple *in vitro* laboratory systems, and provide photographs of complex self-assembled microtubule structures which automatically formed in their experiments.

To return to Behe’s famous mousetrap model, problems have been mentioned concerning using a wood and metal human-constructed system as an analog of a living system. What would happen if Behe had chosen a living model which traps its prey in much the same way? Some living systems already come closer to the structure of a mousetrap than it might at first seem. All one has to do is to examine a Venus Fly Trap and the Bladderwort (both of which are very efficient, rapidly functioning, “mechanical” traps), not to mention the Sundew’s insect trapping (and digesting) leaves, the Pitcher Plant, and even the fungus which catches nematodes in nooses which it constructs. Note that the Venus Fly Trap (Slack, 1980) has essentially the same functional parts as does the mousetrap (although it is more complete than the mousetrap because it has its own nectar which functions as an insect attractant). There are several of its parts that today’s Venus Fly Trap (a result of evolutionary processes) could lose or become damaged, and the plant would still be able to catch insects. It is not difficult, however, to imagine evolution of this system to the state of supposed irreducible complexity. In parallel to this story, there are several ways in which the mousetrap could lose or have damaged parts and still catch mice; a number of people have suggested some of them.

There are several ways in which “irreducible complexity” might evolve through natural processes. Orr (2002) points out that Behe’s claim is directly refuted “in at least two ways. Both show(ed) how irreducibly complex systems could be reached via gradual, Darwinian paths. Dembski calls the first path “scaffolding”: “At each step, a part gets added that improves a structure’s function. At some point, however, a substructure might appear that no longer needs the remaining parts. These useless parts could then fall away. The key point is that the substructure we’re left with might be irreducibly complex. Remove any part *now* and all hell breaks loose.”

In addition, according to Orr, Dembski calls the second path “incremental indispensability.” Here “some part (A) initially does some job (not very well, perhaps). Another part (B) later gets

added because it helps A. This new part isn’t essential, it merely improves things. But later on, A (or something else) may change in such a way that *B now becomes indispensable*. This process continues as further parts get folded into the system. And at the end of the day, many parts may *all* be required.”

This has been a very abbreviated consideration of this problem; for more information see some of the references provided in the annotated bibliography at the end of this article (a suggestion which applies to all of the discussions provided here).

The neo-creationists in the past often have used the example of gross anatomy of the camera-type eye that humans have, claiming that this eye is irreducibly complex because all of its parts must be present before it will function. Presumably, the reason that they now use this example much less often is that biologists have pointed out to them that there are light sensitive structures of many levels of complexity, from a simple sensitive spot in the cytoplasm of some single celled organisms, to a small group of light sensitive cells in other simple organisms, and then up, with many variations, to the “complete” camera-type eyes of vertebrates and cephalopods. (There is even an eye with lens, capsule, and sensitive surface in single-celled dinoflagellates.) With all of these working models available, displaying an immense range and variety of eye morphologies, it is easy to imagine how eyes could become more and more effective through time as mutation and natural selection increased quality (because of their selective advantages). Keep in mind that even a very poor eye is much better than none.

There is another example, this one supported by data in both the fossil record and in the pattern of embryological development in mammals. It has to do with the evolutionary increase of acuteness of hearing in animals which live in air instead of water, and gives a powerful instance of structures which originally served one function but through evolution took on another completely different function.

The problem was, as some animals left the water for life on land, that the ease with which sound vibrations get into the inner ear was diminished by their movement from liquid to air as the surrounding medium. A relatively early evolutionary development produced a tympanic membrane (eardrum) which helped with the problem and is today found in amphibians, reptiles, and mammals. In a later development, two of the smaller jaw bones of the early mammals lost their function as part of the lower jaw as the large dentary bone evolved, became stronger, and in the process “took over” their previous function (and did a better job of it). These two bones which were no longer useful as jaw bones, were “released” from their function as jaw bones and could have either simply disappeared or taken on another function. What happened was that they then evolved and became an additional two small bones in the inner ear, the malleus (hammer) and the incus (anvil). They are now associated with the stapes (stirrup) which was already present in reptiles and amphibians. Together these three small bones, along with other features of the ears anatomy, provide a better than 30 times amplification of the sound which reaches the outer surface of the eardrum. In addition, hearing is improved by this development as the auditory apparatus became more effectively isolated from the noise made by the chewing actions of the jaw. This example shows how the “irreducibly complex” structure of the inner ear evolved (take one of these small bones away without replacement and deafness results). It also provides a very nice example of how structures which originally carried out one function can be “released” and then evolve to operate in a very different way to and

perform a very different function from their original one. See Freeman and Herron, 2001, for more detail.

Behe's claims about the importance of irreducible complexity in attempting to counter evolutionist's claims are countered by evidence from the natural world. As the active research workers in biological/biochemical world add to our understanding of subcellular systems, the problems that he raises, which depend (essentially) on our current limitations with respect to understanding these systems, will decrease. Scientists working in the field agree that his claims have little evidentiary support.

Complexity Specification

A related approach to Behe's ID challenge to neoDarwinism is made by William Dembski using what he calls **complex specified information**. The irreducible complexity of Behe, Dembski claims, is a special case of his specified complexity. I will briefly consider two of Dembski's approaches.

In one he plays a probabilistic numbers game that looks impressive and formidable until you realize what he is up to. First of all, in his model, he in effect isolates the various "irreducibly complex" sub-systems of a cell one from another. This is a major violation of the natural situation where sub-systems interact greatly with one another. Nevertheless, using this flawed model, Dembski then calculates the probability of all of the appropriate parts of his chosen system (a flagellum) coming together at once, by chance alone, and forming the finished product. He makes assumptions concerning the necessary number, kinds, and order of the amino acids required to produce the appropriate proteins, and then does his quick calculation. He then comes up with a probability of 10^{-1170} that chance alone could produce a flagellum. This probability is so low that the event, *as he modeled it*, would not occur, on the average, in time much greater than the age of our universe.

Therefore, Dembski claims, chance clearly won't work, and the only feasible remaining hypothesis is that the structure of the flagellum was designed by some intelligence who/which knew ahead of time what was wanted and how it would work. (Also, what about the actual production of this "artifact" (flagellum) by this designer, who is/was who/what?)

This argument of Dembski has at least two major flaws: The first is that, as mentioned, he isolates his subsystem from all of the other subsystems of the cell. You will recall, from Miller's discussion in the section on irreducible complexity, outlined above, the great importance of interactivity among sub-cellular components in the evolution of the flagellum (or other sub-cellular component).

To put this another way, the development of the various parts of a system does not depend on their simultaneous production together. Different parts often develop in different systems or subsystems, often partaking in different functions, and then they (or "twins" easily derived from them) become combined (with perhaps some changes) in such a way that they carry out some unique new structure which carries out a new and useful function. And remember that "perfection" is not needed for natural selection to occur – all that is necessary is that there is some (perhaps very small) improvement in the ability of the organism to compete and to reproduce.

In another approach, Dembski claims that explanations must invoke chance, necessity, or design. By this he means that there are three kinds of events: **a.** *random* events such as getting a heads when flipping a coin, **b.** *necessity* which includes the laws of physics which must be obeyed, and **c.** *specification*, which is

the choosing of some particular outcome(s) from a large number of alternatives, "*and doing this by foresight and not by hindsight.*"

I suspect that it is unlikely that Dembski's category of "necessity" includes chaos and the self-organization which may arise within chaotic systems (as the production of a tornado within a chaotic weather system). If he does not, his list of three kinds of events is inadequate; also, even if he does include chaos and self-organization as parts of physics, I suspect that these raise additional problems for him.

Recent scientific literature contains many peer reviewed papers which discuss this phenomenon of self-organization and its products (in addition to the paper by Surrey, et al. mentioned above in this article). The general scientific journal, *Science*, for example, contains 17 papers between 1995 and September 2003 that have the phrase "self-organization" in the title, and there are many more which discuss this process but do not have this phrase in the title.

In another part of his effort to discredit neoDarwinism, Dembski uses some other complex mathematical models, and with the results claims that evolution is formally incapable of explaining certain features of organisms. H. Alan Orr (2002) points out that this kind of claim will really make an impression, "(e)specially if this claim gets dressed up in fancy mathematics of the sort that presumably intimidates biologists but snows the general reader." Orr goes on to say: "this is precisely how Dembski dresses his claims. Borrowing results from computing theory – the so-called No Free Lunch theorems, Dembski claims to prove that Darwinism is utterly impotent before organismic complexity. Hence a designer. Unfortunately (for him) Dembski's proof has nothing whatsoever to do with Darwinism and his claim to the contrary [is completely wrong]."

The argumentation becomes too elaborate and drawn out to include here, so I will only provide a few small pieces to give the flavor of its content (for more see Orr, 2002, and also see Pennock, 2002, for a somewhat different but no less critical analysis).

In addition to all of this, the "complexity specification" of Dembski has an additional problem when applied to the process of evolution. According to Dembski (2002), "Intelligence leaves behind a characteristic trademark or signature – what I call 'specified complexity.' An event exhibits specified complexity if it is contingent and therefore not necessary [by the laws of physics], if it is complex and therefore not easily repeatable by chance, and if it is specified in the sense of exhibiting an independently given pattern...The important thing about specifications is that *they be objectively given and not just imposed on events after the fact.*"

My question here is: How does one choose some objective specification (morphological, chemical, or other target) *before the fact* for living organisms?

Specified complexity, claims Dembski, exists in organisms, and that chance and necessity (laws of physics) are insufficient to produce that specified complexity in organisms (and, therefore, there needs to be room left for design). The problem with this, as Orr points out, is that for specification (as in Dembski's quote in the last part of the preceding paragraph) there must be a previously specified target or set of criteria to be met. *However*, in natural selection, the only thing that counts is relative reproductive success. There are no long term goals. To put it simply, I (my line) will win if I have more kids than you do. Evolution does not have a goal. If an organism happens to be especially successful in its reproduction compared to its competitors, its genome will play a greater role in fashioning future members of the species population.

Physicist Tanner Edis (2001) also examined Dembski's extensive mathematical (and logical) arguments and found fundamental flaws in how they were applied. He agrees with Orr and others that Dembski's analysis does not, in spite of his claims, have any negative impact on the neoDarwinian theory of evolution. Edis ends his paper saying: "Confronting the information-based arguments of ID is especially helpful in revealing how profound an idea evolution is. As ID proponents suspect, Darwinian thinking is not confined to biology; it anchors a naturalistic understanding of all complex order, even including our own intelligence. Hence, today, Darwinism is central to a thoroughly naturalistic picture of our world...Defenders of evolution can now allow themselves a wry smile. Intelligent Design is as close to respectable as anti-evolution intuitions are likely to get, and Dembski has made a good stab at making ID rigorous. And what we end up with is a Darwin detector."

There are other places where Behe's and Dembski's suggestions can be shown to be wrong, but space constraints will not allow further exploration of their faults. There is a lot more in the literature which is cited below. However, of the many scientists who have criticized the ID claims, Kenneth R. Miller of Brown University has written what may be a couple of the most accessible (and relatively short) anti-ID arguments, especially concentrating on subcellular systems. You can access them on the web at: <http://www.millerandlevine.com/km/evol/design1/article.html> <http://www.millerandlevine.com/km/evol/design2/article.html>

These discussions concentrate on the biochemical and flagellar arguments of the ID people and do a wonderful and very understandable job of showing why they are wrong.

Some of Wells' Claimed Weaknesses in Textbooks

In *Icons of Evolution*, Jonathan Wells lists a large number of what he calls "weaknesses" of the modern theory of evolution and its presentation in high school biology textbooks. If one includes awkward and poorly worded statements, he is very occasionally correct – some textbook accounts should be better. Most of the time, however, he is talking about something that he appears not to understand or appears to wish to confuse the reader about (with respect to the Neo-Darwinian theory of evolution).

Wells is a fierce anti-evolution activist, and frequently misinterprets, for the sake of supporting his anti-evolutionary argument, what some evolutionary research scientists have written. For example, in his testimony about textbooks before the Texas State Board Of Education on June 9, 2003, David Hillis, a very highly respected evolutionary biologist, pointed out this about one of Wells' discussions of what he, Hillis, had published in the scientific literature: "My son's high-school biology teacher first pointed out to me that Jonathan Wells quotes me extensively in his book *Icons of Evolution*, implying that I do not think that the concept of homology can be applied to molecular biology, a point which he then uses to dismiss molecular studies of phylogeny. In fact, those quotes are taken completely out-of-context from a chapter in which I discussed exactly the opposite point: namely that all of molecular biology can be understood only in the light of homology, and that the phylogenetic relationships among all living organisms are clearly recorded in the genomes of those organisms. No one could have read my writings and thought that I supported Wells' argument, and yet he presents my quotes as if I had. His arguments are clearly meant to confuse and misinform the public, not to inform them of the scientific literature." (This is from the official record of the

hearings). For Hillis' full [brief] text, as well as for other testimony given to the SBOE, go to: <<http://www.tea.state.tx.us/textbooks/adoptprocess/index.html>>

With the above as context, I will briefly examine four of the "icons" that Wells attacks, and rely on the analyses of submitted biology textbooks presented to the Texas State Board Of Education (SBOE) in the spring of 2003 by scientists actively carrying on research in their fields (see citations below).

The Discovery Institute is an anti-evolution think tank of which Wells is a leading member. A number of its members presented critiques of the textbooks at the SBOE hearings, critiques which were largely based on Wells' *Icons of Evolution* (published in 2000); the 4 topics which they have most strongly attacked are considered below:

1. The Miller-Urey experiment was a breakthrough experimental approach to the origin of life, and has been the stimulus for a number of later experiments (variously designed to be somewhat different, and which are reported on in the more recent literature). Miller, in 1953, used an electric spark in an atmosphere of H₂, CH₄, NH₃, H₂O and demonstrated the abiotic production of amino acids. Wells is correct when he claims that the early atmosphere of the earth was different (less reducing) than that which Miller used. However, he is wrong in his claim that when atmospheres closer to what we now believe existed on the early earth are used, the experiments fail. What actually happens in an experiment depends on the kinds and relative amounts of the initial materials, the conditions (pressure and temperature, for example), and on the experimental energy source. In many experiments since Miller's groundbreaking contribution, whatever the experimental conditions (within a wide range of estimated possible early atmospheres), organic molecules (almost always including amino acids) were produced.

2. The Cambrian explosion is the phrase used to describe a rapid increase in the number of fossils and kinds of fossils found in rocks of the early Cambrian around 560 million years ago. Neocreationists claim that the various groups of organisms appeared in the fossil record over much too short a period for evolution to have produced them, and that the pattern of the appearance of the various groups is counter to what evolution would have produced. However, according to geology professor Long's testimony, which he provided for the September 2003 hearings of SBOE, this "so called explosion" took at "least 50 million years, possibly much longer". (Professor Long is a highly regarded geochronologist at The University of Texas at Austin.) Furthermore, he added, "it was an explosion of fossil preservation, not necessarily an explosion of other aspects of life's development." He goes on to point out that 50 million or more years is a very long time, and that the problems that neocreationists have with the "sudden" appearance of many kinds of animals are not reasonable.

In my own testimony at these hearings, I referred to a paper in the July 5th 2003 issue of the journal *Nature* written by Shen, et al. In their paper, based on data which they provided, they estimated the amounts and distribution of oxygen in the ocean about 1.5 billion years ago. They conclude, using their data and empirical evidence from the papers of others (which they cite), that following an earlier increase, there was an additional rise in oxygen levels during the period from about 800 to 580 million years ago. This was just before the Cambrian explosion, and it has been postulated by a number of scientists (including Shen, et al) that this increase of available oxygen may have made conditions more favorable for

both increased evolutionary rates and for the production of hard parts by the animals. Because hard parts fossilize much more readily than do the soft parts of organisms, there are greater practical difficulties with respect to fossils of organisms that did not have hard parts. Furthermore, scientists actually doing the work on the fossil record of this early time do not see that their evidence contradicts the widely held current view of the origination of and evolution of the major groups of organisms (which Discovery Institute people often dispute).

3. Comparative embryology. Martin Shankland, who is a professor in the section of Molecular, Cell and Developmental Biology at the University of Texas at Austin, says that embryology provides compelling evidence of evolution. With respect to the idea that there is a common ancestor of a number of now different groups, he points out that the early embryos of humans, mice, and chickens have “rudimentary gills that are anatomically similar to those found in the embryos of fish.” He then explains that this simply shows that “modern species have arisen by the modification of ancient species, and the early embryos of existing species still manifest many of the traits of their ancient ancestry, even though some of those traits are then lost or obscured prior to birth.” This is in answer to Wells’ diatribe against embryological evidence for evolution.

Wells concentrates his attack on 19th century embryologist Ernst Haeckel, emphasizing that Haeckel made some incorrect drawings of embryos. The problem with Haeckel has been well known for some time, and is given nothing more than an historical note in embryological literature. The previous use of some of his drawings in a few high school text books is unfortunate, but these few are now being replaced by better illustrations. In any event, Wells’ extended fury against a historical figure, instead of effective attempts to discredit modern embryology’s large contribution to our understanding of evolution, appears to be another example of the “bait and switch” tactics that Wells and other associates of the Discovery Institute frequently employ.

4. Peppered Moths. Wells and company complain at length about the fact that many high school biology textbooks contain photographs showing melanistic (darker) and non melanistic peppered moths near to each other on a tree trunk. The point of the photographs, which is explained in the books, is to show the students how much easier it is to see one form of the moth compared to the other, depending on the degree of melanism (darkness) of the moth and the amount of soot-caused darkness and lichen patchiness of the bark of the trees. These photographs provide the students with direct visual evidence that visual predators would be expected, other things being equal, to prey on those moths which had greatest contrast with the background on which they rested.

Wells’ complaints about the photographs are largely true but irrelevant. That the moths are dead and glued or pinned to the tree has no bearing on this visual difference, as it is well known that moth’s and butterfly’s wings keep their color and pattern for a long time after the animal is dead (after all, most of these colors and patterns are produced by large numbers of minute scales on their wings, and these scales are dead even on a living animal). I included this in my testimony to the SBOE at their 9 June 2003 meeting, and then went on to point out that Wells abuses the scientific literature when he writes that “peppered moths in the wild don’t even land on tree trunks”. Some of the works that he cites as sources for this statement, however, provide data showing that *the moths do naturally land on tree trunks* (and even when they don’t

land there, they light on tree branches and leaves which also will be darkened by the soot, and therefore the darker color of a moth will tend to protect it from predation of birds which are visual predators). Deceptions of this kind above are common in Wells’ writing (recall also the deception that Hillis reports on).

Professor Linder’s later testimony to SBOE, on 10 September 2003, corroborated my earlier discussion and nicely expanded on it (see it on the state of Texas website: <<http://www.tea.state.tx.us/textbooks/adoptprocess/index.html>>).

He is on the faculty of The University of Texas at Austin, and he also provided a useful summary of the nature of the scientific method and pointed out that there was experimental verification of the hypothesis that the degree of match of a moth to its background is correlated with its survival.

Evolutionary Theory

The neo-Darwinian theory of evolution is supported by an immense amount of observational data which has produced a strong group of interlocking and mutually-supporting, falsifiable hypotheses about how the living world has developed. One of the great strengths of this theory is not only that the parts of it come from all of the subdisciplines of biology, from chemistry and geology, and other fields, but additionally that they fit so well together and into it. Each part is strong in itself, and together they give major support to each other and to the entire theoretical structure of which they have become parts. This still growing and changing scientific edifice provides us with an awesome view of life on Earth and an explanation of how it got to be what it is today. It also gives us an expanded view of the magnificence and beauty of the biological enterprise in many of its areas and at the various levels of its organization.

This modern theory of evolution also provides great organizational and predictive power. One of the many ways to think of its usefulness is to liken real world data and hypotheses within this theory to pieces of a picture puzzle. Consider how much more meaningful the pieces are when they are arranged together to show the puzzle’s picture than they are when scattered haphazardly across the table. In an assembled puzzle, remembering all or part of the picture is easy and meaningful. On the other hand, when the pieces are scattered across the table it is difficult to remember each piece and to appreciate its relationships to the others.

With respect to prediction, examination of the structure of modern evolutionary theory provides important clues as to what continuation of observed evolutionary processes will produce. Examples include the evolution of antibiotic resistance in many disease-causing bacteria (a dynamic that the creationists have finally been reluctantly driven to accept – by the hard facts of recent real world events). Similar to this in much of its fundamental mechanism, is the predicted development of pesticide resistance by a number of insect species. Some of the important insects in which this has been observed are disease vectors, and examples include mosquitoes that have become resistant to the insecticides to which they previously were sensitive. The recent disastrous increase in the frequency of malaria in many tropical regions of the world is one result. The death rate from malaria, which generally was quite low before the development of this insecticide resistance, is now up to a million people per year, and possibly appreciably more. In this all too real world example, a species made up of very complex organisms has demonstrated, as expected, the same kind of evolution that disease-causing bacteria have shown in the past

and unfortunately continue to show.

To return to the picture puzzle analogy for another important point: The neoDarwinian model can be viewed as a large, fitted together, complex, and multi-dimensional picture puzzle which has (and always will have) missing pieces within it, and also will have many unfinished edges. These missing pieces and unfinished edges provide research scientists with very important guides concerning what observations, experiments, and hypotheses might be most useful towards gaining more understanding of the structure and dynamics of our biological world. Neocreationists often claim that some of the things that we don't know are *weaknesses* in our theory of evolution. They are indeed things that we do not know, but when we know what we do not know, and know where in the great pattern of evolution that we do not know it, in a very real sense these are not weaknesses, they are *strengths!* They provide some of the best guides concerning where useful and rewarding effort can be spent in improving our view and understanding of nature's complex evolutionary dynamics.

Another frequent claim of some ID people is that not enough "new" information can be generated by mutation to produce the rise of species and larger systematic groups claimed by Darwinists. They ask, how could a new species arise? There are many well known and often observed acquisitions of genes, chromosomes, and other information-bearing genetic material by organisms through a variety of mechanisms which answer this question. For elaboration of this point, see any of the more complete modern textbooks of genetics now in print.

For a specific example, the paper Reiseberg et al in the 29 August 2003 issue of *Science* reports on the hybridizations of two sunflower species which produced entirely new species containing the genetic material of *both* parents. Totally new species have been produced (both by natural and by in-the-lab hybridization). Figure 1 provides a photograph of one of the hybrids which was produced in nature without human help.

There are thousands of peer-reviewed, scientific papers published each year which support and add to this huge, exciting, and beautiful puzzle which represents our continuously growing understanding of what life on earth is like and how it has developed to be what we see today. There are no peer reviewed papers in the scientific literature which support ID.

For an up-to-dated, technical discussion of the pattern of life as we understand, see the section "The Tree of Life" in *Science*, 13 June, 2003, Vol. 300, pp. 1691-1709. (See also a comment on p. 1621.)

Note the recent dates of publication of the papers in scientific journals which are cited in this article. This is a reasonably fair sample of recent papers related to this topic in *Nature* and *Science* – it illustrates the great amount of interesting activity going on with respect to the scientific examination and extension of the theory of neoDarwinism.

Summary

Science is based on data obtained by repeatable observations of the natural world (universe). Empirical information so obtained is organized into logical hypotheses and theories which provide insight into how the world is structured, how its dynamics operate, and how various components interact with other parts of the world.

Scientists do research following these precepts and publish the results of their investigations in scientific journals which

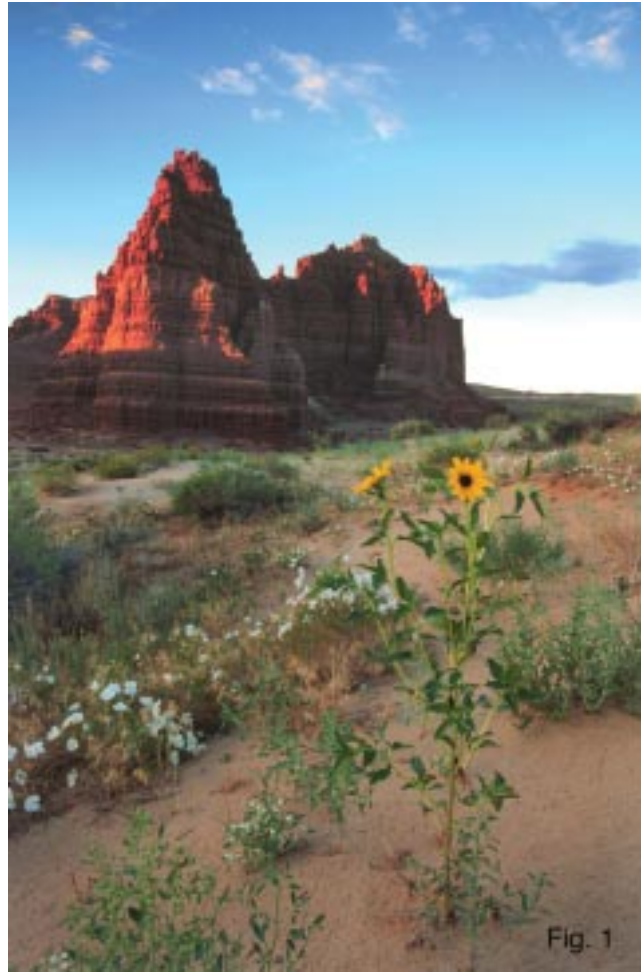


Fig 1.

Helianthus anomalus, a hybrid sunflower species living on sand dunes of Utah and northern Arizona, was produced by the natural crossing of *H. Annus* with *H. petiolaris* some 60,000 to 200,000 years ago (long before humans arrived in North America). There are also two other naturally occurring hybrid species (*H. deserticola* and *H. paradoxus*) which were produced by the natural crosses of these same parents. Photograph provided by H. Rieseberg.

are peer reviewed. (Peer review is where the editor of a scientific journal sends submitted manuscripts to scientists who are specialists in the subject of the manuscript, and these scientists critically review it and advise the editor concerning the scientific quality of the work and the desirability of its publication. The manuscript's author(s) are not told who the reviewers were.)

ID advocates wish to degrade the quality of science in high school textbooks, particularly that which discusses biological evolution. They also are making efforts to add supernatural components (ID), *which are unobservable*, to the teaching of science. They do not gather data from the natural world to support their claims. They do not publish in peer reviewed *scientific* journals.

They have failed to make any headway with scientists who gather data to study nature. They now attempt to find success for their supernatural claims, not with science, but with public

relations, and with pressures that they and of some of their followers apply to state and local school boards, and to high school administrators and teachers. They use arguments that may sound scientific, and are sometimes dauntingly complex, but their arguments contain fundamental argument-destroying flaws when they are carefully examined by someone who is knowledgeable in the appropriate field.

In their own writing, some ID supporters often cite proper scientific papers without providing reference to their content. This gives a façade of legitimacy to their articles – it looks very impressive to have a citation list which includes many illustrious authors and scientific journals. Some of these neocreationists pervert the meanings of scientist’s papers so that the reader is directly given the impression that a particular scientist believes the opposite of what his scientific paper actually says (see Hillis’ comments above).

It is very important to our schools, to our economy, and to our country that science in our high school (and other) textbooks remain about science, and is not contaminated by the supernatural ingredients which the ID advocates wish to insert.

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SBOE testimony:

(All of these testifiers supported the theory of evolution and the nature of science; the topics of the particular points made, in addition to those, are indicated.) Testimony by each of the people listed below will be on the web page the State of Texas: <<http://www.tea.state.tx.us/textbooks/adoptprocess/index.html>> Testimony of July 9, 2003

Hillis (Discovery Institute perversion of Hillis' homology/molecular biology/phylogeny discussion in his scientific writings.)

Maguire (Peppered moth)

Testimony of September 10, 2003

Linder (written), Linder (spoken) (Peppered moth)

Long (Geochronology and Cambrian explosion)

Maguire (Cambrian explosion)

Shankland (Embryology and evolution)

Appendix

From the National Center for Science Education (www.ncse.org)

Responses to Jonathan Wells's Ten Questions to Ask Your Biology Teacher

Jonathan Wells, the author of *Icons of Evolution*, composed "Ten questions to ask your biology teacher about evolution", based on the antievolutionary claims he makes in his book. However, many of Wells's claims are incorrect or misleading; *Icons of Evolution* and "Ten questions" are intended only to create unwarranted doubt in students' minds about the validity of evolution as good science.

Wells is wrong to think that his questions pose any challenge to evolution. In the interest of responding to Wells's erroneous claims and setting the record straight, NCSE has prepared answers to his ten questions. Please feel free to copy and distribute this document to teachers, students, parents, and any interested parties.

(Wells's questions appear in italics with our response immediately below in bold.)

Q: ORIGIN OF LIFE. Why do textbooks claim that the 1953 Miller-Urey experiment shows how life's building blocks may have formed on the early Earth — when conditions on the early Earth were probably nothing like those used in the experiment, and the origin of life remains a mystery?

A: Because evolutionary theory works with any model of the origin of life on Earth, how life originated is not a question about evolution. Textbooks discuss the 1953 studies because they were the first successful attempt to show how organic molecules might have been produced on the early Earth. When modern scientists changed the experimental conditions to reflect better knowledge of the Earth's early atmosphere, they were able to produce most of the same building blocks. Origin-of-life remains a vigorous area of research.

Q: DARWIN'S TREE OF LIFE. Why don't textbooks discuss the "Cambrian explosion," in which all major animal groups appear together in the fossil record fully formed instead of branching from a common ancestor — thus contradicting the evolutionary tree of life?

A: Wells is wrong: fish, amphibians, reptiles, birds, and mammals all are post-Cambrian - aren't these "major groups"? We would recognize very few of the Cambrian organisms as "modern"; they are in fact at the roots of the tree of life, showing the earliest appearances of some key features of groups of animals - but not all features and not all groups. Researchers are linking these Cambrian groups using not only fossils but also data from developmental biology.

Q: HOMOLOGU. Why do textbooks define homology as similarity due to common ancestry, then claim that it is evidence for common ancestry — a circular argument masquerading as scientific evidence?

A: The same anatomical structure (such as a leg or an antenna) in two species may be similar because it was inherited from a common ancestor (homology) or because of similar adaptive pressure (convergence). Homology of structures across species is not assumed, but tested by the repeated comparison of numerous features that do or do not sort into successive clusters. Homology is used to test hypotheses of degrees of relatedness. Homology is not "evidence" for common ancestry: common ancestry is inferred based on many sources of information, and reinforced by the patterns of similarity and dissimilarity of anatomical structures.

Q: VERTEBRATE EMBRYOS. Why do textbooks use drawings of similarities in vertebrate embryos as evidence for their common ancestry — even though biologists have known for over a

century that vertebrate embryos are not most similar in their early stages, and the drawings are faked?

A: Twentieth-century and current embryological research confirms that early stages (if not the earliest) of vertebrate embryos are more similar than later ones; the more recently species shared a common ancestor, the more similar their embryological development. Thus cows and rabbits - mammals - are more similar in their embryological development than either is to alligators. Cows and antelopes are more similar in their embryology than either is to rabbits, and so on. The union of evolution and developmental biology - “evo-devo” - is one of the most rapidly growing biological fields. “Faked” drawings are not relied upon: there has been plenty of research in developmental biology since Haeckel - and in fact, hardly any textbooks feature Haeckel’s drawings, as claimed.

Q: ARCHAEOPTERYX. Why do textbooks portray this fossil as the missing link between dinosaurs and modern birds — even though modern birds are probably not descended from it, and its supposed ancestors do not appear until millions of years after it?

A: The notion of a “missing link” is an out-of-date misconception about how evolution works. Archaeopteryx (and other feathered fossils) shows how a branch of reptiles gradually acquired both the unique anatomy and flying adaptations found in all modern birds. It is a transitional fossil in that it shows both reptile ancestry and bird specializations. Wells’s claim that “supposed ancestors” are younger than Archaeopteryx is false. These fossils are not ancestors but relatives of Archaeopteryx and, as everyone knows, your uncle can be younger than you!

Q: PEPPERED MOTHS. Why do textbooks use pictures of peppered moths camouflaged on tree trunks as evidence for natural selection — when biologists have known since the 1980s that the moths don’t normally rest on tree trunks, and all the pictures have been staged?

A: These pictures are illustrations used to demonstrate a point - the advantage of protective coloration to reduce the danger of predation. The pictures are not the scientific evidence used to prove the point in the first place. Compare this illustration to the well-known re-enactments of the Battle of Gettysburg. Does the fact that these re-enactments are staged prove that the battle never happened? The peppered moth photos are the same sort of illustration, not scientific evidence for natural selection.

Q: DARWIN’S FINCHES. Why do textbooks claim that beak changes in Galapagos finches during a severe drought can explain the origin of species by natural selection — even though the changes were reversed after the drought ended, and no net evolution occurred?

A: Textbooks present the finch data to illustrate natural selection: that populations change their physical features in response to changes in the environment. The finch studies carefully - exquisitely - documented how the physical features of an organism can affect its success in reproduction and survival, and that such changes can take place more quickly than was realized. That new species did not arise within the duration of the study hardly challenges evolution!

Q: MUTANT FRUIT FLIES. Why do textbooks use fruit flies with an extra pair of wings as evidence that DNA mutations can supply raw materials for evolution — even though the extra wings have no muscles and these disabled mutants cannot survive outside the laboratory?

A: In the very few textbooks that discuss four-winged fruit flies, they are used as an illustration of how genes can reprogram parts of the body to produce novel structures, thus indeed providing “raw material” for evolution. This type of mutation produces new structures that become available for further experimentation and potential new uses. Even if not every mutation leads to a new evolutionary pathway, the flies are a vivid example of one way mutation can provide variation for natural selection to work on.

Q: HUMAN ORIGINS. Why are artists’ drawings of ape-like humans used to justify materialistic claims that we are just animals and our existence is a mere accident — when fossil experts cannot even agree on who our supposed ancestors were or what they looked like?

A: Drawings of humans and our ancestors illustrate the general outline of human ancestry, about which there is considerable agreement, even if new discoveries continually add to the complexity of the account. The notion that such drawings are used to “justify materialistic claims” is ludicrous and not borne out by an examination of textbook treatments of human evolution.

Q: EVOLUTION A FACT? Why are we told that Darwin’s theory of evolution is a scientific fact — even though many of its claims are based on misrepresentations of the facts?

A: What does Wells mean by “Darwin’s theory of evolution”? In the last century, some of what Darwin originally proposed has been augmented by more modern scientific understanding of inheritance (genetics), development, and other processes that affect evolution. What remains unchanged is that similarities and differences among living things on Earth over time and space display a pattern that is best explained by evolutionary theory. Wells’s “10 Questions” fails to demonstrate a pattern of evolutionary biologists’ “misrepresenting the facts.” The National Center for Science Education is a nonprofit organization, based in Oakland, California, dedicated to defending the teaching of evolution in the public schools. For more information, visit us on the web at www.ncseweb.org or call 510-601-7203.

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