SETTING UP

NONRELIGIOUS, SCIENTIFIC

MODELS FOR TEACHING

ORIGINS

IN THE PUBLIC SCHOOL

CLASSROOM

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APPENDIX A

Critical Thinking Skills

SETTING UP NONRELIGIOUS, SCIENTIFIC MODELS FOR TEACHING CREATION AND EVOLUTION IN THE PUBLIC SCHOOL CLASSROOM

Any school district or individual school that even considers a policy concerning the teaching of evidence favorable to creation in public school science classes will arouse a storm of controversy. Public hearings are sure to bring vocal opposition from private citizens and college professors alike, all claiming that creationism is nothing but religion. This paper is an attempt to expose the error of such thinking by showing how a creation model can be presented in a scientific, nonreligious manner. Its purpose is not to prove creation, but to help school boards develop curricula that present the creation/evolution controversy in a way that enhances science education without advancing religion.

This presentation is divided into two parts. The first outlines the legal and philosophical reasons why multiple theories of origins can and should be taught in a public school science classroom. The second presents one possible way to set up scientific, nonreligious models of evolution and creation that will help motivate students not only to learn the materials in their textbooks, but also to press on into independent research.

PART I. LEGAL AND EDUCATIONAL RATIONALE FOR PRESENTING MULTIPLE THEORIES OF ORIGINS.

Visual # 1

Before we examine ways in which a public school system might present the evolution/creation controversy in the classroom, it is important to establish both the legality of such a practice and the academic benefit to students.

A. RELEVANT SUPREME COURT DECISIONS.

Despite what many people think, the U.S. Supreme Court has never held it to be either illegal or unconstitutional to teach scientific evidence for creation in public schools. In *Epperson v. Arkansas*, 393 U.S. 97, 89 S.Ct. 266 (1968), the Court struck down an Arkansas law which made it illegal to teach evolution, saying that

> "The First Amendment mandates governmental neutrality between religion and religion, and between religion and nonreligion."

The problem was not the inclusion of creation; it was the exclusion of evolution. As the Court put it, the First Amendment

> "does not tolerate laws that cast a pall of orthodoxy over the classroom."

Likewise, the Court struck down the Louisiana "Balanced Treatment Act" requiring the presentation of scientific evidence for creation alongside that for evolution (*Edwards v. Aguillard*, 482 U.S. 578, 107 S.Ct. 2573, No. 85-1513, 1987). The decision did not prohibit the teaching of creation. Rather, the Justices held that this particular law violated its own stated purpose, the enhancement of academic freedom, by requiring that creation be taught side by side with evolution. Their reasoning was that teachers uncomfortable with creation would probably teach neither idea rather than having to teach both. This would limit academic freedom instead of enhancing it. Besides, the

Visual # 2

Court's majority opinion stated that the law was not needed to protect academic freedom because

> "The Act does not grant teachers a flexibility that they did not already possess to supplant the present science curriculum with the presentation of theories, besides evolution, about the origin of life. Indeed, the Court of Appeals found that *no law prohibited Louisiana public schoolteachers from teaching any scientific theory*... The Act provides Louisiana schoolteachers with no new authority. Thus the stated purpose is not furthered by it." (italics added)

Would the Court allow a state legislature or school district to require the teaching of other theories about the origin of life besides evolution? Yes, providing the purpose is to enhance science instruction and not to endorse a particular religious doctrine. As the Court's majority opinion in *Edwards v. Aguillard* said,

Visual # 3

> "We do not imply that a legislature could never require that scientific critiques of prevailing scientific theories be taught. Indeed, the Court acknowledged in *Stone* that its decision forbidding the posting of the Ten Commandments did not mean that no use could ever be made of the Ten Commandments, or that the Ten Commandments played an exclusively religious role in the history of Western Civilization. In a similar way, teaching a variety of scientific theories about the origins of humankind might be validly done with the clear secular intent of enhancing the effectiveness of science instruction."

According to the Court, then, a legislature or school board may require the teaching of multiple theories of origins, as long as this teaching serves to enhance science instruction.

Few school boards would dare to consider such a requirement at this time, though they have the right to do so. In most cases, proposed policies have served merely to clarify and reinforce teachers' right to present alternative theories. Such policies do not attempt to take away this right, but to show how it may be exercised within the limits the Court has set.

To summarize these limits: as long as the principal purpose is not the advancement of religion, teachers may present any theory of origins which serves to enhance science education. It does not matter whether or not it coincides with religious beliefs. The question is: *can we present the creation/evolution controversy in a scientific, nonreligious way?* This paper demonstrates that the answer is yes.

B. NEXT GENERATION SCIENCE STANDARDS.

Visual # 4

For years, test scores of students in the U.S. have fallen compared to those in other countries. In an attempt to have American students catch up, most of the states have agreed to adopt common standards in mathematics and English known as the Common Core State Standards (CCSS). Not as widely discussed are the Next Generation Science Standards (NGSS), broken down into Physical Science (PS), Life Science (LS), Earth and Space Science (ESS), Engineering (ETS), and so on.

Some of these standards (HS-LS1-1, HS-LS3-1, HS-LS3-2, HS-LS3-3, HS-LS4-1, HS-LS4-2, HS-LS4-5, HS-ESS1-2, HS-ESS1-6, et al.) call for students to use scientific reasoning to evaluate the evidence for various aspects of evolutionary theory. Evaluating evidence implies understanding both the claims and counterclaims that concern it. In addition, HS-ETS1-2 calls for students to learn how to work the way scientists do:

> "Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering."

Students should not be limited to memorizing items that are supposed to be evidence for evolution, but should be taught to break down these items into their parts, analyze them, and evaluate them. They cannot do so if kept ignorant about problems with current theory.

C. DEFINITION OF TERMS.

Most people are under the impression that evolution is science, but creation is religion. However, few have carefully thought about what the words "evolution" and "creation" really mean. Let's strip away the emotionalism and see what the controversy is all about.

Visual # 5

- *Evolution* in its most fundamental form is the concept that the universe, the earth, and life were each in a primitive, disorganized condition when they first came into existence. Each has steadily increased in complexity ever since. Thus, evolution has to do with initial disorganization. Evolution requires not just change, but change in the direction of increasing complexity.

  Visual # 6

  Though the concept of evolution applies to the entire universe, there are two major models that have to do with living things. The more commonly taught one is Neo-Darwinism, which says that evolution has been slow, steady, and gradual. However there is an alternative model seldom mentioned to high school students. Because of the rarity of fossils considered to be transitional forms, some paleontologists instead believe in a model called Punctuated Equilibria. This says that evolution has occurred in sudden jumps. Punctuationists object to Neo-Darwinism (gradualism) because of the lack of fossil evidence; Neo-Darwinists object to Punctuated Equilibria because they believe the large number of mutations needed would be fatal.

- The alternative view is the concept that the universe, the earth, and life were in a complex condition when they first came into existence. Each has steadily deteriorated ever since. We need not refer to the emotionally charged word "creation" in science classes but can use "Initial Complexity" instead. The concept implies not just change, but change in the direction of decreasing complexity.

  Visual # 7

  Visual # 8

  Just as there are differences of opinion regarding initial disorganization, there are also contrasting ideas about initial complexity. Some believe the beginning of the earth was relatively recent, but others believe it was billions of years ago. We will see that evaluating the arguments of both sides need not necessarily be religious, but may be dealt with in a technical manner.

Visual # 9

Is the study of origins innately religious? It depends how we approach it. Whether the matter and energy that comprise the universe were disorganized or complex at the beginning, *something* beyond the limits of scientific investigation brought it all into existence.

Visual # 10

There is no question that we must appeal to philosophy and religion in considering what or who that "something" was. However, we can deal with the subject of origins a different way. If we try to find out *what* happened rather than *who* made it happen, we can investigate the initial conditions with no reference to religion. Part II of this paper shows one way to perform such an investigation.

D. A NON-ISSUE: SCIENCE AND THE EXISTENCE OF AN INFLUENCE OUTSIDE NATURE.

Note that this is the only section in this entire paper that deals with any characteristics of a creator. It is ***not*** *intended to be part of science education, but is included so as to expose a common fallacious argument against teaching the evidence for creation.*

Visual # 11

Granted, there is no known natural process that would cause matter and energy to come into existence in a complex, organized condition. But neither is there a known natural process that would come into existence in a disorganized condition. Whether we believe in initial complexity or initial disorganization, we have to look to some process that cannot be explained by our present understanding of nature.

Still, some argue that since creation's premise of initial complexity requires a creator, it is automatically unscientific. It is true that we cannot do experiments to determine who or what this creator might be. So what? Most evolutionists believe in theistic evolution, which says that some sort of intelligent being outside the scope of nature guided the process of evolution. This belief depends upon a supernatural being as much as does creation. If we rule out creation, we should automatically rule out theistic evolution also.

It would appear that atheistic evolutionists are the only ones who can be truly scientific. But appearances are deceptive. To see why, let us consider their reasons for rejecting as unscientific anything that depends on an entity outside the realm of nature.

1. Necessary Characteristics of a Creator.

No matter who or what the creator might be, he would have to have certain characteristics.

Visual # 12

- **a.** An atheist will say that he won't believe in something he can't see. We can concede this point: there is no question that a creator would be **invisible**. His presence can only be detected by what he does.
- **b.** If a creator brought the laws of nature into existence, then he is not subject to those laws. He is above nature, or **supernatural**.
- **c.** The creator would have had to exist before the universe began. He must be **eternal**.
- **d.** His influence would have to extend throughout the universe. He is everywhere, or **omnipresent**.
- **e.** If a creator brought matter and energy into existence and established laws of nature to govern their operation, then he is either directly or indirectly responsible for everything that has ever happened. He is all-powerful, or **omnipotent**.
- **f.** Who made the creator? Nobody. He is **self-existent**.

To summarize: atheistic evolutionists call creation and theistic evolution unscientific because both depend upon an entity who is **invisible, supernatural, eternal,**

omnipresent, omnipotent, and **self-existent**.

2. Necessary Characteristics of Random Chance.

Visual # 13

Let's use the same criteria to see if atheistic evolution is truly scientific. If there was no intelligent entity responsible, how did everything come into existence? An atheist might call it accident, quantum fluctuation, or some other term, but ultimately, he has to believe that the universe is the result of a long series of forces, processes, and events operating over billions of years without any particular purpose. Rather than continually repeating "a long series of forces, processes, and events operating over billions of years without any particular purpose," let's call the whole series "random chance" for the sake of brevity. Following are some of the characteristics that logic dictates random chance would have to possess.

Visual # 14

a. What does random chance look like? Random chance is **invisible**. Its presence can only be detected by what it does.

b. If random chance brought the laws of nature into existence, then it is not subject to those laws. It is above nature, or **supernatural**.

c. How long has random chance been here? Forever! It is **eternal**.

d. Where is random chance? Its influence extends throughout the universe. It is everywhere, or **omnipresent**.

e. If random chance brought matter and energy into existence and then established laws of nature to govern their operation, then it is either directly or indirectly responsible for everything that has ever happened. It is all-powerful, or **omnipotent**.

f. Who made random chance? Nobody. It is **self-existent**.

An atheistic evolutionist rejects any belief that relies on a creator, but his belief relies just as much on Random Chance. Both have exactly the same characteristics. Either would have to be **invisible, supernatural, eternal, omnipresent, omnipotent,** and **self-existent**. The atheist rejects the possibility of a personal entity, a creator, while believing in an impersonal entity, random chance, that must by necessity possess all the same characteristics.

Visual # 15

The point is that neither atheistic evolution, theistic evolution, nor creation has any scientific advantage or disadvantage over the others simply because of dependence on a higher power, whether an intelligent being or random chance. If we eliminate one from scientific consideration in the classroom, we should eliminate all; if we allow one, we should allow all.

E. EDUCATIONAL ENHANCEMENT: SCIENCE AND THE SEARCH FOR DESIGN.

The search for design is a normal part of many branches of science. A few examples:

Visual # 16

- Archaeologists look for evidence of design in order to distinguish whether an item is a human artifact (arrowhead, stone hut, etc.) or a natural result of erosion.
- Those who believe life exists out in space work have been working diligently for many years on the SETI program (Search for ExtraTerrestrial Life) searching for nonrandom radio signals indicating intelligent origin.

- National Transportation Safety Board investigators search through the rubble of plane crashes to determine if they were the result of accident or sabotage.
- Arson investigators sift through evidence to see if a fire was accidental or deliberately set.
- In the event of a suspicious death, a medical examiner looks for subtle clues to determine if the person died naturally or was murdered.

These are but a few areas which require scientists to be able to recognize evidence of design.

Unfortunately, a number of courts across the nation have refused to allow school districts to require the teaching of intelligent design. The judges have bought into the mistaken idea that the concept of design must be religious because it requires a designer. While it is true that we cannot scientifically test the **existence** of God, it is equally true that we cannot scientifically test the **nonexistence** of God. The courts have ignored the fact that teaching the **possibility** of intelligent design is no more or less a matter of philosophy and religion than teaching the **impossibility** of intelligent design.

Visual # 17

Despite the claims of those who want to stifle debate, the study of design does not automatically support any particular religion's concept of God. Evidence of design does not necessarily identify the designer. For example, one group of scoffers who call themselves "Pastaferians" sarcastically say they believe the designer of the universe is the "Flying Spaghetti Monster." While many would consider this blasphemous, it illustrates the point that design in itself does not tell us who the designer might be.

Visual # 18

Though courts have refused to allow school districts to require the teaching of intelligent design, individual teachers may recognize the value in such a study. They need to be very cautious about how they present the material so as not to be accused of teaching religion.

1. Arguments Against Design.

Many who reject the possibility of design do so for philosophical rather than scientific reasons.

Visual # 19

a. We already dealt with the claim that allowing for the possibility of design would bring God into science. While it would imply the existence of an intelligence outside nature, it would not necessarily support any specific religion's concept of God.

b. Some say that things can't be designed be cause they don't like the way they are put together, e.g. Stephen Jay Gould's book about the panda's "thumb". This might show that there is no designer, but it could also show that we just disagree or don't understand why He did things a certain way.

2. Arguments For Design.

Visual # 20

Those who look for design in such areas as the ones mentioned on the previous page can apply scientific techniques that are far more powerful than mere opinion. After all, an opinion that nature is beautiful would not be very persuasive to someone who thinks the sunset is ugly.

a. Extreme Improbability in a Specific Direction.

We can use mathematical tools to look for the probability that an event is

Visual # 21

random. The lower the probability for randomness, the higher the probability for design.

In any collection of matter, no one arrangement is more or less improbable than any other. (***Somebody*** is going to win the lottery sooner or later.) However, this is not what the search for design is about. We are looking not just for improbability, but improbability in a specific direction. In nature, most arrangements produce meaningless junk. Only a few produce life. The question is, how improbable is it that those specific arrangements could arise by chance?

Visual # 22

Probability studies are a normal part of biology, ecology, psychology, and many other branches of science. Scientists often use statistical tests such as "chi-square" distribution to determine whether a phenomenon seems to be random or nonrandom (e.g., location of ant hills along a levee). Yet many are unwilling to admit that Intelligent Design is simply a reasonable application of probability testing to see if there are indications of non-randomness in nature.

b. Irreducible Complexity.

If we carry the concept of improbability to its extreme, we eventually approach impossibility. Such a situation seems to be the case with irreducible complexity, a term popularized by biochemist Michael Behe in his book *Darwin's Black Box*.

Visual # 23

Visual # 24

An irreducibly complex mechanism is one in which every part must be present and functioning at the same time in order for the mechanism to perform a specific function. A mousetrap is an example of this type of machine. It must have a base, hammer, spring, latch, and trigger. If any part is missing or not performing at least a minimal function, it is not a mousetrap but a pile of junk -- a useless waste of materials.

Living things contain a great many such mechanisms, some of which we will see later (e.g., blood coagulation, the relationship between DNA and enzymes, bacterial flagellar motors, and many others). It is not possible to make an irreducibly complex machine by gradual changes in a different type of machine. You could modify a rat trap to make a mouse trap, but you could not make one out of a can opener. You would quickly have a piece of junk that could neither open cans nor catch mice. Likewise, irreducibly complex mechanisms in living things almost certainly could not have evolved from mechanisms of a different type. Natural selection would have eliminated the non-functioning intermediates.

Visual # 25

The study of irreducibly complex machines in living things can be a great opportunity for learning if one is willing to consider the possibility of design. Of course, many atheists have already made up their minds that there could not possibly be any sort of intelligence beyond the realm of nature. Behe, a theistic evolutionist, likens much of modern biological research search to a group of detectives investigating a flattened body. As they search for clues to the cause of death they have to keep stepping around the elephant in the room. However, because they have agreed in advance that there is no such thing as an elephant, none of them is willing to say, "Maybe the elephant did it." Rather than go against the majority view and be labeled incompetent or superstitious, they keep searching for other explanations. Behe's point is that we are robbing our children of a great deal of knowledge by not teaching them about the possibility of design.

Teaching students how to look for evidence of design has nothing to do with advancing religion; it will help prepare them for more serious scientific study at higher educational levels.

F. WHAT IS SCIENCE?

Still, critics say that evolution is science, but creation is religion. Once again, we should be certain exactly what words mean. What is "Science?" Webster's dictionary defines it as "systematized knowledge derived from observation, study, and experimentation carried on in order to determine the nature or principles of what is being studied."

1. The Nature of Knowledge. Just what does it mean to "know" something?

Visual # 26

a. The most obvious method of gaining knowledge is **personal sense experience**. For instance, you may know what a bee sting feels like because you have been stung. A caution: when relying on our senses, we always have to keep in mind that they are not perfect. This is why we repeat experiments and use measuring devices. Regardless, science depends on our observing the results of experiments by using the senses.

b. We say we know many things when we actually mean that some **authority** told us and we decided to trust them. For instance, you probably do not remember being born. Nevertheless, you say you know your birthday because your mother told you. How do you know she really is your mother? She told you that too, and you decided to trust her.

The starting point in most scientific investigation is to search the work others have published - that is, authority.

c. We also say we know things because we figured them out with **logic**. Though you have probably never seen or felt your own brain, you are sure you have one because you figured it out logically: it just makes sense.

Scientific models, theories, and laws are the result of logical thinking.

d. You may think you know something through a "gut feeling," or **intuition**. While you may be right, scientists generally do not trust their intuition. They want confirmation through sense experience, authority, and logic.

e. Some of what passes for knowledge is actually wishful thinking -- you want it to be true and you hope it will be. However, wishful thinking has no part in science.

f. Sadly, people sometimes pretend to know things when they are actually bluffing (lying). In this case they don't even believe it themselves but want others to, usually for some ulterior motive. Even in science, we should always check our sources to be sure they are telling us the truth.

2. Science and the Scientific Method. How do we "do science?" By using the scientific method.

Many volumes have been written about the subject, but each description of the scientific method will contain the same basic elements.

Visual # 27

a. Ask a **question**, usually based on something you observe in nature.
b. Gather Information based on the work of others (authority).
c. Formulate a **hypothesis** (an educated guess, probably based on logic) about what you think will happen.
d. Devise a method (an experiment) to test your hypothesis.
e. Perform the test and **observe** what happens, using one or more of your senses or some sort of measuring device. (Sense experience)
f. Draw a **conclusion**, then report on your observations so that others can repeat, test, and build on your work. (Logic)

3. Science, History, and Belief.

Visual # 28

The key elements of science are *observation*, *repetition*, and *testing*. And since we can't repeat and test the past (we can't put 1492 in a test tube and experiment on it), science has to do with *present* processes and events.

How about the past? How do we know, for instance, that George Washington was the first President of the U.S.? We can't speak scientifically because we can't observe, repeat, or test his inauguration. However, because we have a number of eyewitness accounts of what happened, we can make **historical** statements. *Nonrepeatable past* events which were reported by *eyewitnesses* fall in the realm of history, not science.

Suppose there were no eyewitnesses to a past event. Can we speak scientifically about it? No, because we can't *repeat*, *observe*, or *test* it. Nor can we speak historically, because no one was there to tell us for certain what happened. All we can do is say what we believe about it. We may be right, but we can never be completely sure. This is neither science nor history, but belief.

With all this in mind, let's consider the claim that creation is religion and evolution is science.

- First, creation.

  Is it occurring in the present or the past? If it happened, it was in the past.
  Can we repeat, test, or observe it? No.
  Do we have any eyewitness accounts? None acceptable to scientists.

Thus, creation is neither science nor history, but belief.

- Now, evolution.

  Is it occurring in the present or the past? No one has ever seen it happen, so if it happened, it must have been the past.
  Can we repeat, test, or observe it? No. Despite the best efforts of scientists for more than a century, no one has ever been able to make anything evolve into anything else.
  Do we have any eyewitness accounts? No, and we could never possibly hope for any. Our primitive apelike ancestors would not have been intelligent enough to write down what they saw.
  Without an eyewitness account, there is no way for us to know for sure whether

everything started in a disorganized or complex condition. All we can say is what we believe. We can never be certain that we are right.

It all boils down to this: despite a great deal of rhetoric to the contrary, the creation/ evolution controversy is not a matter of science versus religion. It is a matter of belief versus belief, with each side claiming that science supports its belief.

4. Laws, Theories, and Models. (Part of Next Generation Science Standards.)

The scientific method starts when we become curious about something we observe in nature, and continues with a hypothesis about why it happens. Two of the most important functions of science, then, are to describe **what** happens in nature, and to try to explain **why** it happens.

a. Laws. Suppose we observe that every time we throw something up it comes back down. Eventually, we conclude that "What goes up must come down." If it happens enough times with no exceptions, we recognize this principle as a scientific law.

Visual # 29

Scientific laws reflect the current state of our knowledge. If a major exception ever occurs to an accepted law, we throw it out. If a minor exception occurs, we usually modify it. For example, when we sent up the first rocket that did not come back down, we could modify our statement to "What goes up must come down unless it is traveling with sufficient velocity to escape the earth's gravity."

A scientific law can often be expressed in the form of an equation, such as Newton's Law of Gravity:

$$F_{grav} = \frac{G\, m_1\, m_2}{d^2}$$

Even if it is not in the form of an equation, a law enables us to make accurate predictions about the future behavior of the phenomenon it describes. In short, a law tells us what happens in nature without attempting to explain why it happens.

b. Theories. Misguided opponents of evolution sometimes criticize it by saying, "Evolution is only a theory." Such a statement shows a lack of understanding of what a scientific theory is.

Visual # 30

A theory is a proposed explanation for why something happens. In ordinary conversation, the word is sometimes used as a synonym for "guess." However, it means something very different in science. A scientific theory is an explanation that has been tested by many experiments and has never yet failed a test. Calling an idea a scientific theory in no way diminishes our confidence in it, but is instead a high compliment.

To illustrate the difference between a law and a theory, consider the phenomenon of gravity. There is only one law of gravity. It lets us predict the force of gravitational attraction between two objects, but does not tell us why gravity exists. Several theories attempt to answer that question. Perhaps space is distorted by the presence of mass, perhaps there are gravity waves, perhaps there is an exchange of particles called gravitons, perhaps Higgs bosons give rise to gravity, and so on. Though we could not say any of these has been proven, at least there are attempts to test them by experimentation. None has failed a test yet, so they are all considered scientific theories.

The so-called "theory of evolution" is not a theory at all. The idea that humans came from apes is impossible to test by experimentation. It is a hypothesis or model instead. Likewise, the term "big bang theory" is incorrect because the idea of a "big bang" is not testable. It relies on computer models rather than experimentation. It, too, is a hypothesis or model rather than a theory.

c. Models. When it comes to trying to be sure what happened in the prehistoric past, we can never be sure we have enough evidence to draw a correct conclusion. Our situation is somewhat like the old John Saxe poem about six blind men who encountered an elephant. Depending on which part they touched, each had a different idea what an elephant was like. One thought it was like a spear, one like a rope, one like a wall, one like a tree, one like a snake, and one like a fan. Each was only partially right. Had they pooled their insight, they would have been better able to understand elephants.

Visual # 31

Like the blind men, we sometimes run into a situation we cannot directly observe (too fast or too slow, too big or too small, too far away, past, future, etc.). When this happens, we should still put together as much information as we can. Instead of a theory or law, we put together a model. It may not be perfect -- it may not even be testable -- but it is still useful because it helps us to better "wrap our minds around the idea."

Visual # 32

Visual # 33

To summarize: A HYPOTHESIS is a tentative explanation for something observed in nature.

A THEORY is a hypothesis that has been thoroughly tested by many experiments. It is an attempt to explain WHY something happens.

A LAW has also been tested by many experiments (usually for many years). It describes WHAT happens, without trying to say WHY it happens.

A MODEL is a description, object, drawing, set of equations, etc. that helps us get a mental picture of something we cannot directly observe.

Just as evolution is not a scientific theory, neither is creation. Both are models.

SUMMARY OF PART I.

The U.S. Supreme Court has ruled that any scientific evidence relating to the subject of origins may be validly presented in science classrooms, provided the primary purpose is the enhancement of science instruction rather than the advancement of religion. We have seen that:

- The search for design is a normal part of many branches of science.
- Neither initial complexity (creation) nor initial disorganization (evolution) has any innate scientific advantage or disadvantage over the other. Both require an entity which is invisible, supernatural, eternal, omnipresent, omnipotent, and self-existent.
- The creation/evolution controversy is not a matter of religion vs. science; it is belief vs. belief, with each side claiming that science supports *its* belief.

PART II.
SETTING UP SCIENTIFIC MODELS.

Though evolution has no innate scientific advantage over creation, a public school must exercise a great deal of caution. The Supreme Court has already indicated that it would only allow the teaching of creation if it enhanced science education without advancing religion. Following is one possible nonreligious model for both creation and evolution which would accomplish that goal.

This model is not intended to replace the current curriculum, but to enhance it. The model includes many topics teachers may use to supplement their class material at appropriate times.

A. HOW TO SET UP MODELS OF THE PAST.

Visual # 34

Science deals with present events and processes. This is not to say that it can never perform investigations relating to the past. For instance, a paleontologist might dig up an unknown type of bone. By looking at previously discovered bones, he decides that it is probably from a new type of dinosaur. Based on the anatomy of other known types, he draws a sketch of what he thinks the complete skeleton will look like. He publishes his work, along with his conclusion that the animal had bad breath and a nasty disposition.

Visual # 35

Part of his work is scientific. He and others can test his hypothesis about the skeletal structure by digging up more bones. (An idea doesn't have to be *right* in order for us to use the scientific method - just testable.) However, there is no way to test the animal's breath or temper. The paleontologist has left science and gone to storytelling.

Visual # 36

Likewise, there are some aspects of the initial disorganization / initial complexity controversy for which we can devise tests, and others for which we cannot. There is no way we can test the identity or motivation of whoever or whatever started the whole process, nor is there any scientific way we can find out details such as the names of the first humans, what they wore, or what they liked to eat. However, all is not lost. Using

Visual # 37

the ideas of initial disorganization or complexity, we can make testable predictions about things that would have occurred under one set of conditions but not the other, and vice versa.

Any comprehensive model of origins must deal with at least four major areas:

Visual # 38

(1.) How matter and energy came into existence.
(2.) How they developed from their initial condition to the present state.
(3.) How life began.
(4.) How it developed from its beginning to its present state.

We can make testable predictions about a great many aspects of each of these. We cannot prove beyond a shadow of a doubt whether initial conditions were disorganized or complex, but we can see which model fits better with what we observe in the universe around us.

B. FIRST PREDICTION: ORGANIZATION OR DISORGANIZATION?

When we consider creation vs. evolution in terms of initial complexity vs. initial disorganization, our first predictions become immediately obvious. They apply not just to the four major areas above, but to every branch of science.

Visual # 39

1. **Initial Disorganization.** Initial Disorganization leads us to believe that there has been a steady *increase* in complexity throughout the universe. There may be exceptions, but there should be an overall trend - a built-in tendency in matter and energy toward increasing organization.
2. **Initial Complexity.** Initial Complexity leads us to believe that there has been a steady *decrease* in complexity throughout the universe. Thus, we expect to find a built-in tendency in matter and energy toward deterioration. Again, we are looking for an overall trend.

These predictions have nothing to do with advancing religion. To see if studying them will enhance the student's science education, consider where such study will lead.

Visual # 40

3. **Educational Enhancement:** Students will be exposed to the discovery, operation, and verification of the Second Law of Thermodynamics (a universal trend toward deterioration). They should learn how it applies in open and closed systems and under what circumstances it can be temporarily overridden. They should also be exposed to pertinent aspects of information theory and chaos theory, such as Prigogine's model of how order might arise in chaotic systems.

It is not the job of the science teacher to force the students to choose whether initial disorganization or complexity is more likely. Perhaps they will decide, perhaps not. It doesn't matter! They will be learning more and more *how* to think, not *what* to think. The critical thinking skills they learn by examining all the available information will serve them well throughout their lives.

Following are just a few of the hundreds of other predictions which follow logically from the initial complexity and initial disorganization models. These are grouped according to the four major topics above.

C. ORIGIN OF MATTER AND ENERGY.

1. **First Appearance - Everything from Nothing.** (Physics and chemistry.)

Visual # 41

   a. **Initial Disorganization.** The atheistic initial disorganization model leads us to believe that matter and energy came into existence through purely natural processes. We would expect that these processes could produce similar results at any time, and that matter/energy could probably go out of existence the same way.

   b. **Initial Complexity.** The initial complexity model and the theistic version of initial disorganization both lead us to believe that matter and energy came into existence because of an influence outside of the physical universe. (Who or what that influence might be is a question outside the realm of science and should be reserved for classes dealing with philosophical matters.) We would expect that natural processes by themselves could not cause new matter/energy to come into existence or old matter/energy to go out of existence.

c. Educational Enhancement: Students will probably wonder why the universe could not be infinitely old. They should be shown how the Second Law of Thermodynamics argues against infinite age. They should learn the strengths and weaknesses of models such as Oscillating Universe, Steady State, and Little Big Bang that attempt to circumvent the Second Law. They should be exposed to the discovery, history, and verification of the First Law of Thermodynamics and how it applies to these models as well as Quantum Fluctuation and multidimensional models for the origin of matter and energy.

Visual # 42

2. Origin of Heavy Elements.

a. Initial Disorganization. Matter must have come into existence in the simplest possible form, hydrogen. Heavier elements would have been produced by processes such as fusion and neutron capture either during the "big bang" (see topic "D" below) or later, perhaps in the interior of stars. Since much of the universe's matter is composed of heavier elements, these processes must be fairly common. It should be relatively easy to produce heavier elements by combining lighter ones.

Visual # 43

b. Initial Complexity. Since the universe is deteriorating, it must have come into existence in a more complex condition than it is now. With few exceptions, all the naturally occurring elements from hydrogen to Lawrencium should have been present from the beginning. We would expect that natural processes would not be sufficient to assemble complex elements (especially those with very high atomic numbers) from simpler ones.

c. Educational Enhancement: Very few students are aware of the fact that scientists starting with hydrogen have never been able to produce any stable element heavier than lithium-4. Every experiment that has produced very heavy radioactive elements (Lawrencium, Nobelium, etc.) has started with heavy elements such as uranium, not with hydrogen or helium. There is no known way to produce heavier elements starting from hydrogen.

Visual # 44

Some have proposed that heavy elements were produced in the interior of stars or supernovae. Students should be made aware of the strengths and weaknesses of these proposals, as well as the failure of experiments designed to confirm them. They should also study work such as Gamow's that shows why heavy elements could not have been produced during the big bang, as well as any theories to the contrary.

D. DEVELOPMENT OF THE UNIVERSE AFTER ITS ORIGIN.

1. The Big Bang. (Physics and astronomy.)

a. Initial Disorganization. I.D. leads us to believe that billions of years ago all the matter/energy in the cosmos was concentrated into a single point, which exploded in a "big bang" and evolved into the present universe. We expect to find that the universe is still expanding, and we expect to find some evidence such as radiation left over from the explosion.

Visual # 45

b. Initial Complexity. I.C. leads us to believe that the universe came into existence in a more orderly condition than it is at present. It does not matter if it is expanding, but there should be a lack of evidence of a big bang.

c. Educational Enhancement: The study of whether there was a big bang is fruitful ground for scientific investigation.

Visual # 46

i. Students should be made aware that there are dozens of contradictory big bang models and several alternative concepts. They should realize that each is purely a mathematical model which can only be tested in computer simulations.

Some people are in awe of anything to do with computers. Students should learn that a simulation is only as good as its programming. To see the limitations of computer models, they should be exposed to programs that try to predict complex earthly phenomena such as ocean currents and weather.

ii. Students should learn how various big bang models deal with problems due to the Second Law of Thermodynamics — how could the most disorderly explosion of all time result in an orderly universe? —, Law of Conservation of Momentum, Law of Conservation of Angular Momentum, etc.

Visual # 47

iii. They should understand that the distribution of matter in the universe is very uneven, but the microwave background radiation is almost perfectly uniform. They should investigate models that have been proposed in order to reconcile the discrepancy - inflation, cosmic strings and textures, etc.

iv. They should be exposed to theories about other possible causes of the microwave background radiation.

v. They should learn how red shifts are used to calculate the expansion rate of the universe. They should be shown the incompatibility between a big bang's non-Euclidean geometry and the red shift method's Euclidean basis, as well as any efforts to reconcile this incompatibility.

2. Size and Age of the Universe. (Physics, astronomy, and mathematics.)

Visual # 48

a. Initial Disorganization. If the universe started in a big bang, we could determine how long ago by measuring its present size and rate of expansion. Since it is believed to be billions of light years across, it must be billions of years old.

b. Initial Complexity. The I.C. model does not make any predictions about the universe's size. Since it started complex, it could be any age. However, its steady deterioration means that it must be young enough for stars not to have burned out, galaxies not to have flown apart, etc.

c. Educational Enhancement: After studying this topic, students will understand that the universe's size and age cannot be directly measured.

Visual # 49

i. They should learn about the uncertainty inherent in methods used to calculate its size (the Hertzsprung-Russell Diagram, Cepheid variable stars, Main Sequence Method, Galactic Red Shift, etc.).

ii. They should be shown clearly that these methods require Euclidean geometry, whereas the big bang concept depends upon non-Euclidean, four-dimensional space.

iii. They should realize that all our size and age calculations are based on the assumption that we correctly understand the meaning of red shifts. They should be made aware that there are alternative explanations for observed redshifts, as well as mitigating circumstances that can change their values.

Visual # 50

iv. They should learn of the recent discovery that redshifts are *quantized*, that is, they do not occur over a continuous spectrum of values but only in discrete steps. If astronomers come up with an explanation for this phenomenon, students should hear about it.

Visual # 51

v. They should learn what the terms "dark matter" and "dark energy" mean. They should understand that these terms were introduced because the distribution of matter and energy in the universe is not what it was expected to be for a universe that is billions of years old. If any actual evidence for these concepts (not just mathematical models) is ever discovered, they should learn of it. They should also be exposed to models that do not require these concepts.

E. ORIGIN OF LIFE.

Visual # 52

1. Initial Disorganization: Since life is believed to have resulted from purely natural processes, we should find evidence that conditions on the early earth were suitable to produce life from lifeless chemicals - vastly different from the way things are now. We would also expect that, under the right conditions, life could again be produced from nonlife.

2. Initial Complexity: The first living things came into existence in a complex, fully functional condition. We would expect to find evidence that from the time these organisms first appeared, conditions on earth have been suitable to sustain life - probably not too different from the way things are now. We also expect to find life coming only from life.

Visual # 53

3. Educational Enhancement: Since this is a broad subject, we can break it down into a number of more specific topics. Some of them deal with objective matters such as geological evidence, while others are more subjective, leading us to search for indications of design versus chance.

a. Historical Background. Students should be aware of historical beliefs about spontaneous generation of life from decaying vegetation, rotting meat and the like. They should be familiar with Pasteur's and similar experiments disproving the spontaneous generation of life in this manner.

b. Understanding Current Models. Students should understand the Oparin-Haldane hypothesis, the most widely accepted evolutionary scenario for the origin of life. This scenario postulates an early atmosphere composed of hydrogen, methane, ammonia, and water vapor, commonly known as the "primordial soup." These are believed to have mixed together and then been bombarded by energy sources such as lightning, ultraviolet, heat, or shock waves. The resulting chemical action should have formed amino acids, then proteins, and finally living cells.

Visual # 54

They should also be aware of a relatively obscure but nevertheless interesting model, "Directed Panspermia." This scenario, proposed by Nobel Prize winner Dr. Francis Crick (codiscoverer of the structure of DNA), holds that life began elsewhere in the universe, then came to earth. His reasoning will be very informative to their understanding of biological processes.

c. **Atmospheric Oxygen.** Students should be aware that the chemical reactions needed in the Oparin-Haldane scenario do not occur in the presence of free oxygen. They should be informed of evidence omitted from most biology textbooks: *oxidized* deposits have been found in every layer of the earth's geologic column, all the *way down to basement rock.* (See Appendix A for references.) This indicates the presence of free oxygen on the early earth. Students should learn how adherents of the Oparin-Haldane hypothesis deal with this potentially devastating evidence.

Few biology textbooks mention this evidence of free oxygen. Examining it and the ways scientists deal with it would help the students learn how to think like a scientist.

d. **The Oxygen-Ultraviolet Dilemma.** Though short-wave ultraviolet (wavelength less than 200 nanometers) is sometimes used as an energy source in origin-of-life experiments, the sun produces far more long-wave (greater than 300 nm) UV than short. Students should understand that the long-wave form, specifically 310 nm, is deadly to organic compounds such as those found in living cells. However, the atmosphere's ozone layer filters out most of it before it can reach the earth's surface.

Visual # 55

We saw in **(c)** that the Oparin-Haldane scenario could only have taken place if there were no free oxygen present in the early atmosphere - but if there were no free oxygen, there would have been no ozone layer. Long-wave UV would have reached the earth's surface at full strength. A typical modern organism would have absorbed a lethal dose in about three tenths of a second (Carl Sagan, "Ultraviolet Selection Pressure on the Earliest Organisms," *Journal of Theoretical Biology* 39, 1973, pp. 195-200).

We are faced with a dilemma. The **presence** of free oxygen prevents the reactions needed to form the components of cells. The **absence** of free oxygen allows long-wave UV to destroy these components as fast as they can form. Students should be exposed to Sagan's and other works that attempt to solve this paradox. They may also wish to explore Dr. Crick's conclusion that conditions on the earth have never been favorable to produce life from nonlife.

e. **The Trapping Mechanism.** Every origin-of-life experiment based on the Oparin-Haldane hypothesis uses some sort of an energy source to produce amino acids from the mixture of gases present in the apparatus. (Amino acids are the basic building blocks of proteins, which are in turn the building blocks of cells.) A trapping mechanism then removes the amino acids before the energy source operates again. This is necessary because the amino acids are easily destroyed by the same energy source that produced them.

The trap is designed into the lab apparatus. However, the subject of natural trapping mechanisms is pure speculation because, though several have been proposed, none has ever been observed. Students should research the scientific literature on this subject in order to determine how reasonable each proposal is. Another area for exploration is this: if amino acids were cut off from energy sources, how could they combine into proteins? And how, without additional energy, could the proteins combine into cells? Investigating possible solutions to this problem will certainly enhance the students' thinking skills.

f. The Problem of Optical Isomers. This topic will lead students to a study which involves not only biochemistry, but also mathematics and probability.

Visual # 56

The simplest known living cell is composed of about 600 proteins, each consisting of about 400 amino acids - a total of about 24,000 amino acids. Most cells are far more complex. The initial disorganization model leads us to believe that the first cell and all its descendants are the product of purely natural processes. They should be made up of the kind of components which occur by natural chemical action. Initial complexity, on the other hand, leads us to expect evidence of design. Cell structure should be far too complex to be the result of random chemical processes.

The educational benefit in this study is twofold: (1) Students will learn new information about biology and mathematics. (2) They will find their thought processes broadening as they learn to consider things they already know in a new light.

i. They will learn that nineteen of the twenty amino acids used in cells, as well as the sugars used in DNA, are 3-dimensional structures which can exist in either a left-handed (*laevorotary* or L-) or right-handed (*dextrorotary* or D-) orientation. These are called *enantiomers*, or sometimes *optical isomers* because we determine their orientation optically by bouncing light off them and seeing which direction they polarize it.

ii. They should study the results of origin-of-life experiments, which when left to themselves have all produced about a 50/50 mix of L- and D- forms. They will be challenged to investigate further when they discover that every amino acid in every protein in every cell yet studied has been the L-form, and that every sugar in every type of DNA has been the D- form. They should consider any proposals for a natural mechanism that would eliminate every one of the "wrong" forms from every living cell.

iii. They should do a mathematical study of the probability that tens of thousands of amino acids of only the L- form and millions of sugars of only the D- form could align themselves by random chemical processes. This study will help them determine if it is more likely that cells are the result of chance or design.

g. Biochemistry and the Origin of Life. This topic will give students a deeper understanding of the structure of cells. It will also help equip them to evaluate the probability of design vs. chance.

i. They should study origin-of-life experiments to see what kinds of compounds have been produced. They will find that these include about 15 of the 20 amino acids used in living cells, about twice as many biologically useless types, a number of the sugars used by DNA and RNA (a roughly 50/50 mix of L- and D- forms of amino acids and sugars) all the bases used in DNA/RNA, and many other biologically useless organic and inorganic compounds.

ii. Students should consider whether biological and chemical principles such as the Law of Mass Action would allow proteins and cells to come together. They should understand that the vast majority of chemical reactions in a random mix such as this are biologically useless or harmful. Many of the products are at least as reactive as amino acids.

A cell requires thousands of L- amino acids linked in correct sequence. The compounds produced by most reactions in a "primordial soup" would get in the way of the amino acids, preventing them from reaching each other and connecting into functional proteins and cells.

iii. They should also be exposed to the work of scientists such as Crick, Hoyle, Wichramasinghe, Ambrose, and Lovel who have used these chemical processes as a basis for probability calculations. Each has concluded that the probability that life began on earth by random chemical processes is incomprehensibly small. Nevertheless, some scientists believe that it happened anyway. Students should study how they attempt to deal with the biochemical problems.

Students should take all the above factors into account as they contrast three points of view: (1) Despite the improbability, life began by random chemical processes on the early earth. (2) Life could not have begun on earth. It must have arisen some other place where chemical conditions were more favorable, then arrived here later. (3) Life began by design.

It is not the function of the school to persuade students that any of these is correct, but to present them with as much information as possible so that they can reach intelligent conclusions on their own. Exposing them to this controversy will help to accomplish that purpose.

h. The DNA/Enzyme Dilemma. The initial disorganization model leads us to believe that all the components of the first cell came together by random chemical action within the life span of that one cell. Since individual cells live for only a short time, it must have been a fairly rapid process. The cell had to be able to reproduce or life would have become extinct. Initial complexity, on the other hand, implies that a self-replicating cell should be too complex to come together rapidly by chemical action alone.

i. Before discussing this topic, students should already know that cells have a built-in program which enables them to reproduce. This program is contained in DNA (deoxyribonucleic acid), which guides the reproduction of every part of the cell including itself.

ii. They may not know that chemical reactions needed to produce the components of a cell normally occur much too slowly to be of any biological use. These processes occur millions or billions of times faster within a cell because of the presence of *enzymes*. These are highly specialized protein molecules that each accelerate a very small number of chemical reactions. DNA contains the information needed to manufacture them.

iv. They will discover that the reactions needed to form DNA occur too slowly outside cells to be biologically useful. The process occurs only in the presence of specific enzymes. Enzymes are needed to manufacture DNA.

Learning that DNA is needed to manufacture enzymes and enzymes are needed to manufacture DNA can be a thought-provoking opportunity for students to contrast the arguments for design vs. randomness. They should be kept informed of current work in this area. If any experiments demonstrate a mechanism that allows DNA and enzymes to form separately and then combine into a cell, they should hear of it.

i. The Cell Membrane. The concept of initial disorganization leads us to expect that cells should be made up of components that occur naturally. Initial complexity leads us to expect evidence of design.

Visual # 57

One of the essential parts of a cell is the protective double-walled membrane which encloses it. Initial disorganization leads us to believe that the first cell was composed of amino acids which came together into proteins which then came together into a complete structure. DNA somehow joined together with it. A membrane composed of fatty substances known as *phospholipids* formed around the whole collection. Soon, the cell began to reproduce.

Phospholipid membranes like those that enclose cells can occur naturally. However, a serious problem arises. A cell in the process of reproducing needs a ready supply of many chemicals including phosphates, which are a crucial component of DNA. However, phospholipid membranes are almost completely impermeable to phosphates and many other important components of cells. Thus the first cell, surrounded by its impermeable membrane, could not have taken in the raw material it needed to reproduce. It would quickly have become extinct.

Living cells are unaffected by the impermeability problem because of a number of microscopic gateways called *permeases* or *ion channels*. Each permease is composed of three or four highly specialized protein molecules that function together to allow only specific molecules or ions in or out of the cell. These are placed at strategic locations around the perimeter of the cell. They allow only the correct components to enter at only the right places. Why do they appear at all, much less at exactly the right places? Because DNA contains the information used to construct the cell membrane and place them where they need to be.

This is a wonderful topic for a study in contrasts. On the one hand, students might take DNA's specification of how to construct permeases and where to place them as evidence for design. On the other hand, they should look for alternative explanations. They should carefully study known and hypothetical chemical processes to look for ways random chemical action could have produced permeases simultaneously with the membrane and the rest of the cell. They may not reach a conclusion, but they will be made to think!

Many of the preceding topics are difficult to deal with in terms of initial disorganization. Thus, they are often omitted from biology classes which present evolution as the only alternative. This situation should be corrected. The study of how the initial complexity and initial disorganization models deal with each of these will challenge students' minds and arouse their scientific curiosity. It has nothing to do with advancing religion.

F. DEVELOPMENT OF LIFE AFTER ITS ORIGIN.

This is such a broad subject that it must be broken down into many subtopics. We will see how dealing with each of these will enhance science education without advancing religion. First, an overview:

Visual # 58

The initial disorganization model holds that the first living thing was a simple cell. As it and its descendants reproduced, mutations (copying mistakes) occasionally took place. Some were beneficial, some harmful. As a result of beneficial mutations, living organisms have gained a great deal of genetic information. Millions of new types have evolved over billions of years. There has been an overall trend toward increasing organization.

Initial complexity leads us to believe that a great variety of living types was present from the beginning. Changes within each type have been within the limits set by the genetic information contained in the first representatives; in no case would any type have acquired more genetic information than it started with. Mutations during reproduction would have been harmful, so there should be mechanisms to minimize them. No new major types should have come into existence since the beginning. Because of an overall trend toward deterioration, some of the types may have become extinct.

1. Correcting Misconceptions.

Visual # 59

Some current biology textbooks are not up-to-date. They contain items that were used as evidence for evolution years ago, but have since been disproved. Not all elementary and high school teachers are aware that professional scientists no longer believe in the following. Thus, students are misled. This should be corrected.

a. Lamarckianism. It is almost embarrassing to point it out, but some people still believe in this 19th century idea. Obviously, regular use of body parts builds them up. Disuse causes them to atrophy. Biologist Jean Baptiste Lamarck reasoned that animals that use body parts would pass on the enhancements to their offspring, while those that did not use the parts would pass on the deterioration. He proposed that the giraffe got its long neck in this way.

Millions of years ago, Lamarck thought, the giraffe's ancestors must have had short necks. There were periodic droughts. Only those animals which stretched their necks far enough to reach the leaves survived, passing on the stretched necks to their offspring. After many generations, the long-neck giraffe had evolved.

The science of genetics was unknown in Lamarck's day. We now know both theoretically and experimentally that use and disuse of body parts has no effect on an animal's offspring. Its characteristics are determined solely by the DNA it inherits from each of its parents. The giraffe story, and any other one based on the Lamarckian misconception, must be corrected!

b. Industrial Melanism. The case of the peppered moth is often used as an example of evolution in action. This moth, properly known as *Biston betularia*, lives in the area around Liverpool, England. It occurs in both light and dark varieties. Before the industrial revolution, most of the moths were light. This was because the dark ones were easy to spot against the light colored trees, making them an easy target for birds and other predators. The light ones had a survival advantage. Then the factories came. As they belched out soot, the trees became darker and darker. Before long, the light moths became easy to see against the now-dark trees. They became the meal of choice for predators. Soon, most of the peppered moths were dark.

The moth population started with light and dark specimens of *Biston betularia*; it ended with light and dark specimens of *Biston betularia*. Nothing new was added. The only thing that changed was the relative percentage of each. Besides, since an industrial cleanup campaign began in the area, the trees have started to lighten again and the percentage of light moths has begun to increase. The peppered moth furnishes a wonderful example of natural selection, but it has nothing to do with evolution.

c. Vestigial Organs. Most people are under the mistaken impression that the human body contains many "vestigial" organs left over from an earlier stage of evolution. They are no longer needed, so they have diminished in size and function. This idea comes from a German biologist named Wedersheim, who in the 1880s compiled a list of over 180 structures he considered vestigial. It is a throwback to Lamarckianism, which would lead us to believe we lose organs when we no longer use them. Now we know better. As long as our DNA contains the information to construct an organ, it continues to appear in each generation, needed or not.

Medical science has long since disproved the idea of vestigial organs. We now know the function of most or all of the structures on Wedersheim's list. For instance, the tonsils and appendix are part of the reticuloendothelial system, which helps fight infection; the coccyx is the anchoring point for the pelvic muscles; the pineal, thymus, thyroid, pituitary, and other glands serve important functions; and so on.

Consider this also: if our ancestors had more functional organs than we do, then they had more complex bodies. We must have deteriorated from them. This is exactly the opposite of what initial disorganization leads us to expect. It certainly cannot be used to argue in favor of evolution.

d. Embryonic Recapitulation. In the middle 1800s a medical doctor named Ernst Haeckel joined the zoology faculty of Jena University in Germany. When Darwin's *The Origin of Species* was translated into German around 1860, Haeckel seized upon the idea of evolution. He began reporting in 1866 that he had dissected the embryos of several species at different stages of development, and that they showed a clear pattern of recapitulating their evolutionary origin. He described this as the "Fundamental Biogenetic Law," which is usually summed up in the slogan "ontogeny recapitulates phylogeny."

As early as 1874, embryologists such as Wilhelm His tried to warn the public that Haeckel was lying. He had altered his drawings to make the embryos appear much more similar than they really were. Unfortunately, few people listened. For over 40 years Haeckel taught his fraudulent ideas as fact, until he was finally forced to confess at a Jena University Court in 1907. (See Appendix A for references.) Amazingly, some biology textbooks still teach embryonic recapitulation over 90 years later.

Social studies classes would find Haeckel's motives a fascinating subject. Biology students would benefit from studying intrauterine photographs to see what an embryo *really* looks like at every stage from conception to birth. They should learn the function of structures in the human embryo that were once mistakenly identified. These include the "gill slits" that are really pharyngeal pouches, the "yolk sac" that contains blood instead of yolk, and the "tail" that is actually the anchoring point for the pelvic muscles. They should investigate accounts of babies supposedly born with tails to see if these are really bony structures or nothing more than fatty tumors.

Now that we've seen some things that should *not* be a factor in the initial disorganization/initial complexity debate, let's look at some that *should*.

2. Error-Checking Mechanisms in the Cell.

a. Initial Disorganization: Since a cell is the result of a long series of chemical accidents, such accidents are a normal part of evolution. The cell should not "care" if it mutates.

b. Initial Complexity: Since life came into existence in a complex, fully functional condition, it is likely that cells will contain some sort of error-checking mechanism to minimize copying mistakes.

c. Educational Enhancement: Students will be exposed, perhaps for the first time, to some amazing processes that go on inside a cell. (See Miroslav Radman and Robert Wagner, "The High Fidelity of DNA Duplication," *Scientific American*, August 1988, pp. 40-46.)

i. Nucleotide Selection. The structure of DNA is a double helix. (A helix is the geometric shape followed by the threads on a screw.) The double strands are composed of millions or billions of *nucleotides*, usually represented by the letters A, C, G, and T. The double strands of DNA both contain all the information needed to produce a cell, but one is the opposite of the other, much like a negative and the photograph made from it. Wherever an "A" occurs on one, a "T" occurs on the other, and vice versa. "C" and "G" pair up the same way. During reproduction the two strands "unzip" and each acts as a template used by the enzyme *DNA polymerase*. This enzyme makes two complete DNA strands out of the one that split in two. It does this by selecting the appropriate nucleotide from those available nearby and inserting it into the proper place on the strand being manufactured. Because of the complementarity of A to T and C to G the DNA polymerase is usually able to select the appropriate nucleotide. The wrong one is inserted only about 1 in 100,000 times.

ii. Preliminary Proofreading. The DNA polymerase then conducts "proofreading exonuclease," named by discoverers Douglas Brutlag and Arthur Kornberg of Stanford University. If a mismatched nucleotide slips into the newly forming strand, it slows down the addition of the next one. When this occurs, the enzyme removes the offending nucleotide and tries again to insert the one that fits. This reduces the frequency of errors to about one in 10 million.

iii. Error Detection and Correction. Finally, another enzyme "reads" the new double strand of DNA to make sure there are no mismatches. If it finds one, it removes the defective segment of the new strand and repairs it by inserting a corrected segment. This brings the rate of copying errors down to about one in 10 billion.

How does the enzyme know which half of the double strand is new and which is old? Apparently, this varies from one organism to another. Somehow, it *does* know and makes corrections only on the newly formed half.

The subject of error-checking mechanisms in the cell will be an excellent springboard for further learning. For example, students may want to examine the operation of enzymes in great detail, contrasting the possibility that they were designed with the possibility that they developed the ability to do exactly the right thing by natural processes. They may want to find out how the enzymes in different organisms know which strand is the new one. Learning will be enhanced; religion will not be advanced.

3. **Origin of New Features in Living Organisms.** (This topic pertains to biology, paleontology, physics, and mathematics.)
   - **a. Initial Disorganization:** Since the first living things were single cells, their descendants periodically gained new features (lungs, eyes, bones, wings, feathers, brains, etc.). Though most mutations during reproduction are harmful, some must have been beneficial in order for these structures to appear for the first time.
   - **b. Initial Complexity:** The first representatives of every major type — not necessarily any modern species, but probably recognizable as the same genus — had all their ordinal characters (those things that identify a dog as a dog, a cat as a cat, etc.) from the very beginning. They possessed all the genetic information the type has ever had. Since then, the genes have been spread around so that only a small portion are expressed in any one individual. Specialization may have occurred because of factors such as natural selection, but no new features have

been added. The total information in the gene pool has not increased from the amount which was present in the first specimens.

Mutations should not add new features because they do not add to the information in the gene pool. They should be harmful or, at best, neutral to the survival of the type.

c. Educational Enhancement: Students will want to research the subject of mutations to see how many have been harmful and how many have been beneficial.

i. They should carefully study mutations claimed to convey a benefit to the individual, to see whether they convey a benefit to the type. For example, one might say that the sickle cell trait (a hemoglobin mutation) is beneficial because a person who inherits it from one parent will have only a mild case of the disease and will be immune to malaria. (One who gets it from both parents receives no benefit and will likely die a painful, lingering death.) So is sickle cell beneficial? Malaria is curable and is not passed on to descendants, but sickle cell is incurable and hereditary. Students should consider whether the benefit to the individual outweighs the harm to the species.

ii. They should investigate claims of beneficial mutations in bacteria and insects. For instance, some strains of bacteria have become resistant to certain antibiotics and some varieties of insects have become immune to specific pesticides. The students should study this carefully. If identical strains have developed in widely differing locations, the potential was probably present in the gene pool all along. If different strains have developed, it is much more likely that they are the result of mutations.

iii. They should study the scientific literature to see if any mutations are known which have introduced new features for the very first time.

iv. They should consider how mutation could drastically but beneficially change the atomic structure of key proteins. If all organisms are descended from the same cell, for instance, it would be informative to study how plants first began to rely on magnesium atoms for photosynthesis. It would also be interesting to study how most animals developed an oxygen transport system that relies on iron atoms (the focal point of hemoglobin), while the octopus developed a system that depends on copper.

v. The subject of mutations furnishes an excellent opportunity to introduce students to *information theory*. Mathematicians have done a great deal of theoretical work and computer simulation in their investigation of what happens to an information-rich system subjected to random changes. Since DNA is such a system, their work is pertinent to this issue. Students should hear what the mathematicians have found.

4. Pleiotropy and the Structure of DNA.

a. Initial Disorganization: Cells are the result of random chemical processes. They should be made of the kind of things that develop randomly.

Visual # 60

b. Initial Complexity: Cells came into existence in a complex condition. They should show evidence of design.

c. Educational Enhancement: Students should be made aware of the phenomenon of *pleiotropy*. Researchers have found that many times when they induce one mutation in a strand of DNA, more than one body structure changes in the affected individual. Many portions of DNA seem to have more than one function during cell reproduction.

Scientists should already know that DNA is a digital information storage system. (The digits are represented by A, C, G, and T.) As they discover more about how it operates, they are learning that during reproduction it assumes a three-dimensional shape that loops back on itself in many places. Apparently, some of the loops are used more than once. DNA behaves in much the same way as a computer program with built-in multipurpose subroutines.

One possible explanation for this behavior is design. Students should also learn of others as they are proposed. The school should not require them to accept one explanation or the other. Its job is to teach, not indoctrinate.

5. "Pseudogenes."

a. Initial Disorganization: All living things are descended from the same cell. There will likely be nonfunctional similarities in their DNA left over from their common ancestry.

b. Initial Complexity: Living things are descended from multiple discrete groups ancestors. Each organism is genetically related only to others that share its ancestry. Similarities between unrelated types reflect common design, not common descent.

c. Educational Enhancement: Students should be made aware of the discovery of "pseudogenes," similar segments of DNA found in dissimilar organisms. Since they serve no known purpose, some consider them to be vestigial evidence of common ancestry. Students should be challenged to consider several factors:

i. Many body structures were once thought vestigial because scientists did not think they did anything. Later, they learned that the organs had a function after all. Our ignorance of what something does may mean it doesn't do anything. On the other hand, it may just mean we are ignorant.

ii. The DNA of many organisms contains the nucleotide sequence *TTAGGG*. Scientists used to think this sequence was meaningless. (Were it not for the fact that the term is a recent invention, they might have called it a pseudogene.) They have lately discovered that it is a "stop" code indicating the end of a chromosome.

iii. Scientists are continually learning more of the mysteries of DNA. They are finding that it assumes a three-dimensional shape during reproduction, looping back on itself in many places. They are not yet certain what makes it do this. Students should investigate the possibility that we have been looking in the wrong place to find out what pseudogenes do. They may contain structural rather than transcriptional information.

Students may not decide whether initial disorganization or complexity is more likely, but they will be led to a fascinating scientific study.

6. Protein Sequences.

a. Initial Disorganization: Since every organism is genetically related, its components should be most similar to those in closely related organisms and less similar to those in its distant relatives.

b. Initial Complexity: From its beginning, each major type of organisms had a gene pool containing a large but limited amount of genetic information. Any genetic similarities between unrelated types were present from the beginning. They did not develop later.

Any two organisms of different types will be more similar in some ways and less similar in others. This is not because one has developed farther from a common ancestor than the other, but because each type of organism has features that enable it to fit well with its environment.

c. Educational Enhancement: Most biology textbooks teach students about the enzyme *cytochrome C*. Just about every known organism contains some form of this enzyme, a protein molecule involved in oxygen transport. As we go up the evolutionary sequence from single cells to man we find that cytochrome C is much different in higher organisms than in one-celled organisms. The farther from single cells the greater the difference.

Though most textbooks stop there, the story doesn't. Students should be informed of the work of Michael Denton, a cell microbiologist who has done extensive research in protein sequences. Of the thousands of proteins in living organisms investigated so far, Dr. Denton reports that cytochrome C is the *only* one that shows a continual gradual change as it progresses up the evolutionary ladder. Any two organisms of different types have some proteins that are more similar and others that are less. There is no overall pattern of gradual development. If proteins evolved gradually, each one did so at a different rate. For instance, a human and a carp (a fish) differ by about thirteen percent in their cytochrome C, but *fifty* percent in their hemoglobin.

Another surprise: the carp's cytochrome C differs by about thirteen percent not only from humans, but from all non-fish vertebrates. The same applies to the thousands of proteins studied so far. Any member of any major group (class, order, etc.) shows a fixed percentage of variation from the comparable proteins of the members of any other major group. All vertebrates might differ from all insects by a certain percentage in one of their proteins and a different percentage in others; within the vertebrates, all mammals differ from all birds by a certain percentage; within the mammals, all primates differ from all rodents by yet another percentage, and so on.

Denton's book *Evolution: A Theory in Crisis*, Adler & Adler Publishers, Bethesda, MD, 1986, is an outstanding resource in the study of cell microbiology. The title is somewhat misleading, since he believes in evolution. His work is also summarized in Percival Davis & Dean Kenyon, *Of Pandas and People: The Central Question of Biological Origins*, Haughton Pub. Co., Dallas, TX.

The lack of evolutionary patterns in proteins is a puzzling phenomenon, sure to lead students into fascinating research. Education will be enhanced; religion will not be advanced.

7. Homology.

The presence of similar structures in dissimilar organisms is called *homology*. An example of homology is the basic mammalian body plan of four limbs with five appendages each. (Of course, there are exceptions such as marine mammals.) The similar structures are considered *homologous*.

a. Initial Disorganization: Similarities in different types of organisms reflect their common ancestry. Since all living things evolved from the same cell, they started from the same DNA sequence. The same relative location on each type's DNA should be responsible for producing structures similar to those in other types. Homologous structures should be produced by homologous genes.

b. Initial Complexity: Similarities in different types of organisms are the result of common design, not common descent. Each type started with a different DNA sequence. Apparently homologous structures need not be produced by homologous genes.

c. Educational Enhancement: Students should study recent discoveries by molecular biologists such as Sir Alister Hardy, Sir Gavin DeBeer, Michael Denton, and R.F. Chapman. They will be fascinated to learn of many apparently homologous structures which are produced by non-homologous genes. A few examples:

i. Adult organ systems in metamorphosing insects develop in many different ways.

ii. The foregut and hindgut of Coeloptera (beetles), Lepidoptera (butterflies), Diptera (flies), and Hymenoptera (ants and bees) develop in completely different ways.

iii. Conifer and angiosperm seeds are considered homologous, but the ovule and endosperm develop in profoundly different ways.

iv. Though adults of the different vertebrate classes have many similarities, they arrive at these through radically different developments in the embryo's blastula and gastrula phases.

v. The alimentary canal in different vertebrate classes is formed from different embryological sites.

vi. The vertebrate forelimb develops from different body segments in different vertebrate species.

Other examples (kidney, ureter, amniotic membranes, etc.) abound. Students should be kept abreast of the latest developments in embryology to see if anyone is able to solve the mystery of homology. Withholding the fact that there is a problem will not help their education; telling them about it may lead them to independent research.

8. Geographic Variation.

The same species or genera are sometimes found in many places around the world, but with variations. This usually occurs because of distance or natural barriers such as volcanoes, canyons, bodies of water, and the like.

a. Initial Disorganization: Each major type has gained a great deal of genetic information through mutations. The variations in different locations arose because the farther the species or genus traveled from its origin, the more it mutated and the more information it acquired.

b. Initial Complexity: Each major type started with a limited but large amount of genetic information. The original specimens comprised what could be called the "founder" population. They contained all the information in the gene pool. Only a small percentage of this information was expressed in any one individual. For instance, a bird which had a curved beak might have contained recessive genes for straight beaks. Some of its descendants would probably have curved beaks, while others would have straight ones.

As the type radiated outward from its point of origin, the migrants encountered differing environmental conditions. Some of the characteristics which had been beneficial at the original location might have been useless in other places. Individuals with those characteristics would be at a disadvantage and would probably die quickly. For example, the food supply in a new location might have been unsuitable for birds with straight beaks. Only those with curved beaks would survive. The genes for straight beaks would gradually be lost as the population became more specialized.

The individuals in the new location could serve as a new founder population, but with a reduced amount of genetic information. As individuals from this group continued to migrate the process could be repeated over and over. Each location would see a more specialized population. The farther the type spread, the greater the difference between the local specimens and those that never left the point of origin.

c. Educational Enhancement: Students will find this a challenging subject. It will take some research into biology, genetics, anthropology, and paleontology to find out whether a specific type of animal or plant has gained genetic information or has merely become more specialized because of information loss. They will have to do some serious thinking to determine whether it is more likely that the population was initially primitive or complex.

Many textbooks withhold the fact that there are two explanations for geographic variation. There is no educational advantage in such censorship. Students will learn much more if they are encouraged to think than if they are prevented from doing it.

9. The Fossil Record.

This is an extremely broad subject, touching on biology, paleontology, chemistry, anthropology, and physics. It is best broken down into subtopics.

a. Uniformitarianism vs. Catastrophism.

i. Initial Disorganization: The basis of the geologic time scale is *uniformitarianism*, the belief that "The present is the key to the past." Just as living organisms developed by the slow, gradual addition of genetic information over billions of years, so likewise the earth's geologic features accumulated

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slowly and gradually. The great majority of fossils were produced by presently observed processes operating slowly and gradually over vast expanses of time.

ii. Initial Complexity: Though natural processes usually proceed slowly and gradually, there may have been times when they operated much faster. One or more catastrophic events may have accelerated the development of geologic features.

Our observations about fossil formation have reinforced this belief. We have never seen fossils forming by slow, gradual processes. We have only seen living things turn into fossils after catastrophic events such as volcanic eruptions and floods. This and the fact that most fossils are found encased in water-laid sediment lead us to believe that much of the fossil record was produced in the aftermath of catastrophic events.

iii. Educational Enhancement:

(a) Students should study how fossils are formed. They should be aware of experiments that have succeeded in turning small bones into fossils in less than ten years (in some cases, less than a day) and garbage into oil in a matter of minutes.

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(b) They should become familiar with the many vast fossil graveyards found throughout the world such as the Karoo Formation, Lance Creek Formation, Cumberland Bone Cave, Dinosaur National Monument, Baltic amber deposits, Geiseltal lignite beds, Sicilian hippopotamus beds, Rocky Mountain mammal beds, California Miocene shales, etc. It will be worth their while to consider the likelihood that these are the result of slow, gradual processes.

(c) They should be made aware of the geologic features (Engineer's Canyon, nascent coal beds on the bottom of Spirit Lake, etc.) that formed rapidly in the aftermath of the Mount Saint Helens eruption.

(d) They should know that many geologists see evidence of repeated catastrophes such as asteroid impact in the fossil record.

(e) They should study the phenomenon of inverted strata (the Matterhorn, the Lewis Overthrust, etc.) to see if current geological explanations are satisfactory.

(f) They should study the scientific literature on the subject of *orogenesis* (mountain building) to see if any presently operating uniform processes have been discovered that are capable of pushing up mountains.

All the above factors have caused a number of geologists to abandon strict uniformitarianism in favor of a modified version that allows for occasional catastrophes. However, they have not abandoned the time scale based on strict uniformitarianism. Students will find it a fascinating intellectual exercise to consider how reasonable it is to remove the foundation but keep the time scale built on it.

b. Adequacy of the Fossil Record.

At this point, it would be advantageous to discuss potential problems with evidence. (See Appendix A.) Scientists have made mistakes in the past because they based their conclusions on incomplete or falsified evidence, or because key evidence was deliberately withheld from them.

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Students should be aware how many fossils have been discovered. There are estimated to be *hundreds of billions* of vertebrate fossils in South Africa's Karoo Formation alone. It would be a conservative estimate to say that over a trillion have been unearthed worldwide. These have been categorized into about a quarter million fossil species.

This amount of evidence is far more than is available in other fields such as astronomy. Most students will conclude that the fossil evidence is sufficient to draw reasonable inferences about what happened in the past. Some may not. There is no reason to force them into a decision. Some scientists have been studying fossils for many years and are still not completely persuaded. (This has led to the development of *cladistics*, a system of classifying organisms which makes no attempt to guess where they might have come from.)

c. Presentation of Alternative Evolutionary Models.

Some biology textbooks present only one model of evolution, *Neo-Darwinism*. This is based on the belief that living things have increased in complexity by an accumulation of extremely small changes rather than sudden jumps. Many biologists accept this model because their understanding of mutations leads them to believe large changes would tend to be lethal rather than beneficial.

Students should be made aware that another evolutionary model, *punctuated equilibria*, is growing in popularity among paleontologists. It holds that living things stay basically the same for periods of equilibrium lasting thousands or millions of years. Suddenly (in geologic terms) a punctuation event takes place which forces a series of mutations in a very short time. Within a few generations - perhaps as rapidly as a century - a new type of organism evolves. (The most extreme example, the "hopeful monster" mechanism proposed by Schindewolf, was the belief that a reptile laid an egg and a bird hatched.) This model is gaining acceptance not because anyone has ever seen a rapid accumulation of beneficial mutations, but because of the fossil evidence. The principal reason for believing in punctuated equilibria is the extreme rarity of transitional forms in the fossil record.

d. Method of Identifying Geologic Strata.

i. Initial Disorganization: The strata of the earth's geologic column represent *time periods*. Since all living things are descended from the same cell and since they now range from single-celled to human, different types must have evolved at different rates in different places. The fossil record should reflect a continual blur of developing life forms. There should not be a consistent worldwide pattern of terminal forms (those which seem to have stopped evolving) in clearly defined fossil communities. The farther apart two places are geographically, the greater the difference there should be in the fossils they contain.

ii. Initial Complexity: As we look in the world around us we see animals and plants living in *ecological communities*. For example: lions, giraffes, zebras, and rhinos tend to be found fairly close together in an African savanna environment, while a completely different group of animals swims around coral reefs. We expect the fossil record to show similar conditions. Fossils should tend to be found in clearly defined communities. Some fossils may be out of place because of geologic activity or because they were out of their native habitat when they died, but in general, creatures which lived together should be fossilized together in ecological communities.

iii. Educational Enhancement: Few people other than geologists have ever studied how geologic strata are identified. Most are under the impression that rocks are dated radioactively. Students investigating this topic will discover a great deal of surprising information that may inspire them to independent research.

(a) They should investigate the geologic column pictured in textbooks. They will find that it is pieced together from different locations around the world. The complete column does not exist in nature. The largest number of strata found in one place is six, at the Grand Canyon. Every layer can be found directly overlying basement rock somewhere in the world. Students should search for explanations for this phenomenon.

(b) They will probably be surprised to know that ages were assigned to the strata before radioactivity was discovered. They should search the scientific literature to see how many *tie-points* (radioactively dated rock samples that match the already assigned stratigraphic age) have been found around the world. They may be shocked to learn how few there are, but they will be learning geology.

(c) They will find that rocks are dated not by radiometric methods but by the characteristic community or "suite" of fossils they contain. They will discover that many of the strata (Cambrian, Ordovician, Silurian, Devonian, Jurassic, Mississippian, Permian, etc.) were named for the location where the characteristic suite of fossils was first identified. Each suite is easily identified anywhere in the world because it contains the same basic types of organisms no matter where we find it.

(d) They will find that the idea that the lowest rock strata must be the oldest, the "Law of Superposition," was originated by Nicolas Steno in the 17th century. Though Steno realized that there could be exceptions, few textbooks mention the fact that the Law of Superposition is not a law at all. Exceptions have been noted on a large scale -- for example, stratification at Mount St. Helens -- and a small scale, e.g., Berthault's work at the University of Colorado on sedimentation in flowing currents. (Berthault, G. 1988. *Sedimentation of heterogranular mixture -- experimental lami-*

nation in still and running water, C.R. Acad. Sc. Paris, 306, II, 717-724.)

e. Age of the Earth.

i. Initial Disorganization: It would have taken billions of years for living organisms to evolve to their present condition. Thus, the earth must be billions of years old.

ii. Initial Complexity: The earth need not be any specific age. However, it was suitable to sustain life from the beginning. Since we know approximately how fast it loses heat, we could work backward from the present to the time when its surface would have been too hot for water to exist as a liquid. Its age must be something less.

iii. Educational Enhancement: The fact that some people believe the earth is only a few thousand years old furnishes an excellent opportunity for students to learn the strengths and weaknesses of various dating methods.

(a) They should learn how the earth's age was first determined. (A single meteorite, the Canyon Diablo meteorite, was radiometrically dated and assumed to be the same age as the earth.)

(b) They should investigate how radiometric dating methods work. This will be an informative exercise in mathematics. They will discover that radiometric techniques depend upon a series of assumptions. In order to obtain an exact radiometric age, we need to solve an equation in at least five unknowns. It can't be done. All a radiometric method can legitimately do is set an upper and lower limit on the age of an object.

(c) They should be aware that radiometric methods are the only techniques that yield ages on the order of billions of years. They should explore other indications that point to ages on the order of millions of years.

(d) They should be made aware of the arguments used for a short age (decay of the earth's magnetic dipole moment, surface-to-interior temperature gradient, atmospheric helium concentration, ratio of Carbon-14 production to decay, etc.). They should be exposed to the strengths and weaknesses of these arguments.

(e) They should learn about geologic features used to indicate great age (salt domes, coral reefs, the Grand Canyon, etc.). They should be exposed to alternative explanations for these features to see if they are reasonable.

Some of the arguments for both an old and a young earth are intriguing. Preventing students from hearing the latter will harm rather than help their science education. Presenting both will give students an opportunity to examine their strengths and weaknesses. Those who believe the earth is old will be better equipped to deal with the arguments of those who believe it is young, and vice versa. They may not reach a conclusion, but they will be made to think.

f. Initial Number of Higher Taxa.

i. Initial Disorganization: Biologists use a classification system in which the highest category or *taxon* is the kingdom, the next highest is the phylum, the next is the class, and so forth. The first living cell was a member of one kingdom, phylum, class, order, family, genus, and species. As its descendants gained genetic information more and more of the higher taxa appeared. Thus, we should see a gradual increase of higher categories in the early fossil record.

Classification in the lower taxa (genus and species) depends upon the ability of organisms to breed with each other. Since we can't be sure which extinct organisms were able to interbreed, we can't be sure we have assigned them to the correct genus and species. Thus, the number of lower taxa may have varied. However, there should have been a continual increase in the number of major types of animals and plants.

ii. Initial Complexity: All the higher taxa were present from the beginning. The more fossils we find, the more higher taxa we will see represented in the earliest fossil-bearing rocks. The number of kingdoms, phyla, etc. has not increased through time; it may have decreased due to mass extinction.

Because classification is uncertain at the lowest levels, the number of lower taxa may have varied. However, there should be fewer major types of animals and plants living today than there were at the beginning.

iii. Educational Enhancement: Students should pay special attention to the Cambrian stratum, the first layer to contain more than a few organisms.

(a) They will learn of the "Cambrian Explosion" in which representatives of all twenty-three phyla of the animal kingdom appeared suddenly and fully formed with no known ancestry, as well as many divisions of the plant kingdom. They should search for ways this phenomenon can be explained in terms of gradually increasing complexity.

(b) They will also find that Cambrian and other early rocks contained many more major types of organisms than the modern world does. Some estimate that as many as ninety-six percent of all the species that have ever lived are now extinct. They should contrast the initial disorganization and initial complexity models to see how this fits with both.

This subject will provide students with an intellectual challenge. The evidence of explosive appearance followed by gradual extinction seems to fit with initial complexity. However, the students should search the scientific literature to see how geologists try to fit this phenomenon into a framework of initial disorganization. They can decide for themselves which is more reasonable. Giving them the opportunity to learn about both sides of the controversy will enhance their science education. It has nothing to do with advancing religion.

g. Gradual Development and Continual Change vs. Sudden Appearance and Stasis.

i. Initial Disorganization: We should find evidence in the fossil record of *gradual development* of each major type, and *continual change* after the type first appeared. It would take millions or billions of transitions for the descendants of the first cell to evolve into all the terminal forms preserved in the fossil record or living today. Ordinal characters should be continually changing. It should be difficult to tell where one type ended and another began. If we dig up enough fossils, we should find at least a few of the transitions along with the terminal forms.

The punctuated equilibria model discards these predictions. It does not offer different ones in their place, but instead tries to explain the extreme rarity of transitional forms in the fossil record. It still holds that transitions took place, but says the changes were too rapid to leave fossil traces. It also acknowledges that fossils show resistance to basic change. It offers the following explanation: Organisms suited to their environment are better off if they do not change. However, if the environment changes suddenly, those that are able to develop new and beneficial features have a survival advantage. They will rapidly take over the ecological niche formerly occupied by their ancestors.

ii. *Initial Complexity:* We should find evidence in the fossil record of *sudden appearance* of each major type, and *stasis* (resistance to basic change) after the type first appeared. The earliest representatives of each type appeared suddenly and fully formed, with all their ordinal characters present. Changes during the type's tenure on earth should be limited and directionless. Diversification has been within the limits set by the initial gene pool. The last representatives should be recognizable as the same basic type as the first. In no case should we find a series of living or fossilized organisms showing the development of a new major type from a previously existing one.

iii. *Educational Enhancement:* Students will find this a broad and challenging field of study.

(a) They should study the criteria used to determine an organism's species, genus, etc. with a view to determining whether living things fall into major groups or if they all blur together. This will lead to an intriguing study in zoology as they attempt to determine how many major types are living and extinct.

(b) They will learn how the phenomena of sudden appearance and stasis have led to a growing acceptance of punctuated equilibria. They should carefully study the biological literature to determine whether any cases of beneficial drastic mutations have been observed.

(c) They should carefully study every one of the forms and sequences which are considered transitional. They should learn the arguments both for and against transitional status. These include:

(1) The origin of vertebrates. Students should know why some consider segmented worms such as *Amphioxus* a transition from invertebrates and others reject it. If any transitional fossils are found showing how bones might have developed gradually, they should be told.

(2) The transition to land. They should study the anatomy and lifestyles of crossopterygian fish such as *Eusthenopteron* and *Tiktaalik* to see

whether they are plausible ancestors not just for ichthyostegid amphibians but for the five other Paleozoic orders belonging to **Class Amphibia**. They should look at the differences as well as the similarities and consider what biological mechanisms might have caused the differences to develop. They should also consider the evidence of geology relating to the Devonian times to determine if there would have been any need for fish to leave the water.

(3) Reptile to bird. Students should carefully study *Archaeopteryx* as a potential transitional form. They should consider its supposedly reptilian features (claws on the wings, teeth, a long bony tail, and a short breastbone) to see if any undisputed true birds have them. They should also consider the structures unique to birds. These include feathers, tube-type lungs, enlarged cerebral hemisphere and cerebellum, and reversed skeletal and muscular operation in the wings. Since birds are supposed to have come from dinosaurs, students should look for any that had structures from which the bird's could have arisen. They should also look for biological processes that would have produced such a highly coordinated series of mutations.

They should be made aware that all the dinosaurs known so far that bore any overall similarity to birds (*Struthiomimus*, *Ornithomimus*, etc.) were members of **Order Saurischia**, characterized by a triradiate lizard type pelvis. The other order of dinosaurs, **Order Ornithischia**, had a tetraradiate bird-type pelvis. No one has proposed that birds came from ornithischians because the rest of the body was far too different. Thus students should look for a biological mechanism whereby the bird-type pelvis evolved twice independently - once in birds and once in ornithischian dinosaurs.

They should also be made aware of other fossil discoveries that cast doubt on *Archaeopteryx* as a transitional form. These include James Jensen's "Protoavis," dated to the same time as *Archaeopteryx*, and Sankar Chatterjee's "Pro-avis," dated 75 million years earlier. As more information verifying or falsifying these becomes available, students should hear of it.

(4) The Horse Series. Students should learn the history of the "horse series," based on an outdated display at the American Museum of Natural History but still found in many textbooks. They should learn the reasons why professional paleontologists have discarded it as an example of evolution. These include dramatic fossil finds that place the modern horse alongside *Eohippus*, long thought to be its earliest ancestor. (See Appendix A for details.)

(5) Fossil Apes and Man. Students should first be aware of the extreme scarcity of hominid fossils. The teacher might then want to lead them on a sequential study of the following:

- Primates (the order that includes monkeys, apes, and man) are supposed to be descended from insectivores. Is there any fossil evidence for such a transition? Why do some consider the tree shrew (*Tupaia*) a candidate while others reject it?
- Did the lowest primates (lemurs, lorises, tarsiers) appear sequentially or simultaneously? Are the oldest fossils any different from modern specimens?
- Is there any fossil evidence for a transition from the lowest primates to anthropoids (monkeys, apes, and man)?
- Are there any proposed ancestors for platyrrhines (New World monkeys)?
- Are there any proposed transitions from the first anthropoids to catarrhines (Old World monkeys, apes, and man)?
- Is there any fossil evidence for the origin of Old World monkeys? • Is there any fossil evidence for the origin of apes (gorillas, chimpanzees, orangutans, and gibbons)?
- We sometimes hear that chimpanzee and human DNA are 98% similar. Who determined this and how? What segments of the DNA were compared? How many actual differences in the DNA of the two groups would be involved? How many point mutations would have to occur to produce this much difference? How long would it take for this number to accumulate?
- How similar are humans and apes physically, and how do they differ? Which proposed common ancestors of apes and man had features that would have enabled them to produce two sets of offspring with at least 19 major differences?
- Is there any fossil evidence for a common ancestor of Asian apes, African apes, and man?
- Why have *Dryopithecus, Ramapithecus, Oreopithecus, Limnopithecus,* and *Kenyapithecus* all been eliminated as potential ancestors of the australopithecines? Are any other candidates presently being considered?
- Why do many consider *Homo habilis* nothing more than an australopithecine? What reasons are there to place it in the genus *Homo*?
- Why do many anthropologists consider *Australopithecus africanus, A. robustus, A. boisei, Zinjanthropus*, and *Paranthropus* evolutionary dead ends?
- How humanlike was *A. afarensis*? If it was able to walk upright, how significant is this ability? How does it compare to living apes such as the bonobo?
- Why were *Pithecanthropus* (Java Man) and *Sinanthropus* (Peking Man) later reclassified *Homo erectus*?
- What are the oldest known fossils or artifacts of *Homo sapiens*?

- What characteristics have led some anthropologists to consider *Homo erectus* a transitional form between apes and humans, while others consider it a true human?
- What are the oldest known fossils or artifacts of *Australopithecus* and *Homo erectus*? How does their age compare with that of the oldest human relics?
- In what ways were Neanderthal and Cro-Magnon different from modern humans? In what ways were they similar?
- Why were Neanderthals at first considered subhuman? Why were they later upgraded to *Homo sapiens*?
- Have any modern humans exhibited the peculiarities typical of Neanderthals?
- What cultural remains did Neanderthal and Cro-Magnon leave? Do they indicate disorganization or sophistication?

These are but a few sample questions and discussion items. They certainly do not exhaust the topic of the fossil record, nor do they "prove" either initial disorganization or initial complexity. They are meant to illustrate the fact that contrasting the two models can greatly enhance science education by stimulating students' curiosity. It has nothing to do with advancing religion. It doesn't matter if the students decide one side or the other is correct; what matters is that they learn to think for themselves.

CONCLUSION

We have seen that the issue of creation vs. evolution can be studied in a logical, scientific way when viewed in terms of initial complexity vs. initial disorganization. We can use each model to make testable predictions in many areas of science. Examining these predictions will lead students to a better understanding of how both science and nature work.

Throughout this work, there has not been a single reference to any religious book or legend. Nevertheless, some will continue to claim that creation is nothing but religion. Their deception is now exposed. They speak out of prejudice, not scientific concern. It is obvious that the creation/evolution controversy can be presented in a manner that greatly enhances science education without advancing religion. Yes, it's legal. It's also good education.

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> The author is a living example of the educational benefit of studying both creation and evolution. A great deal of the information in this work was acquired before he became certified to teach biology, through independent research inspired by curiosity about creation and evolution.

APPENDIX A.

CRITICAL THINKING SKILLS.

The very fact that neither initial complexity nor initial disorganization is proven affords a marvelous opportunity to teach students skills they can use not only in science but also in many other areas of life. These skills will enable them to press on beyond the classroom material and learn new things on their own - surely a worthy goal in the educational process.

1. Potential Problems With Evidence.

As students examine the evidence for both initial complexity and initial disorganization, they should be made aware that there are potential problems with evidence in any field of study. Evidence may be incomplete, withheld, or falsified.

a. Incomplete Evidence.

Anyone who has ever watched a murder mystery on TV has experienced the frustration of drawing the wrong conclusion. Five minutes before the end you're sure you know who did it. Four minutes before the end you're really sure. Three minutes before the end you suddenly learn one more crucial piece of information and find out you were wrong. It wasn't the butler, it was the chauffeur! And why did you draw the wrong conclusion? Because you didn't have enough evidence.

Science works the same way. A hundred years ago, physicists thought they knew all the laws of the universe to within a few decimal places. Then came the discovery of quantum mechanics, and physics had to be rewritten. Why? Because crucial new evidence forced them to reinterpret everything they thought they already knew.

The same principle applies to the study of origins. We have no scientifically acceptable eyewitness accounts of what happened in the distant past. We can only be sure of drawing the correct conclusion if we have all the evidence. And since we have no idea how much evidence exists, we have no way of knowing how much we don't know. Thus, the school system should not try to persuade students of either side. The schools should try to present as much evidence as possible and let the students decide whether they want to draw a conclusion.

b. Withheld Evidence.

Unfortunately, not everyone is completely honest all the time. Sometimes scientists and textbook authors withhold key bits of evidence that might prove damaging to a pet theory. Two examples:

i. Atmospheric Oxygen on the Early Earth.

The Oparin-Haldane hypothesis for the origin of life requires an atmosphere devoid of free oxygen in order to for the necessary chemical reactions to occur. However, geologists have discovered traces of free oxygen in every layer of the earth's sediment, all the way down to basement rock. (Henderson-Sellers, Benlow, & Meadows, "The Early Atmospheres of the Terrestrial Planets," *Quarterly Journal of the Royal Astronomical Society*, Vol. 21, 1980, p. 74; Philip H. Abelson, "Chemical Events on the Primitive Earth," *Proceedings of the National Academy of Sciences*, Vol. 55, 1966, p. 1365; Erich Dimroth & Michael Kimberley, "Precambrian Atmospheric Oxygen: Evidence in the Sedimentary Distributions of Carbon, Sulfur, Uranium, and Iron," *Canadian Journal of Earth Sciences*, Vol. 13, No. 9, Sept. 1976, p. 1161)

The evidence of free oxygen is a serious objection to the Oparin-Haldane hypothesis, but most biology textbooks neglect to mention it.

ii. The Horse Series.

Many decades ago the American Museum of Natural History put on an exhibit showing the evolution of the horse. Most people are familiar with a chart based on this exhibit. It shows tiny *Hyracotherium* (better known as *Eohippus*) at the root of the equine family tree in the Eocene epoch, followed by progressively more modern-type horses through the Oligocene, Miocene, and Pliocene, culminating in the appearance of *Equus* in the Pleistocene. The sequence looks very simple and straightforward, and seems conclusive. It is not. Since the American Museum exhibit was put together, some crushing fossil evidence has surfaced.

GEOLOGIC AGE WHEN GENUS FIRST APPEARED

Pleistocene	**Equus**
Pliocene	**Pliohippus**
Miocene	**Merychippus**
	Parahippus
Oligocene	**Miohippus**
	Mesohippus
Eocene	**Epihippus**
	Orohippus
	Eohippus

The "Horse Series"

Equus, the modern horse genus, is not supposed to have appeared until the Pleistocene. However, one species of this genus, *E. laparensis*, has been found in late Miocene. (D.E. Savage & D.E. Russell, *Mammalian Paleofaunas of the World*, Addison-Wesley Publishing Co., Reading, Mass., 1983, p. 270) This places the modern horse ahead of two of its "ancestors." Most devastating, two species (*E. occidentalis* and *E. nevadensis*) have been found in the same strata as *Eohippus*. (Francis Hitching, *The Neck of the Giraffe*, Ticknor & Fields, New Haven, Conn., 1982, pp. 31-32; R.L. Wysong, *The Creation-Evolution Controversy*, Inquiry Press, Midland, Mich., 1976, p. 301) This places the modern horse before any of its "ancestors," rendering the "horse series" invalid. Yet this information is nowhere to be found in textbooks.

c. Falsified Evidence.

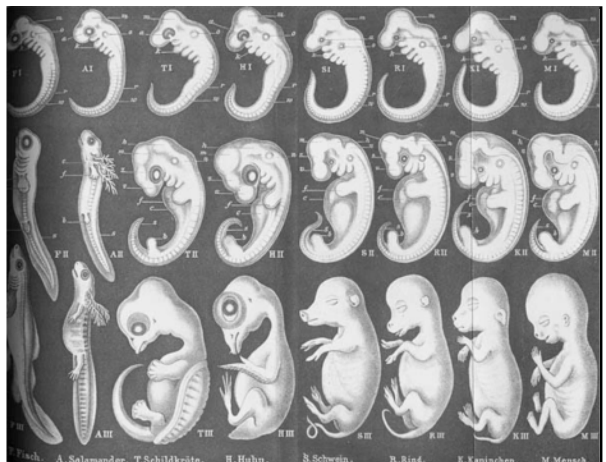
The initial complexity/disorganization debate furnishes an excellent arena to show students the need for caution before believing everything they hear. Scientists are as human as anybody else. For whatever reason, sometimes some of them lie.

Two relevant examples of falsified evidence:

i. Piltdown Man.

Though some scientists immediately suspected that the Piltdown skull was a fraud, for 40 years many books presented it as a transitional form between ape and man. Finally, a team of medical doctors reexamined it and announced it was a hoax.

ii. Embryonic Recapitulation.


One of Haeckel's fraudulent drawings supposedly showing eight stages of development in three types of embryos. He altered the embryos to make them look much more similar than they really are. (From his 1874 book *Anthropogenie*.)

Ernst Haeckel first published the fraudulent idea of "embryonic recapitulation" ("ontogeny recapitulates phylogeny") in Germany in 1866. Within a few years, embryologist Wilhelm His pointed out Haeckel's deception. However, Haeckel was undeterred. He taught this "Fundamental Biogenetic Law" at lectures and seminars all over Europe for over 40 years until he was finally convicted of fraud by Jena University Court of his peers in 1907.

(Ian T. Taylor, *In the Minds of Men*, TFE Publishing, Toronto, Canada, 1987, pp. 275-277; R.L. Wysong, *The Creation-Evolution Controversy*, Inquiry Press, Midland, Mich., 1976, p. 401; C. Singer, *A History of Biology*, 1931, p. 487; F.F. Meldau, *Why We Believe in Creation Not in Evolution*, Christian Victory Publishing Co., Denver, CO, 1974, p. 217.) Though he was disgraced over a century ago, most high school and college biology students are unaware of Haeckel's deliberate deception.

2. Analytical Skills.

Students aware of the need for caution in examining evidence will be much better equipped to study both sides of any issue, not just origins. The principal benefit of including this material in the study of origins lies in the nature of the controversy. Since it is such an emotional topic, it furnishes a good backdrop to teach them how to see through emotionalism and find the facts. One way teachers might do this is to show them the sort of questions scientists ask.

Suppose the student hears an allegedly proven statement about one side or the other. Such questions as the following will help to determine if it really is proven, or if it is a made-up story *posing* as science... a mere belief.

a. Who saw it? Are there any eyewitness accounts? If there are any such claims, how reliable are they? (Remind the students that there have been frauds perpetrated in the name of science before.)

b. What did they actually see? How much is actual observation, and how much is guesswork? Scientists routinely *extrapolate*, that is, they go beyond their data and make educated guesses. A certain amount of extrapolation is reasonable, but especially in the study of origins, scientists sometimes go thousands or millions of times beyond the available data. This would be a good opportunity for a discussion of how much extrapolation is reasonable.

c. What are they not telling us?

- Is there some sort of bias? For instance, can we really trust a report from a tobacco company that says cigarettes are safe?
- Is somebody deliberately withholding evidence? Remember the evidence of atmospheric oxygen on the early earth.
- What assumptions are involved? For example, the assumption that evolution is the only possible explanation for the origin of everything.
- How reasonable are the assumptions? As a case in point, students might be made aware that radiometric dating techniques depend on a series of assumptions. If we are wrong about any of them, we can obtain an age which is incorrect by millions or billions of years. If we are to achieve any kind of reliable results from such techniques, we need to make sure our assumptions are reasonable. Students should carry this awareness over into every area of scientific study.

d. How could it be repeated and tested? If it could not, it is not necessarily false, but it is not part of science. Until we can devise a way to test it, the statement remains in the realm of history or belief.

These are certainly not the only questions a scientist might ask, but they represent the kind of tools that will help students to develop critical thinking skills. And though these skills are applicable to any area of science, the emotional nature of the origins controversy furnishes perhaps the most sharply focused area in which to learn how to use them effectively.