BIOLOGY LESSON:

A CRITICAL APPROACH TO STUDYING THE ORIGIN OF LIFE

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Background:

This lesson is intended as a stand-alone supplement to high school biology classes that deal with the origin of life. As such, it is much more detailed than most lesson plans. The teacher or student who wants to obtain still more details will greatly benefit from the following sources:

Biological information - Charles Thaxton, Walter Bradley, & Roger Olsen. *The Mystery of Life's Origin: Reassessing Current Theories*. Philosophical Library. New York. 1984.

Design in nature - Michael Behe. *Darwin's Black Box*. The Free Press. New York. 1996.

Text Format

Throughout this lesson you will notice variations in type style, and occasional boxes around text. Their significance is as follows.

The type style used on this line indicates teacher's material.

This type style in a box indicates a fill-in-the-blank line or group of lines on the student handout (attached at the end of the lesson).

Italics inside a box indicate suggestions for student research.

These suggestions might include outside readings, CD encyclopedia searches, Internet searches, and the like.

Preparing to Teach the Lesson:

This lesson delves into the question of how life began. There are two possibilities:
(1) Life began in at least as complex a condition as we find it today, or
(2) It began in a less complex condition and gradually evolved to where it is today.

Some might immediately object to the first possibility on the grounds that initial complexity would require the intervention of intelligence. True, but the objection is irrelevant to our study. We are not concerned with who or what started everything, but only with what happened. Whether life started in a complex or disorganized condition, someone or something had to be responsible, be it an intelligent being or a collection of impersonal forces, processes, and events operating without any particular purpose. It doesn't matter. Our topic of study is not Who or what started life, but instead What were the conditions at the time?

The concept of initial disorganization with later increase in complexity seems to hold a monopoly in biological circles. Almost every biology textbook contains the same evolutionary scenario about how life on earth began billions of years ago by random chemical processes. In this lesson we will examine that scenario to see how reasonable it is.

Aim of the Lesson:

This lesson is not meant to disprove the idea of initial disorganization or prove the opposite, initial complexity. Instead, it is meant to stimulate critical thinking processes in students who have probably had no exposure to most of the material contained herein.

Materials Needed:

Overhead transparencies or powerpoint projector (for accompanying overhead master pages)

Enough coins such as pennies for each student to have six or seven to use in a demonstration of probability.

Instructional Procedure:

The teacher will present the lesson in a lecture format, referring to powerpoint visuals for clarification. Students will follow along on fill-in-the-blank handouts.

If technological resources such as Internet access or CD encyclopedias are available, the teacher will occasionally interrupt the lesson to have different groups of students research topics and report back to the class.

Students will perform a hands-on activity involving flipping coins to acquire a feel for how probability works.

Introducing the Lesson:

Where did life come from? It could have begun in at least as complex a condition as we find it today (Initial Complexity), or it could have begun in a very disorganized condition and later evolved to its present state (Initial Disorganization). Since the former would require the intervention of some sort of intelligence, many choose to reject it out of hand on philosophical grounds.

Rejection of design because it requires a designer has nothing to do with science.

Visual #1

1. The search for **design** is a normal part of many areas of science.

- The government spends billions of dollars searching for extraterrestrial intelligence. What are they looking for? Evidence of design in radio signals from space.
- Every time a plane crashes federal investigators search the wreckage for clues as to whether it was accidental or deliberate.
- Arson investigators search burned buildings to see if fires were accidental or happened by design.
- Medical examiners perform autopsies in case of suspicious deaths to see whether they were due to natural causes or design.
- Archaeologists look for design every time they dig something out of the ground. Is this an eroded rock or an arrowhead? A natural formation or a stone hut?

The search for design is not a problem in science, because evidence for design in and of itself does not tell us anything about the character or nature of the designer.

Nevertheless, some reject the possibility of design in nature for personal reasons. They have no choice but to believe in Initial Disorganization, the only option that might conceivably involve the spontaneous generation of life from non-life by purely natural processes.

In centuries past, the idea of spontaneous generation was widely accepted. For example, it was thought that rotting meat would automatically produce maggots, and piles of garbage would produce mice. However, careful observation showed that these animals did not come from the meat and garbage but were intruders. Experiments by such great scientists as Louis Pasteur showed that life comes only from life.

Student Research Project: use the Internet to learn about Pasteur's experiments.

The battle has shifted. Nobody believes anymore that complex animals could arise from non-living substances. However, since many find the idea of intelligent design abhorrent on philosophical grounds, their only alternative is to believe that everything must be explainable by purely natural processes. Darwin himself admitted that if there were even a single organ that could not be explained by the gradual accumulation of very slight changes -- that is, if supernatural intervention had to be invoked a single time -- evolution was useless as a scientific theory.

Student Research Project: use encyclopedias and the Internet to learn about Darwin's changing attitude toward the supernatural at various stages of his life.

If the origin of life must be explained by purely natural processes, then some extremely primitive microscopic organism must have developed billions of years ago by natural processes operating on lifeless chemicals. Everything that has ever lived would have to be descended from this first living thing.

The opposing ideas of initial complexity and initial disorganization lead us to expect sharply different evidence in nature:

Visual #2

2. The idea of Initial Disorganization says that life developed from non-living **chemicals**. We expect that under the right conditions, it could happen again. Also, since the conditions needed would be very different than those in the world today, there should be evidence in nature that conditions on the early earth were very **different** than at present.
3. Initial Complexity says that life should be far too **complex** to develop from non-life. Also, since the earth was able to sustain modern-type plants and animals from the time life began, we should find evidence that the environment on the early earth was fairly **similar** to the way it is today.

In order to determine which possibility is more reasonable we need to look at some of the details of life.

First, what is life? Nobody knows. Imagine two chemically identical collections of matter. One of them takes in nutrition, excretes wastes, interacts with the environment, grows, and reproduces. The other does not. Though they are chemically identical, one is alive and the other dead.

Visual #3

4. Science can describe how **life** operates but cannot tell us what it is nor why it exists.

The source of life remains a mystery to science.

Second, are living things haphazard arrangements of chemicals? Far from it. Life is extremely orderly. It is arranged in a hierarchical structure in which simple components such as amino acids are used in more complex components such as protein molecules which are in turn used in more complex ones such as parts of a cell. None of the simple components by itself is alive, though.

5. The basic unit of life is the **cell**.

A living thing may consist of a single cell as in an amoeba, or trillions of them as in mammals. Thus, in looking for a way life could have come from lifeless chemicals, biologists focus on how to put together the simplest possible cell.

6. Even the simplest known cell is made up of hundreds of various types of protein molecules linked together into an intricate structure. The protein molecules themselves are composed of hundreds of smaller components known as amino acids.

The question, then, is: could amino acids have come together on the early earth into proteins which then linked up into a primitive living cell?

The presently accepted scenario for how life could have begun by accident is known as the Oparin (ō-pár-in)-Haldane hypothesis, proposed in 1924 by Russian biochemist A.I. Oparin and developed further by British biologist J.B.S. Haldane in 1928. As atheists they looked for a purely natural explanation for the origin of life.

Student Research Project: use the Internet to learn biographical information about A.I. Oparin and J.B.S. Haldane.

Since life is not forming from non-life today, Oparin and Haldane theorized that conditions on the early earth must have been much different. The atmosphere had to be composed of a different mix of gases; the oceans must have contained a mixture of chemicals (commonly known as the primordial or primeval soup) that contained the elements needed to form living things -- hydrogen, nitrogen, carbon and so on. The soup was bombarded by some sort of energy source which enabled its components to form amino acids, then proteins, and finally living cells.

7. In order for life to begin from non-living chemicals, the right mixture would have to come together in the right place at the right time and experience exactly the right **conditions**.

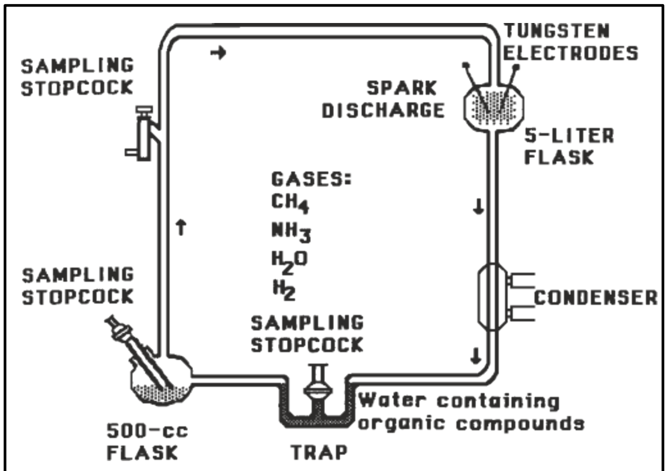
Visual #4

In the 1950's chemist Stanley Miller devised an experiment to test part of this hypothesis. Since Oparin and Haldane had proposed that life began in a primordial soup consisting of various gases dissolved in the early oceans, he attempted to simulate such conditions by bringing together methane, ammonia, water vapor, and hydrogen in a spark chamber. (These gases contain carbon, hydrogen, nitrogen, and oxygen, most of the elements needed to produce amino acids.) The mixture was struck periodic-ally by electric sparks, then the substances produced were removed by a trapping mechanism. After a while he found that his apparatus had produced a number of chemical compounds including some amino acids.

As a result of Miller's experiment and others based on it, many people think that life has been produced in the lab. It has not. The experiments have produced only the simplest components of living things such as amino acids. Those who claim that scientists have produced life under laboratory conditions either don't know, or else deliberately ignore, the fact that a living cell is far more complex than just a few amino acids.

Visual #5

Cells are made of hundreds or thousands of proteins, each of which are made of hundreds of amino acids of various types connected in precise order. Though amino acids come in hundreds of possible varieties, cells use only twenty specific kinds. While Miller's experiment and others based on it have produced at least fifteen of these twenty as well as most of the bases used in DNA and RNA, the vast majority of compounds produced are biologically useless or even harmful. They include dozens of the varieties of amino acids not used in living things, various sugars, and many other miscellaneous organic (carbon based) and inorganic compounds.



Basic design of Miller's apparatus

With this in mind, let's look in detail at some problems with the Oparin-Haldane hypothesis that students seldom hear.

8. Besides the fact that no traces of the primordial soup have ever been found, there are at least **eight** reasons to doubt that conditions on earth have ever been right for life to begin by natural chemical processes.

a. Oxygen in the Atmosphere.

Because of its small size and high electronegativity, oxygen is a highly reactive substance. If it were freely available in the early atmosphere, the other gases mentioned above would react with it at least as rapidly as with each other. The results would be garbage compounds that were of no use in putting together living things..

i. If **oxygen** were freely available in the early atmosphere, the resulting compounds would be useless in forming living cells.

As a result, free oxygen has been excluded from origin-of-life experiments. The only oxygen present in such experiments has been bound to hydrogen in the form of water (H_2O) so that it cannot interfere with other reactions.

Visual #6

The evidence of geology shows that such conditions have never existed in nature. The very lowest Precambrian sediments contain "red beds,"geologic formations that obtained their characteristic color through oxidation. Oxidation requires free oxygen. (Rust -- iron oxide -- is the best known form of oxidation, but there are many others such as uranium oxide, zinc oxide, and so on.)

Student Research Project: use the Internet to learn about evidence of early Precambrian oxygen. Authors to search for include Abelson, Henderson-Sellers, Dimroth, and Kimberley. Or you can search for "Precambrian atmosphere," "chemical events on the early earth,"or similar terms.

According to the evolutionary time scale, some of the sedimentary rocks containing evidence of oxygen were here hundreds of millions of years before life began.

ii. The evidence from geology indicates that from the time sediments began to accumulate, the earth's **atmosphere** has always contained free oxygen. This fits much better with initial complexity than with initial disorganization.

Living things are able to overcome the problem of oxygen reactivity because their DNA provides the blueprint to bring the right chemicals together in the proper order despite the tendency of oxygen to interfere. DNA would not have been present to allow the first living cell to overcome this obstacle. Without it, oxygen would have stopped the chemical reactions needed to produce life from lifeless chemicals.

The evidence of oxygen in the sediments is no secret to the scientific community. However, almost all biology textbooks say that the early atmosphere did not contain free oxygen but that the oxygen was released from inside the earth's crust long after life appeared. We have to wonder about the motives of textbook authors who withhold the evidence of free oxygen. Could it be for other than scientific reasons?

b. The Oxygen-Ultraviolet Dilemma.

Visual #6

Let's suppose that contrary to the evidence, there was no free oxygen in the early atmosphere. In that case, it would be possible for some amino acids to come together by random chemical action. What then? They would be quickly destroyed. As carbon-based compounds, they are highly vulnerable to damage by long-wave ultraviolet light.(If your students want details, long-wave UV has wavelength greater than about 300 nanometers, with the greatest destruction occurring at just under 310 nm). This form of UV constantly pours down on the earth from the sun. As soon as amino acids and other organic compounds came together, the long-wave UV would break them down into their components.

Sunburn is a mild effect of long-wave UV. Things would be a lot worse if it weren't for the ozone layer of the atmosphere, which filters out most of it before it can reach us. Without the ozone layer we would soon be dead. Just how destructive is this long-wave UV? The late Carl Sagan estimated that a typical modern organism subjected to the intensity of UV that would reach the earth's surface in an oxygen-free atmosphere would absorb a lethal dose in an average of 0.3 seconds! And what is ozone? A form of oxygen. If we insist that life began by random chemical action, we are faced with a dilemma:

i. If there was free oxygen in the early atmosphere the chemical **reactions** needed to produce life could not have occurred;
ii. If there was no free oxygen the sun's long-wave ultraviolet radiation would have **destroyed** any amino acids as fast as they could form.

Some experiments based on Miller's have used a form of UV to furnish the energy the chemicals need to come together into amino acids. However, they use short wavelengths (about 200 nm) rather than long.

Student Research Project: use the Internet to find what UV wavelengths have been used in origin-of-life experiments and to learn how theorists deal with the long-wave UV problem.

Long wavelength UV is far more prevalent in nature than short-wave. Long-wave UV has been unnaturally excluded from the experiments because it destroys organic compounds as fast as they can form.

c. The Trapping Mechanism.

Visual #8

The compounds produced in origin-of-life experiments must be removed from the system before the energy source that formed them (sparks, UV, heat, etc.) operates again. Because a second burst of energy would quickly destroy them, experimenters use a trapping mechanism to get them out of the system.

Natural energy sources such as lightning and volcanic heat are many times more powerful than those used in the lab. It would be even more important for the compounds in nature to be removed from repeated contact with such sources.

No one has identified a plausible **trapping** mechanism in nature or demonstrated how one might have operated. There is no evidence that such a mechanism ever existed.

A natural trap would have to be far more complex than those used in the lab. Not only would it have to remove the amino acids from contacting the energy at the wrong times, it would also have to bring them back into contact at the right times in order for them to link up into more and more complex molecules, which in turn would have to be removed and brought back into contact with the energy repeatedly, at exactly the right times, until a complete cell came together.

Student Research Project: use the Internet to search for information about any possible trapping mechanisms that may have been identified in nature.

d. Nitrogen Fixation.

Visual #9

As noted previously, all known life is made of calls and all cells are made of proteins. These in turn are made of amino acids. Amino acids center around an *amine* group (NH_2^+), which in turn is based on a nitrogen atom. Miller's experiment and others like it use ammonia to furnish the nitrogen for the amine groups. However, the source of the ammonia – and thus the nitrogen – in the hypothetical primordial soup poses a problem.

Unless forced otherwise by an outside influence, processes in nature tend toward the lowest potential energy level. In the case of nitrogen, the lowest energy level is found when two nitrogen atoms are bound together with a triple covalent bond into the diatomic molecule N_2. (The reason explosives such as TNT release so much energy is that nitrogen atoms, previously separated in the explosive, are allowed to come back together into their lowest energy state.)

This triple bond is extremely hard to break, to the point that atmospheric nitrogen is almost inert and can even be used to put out fires. Because of the extreme unreactivity of nitrogen, living things require that it be *fixated* before they can use it in forming amino acids. The diatomic molecule must be split apart in order to produce the nitrogen ions that they need.

The great majority of nitrogen fixation in nature is done by bacteria. Bacteria are made of cells, which require fixated nitrogen. Since it takes bacteria to make fixated nitrogen and it takes fixated nitrogen to make bacteria, we have a problem.

Visual #10

Before life began, no **bacteria** would have been present to furnish the fixated nitrogen to form amino acids so that life could begin.

Though textbooks usually ignore this problem, they could point out that there is one naturally occurring non-biological mechanism for nitrogen fixation: lightning. (The other energy sources such as UV, impacts, and heat used in origin-of-life experiments do not produce fixated nitrogen and so must be ruled out.) This means that our trapping mechanism must (1) allow lightning to strike atmospheric nitrogen in order to fixate it, then (2) allow the ammonia produced to spread around but still stay in the vicinity of the other necessary chemicals nearby (though ammonia tends to dissipate quickly), then (3) hold all the components in place until needed, then (4) allow the lightning to strike exactly the same place again, at a greatly reduced strength, so as to combine the ingredients without frying them.

Such a trap would be far more sophisticated than anything found in nature.

e. Optical Isomers: Left-Handed Amino Acids.

Cells are made of proteins, which in turn are made of amino acids. The DNA within the cells is made of sugars linked by bases. Most of these amino acids and sugars can exist in at least two forms known as optical isomers, designated right-handed (abbreviated as “D-” for dextrorotary) or left-handed (”L-” for laevorotary) according to the direction they polarize light. Unless D- acids are continually removed, the experiments previously mentioned produce about a 50/50 mix of left- and right-handed.

It stands to reason that if amino acids were the result of random chemical action, cells should contain about a 50/50 mix of L- and D- forms. They do not.

Visual #11

i. Contrary to the 50/50 results of origin-of-life experiments, living things use 100% left-handed amino acids in their proteins, while the sugars in their DNA are 100% right-handed forms.

(A few organisms use D- acids in hard structures such as shells, but not in any of their proteins.)

Only with sophisticated equipment and careful supervision can we increase the percentage of L- acids in origin-of-life experiments. Even then, scientists have been unable to obtain 100% L- acids under such conditions. Even if we bypass the chemistry of these experiments and start with only the L- form, we still have a problem: L- amino acids isolated anywhere except in living organisms undergo a process called racemization by which some become right-handed, moving the mixture toward a 50/50 ratio. L- amino acids are only stable in living things.

Could this exclusive use of L- acids happen by chance? The simplest known cell consists of about 600 proteins, averaging about 400 amino acids each. Let’s suppose the first living cell was far simpler, with only 125 proteins of 100 amino acids each. Let’s not even think about the fact that there are 20 different kinds of amino acids; we’ll assume it was made up of only one kind. Thus, we need 12,500 L- amino acids in a row. If the L- and D- forms were equally available, what would be the probability that only the L- acids would be used?

PROBABILITY EXERCISE.

To give your students a feel for how probability works, you will need enough coins such as pennies for each student to have six or seven to flip. Let them tell you what the odds of flipping heads once are (1 in 2). What about heads twice in a row? 1 in 4. Three times? 1 in 8. Four times? 1 in 16. They should understand that rather than adding, probabilities multiply. Thus, for any number of coins n, the probability of getting all heads is 1 in 2^n. For 6 coins the probability is 1 in 2^6 or 64; for 7 it is 1 in 2^7 or 128.

To verify this, give each student six or seven coins. Making sure they have a level place to toss them, have each student start tossing his or her coins while keeping track of the number of tosses. Let them do this a few times, then see how many times someone in the class got all heads. Also, see what the total number of tosses was for all the members of the class together. On the average, someone should have gotten all heads about 1 out of 64 tosses for 6 coins, or 1 out of 128 for 7 coins.

APPLICATION.

Even with such a small number of coins, it's hard to get all heads. But imagine that you had 12,500 coins instead of just 6 or 7. Your chance of getting all heads on any one toss would be 1 in $2^{12,500}$, or less than 1 in 10^{3760}. This is a "1" with 3,760 zeroes after it, a number far beyond human comprehension. By comparison, the number of atoms in the whole universe is commonly estimated at about 10^{80}.

It probably took the whole class working together to get all heads just one or two times with only 6 or 7 coins. How many students would it take to be reasonably sure of getting all heads even once if there were 12,500 coins instead? If a student had been flipping this many coins a billion (10^6) times a second for 30 billion years (about 10^{17} seconds), he or she would have flipped about 10^{23} times by now. In order to be reasonably certain to have achieved all heads even one time, you would need about 10^{3737} students -- 10^{3657} times as many as there are atoms in the universe.

That's how likely it is that random chemical processes could select only the left-handed form of 12,500 amino acids in order to produce the hypothetical cell mentioned above.

Visual #12

Another way we can visualize this probability is to picture a groundhog who wants to cross a superhighway thousands of lanes wide. Traffic is zipping by constantly in both directions. If the groundhog has a 50/50 chance of making it across any lane without being splattered, how likely is it that he could cross 12,500 lanes? He has only a 1 in 2^{10} chance, about one in a thousand, of making it across 10 lanes; 1 in 2^{20} or about one in a million for 20 lanes; 1 in 2^{30} or about one in a billion for 30 lanes, and so forth. The chance that he will make it across all 12,500 lanes is one in $2^{12,500}$, or less than one in 10^{3760}.

ii. Even if the first cell had only 125 proteins of 100 amino acids each, the odds of it having all left-handed amino acids would be about 1 in $10^{\underline{\mathbf{3760}}}$.

Let's improve the odds by turning loose as many groundhogs as there atoms in the universe. It doesn't do much good. On the average, half are killed in each lane. For every 10 lanes, their number decreases by a factor of about 10^3. Thus, after 27 groups of 10 lanes, the number has decreased by a factor of about 10^{81}. This means that the last one most likely gets splattered somewhere around lane 270. Even if a heroic groundhog makes it dozens of lanes farther, there are still over 12,200 lanes to go!

The groundhog example shows us that the odds against random chemical processes being able to produce even this single characteristic, exclusive use of left- handed amino acids, are so overwhelming that it is a virtual impossibility. (Mathematicians usually consider an event with odds of less than one in 10^{50} impossible.) Real cells are much more complex than our hypothetical example. In addition, there would be many types of chemicals trying to react with each other, not just one type of amino acid.

Even the most daring gambler would not likely bet on odds like these.

f. The Problem of Chemistry.

Visual #13

A cell is much more than a few amino acids strung together. Hundreds or thousands of them have to link up into any one of thousands of possible types of proteins. In turn, hundreds or thousands of the correct types of proteins have to link together in the proper order to form a cell.

Let's assume for the sake of argument that the early earth had the right conditions to form amino acids and other essential components of cells. At least four more stages would be necessary to produce a cell by random chemical action:

- The components would have to work their way through all the useless compounds in their way and link into longer segments known as polymers, such as starches, proteins, and partial or complete strands of DNA and RNA. Remember, these are lifeless chemicals that don't know what they are supposed to do.
- These polymers would have to join together into gelatinous blobs (called *coacervates* or *microspheres*), which would then be capable of attracting other potentially useful molecules to themselves.
- At least one of these would have to absorb just the right molecules to be able to reproduce and get evolution started. In order to reproduce, it would need to make or capture at least a minimally functional strand of DNA or something like it.
- Finally, some unknown process would have to happen to make the whole collection come alive.

Could it happen?

> i. Even under tightly controlled conditions, origin-of-life experiments produce mostly **useless** material.

The products of such experiments include not only 15 of the 20 types of L- amino acids used by living cells but also the useless D- form of these types, at least 40 other useless kinds of both L- and D- amino acids, many types of L- and D- sugars, at least 5 kinds of bases, and numerous other biologically useless compounds. Because these can combine in myriads of possible ways, there would be constant interfering cross-reactions. Anything with a positive charge would react indiscriminately with the nearest negative charge, rendering great quantities of potentially useful material useless or even harmful. The proper amino acids would be physically prevented from linking up into proteins by all the other chemicals in their way. Remember, these are lifeless chemicals. The amino acids don't know where they are supposed to go and what other amino acids they are supposed to link up with; they react with whatever comes along first.

Chemically speaking, it isn't too hard to put together a few gases to produce some amino acids and other simple organic compounds. However, joining these products into more complex substances such as proteins and DNA is a different story. Even the most sophisticated experiments produce mostly the wrong types of chemicals. As a result,

> ii. Biochemists attempting to manufacture more complex substances do not start with the kind of chemical soup that comes out of an apparatus like Miller's. They buy the correct amino acids, bases, and sugars in purified form from a **chemical supply** house.

They don't buy a mixture; they buy the desired chemicals individually. Only then do they have any hope of assembling more complex biological substances. It's like giving the groundhogs we mentioned earlier a head start by bringing them across hundreds of lanes of the highway in helicopters.

Visual #14

It's not enough, though, because Miller's primordial soup of methane, ammonia, hydrogen, and water vapor is too simple. The only elements available in this soup are carbon, hydrogen, nitrogen, and oxygen. However, at least two other elements would be needed to form even the simplest cell. The amino acids cysteine and methionine require sulfur. In addition, the nucleotides in DNA/RNA require phosphorous.

iii. Besides the elements available in the "primordial **soup**" used in experiments, living things also need sulfur, phosphorous, iron, copper, calcium, magnesium, and many others.

When we add these into the mix, the chemistry gets so complicated that biochemists trying to prove life was an accident don't even try to make the substances they need. They buy them from a very non-accidental source, a chemical manufacturing lab.

Visual #15

If you thought the odds of using only left-handed amino acids were bad, imagine how it would be to put together a complete cell from all these pieces. The odds against such an event have been calculated at anywhere from 1 in $10^{78,356}$ to 1 in $10^{2,000,000}$. (The groundhog has to make it across not thousands, but millions of lanes on the highway.)

Student Research Project: search the scientific literature and the Internet to find the probabilities calculated by different authorities. What factors do they consider in their calculations?

Even if the cell structure could have come together by random chemical action, the cell still couldn't have reproduced. It would have needed some sort of building plan and information storage system to guide the process. We haven't even considered how DNA or something like it might have come together at the same time as the amino acids and proteins.

Student Research Project: search the Internet to find out what alternatives to DNA scientists have proposed. What scientific evidence do they use in support of their proposals?

iv. Even if all the right chemicals came together in the right order, the whole collection still would not be **alive**. We do not know what causes life.

g. *The DNA/Enzyme Dilemma.*

Visual #16

Let's suppose the first cell was trying to put together something that would work like a primitive form of DNA. Though DNA is crucial to a cell's reproduction, it's not enough for the cell's day-to-day operation. This requires many other chemicals as well. A cell depends on a great number of reactions which take place much too slowly on their own to be biologically useful. These are speeded up by thousands of special types of protein molecules known as *enzymes*. In some cases, enzymes allow reactions to take place billions of times faster than normal. Without them life would be impossible.

One of the key functions of enzymes is to perform the chemistry to manufacture DNA. However, the cell needs DNA to perform the chemistry to manufacture them! If the first living cell didn't have DNA it couldn't have made enzymes, but if it didn't have enzymes it couldn't have made DNA. This is an irreducibly complex pairing.

Student Research Project: prepare a report on the principle of irreducible complexity in machines. You can start with Michael Behe's book Darwin's Black Box for an in-depth discussion, then search the Internet for more details.

Since DNA and enzymes work together, they operate as an irreducibly complex mechanism. They could not have evolved by **gradual** changes in dissimilar mechanisms.

Student Research Project: search the Internet for proposed ways these two interdependent mechanisms – DNA and enzymes – could have evolved separately and then merged. What evidence is used to support such proposals?

h. The Cell Membrane.

Visual #17

Even if chemical processes were able to put together the proper amino acids to make a cell and add the DNA it needed to reproduce, at least one more hurdle remains. There needs to be a protective covering around the whole thing to keep it together. Some would say this is the easy part, because fatty compounds called phospholipids (fos-fo-lip-ids) combine readily to form membranes. This is true, but it is much too simplistic an explanation of what happens.

Phospholipids look somewhat like tadpoles, with a head and a tail. They link up in pairs to form a double layered membrane, with the tails inward and the heads outward. This membrane does too good a job of protection for random chemical processes to go any further. It keeps out most of the substances a cell needs for reproduction and growth. Phosphates, key ingredients in DNA, have an especially difficult time getting in.

Suppose you were able to make some amino acids come together into proteins while DNA formed in the same place at the same time, all enclosed in the type of membrane that forms spontaneously. What would happen next? Nothing! The membrane would prevent most of the additional substances the cell needed from getting in. Whatever was inside would be cut off from the nutrients and raw materials needed for further growth. The cell could neither grow nor reproduce. It would soon be dead.

This doesn't happen to real cells because their membranes are much more than just a double layer of phospholipids. They contain thousands of microscopic gateways called *ion channels* or *permeases* which let specific materials and electrical signals in and out of the cell, but only at specific places. The ion channels are made of specific types of proteins. When one of the gates opens, only a few types of molecules or ions can get through. The rest have to find some other gate designed to let them through, then wait for it to open.

What determines which proteins comprise which gates to let which materials through at which locations? DNA. It is needed to produce all the parts of a cell, even the outer membrane. If not for DNA, nothing useful could get into the cell. It could never grow or reproduce.

Yet another dilemma for those who appeal to random chemical processes:

> Without **gateways** called *ion channels* or *permeases* through the cell membrane, DNA could not come together. However, DNA is needed to form these gateways.

This pairing, too, is irreducibly complex. You can't have one without the other.

> *Student Research Project: search the Internet for proposed ways that random chemical action could have overcome this problem. What evidence is used in support of such proposals?*

When we take all these factors into account, we see that there is no positive evidence that conditions on earth have ever been right for life to begin by accident. There is strong evidence to the contrary.

Visual #18

The chemistry of life is extraordinarily complicated. It doesn't matter how many planets are available or how long the universe has existed -- even under ideal circumstances (which don't exist anyway), the probability that life came into existence purely by chemical processes is vanishingly small.

9. Directed Pan-Spermia.

Because of such problems, a number of scientists (such as Dr. Francis Crick, recipient of the Nobel Prize for his co-discovery of the structure of DNA) admit that the accidental formation of life on earth seems impossible.

Rather than admit that life might be the result of design, some have embraced a model called "Directed Pan-Spermia," which says that life was sent to this planet by another civilization somewhere out in **space**.

Panspermia has nothing to do with science because it cannot be observed or tested. The fact that it has gained acceptance as an alternative to design underscores the impossibility of life on earth beginning by accident. Sir Fred Hoyle, a mathematician, likens the possibility of such an event to the possibility of a tornado sweeping through a junkyard and assembling a Boeing 747, ready to fly. But even this is far too simplistic. It does not take into account the fact that in order to be like a cell, the jet must include a factory to keep itself repaired and to manufacture others like itself while in flight -- not to mention that it needs a pilot (corresponding to DNA) to guide the whole process.

Panspermia doesn't eliminate the need for design anyway. It just pushes it out into space. This leads to a logical question:

10. Is there life on other planets?

Every so often some astronomer reports finding planets around other stars. This always raises the question: Is there life on other planets? Besides the evidence we've seen in this chapter,

Visual #19

*i. We cannot directly **observe** the existence of other planets outside the solar system.*

Even our most powerful light telescopes can't tell if there are any in our own system beyond Pluto. The way we decide that a distant star has a planet orbiting it is by looking for tiny periodic variations in the wavelength of its light, which we interpret to mean that some object is pulling the star back and forth.

Student Research Project: search the Internet for up to date reports on possible planets around other stars. What data are used to support these reports? How valid is the assumption that variations in wavelength are due to a Doppler shift? What other possible interpretations of the data might be reasonable? (See "Study Puts in Doubt Existence of 'Nearby' Planets," Reuters' News Service, Feb. 26, 1997.)

However, only an extremely massive object orbiting very near a star could produce enough variation in the wavelength to be detectable from earth. Therefore,

*ii. If the variations in wavelength detected from distant stars really represent objects in orbit, the objects would be far too massive and far too close to the stars to support life. The amount of **gravity** and **heat** would render life impossible.*

Because no other element shares carbon's unique ability to form multiple bonds and long chains, life cannot exist without it. Carbon-based compounds break down at the temperatures that would exist on such bodies.

Remember, we don't actually see planets anyway. All we see is a tiny periodic variation in the wavelength of the light from the stars, which we interpret as an indication that they are wobbling because of an orbiting companion. Even if this is correct the orbiting objects need not be planets. A brown dwarf star could induce the same type of variation.

Conclusion.

When we take all the evidence into account, we see that no matter how much time is available, it is virtually impossible for life to come into existence from non-living chemicals anywhere in the universe, even under ideal circumstances. If there is life in space, it is not likely to have gotten there by accident either.

This lesson has not proved or disproved either position regarding the origin of life, Initial Complexity or Initial Disorganization. However, because of the extreme improbability that random chemical processes could be responsible, it is reasonable to say that

11. The probability that life is an accident is vanishingly small. A reasonable explanation for its origin is that it may be the result of **design**.

The point of this lesson is not to make students believe one way or the other about where life came from, but rather to teach them to be open to any possibility. That's how science grows.

STUDYING THE ORIGIN OF LIFE

Student Worksheet

1. The search for ___________ is a normal part of many areas of science.

2. The idea of Initial Disorganization says that life developed from non-living __________. We expect that under the right conditions, it could happen again. Also, since the conditions needed would be very different than those in the world today, there should be evidence in nature that conditions on the early earth were very ______________ than at present.

3. Initial Complexity says that life should be far too __________________ to develop from non-life. Also, since the earth was able to sustain modern-type plants and animals from the time life began, we should find evidence that the environment on the early earth was fairly _____________ to the way it is today.

4. Science can describe how __________ operates but cannot tell us what it is nor why it exists.

5. The basic unit of life is the ______.

6. Even the simplest known cell is made up of hundreds of various types of protein molecules linked together into an intricate structure. The protein molecules themselves are composed of hundreds of smaller components known as _________ acids.

7. In order for life to begin from non-living chemicals, the right mixture would have to come together in the right place at the right time and experience exactly the right _____________________.

8. Besides the fact that no traces of the primordial soup have ever been found, there are at least _________ reasons to doubt that conditions on earth have ever been right for life to begin by natural chemical processes.
   a. Oxygen in the Atmosphere.
      i. If ____________ were freely available in the early atmosphere, the resulting compounds would be useless in forming living cells.
      ii. The evidence from geology indicates that from the time sediments began to

accumulate, the earth's ____________________ has always contained free oxygen. This fits far better with initial complexity than with initial disorganization.

b. The Oxygen-Ultraviolet Dilemma.

If there was free oxygen in the early atmosphere the chemical ___________ needed to produce life could not have occurred;

If there was no free oxygen the sun's long-wave ultraviolet radiation would have ____________ any amino acids as fast as they could form.

c. The Trapping Mechanism.

No one has identified a plausible ___________ mechanism in nature or demonstrated how one might have operated. There is no evidence that such a mechanism ever existed.

d. Nitrogen Fixation.

Before life began, no ____________ would have been present to furnish the fixated nitrogen needed to form amino acids so that life could begin.

e. Optical Isomers: Left-Handed Amino Acids.

i. Contrary to the 50/50 results of origin-of-life experiments, living things use ______% left-handed amino acids in their proteins, while the sugars in their DNA are ______% right-handed forms.

ii. Even if the first cell had only 125 proteins of 100 amino acids each, the odds of it having all left-handed amino acids would be about 1 in 10_____.

f. The Problem of Chemistry.

i. Even under tightly controlled conditions, origin-of-life experiments produce mostly __________ material.

ii. Biochemists attempting to manufacture more complex substances do not start with the kind of chemical soup that comes out of an apparatus like Miller's. They buy the correct amino acids, bases, and sugars in purified form from a __________ _____________ house.

iii. Besides the elements available in the "primordial __________" used in experiments, living things also need sulfur, phosphorous, iron, copper, calcium, magnesium, and many others.

iv. Even if all the right chemicals came together in the right order, the whole collection still would not be __________. We do not know what causes life.

g. The DNA/Enzyme Dilemma.
Since DNA and enzymes work together, they operate as an irreducibly complex mechanism. They could not have evolved by _____________ changes in dissimilar mechanisms.

h. The Cell Membrane.
Without _______________ called *permeases* or *ion channels* through the cell membrane, DNA could not come together. However, DNA is needed to form these gateways.

9. Directed Pan-Spermia.
Rather than admit that life might be the result of design, some have embraced a model called "Directed Pan-Spermia," which says that life was sent to this planet by another civilization somewhere out in ___________.

10. Is there life on other planets?
    i. We cannot directly _______________ the existence of other planets outside the solar system.
    ii. If the variations in wavelength detected from distant stars really represent objects in orbit, the objects would be far too massive and far too close to the stars to support life. The amount of _____________ and ____________ would render life impossible.

1. The probability that life is an accident is vanishingly small. A reasonable explanation for its origin is that it may be the result of _____________.

STUDENT RESEARCH PROJECTS:

1. Use the Internet to learn about Pasteur's experiments.

2. Use encyclopedias and the Internet to learn about Darwin's attitude toward the supernatural at various stages of his life.

3. Use the Internet to learn biographical information about A.I. Oparin and J.B.S. Haldane.

4. Use the Internet to learn about evidence of early Precambrian oxygen. Authors to search for include Abelson, Henderson-Sellers, Dimroth, and Kimberley. Or you can search for "Precambrian atmosphere," "Chemical events on the early earth," or similar terms.

5. Use the Internet to find what UV wavelengths have been used in origin-of-life experiments and to learn how theorists deal with the long-wave UV problem.

6. Use the Internet to search for information about any possible trapping mechanisms that may have been identified in nature.

7. Search the scientific literature and the Internet to find the probabilities calculated by different authorities. What factors do they consider in their calculations?

8. Search the Internet to find out what alternatives to DNA in early cells scientists have proposed. What scientific evidence do they use in support of their proposals?

9. Prepare a report on the principle of irreducible complexity in machines. You can start with Michael Behe's book *Darwin's Black Box* for an in-depth discussion, then search the Internet for more details.

10. Search the Internet for proposed ways that two interdependent mechanisms, DNA and enzymes, could have evolved separately and then merged. What evidence is used to support such proposals?

11. Search the Internet for proposed ways that random chemical action could have overcome the problem of the impermeability of phospholipid membranes to phosphates and other necessary cell components. What evidence is used in support of such proposals?

12. Search the Internet for up to date reports on possible planets around other stars.What data are used to support these reports? How valid is the assumption that variations in wavelength are due to a Doppler shift? What other possible interpretations of the data might be reasonable? (See "Study Puts in Doubt Existence of 'Nearby' Planets,' Reuter's News Service, Feb. 26, 1997.)