Evolution Handbook
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Quotes

I have used some quotes to illustrate how science works. Quotes from anyone, whether they agree with the facts of evolution or disagree with the facts of evolution are not proof of any scientific theory. One of the first things that must be understood is that science is based on evidence. That evidence must be based on the scientific method of investigation. Quotes (authority), revelation (from a supernatural source), or tradition (voices from the past) play no part in science.

Be very suspicious of any source of material that does not give a bibliography or foot notes so that the information can be checked. It is a pretty good idea to be very skeptical of anyone who says, “In my opinion....” or “It could have been...”

The quotes appear in bold type.

“Scientists do not invoke the supernatural to explain how the natural world works and they do not rely on divine revelation to understand it.”
-Ernst Mayr-Prof of Zoology- Harvard

1. Introduction

There have been many events on our planet that could be described as major. Two that stand out are the formation of the first ocean and the first land.

Imagine an ocean with pure water, with different degrees of light and temperature. Now think of the huge number of niches that would be there when life first evolved. A niche is the physical and biological range in which a species can live and reproduce.

Any form of life might fill a niche, but if competition became too strong, a slight change in that life form would allow it to move to another niche. Life forms would reproduce and expand to fill many niches, but eventually they were in competition with each other for space. The organisms that produced their own chemicals necessary for survival had a better chance of meeting competition. Other organisms would change to live off of these different life forms.

This same process happened on the first land. Imagine all of the land on earth with nothing living on it. The first organisms that ventured onto land had it all to themselves, but it did not last long. Others came and then there was competition for space and for food. Being able to survive and reproduce was challenging.

Evolution was progressing from the first life forms, to cells, and then to plants and animals. There is much that scientists want to learn about how life evolved on our planet. There is much that is known. There are many excellent books, beautiful and accurate video shows, and many magazines on the subject of evolution. Even with all of this, we still need to ask interesting and thoughtful questions.

In a series of short articles I would like to answer some of these questions - not as a scientist, but as a teacher. Most of the information in this booklet can be found in any good biology text book. My hope is that you will want to learn more, not by accepting what I have written, but by challenging it.

> **"The immensity of geologic time and the evolutionary origin of species are concepts that pervade modern geology and biology. These concepts must therefore be central themes of science in public schools; creationist's ideas (intelligent design) have no place in these courses because they are based on religion rather than science. Without knowledge of deep time and the evolution of life, students will not understand where they and their world came from, and they will lack valuable insight for making decisions about the future of their species and its environment."**
> **-from The Geological Society of America - Statement on Evolution, Report of the National Center for Science Education, Sept/Oct. 2002.**

2. Plant and Animal Similarities

If plants and animals evolved at the same time, why are they so different?

This is a basic question which is often asked by students. The answer is not simple, and will take some understanding of what life is in order to answer.

The first thing to understand is that plants and animals are more alike than they are different.

Of course an apple tree is different from a dog, but the cells that make up an apple tree and the cells that make up a dog are very much alike. By comparing the cells in a plant and the cells in an animal, the similarities are easily seen.

An adult plant or animal has organs that carry on different functions. Cells have within them very small structures that also carry on different functions. These structures are called organelles. It is at the cellular level that most evolution takes place.

Cells need nourishment to carry out functions and they need to get rid of the waste that is produced from these processes.

It is the organelles in a cell, whether it be a plant cell, or animal cell that accomplish these tasks. Organelles are alive, but cannot live outside of the cell; just like a heart is alive, but cannot live outside of a body.

Organelles that are found in plant cells are almost exactly like those found in animal cells.

The typical plant or animal cell has a plasma membrane as the outermost covering. It has a mitochondria which produces energy. It has a Golgi body which forms and packages proteins. These proteins are then secreted from the cell. These organelles and others are controlled by the DNA found in the nucleus of cells.

So plant cells and animal cells are very much alike. To answer the original question, we need to examine what makes them different.

Plant cells are very superior to animal cells because of a very important organelle, the chloroplast. This amazing structure enables the cell to carry on photosynthesis. This is a complicated chemical process, but it can be summed up as using sunlight to produce sugar and oxygen from carbon dioxide and water.

Plant cells need the sugar as a source of energy and to manufacture secretions (like sap and nectar). The oxygen is required for this process.

Cells that have chloroplasts can take carbon dioxide from the air, and by using the energy of sunlight, they can combine it with water to produce the two ingredients that support life.

With rare exceptions, all of the energy that animals get from eating comes from the sun. It has been stored in sugar by plants. Of course this sugar is often converted to starch or fat, but it is still basically sugar. It also means that the basic fuels that humans use (oil, coal, and natural gas) are also basically sugar, because these fuels came from decomposing plant materials. Even when animals eat other animals, the energy provided is still proteins that were made from sugar.

To put it another way, when you had a hamburger for lunch in order to get materials for growth and energy, you were getting it from sugar.

Animals are just like plants in that they must combine sugar with oxygen to release the stored light energy. This oxygen is all produced by plants. Almost all of the free oxygen in our atmosphere is produced by plants and different forms of algae.

3. Photosynthesis

As I have stated, animals are just like plants in that they must combine sugar with oxygen to release the stored energy. This oxygen is all produced by plants and other living things that contain chlorophyll. Almost all of the oxygen in our atmosphere is produced by chlorophyll. Before the cells which carry on photosynthesis evolved, the earth's atmosphere was very different.

Oxygen is essential in this process, because it combines with the carbon molecules (sugar) to release the energy that it takes to hold these molecules together.

Photosynthesis is the process which takes two small molecules, water and carbon dioxide, and combines them to make larger molecules (sugar) and free oxygen. This takes energy supplied by the sun. When plant and animal cells use the products that are made from sugar, the process is reversed. Oxygen combines with sugar, and carbon dioxide and water are formed. The energy from the sun that held the larger molecules together is released in the form of heat ener gy. That is what enables warm blooded animals like humans to have a 98.6° body temperature. It is also why heat is released when wood, coal, or oil is burned. The burning of any carbon compound is just turning big molecules into small molecules. The same process happens in our bodies cells, it just happens much more slowly.

So, the short answer to the original question is: Plant cells evolved the ability to produce sugar and free oxygen for their survival. Animal cells evolved to survive off of the extra sugar and oxygen that plant cells produce. It is the overproduction by plants that enables animals to survive.

Of course there are some other basic differences between plant and animal cells.

One interesting difference between plants and animals is their method of handling cell waste. Excretion is a process that must take place or the cell will die. All animals have some method of removing waste. Some of the simple animals like sponges do not have a special organ to accomplish this. The more complex animals have kidneys that filter waste out of their blood. Each functioning cell deposits its waste in the blood which then gets pumped to the kidney where it is filtered. In the higher animals, this waste is then stored in the urinary bladder until it is emptied.

It is a different story for plants. Plants have evolved cell walls around some cells; they cannot get rid of waste. Instead it is stored in the cell in a bubble like structure called a vacuole. When the vacuole gets full, the cell dies. This is no problem for parts of plants that only live a few months, like flowers and leaves. It turns out to be a very good thing for some parts of the plant, like the stem.

These special cells that have evolved cell walls and a vacuole, are referred to as xylem (the stringy stuff in celery is xylem). It is better known to most of us as wood. It is the xylem that shapes trees and bushes Before wood evolved there were no tall plants, shrubs, or vines. If there were more of it in the celery, we would call it wood. It is good for us; it is the roughage of our diet.

Because animals can get rid of waste, they can rebuild and repair cells. Some of the cells in your body will live for years because they can be repaired and the waste removed. That is good for us and all animals.

Plants have evolved a different method and it is just as successful for them. They evolved so that almost all of their cells live less than a year.

These short chapters on evolution should be making you ask more questions than they answer. In science it is easier to answer the "how" questions than the "why" questions. We can answer how it is that certain plants have opposite leaves, but we cannot answer why it is that certain plants have opposite leaves.

"We humans pride ourselves on being the dominate life form on this planet, but these tiny beings-- unobtrusive, the perfect guests-- are in a sense running the show. Without them, almost all life on Earth would die." -Carl Sagan & Ann Druyan (talking about chloroplasts) Shadow of Forgotten Ancestors, 1992, page 101

4. The Living Fossils

It became obvious to early scientists that evolution was a theory that had much factual evidence to support it. That meant that they could begin to predict what they might find in the way of undiscovered living species (living fossils), and what might be uncovered in later excavations of preserved fossils.

Fossils of the ginkgo tree have been found in North America that date back seventy-five million years. They were thought to be extinct. Imagine the delight of western scientists when they discovered that they had been cultivated around Buddhist temples in China for thousands of years. There may be some wild ginkgoes in remote areas of China, but it appears that there is only one surviving species of a group of plants that were very numerous during the age of the dinosaurs. This has made the ginkgo a popular tree to cultivate, and it can safely be said that there are ginkgoes on almost every college campus in the United States. It is a classic example of a living fossil.

There are, of course, a number of living fossils. Plants and animals that were thought to be extinct only because no one was looking for them. Some were discovered by accident, like the coelacanth fish, and others were discovered through diligent scientific work, like the Peripatus (an animal referred to as “walking worms” that has characteristics of an earthworm and an arthropod).

An interesting example of a living fossil discovered through scientific research is the alligator. For years it has been classified as a reptile. After all, it looks like a reptile - but it does not behave like a reptile.

Alligators build a nest; reptiles do not. They communicate with their young before and after they hatch from eggs; reptiles do not. Both alligator parents guard the nest and young, and bring them food; reptiles do not. Alligators stay in family groups for years; reptiles do not.

There are physical differences between alligators and reptiles. Alligators have a four-chambered heart like birds and mammals, reptiles have a three-chambered heart. Alligators have a breathing muscle, the diaphragm; reptiles do not. They also have a highly developed brain part called a cerebral cortex; reptiles do not.

Their behavior and their special anatomy are more bird-like than reptile like. Now that scientists are able to sequence the DNA of living things, it is possible to determine close relationships by doing comparisons. It was not surprising to find that the DNA of alligators is more closely linked to birds than it is to reptiles.

Biology text books still classify the alligator as a reptile, but it is apparent that alligators are somewhere between birds and reptiles in the evolutionary scheme of things.

5. Scientists and Evolution

If evolution is a fact, why are there some scientists who do not believe it?

It is true, there are some so-called scientists who do not accept evolution as a fact, but we must be careful to know who are scientists and who are not.

There are people and organizations that do not accept evolution. It is important to know that there is no evidence to support any other cause for the diversity of life on earth. There is no other theory to explain life on earth because a theory must be supported by evidence. There are scientists who do not accept evolution and yet offer no theory to take its place. That is not the way science works. Proving a theory to be wrong does not make another theory right. As an example: when it was discovered that the flu is not caused by bacteria, we still did not know what did cause it. It took more research to discover that it was caused by a virus.

If the theory of evolution is wrong, then there must be evidence to support another theory that would explain the diversity of life on the planet. No one has discovered such evidence.

Every college and university in the world that does scientific research accepts evolution. Every major scientific publication and organization accepts evolution.

Long before Darwin wrote, On The Origin of Species, evidence was being gathered to support the theory of evolution. It should be apparent, even to the most uninformed, that advances have been made in gathering evidence to support the theory. Charles Darwin did not have the benefit of computers, ultra-sound, the electron microscope, radioactive dating, X-ray, plate tectonics, DNA sequencing, or any other scientific advancement of the last one hundred and fifty years.

The scientific instruments that are used in the study of medicine, immunology, endocrinology, and other health related fields are the same instruments that are used to study evolution. The instruments that are used to search for natural resources, develop agriculture, advance animal husbandry, investigate crimes, and further environmental studies are the same instruments that are used to study evolution. It would not be good science to accept all of the knowledge gained in these areas and ignore the knowledge acquired about evolution.

It is these advanced scientific instruments and the scientific method that supports all scientific research.

The scientific method is based on observation and experimentation. These must be repeatable, and others must get the same results. Every scientific theory must have evidence to support it. The word “theory” is often not used scientifically. We must be careful to use it correctly.

The evidence that supports evolution should be able to stand the test of reliability. That is what science is all about and why evolution is based on science.

We should be able to evaluate and challenge any textbook or authority, whether it supports evolution or not.

The important thing to remember is that the scientists in all of the major research universities are gathering more evidence every day in support of the theory of evolution. This information is available to everyone who wants to read the books and journals.

One of the best places to go to find out about the theory of evolution is a natural science museum. There are major museums like the Smithsonian or the Natural History Museum in New York City. Every state has smaller excellent natural history museums. These are usually found on the campus of larger universities, and always at state universities. Most of these museums have information on the Internet, but a trip to observe fossil evidence, preserved specimens, and displays that show and explain evolution is something that every educated person should take the time and energy to do.

There will always be someone who does not accept this research. What science demands is that they show their evidence for the challenge and the evidence for their replacement theory.

6. The Darwin Centre

There are hundreds of natural history museums around the world that have excellent fossil collections and displays on evolution for the general public. The London Natural History Museum has an “Origin of Species” wing which explains the concept of evolution by using Charles Darwin’s approach.

It became evident to scientists around the world that much of the evidence was not on display in most museums. They understood that there should be a place where scientists could send specimens, borrow specimens, and study all evolutionary collections.

That place is the new Darwin Centre in London. The goal is to systematically classify all plants and animals living and extinct that have ever lived on earth. This is a tremendous challenge. At present the first phase has been completed. There are 22 million specimens, 450,000 jars, and over 15 miles of shelving. Many of the specimens were collected by Charles Darwin.

There will be video links from the labs, and from researchers in the field, to the museum and the Web.

Phase two, which will be completed in 2007, will add 28 million insects and 6 million plants.

Imagine what this will mean for the continuing battle with those who support intelligent design. It is not that we will contact the museum often, but we will have a resource with world wide status supported by scientists and universities everywhere.

Everything available at the Darwin Centre will be available to anyone with a computer. On completion, there will be over 60 million specimens and an unbelievable amount of scientific information to support the theory of evolution. if you are on line just type in www.DarwinCentrecom to access and put yourself in the world of evolutionary science.

7. Lower Forms of Life and Evolution

We humans seem to get great joy from comparing things. We do it in sports, music, intelligence, and even with living things.

Of course we put ourselves at the top and then compare the lower forms with each other. Hopefully, by now you will have learned that there is usually another way to look at most questions involving living things.

The amoeba is a very interesting lower form. It must carry on most of the functions that most living things do, and yet it is a single cell. This single cell must find food, digest it, get rid of waste, use oxygen, repair worn out parts, and reproduce - not bad for a lower form.

Let us compare this single cell with any single cell in your body. How about a white blood cell? They look very much like an amoeba and they carry on the same functions. What about a muscle cell or a liver cell? Well, they don't look much like an amoeba, but they must carry on the same functions to stay alive. In the case of the muscle cell, it must contract, and in the case of the liver cell, it must secrete chemicals useful to other cells.

Now you can see what I am getting at. Our bodies are composed of lots of cells that we considered lower forms. The main reason that the lower forms in our body differ from the lower forms found in a pond is that our cells have become so specialized that they need help from other cells in order to stay alive and do their jobs. They have become so specialized that they cannot make it on their own like an amoeba can.

Would you say that the specialized cells that make up our body are a higher form of life than the amoeba which can survive on its own? I do not want an answer to that question, I just want you to think about what your answer would be and why.

This leads to an even more interesting question. What is the reason for the specialized cells gathering together to form organs? We all know that the heart pumps blood, the lungs take in oxygen, the kidneys filter out waste and the muscles make us move, but why?

Most of us want to say that our brain must be kept alive. After all, that is what makes us who we are. True, but let us use that same logic on an earthworm or a pine tree. What is the function for the organs in an earthworm? They do the same for the earthworm as they do for us. For some reason the earthworm brain does not seem that important to us. And what about the organs in a pine tree? Of course they have organs too. What is the real function of the leaves, roots, bark, and stem?

Let us go back to the lower forms of life. What do they do that all the higher forms do in order to insure that their species survives? They pass on their DNA to future generations. All of the organelles in one-celled creatures,

and all of the organs in higher plants and animals must keep the individual alive long enough in order pass on DNA.

Now comes the lesson. Of vital importance is the fact that sometimes DNA has changes in its chemical structure. Those changes may lead to individuals that are more able to survive. This is the wonder of that process called evolution. What we refer to as the lower forms of life have evolved into earthworms, pine trees, and you and me. Feel better about the lower forms of life now?

> "**Charles Darwin said, "It is not the stronger of the species that survive, nor the most intelligent, but the one most responsive to change." Philip Johnson, Darwin on Trial: In reference to Intelligent Design, declared, "This isn't really, and never has been, a debate about science. It's about religion and philosophy." From Natural History 4/02**

8. Lowest Form of life?

Just what is a lower form of life? It depends on the definition used. If the definition is one of structure and physiology, then the lowest form would probably be bacteria. (Virus is not considered living; it is classified as an infectious chemical.)

If the definition includes the functions of all organisms in the biosphere, it is a different story. Bacteria are not lowly. They are one of the main sources of decomposition, and life on this earth would not be possible without them. The same can be said for the fungi.

Just what would an eco-biologist classify as lower forms of life?

The best way to answer that is to ask, “What would an eco-biologist classify as the highest form of life?”

Hands down it is a maple tree (you may substitute any other tree that is wind pollinated, but be careful). Maple trees overproduce leaves which fall to the ground, and with the help of bacteria, become soil. They carry on photosynthesis and overproduce sugar which is the building block for all forms of life (without sugar there would be no higher forms of life; you are basically sugar).

Through this same process they overproduce oxygen. Some is used, but the rest is snapped up by the environment and makes a suitable environment for animals. This process also takes ground water and releases it into the atmosphere, helping to make rain clouds. The maple tree also overproduces seeds - billions of them. The extra serve as a great source of nourishment for a multitude of critters. While this is going on, the tree is an ecosystem for hundreds of living things.

They give off enough warm moisture, through transpiration, to cause air currents. The maple tree produces very tiny male plants called pollen. This pollen travels with these air currents to other trees where they meet a female flower which has an ovary. The little pollen grain then grows a tube to unite with the ovary. It then produces a sperm which swims through this tube and fertilizes the egg produced by the ovary. It even make its own delivery system for sex.

I tell you this story to let you know that the maple tree is almost completely self-sufficient.

Let’s add this up. Maple trees make their own soil, which others use. They make their own food, which others use. They make their own oxygen, which others use. They make rain clouds, which others use. They produce seeds, which others use. They furnish habitat for others. They do not count on other living things for reproduction. So if some biologists think the maple tree is the highest form of life, what is the lowest?

9. More Lower Forms of Life

To a biologist, the highest form of life is the gene, and the lowest is the adult that any gene helps produce. A harsh statement? No, think of it this way: the gene passes from generation to generation for thousands, millions, and even hundreds of millions of years by the process of replication, sometimes with little or no change. Adults on the other hand, last a few years or decades at most. Almost every human and maple tree alive today will be dead in seventy-five years. They will be replaced, and none will be exactly like those alive today. But, that future gene pool will most likely be almost exactly like the one in existence today.

What does any adult of any living organism actually do? It preserves and passes on genes. All of the organs in any living thing, plant or animal, have cells that are there for only one purpose - to preserve and pass on genes. The genes in any organ, heart, liver, leaf , etc. have no effect on the gene pool of future generations. Even the cells that make up the ovaries in plants and animals, and the cells that make up testicles and pollen are of little consequence. It is the genes in eggs and sperm that determine the next generation. It is a mutation or change in the DNA of a gene that accounts for the process of evolution. Genes evolved cells, organs, and organisms to preserve their existence.

But most of the genes in that species will be found in similar species that survive. The basic principle of evolution is the survival of genes and other genetic material.

In 1976, The Selfish Gene, by Richard Dawkins was published. It created quite a controversy, especially in religious circles. Imagine saying genes produce adult humans. Not the way we usually think, humans producing humans (the biblical approach) by passing on genes. The concept of the gene being much more important than the adult is very different and sometimes it is compared to the “which came first, the chicken or the egg,” riddle. Of course by understanding evolution, we know that the egg came first. Obviously, the parents of the chicken may have been very different from her, and her offspring may not be like her or the rooster who mated with her. It is the egg and sperm that cause a difference, and given enough time and the right environment, may even lead to a new species. The chicken, or for that matter, you and I, are just the factories where the genes do their work.

If you have any interest in evolution, get a copy of The Selfish Gene. It is easy reading and guaranteed to make you think. There were biologists who disagreed with what Dawkins had to say, but he quieted most with a second book, The Extended Phenotype (1982). This book is not as easy to read, but it is well worth the effort.

10. Secretions

Secretions are the useful chemicals produced by a cell. The cell is living, but secretions are nonliving substances. They are not to be confused with excretions, the waste materials given off by a cell. All secretions are valuable because they aid in the survival of the organism. Some of them are obvious and well known to us, like claws, teeth, and bone. Others are not as obvious, but just as important.

About three billion years ago, there were no multi cellular living things. All bacteria and cells were unicellular. That is, each cell carried on all the functions to maintain life. Then one of the most important events in the history of evolution occurred. Mutations in the DNA caused a secretion that allowed cells to remain together. This was extremely important because it meant that organisms could be multi-cellular. Because of this development, some cells in the organism could develop special functions and, therefore, be more efficient. Some cells could produce a secretion for digestion, some could produce a secretion for movement, some could produce a secretion for protection. The possibilities were enormous. With all of these different cells working for the survival of the organism, it helped to ensure that the cells that carried on reproduction in the organism had a better chance for survival.

The process of cells forming different specialized tissue is known as differentiation and it is what led to the beginning of plants and animals.

In our own bodies we can see how important it is for muscle, skin, and nerve tissue to hold together. We can also see that some cells do not produce the secretion or else blood would not be a liquid and sperm would not be able to swim.

Many other secretions that are responsible for growth and development in both plants and animals are the hormones. Each hormone is the result of a specific bit of DNA (a gene) producing the proper protein.

The beak of a bird, the cartilage of an ear, the venom of a snake, the lens of an eye, milk, honey, and saliva are all secretions.

In plants, the same secretion that forms cell walls also forms the veins of a leaf and the wood of a tree. Plant cells also produce other secretions, such as peanut oil, maple sugar, sap, and poison.

Almost everything we think of as living is made of cells and the secretions made from those cells.

11. EXCRETIONS

Whenever a biological process takes place and energy is stored or released, or chemicals are changed in form, some waste material is a by-product. Therefore, when the energy stored in sugar is released or a secretion is produced, a waste product is produced which must be removed (excreted).

Because this is a waste, it can be dangerous to the cell or organism. If the waste is inside of a plant cell it cannot escape because of the non-living cell wall. In this case, the waste is stored in a vacuole inside the cell until the cell dies, usually in less than a year. This is the reason that some types of wood have a different color.

If the waste is produced by a one celled organism living in water, it simply protects itself by discharging it and moving away from the waste. If the waste is produced by a cell in a multi-cellular organism like yourself, the waste must be carried away. When any cell in your body functions, it will produce some waste. That waste will be picked up by the blood stream and carried to the kidneys. The kidneys are made up of special cells which form nephrons. They have the ability to remove the waste and transport it to the bladder in the form of urine. It can be stored safely there until urination. All vertebrate animals function this way.

This process is important, because if the kidneys stopped working you would be very ill in a few hours, and dead in a few days. This rarely happens, and usually enough nephrons function to keep us healthy, or at least alive, when we have kidney infections until some other biological mechanism (the immune system) saves us.

As you might imagine, the evolution of these specialized cells was very important in the evolution of all forms of animal life. So much so that the nephrons found in frogs, fish, and you are almost identical. They are also very much like the nephridia, which perform the same function in worms and insects. It was the evolution of this specialized cell that enabled multi-cellular animals to develop. Without nephrons and nephridia, no animal life could exist.

Of course, different cells produce different wastes. Yeasts produce alcohol, and bacteria produces a variety of acids.

As you might imagine, because evolution is a never ending process, some organisms have evolved to use the waste of others. So the alcohol excreted by yeasts in making beer, wine, and other alcoholic beverages is consumed to keep bacteria alive, and they in turn excrete different acids. A good example is sweet cider, containing sugar, which the yeast use for food. The yeast then give off alcohol that the bacteria use, and the bacteria then excrete acid: sugar to alcohol to acid. In other words, sweet cider to hard cider to vinegar. The alcohol in hard cider or wine is “yeast pee” and the acid in vinegar is “bacteria pee.”

The reason that milk is pasteurized is to kill the bacteria which would produce acid and make the milk curdle (sour). On the other hand, we can

introduce certain bacteria to cause the milk to curd and form cheese. Wine and beer can also be pasteurized to stop bacterial growth.

"The rock record is a treasure trove of fossils, and by 1841, eighteen years before Charles Darwin published On the Origin of Species, geologists had not only assembled much of the geologic time scale from physical relationships among bodies of rock, but they had also recognized that fossils document profound changes in life through earth's history. Darwin showed that biological evolution provides an explanation for these changes. Since the time of Darwin, geologists have continued to uncover details of life's history, and biologists have continued to elucidate the process of evolution. Thus, our understanding of life's evolution has expanded through diverse kinds of research, much of it in fields unknown to Darwin, such as genetics, biochemistry, and micro-paleontology. In short, the concept of organic evolution has not only withstood the test of time - the ultimate test of any scientific construct - but has been greatly enriched."

From: The Geological Society of America- Statement on Evolution, Report of the National Center for Science Education, Sept/Oct. 2002.

12. Digestion

Digestion is the chemical process of getting food ready for cell use. Almost all digestion takes place outside of the cell and usually involves turning large chemicals, like proteins, into smaller chemicals, such as amino acids, so they can be used by the cell.

Plants must digest the sugars and starches that they store before they can be used by the cells. Animal's evolved a different way when it comes to digestion. As the food enters an animals mouth, it may bring with it many useless and dangerous chemicals for cell survival.

As animals evolved and became more complicated, with many types of tissues and organs, a gut evolved to carry on digestion. At the same time, the gut protects the cells that make up the animal. Animals have a protective outer lay er of cells (skin) to protect the living cells from the external environment and they also have a layer of cells lining the gut to protect cells from the substances in the gut.

Although it may seem like the food we eat is inside of us, it is not. It is in a tube that starts with our mouth and ends with our anus. In order for food to get into our body it must enter the blood. Almost everything we put into our mouths would be poison to our cells if it went directly into the blood. Meat, and eggs are just a few things that must be digested before they enter the blood stream or they would kill us.

Because evolution is an ever changing process, some animals evolved digestive juices to digest only certain foods. Many insects live off of only one type of plant. Some animals, like owls, evolved a method of regurgitating indigestible materials. Snakes have very strong digestive juices and can break down almost anything they eat.

This information is important in the study of evolution because some bacteria and worms have evolved that not only can survive in a gut, but in many cases must survive in a gut. Almost every animal from insects to humans have these parasites.

An understanding of how our digestive system works and the parasites that invade it has been, and will continue to be, significant in medicine and healthful living. It is possible to follow the branches of the evolutionary tree back to the first digestive systems. These first systems have been very successful, because many of the animals that have them have been on earth long before animals evolved to live on land. There are many similarities between your digestive system and that of a shark.

There are many interesting side issues in the digestive process that are very meaningful to people around the world. Animal "waste" (feces) is still one of the main sources of fertilizer. In many countries, intestinal "waste" is dried and

used as fuel. And, of course, there are thousands of insects, worms, fungi, and bacteria that survive because of what we term as “waste.”

“Life on Earth began about 3.5 billion years ago. At first, living organisms were simple, like present-day bacteria, in both their metabolism and structure. However, over thousands of millions of years cells gradually increased in complexity through evolution by natural selection. The process is easy to understand: As organism reproduce, their offspring differ slightly from each other in their features - they are not identical. Offspring with features that make them poorly adapted to the habitat probably do not grow well and reproduce poorly if they live long enough to become mature. Offspring with features that cause them to be well-adapted grow well and reproduce abundantly, passing on the beneficial features to their own offspring.”
From, Botany - An Introduction to Plant Biology, James D. Mauseth, 1998, Page 9.

13. The Stuff of Evolution

You and I started out as one complete cell, as did most plants and animals. That one cell produced other cells that carried on different functions. Scientists are still not sure exactly how the DNA of a cell works, but they have found out enough so that we can understand much of how evolution works.

As an example, suppose there is a cell which has the capacity to produce a hard substance. Let's suppose that that substance becomes specialized and serves as a claw. This is good, and there may be many kinds of claws serving slightly different functions. Some may be used to kill, or to climb, or to scratch, or even to dig. But if there is a change in the DNA, and the cell produces something very different it may lead to something that better suits another creatures survival. The claw could become a finger nail and aid in dexterity, or a hoof and aid in running. The cells that produce fingernails, claws, and hooves are all basically the same.

In this same way, cells that produce scales, feathers, and hair are the same. The cells that at one time only produced scales changed and some gained the ability to produce feathers. This change was necessary in order to have birds evolve. Some changed and produced hair. This change was necessary in order to have mammals evolve.

During the evolutionary process, some DNA within some cells have changed a great deal while others have changed very little. There seems to be a big difference between a tooth and a tusk or fang, but the way they are formed by cells is much the same. The difference between a hair and a feather is dramatic even though the way they are formed is much the same.

Keep in mind that most of the chemical changes in DNA (mutations) would be harmful and would not aid in the survival of the plant or animal; the change would not be passed on to future generations. In a few instances, however, these changes would aid in the survival of individuals who could then pass the better characteristics on to future generations.

This is what evolution is all about. That is, random changes in DNA and natural selection by the survivors of that change.

This explains why not every species evolved into something else. Not all animals that have cells that produce scales had a mutation in DNA in order to begin to produce feathers and hair. Only a few did. They then were in competition with the creatures who still had scales.

Survival means a struggle for space and food. The animals that had control of the space and food usually had some survivors, even though the new feathered and hairy creatures were becoming better suited to the environment by evolving lots of types of feathers and many kinds of fur.

This should make you wonder about other substances that cells produce.

The cells that produce the bones in a mouse are the same as the cells that produce bones in an elephant. They have the same bones. So why the big difference in size? The answer is that other cells are producing chemicals that effect how much bone gets produced. Producing a lot results in a big animal, producing a little results in a little animal.

These chemicals are hormones and they are as important in evolution as physical features. Behavior must be passed from one generation to another. It is obvious to us that a ducks bill and the beak of a woodpecker must be programed for different uses. The bones of the forelimb of a frog, a turtle, a bird, a whale, a bat, a horse, and a human are fundamentally the same. Hormones are necessary to guide the animal to use their limbs properly.

Hormones not only direct growth, but also fear, sexual behavior, and much of what we call life functions.

Any useful chemical produced by cells is called a secretion. Some secretions become teeth, some become ear wax, some become hair, some help determine behavior, and some aid in digestion and all the other vital chemical reactions that support life.

14. Charles Darwin

February 12, 1809, is the birth date of Charles Darwin. He changed scientific thought forever. First with his evidence on evolution and then with his ability to write so that everyone could understand his scientific books.

The Origin of Species was not the first book on evolution. The idea goes back to antiquity, and among nineteenth century authors the evolutionary notions of others had been widely discussed since the early 1800â€™s. What Darwin actually accomplished for evolution was to make it more than just speculation.

He was the first to discover the compelling evidence for evolution, and to show how evolutionary thinking could be used as the basis for scientific investigation. He also provided a plausible cause, or mechanism, for evolution.

This was his principle of "natural selection," which he explained by analogy with selective breeding in agriculture. The breeder selects the kind of animal or plant he wants from a varying group of organisms (artificial selection), subsequent generations become more and more like the kind he chooses. Darwin proposed that something very much like that occurs in nature, and therefore called it “natural selection”.

Most scientists believe that Darwin’s greatest contribution to understanding our world is the theory of natural selection. As a result of this theory, scientists were able to leave the outdated explanations that they had been dealing with for so long and enter the realm of answering why certain phenomena occur. In other words, they had a testable method of proving where certain traits appeared, and why they were successful.

Prior to 1859, when the On Origin of Species became a topic of conversation, scientists were forced to answer questions with the same types of explanations that are sometimes still used today: intelligent design, abrupt appearance, or created by God.

With the natural selection theory, they were finally able to show a route by which certain phenomena were reached while others were rejected. Suddenly, reasons for why many things occur became understandable.

Natural selection gave us a method of understanding why all biological phenomena arise.

The Darwin revolution has grown steadily since 1859, and has resulted in a theory that is more easily explained scientifically, predictive, socially significant, and also more easily applied than any previous model has been in the history of science. And yet, with all of these changes, the real work for Darwinâ€™s theory was yet to come.

The study of genetics, discovering DNA, advances in biochemistry, and amazing technical advancements, such as the computer have all added strength

to the theory. So much so, that it is considered by most scientists to be a scientific law.

Modern scientists (William Hamilton of Oxford, Richard Dawkins of Oxford, Stephen J. Gould of Harvard, and others) began using a gene-focused and kin-selected variant of natural selection that Darwin could have never dreamed about. Darwin's ideas were sharpened to such an extent that there are few phenomena that it does not seem to readily explain.

It is the application of "survival of the fittest" to genes rather than individuals which gives natural selection the scientific authority it truly needs.

Charles Darwin died at the age of seventy-three, and the world has not been the same since.

15. The History of Evolutionary Thinking

Evolutionary thinking has a long and interesting past. There have always been people who did not accept the biblical account of creation, or the myth of Noah's ark and the world-wide flood. Most did not make their views known publicly due to of fear of imprisonment or death.

Over five hundred years ago, Leonardo da Vinci wondered how fine, delicate seashells could survive intact from the ocean to the high mountains of Italy. He also wondered about these shells being in layers as if there had been more than one flood.

Time passed, and more and more physical evidence began to be discovered. Three hundred years ago, fossilized bones, plants, footprints, and shells had been found in great numbers; but this evidence was still being interpreted in the western world from the traditional biblical view.

In the middle 1700's, two French biologists, Buffon and Lamarck, were sure that evolution took place, but they had the wrong idea as to how it came about.

In England, Charles Lyell and other geologists were convinced that different plants and animals lived at different times, because of extinct fossils found in different layers of rock.

So it was not unusual that in the mid 1800's, a mere 150 years ago, the biblical view began to be challenged. This was the result of other things that were going on at the time. People were mining, building canals, digging quarries, trading in distant lands, and breeding different varieties of plants and animals (artificial selection). The evidence to support a more scientific way of understanding the history of our planet and living things was a natural result of accumulated evidence.

Charles Darwin and Alfred Wallace presented their views on evolution to the Linnaean Society in 1858. They were not the first to suggest a changing world of plant and animal life, but they were the first to argue that natural selection is the mechanism for evolution.

Alfred Wallace had done his work in the East Indies using mostly insects. Tragically, a fire aboard ship destroyed most of his specimens and evidence. Darwin had most of his collected materials and evidence stored in museums. That placed Darwin in the position of being the main defender of the new theory of evolution. How fortunate we are that Charles Darwin collected so many specimens, and wrote so many books.

Darwin, of course, was never able to answer some of his critics because they were asking questions that at the time had no answers. But science is not a static thing, and with new techniques and much more evidence, all but a few

have been convinced that life on this planet evolved. Every major university in the world accepts evolution as fact.

Much of the early investigation of evolution was based on fossils and the geologic record, artificial breeding, and structures of plants and animals. All of these have advanced greatly in the last 150 years and the evidence for the evolution of different species does come from these sources, but now we can also include radioactive dating, comparative biochemistry, comparative embryology, and genetics.

Those who do not accept the evidence for the theory of evolution are still using old worn-out arguments, so it is important to review the established evidence from time to time and also to explore the new evidence.

"The Phrase ˜survival of the fittest," often used in discussions of evolution, suggests that the important outcome of natural selection is survival; it is not. Rather it is contribution of genes to future generations." From Biology, by Arms and Camp, 1995. Page 368.

16. Biogeography

In 1831, Charles Darwin started a five year voyage around the world on the HMS Beagle. This experience gave him the insight that isolation can lead to different species. When he compared the life on continents with isolated islands, he found that some species were very different. Isolation, time, and reproduction had a telling effect on the evolution of isolated species.

Today we have the advantage of advanced scientific methods to help us understand the importance of biogeography. The science of plate tectonics proves that continents once were connected and that they have drifted apart. They are still moving, and the rate can be measured.

Studying the distribution of plants and animals allows scientists to draw evolutionary conclusions. This information can offer explanations as to the center of origin of each species.

The advantage that scientists have today that Darwin did not have is an understanding of genetics and the genes in a species population, known as the gene pool. When a species and its gene pool becomes isolated, it can follow its own evolutionary course.

Many factors can isolate a population. It may be a mountain range, highlands and lowlands, lakes, and especially the ability of the organism to move.

The earth evolves, and in order for living things to survive they must also evolve to keep up with the changes.

Geography offers barriers that allow species to evolve separately, but there are other barriers that can cause isolation. There are reproductive barriers that prevent populations that belong to closely related species from interbreeding even when their ranges overlap.

Mating may take place at two different times. This can be at different times of the year, or even different times of the day. As an example, some owls do their mating in the winter; others in summer. Some mosquitoes are early morning breeders, while others are late afternoon breeders.

There can be behavioral isolation where there is no sexual attraction between males and females of different species. As an example, fireflies mate by using signals and they only respond to the pattern of their own species.

Mechanical isolation occurs when the structure of reproductive parts are not compatible. In fleas, the reproductive organs are like a lock and key. Each female of a species has her own lock (vagina) and only the key (penis) of her species will fit.

There is also genetic isolation. That is, when it is chemically impossible for sperm and egg to unite. The value of this can be easily seen when we realize

how many different types of pollen grains are in the air and are likely to land on a flower of a different species.

17. Fossil Evidence

Charles Darwin realized that evolution was not a process which was destined to lead to higher forms of life. He referred to evolution as buds on a branch, each bud with the capacity to be different. Each living thing that evolves and survives to reproduce is adapting to a specific niche. It is not evolving to become a higher form of life. Some adaptations are so specific that the organism actually decreases its chance of survival if a slight change takes place in its environment.

The fossil record has many examples to show that this is true. It shows very clearly that evolution is not a direct line in any direction, but has thousands of directions. Some survive, others do not. In other words, there is no intelligent design.

Almost all the evidence to support evolution comes from sources other than fossils. Less than 15% of Charles Darwin's work involved fossils. The reason is that very few fossils retain their original organic matter. Usually when an organism dies, the decomposers and scavengers quickly devour it. Rarely is something left behind to show evidence of life long past. A bone may be replaced with minerals, a footprint or leaf print, an insect caught in amber, chemical remains (oil), and even preserved excrement are all fossils.

One of the main reasons that fossil evidence proves evolution is that predictions can be made and verified. That does not mean a prediction of the future, but a prediction that another scientific discipline will be able to verify some already discovered evidence. Any theory that is established in science to the point that it becomes a scientific law must be able to be counted on to be reliable. Think of all the scientific principles that we predict will happen when we drive a car, fly a plane, take a medicine, or put on glasses. These things work because science works. Science works because with most sciences we can predict what will happen in nature very accurately.

There are many examples of evolutionary predictions about fossils that were later proven to be correct. Three examples are whales, elephants, and gill slits.

It was predicated that fossil evidence would be found that would show the transitional forms between land mammals and the marine mammals. At least three new fossil forms of whales have been found to show a connection between the modern whale and their land dwelling ancestors. In the process, scientists have learned much about adaptation of the skeletal structure for life in the ocean.

Secondly, elephant embryological evidence shows development of four tusks - two upper, two lower. The two lower degenerate and do not develop. This led scientists to predict that some day fossil remains would be found of elephant ancestors with four tusks; they were also found.

Some fossil sharks have seven gill slits and some have five. It was predicated that fossil sharks would be found in transition with six gill arches; they were found also.

There are a number of predications that have been made concerning extinct plants as well as animals, but the important point to remember is that there is no reliable explanation, other than evolution, to explain fossils.

“There are thousands of “missing link” fossils, and every year more are found. Examples are the stages between reptiles and mammals, between reptiles and birds, between land mammals and whales, between horses and their progenitors, and between humans and their extinct ape-like ancestors. The so-called fossil “gaps” are partly due to the rarity of conditions for fossilization and to the relatively rapid series of mutations emphasized by Gould and his associates.”
From Notes of a Fringe-Watcher, Skeptical Inquirer, November\December, 1997.

18. Comparative Morphology

Comparing the structure of living things is one of the oldest methods to show that evolution has taken place. Of course, now that the structure of DNA and biochemical analysis has come into use, these much more detailed and accurate methods shed more light on how and when evolution occurred. Even so, comparative morphology is still one of the strongest sources of evidence in support of evolution.

The bones in the skull of a human, a monkey, a bird, or even a fish are basically the same. They have evolved different shapes to accommodate the differences in brain shapes.

It was obvious to the people long before Charles Darwin's time that the bones in human arms and legs were basically the same as other vertebrate animals. The leg of a chicken has the same bones we have. One upper leg bone (the femur), two lower leg bones (the tibia and fibula), long foot bones (metatarsals), and toe bones (phalanges). The chicken and many other animals look different to us because they walk on their toes and not on their metatarsals.

These animals also have the same brain parts; a cerebrum, a cerebellum, an optic lobe, etc.

The glands that are found in a human are also found in all the other vertebrates and serve almost the same functions. The pituitary glands, the adrenal, the thyroid, and all the other glands show that these animals have a common ancestor.

The reason cats are dissected in anatomy classes in college is because they have the same muscles and other organs that humans have. When we eat frog legs the muscles we eat have the same name and location as the muscles in our legs because they came from the same primitive tissue. The same can be said about chicken wings

We commonly think of animals when we discuss evolution, but we must not forget that plants also have their evolutionary history. The evolution of the structure of flowers, roots, stems, and leaves can also be traced. In some cases, the history of plants is even easier to trace because many plant fossils are better preserved and intact.

What all of this means is that we can trace plants and animals back to original ancestors. We can show that fish, birds, amphibians, reptiles, and mammals have a common ancestor. We can also show that oak trees, carrots, and moss have a common ancestor.

The world of insects is one of the easiest places to show evolutionary development. When Alfred Wallace, along with Charles Darwin, presented the first scientific paper on the Theory of Evolution he used insects and their structure to illustrate his findings.

19. Natural Selection

Long before the time of Charles Darwin many people realized that species changed into other species, but there was not enough scientific evidence to support this belief. At that time it was called transmutation.

Thomas Malthus had written a book stating that human populations could outgrow food supplies. Darwin thought that this might apply to all forms of life. When Darwin studied the works of geologist Charles Lyell and found that the earth was millions of years old, he realized there was time for small changes to result in whole new species.

He reasoned that because the earth was changing, life must also change, and that nature provides the environment that causes certain variations to survive.

Darwin knew nothing about genetics, but he had observed that humans provided artificial selection in agriculture and animal breeding. This along with fossil evidence, the study of anatomy, geology, and geographic distribution showed evolution was taking place.

What natural selection means is that there is over production in all species, that there is a struggle for food and space between species, and members of the same species, and there is competition for mating. The best suited survive and reproduce.

20. Comparative Embryology

Soon after the invention of good microscopes, scientists began to trace the development from embryo to adult to see where each tissue came from.

It was obvious that the four buds that formed on the vertebrate embryos were going to develop into fins, wings, or limbs. We could also see that an elephant's trunk and a dog's nose came from the same tissue, or that the tissue in every animal that makes an ovary also may turn out to be a testicle given the right hormones. In the beginning of any animal's development, it is difficult to see what it is going to become. Later on in embryo development, things happen that anyone can see without the aid of a microscope.

It is now possible with many animals to trace back to the very cells that produced the organs that adults have. When the egg and sperm unite to form a complete cell, the zygote, it begins to divide: two, four, eight, sixteen, thirty-two, sixty-four, etc. Soon some of these cells, because of their location on the zygote, will become different from others. They are about to form an embryo with different tissues.

The cells that produce the tissues that become organs are referred to as stem cells. Stem cells in a turtle, a bird, or a bat that produce, as an example, the liver, come from the same place. The adult liver is slightly different in each animal because the egg and sperm that created them were slightly different. The reason that medical science is so interested in stem cells is that they have the ability to become tissues that may help in the cure of an illness or deformity.

What this shows is that animals all have the same ancestor. They are all related to some creature in the past that evolved into many different forms. Most of these forms died out and became extinct, but a few survived to become the life we are familiar with on this planet Earth.

The same can be said about plants. They have stem cell too. The stem cells that produce the leaf of an orange tree are the same that produce a leaf of a corn plant. The difference is caused by the difference in the sperm and egg that united to produce the plant embryo (remember that pollen produces sperm). This shows that the orange tree and the corn plant are related by some distant ancestor.

When embryo development of different plants or animals are compared, it is quite easy to see that they go through roughly the same stages. The journey from fertilized egg to adult is almost the same in all living things.

21. Evolution and Geology

All of the studies in astronomy show that the Universe is evolving. All of the studies in geology show that the Earth is evolving. What we sometimes forget is that these processes have a great effect on the evolution of living things.

It is obvious that the sun and moon have had an effect on the evolution of life on Earth. It may be more difficult to understand the effects of the changing Earth on evolution of living things.

We do not feel the continents move, a process called plate tectonics, but it happens. We do not see huge meteorites collide with the Earth, but it has happened. We do not feel the mountains rise, but it happens. All of these things can be measured by using scientific instruments. Add to that weather changes, volcanoes, hurricanes, and lightning, and a very hostile environment is seen.

The only possible way that living things can possibly survive the physical changes that have occurred on the planet for billions of years is to evolve and adjust to these changes.

As an example, let's look at the creatures that live in the oceans. At one time in eons past, the oceans had no minerals in them. The minerals that make the oceans salty came from rivers that washed minerals from land into the sea. These minerals made the ocean an extremely hostile environment, a deadly and impossible place to live because such a high concentration of minerals will kill cells. So why is the ocean teaming with life? It is because the change in the ocean water took place so slowly that living things had a chance to evolve protection against the effects of salt water and other minerals. Plants that live in the ocean protect their cells by having non-living cell walls. Animals that live in the ocean have protective skin, and they have evolved ways of getting rid of excess salt.

The same can be said about deserts, the arctic, and rain forests. All have hostile environments for cells. All cells have had to evolve some way to protect themselves from the effect of these environments.

Our own bodies are a good example. We have dead outer skin to keep us from losing too much water and to protect us from sun and wind. We can produce heat to keep our cells at the right temperature, and sweat as a cooling mechanism to keep us in balance.

Plants have had to go through the same process. Bark on trees is made up of dead cells which keeps them from drying out. The leaves of plants evaporate water which helps keep the cells in a temperature range so that they can function.

Because the physical changes on the planet are constantly changing, the process of evolution continues. We humans have a short life span compared to the earth, that we must use science and scientific instruments to measure the

rate of evolution. Considering the fact that we have only been at it for such a short time we have made amazing progress. It is true that the whole story of evolution is all around us and maybe we should have seen it sooner, but there have always been doubters standing in the way of scientific knowledge. Now there is no major college or university in the world, that carries on scientific research, that does not accept the facts of evolution. The only theory involved is how it took place and is continuing to take place.

Charles Darwin realized that the small changes that take place every day had a great effect on evolution. He knew that all living things were under pressure to adapt to these changes.

> **“The plough (plow) is one of the most ancient and most valuable of man’s inventions; but long before he existed the land was in fact regularly ploughed, and still continues to be thus ploughed by earthworms. It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures. Some other animals, however, still more lowly organized, namely corals, have done more conscious work in having constructed innumerable reef and islands in the great oceans; but these are almost confined to the tropical zones.”**
>
> **From, The Formation of Vegetable Mould, through the Action of Worms, by Charles Darwin; 1881, page 313.**

22. Genetic Evidence

When Charles Darwin and Alfred Wallace presented their joint paper on evolution in 1858, nothing was known about genes and DNA. Gregor Mendel had worked out the basics of heredity, but his papers were not widely read. In 1858, heredity was thought to be a blending of characteristics from both parents. Something like mixing paint. Mix black and white paint and get gray. No matter how many times gray paints are mixed the result is never black or white. Obviously something was wrong with the blending idea. Because of this lack of knowledge, it was impossible to answer all of the critics of evolution.

In the years since 1858, an unbelievable amount has been learned about heredity. It is now possible to answer almost every challenge offered by the detractors of evolution. It was an amazing discovery when it was found that all living things have DNA that control their structure and behavior. We can show that a characteristic can stay hidden for generations and suddenly show up. We can trace the changes in a gene, a mutation, through generations. We know the chemical make up of DNA, and can show the similarities and relationship of DNA of one species to another. By studying the DNA, we can tell if a rose bush is more closely related to a tulip or cactus. We can tell if humans are more closely related to chimps or gorillas.

Everyone knows that genetics is a powerful tool in crime detection and determination of family relationships. Yet, some people refuse to believe that the knowledge that is known about genetics can be applied to evolution.

Science is now able to determine what genes most living things have. This is very important, but it means that they still must determine what they do and how they do it. This is a gigantic undertaking, but it will be done.

So far every new discovery that has been made concerning DNA, genes, and their place in nature has added more proof to the fact of evolution. The theories of how evolution occurred are being uncovered every day in scientific laboratories world wide. This can be done because predications can be made about what will happen if genes are spliced from one living thing to another.

One of the most rewarding aspects of this knowledge is its use in medicine, known as “red biotechnology.” Some diseases are already being treated by using this method.

Genes from bacteria have been transferred to potatoes and corn to protect these crops from insects. Genes have been transferred from bees to crops to protect them from fungus. This is known as “green biotechnology.”

Industrial “white biotechnology” has already produced goats which have spider silk protein in their milk. This silk is extracted and used to make medical instruments that are much stronger than steel or plastic.

Humans have entered the arena of evolution by being able to change characteristics of living things that will then be passed on to future generations. The knowledge about evolution is increasing so fast that it is almost impossible to keep up with all of it. The basics of Gregor Mendel's work is still important, but like all science, be it evolution, genetics, medicine, or physical science, new important information is being added almost daily. That is why science works. We can gather new evidence and if necessary, change our minds. It can even change the way we perceive life. I am sure that even more amazing things await future generations.

"If the major problem with the fossil record is its incompleteness, then the major problem with molecular evidence for evolution is just the opposite - there is so much information that researchers can't analyze it fast enough." from, Life 4th ed. Lewis, Gaffin, Hoefnagles and Parks McGraw Hill 2002 page 330

23. Failed Hypothesis

John Jones believes in alchemy, the transmutation of base metals into gold. Don Miller believes in phlogiston, a belief which states that a volatile substance is found in all combustible materials. Dick Smith believes in intelligent design, and Tom Taylor believes in ESP and psi phenomena. Each is an expert in their particular belief. Each would like time to explain their theory to high school science classes.

This presents a problem to educators. Although these four men are fictitious, the beliefs are not. To be more exact, these are examples of "failed hypotheses." They did not pass the scientific method of testing. They are hypotheses that will not become scientific theories. If the proponents of these hypotheses want them taught in the classroom, they must first of all convince scientists that the scientific method has been followed and that empirical scientific evidence is available for everyone to examine. The reason that scientists remain unconvinced of each is that there is no theory on how they work.

The public school classroom is no place to argue the viability of a scientific theory. Scientists should determine what science is, and that is what should be taught. But more important is to teach how science works. What is the scientific method, what constitutes empirical evidence, and what evidence is necessary to form a theory, are to questions which students of all ages should be exposed.

The overwhelming evidence is that these hypotheses do not meet scientific standards. If they are to be discussed, it should be as examples of failed ideas.

Of these examples here, only intelligent design is being suggested in today's educational circles. The definition of intelligent design is not only rejected by scientists, but also the United States Supreme Court. The people who support it have not described the mechanism, a model, or how it advance our understanding of such things as medicine, agriculture, and dozens of related fields.

The main thrust of intelligent design is to attack evolution. This has nothing to do with science. Any theory must be able to stand on its own. The burden of proof rests with the hypothesis. Statements that evolution is wrong and therefore intelligent design must be right is, not only unscientific, but not logical.

24. Evolution Redefined

In the days before Charles Darwin, and even during his time there were many who realized that species were not static. A common term used then was transmutation. After all, farmers and even some scientists could see that there were changes within a species and the close relationship between species could also be observed. Darwin's great contribution was to show a way that this could happen.

Once Charles Lyell and others showed that the earth was not six thousand years old, but at least millions of years old, Darwin saw that there was time for natural selection to take place.

Darwin used artificial selection, fossils, geographic distribution, and anatomical structures to support the theory of evolution. We know now that the picture was far from complete. Darwin and others thought that offspring resulted from a blending of something from the parents. Something like mixing white and black paint to get gray paint. This made evolution difficult to explain. With the discovery of genes the picture became more clear, but more needed to be discovered.

Within a short period of time, not only was DNA and RNA discovered, we now know that there are bits of chemicals (viral genes) that are attached to strands of DNA that effect inheritance. All of this information has resulted in a much better definition of evolution and how it works. That does not mean that the evidence that Darwin used was wrong, it just means that we now have the answers to many questions that Darwin could never have answered.

Any good scientific definition should be as simple as possible. The definition for photosynthesis is short and simple. It is the process that is complicated. Not so with evolution. The definition is short and simple. The process is also simple, and easily understood.

Biology text books are now using a definition accepted by almost all of science. BIOLOGICAL EVOLUTION IS CHANGE IN THE GENETIC MATERIAL OF A POPULATION OVER TIME.

We must keep in mind that this refers to all of the chemistry effecting inheritance.

It is these changes reacting in different environments that determine if a species succeeds or becomes extinct. The purpose is to separate Darwinism from evolution. We understand how important Darwin's work was and how the evidence he used proved the theory. That was over 150 years ago. New discoveries, new ways of interpretation, and vast improvements in scientific instruments have made evolution an undeniable fact. We will continue to explore different avenues, and I am sure that much more amazing information will come forth in the future.

From now on when confronted by creationists or those who accept intelligent design, we should use the correct definition and take Darwinism out of the argument. Attacking Darwinism should fall on deaf ears. The argument can now be, as it always should have been, about science and not individuals.

> **“Every tribe has had its origin myth - its story to account for the universe, life and humanity. There is a sense in which science does indeed provide the equivalent of this, at least for the educated section of our modern society. Science shares with religion the claim that it answers deep questions about origins, the nature of life, and the cosmos. Scientific beliefs are supported by evidence, and they get results. Myths and faith are not and do not. From River out of Eden, by Richard Dawkins, 1995, page 32**.

BIBLIOGRAPHY OF SOURCES

The Formation of Vegetable Mould, through the Action of Worms, Charles Darwin, 1881
Autobiography of Charles Darwin, Edited by Nora Barlow, 1958
Darwin and the Beagle, Alan Morehead, 1969
The Survival of Charles Darwin, Ronald Clark, 1984
CROCODILES AND ALLIGATORS, FACTS OF LIFE, 1989
BIOLOGY, Arms and Camp, 4th, 1995
Charles Darwin His life and discoveries, Caroline Overy, 1997
BOTANY and Introduction to Plant Biology; Mauseth,1998
Biology, the unity and diversity of life, Starr and Taggart, 9th, 2001
National Center for Science Education Report, The Origin of Whales and the Power of Independent Evidence, Raymond Sutera, Sept/Oct, 2000,

SCIENTIFIC AMERICAN, Biotech's Clean Slate, editors, Oct. 2003

"And that's all I have to say about that." Forrest Gump

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His publications are:

A Simple Method of Preparing Skeletons, Metropolitan Detroit Science Review, December 1967;

Living Crayfish in the Laboratory, The American Biology Teacher, Vol. 31 No. 3, March, 1969;

A Simple Method of Taxidermy, American Biology Teacher, March 1969;

Microscopic Photography, The American Biology Teacher, June, 1971;

Preserving Snakes in Glass Tubing, TURTOX News Letter, August, 1974;

The Scopes Evolution Trial, The Battle Continues, Humanists of Canada, Fall 1994 (#110);

The Golden Silk Spider, Florida Wildlife, May-June 1994, Vol. 48, No. 3;

Thomas Huxley Debates Bishop Wilberforce, Humanists of Canada, Winter 1993/94 (#107);

Creating Creationists; Creationist's Use Of "Science" Texts, American Atheist, Summer 2001, Vol. 39, No. 3;

and he has co-authored an article, Creation vs. Evolution: Effects on Learning Biology; March 2002, American Biology Teacher.