DNA and the History of Life

Angela Soraya Galindo
Benbrook Elementary School

INTRODUCTION

This unit talks about life: The beginning of life, microbiology, photosynthesis, food chains, habitats, adaptations, heredity, probability and the evolution of species or changes through time. Many of these concepts are core curriculum for fourth grade, but they are usually presented as separate topics, with no correlation among them. Photosynthesis is explained as a process through which plants produce oxygen, but many times the definition falls short of showing how this same process is the basis for most food chains. Habitats and adaptations are usually studied separate from heredity, when in reality they define each other. Habitats determine what species survive and heredity determines adaptations. The purpose of this unit is to show the fascinating map of life written in our genes. The unit will include all the core concepts in a level that shows the intricate relation among them.

The methodology proposed will be a collection of activities to present the sequence of life and the rules that determine it to 4th grade students. The unit begins, therefore, with a question. What is life? What makes us alive?

Movement, breath, the capacity to reproduce: our body is made of multiple systems that work cooperatively to let us function. The respiratory, digestive, circulatory, excretory, and nervous system: some of them are vital while some others are more luxury. The first lessons will be dedicated to explore what students can accept first hand which is familiar in their own lives, like we need to breathe and eat to be able to keep living. From this initial analysis, some time can be dedicated to build models of the human body systems for them to deepen their understanding of how these systems work and interrelations between them.

Students will be divided into groups to build models of the different human body systems. For example, lungs will be represented by balloons inside a big soda bottle connected through straws. A game of the travel of the blood cells will be done, as shown in the HISD science model lessons for fourth grade. *The Body Book*, edited by Scholastic, can be used for students to cut-out and identify the parts of the body.

The next class will be dedicated to some classification activities, where students separate objects such as animals and plants according to their characteristics. Plastic models of as many kinds of animals from all the major taxonomic groups should be present. Students will be asked to separate the objects in two major groups, and then in smaller groups, giving reasons for their choices. The taxonomic groups, as scientists have organized them based on the Linnaeus classifying system, will be introduced after the students' work has been discussed.

Students will be introduced to the terms *kingdom*, *phylum*, *class*, *order*, *family*, *genus*, and *specie*. Even though it may seem too advanced a study for fourth graders, there are only 7 levels of classification and they will appreciate the broader understanding of the concept. The National Geographic book *Classification Clues* includes a mnemonic sentence that helps students remember these levels: "King Phillip Creates Order From General Stuff" in which each word starts with the same letter of the seven levels. We will concentrate in the Animal Kingdom from which they will learn the different Phyla. Phyla are the major groups into which the animal kingdom is divided. The two main groups that we usually study are Arthropods and Vertebrates (included in the Chordates Phylum). Arthropods are the most abundant in earth and include insects, crustaceans and spiders. Their common characteristic is their jointed legs. Vertebrates are the least abundant, but include the biggest animals and the human species. Their common characteristic is that they have a backbone. Even though we will study mainly these two groups, students should be aware of other phylum and the animals that belong to them such as Annelida (worms), Echinodermata (sea stars and sea horses), and Mollusca (octopuses).

From the Phylum Arthropoda, the main classes will be differentiated such as Crustacea (which includes shrimp and crabs), Trilobitomorpha (interesting extinct bug like animals), Myriapoda (millipedes), Chelicerata (Spiders), Uniramia, and Insecta (all insects which includes more than 1,000,000 of the known species).

From the Phylum Chordata, we will touch slightly on the simpler classes that are found in this phylum, such as Agnatha. Then we will talk about the classes more familiar to 4th grade students, like Chondrichthyes (sharks and rays) which don't have real bones, but instead have cartilage and therefore are different from fish. Other classes are Osteichthyes (fish), Amphibia (frogs) Reptilia (lizards and snakes), Aves (birds), and Mammalia. Rodentia make up the biggest order in Mammalia, with more than 4,000 species. We will also include other orders such as Insectivora, the anteaters, and Chiroptera which is the scientific name for Bats. Primates will be identified among the Mammalia class, and the human being will be classified in this big picture. Common names could be used with students to avoid confusion, but are included here as reference.

The existence of these taxonomic groups has been determined by the survival of the fittest by natural selection. The food chain and the species adaptations are a major result of this struggle for survival. Our most common food chains usually begin with the photosynthesis process. We will note that some special bacteria live in harsh conditions where there's no light and they live under great temperatures, which get their food differently. Scientists believe that life might have begun in such critical conditions. Later on, plant cells emerged with their capacity to process sun's energy and produce their own food and food for others. Photosynthesis takes a major role in the evolution of species, since plants are the main food producers.

Photosynthesis

A good question to begin the understanding of photosynthesis is to bring to class a seed and a big log and ask students, “If the tree started as a seed, where did all the mass of that log and of the mass of the complete tree came from?” Usually students and many adults will answer that it comes from the soil and from the water that the plant gets, but besides those two components, it comes, in a big proportion, from the air (carbon dioxide) that the plant uses during photosynthesis. The National Science Teachers Association describes clearly the history of the scientific experiments to explain photosynthesis on their web site <http://www.nsta.org/Energy/find/primer/primer2_1.html>. Jan Baptista van Helmont (1580–1644) observed a willow tree that grew 20 pounds, but the dirt where it was growing only lost a few ounces. It showed that soil was not the main source of energy for plants and he deducted that it must be water where they take their nutrients from, but this theory needed to be proven as well. Stephen Hales (1677–1761) grew a plant in a closed system and observed a reduction of about 14% in the volume of air, and so he deducted that air also played a major role in the growth of plants. Joseph Priestley (1733–1804) conducted experiments with plants and candles, where the fire of the candle removes oxygen and the plant is able to replenish it.

This is how the photosynthesis process takes place inside the plant: The plant takes H_2O (water) and CO_2 (carbon dioxide), and with the energy from the sun transforms these compounds into glucose, which is a kind of sugar, and oxygen. A simple equation made of 6 molecules of water and 6 molecules of carbon dioxide produces a molecule of glucose and 6 molecules of oxygen for us to breathe. $6H_2O + 6CO_2 = C_6H_{12}O_6 + 6O_2$. With a little dedication and guidance, even 4th graders could understand this combination. They know H_2O to be water, because they have seen the symbol in many places. They could understand the H is Hydrogen and O is Oxygen, and then they could also understand that carbon dioxide has its own formula, where C is Carbon and O is again Oxygen. To clarify, cards could be made for students to hold. Some students will have one or two H cards, other students will hold one or two O cards, some others will have C cards and the rest O cards. They could arrange molecules of water and carbon dioxide. With the presence of sunlight (maybe a lamp held by the teacher), they will rearrange to form glucose molecules, which are bigger, and students could observe this change of magnitude when they get together in groups. The trunk of the tree and potatoes are made from these sugar molecules. Plants form other sugar molecules similar to glucose to make all kind of food for themselves and for the rest of the animals. Plants are therefore the main food producer of the food chain. Almost no other creature could live if it were not for plants and the photosynthesis process.

From this basic understanding the selection process could be explained, where certain creatures establish a relationship with others for survival. Some plants are eaten by a certain animal and that animal develops more complex traits. Birds’ beaks change depending upon the food they eat. Some of the species die because the relationship is not strong or one of the parts of the relationship is removed, so the other one ceases to exist as well. To prevent extinction, creatures establish relations with other different creatures and adapt to their environment, creating more complex systems which are called ecosystems. Scientists are researching the evolution of these relations and adaptations as it is written in the DNA of each living organism.

Heredity

The history of this struggle is written in each living creature's cells through heredity. Parents transfer information to their offspring when they are conceived as a cell. To demonstrate this model, a first hand connection to heredity will be established. A family research will be conducted. Each student will collect information about 4 or 5 traits for every member of their close family, including their ancestors, as far back as they could research. The commonalities will be counted and graphed. They will observe how similar information is transferred from parents to children.

The results will be related to Mendel's research on peas. Mendel was a monk that planted different kinds of peas and observed the results on specific traits that he studied. For instance he studied the tallness of the plants, or the color and shape of the peas. He studied one kind of plant, and which of its traits were retained in subsequent generations. Then he cross-pollinated two plants of different traits and observed the result in two or three continuing generations. These results will be graphed to demonstrate a specific mathematical combination to explain and predict the traits that will appear in future generations.

A similar experiment could be conducted in the classroom, even though it will take a long time to see the results. This experiment will be useful both to observe the parts of the plant as they relate to the basic needs of living things and to their functions. Included in this study will be the process of pollination, and how this was used to first demonstrate genetic combinations for all living things.

The research done with students' families will have data that is easier to analyze. The teacher's own family (mine) is a good example, since there were 9 siblings on my mother's side, 9 on my father's side and we were also 9 siblings. A large amount of data is available here to demonstrate Mendel's logic. On my mother's side, my grandfather had brown eyes, and my grandmother had green eyes. On my father's side, my grandfather had blue eyes, and my grandmother had brown eyes. However, my parents and all my aunts and uncles had brown eyes, which demonstrates that brown is a dominant trait.

The combination of traits is shown next, where B is the dominant trait of brown eyes, g is the recessive trait of green eyes and b is the recessive trait of blue eyes. The dominant trait is the one that will be expressed.

Mother's Side

Grandpa / Grandma	B	B
g	Bg	Bg
g	Bg	Bg

Father's Side

Grandpa / Grandma	b	b
B	Bb	Bb
B	Bb	Bb

As determined in the combinations of the table, the next generation will show, as they did, the dominant trait of brown eyes. That's why all of my aunts or uncles, or parents had brown eyes. The recessive trait, however, was present in their DNA, as will be shown in the next generation.

In my family, five of us have brown eyes, two have green eyes, and two have blue eyes, which shows the manifestation of recessive traits in other generations. The combination of traits is shown next, where B is the dominant trait of brown eyes, g is the recessive trait of green eyes and b is the recessive trait of blue eyes. The dominant trait is the one that will be expressed.

Father / Mother	B	b
B	BB	Bb
g	Bg	gb

According to the table, there will be a ¾ probability of brown eyes to be expressed and ¼ probability of blue or green eyes to be expressed. Even though the results of my family (5/9 brown eyes, 2/9 blue eyes, and 2/9 green eyes) don't correspond directly with the Mendel model, it is interesting to note that the blue and green results were the same and the brown result was evidently higher. For bigger numbers the results will show closer correspondence with the Mendel model, but, when I suggested it today, my mother didn't think it was a good idea for her to have more children to prove the hypothesis for me.

The data collected by students about their families will be used to study the Mendel model with different traits, which might be evident in the structure of their families. Ask students to select a trait that shows different manifestations in the same family. The color of the eyes, like in my family, is a possibility, but if all of their relatives have the same color of eyes the data would be not very valuable. Some families could use curly and straight hair, or a particular detail, such as the hitchhikers thumb.

Heredity affects natural selection. Some traits are more valuable for survival in a determined environment, while some could prove to be fatal in other environments. To show natural selection of sexually reproductive organisms, the game of survival and reproductive success written by Joseph Lapiana will be used (refer to my bibliography for the web address). This is a very interesting and easy to understand game where the probability of survival could be analyzed using M&Ms to explain the random combination of traits. First, the game will be played as explained in the web site. Then, the same game will be applied to other concepts. Colored beads could take the place of M&Ms and would represent genes able to use oxygen, and genes that wouldn't, since this is believed to be one of the first steps in the evolution of life. Following the procedure explained in the website, students should randomly select beads from the genetic pool (bag), and record their data. Once the probability has been established, a change in the environment will be studied and how it would affect the species. More data will be collected. Another option will be an aquatic organism, and the possibility of survival outside of water, which was a major step in the evolution of species.

These changes in the genes happen because of radiation. By random chance, some of the organisms receive the change and others don't. If the "water" environment is removed, the organism that will survive will be the one that has received the change. These are the adaptations. The genetic change gives the organism the possibility to survive. The expression of the gene varies according to the needs of the environment.

Natural selection is the basis for evolution as shown by our game. More complex models of food chains will be shown to understand ecosystems and their fragility if one of the parts is removed. Students holding several pictures of animals and plants will be connected through a piece of yarn. Students should analyze the consequences and let the yarn go if the source of food for the creature they are holding doesn't exist any more. Camouflage will be studied as one of the animal adaptations in their struggle for survival. A connection to math is clear in this activity where students work on the deduction of probabilities and possible combinations.

History of Microbiology

All living things, cells and microbes, have the same needs. A cell is the fundamental unit of life, which makes our skin, our eyes, and every part of our body. But how do we know? How did Scientists come first to such a conclusion? Why do we say that every part of our body and every part of plants as well, are made of cells? They certainly look very different to the naked eye.

The history of scientific discoveries is very interesting. Students will enjoy knowing the process that has brought us to the level of knowledge or our world today, because this history will bring science closer to their reality. One day long ago, scientists didn't know, just like students don't know yet, and through some simple experiments, they started knowing.

Antony van Leeuwenhoek was the first person who saw microorganisms through a microscope around 1650. He liked to play with lenses and he constructed a special apparatus to see very small things. We can play with lenses with students as well. Maybe we can construct a replica of the microscope that Leeuwenhoek used. Local optometrists will be glad to help a teacher collect enough different lenses for students to try different combinations.

Another scientist of the time, Robert Hooke, looked at a piece of cork through a microscope lens and saw some regular holes or "cells", where he thought some "life juices" accumulated when the cork tree was alive. Even though these scientists didn't know exactly what it was that they were watching, they were very interested in their discoveries and they published them for others to learn and to build more knowledge from those discoveries. We can look at cork with our lenses and microscopes and see what they saw.

Even though it was 1650 when scientists started seeing cells, they didn't know their function for two hundred more years. People kept looking at small objects, plants and animals, but it was not until 1838, during a dinner conversation, that two scientists established the relationship between plant cells and animal cells. Matthias Schleiden was a botanist who had been studying plant cells, and Theodor Schwann was a zoologist who had been studying animal tissue. During their dinner they realized that the objects they had been observing had too many things in common to be just a coincidence. Since that discovery, scientists have being building onto the idea that every living being is made out of cells, and that cells have similar structures.

From this story, students could observe different living tissues with their school microscopes and observe the cells and their similarities like Schleiden and Schwann did. Onion tissue and cheek cells will be used for this purpose. The most interesting part of cells is that each of them "bears in itself the complete characteristics of life," which means that each cell also breathes, feeds, excretes, reacts to the environment, and reproduces, just as animals and humans do.

The parts of the cell will be related to the human life functions. The nucleus will be the "brain" of the cell and DNA and RNA will be identified as the reproductive organelles of the cell. In 1944, using much more sophisticated microscopes, Oswald T. Avery discovered where this process of reproduction took place. DNA is a large macromolecule present in the nucleus of every living cell. It is organized in a double stranded sequence of 4 different types of bases, identified by geneticists with the letters TGAC, which always pair in the same way. T always pairs with A and G always pairs with C, this way a single half (strand) can generate the other half (strand). Francis Crick and James Watson described the organization of these molecules in 1953.

The knowledge acquired about heredity will be translated to the cellular level through a model of the double helix. Students will be provided bowls with 4 different colored beads and string. They should create a random sequence of about 20 beads on their strings. From there, they should create the appropriate pairs for a complete model of the double helix. They should also write down the sequence of their beads and try to find in the classroom another person that has chosen a sequence that is identical to theirs in at least 5 of the consecutive beads. The common physical characteristics of the actual students that have similar bead sequence will be identified to demonstrate what scientists do and how that sequence could code for the common trait that they share. It is important to inform students that the human genome has a sequence of 3 billion bases of ordered pairs, or beads, in our model, and that this sequence of 3 billion bases is built in the nucleus of each of our cells.

To deepen into the study of science history and the scientific process, we will learn about other important scientific discoveries in microbiology. As mentioned before, students could relate more to scientists if they could see the struggles that thinkers went through to explain the world. They didn't have enough evidence, so they gave their own explanations to the world around, even if those explanations didn't have enough empirical support. One of the ideas they had was about the "life juice" that we mentioned before which they believed to run through cells.

They also had the idea that life originated everywhere, all the time, just because. When you have standing water (mud puddles), you will find a lot of mosquitoes. Some times when you have old rotten fruit on your table for several days, suddenly, apparently from nowhere, maggots appear. The same thing happened a long time ago, and people thought then that life just originated anywhere. They thought that life originated from decaying matter, such dead animals, garbage, or mushy fruits. When Leeuwenhoek and Hooke were playing with magnifying lenses, another scientist, Francesco Redi conducted a different experiment to prove that decaying meat would not spontaneously produce maggots. He put three different pieces of meat in three containers. The first one was covered with paper, the second one with gauze, and the third one was uncovered. Maggots only appeared on the uncovered meat and on the gauze, but not on the meat inside of the two covered containers. He proved that life didn't originate by itself, it needed some external intervention and that external intervention was a fly that placed the eggs on the meat. This experiment could be conducted in class. At the same time that students are conducting the experiments, they could learn how those simple experiments helped develop knowledge in the past.

The discovery of cells brought the discovery of other small living creatures called bacteria. Much sickness and death were caused by bacteria, but people didn't know what caused this to occur. Plants also withered and died because of bacteria. Louis Pasteur filtered air and found spores in it. He deducted that substances would not spoil if such organisms were not present. He used flasks with curved necks and the substances inside didn't spoil because dust and bacteria had been trapped in the curved neck of the flask. At least a picture if not a flask could be shown to the students to show how Pasteur made his discovery. The word "pasteurized" should be found on their lunch milk to show them how far this discovery went. Now, most food that we drink and eat is pasteurized.

This discovery was also important for medicine. Before pasteurization (sterilization), surgeries were conducted on butcher's tables or barber chairs. Surely, no student would like an operation done on them in such a place. They would prefer the clean hospitals with proper sterilization that we have today. Joseph Lister developed antiseptic surgery. He was interested in Pasteur's discoveries and he applied them to surgery, cleaning every object needed to perform an operation, as well as the place, and the wound. His results were tremendous and saved many lives, because before his approach too many people died of bacterial infections obtained while doctors performed surgery. Students will find it interesting that Lister's name is present today in many bathroom cabinets.

Another important researcher on bacteria was Robert Koch, who isolated a specific bacillus in 1876 that was recently revived in the news, anthrax. Anthrax is a disease that killed many animals and people long ago, but thanks to Koch's discoveries, illness from anthrax was nearly eliminated. This was not the only type of bacteria that he studied. He worked in other terrible diseases such as rabies and tuberculosis.

Koch contributed to science a method of study which he designed for bacteria and small organisms that allowed for the systematic learning about other diseases. He wrote specific steps to prove a relationship between cause and effect with a microorganism and a specific disease. Science is organized by rules that guarantee that the results are accurate and close to reality. The rules that Koch stated said that to study a microorganism related to a disease, the microorganism must be present in every case of the disease, but absent from healthy organisms. It must then be isolated and grown in a pure culture. From this culture, the microorganism should be inoculated in a healthy animal, and the animal should get sick with the disease. Finally, the same microorganism should be taken again from this induced sick animal. Koch used mice to test these cultures. These rules help ensure that the bacteria studied is really the bacteria that causes the disease. This method allowed cures to be developed that were really effective. If mistakes are made or the method not followed, further research based on those results are futile.

Even though we will not deal with diseases, we can create a culture in a Petri dish in our class to show the process that Koch might follow. It will be interesting to try to use different containers to generate the culture, and see the importance of the development of specific tools, such as the Petri dish, developed by Richard Petri, one of Koch's assistants. Another less known tool was the agar medium suggested by the wife of another of Koch's assistants. One Petri dish with Agar will be shown to the class. Other substances such as jelly could be tried. The growth of yeast will also be shown as an example of reproduction in microorganisms.

These cultures are samples of the reproductive stage of bacteria, where they replicate themselves in other living organisms, using the energy obtained through their food. Reproduction is the signature of life: the capacity of repeating oneself.

The activity will be useful to observe unicellular organisms, to observe cellular reproduction, and to demonstrate the spreading of diseases when hygienic precautions are not taken. Samples will be taken from door knobs, from students' nails and from the school bathroom sink. Such samples will be cultured in Petri dishes and the variety of organisms will be observed once they have grown in the Petri dish. These cultures need to be properly disposed of after study (zapping them in a microwave or treating them with full strength Clorox bleach before throwing them away will be appropriate).

Taxonomy and DNA

A final major research project will be conducted about the evolution and classification of species. A mural containing the family tree of Life itself will be constructed by the entire class. Each student will be assigned to study one or numerous species. It could be limited to finding or drawing a picture, defining the taxonomic name for at least 4 strata, the ecosystem to which it belongs, and the special adaptations that define the specie and contribute to its survival. The result will be posted on a bulletin board where animal families are well defined. A good resource for the students' research on this activity is the Enchanted Learning website <http://www.enchantedlearning.com/coloring/>, where many animals are correctly classified and the information is grade level appropriate. Instructions for the final product are included in the lesson at the end of this unit.

This project could be complemented with an "abacus" of the species, which will represent the sequence of amino acids of cytochrome c,a protein that has been analyzed for 38 different species. The "abacus" or table of comparisons shows the similarities in the protein sequence from all 38 species, and a big proportion (37%) of them do not vary from one specie to the next. These proteins are produced through the interrelation of DNA and RNA, where RNA works as the transcriber of the information contained in the DNA. RNA takes the information from pieces of DNA and uses such information to translate the DNA/RNA sequence into the protein sequence. Different proteins are the manifestation of the different genes studied before and make the parts of the organisms, such as hair, nails, etc. Colored beads could be used to represent the sequence of some of the proteins analyzed by Emanuel Margoliash, Emil Smith and others that can be seen on the web site <http://www.richmond.edu/~jbell2/05T06.PDF>.

Even though the human genome is made out of 3 billion base pairs, scientists have started to compare some of these genes similar (homologous) genes from other species. For instance, they have been able to isolate a protein called cytochrome C, which is present in all species and compared the sequences of these homologue proteins. The differences they have found are minimal in closely related species, such as of mammals (8-10), while the number of differences increase when compared to other species. There is an average difference of 26 to 31 between insects and mammals, but they still share 37% of the same sequence. Fungi and mammals have an average of 50 to 60% difference in sequence, but they still share the same sequence for the other 37% of the protein.

The details of this amino acid analysis are too advanced for fourth graders, but the proportion of similarities could be a good mathematics lesson and are the current scientific support for evolution of the species.

LESSONS

The proposed sequence for this unit is a collection of 12 lessons to guide students through the multiple relations and changes of life through time.

Lesson 1: What is Life?
Lesson 2: Human Body Parts
Lesson 3: Classification of Different Objects
Lesson 4: Classification of Animals
Lesson 5: Photosynthesis
Lesson 6: Food Chains
Lesson 7: Heredity
Lesson 8: Probability and Natural Selection
Lesson 9: The Cell
Lesson 10: Cultures in a Petri Dish
Lesson 11: The Tree of Life
Lesson 12: Geologic Time, and Evolution Written inside the Cell.

I have selected to develop in detail three important and original lessons of this unit. Others are simple to imagine, such as the first one, "What is Life?" which is direct discussion with students to assess their knowledge and preconceptions about the subject. Others are better taught as they are explained in the websites used as resources, such as the Natural Selection game explained in Joseph Lapiana's website.

"Human Body Parts" is a lesson to create models of the human body, from any resource, like the Scholastic *Body Book*. To work on classification, the book "I Spy – School Days" has a wonderful picture, which could be used for students to identify the common traits of the groups as a skills builder and an introduction to animal or life classification. The book *Inside the Cell* is an excellent resource about the cell, and is provided free of charge by the U.S. Department of Health and Human Services. I will keep working on this unit. For more information you can write me at asgalindo@academicplanet.com

LESSON PLANS

Lesson 5: Photosynthesis

Objective
Students will understand the major role of plants in the food chain, production of oxygen and energy flow, and will be able to synthesize the process that occurs in plants during photosynthesis.

Resources
The web page *What do plants eat?* (See bibliography for specific web address.)

Materials
12 cards with the letter H
18 cards with the letter O
6 cards with the letter C

Procedure
Divide the cards among the students, but make sure to give each student the same kind of cards, don't mix them. Write the formulas H_2O and CO_2 on the board. Ask the students to form those molecules among them, getting in groups with other students that complete the formula. Since they will have more than one card, ask them to form the molecules on their desks, or to redistribute the cards so each student holds a complete H2O or CO_2 molecule. Explain that H_2O is the formula for water, which students should already be familiar with, and that CO_2 is the formula for carbon dioxide. Explain that this is the gas that we breathe out and is somewhat similar to what cars expel. Carbon dioxide would not sustain life. If air contained only CO_2, plants and animals would die.

If students haven't been exposed to the concepts, explain that the O stands for Oxygen, which probably they have heard before, the H stands for Hydrogen, and the C for Carbon. Oxygen, Hydrogen and Carbon are basic elements that are found in the universe. Hydrogen is the main substance that makes up the sun and Carbon is one of the basic elements of life. Every living thing, as we know it, contains Carbon. These elements could exist by themselves, but usually are found as compounds like water and carbon dioxide. Oxygen and Hydrogen are gases in their free state, but become liquid when they get together as water. Carbon is a solid, but becomes a gas when mixed with hydrogen or oxygen.

Maybe you can have a giant leaf made out of butcher paper as a display while you explain how the inside of the leaf is a factory that takes the light energy from the sun as its fuel and transforms water and carbon dioxide into different compounds. Once the students "enter" into the side of the display leaf, they should combine to form sugar, called glucose, and the oxygen that we breathe. $6H_2O + 6CO_2 = C_6H_{12}O_6 + 6O_2$. Therefore, 6 molecules of water should get together with the 6 carbons of the carbon dioxide to form larger molecules of sugar. The oxygen left out will be lighter and will get out of the leaf as oxygen for us to breathe. Direct the students to represent these changes. Once they have rehearsed several times, you could turn the lights off and on to represent the sun. As soon the light is turned on, the choreography should begin. The big molecules of sugar remain inside the plant, and that's how the plant grows and makes its different parts, such as potato or carrot root, or spinach leaf, or a corn cob which is a fruit. The smaller molecules of oxygen are released into the environment. Plants are therefore the main food producer in the food chain. Most other creature could not live if it was not for plants and the photosynthesis process.

Evaluation

The "Photosynthesis Test" below

Photosynthesis Test

Name: ___________________________________ Date: ____________________

O_2	**H_2**	**O**	**C**	**H_2**	**C**	**O**	**H2**
H_2	**O**	**O_2**	**O_2**	**O**	**O_2**	**H_2**	**O**
C	**H_2**	**H_2**	**O**	**C**	**C**	**O**	**C**
C	**O**	**O**	**O**	**H_2**	**O**	**O_2**	**H_2**
C	**H_2**	**C**	**H_2**	**O**	**C**	**H_2**	**O_2**

What would you have left over? ____

If there was a plant around and it was a sunny day, how many molecules of sugar ($C_6H_{12}O_6$) would the plant be able to form through photosynthesis using the water and carbon dioxide molecules from the previous questions? ____________________

What other sub-product would result from this process? ____________________.

Explain photosynthesis in your own words: ______________________________________

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Lesson 11: The Tree of Life

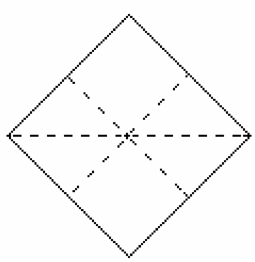
Objective
Students will explore the classification of animals according to their characteristics and will learn the system used today by scientist for such classification.

Resources
Jeananda Col's animal printouts on the Enchanted Learning website.

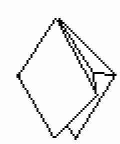
Time Required
2 or 3 class periods plus individual research time at home.

Materials
Construction Paper
Butcher Paper
Data collection forms.
Research resources such as the Internet.

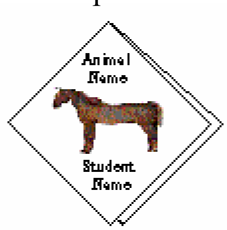
Procedure
Assign one or two animals to each student. Make sure that the assigned animals include samples from different classes and phylum. Students should research the seven taxonomic levels for their animal; their habitat, diet, special characteristics, and adaptations that help them survive in their specific environment. They could use the research worksheet attached. Once everybody has found the appropriate information, the classroom taxonomy display should be prepared.



Each student is to cut a square from a construction paper page of different colors. Fold it in half three ways, as shown in the picture, but the diagonal in the opposite direction of the plus sign folds.

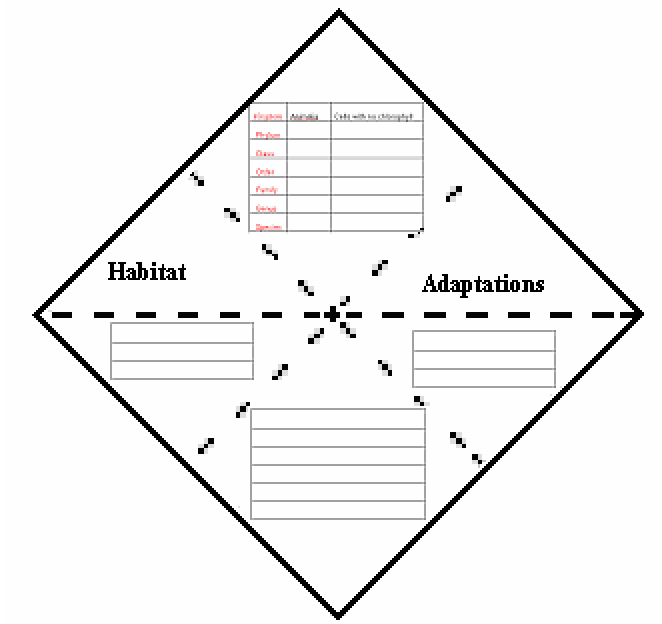


Fold it like an accordion. The diagonal folds should go inside while the two smaller squares will form the front and back. The entire piece should open like a book.

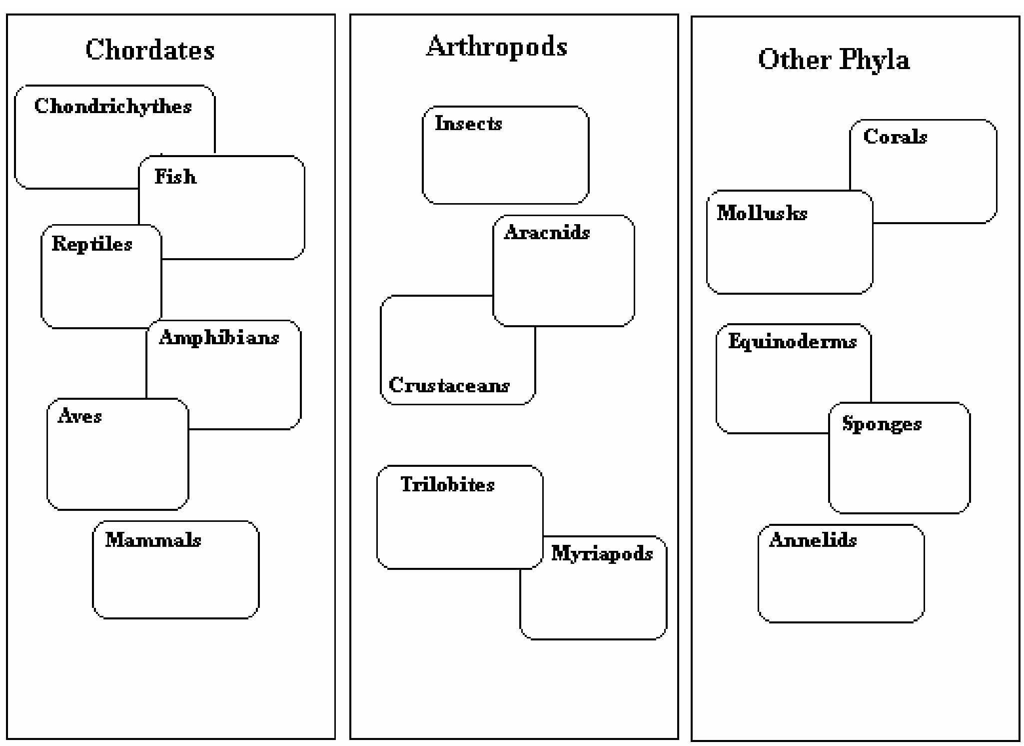


Students should draw or paste the picture of their assigned animal on the front of the display and write the name of the animal and their own name to identify it.

Inside the display the students should paste information about their selected animal, including the taxonomic classification. A format is included after this lesson.



Once each student has completed the individual animal display, they will be exhibited in a colorful bulletin board that will include space for the major taxonomic groups. Students should place their work in the group that it belongs. Here is a sample of what the display could look like, with each group in a different color.



Taxonomy Project

Name: ______________________________________ Date: _________________

Animal		
Kingdom	Animalia	Cells with no chlorophyll
Phylum		
Class		
Order		
Family		
Genus		
Species		

Habitat

Diet

Predators

Adaptations

Special Characteristics

Geologic time

Bibliography (Books and web sites where I found this information)

Cut these forms for individual students. They should fill the different levels of classification for the animal they are researching in the first column and the reason for such level. For instance, they should write "Arthropods" in the Phylum level of every insect and "Jointed Legs" in the second column to clarify that all Arthropods have jointed legs.

Kingdom	Animalia	Cells with no chlorophyll
Phylum		
Class		
Order		
Family		
Genus		
Species		

Kingdom	Animalia	Cells with no chlorophyll
Phylum		
Class		
Order		
Family		
Genus		
Species		

Kingdom	Animalia	Cells with no chlorophyll
Phylum		
Class		
Order		
Family		
Genus		
Species		

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Phylum		
Class		
Order		
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Genus		
Species		

Kingdom	Animalia	Cells with no chlorophyll
Phylum		
Class		
Order		
Family		
Genus		
Species		

Kingdom	Animalia	Cells with no chlorophyll
Phylum		
Class		
Order		
Family		
Genus		
Species		

Lesson 12: Geologic Time, and Evolution Written inside the Cell

Objective
Students will understand the process used to determine the age of fossils.
Students will observe the scientific conclusions regarding geologic time and amino acid sequence and will synthesize this information in a table to compare a contrast the time of appearance of different species and the sequence of amino acids in a part of their sequence called cytochrome c.

Resources
Understanding Geologic Time
- <http://www.ucmp.berkeley.edu/education/explorations/tours/geotime/>.

Amino Acid Sequences of cytochrome c from 38 Species
- <http://www.richmond.edu/~jbell2/05T06.PDF>.

Biochemical Divergence of Species
- <http://www.enigmas.org/aef/lib/biogen/moldist.shtml>.

Time Required
2 or 3 class periods

Materials
Internet
Computer connected projector to show websites.
Geologic Time Line Summary (attached)

Procedure
Go through the “Understanding Geologic Time” web site included in the Resources section with your students. This is an interactive presentation to explain how scientists determine the age of the fossils they discover. It is grade level appropriate and has specific points where students could express their own hypothesis and verify through trial and error.

Once the procedure for determining the age of fossils has been studied, students could research the different geologic periods, the main events that characterized each period and the animals that thrived in each of them. Or, you could provide the “Geologic Time Line Summary” that appears at the end of this lesson.

At this point students have already been introduced to DNA. Explain that scientists have separated a piece of DNA present in the genome of different species. This piece encodes a sequence of amino acids called cytochrome C. There is a table showing part of such sequence in the second web site of the resource list. Even though this information is aimed to biochemistry college students, the differences are marked with different colors. You can avoid the details, but just explain that when the colors are similar, the protein sequence is also similar for the different species.

The last web site shows a table of the number of differences encountered for different species. For instance, there are 6 differences in the cytochrome C of dogs and horses, and 2 differences between tuna and bonito, which are two species of fish. But there are 40 differences between a horse and a type of yeast, and 65 differences between a horse and bacteria.

As a culmination activity and assessment, students should elaborate a chronological table where they synthesize the information of the two sources, the geologic time line and the number of differences among species table. They should select 7 or 10 species for which they could determine the geologic time and the cytochrome C differences. This activity would allow them to experience how scientists draw conclusions about nature.

Assessment
Students should create a table to compare the geological time and the differences in Cytochrome C for different species, from different phyla. A sample table is shown below.

Differences of Cytochrome C in different species

Specie	**Geologic Time**	**Bacteria**	**…**	**…**	**…**	**Horse**
Bacteria	4 B. yr.	0				64
…						
Horse	24 Myr	64				0

Geologic Time Line Summary

<u>Hadean Eon</u> - 4.6 to 3.9 billion years ago. Rockless Eon. The solidifying of the Earth's continental and oceanic crusts occurs.

<u>Archeozoic Eon</u> - (Archean) 3.9 to 2.5 billion years ago. "Ancient Life" - The first life forms evolve. One celled organisms. Blue - green algae and bacteria appear in the sea and begin to produce free oxygen into the atmosphere.

<u>Proterozoic Eon</u> - 2.5 billion years ago to 540 million years ago (Myr). Edicara Fauna. Multi-celled animals appear, including sponges. Single super-continent called Rodinia. Most of this fauna later disappeared.

<u>Phanerozoic Eon</u> - "Visible Life". 540 million years ago through today.

Paleozoic Era "The age of Trilobites" 540 to 248 mya

Cambrian Period - 540 to 500 Myr. Cambrian explosion of life. All existent phyla develop. Many marine invertebrates, such as Mollusks, populate the oceans.

Ordovician Period - 505 to 438 Myr. Primitive plants, corals, fishes, seaweed and fungi prevail. Volcanism is constant. Huge extinction due to glaciation end the period.

Silurian Period - 438 to 408 Myr. First jawed fishes appear, as well as Centipedes and millipedes. Vascular plants (not only mosses).

Devonian Period - "The Age of Fishes" 408 to 360 Myr. Fish, Land plants, First amphibians, Sharks, and Coral reefs.

Mississippian Period - 360 to 325 Myr. First winged insects appear.

Pennsylvanian Period - 325 to 280 Myr. First reptiles, many ferns, and Cockroaches are common in this period.

Permian Period "The age of Amphibians" - 280 to 248 Myr. Gymnosperms plants are born. Pangea. Oxygen starts to be prevalent in atmosphere. Bugs, beetles are common. Largest mass extinction caused by glaciations or volcanism.

Mesozoic Era "Age of Reptiles" 248 to 65 Myr

Triasic Period - 248 to 208 Myr. First Dinosaurs, mammals and crocodyloformes appear. Mollusks are the dominant invertebrate. Flies and Turtles evolve.

Jurasic Period - 208 to 146 Myr. Dinosaurs, First birds, First flowering plants, Ferns, and conifers are common in this period.

Cretaceous Period - 146 to 65 Myr

Lower 146-98 Myr. Dinosaurs, Crocodilians, Butterflies, ants, and bees prevail.

Upper 98-65 Myr. Marsupials appear. Continents separate. Extinction of dinosaurs and 50% of marine invertebrate species mark the end of this period.

Cenozoic Era "Age of Mammals" 65 Myr through today

Tertiary Period "Other Mammals" - 65 to 1.8 mya

Paleocene - 65-54 Myr. First large mammals appear.

Eocene - 54-38 Myr. Many Mammals are now common. Rodents begin to spread.

Oligocene - 35-24 Myr. Pigs, cats, and rhinos make their appearance.

Miocene - 24 - 5 Myr. Monkeys begin to be common.

Pliocene - 5 - 1.8 Myr. Hominids (Australopithecines) and Whales evolve.

Quaternary Period " The Age of Man" 1.8 Myr to today

Pleistocene (Last Ice Age) - 1.8 to .011 Myr. First Humans appear.

Holocene - 11,000 yr to today. This is the name for the period of human civilization since use of Fire, which means us.

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Enchanted Learning is a very useful website for elementary teachers and students. It contains tons of information about diversity of topics. For this unit, the animal printouts are used to research the taxonomy of the animal as well as its habitat and adaptations. Even though it is not exhaustive for every animal, some of them are pretty complete. The drawings and the language are excellent for students to work, and the variety of species studied offer any teacher endless possibilities.

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