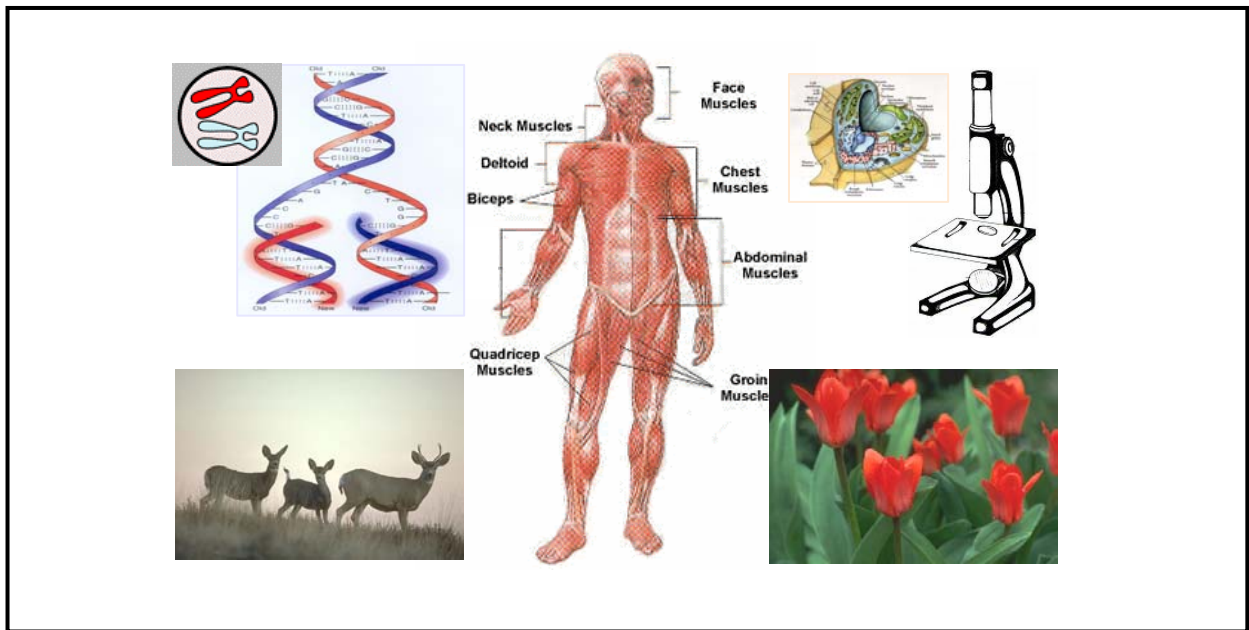


Project EASE

(Effective Alternative Secondary Education)

BIOLOGY



MODULE 15 *Evolution*



BUREAU OF SECONDARY EDUCATION
Department of Education
DepED Complex, Meralco Avenue
Pasig City



Module 15

Evolution



What this module is about

Welcome to Evolution self-learning kit!

This module will take you to a historic voyage that has changed our view of life history. Come and join me in this exploration and discover what Charles Darwin has written about how species evolve through the course of time! To open the state-of-the-art capsule that will allow us to understand how organisms evolve to what they are today, you must say this password: I Evolve, You Evolve, and They Evolve!

The module includes the following lessons:

- **Lesson 1 – The Origins of Evolutionary Thought**
- **Lesson 2 – Evidences for Evolution**
- **Lesson 3 – Process of Evolution**



What you are expected to learn

After going through this module you should be able to:

1. Describe evolution by natural selection.
2. Define direct and indirect evidence for evolution.
3. Describe the different agents for evolutionary change.
4. Differentiate allopatric and sympatric speciations.



How to learn from this module

Before getting started, I have here some tips for you to successfully achieve the objectives of this self-learning kit.

1. Read and follow instructions carefully.
2. Answer the pretest before you start the lesson.

3. Take note and record points for clarifications.
4. Try to achieve at least a 75% level of proficiency in the tests.
5. Answer the posttest.
6. Work diligently and honestly.



What to do before (Pretest)

Before we proceed, let us see if you can answer these simple questions about our lesson.

Multiple Choice. Choose the letter of the correct answer. Write the chosen letter on a separate sheet of paper.

1. Which idea stems from the theory of evolution?
 - a. The earth is relatively young.
 - b. Each organism is specially created.
 - c. Species are related by common descent.
 - d. A mix of fossils in a region indicates that a local catastrophe occurred.
2. An adaptation promotes
 - a. the chance to reproduce
 - b. the chance to survive
 - c. the chance to survive and reproduce
 - d. none of the above
3. Vertebrate forelimbs are most likely to be studied in
 - a. biogeography
 - b. comparative anatomy
 - c. ecology
 - d. embryology
4. Which is **NOT** true of fossils?
 - a. They indicate that life has a history.
 - b. They are evidences of life in the past.
 - c. The older the fossils, the less they resemble modern day species.
 - d. They look exactly like modern-day species, regardless of their age.
5. During the usual process of speciation, a species is first isolated
 - a. behaviorally
 - b. genetically
 - c. geographically
 - d. reproductively
6. Which type of speciation requires a geographical barrier?
 - a. allopatric
 - b. convergence
 - c. divergence
 - d. sympatric
7. The criterion used to distinguish between two species is based on
 - a. geography
 - b. physical traits
 - c. reproduction
 - d. time

8. Which of the following statements does NOT describe Darwin's theory of natural selection?
- Members of a population will compete.
 - Populations tend to reproduce in small numbers.
 - Members of a population have heritable variations.
 - Some members of a population have adaptive traits.
9. Which of the following describes indirect evidences for evolution?
- consists of actual observation
 - is actually observed or seen
 - is something that does not involve actual observation of evolution but for which we can infer that evolution has taken place
 - None of the above.
10. Which of the following mechanisms will cause the gene pool of two populations to become similar?
- gene flow
 - genetic drift
 - mutation
 - natural selection
11. Which of the following describes mutation?
- A result of inbreeding.
 - Any change in the structure of chromosomes.
 - Change in gene pool due to unpredictable situation.
 - Differential survival and reproduction of organisms.
12. What agent of evolutionary change can result to a population whose members are alike in appearance, fitness and lifestyles?
- inbreeding
 - gene flow
 - genetic drift
 - mutation
13. What is genetic drift?
- a change in gene pool due to chance alone.
 - A mechanism that increases variations in the population.
 - The differential survival and reproduction of organisms.
 - A change in the structure of chromosomes and gene composition.
14. Which type of speciation does not require a geographical barrier?
- allopatric
 - convergence
 - divergence
 - sympatric
15. What does it mean by direct evidence for evolution?
- consists of observations of actual evolution
 - does not involve direct observation of evolution
 - is something that is not actually observed or seen
 - None of the above.



Key to answers on page 21.

Lesson 1. The Origins of Evolutionary Thought

How did life forms occur?

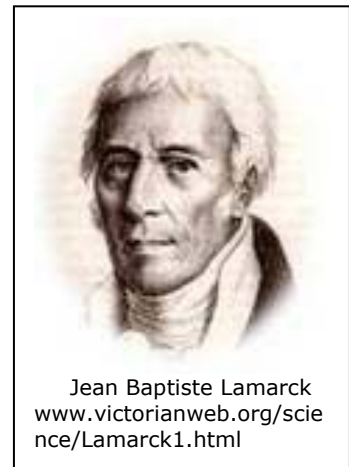
There are many different theories which explain how different life forms exist. In the mid- 18th century, most people believed in creationism. **Creationism** held the idea that all forms of life were created in its present form and they remain unchanged since the beginning. Do you know that even the famous Carl von Linnaeus, the Father of Taxonomy, believed in the fixity of species?

George Louis Leclerc, known as Count Buffon, was a French naturalist who first described descent with modification such as environmental influences, migration, geographical isolation and the struggle for existence. However he was hesitant in sharing his idea to the public.

In the late 18th century, Georges Cuvier, a vertebrate zoologist and paleontologist proposed the **theory of catastrophism**. One day he had observed that a particular region showed a succession of life forms in the soil layers. His observation seemed to contradict with his belief in special creation of each species. Cuvier explained that there might have been violent and sudden natural catastrophes such as great floods, tectonic earthquakes, and rapid formation of mountain chains, which resulted to death and extinction of most plants and animals. After each catastrophe, God created new sets of life forms.

In contrast to catastrophism, James Hutton and Charles Lyell believed that natural forces now changing the shape of the earth's surface have been operating in the past much the same way. This idea is known as **uniformitarianism** - large geological changes occurred not in catastrophic events but by gradual accumulation of small geological changes over long period of time.

Jean Baptiste de Lamarck was the first biologist to believe that life forms evolve. He proposed the Inheritance of Acquired Characteristics, which is also called Lamarckian Evolution. He believed that every organism has the will to survive, and that will has allowed us to change to more advantageous traits that suit us to the environment. The acquired traits are then inherited by the next generation. One example that Lamarck gave is the elongation of giraffes' necks over time because animals stretched their necks to reach for food and then passed on a long neck to their offspring. Today, Lamarck's idea was proven to be incorrect. Phenotypic changes acquired during an organism's lifetime cannot pass onto next generations. Cutting the cat's tail will not produce kittens without tail!



In 1859, Charles Darwin published his book, *On the Origin of Species by Means of Natural Selection*. Contrary to creationism, Darwin believed that organisms evolve from

common ancestor. Because we all share a common ancestor, we are all related to one another no matter how different we are. The relationships among organisms can be illustrated on a family tree. Look at the illustration below.

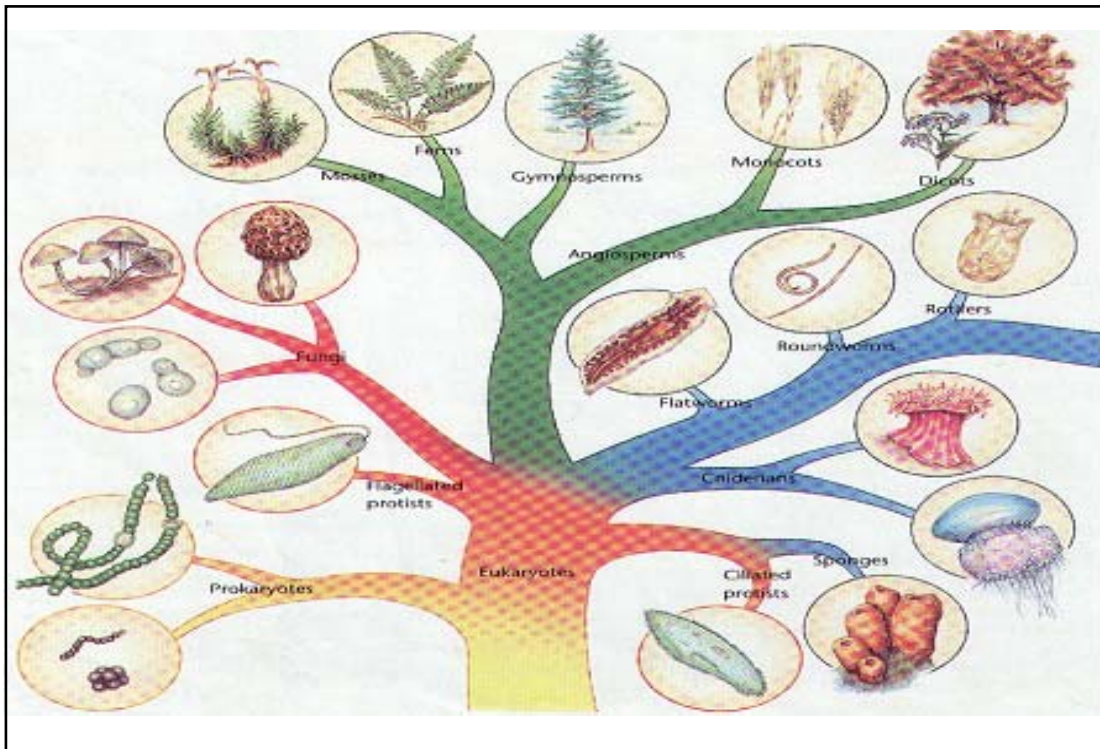


Figure 1

Living organisms sit like leaves at the tips of the branches of the Tree of Life.

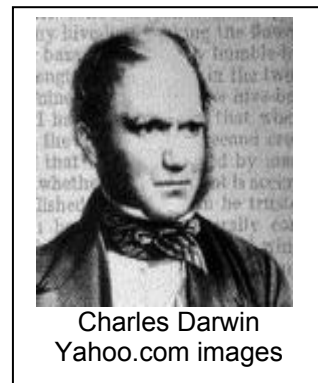
Living things share a common ancestor. All organisms are related to one another no matter how different they seem.

www.sirinet.net/~jgjohnso/tree.html

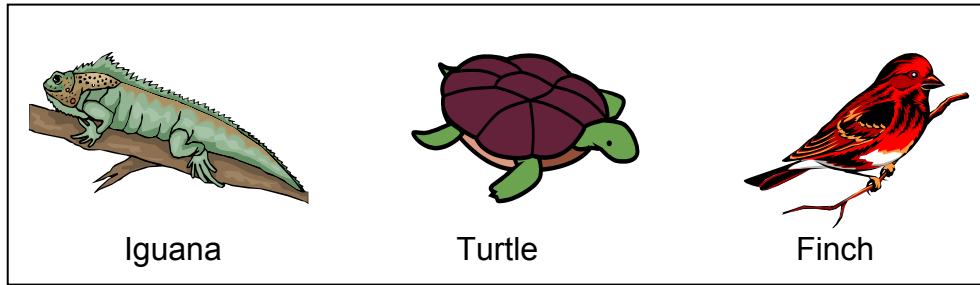
Who is Charles Darwin? How did he think species evolve?

Charles Darwin was only 22 years old when he got a chance to set sail aboard the Beagle, to travel around the world and map the coasts of South America. He was an assistant for Captain Robert FitzRoy. His Beagle voyage allowed him to develop a theory that would contradict the special creation of every organism and imply that all species evolve from common ancestors through a process called natural selection.

While on his visit to Galapagos Islands, he had observed that organisms are geographically distributed and isolated on the separate islands. He noted that similar animal types show distinct differences in body form and functions from island to island. He explained that these differences represent adaptations to differing environment. Darwin believed that over the course of time isolated groups of animals had become reproductively isolated, and then



gradually they become separate species.



But what is adaptation?

Adaptation is a set of genetically acquired traits that make the organism better suited to its environment. Individuals with advantageous adaptations are more likely to survive and reproduce than those individuals lacking the adaptations.

Do organisms simply change to fit or adapt to their environment?

No, since adaptation is a set of inherited traits, you cannot change yourself just to suit to certain environmental changes. Adaptation is not something you can do purposively or intently. For example, bears and wolves are adapted to live in extremely cold places like polar region. Their thick fur gave them an advantage over animals without fur. Other animals without fur, including humans, are not adapted to live in such places. No matter how much we want to have fur to suit to that environment we simply cannot. Remember that any modification or change during your lifetime is not an adaptation. If you cut the tail of a mother mouse, do not expect her to produce tailless mittens.



Polar Bear

<http://ceso.netfirms.com/homework%202.htm>

What is Natural Selection?

Natural selection is the mechanism Darwin proposed for how evolution comes about.

Natural selection refers to the differential survival and reproduction of organisms. He stressed that in a population, the fittest organisms are those possessing characteristics that allow them to acquire more resources, survive, and reproduce more than the less fit.

Darwin's argument for natural selection is based on a series of five observations and three inferences:

- Observation 1 – Organisms have great potential fertility.

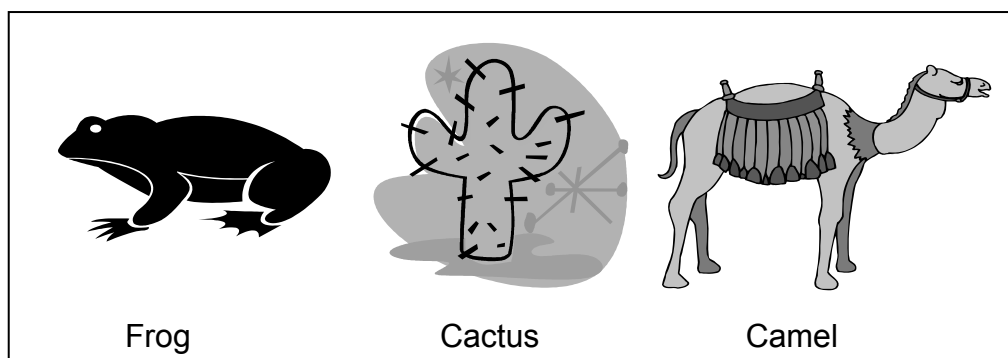
- Observation 2 – Natural populations normally remain constant in size, except for minor fluctuations.
- Observation 3 – Natural resources are limited.
- Inference 1 – There exists a continuing struggle for existence among members of a population.
- Observation 4 – All organisms show variation.
- Inference 2 – There is differential survival and reproduction among varying organisms in a population.
- Inference 3 – Over many generations, differential survival and reproduction generate new adaptations and new species.

What does the phrase “survival of the fittest” mean?

The phrase survival of the fittest relates to fitness. Fitness depends on how well certain traits can function in their specific environment. It includes the organism’s ability to survive, to mate, and to reproduce successfully. It does not necessarily mean biggest, fastest, or strongest. A trait may have high fitness in one environment and low fitness in another.

How are the concepts of natural selection and survival of the fittest related?

Because some survive better than others, natural selection tends to eliminate less fit characteristics. The fittest are those with favorable traits adapted to a specific environment. For example, camels and cactuses are adapted to live in dry places like desert. This is because camels are capable of storing large amount of water on their back. Similarly, cactuses store water on their fleshy tissues that prevent them from dehydration. Other plants and animals which lack traits similar to camels and cactuses cannot live as well in such excessively dry places.



Do the following activity to find out how adaptation can give an organism a reproductive advantage over other organisms.



What you will do Activity 1.1 I Can See You!

Spread out a sheet of newspaper on the floor. Cut ten 2 cm x 2 cm paper circles out of another newspaper, 10 paper circles out of black paper, and another 10 paper circles out of white paper. Scatter the 30 paper circles randomly across the sheet of newspaper on the floor. Ask a partner to time you for 10 seconds, and pick up paper circles as many as you can. Count and record the number of paper circles of each color you picked up. If the paper circles represent organisms in an environment, infer which one would not likely be found by its predator? Which one is the fittest? What does it mean by evolution through natural selection?



Key to answers on page 22.



What you will do Self-Test 1.1

1. Natural selection allows certain species to survive. The organisms that survive are those best adapted to their environment. Does natural selection make organisms more complex and perfect?
2. A giraffe's long neck enables it to eat leaves of trees. How does this adaptation help the giraffe survive?



Key to answers on page 22.

Lesson 2. Evidences for Evolution

Can the process of evolution be described theoretically or can it be actually observed? Evidences to support the theory of evolution come from different areas of science. Let's look at some of the evidences that support evolution. Evidences of evolution are divided into two groups: direct and indirect. However, experts are arguing as to what the direct evidences and what indirect evidences are. This issue is yet to resolve.

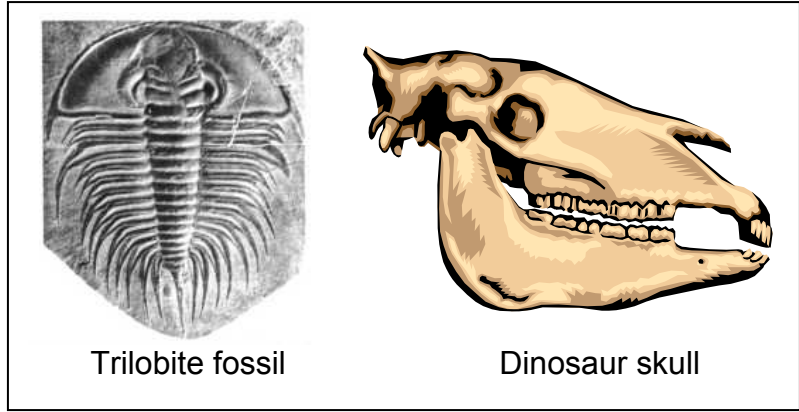
What does it mean by direct evidence?

Direct evidence is something that can be directly observed or seen. Fossils are the remains or impression left by an animal or by plants preserved in the earth crust. A considerable number of experts claim that fossils provide direct evidence for evolution (if you have access to internet, visit these web sites:
<http://library.thinkquest.org/22446/Evidences.html?qskip1=1>,
<http://www.coreknowledge.org/CKproto2/resrcs/lessons/498HxEarth.htm>,

<http://www.talkorigins.org/faqs/evolution-research.html>, <http://www.rwor.org/a/v24/1161-1170/evol5.htm>,
http://www.life.umd.edu/classroom/biol1106h/Lec9/Biol1106_L9.html,
<http://nitro.biosci.arizona.edu/courses/EEB182/Lecture02/lect2.html>).

How can fossils provide evidence of the past life?

According to many experts, fossil provides direct evidence for evolution because it can tell what has happened. In other words, it can prove that change in time has occurred. When certain fossils are arranged in the order of how old they are, we can make a direct comparison of their body structures. Through these fossils experts can confirm that species are not fixed but can evolve into other species over time.



What problems are encountered in interpreting fossil evidence?

Experts are having difficulty interpreting fossil evidence because the fossil record is relatively incomplete. Do you want to know why?

The first reason is that only a small number of fossils are found. Many organisms die and vanish without leaving a trace. The quality of preservation also varies. Some are preserved so perfectly and some are not. Soft tissues are rarely preserved. Erosion and earthquakes have destroyed other fossils. Moreover, that remains of organisms are preserved only in places where condition is favorable.

What does it mean by indirect evidence?

Indirect evidence is something that does not involve actual observation of evolution but for which we can infer that evolution has taken place. Many scientists considered genetics, comparative anatomy, embryology, and biogeography as indirect evidences for evolution.

How do homologous, analogous and vestigial structures indicate that evolution has or has not occurred?

Comparing the anatomy and the development of organisms reveals a unity of plan among those that are closely related. The more body structures that two species have in common, the more closely they are related. It supports the idea of “descent from a common ancestor”.

Would you first like to know what homologous and analogous structures mean?

Similar structures in different species irrespective of their functions are called **homologous** structures. Homology seems to indicate descent from common ancestor. The limb skeletons of vertebrates are homologous structures. Figure 2 illustrates homologous structures among vertebrates.

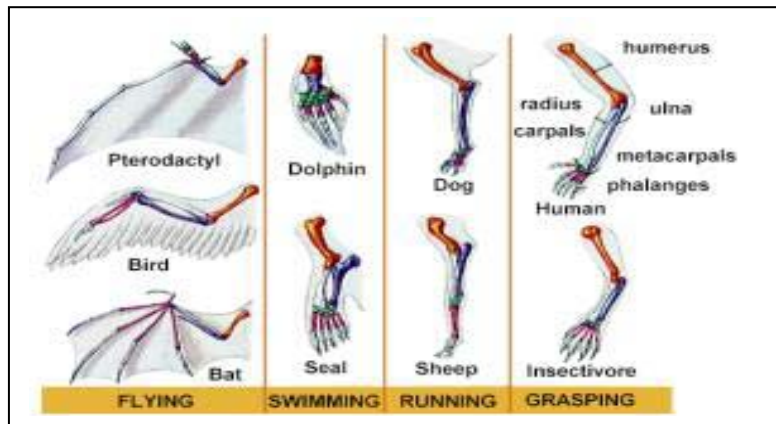


Figure 2. The limb skeletons of vertebrates are homologous structures.

<http://www.geo.arizona.edu/Antevs/nats104/00lect12.html>

Analogous structures are structures, which are different in appearance but have the same function. Analogy does not indicate common ancestry. Examples of analogous structures are the legs of insects and mammals, and wings of butterflies and birds. Figure 3 illustrates analogous structures among vertebrates.

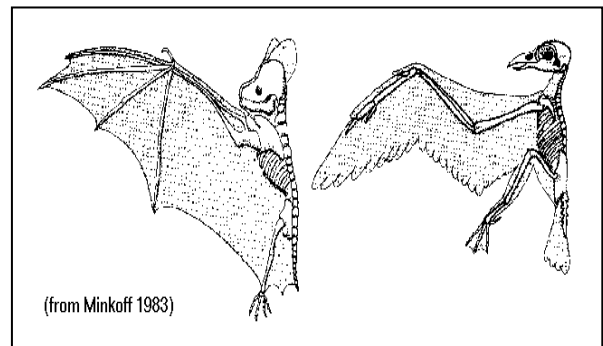


Figure 3. Analogy of bat & bird wings

http://www.mun.ca/biology/scarr/Analogy_of_forelimbs.htm

Vestigial structures seem to provide further evidence for evolutionary change. Vestigial structures are anatomical features that are usually reduced and have no function in many organisms. These are organs that were once functional in the ancestors of the species but are only remnants in the present species. For example, skeletal limbs found in some snakes have no known use to these animals. In humans, appendix is thought to have no use, but in other mammals it aids in the digestion of cellulose. What other vestigial structures are thought to be found in humans?

Some Asserted Vestigial Organs in Man	
Tonsils	Adenoids
Coccyx (tail bone)	Nictitating membrane of eye
Thymus	Appendix
Little toe	Wisdom teeth
Nipples on males	Parathyroid
Nodes on ears "Darwin's points"	Ear muscles for wiggling
Pineal gland	Body hair

"Note; Most of these organs are now found doing their function/s."

How can genetics and molecular biology support evolution?

Living things shared several similar biochemical molecules, such as DNA, ATP, amino acids, and enzymes. This finding supports descent from a common ancestor. The more closely related organisms are the more similar is their biochemical makeup.

How can biogeography prove descent from common ancestor?

Biogeography is the study of the distributions of organisms. Darwin's trip around South America allowed him to observe the diversity of organisms in different areas and the resemblance of such species of birds and tortoises in an island to nearby mainland. Darwin believed that the group of animals in each island is adapted to a different way of life. The common ancestors of these organisms had come from one locale, spreading out into other accessible areas.

How can embryology tell whether evolution has or has not occurred?

The unity of plan shared by vertebrates extends to their embryological development. The embryonic development of all vertebrates shows remarkable similarities. At some time during development, all vertebrates have a supporting dorsal rod, called a **notochord**, and exhibit paired pharyngeal pouches. This could indicate that an organism passes through some of the embryonic stages that its ancestors passed through. Then several modifications happen in ways appropriate to an organism's final form. Look closely at the illustration below. What similarities do you observe among the eight vertebrates (fish, salamander, tortoise, chick, hog, calf, rabbit and human)?

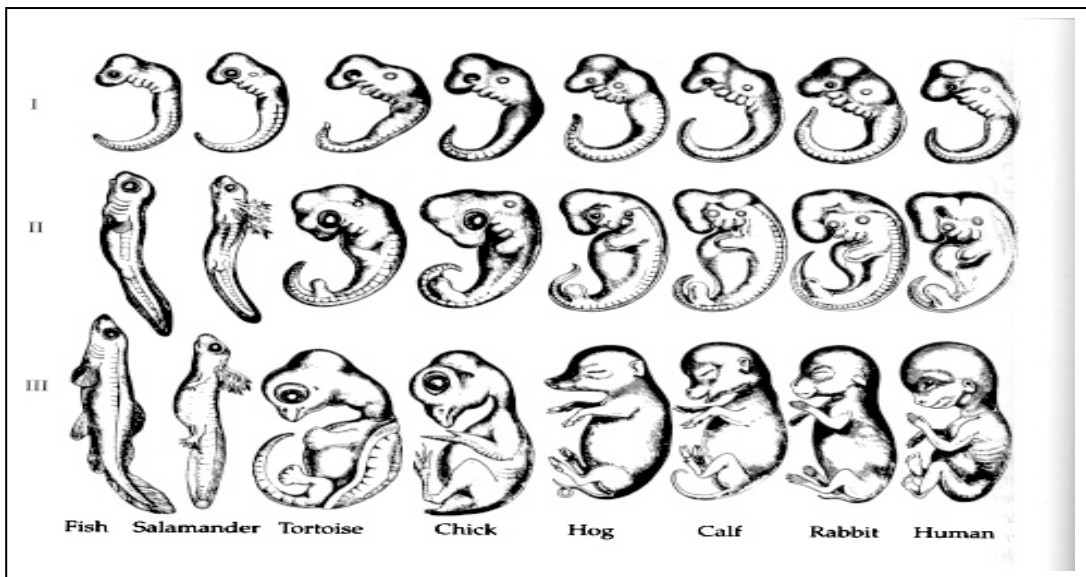


Figure 4. Vertebrate embryonic development
<http://zygote.swarthmore.edu/evo5.html>

In the next activity you will appreciate a body structure that is present in us and in some organisms related to humans.



What you will do

Activity 2.1 What a Thumb Can Do For You

Do you know how important your thumbs are? Only primates have hands capable of grasping objects. The grasp is made possible by the opposable thumbs. Are you aware that you perform a lot of tasks using your thumb and fingers? Have you experienced doing a series of tasks without the aid of your thumb?

Ask a friend to tape your thumbs to the palms of each hand with masking tape. Be careful not to wrap the tape too tightly because it will cut off the blood circulation to your hand. Then do the following:

- a. write your name with a piece of chalk on the blackboard
- b. pick up your pencil
- c. turn the doorknob
- d. pick up a drinking glass
- e. unbutton or rebutton a shirt

Question:

How has having an opposable thumb helped primates, especially humans to adapt to their environment and survive better than other animals?



Key to answers on page 22.



What you will do

Self-Test 2.1

1. Can you explain why some extinct plants and animals were not fossilized?
2. A friend tells you, “man came from apes” because many structural and biochemical similarities are found between them. How would you react to this?
3. What does it mean by direct evidence for evolution? Indirect evidence for evolution? Do you agree that fossils provide direct evidence for evolution? Why or why not?



Key to answers on page 22.

Lesson 3. Process of Evolution

When Darwin wrote his book, *On the Origin of Species*, he knew nothing about genetics. Today, population geneticists apply the principle of genetics to determine evolutionary relationships among species.

From the geneticist point of view, evolution is defined as a change in gene pool.

Do you know what gene pool is? Gene pool pertains to genetic composition of individuals in a population.

Let's say, in a population of puppies, the gene pool is 50 pure black puppies, 25 spotted (black and white) puppies, and 25 pure white puppies.

If all the males and females in the same population mate and reproduce, there is a tendency for the gene pool to remain the same generation after generation. No change in gene pool or genetic composition will occur.

So how can evolution or change in gene pool occur?

In real life animals migrate and find other mates, genes continually mutate, and nature allows the fittest organisms to survive. When these conditions happen evolution has occurred. Let's discuss the specific conditions for evolution to occur.

A. Non-random mating

By non-random mating, we mean that sexual selection is not merely by chance. Individual's choice of mate is influenced by some physical and behavioral characteristics. For example, white rabbits preferentially mate with rabbits of their own color. In humans, tall women prefer tall men rather than short men.

Inbreeding, which is commonly observed in plants and in some kinds of animals, is a very good example of non-random mating. Inbreeding in plants is sometimes called self-fertilization. Animals like dogs, rats, cats, rabbits, pigs, and many other animals practice inbreeding. Inbreeding can result to a population whose members are alike in appearance, fitness, and lifestyles.

B. Mutation

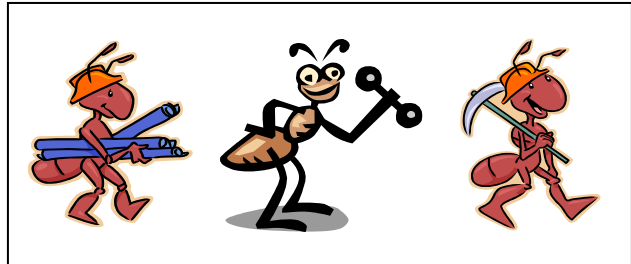
The organism's appearance is dictated by the information stored in its chromosomes. So, if the chromosome's structure or gene composition is changed, the appearance of the organism will also be changed. Any change in the structure of chromosomes and gene composition is called mutation.

What causes mutation? There are several agents for mutation (mutagens) like ultra violet radiation and hazardous chemicals in the environment. These mutagens can change the information stored in individuals' chromosomes or genes. Therefore,

when mutation occurs, the appearance of individuals in the population changes, and the gene pool becomes different from the original population.

C. Genetic drift

Genetic drift means change in gene pool due to chance alone. Unpredictable disasters or accidents such as earthquakes, floods, fires and diseases can reduce or totally eliminate certain traits in the population. Let's say flood wiped out a population of ants. No matter how good the ants are adapted to its environment, they could be killed by such event. In this situation, the survival or death of individuals in the population has nothing to do with their fitness.



Genetic drift is also observed when a harmful insecticide has killed a big population of fruit fly, leaving a few members with particular trait. The next generation of fruit flies will inherit only the trait present in the survivors. The success of this trait is due to chance but not because it is the fittest trait.

Genetic drift also happens when a small population breaks off from a larger population and forms a new population. The resulting population inherits the traits of the founders, so the new population becomes very different from the ancestral population.

This mechanism is seen in all the cattle in Iceland. The ancestors of these cattle are believed to come from a small group that was brought to the island more than one thousand years ago. Studies revealed that the genetic make-up of the Icelandic cattle is now different from that of their cousins in Norway.

Do you know some families or groups of people who isolated themselves from the surrounding populations?

One example is the Amish group of Pennsylvania. This isolated group was founded by a family that carries a very rare condition known as Ellis-van Creveld Syndrome. The Amish with this syndrome has an unusual dwarfism and polydactylism, or extra fingers. Today, this rare syndrome is common among the Amish group.



Figure 5.

Amish child with Ellis van Creveld syndrome
www.visual-evolution.com/polydactylism.htm
www.mercydesmoines.org/ADAM/.../

Figure 5 shows an Amish child with Ellis-van Creveld Syndrome.

D. Gene Flow

Gene flow occurs when individuals migrate from one population to another. Gene flow increases variations in the population. An effective sharing of traits happens when one migrates and interbreeds with the individuals of newly found population. Often, this results to an increase in the intermediate phenotypes in the population.

Gene flow can also occur without migration. When people travel to another area and interbreed with the existing population there, an effective exchange of genes occurs between the reproducing individuals, even though the traveler returns home. For example, during the U.S and Vietnam War in early 1970's, many American soldiers had children with Vietnamese women. Because of that, the gene pool of the Vietnamese population has altered.

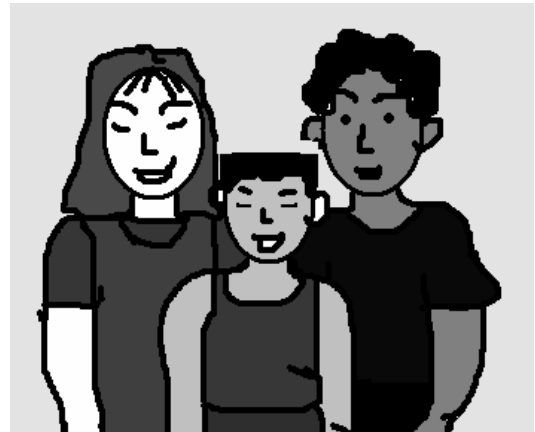
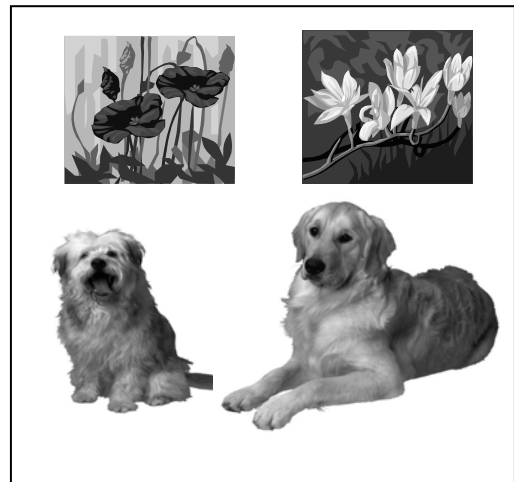


Figure 6
Marriage between races often produces individuals of intermediate appearance.

Look around you. Have you noticed that plants and animals are so diverse? There are red, white, pink, and yellow rose flowers? There are white, brown, and black dogs, some are big, and some are small. Gene flow or genetic exchanges similar to these make a population more diverse.

Human species is also diverse. Asians, Americans, Africans, Europeans are physically different. However, no matter how diverse the human population has become, humans still remain as one species as long as the members continue to interbreed successfully and share a common gene pool.



E. Natural Selection

So how does natural selection affect the evolution of a population?

Based on what you have discussed in Lesson 1, nature selects which trait will survive and which will not. These organisms with favorable traits, meaning those who are

best suited in the environment, have a better chance of survival. The survivors pass on the favorable traits to their offspring, then after many generations, the population will produce organisms with traits that are very different from their ancestors.

What is speciation?

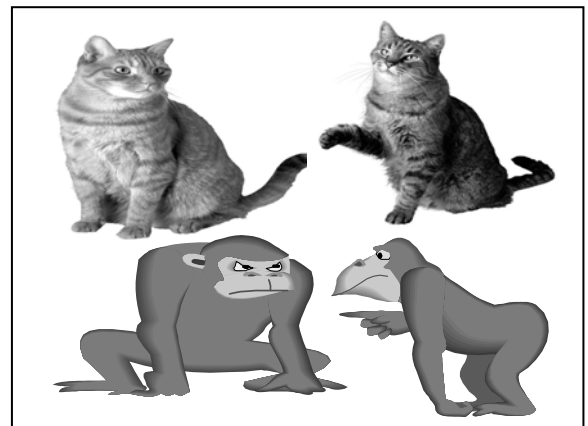
Speciation is simply the formation of new species. Oops! You should not confuse evolution with speciation! Evolution can lead to speciation. Speciation requires numerous changes in the gene pool of a population, usually over a long, long period of time.

Are you excited to know how new species occur? Before we reveal it, first you need to define the meaning of **species**.

Very good! A species is a group of organisms that are able to interbreed successfully, and produce fertile offspring who themselves can reproduce. Each species is reproductively isolated from every other species.

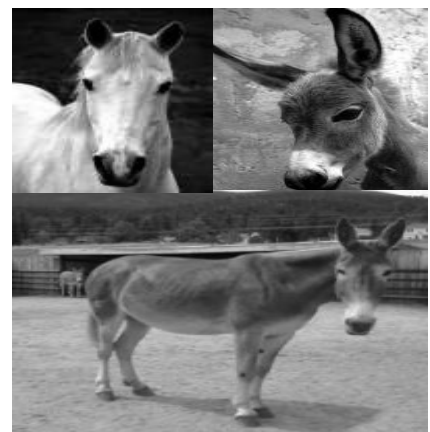
Normally, gene exchange occurs only between the populations of a species but not between populations of different species.

In other words, members of a species cannot interbreed with members of another species. For example, *Felis tigris* (tiger) is one of the cat species, but they cannot reproduce with *Felis domestica* (domesticated cat), which is another cat species. Man is a primate; it reproduces only with man but not with other primates like apes and monkeys.



But wait look at the picture below! Mating a horse and a donkey produces a mule???

Well, as what the picture tells you, horses and donkeys can have offspring! Sometimes breeding may take place but if so, the offspring are not so fertile and well adapted as the parents. For your information, the mule produced is sterile; they cannot have offspring!



<http://www.fs.fed.us/r2/psicc/spl/string.shtml>
<http://www.archiveangel.com/gallery/white-horse-2.htm>
<http://www.execulink.com/~wblank/donkey.htm>

What happens when gene flow does not occur between the populations?

When there is no gene flow, the populations become reproductively isolated and over time the populations will become separate species – a process known as speciation.

What are the two types of speciation?

There are two types of speciation: allopatric and sympatric.

In **allopatric** speciation, a population is split into two by a geographic barrier. The barrier may be a mountain, river, ocean, valley, desert, or anything that physically prevents the mating between individuals of two populations of the same species.

The two sub-populations experienced the mechanisms we have mentioned previously (natural selection, mutation, or genetic drift). Gradual changes accumulate to each of the sub-populations until they become very different from each other.

If they do come to occupy the same territory again and successful mating occurs, speciation has not occurred. But if they fail to reunite and produce offspring, speciation has occurred and they have become separate species.

In **sympatric** speciation, two or more species arise from a single ancestral species in the absence of physical barriers. Some pre-mating and post-mating barriers such as food preference, mating behavior or sterility, prevent effective gene exchange between the reproducing individuals. And when reproductive isolation has been established, speciation will have occurred.

Do this activity to find out how evolution by natural selection works.



What you will do Activity 3.1 Beak Variation

Materials needed:

“Food” stuff (beans, stones, marble, and anything else in that size range)
A large basin
Bird’s beaks (chopsticks, large forceps, clothes slip, shovel)

Procedure:

1. You will play different types of birds with different types of beak shapes and sizes.
2. As a bird, you need to get more food to sustain your large body.
3. One at a time use different types of beaks (chopsticks, forceps, shovel and clothes clip) to feed on whatever you can grab with your beak. Do this for two minutes for each type of beak.

Questions:

1. With which beak type were you able to grab more food?
2. Which beak type is the fittest?
3. How can nature choose which variations appear in the next generation and which do not?



Key to answers on page 23.



What you will do

Activity 3.2 Agents of Evolutionary Change

Label each statement with the correct agent of evolutionary change. Write your answer on a separate sheet of paper.

Choices: gene flow, genetic drift, mutations, natural selection, and non-random mating.

- _____ 1. A female peacock chooses mates with the most colorful feathers.
- _____ 2. Giraffes with longer neck get a larger share of resources and tend to have more offspring.
- _____ 3. Bacteria and insects become resistant to agents that formerly kill them.
- _____ 4. The Inca Indian population was founded by a small number of individuals, all of which had type O blood.
- _____ 5. During American and Vietnamese War, many U.S soldiers had children with Vietnamese women.



Key to answers on page 23.



What you will do

Self-Test 3.1

1. Why is reproductive isolation needed for a new species to form?
2. Differentiate allopatric speciation and sympatric speciation.
3. Can the process of evolution be described theoretically or can it be actually observed?



Key to answers on page 23.



Let's Summarize

What are the things that you have learned from this module?

1. **Creationism** is the idea that living things are created and remains unchanged since the beginning.
2. **Catastrophism** is the idea that violent and sudden natural catastrophes have resulted to death and extinction of most plants and animals. After each catastrophe, God created new sets of life forms.
3. **Uniformitarianism** claims that large geological changes occurred not in catastrophic events but by gradual accumulation of small geological changes over long periods of time.
4. Jean Baptiste de Lamarck believed that the environment could bring about inherited change.
5. Darwin proposed the theory of evolution through natural selection. He believed that all organisms come from a common ancestor.
6. Evidences for evolution come from many sources. Evidences are classified as direct and indirect. Direct evidence means something that can be directly observed or seen. Fossils provide direct evidence for evolution. Indirect evidence is something that does not involve actual observation of evolution but for which we can infer that evolution has taken place. Genetics, comparative anatomy, embryology, and biogeography offer indirect evidences.
7. Similar structures in different species irrespective of their functions are called **homologous** structures. **Analogous** structures are those that generally perform the same function though possibly in very different ways. Vestigial structures are anatomical features present in organism but have no function.
8. Natural selection is not the only driving force for evolution to occur, other mechanisms include non-random mating, gene flow, genetic drift, and mutations.
9. Two types of speciation are identified: allopatric and sympatric. Allopatric speciation happens when a population is split into two by a geographic barrier. In **sympatric** speciation, a population is split into two or more in the absence of physical barriers.



Posttest

After going through the module, I am sure you can now perfectly answer the following questions.

Multiple Choice. Choose the letter of the correct answer. Write the chosen letter on a separate sheet of paper.

1. Which idea stems from the theory of evolution?

- a. The earth is relatively young.
 - b. Each organism is specially created.
 - c. Species are related by common descent.
 - d. A mix of fossils in a region indicates that a local catastrophe occurred.
2. An adaptation promotes
 - a. the chance to reproduce
 - b. the chance to survive
 - c. the chance to survive and reproduce
 - d. none of the above
 3. Vertebrate forelimbs are most likely to be studied in
 - a. biogeography
 - b. comparative anatomy
 - c. ecology
 - d. embryology
 4. Which is **NOT** true of fossils?
 - a. They indicate that life has a history.
 - b. They are evidences of life in the past.
 - c. The older the fossil, the less it resembles modern day species.
 - d. They look exactly like modern-day species, regardless of their age.
 5. During the usual process of speciation, a species is first isolated
 - a. behaviorally
 - b. genetically
 - c. geographically
 - d. reproductively
 6. Which type of speciation requires a geographical barrier?
 - a. allopatric
 - b. convergence
 - c. divergence
 - d. sympatric
 7. The criterion used to distinguish between two species is based on
 - a. geography
 - b. physical traits
 - c. reproduction
 - d. time
 8. Which of the following statements does NOT describe Darwin's theory of natural selection?
 - a. Members of a population will compete.
 - b. Populations tend to reproduce in small numbers.
 - c. Members of a population have heritable variations.
 - d. Some members of a population have adaptive traits.
 9. Which of the following describes indirect evidences for evolution?
 - a. consists of actual observation
 - b. is actually observed or seen
 - c. is something that does not involve actual observation of evolution but for which we can infer that evolution has taken place
 - d. None of the above.
 10. Which of the following mechanisms will cause the gene pool of two populations to become similar?

- a. gene flow
- b. genetic drift
- c. mutation
- d. natural selection

11. Which of the following describes mutation?

- a. A result of inbreeding.
- b. Any change in the structure of chromosomes.
- c. Change in gene pool due to unpredictable situation.
- d. Differential survival and reproduction of organisms.

12. What agent of evolutionary change can result to a population whose members are alike in appearance, fitness and lifestyles?

- a. inbreeding
- b. gene flow
- c. genetic drift
- d. mutation

13. What is genetic drift?


- a. a change in gene pool due to chance alone.
- b. A mechanism that increases variations in the population.
- c. The differential survival and reproduction of organisms.
- d. A change in the structure of chromosomes and gene composition.

14. Which type of speciation does not require a geographical barrier?

- a. allopatric
- b. convergence
- c. divergence
- d. sympatric

15. What does it mean by direct evidence for evolution?

- a. consists of observations of actual evolution
- b. does not involve direct observation of evolution
- c. is something that is not actually observed or seen
- d. None of the above.

 Key to answers on page 24.



Key to Answers

Pretest

- | | | |
|------|-------|-------|
| I. | | |
| 1. a | 6. a | 11. b |
| 2. c | 7. c | 12. a |
| 3. d | 8. b | 13. a |
| 4. d | 9. c | 14. d |
| 5. c | 10. a | 15. a |

Lesson 1

Activity 1.1

Organisms that blend well with their environment would not likely be found by their predators, so they have greater chance to survive and leave more offspring than others who can not blend as well; they are the fittest organisms in the environment. Natural selection according to Darwin is one mechanism for evolution. Because some survive better than others, natural selection tends to eliminate less fit characteristics. Over many generations, differential survival and reproduction generate new adaptations and new species.

Self-Test 1.1

1. Natural selection does not make an organism more complex and perfect. In some environments it is better to be less complex, and in such environments complex organisms may be eliminated by natural selection.

Natural selection does not result in species that are perfectly adapted to its environment. As environment changes, species may be likely to be adapted to a previous environment, rather than the present one.

2. Giraffes with long neck have advantage in obtaining more food over giraffes with short neck. They can reach tall trees for food, thus they have greater chance to survive and reproduce more than the short-necked giraffes.

Lesson 2

Activity 2.1

The opposable thumbs enable primates to perform a lot of tasks efficiently. The opposable thumbs allow both precision manipulation and a power grip.

Self-Test 2.1

1. Not all organisms leave a proper fossil. They may die and vanish without leaving a trace. Other fossils are not preserved well. Some fossils are destroyed by earth's movement before they are dug up and studied.
2. It is true that many structural and biochemical similarities are found between man and apes. But it is wrong to say that man came from apes. Based on fossil, embryological and DNA analyses, we are close relatives of apes. These evidences for evolution suggest that man and apes shared a common ancestor. Apes did not transform to become man. If they did, you will hardly see a population of apes today. Do not confuse evolution of species with transformation of species.

3. Direct evidence for evolution consists of observations of evolution. Indirect evidence does not involve actual observation of evolution but for which you can infer that evolution has taken place. Answers of students, as to whether fossils are direct or indirect evidences for evolution, may vary.

Lesson 3

Activity 3.1

1. The shovel (as beak type) allowed the bird to grab more food than other beak type.
2. The fittest bird has beak type that allowed it to get more food than other birds with different beak type. More food resources mean better survival and reproduction.
3. The organisms with favorable traits are allowed to adapt to a changing environment. Their traits have the greater chance to become prolific in the next generation. Those who are unable to adapt are reduced or eliminated in the population.

Activity 3.2

1. Non-random mating
2. Natural selection
3. Mutation
4. Genetic drift
5. Gene flow

Self-Test 3.1

1. Reproductive isolation can prevent gene flow; it can split interbreeding populations into genetically distinct species.
2. Allopatric speciation happens when a population is split into two by a geographic barrier. These barriers physically prevent the mating between individuals of two populations of the same species. Gradual changes accumulate to each of the sub-populations. If they do come to the same territory but fail to reunite and produce offspring, speciation has occurred and they have become separate species. In **sympatric** speciation, a population is split into two or more in the absence of physical barriers. Some pre-mating and post-mating barriers such as food preference, mating behavior or sterility, prevent effective gene exchange between the reproducing individuals. And when reproductive isolation has been established, speciation will have occurred.
3. Based on the evidences it presents (fossils, comparative anatomy, embryology, biochemistry and biogeography) and the mechanisms that work in nature, evolution seems to be actually observed.

Posttest

- | | | |
|------|------|-------|
| I. | | |
| 1. a | 6. a | 11. b |
| 2. c | 7. c | 12. a |
| 3. d | 8. b | 13. a |
| 4. d | 9. c | 14. d |
| 5. c | 10.a | 15. a |

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