Overview:

Evolution is an ongoing process of change in species over time. These changes have their origin in genetics. When changes in genes occur, the result is variation, which is the basis for evolution. Evolution within a species can include changes in structure, function, or even behavior over a period of time. A widely held mechanism for evolution involves a process known as natural selection. Natural selection is a process where certain organisms are selected based on their genetic makeup. These organisms pass those successful genes on to future generations, ultimately changing the species. Evidence from fossils, anatomy, and biochemistry supports the concept of evolutionary change.

Essential Information:

Evolution Evidence – According to the basic evolutionary theory, species that exist on present day Earth evolved from earlier species that may have been distinctly different. Various types of evidence support this theory of change. The fossil record provides support that earlier species changed structurally into modern day species. Scientists have been able to piece together the history of a species by examining fossil evidence in successive layers of undisturbed sedimentary rock. By examining vertebrate anatomy, such as bone structures and embryo features, scientists have been able to conclude that certain species have a common ancestry based on shared characteristics. Scientists have used biochemical similarities in proteins and DNA to link species together and understand their evolutionary relationships and ancestry. Using biotechnology methods, such as gel electrophoresis and DNA sequencing, scientists can examine different species’ DNA for common sequences. The more shared DNA sequences, the more closely related the species. Through various types of evidence, evolutionists have a more complete picture of the changes that occurred to species over time and the relationships that those species share.

Natural Selection – The most widely held mechanism for evolution is the process of natural selection. The concept of natural selection was developed by Charles Darwin through his visits to the Galapagos Islands and his study of variation among finch beaks, as well as other variations in animal species. The process is based on the idea that environments on Earth change. When changes occur, there may be fewer or different resources available for species to use. Because of this, species will either adapt or possibly become extinct. When resources are available, species’ population numbers will increase until a point where competition occurs for those resources. Certain individuals with more desirable traits, will be more successful and their frequency will increase in population.

Within a population, there exists genetic variation. These variations may occur through several sources. Mutations occur when a gene sequence is suddenly changed. These changes may occur as a result of agents such as harmful chemicals or radiation. During sexual reproduction, recombination or crossing over can also lead to new variations of genetic information. These variations may be slight modifications of a structure, process, or behavior that allow for those individuals to be better competitors for available
resources. This is sometimes called survival of the fittest. Variation is an important factor that ensures that at least some of the individuals within a species may survive when conditions are not favorable. Those that survive will continue to reproduce, passing that successful genetic variation on to their offspring. Over time, the genetic makeup of the population may change to reflect those successful variations. The percentage of individuals with the variation will increase. Individuals with a genetic makeup that prevents them from competing will diminish in numbers and they may eventually become extinct. Most species that have lived on Earth are now extinct. As one can see, natural selection allows for a changing environment where individual members of populations that have successful genetic variations are selected for survival.

Evolutionary Model – Scientists believe that life on Earth began with simple unicellular organisms. Billions of years later, today’s complex multi-cellular organisms have evolved. To help explain what evolution looks like, scientists have suggested a evolutionary model that somewhat resembles the look of a tree. At the base of the tree are the simpler, less complex organisms from which modern day life evolved. As variation occurred and new, more complex life forms developed, branching began to occur, leading to new and different species. Some branches extend to the present, and species at the end of those branches exist today. Some branches do not reach present day, and those species have died out becoming extinct. Species that have had relatively minor changes throughout their existence will be represented by a single branch that extends to the present time. Species that are found on the same branches are more closely related than those on separate branches, as evidenced by their related DNA base sequences. The rate of reproduction may also influence how rapidly species can change and the number of branches that exist. Organisms with a short reproductive cycle, such as bacteria, have the capacity to develop many more evolutionary changes than those organisms with longer reproductive cycles. Thus, those rapidly reproducing species will have more branches in their part of the evolutionary model.

Additional Information:

- Humans did not evolve from chimpanzees. Humans and chimpanzees are evolutionary cousins and share a common ancestor that was neither chimpanzee nor human.
- Radiometric dating (absolute dating) relies on the constant half-life of radioactive elements to arrive at a specific date of the organic or inorganic material.
- Relative dating relies on using the layers of undisturbed sedimentary rock to determine the sequence of organisms and their relative ages to each other within the fossil strata.
- As biotechnology continues to develop, more evidence is provided to create a clearer and more accurate picture of evolutionary relationships.
- There is ongoing speculation that dinosaurs could be cloned from DNA found within dinosaur bones. This is highly unlikely since most bones have been mineralized (changed to a rock) and DNA, consisting of billions of individual “base pairs,” is relatively fragile and breaks down over time.
- There is good evidence that dinosaurs evolved into birds. The famous fossil – Archaeopteryx – shows the procession of a feathered dinosaur that took flight.
- The evolution theory is still a theory, and there exist other views/theories that conflict with evolution and deserve credence.
Diagrams:

1. **Evolutionary Model** – This model shows that evolution involves changes that give rise to a variety of organisms, some of which continue to change through time, while others die out. In this evolutionary model, all organisms have a common ancestral linkage to A. Organisms F, I, H, and G are still alive. Of these, F and I are most closely related and would have the most similar DNA base sequences.

2. **Vertebrate Anatomy** – Vertebrate anatomy is often used to conclude common evolutionary linkage of organisms. In this diagram, bones of forearms of two animals that are alive today are so similar they most likely evolved from a common ancestor. Members of the original ancestral population may have been separated by natural events. Over time, changes to the forearms contribute to the survival of the organism in its new environment.

3. **Variation** – Variation within a species is important to the survival of that species, especially when conditions are not favorable. Species A has the best chance of survival because it has the most genetic diversity. Genetic diversity provides for the chance that a trait might help an organism adapt and survive a change in its environment.

4. **Variation of Finch’s Beaks** – Darwin, through his visits to the Galapagos Islands, studied the variation in organisms on these islands, especially the variation in the beaks of finches. From his observations and research, he proposed the theory of natural selection.
5. **Links to a Common Ancestor** – Although variation exists within the many species of finches, each type of finch shares a common ancestor with the others. Different environments and food sources lead to natural selection and the development of many new species.

6. **Amino Acids and Biochemical Similarities** – Biochemical similarities in proteins and amino acids are used to link species together and to understand their evolutionary relationships and ancestry. In this chart, amino acids sequences are being compared. The more shared amino acids sequences, the more closely related the species are to each other.

<table>
<thead>
<tr>
<th>Species</th>
<th>Sequence of Four Amino Acids Found in the Same Part of the Hemoglobin Molecule of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>human</td>
<td>Lys–Glu–His–Phe</td>
</tr>
<tr>
<td>horse</td>
<td>Arg–Lys–His–Lys</td>
</tr>
<tr>
<td>gorilla</td>
<td>Lys–Glu–His–Lys</td>
</tr>
<tr>
<td>chimpanzee</td>
<td>Lys–Glu–His–Phe</td>
</tr>
<tr>
<td>zebra</td>
<td>Arg–Lys–His–Arg</td>
</tr>
</tbody>
</table>

7. **Banding Pattern in Gel Electrophoresis** – This diagram represents the results of gel electrophoresis, where DNA fragments are moved through a gel creating a banding pattern. In this case, evolutionary relationships can be determined by comparing the banding pattern for species A, B and C. Species A and C are more closely related because they share more common bands with each other than with B.
Vocabulary Refresher

Group A  Directions - Match the correct definition for the following terms:

1. ______ Natural selection  A. Different sets of genes that are expressed as different forms of a trait within a population.

2. ______ Vertebrate anatomy  B. A process where nitrogen base sequences of an individual’s genetic code is determined.

3. ______ Common ancestry  C. Organisms having similar genetic traits that can be traced back to a shared ancestor.

4. ______ DNA sequencing  D. A natural process where organisms that are best adapted to their environment survive and pass those favorable traits to the next generation.

5. ______ Genetic variation  E. Evidence found in sedimentary rocks that shows the existence and changes that have occurred within populations of organisms.

6. ______ Available resources  F. Having common sequences of DNA, amino acids, or common proteins or even sharing chemical processes.

7. ______ Gel electrophoresis  G. Obtainable nutrients and materials that are essential for organisms to survive.

8. ______ Fossil record  H. The term given when variations occur that allow for individuals to be better competitors for available resources and survive as a result of this.

9. ______ Biochemical similarities  I. A biotechnology process that uses the movement of fragments of DNA to determine evolutionary or genetic relationships.

10. ______ Crossing over  J. Physical features, such as bone structure, used to compare animals with backbones for evolutionary relationships.

11. ______ Survival of the fittest  K. The trading of sections of two homologous chromosomes during meiosis which leads to variation.
Vocabulary Refresher

Group B  Directions - Match the correct definition for the following terms:

1. _____ Radiation
A. A model containing branches coming from common ancestors that show the relationship between ancestral and modern day species.

2. _____ Extinct
B. The amount of time between reproduction in one generation and reproduction in the next generation.

3. _____ Unicellular organisms
C. Sudden changes within the genetic code or DNA that may contribute to evolutionary differences.

4. _____ Evolution model
D. This occurs when individuals or populations go after the same food, space or mates.

5. _____ Reproductive cycles
E. These single cell organisms that have rapid reproductive cycles are more likely to exhibit genetic diversity among the offspring in a short period of time.

6. _____ Species
F. High energy waves or particles that can damage DNA molecules, which may lead to mutations.

7. _____ Evolution
G. A group of individuals that are able to interbreed and produce viable offspring.

8. _____ Mutations
H. A slow process of change in species, populations, or individuals across successive generations.

9. _____ Recombination
I. A species that could not successfully adapt to a changing environment or lacked needed variations for survival and died out.

10. _____ Competition
J. The joining of genetic information from each gamete (sperm and egg), resulting in genetic variation.
1. Natural selection and its evolutionary consequences provide a scientific explanation for each of the following except
   (1) the fossil record
   (2) protein and DNA similarities between different organisms
   (3) similar structures among different organisms
   (4) a stable physical environment  

2. Which statement represents the major concept of the biological theory of evolution?
   (1) A new species moves into a habitat when another species becomes extinct.
   (2) Every period of time in Earth's history has its own group of organisms.
   (3) Present-day organisms on Earth developed from earlier, distinctly different organisms.
   (4) Every location on Earth's surface has its own unique group of organisms.

3. Which situation would most likely result in the highest rate of natural selection?
   (1) reproduction of organisms by an asexual method in an unchanging environment
   (2) reproduction of a species having a very low mutation rate in a changing environment
   (3) reproduction of organisms in an unchanging environment with little competition and few predators
   (4) reproduction of organisms exhibiting genetic differences due to mutations and genetic recombinations in a changing environment

4. Some behaviors such as mating and caring for young are genetically determined in certain species of birds. The presence of these behaviors is most likely due to the fact that
   (1) birds do not have the ability to learn
   (2) individual birds need to learn to survive and reproduce
   (3) these behaviors helped birds to survive in the past
   (4) within their lifetimes, birds developed these behaviors

5. Which statement is not part of the concept of natural selection?
   (1) Individuals that possess the most favorable variations will have the best chance of reproducing.
   (2) Variation occurs among individuals in a population.
   (3) More individuals are produced than will survive.
   (4) Genes of an individual adapt to a changing environment.

6. The diagrams how the bones in the forelimbs of three different organisms.

   Differences in the bone arrangements support the hypothesis that these organisms
   (1) are members of the same species
   (2) may have descended from the same ancestor
   (3) have adaptations to survive in different environments
   (4) all contain the same genetic information
7. Which population of organisms would be in greatest danger of becoming extinct?
   (1) A population of organisms having few variations living in a stable environment.
   (2) A population of organisms having few variations living in an unstable environment.
   (3) A population of organisms having many variations living in a stable environment.
   (4) A population of organisms having many variations living in an unstable environment.

10. A characteristic that an organism exhibits during its lifetime will only affect the evolution of its species if the characteristic
   (1) results from isolation of the organism from the rest of the population
   (2) is due to a genetic code that is present in the gametes of the organism
   (3) decreases the number of genes in the body cells of the organism
   (4) causes a change in the environment surrounding the organism

11. Which statement best explains the significance of meiosis in the process of evolution within a species?
   (1) The gametes produced by meiosis ensure the continuation of any particular species by asexual reproduction.
   (2) Equal numbers of eggs and sperm are produced by meiosis.
   (3) Meiosis produces eggs and sperm that are alike.
   (4) Meiosis provides for variation in the gametes produced by an organism.

12. The evolutionary pathways of ten different species are represented in the diagram below.

Which two species are the most closely related?
   (1) C and D
   (2) E and I
   (3) G and J
   (4) A and F
13. Which two processes result in variations that commonly influence the evolution of sexually reproducing species?

(1) mutation and genetic recombination
(2) mitosis and natural selection
(3) extinction and gene replacement
(4) environmental selection and selective breeding  

16. Which species is most likely to survive changing environmental conditions?

(1) a species that has few variations
(2) a species that reproduces sexually
(3) a species that competes with similar species
(4) a species that has a limited life span  

17. What will most likely occur as a result of changes in the frequency of a gene in a particular population?

(1) ecological succession
(2) biological evolution
(3) global warming
(4) resource depletion  

18. Some evolutionary pathways are represented in the diagram below.

An inference that can be made from information in the diagram is that

(1) many of the descendants of organism B became extinct
(2) organism B was probably much larger than any of the other organisms represented
(3) most of the descendants of organism B successfully adapted to their environment and have survived to the present time
(4) the letters above organism B represent members of a single large population with much biodiversity  

14. The percent of DNA that species A has in common with species B, C, D, and E are shown in the graph below.

Which statement is a valid conclusion that can be drawn from this graph?

(1) Species A is closely related to species B, but is not related to species E.
(2) Fewer mutations have occurred in species B and C than in species A.
(3) Species A and E have the greatest similarity in protein structure.
(4) Environment influences the rate of evolution.  

15. Woolly mammoths became extinct thousands of years ago, while other species of mammals that existed at that time still exist today. These other species of mammals most likely exist today because, unlike the mammoths, they

(1) produced offspring that all had identical inheritable characteristics
(2) did not face a struggle for survival
(3) learned to migrate to new environments
(4) had certain inheritable traits that enabled them to survive
19. Which species in the chart below is most likely to have the fastest rate of evolution?

<table>
<thead>
<tr>
<th>Species</th>
<th>Reproductive Rate</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>slow</td>
<td>stable</td>
</tr>
<tr>
<td>B</td>
<td>slow</td>
<td>changing</td>
</tr>
<tr>
<td>C</td>
<td>fast</td>
<td>stable</td>
</tr>
<tr>
<td>D</td>
<td>fast</td>
<td>changing</td>
</tr>
</tbody>
</table>

(1) A  (3) C  (2) B  (4) D

19

20. What is the most probable reason for the increase in the percentage of variety A in the population of the species shown in the graph below?

- There is no chance for variety A to mate with variety B.
- There is no genetic difference between variety A and variety B.
- Variety A is less fit to survive than variety B is.
- Variety A has some adaptive advantage that variety B does not have.

20

21. Which statement provides evidence that evolution is still occurring at the present time?

1. The extinction rate of species has decreased in the last 50 years.
2. Many bird species and some butterfly species make annual migrations.
3. New varieties of plant species appear more frequently in regions undergoing climatic change.
4. Through cloning, the genetic makeup of organisms can be predicted.

21

22. Which process is correctly matched

<table>
<thead>
<tr>
<th>Process</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) extinction</td>
<td>adaptive characteristics of a species are not adequate</td>
</tr>
<tr>
<td>(2) natural selection</td>
<td>the most complex organisms survive</td>
</tr>
<tr>
<td>(3) gene recombination</td>
<td>genes are copied as a part of mitosis</td>
</tr>
<tr>
<td>(4) mutation</td>
<td>overproduction of offspring takes place within a certain population</td>
</tr>
</tbody>
</table>

22

23. The table below shows adaptations in two organisms.

<table>
<thead>
<tr>
<th>Environmental Adaptations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organism</strong></td>
</tr>
<tr>
<td>desert rat</td>
</tr>
<tr>
<td>Arctic poppy plant</td>
</tr>
</tbody>
</table>

The presence of these adaptations is most likely the result of

1. reproductive technology
2. natural selection
3. asexual reproduction
4. human interference

23
Base your answers to question 24 on the diagram. Letters A through L represent different species of organisms. The arrows represent long periods of geologic time.

24. a) Which two species are the most closely related?
   (1) J and L  (3) F and H
   (2) G and L  (4) F and G  a _____

   b) Which species was best adapted to changes that occurred in its environment over the longest period of time?
   (1) A  (2) B  (3) C  (4) J  b _____

   c) Which two species would most likely show the greatest similarity of DNA and proteins?
   (1) B and J  (2) G and I  (3) J and K  (4) F and L  c _____

   d) The pattern of these evolutionary pathways is most likely the result of alterations within which structure?
   (1) vacuole  (2) cell membrane  (3) nucleus  (4) ribosome  d _____

Base your answers to question 25 on the information below.

Evolutionary changes have been observed in beak size in a population of medium ground finches in the Galapagos Islands. Given a choice of small and large seeds, the medium ground finch eats mostly small seeds, which are easier to crush. However, during dry years, all seeds are in short supply. Small seeds are quickly consumed, so the birds are left with a diet of large seeds. Studies have shown that this change in diet may be related to an increase in the average size of the beak of the medium ground finch.

25. a) The most likely explanation for the increase in average beak size of the medium ground finch is that the
   (1) trait is inherited and birds with larger beaks have greater reproductive success
   (2) birds acquired larger beaks due to the added exercise of feeding on large seeds
   (3) birds interbred with a larger-beaked species and passed on the trait
   (4) lack of small seeds caused a mutation which resulted in a larger beak  a _____

   b) In exceptionally dry years, what most likely happens in a population of medium ground finches?
   (1) There is increased cooperation between the birds.
   (2) Birds with large beaks prey on birds with small beaks.
   (3) The finches develop parasitic relationships with mammals.
   (4) There is increased competition for a limited number of small seeds.  b _____
26. When Charles Darwin traveled to the Galapagos Islands, he observed 14 distinct varieties of finches on the islands. Darwin also observed that each finch variety ate a different type of food and lived in a slightly different habitat from the other finches. Darwin concluded that the finches all shared a common ancestor but had developed different beak structures.

The 14 varieties of finches are most likely the result of
(1) absence of biodiversity    (3) asexual reproduction
(2) biological evolution       (4) lack of competition

Base your answers to question 27 on the diagram. The diagram shows the heads of four different species of Galapagos Islands finches.

27. a) The four different types of beaks shown are most likely the result of
(1) gene manipulation
(2) natural selection
(3) unchanging environmental conditions
(4) patterns of behavior learned from parents

b) Scientists observed that when two closely related species of predatory birds live in different areas, they seek prey early in the morning. However, when their territories overlap, one species hunts at night and the other hunts in the morning. When these two species live in the same area, they apparently modify their

(1) habitat    (2) niche    (3) ecosystem    (4) biodiversity

28. The diagram represents possible evolutionary relationships between groups of organisms.

Which statement is a valid conclusion that can be drawn from the diagram?

(1) Snails appeared on Earth before corals.
(2) Sponges were the last new species to appear on Earth.
(3) Earthworms and sea stars have a common ancestor.
(4) Insects are more complex than mammals.
Base your answers to question 29 on the information below.

A plant known as caltrop is found on one of the Galapagos Islands. The caltrop plant produces seeds with tough, spiny coats. There is a bird species, *Geospiza fortis*, that can crack the tough seed coat and eat the contents inside. On one part of the island where there are many of these birds, the caltrop plants produce fewer seeds and the coats of the seeds have longer and more numerous spines. On another part of the island where there are few of these birds, the plants produce more seeds and the seed coats have fewer, shorter spines.

29. a) Identify one variation the caltrop seeds have for survival. ________________________________

______________________________

b) Identify one process that can result in adaptations. ________________________________

______________________________

30. The data table shows the number of amino acid differences in the hemoglobin molecules of several species compared with amino acids in the hemoglobin of humans.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of Amino Acid Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>human</td>
<td>0</td>
</tr>
<tr>
<td>frog</td>
<td>67</td>
</tr>
<tr>
<td>pig</td>
<td>10</td>
</tr>
<tr>
<td>gorilla</td>
<td>1</td>
</tr>
<tr>
<td>horse</td>
<td>26</td>
</tr>
</tbody>
</table>

Based on the information in the data table, write the names of the organisms from the table in their correct positions on the evolutionary tree below.

31. The evolutionary pathways of several species are represented in the accompanying diagram.

Which species was best adapted for survival in changing environmental conditions? Give a supporting statement for your answer.

Species: __________

Supporting statement: ___________________________________________
Base your answers to question 32 on the diagram that shows variations in the beaks of finches in the Galapagos Islands.

32. a) The diversity of species seen on the Galapagos Islands is mostly due to

(1) gene manipulation by scientists
(2) gene changes resulting from mitotic cell division
(3) natural selection
(4) selective breeding

b) Warbler finches are classified as

(1) producers
(2) herbivores
(3) carnivores
(4) decomposers

c) Finches that eat mainly plant food are given what classification?

d) State one reason why large ground finches and large tree finches can coexist on the same island.

________________________________________________________________________

________________________________________________________________________

e) The cactus finch, warbler finch, and woodpecker finch all live on one island. Based on the information in the diagram, which one of these finches is least likely to compete with the other two for food?

Answer: ____________________________

Support your answer with an explanation.

________________________________________________________________________

________________________________________________________________________

f) How would the introduction of another species of seed-eating ground finch to the Galapagos Islands most likely influence the medium ground finch?

________________________________________________________________________

________________________________________________________________________
Base your answers to question 33 on the information below.

Scientists attempted to determine the evolutionary relationships between three different plant species, A, B, and C. In order to do this, they examined the stems and DNA of these species. Diagram 1 represents a microscopic view of the cross sections of the stems of these three species. DNA was extracted from all three species and analyzed using gel electrophoresis. The results are shown in diagram 2. Based on the data they collected, they drew diagram 3 to represent the possible evolutionary relationships.

Diagram 1

Species A  Species B  Species C

Diagram 3
Possible Evolutionary Relationships Between Species A, B, and C

A  B  C

Diagram 2

DNA from species A  DNA from species B  DNA from species C

33. a) State why the evolutionary relationships shown in diagram 3 are not supported by the data provided by the stem cross sections in diagram 1.

b) Explain how the DNA banding pattern in diagram 2 supports the evolutionary relationships between the species shown in diagram 3.

c) This technique used to analyze DNA involves the
   (1) synthesis of new DNA strands from subunits
   (2) separation of DNA fragments on the basis of size
   (3) production of genetically engineered DNA molecules
   (4) removal of defective genes from DNA
1. A certain plant species, found only in one particular stream valley in the world, has a very shallow root system. An earthquake causes the stream to change its course so that the valley in which the plant species lives becomes very dry. As a result, the species dies out completely. The effect of this change on this plant species is known as

(1) evolution (3) mutation
(2) extinction (4) succession 1

2. Scientists in the United States, Europe, and Africa have now suggested that the hippopotamus is a relative of the whale. Earlier studies placed the hippo as a close relative of wild pigs, but recent studies have discovered stronger evidence for the connection to whales. This information suggests that

(1) genetic engineering was involved in the earlier theories
(2) structural evidence is the best evolutionary factor to consider
(3) natural selection does not occur in hippopotamuses
(4) scientific explanations are tentative and subject to change 2

3. Exposure to cosmic rays, x rays, ultraviolet rays, and radiation from radioactive substances may promote

(1) the production of similar organisms
(2) diversity among organisms
(3) an increase in population size
(4) a change from sexual to asexual reproduction 3

4. A species in a changing environment would have the best chance of survival as a result of a mutation that has a

(1) high adaptive value and occurs in its skin cells
(2) low adaptive value and occurs in its skin cells
(3) high adaptive value and occurs in its gametes
(4) low adaptive value and occurs in its gametes 4

5. A current proposal in the field of classification divides life into three broad categories called domains. This idea is illustrated below.

```
Present         Bacteria   Archaea   Eukarya
               
               Past
```

Which concept is best supported by this diagram?

(1) Evolutionary pathways proceed only in one set direction over a short period of time.
(2) All evolutionary pathways will eventually lead to present-day organisms.
(3) All evolutionary pathways are the same length and they all lead to present-day organisms.
(4) Evolutionary pathways can proceed in several directions with only some pathways leading to present-day organisms. 5
6. Thousands of years ago, giraffes with short necks were common within giraffe populations. Nearly all giraffe populations today have long necks. This difference could be due to

(1) giraffes stretching their necks to keep their heads out of reach of predators
(2) giraffes stretching their necks so they could reach food higher in the trees
(3) a mutation in genetic material controlling neck size occurring in some skin cells of a giraffe
(4) a mutation in genetic material controlling neck size occurring in the reproductive cells of a giraffe

7. Which statement is most closely related to the modern theory of evolution?

(1) Characteristics that are acquired during life are passed to offspring by sexual reproduction.
(2) Evolution is the result of mutations and recombination, only.
(3) Organisms best adapted to a changed environment are more likely to reproduce and pass their genes to offspring.
(4) Asexual reproduction increases the survival of species.

8. To determine evolutionary relationships between organisms, a comparison would most likely be made between all of the characteristics below except

(1) methods of reproduction
(2) number of their ATP molecules
(3) sequences in their DNA molecules
(4) structure of protein molecules present

9. The diagram below represents a process involved in reproduction in some organisms.

This process is considered a mechanism of evolution because

(1) mitosis produces new combinations of inheritable traits
(2) it increases the chances of DNA alterations in the parent
(3) it is a source of variation in the offspring produced
(4) meiosis prevents recombination of lethal mutations

10. The first life-forms to appear on Earth were most likely

(1) complex single-celled organisms
(2) complex multicellular organisms
(3) simple single-celled organisms
(4) simple multicellular organisms

11. The teeth of carnivores are pointed and are good for puncturing and ripping flesh. The teeth of herbivores are flat and are good for grinding and chewing. Which statement best explains these observations?

(1) Herbivores have evolved from carnivores.
(2) Carnivores have evolved from herbivores.
(3) The two types of teeth most likely evolved as a result of natural selection.
(4) The two types of teeth most likely evolved as a result of the needs of an organism.
12. Which statement best describes a current understanding of natural selection?

(1) Natural selection influences the frequency of an adaptation in a population.
(2) Natural selection has been discarded as an important concept in evolution.
(3) Changes in gene frequencies due to natural selection have little effect on the evolution of species.
(4) New mutations of genetic material are due to natural selection.  

13. Which statement describing a cause of extinction includes the other three?

(1) Members of the extinct species were unable to compete for food.
(2) Members of the extinct species were unable to conceal their presence by camouflage.
(3) Members of the extinct species lacked adaptations essential for survival.
(4) Members of the extinct species were too slow to escape from predators.  

14. The bones in the forelimbs of three mammals are shown.

For these mammals, the number, position, and shape of the bones most likely indicates that they may have

(1) developed in a common environment
(2) developed from the same earlier species
(3) identical genetic makeup  
(4) identical methods of obtaining food

15. In an area of Indonesia where the ocean floor is littered with empty coconut shells, a species of octopus has been filmed "walking" on two of its eight tentacles. The remaining six tentacles are wrapped around its body. Scientists suspect that, with its tentacles arranged this way, the octopus resembles a rolling coconut. Local predators, including sharks, seem not to notice the octopus as often when it behaves in this manner. This unique method of locomotion has lasted over many generations due to

(1) competition between octopuses and their predators
(2) ecological succession in marine habitats
(3) the process of natural selection
(4) selective breeding of this octopus species

16. The diagram below shows the effect of spraying a pesticide on a population of insects over three generations.

Which concept is represented in the diagram?

(1) survival of the fittest
(2) succession
(3) dynamic equilibrium
(4) extinction
17. Which statement is best supported by the theory of evolution?
(1) Genetic alterations occur every time cell reproduction occurs.
(2) The fossil record provides samples of every organism that ever lived.
(3) Populations that have advantageous characteristics will increase in number.
(4) Few organisms survive when the environment remains the same.  17 ___

18. A species that lacks the variation necessary to adapt to a changing environment is more likely to
(1) develop many mutated cells
(2) become extinct over time
(3) begin to reproduce sexually
(4) develop resistance to diseases  18 ___

19. The graph below shows the percent of variation for a given trait in four different populations of the same species. The populations inhabit similar environments.

![Graph showing percent of variation for a given trait](image)

In which population will the greatest number of individuals most likely survive if a significant environmental change related to this trait occurs?
(1) 1  (3) 3
(2) 2  (4) 4  20 ___

20. A researcher recently discovered a new species of bacteria in the body of a tubeworm living near a hydrothermal vent. He compared the DNA of this new bacterial species to the DNA of four other species of bacteria. The DNA sequences came from the same part of the bacterial chromosome of all four species.

<table>
<thead>
<tr>
<th>Species</th>
<th>DNA Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>unknown species</td>
<td>ACT GCA CCC</td>
</tr>
<tr>
<td>species I</td>
<td>ACA GCA CCG</td>
</tr>
<tr>
<td>species II</td>
<td>ACT GCT GGA</td>
</tr>
<tr>
<td>species III</td>
<td>ACA GCA GGG</td>
</tr>
<tr>
<td>species IV</td>
<td>ACT GCA CCG</td>
</tr>
</tbody>
</table>

According to these data, the unknown bacterial species is most closely related to
(1) species I  (3) species III
(2) species II (4) species IV  20 ___

21. A population of animals is permanently split by a natural barrier into two separate populations in different environments. What will likely result after a long period of time?
(1) The evolution of the two populations will be identical.
(2) The production of variations will stop in the two populations.
(3) The two populations will evolve into separate species.
(4) Autotrophic nutrition will replace heterotrophic nutrition in the two populations.  21 ___

22. Which characteristics of a population would most likely indicate the lowest potential for evolutionary change in that population?
(1) sexual reproduction and few mutations
(2) sexual reproduction and many mutations
(3) asexual reproduction and few mutations
(4) asexual reproduction and many mutations  22 ___
23. Even though the environment changes, a population that occupies a given geographic area will most likely continue to be found in this area if the
(1) variations in the population decrease over time
(2) members of the population decrease in number
(3) members of the population exceed the carrying capacity
(4) population passes on those genes that result in favorable adaptations

24. Which statement is best supported by fossil records?
(1) Many organisms that lived in the past are now extinct.
(2) Species occupying the same habitat have identical environmental needs.
(3) The struggle for existence between organisms results in changes in populations.
(4) Structures such as leg bones and wing bones can originate from the same type of tissue found in embryos.

Researchers discovered four different species of finches on one of the Galapagos Islands. DNA analysis showed that these four species, shown in the accompanying illustration, are closely related even though they vary in beak shape and size. It is thought that they share a common ancestor.

25. a) Which factor most likely influenced these differences in beak size and shape?
(1) Birds with poorly adapted beaks changed their beaks to get food.
(2) Birds with yellow beaks were able to hide from predators.
(3) Birds with successful beak adaptations obtained food and survived to have offspring.
(4) Birds with large, sharp beaks become dominant.

b) Which factors most likely had a role in the development of beak characteristics in these finches?
(1) mutation and cloning
(2) genetic engineering and selective breeding
(3) unchanging environment and the need to reproduce
(4) variation and recombination

b_____

c) Relationships between animal species may most accurately be determined by comparing the
(1) habitats in which they live
(2) structure of guard cells
(3) base sequences of DNA
(4) shape of these cells

c_____

26. Which concept is best illustrated in the flowchart?
(1) natural selection
(2) genetic manipulation
(3) dynamic equilibrium
(4) material cycles

26_____

Set 2 – Evolution
27. Which evolutionary tree best represents the information in the chart?

<table>
<thead>
<tr>
<th>Species</th>
<th>Sequence of Four Amino Acids Found in the Same Part of the Hemoglobin Molecule of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>human</td>
<td>Lys–Glu–His–Phe</td>
</tr>
<tr>
<td>horse</td>
<td>Arg–Lys–His–Lys</td>
</tr>
<tr>
<td>gorilla</td>
<td>Lys–Glu–His–Lys</td>
</tr>
<tr>
<td>chimpanzee</td>
<td>Lys–Glu–His–Phe</td>
</tr>
<tr>
<td>zebra</td>
<td>Arg–Lys–His–Arg</td>
</tr>
</tbody>
</table>

28. R, S, and T are three species of birds. Species S and T show similar coloration. The enzymes found in species R and T show similarities. Species R and T also exhibit many of the same behavioral patterns.

Show the relationship between species R, S, and T by placing the letter representing each species at the top of the appropriate branch on the diagram.

29. When Charles Darwin was developing his theory of evolution, he considered variations in a population important. However, he could not explain how the variations occurred. Name two processes that can result in variation in a population. Explain how these processes actually cause variation.

First process: ____________________________
Explanation: ______________________________

Second process: __________________________
Explanation: _____________________________
Base your answers to question 30 on the finch diversity chart, which contains information concerning the finches found on the Galapagos Islands.

30. a) Identify one bird that would most likely compete for food with the large tree finch. Support your answer.
   
   Bird: ____________________________
   
   Supporting statement: ____________________________

   b) Identify one trait, other than beak characteristics, that would contribute to the survival of a finch species and state one way this trait contributes to the success of this species.
   
   Trait: ____________________________ Statement: ____________________________

   c) Three different species of finch inhabit one particular Galapagos Island. All three species of finch prefer plant food and have edge-crushing bills. Explain how all three species of finch can live successfully on the same island.

   Base your answers to question 31 on the diagram. Letters A through E represent different species of organisms. The arrows represent long periods of geologic time.

31. a) Which species would most likely show the greatest similarities in their amino acid sequences?
   (1) A and E   (3) B and D
   (2) A and B   (4) C and E
   a. ____________________________

   b) Which species is the common ancestor to all of the other species?
   ____________________________

   c) Identify one species that was not able to adapt to its environment.
   ____________________________

   Support your answer: ____________________________
Base your answers to question 32 on the information below.

Scientists found members of a plant species they did not recognize. They wanted to determine if the unknown species was related to one or more of four known species, A, B, C, and D.

The relationship between species can be determined most accurately by comparing the results of gel electrophoresis of the DNA from different species.

The chart below represents the results of gel electrophoresis of the DNA from the unknown plant species and the four known species.

![Table of Gel Electrophoresis Results]

32. a) The unknown species is most closely related to which of the four known species? 

Support your answer:

b) Identify one physical characteristic of plants that can be readily observed and compared to help determine the relationship between two different species of plants.

c) Explain why comparing the DNA of the unknown and known plant species is probably a more accurate method of determining relationships than comparing only the physical characteristic you identified in question b.

d) Of the 4 known species (A, B, C and D), which two are most closely related? _____ and _____

e) Identify one additional way to determine the evolutionary relationship of these plants.
Base your answers to question 33 on the information below.

In birds, the ability to crush and eat seeds is related to the size, shape, and thickness of the beak. Birds with larger, thicker beaks are better adapted to crush and open seeds that are larger.

One species of bird found in the Galapagos Islands is the medium ground finch. It is easier for most of the medium ground finches to pick up and crack open smaller seeds rather than larger seeds. When food is scarce, some of the birds have been observed eating larger seeds.

33. a) Describe one change in beak characteristics that would most likely occur in the medium ground finch population after many generations when an environmental change results in a permanent shortage of small seeds.

b) Explain this long-term change in beak characteristics using the concepts of:

1) competition

2) survival of the fittest

3) inheritance

c) Explain what would happen to the medium ground finch if they were unable to crack the larger seeds.

34. The chart below contains amino acid sequences for part of a protein that is found in the feathers on each of these three species of birds.

<table>
<thead>
<tr>
<th>Species</th>
<th>Amino Acid Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Arg-Leu-Glu-Gly-His-His-Pro-Lys-Arg</td>
</tr>
<tr>
<td>B</td>
<td>Arg-Gly-Glu-Gly-His-His-Pro-Lys-Arg</td>
</tr>
<tr>
<td>C</td>
<td>Arg-Leu-Glu-Gly-His-His-Pro-Lys-Arg</td>
</tr>
</tbody>
</table>

State one way this data supports the inference that these three bird species may be closely related.

Base your answers to question 35 on the information below.

In the Beaks of Finches laboratory activity, students were each assigned a tool to use to pick up seeds. In round one, students acting as birds used their assigned tools to pick up small seeds from their own large dishes (the environment) and place them in smaller dishes (their stomachs). The seeds collected by each student were counted. Some students were able to collect many seeds, while others collected just a few.

In round two, students again used their assigned tools to collect seeds. This time several students were picking up seeds from the same dish of seeds.

35. a) Explain how this laboratory activity illustrates the process of natural selection.

b) One factor that influences the evolution of a species that was not part of this laboratory activity is
   (1) struggle for survival
   (2) variation
   (3) competition
   (4) overproduction
   b ______

c) Identify one trait, other than beak characteristics, that could contribute to the ability of a finch to feed successfully.

Base your answer to question 36 on the information and data table.

36. Explain why it would be difficult to determine which one of the other three organisms from the table should be placed in box 1.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Body Structures</th>
<th>Reproductive Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>pigeon</td>
<td>feathers, scales</td>
<td>lays eggs</td>
</tr>
<tr>
<td></td>
<td>2 wings, 2 legs</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>scales</td>
<td>lays eggs</td>
</tr>
<tr>
<td></td>
<td>4 legs</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>fur</td>
<td>gives birth to live young</td>
</tr>
<tr>
<td></td>
<td>2 leathery wings, 2 legs</td>
<td>provides milk for offspring</td>
</tr>
<tr>
<td>C</td>
<td>fur</td>
<td>lays eggs</td>
</tr>
<tr>
<td></td>
<td>4 legs</td>
<td>provides milk for offspring</td>
</tr>
</tbody>
</table>

b) What could be done to help to determine which organism should be placed in box 1?