Unit 8 Evolution Review Outline

Key Vocabulary

1. Atmosphere
2. Inorganic Molecules
3. Organic Molecules
4. Darwin
5. Lamarck
6. Evolution
7. Natural Selection
8. Adaptation
9. Acquired Characteristic
10. Hardy-Weinberg Equilibrium
11. Directional Selection
12. Disruptive Selection
13. Stabilizing Selection
14. Random Mating
15. Gradualism
16. Punctuated Equilibrium
17. Homologous Structures
18. Analogous Structures
19. Convergent Evolution
20. Divergent Evolution
21. Vestigial Structure
22. Common Ancestor
23. Cladogram
24. Fossil Record
25. Relative Dating
26. Biogeography
27. Embryology
28. Speciation
29. Extinction

LT 8.1 – I can describe the conditions of early Earth’s atmosphere and explain how these gave rise to life on Earth.

- Earth formed about 4.6 billion years ago and was too hostile for living things until about 3.9 billion years ago. Water has been present on Earth since very early on, but it was water vapor conditions were too hot for liquid water to exist.
- The oldest fossils date to about 3.5 billion years ago. From this evidence and geological timescales, scientists have determined that life on Earth first arose between 3.5 and 3.9 billion years ago.
  - The oldest fossils are stromatolites, fossilized layers of single-celled organisms such as cyanobacteria.
- It is generally scientifically accepted that life first arose on Earth in some variation of the following scenario:
  - Earth provided inorganic precursors from which organic molecules could have been synthesized due to the presence of available free energy and the absence of a significant quantity of oxygen.
  - In turn, these molecules served as monomers or building blocks for the formation of more complex molecules, including amino acids and nucleotides.
  - The joining of these monomers produced polymers with the ability to replicate, store, and transfer information.
  - These reactions could have occurred in solutions (Organic Soup Model) or as reactions on solid reactive surfaces (Biogenic Surfaces Model).

Miller-Urey Experiment

In 1952, Stanley Miller and Harold Urey researched heavily the types of chemicals found in the early stages of Earth’s life.

After trying to recreate the conditions of Earth at that time, Miller and Urey made an artificial “Primordial Soup”

Primordial soup: the place where scientists suggest all life began from the combination of different elements and molecules in the early years of Earth’s existence (about 4 billion years ago)

LT 8.2 – I can compare and contrast Lamarke’s theory of evolution with Darwin’s theory of evolution and explain why Darwin’s theory is accepted and Lamarke’s theory is rejected.

- An early scientist that began considering ideas regarding evolution was Lamarck. He proposed that organisms were “evolving toward perfection” and that organisms change during their lifetime in order to adapt to its environment, called acquired characteristics, and those changes are passed on to its offspring. He said that change is made by what the organisms want or need. Example: Giraffe neck length.
• Lamarck’s ideas were incorrect, however, since acquired characteristics cannot be passed on from parents to offspring. Only genes in the eggs or sperm of an organism contribute to the phenotype of the offspring.

• Darwin proposed his Theory of Evolution, which are the current, accepted ideas regarding evolutionary change:
  o Individual organisms do not evolve. Populations of organisms evolve. Evolution is change in allelic frequencies in a population’s gene pool over time as a result of external factors affecting reproductive success.
  o Natural selection is one mechanism of evolutionary change, first proposed by Charles Darwin. Darwin concluded that natural selection acts only by taking advantage of slight successive variations; it can never take a great and sudden leap, but must advance by short and sure, though slow steps.
  o In order for evolution to occur by natural selection, selective pressure must be present. Selective pressures are factors in the external environment that lead to increased “fitness”, and therefore increased reproductive success, for individuals within a population that possess certain advantageous traits. Selective pressures can include factors such as: predation, resources availability, disease, and environmental conditions.
  o Natural selection is a mechanism of evolution because it causes change in the allelic frequency in a population in the following way: The individuals that possess the trait that is “selected” for, or rather the trait that allows these individuals to better survive, are better able to reproduce. These individuals pass their genes and traits on to the next generation, whereas those without the advantageous trait are less likely to reproduce. Because those with the trait reproduce more, these genes are represented in a larger percent of the next generation. Over time, if the trait continues to be advantageous, the individuals possessing it will dominate in reproduction and in turn, eventually represent the majority of the population.

**Darwin’s Finches**

Adaptive evolution in finches: Through natural selection, a population of finches evolved into three separate species by adapting to several different selection pressures. Each of the three modern finches has a beak adapted to its life history and diet.

**LT 8.3 – Given a graph, I can identify the different types of natural selection and describe conditions that would cause each. If a population is at equilibrium, I can identify the 5 conditions that must be met.**

• Selective pressure creates conditions in which a certain phenotype or trait might allow for increased survivability. When this occurs, phenotypes may shift following one of three patterns:
  o Stabilizing Selection: Phenotype variation decreases, selecting for the intermediate phenotype.
  o Directional Selection: Phenotype frequency shifts from majority one condition, to majority another,
  o Disruptive Selection: Extreme phenotypes are selected for, and there is decreased advantage for intermediates.
Hardy-Weinberg Equilibrium is a theory produced by G.H. Hardy and W. Weinberg. It states conditions for an ideal population that is not evolving and in which genetic variation remains constant due to the absence of disturbances.

Five conditions must be met for a population to attain Hardy Weinberg Equilibrium:

1. Large Population Size
2. Absence of Natural Selection
3. Absence of Mutations
4. Absence of Immigration and Emigration
5. Absence of Sexual Selection (Random Mating)

If a population maintains ALL 5 proponents of the Hardy-Weinberg Equilibrium, the population is NOT evolving. No known population has attained Hardy-Weinberg Equilibrium; therefore, all populations are evolving. However, the equation can still be used to make predictions about genotypic/allelic frequencies in a population.

Equations

- Allelic Frequency Equation: \( p + q = 1 \)
  - \( p \) = freq of Dominant allele
  - \( q \) = freq of Recessive allele

- Genotypic Frequency Equation: \( p^2 + 2pq + q^2 = 1 \)
  - \( p^2 \) = freq of Homozygous Dominant genotype
  - \( 2pq \) = freq of Heterozygous genotype
  - \( q^2 \) = freq of Homozygous Recessive genotype

LT 8.4 – I can identify different pieces of evidence for evolution and explain how they support the theory of evolution.

There are six key categories of evidence that support the Theory of Evolution:

- Homologous Structures / Morphology:
  Homologous structures are any tissue/bone/organ that appear to be present in different species. These structures are evidence of evolution as are anatomical commonalities indicating descent from a common ancestor. Homologous structures can also be used as examples highlighting divergent evolution.

- Fossil Record:
  Fossils are preserved remains, or imprint evidence of remains, from once-living organisms. They can be used as a timeline or record of life on Earth for comparing related species, both extant and extinct, and their structures. However, the fossil record is incomplete as a result of natural processes - the record is skewed toward organisms that preserved well and were widely/densely distributed.
Embryology:
An embryo is a developing organism in its earliest phases (this refers to vertebrates in this context. Embryos of many different kinds of vertebrates: mammals, birds, reptiles, fish, etc. look very similar and it is often difficult to tell them apart visually based on their development and structures. Many traits of one type appear in the embryo of another type. For example, fish and human embryos both have gill slits, or pharyngeal arches. In fish they develop into gills, but in humans they form other structures, like the inner ear, before birth. This shows that the animals share similarities during rudimentary development, implying that they are related through common ancestry.

Molecular Evidence (DNA Sequences):
Comparing DNA sequences of organisms is currently the most precise way to assess evolutionary relationships. This method has become more and more readily available as genomes of organisms have been sequenced. Various genes and noncoding regions can be compared and used to determine commonalities that can be used as a diagnostic in determining the divergence from a last common ancestor for the organisms in question.

<table>
<thead>
<tr>
<th>Amino acids reveal evolution</th>
<th>Cytochrome c Evolution</th>
<th>Number of amino acid differences from humans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chimpanzee</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Rhesus monkey</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Rabbit</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Cow</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Pigeon</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Bullfrog</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Fruit fly</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Wheat germ</td>
<td></td>
<td>37</td>
</tr>
<tr>
<td>Yeast</td>
<td></td>
<td>42</td>
</tr>
</tbody>
</table>

Biogeography:
The geographic distribution of organisms shows that extant species with common ancestry can be located in isolated and far-reaching regions of Earth. This links to the concept of continental drift and the theory that all major landmasses were once part of a larger supercontinent called Pangea. This accounts for how closely related species can be found in different locations worldwide.
• Cladograms graphically arrange organisms based on proposed evolutionary relationships in order to illustrate which groups are more closely related. A clade is a group of species used in cladograms which consists of one ancestor and all its descendants, typically associated with a particular shared trait.
• These representations are hypotheses of degrees of relatedness. New evidence such as the discovery of a new fossil, species, or genetic evidence, could call for the reevaluation of currently proposed relationships.

LT 8.5 – I can explain how patterns or evolution and types of reproductive isolation give rise to new species.

• Most evolution occurs slowly, over long periods of time: **Gradualism**: selection and variation that happens gradually (slowly over time).
  o Over a short period of time it is hard to notice.
  o Small variations/adaptations that are slightly better are selected for:
  o A few more individuals with the helpful trait survive, and a few more without the helpful trait die
  o Very gradually, over a long time, the population changes.
  o Change is slow, constant, and consistent.
  o **EXAMPLE:**
    ▪ **Giraffe necks have gotten longer and longer slowly over time because it allows them to have an advantage in reaching food**
    ▪ **Long neck giraffes are more successful at reproducing as a result of accessing more food**
• However, in some instances of mutations or rapid change in environmental pressures, evolution has been observed to occur rapidly. This is called **Punctuated Equilibrium**: change comes in spurts. There is a period of very little change, and then one or a few huge changes occur, often through mutations.
  o Mutations are random changes in the DNA that can be passed on to offspring when they occur in reproductive cells.
  o If the mutation is helpful, the individuals with it will reproduce better than those that do not.
  o Quickly, more and more of the population will have this trait.
  o The species changes very rapidly over a few generations, then settles down again to a period of little change.
  o **EXAMPLE:**
    ▪ **A type of moth is usually all light gray, which is helpful to camouflage against the birch trees in their habitat.**
    ▪ **Sometimes a mutation occurs that will produce other colored moths, such as white or black, but these do not blend in well and are always eaten by birds before they reproduce.**
    ▪ **On day, nearby where the moths live, a factory is built and cover the gray tree trunks in black soot.**
    ▪ **When a mutation causes a black moth to be born, this time it is not eaten and actually blends in better than all moths now.**
    ▪ **It reproduces and thrives, and suddenly the moths in this forest are mostly all black.**
- Divergent evolution occurs when various species sharing a common ancestor evolve differently based on selective pressures, becoming more and more dissimilar in terms of structure and function. Example: homologous structures of vertebrate forelimbs

- Convergent evolution occurs when species that are not closely related evolve similar structures due to similar environmental pressures. Example: bats wings and butterfly wings