Chapter 15: Darwin
1. What was the common belief before Darwin?
2. Know the following people and their contributions: Linnaeus, Cuvier, Lamarck, Wallace, and Malthus. Who else independently proposed the theory of natural selection?
3. On what continent and islands did Darwin make most of his observations about evolution? Name two important organisms that Darwin studied in the Galapagos Islands.
4. What are the four points to Darwin’s theory of evolution? How could you summarize Darwin’s theory of evolution in one phrase?
5. What are different types of evidence for evolution? What type of evidence is used to compare living organisms with extinct organisms?
6. What are comparative anatomy, biogeography, comparative embryology, and comparative biochemistry?
7. Which of #6 would tell you about homologous structures? What are homologous, analogous and vestigial structures? Be able to give examples of each.
8. Which of the following experiences evolution—an individual or a population?

Chapter 16-17: Evolution
1. What are the preconditions for natural selection to work?
2. Which of the following is true about natural selection?
   a. It acts on genotypes rather than phenotypes
   b. It assures the survival of each fit individual
   c. On average, it favors the survival of more offspring with adaptive characteristics
   d. It always selects for more complex forms.
   e. All of the above are correct.
3. What happens to a species that has adaptations that are no longer useful in the changing environment and the species do not change?
5. What are the requirements of the Hardy-Weinberg equilibrium? What happens when those requirements are/aren’t met? Be able to use the equation to find genotypic and allelic frequency of a population.
6. What is the most common source of genetic variation in sexually reproducing organisms?
7. What is the consequence of gene flow?
8. Understand the differences between the founder and the bottleneck effect.
9. What are the different types of natural selection?
10. What are allopatric and sympatric speciation?
11. What are random mating, nonrandom mating, and sexual selection?
12. What is meant by “heterozygote advantage?” (Example: sickle-cell disease in Africa)
Chapter 18-19: Origin and History of Life/Cladograms and Taxonomy

1. Of what was the atmosphere of the early Earth composed? What were the sources of energy on the early Earth?
2. Who was the first scientist to propose that small organic molecules could have arisen by chemical evolution? Who was the first scientist to test the other dude’s hypothesis?
3. Be familiar with these names and what they contributed to our understanding of the early Earth: Stanley Miller, Graham Cairns-Smith, Thomas Cech, Aleksander Oparin, and Sidney Fox.
4. What is thought to be one of the first metabolic pathways?
5. Know the major events in each era of the geologic time scale.
6. When did prokaryotes first appear in the fossil record?
7. What is radiometric dating? What do you know about the different types of radioisotope decay? Can all radioisotopes be used to date all rocks and fossils?
8. What is continental drift? Does it still occur?
9. What are mass extinctions? How many have occurred? Why/How did they occur?
10. How do you define each of the three domains?
11. How do you identify each of the four kingdoms of Eukaryotes?

2001 Question 2
Charles Darwin proposed that evolution by natural selection was the basis for the differences that he saw in similar organisms as he traveled and collected specimens in South America and on the Galapagos Islands.

a) Explain the theory of evolution by natural selection as presented by Darwin.

b) Each of the following relates to an aspect of evolution by natural selection. Explain three of the following:
   • Convergent evolution and the similarities among species (ecological equivalents) in a particular biome (e.g., tundra, taiga, etc.)
   • Natural selection and the formation of insecticide-resistant insects or antibiotic-resistant bacteria
   • Speciation and isolation
   • Natural selection and behavior such as kinesis, fixed-action pattern, dominance hierarchy, etc.
   • Natural selection and the heterozygote advantage

2003 Form B Question 4
Biologists are interested in preserving the diversity of living organisms on the planet.

a) Explain three of the following processes or phenomena, using an appropriate example for each.
   • Mutation
   • Adaptive radiation
   • Polyploidy
   • Population bottlenecks
   • Growth of the human population

b) For each process or phenomenon you selected in (a), discuss its impact on the diversity of life on Earth.
2004 Question 2
Darwin is considered the “father of evolutionary biology.” Four of his contributions to the field of evolutionary biology are listed below.

- The nonconstancy of species
- Branching evolution, which implies the common descent of all species
- Occurrence of gradual changes in species
- Natural selection as the mechanism for evolution

a) For each of the four contributions listed above, discuss one example of supporting evidence.
b) Darwin’s ideas have been enhanced and modified as new knowledge and technologies have become available. Discuss how two of the following have modified biologists’ interpretation of Darwin’s original contributions.

- Hardy-Weinberg equilibrium
- Punctuated equilibrium
- Genetic engineering

2008 Form B Question 3
Evolution is one of the unifying themes of biology. Evolution involves change in the frequencies of alleles in a population. For a particular genetic locus in a population, the frequency of the recessive allele (a) is 0.4 and the frequency of the dominant allele (A) is 0.6.

a) What is the frequency of each genotype (AA, Aa, aa) in this population? What is the frequency of the dominant phenotype?
b) How can the Hardy-Weinberg principle of genetic equilibrium be used to determine whether this population is evolving?
c) Identify a particular environmental change and describe how it might alter allelic frequencies in this population. Explain which condition of the Hardy-Weinberg principle would not be met.

2008 Form B Question 4
Scientists use the concept of homology in identifying evolutionary relationships among organisms. Features shared by two groups of organisms are said to be homologous if the similarities reflect shared ancestry. Homology is found in comparisons of structural, molecular, biochemical, developmental, physiological, and behavioral characteristics of organisms. Select three of the following hypotheses and explain two examples of homology that support each hypothesis.

a) Chloroplasts are related to photosynthetic prokaryotes.
b) Spiders and insects are closely related.
c) Echinoderms (sea stars and their relatives) are closely related to the chordates (the phylum that includes vertebrates).
d) Reptiles and birds are closely related.
e) Humans and chimpanzees are closely related primates.
2009 Question 3

Phylogeny is the evolutionary history of a species.

a) The evolution of a species is dependent on changes in the genome of the species. Identify two mechanisms of genetic change, and explain how each affects genetic variation.

b) Based on the data in the table below, draw a phylogenetic tree that reflects the evolutionary relationships of the organisms based on the differences in their cytochrome c amino-acid sequences, and explain the relationship of the organisms. Based on the data, identify which organism is most closely related to the chicken and explain your choice.

c) Describe two types of evidence – other than the comparison of proteins – that can be used to determine the phylogeny of organisms. Discuss one strength of each type of evidence you described.

<table>
<thead>
<tr>
<th></th>
<th>Horse</th>
<th>Donkey</th>
<th>Chicken</th>
<th>Penguin</th>
<th>Snake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horse</td>
<td>0</td>
<td>1</td>
<td>11</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>Donkey</td>
<td></td>
<td>0</td>
<td>10</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Chicken</td>
<td></td>
<td></td>
<td>0</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>Penguin</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Snake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>
**2010 Question 3**

A new species of fly was discovered on an island in the South Pacific. Several different crosses were performed, each using 100 females and 100 males. The phenotypes of the parents and the resulting offspring were recorded.

Cross I: True-breeding bronze-eyed males were crossed with true-breeding red-eyed females. All the F₁ offspring had bronze eyes. F₁ flies were crossed, and the data for the resulting F₂ flies are given in the table below.

<table>
<thead>
<tr>
<th>F₂ Phenotype</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronze Eyes</td>
<td>3,720</td>
<td>3,800</td>
</tr>
<tr>
<td>Red Eyes</td>
<td>1,260</td>
<td>1,320</td>
</tr>
</tbody>
</table>

Cross II: True-breeding normal-winged males were crossed with true-breeding stunted-winged females. All the F₁ offspring had stunted wings. F₁ flies were crossed, and the data for the resulting F₂ flies are given in the table below.

<table>
<thead>
<tr>
<th>F₂ Phenotype</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Wings</td>
<td>1,160</td>
<td>1,320</td>
</tr>
<tr>
<td>Stunted Wings</td>
<td>3,600</td>
<td>3,820</td>
</tr>
</tbody>
</table>

Cross III: True-breeding bronze-eyed, stunted-winged males were crossed with true-breeding red-eyed, normal-winged females. All the F₁ offspring had bronze eyes and stunted wings. The F₁ flies were crossed with true-breeding red-eyed, normal-winged flies, and the results are shown in the table below.

<table>
<thead>
<tr>
<th>F₂ Phenotype</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronze eyes, stunted wings</td>
<td>2,360</td>
<td>2,220</td>
</tr>
<tr>
<td>Bronze eyes, normal wings</td>
<td>220</td>
<td>300</td>
</tr>
<tr>
<td>Red eyes, stunted wings</td>
<td>260</td>
<td>220</td>
</tr>
<tr>
<td>Red eyes, normal wings</td>
<td>2,240</td>
<td>2,180</td>
</tr>
</tbody>
</table>

a) What conclusions can be drawn from cross I and cross II? Explain how the data support your conclusions for each cross.

b) What conclusions can be drawn from cross III? Explain how the data support your conclusions.

c) Identify and discuss two different factors that would affect whether the island’s fly population is in Hardy-Weinberg equilibrium for the traits above.

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**2011 Question 3**

Reproduction can be either asexual or sexual.

a) Using a specific example, describe how organisms can reproduce asexually. Discuss TWO evolutionary advantages of asexual reproduction.

b) Identify THREE ways that sexual reproduction increases genetic variability. For each, explain how it increases genetic diversity among the offspring.

c) Discuss TWO prezygotic isolating mechanisms that prevent hybridization between two species. Include in your discussion an example of each mechanism.
Phylogeny reflects the evolutionary history of organisms.

a) Discuss TWO mechanisms of speciation that lead to the development of separate species from a common ancestor.

b) Explain THREE methods that have been used to investigate the phylogeny of organisms. Describe a strength or weakness of each method.

c) The two phylogenetic trees represent the relationship of whales to six other mammals. All of the organisms shown have a pulley-shaped astragalus bone in the ankle except for the whale.

- For each tree, describe a monophyletic group, the closest relative to the whale, and the point at which the pulley astragalus was lost or gained.
- Based on the principle of parsimony (the simplest explanation is the best) and the genomic information in the table shown, identify which tree is the best representation of the evolutionary relationship of these animals and justify your answer.
Fossils of lobe-finned fishes, which are ancestors of amphibians, are found in rocks that are at least 380 million years old. Fossils of the oldest amphibian-like vertebrate animals with true legs and lungs are found in rocks that are approximately 363 million years old.

Three samples of rocks are available that might contain fossils of a transitional species between lobe-finned fishes and amphibians: one rock sample that is 350 million years old, one that is 370 million years old, and one that is 390 million years old.

a) **Select** the most appropriate sample of rocks in which to search for a transitional species between lobe-finned fishes and amphibians. **Justify** your selection.

b) **Describe** TWO pieces of evidence provided by fossils of a transitional species that would support a hypothesis that amphibians evolved from lobe-finned fishes.

2014 Question 1

Trichomes are hairlike outgrowths of the epidermis of plants that are thought to provide protection against being eaten by herbivores (herbivory). In a certain plant species, stem trichome density is genetically determined. To investigate variation in stem trichome density within the plant species, a student counted the number of trichomes on the stems of six plants in each of three different populations. The students used the data to calculate the mean trichome density (numbers of hairs per square centimeter) for each population. The results are provided in the table below.
TRICHOME DENSITY IN THREE PLANT POPULATIONS (number of trichomes/cm²)

<table>
<thead>
<tr>
<th>Population</th>
<th>Plant 1</th>
<th>Plant 2</th>
<th>Plant 3</th>
<th>Plant 4</th>
<th>Plant 5</th>
<th>Plant 6</th>
<th>Mean</th>
<th>Standard Error of the Mean (SEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>8</td>
<td>11</td>
<td>9</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td>12</td>
<td>6</td>
<td>15</td>
<td>9</td>
<td>13</td>
<td>8</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>III</td>
<td>13</td>
<td>17</td>
<td>9</td>
<td>14</td>
<td>12</td>
<td>16</td>
<td>14</td>
<td>1</td>
</tr>
</tbody>
</table>

a. On the axes provide, create an appropriately labeled graph to illustrate the sample means of the three populations to within 95% confidence (i.e., sample mean ± 2 SEM).

b. Based on the sample means and standard errors of the means, identify the two populations that are most likely to have statistically significant differences in the mean stem trichome densities. Justify your response.

c. Describe the independent and dependent variables and a control treatment for an experiment to test the hypothesis that higher trichome density in plants is selected for in the presence of herbivores. Identify an appropriate duration of the experiment to ensure that natural selection is measured, and predict the experimental results that would support the hypothesis.

2015 Question 3
The amino acid sequence of cytochrome c was determined for five different species of vertebrates. The table below shows the number of differences in the sequences between each pair of species.

<table>
<thead>
<tr>
<th></th>
<th>E. Ferus</th>
<th>D. polylepis</th>
<th>G. glalus</th>
<th>A. forsteri</th>
<th>E. africanus</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. Ferus</td>
<td>0</td>
<td>21</td>
<td>11</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>D. polylepis</td>
<td>0</td>
<td>18</td>
<td>17</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>G. glalus</td>
<td>0</td>
<td>3</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. forsteri</td>
<td>0</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. africanus</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Using the data in the table, create a phylogenetic tree on the template provided to reflect the evolutionary relationships of the organisms. Provide reasoning for the placement on the tree of the species that is least related to the others.

(b) Identify whether morphological data or amino acid sequence data are more likely to accurately represent the true evolutionary relationships among the species, and provide reasoning for your answer.
2015 Question 6

In an attempt to rescue a small isolated population of snakes from decline, a few male snakes from several larger populations of the same species were introduced into the population in 1992. The snakes reproduce sexually, and there are abundant resources in the environment.

The figure below shows the results of a study of the snake population both before and after the introduction of the outside males. In the study, the numbers of captured snakes indicate the overall population size.

(a) Describe ONE characteristic of the original population that may have led to the population’s decline in size between 1989 and 1993.

(b) Propose ONE reason that the introduction of the outside males rescued the snake population from decline.

(c) Describe how the data support the statement that there are abundant resources in the environment.

Campbell/Reece Review pg. 123

Microevolution is the change in the gene pool from one generation to the next.

a) Describe three ways in which microevolution can take place.

b) Describe the difference between microevolution and macroevolution.