16.4 The Evidence of Evolution

Adapted from following Materials;
• Biology, Miller & Levine (2010)
• Understanding Evolution (evolution.berkely.edu)
Guiding Question:
• What are the main lines of scientific evidence that support Darwin’s theory of evolution by natural selection

Key Questions:
• How does the geographic distribution of species today relate to their evolutionary history?
• How do fossils help to document the descent of modern species from ancient ancestors?
• What do homologous structures and similarities in embryonic development suggest about the process of evolutionary change?
• How can molecular biology be used to trace the process of evolution?
Evolution – Modern Definition

• **Evolution** is defined as the change in allele (gene) frequencies in a population, over generations (time).

• **Descent with Modification** – Darwin’s idea that species today descended, with changes, from common ancestors.

• Evidence of descent with modification, or common descent, of species supports the theory of evolution (in that populations’ genes are changing over time, which can eventually lead to species changing over time)
Evidence of Evolution

• Evidence for evolution and common descent is found in the following:
  • **The fossil record**
  • **Biogeography**
  • **Homologies**
    - Anatomical homologies
    - Molecular homologies
    - Developmental homologies
The Fossil Record

- Darwin’s observations of the fossil record convinced him that evolution was occurring.
- Many recently discovered fossils form a series that trace the evolution of modern species from extinct ancestors.
- Fossils help “connect the dots” of the evolutionary path of many species.
Bellringer 1/18/2013

• On page 37 of your notebook write the bellringer as shown below, and answer BOTH parts

| 6 | Bellringer 1/18: Use figure 16-13 to describe how a modern Mysticete whale is different from Ambulocetus: |
| 7 | |
| 8 | |
| 9 | |
| 10 | What kind of evidence is this? |

• Use the picture you picked up on your way in!
Biogeography

- **Biogeography** is the study of where organisms live now and where they and their ancestors lived in the past.

- Two biogeographical patterns are important to Darwin’s theory
  - When closely related species differ in slightly different climates
  - When distantly related species develop similar characteristics in similar environment
Biogeography – Closely Related but Different

- Darwin observed that closely related species on the Galapagos islands had variations from each other due to varied conditions on the different islands
- Darwin hypothesized that the different populations on the Galapagos had evolved from a mainland species. - (descent with modification)
- Over time, natural selection on the islands produced variations among populations that resulted in different, but closely related, species
- EX/ the finches on the Galapagos islands... different species have different beaks, but evolved from a common ancestor
Biogeography – Distantly Related but Similar

• Darwin noted that similar ground dwelling-birds inhabit similar grasslands in Europe, Australia, and Africa.
• Differences in body structure provide evidence that they evolved from different ancestors.
• Similarities among these birds provide evidence that similar selection pressures (in the similar habitats) cause distantly related species to develop similar adaptations.
CFU - Biogeography

• Copy the CFU Question shown below into your notebook (PAGE 37) (do not use more than 3 lines)

• Answer the question

11 CFU: Why do distantly related species in very different locations sometimes share common traits?
12
13
14
15
Homologies

- **Homologies** are similar characteristic shared due to relatedness
  - ex/ a whale and a dolphin both have lungs because they inherited them from a common ancestor

- **Homologies** can be;
  - **Anatomical/Structural**: body parts or physical features
  - **Molecular**: Similar molecules (such as DNA, RNA, proteins)
  - **Developmental**: developing in similar patterns
Anatomical Homologies

• Structures shared by related species that have been inherited from a common ancestor are called **homologous structures**

• According to evolutionary theory, homologous structures adapted to different purposes as the result of descent with modification from a common (shared) ancestor

• Similarities and differences in homologous structures help scientists determine how recently species shared a common ancestor
Homologous Structures in Plants

- **Pitcher Plant**: leaves modified into pitchers to catch insects
- **Venus’ Flytrap**: leaves modified into jaws to catch insects
- **Poinsettia**: bright red leaves resemble flower petals
- **Cactus**: leaves have become spines

Image: [http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_04](http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_04)
Homologous Structures in Animals

- Humerus
- Radius
- Ulna
- Carpals
- Metacarpals
- Phalanges

Human  Cat  Whale  Bat
Homologous Structure vs. Analogous Structure

• Homologous structures are passed on from a common ancestor, and infer relation between two species

• Body parts that are similar in function but not in structure (and do not come from a common ancestor) are called analogous structures
  
  • Ex – a bird’s wings and a fly’s wing
  
  • Same function – flight.... But different structure and different ancestors

• Shark’s tail vs. dolphin’s tail
Analogous Structure Examples
Analogous Structures Example 2

Shark (Fish)

Dolphin (Mammal)
Vestigial Structures

- **Vestigial structures** are homologous structure that have lost some or all of their original function due to different selection pressures acting on the descendant.

- Hipbones in whales and dolphins are leftover from the 4-legged ancestors of these species
  - Hipbones connect hind (lower/back) legs to the backbone.

- Once whale and dolphin populations adapted to locomotion (movement) in water by developing tails, they no longer needed hind legs.
  - Since they got their developmental plan from their ancestors (who had hipbones because they walked on all fours on land) they still develop small, non-functional, hipbones.
Vestigial Structures examples

Tailbones (but no tail) in humans

The blind mole rat (Spalax typhlus) has tiny eyes completely covered by a layer of skin.

Hipbones (pelvis) in whales
CFU - Homologies

- Write the following into your notebook (pg 37) and answer

<table>
<thead>
<tr>
<th>16</th>
<th>CFU: use a chart to show differences between homologous and analogous structures.</th>
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<tbody>
<tr>
<td>17</td>
<td>Homologous structures</td>
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Developmental Homologies - Embryology

- Similar patterns of embryological development provide further evidence that organisms have descended from a common ancestor.
- The same groups of embryonic cells develop in the same order to produce homologous tissues and organs in vertebrates (animals with a backbone).

Figure 3.13 - Developmental homologies. Embryos from different vertebrates show striking similarities early in development.
Molecular Homologies

- All living things are made of ... CELLS!
- Life shares a common genetic code...DNA. All living things use DNA and/or RNA as their genetic code to carry information from one generation to the next
  - All life evolved from an early prokaryotic life-form that used DNA/RNA
- Traits of organisms are coded for in sections of DNA called genes (which code for the production of proteins)
  - Many genes are homologous... different organisms use similar genes (Hox genes)
Molecular Homologies - Proteins

• Many organisms have **homologous proteins** – similar proteins that are used by many different types of life.

• **Cytochrome c** is a protein that is involved in cellular respiration, and is found in almost all living things
  • From cells in yeast to cells in humans!
Exit Ticket

• Copy the exit ticket shown below onto the bottom of page 37 in your notebook

• Answer it!

Exit Ticket: Organism A and B have very similar genes, and develop in a very similar manner. What do these similarities suggest about the ancestry of organisms A and B?