

Session 3: Evidence of Evolution

Overview:

Some of Darwin's earliest supporters found evidence of evolution in fossils. Fossils continue to inform our ideas of evolution as Neil Shubin tells us. He describes his search for a fossil link between fish and land animals and the excitement of finally finding it. In a review of session 2, Sarah Tishkoff reminds us of what fossils tell us about human evolution and migration. Further evidence of evolution comes from comparing DNA sequences. Hopi Hoekstra studies the impact of genes and the environment on the evolution of specific phenotypes. She found that populations of mice living on white sand beaches were more likely to evolve light colored fur than populations in areas with dark soil. (Why do you think this happens?) In about half of the populations, this change was due to a single mutation in the MC1 receptor. In an interesting example of convergent evolution, the same mutation causes coat color variation in some dogs and may have caused coat colors to vary in woolly mammoths!

First Video:

Title: Finding Tiktaalik, the Fossil Link Between Fish and Land Animals

Speaker: Neil Shubin



Second video (Review from Session 2):

Title: African Genomics: Human Evolution

Speaker: Sarah Tishkoff

Please watch this video from time 00:00 to 6:51.

Key Challenges in Human Genomics Research



How do ethnically diverse humans differ in regard to genomic and phenotypic variation?



Questions for Part 1 & Part 2:

1. Why is the fossil record not a complete catalogue of biological history?
 - a. Not all organisms fossilize with equal probability.
 - b. Fossilization destroys the structure of DNA.
 - c. The process of fossilization often destroys anatomical features of the organisms being preserved.
 - d. Fossils only preserve organisms for about 10 million years; older organisms are destroyed by geological processes.
 - e. Only animals, not plants, are fossilized

2. Which of the following characteristic(s) is/are important evolutionary features of the *Tiktaalik* fossil? Choose all of the answers that apply.
 - a. Brain.
 - b. Scales.
 - c. Flat head.
 - d. Lungs.
 - e. Fins.
 - f. None of the above.
 - g. All of the above.

3. The cetaceans (whales, dolphins and porpoises) are marine mammal descendants of land mammals. If you are studying a fossil that is a possible evolutionary link between early cetaceans and land mammals, which of the following characteristic(s) would you expect to find? Choose all of the answers that apply.
 - a. Fins.
 - b. Gills.
 - c. Wings.
 - d. Cartilaginous skeleton.
 - e. None of the above.

For questions 4 -6, determine if the statement is true or false. If the statement is false, change one word or phrase to make it true.

4. One of the most important features of the *Tiktaalik* fossil is the presence of the neck.

5. The *Tiktaalik* fossil provides an evolutionary link, or transitional form, between fish and early hominids.

6. The study of fossils has helped scientists identify the migratory tendencies of *homo erectus* species.

7. What characteristics do paleontologists look for when they are trying to find a new place to discover fossils?

8. *Archaeopteryx* is a bird-like dinosaur that is thought to be the evolutionary link between non-avian feathered dinosaurs and modern birds.



(Wikipedia:H Raab; Jim, the photographer)

- a. Describe two characteristics that *Archaeopteryx* may have had and why these characteristics suggest that it may be the evolutionary link between non-avian feathered dinosaurs and modern birds.

- b. If an extremely well preserved example of *Archaeopteryx* was found, what other technique could you use to prove that *Archaeopteryx* is the missing link between non-avian feathered dinosaurs and modern birds?

9. List two pieces of evidence for evolution, and for each, briefly explain why they provide strong support for this theory.

Third Video:

Title: Genetics of Morphology

Speaker: Hopi Hoekstra



Questions for Part 3:

1. The deer mice that live on Santa Rosa beach have evolved a lighter colored coat than other populations of deer mice. Which of the following options may explain this observation? Choose all of the answers that apply.
 - a. Light coat color attracts predators.
 - b. Light coat color helps to attract a mate.
 - c. Light coat color provides better camouflage.
 - d. Light coat color is a result of diet.
 - e. None of the above.

2. Although deer mice living on the Atlantic and Gulf island evolved from different ancestors, they both evolved to have light coat color. This is an example of
 - a. Mimicry.
 - b. Speciation.
 - c. Convergent evolution.
 - d. All of the above.
 - e. None of the above.

3. An Amazonian butterfly looks like a poisonous species of spider. This is an example of
 - a. Mimicry.
 - b. Speciation.
 - c. Convergent evolution.
 - d. All of the above.
 - e. None of the above.

4. The beluga whale and the manatee are mammalian marine species that evolved the same general shape. This is an example of
 - a. Mimicry.
 - b. Speciation.
 - c. Convergent evolution.
 - d. All of the above.
 - e. None of the above.

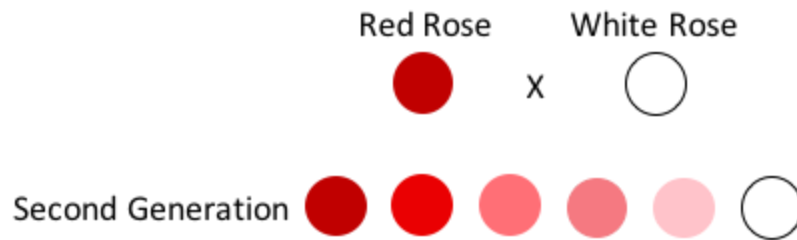
5. Divergent evolution is the accumulation of traits that lead to speciation. Which of the following options is an example of divergent evolution? Choose all of the answers that apply.
 - a. Wolf and domestic dog.
 - b. Shark and dolphin.
 - c. Bats and birds.
 - d. Different species of galapagos island finches.
 - e. Desert fox and arctic fox.

For questions 6-8, determine if the statement is true or false. If the statement is false, change one word or phrase to make it true.

6. The MC1R gene has been linked with coat color in different species of animals.

7. Whale flippers and human hands are an example of analogous evolution.

8. Distantly related organisms have similar embryological structures during late stages of development.
9. Alex is studying a rose species that lives in the south of Puerto Rico. She observes that this rose comes in 2 main colors; red and white. If she breeds a red plant with a white plant, she obtains the result shown below.



- a. Alex argues that this result shows that the flower color is determined by a handful of genes (more than 1, but less than 100). Propose an explanation that supports Alex's hypothesis. (Assume that the red rose and the white rose are homozygous.)
- b. Alex observes that the pollinator spends more time close to the red flower than the white flower. What consequences could this have in the evolutionary path of this flower.
10. For each of the examples listed below, indicate if the organisms evolved due to convergent evolution, or divergent evolution. Briefly explain your answer, and note that more than one answer may be correct.
- a. The Hawaiian silversword 'ohana plant evolved from one species and now comprises 28 different species occupying many different habitats and niches on the different islands. These plants all look very different from each other.

- b. Antifreeze proteins are found in both Arctic and Antarctic cod. These fish descended from different ancestors which lived in warmer waters.

Answers for Session 3:

Questions for Part 1 & Part 2:

1. Why is the fossil record not a complete catalogue of biological history?
 - a. **Not all organisms fossilize with equal probability.**
 - b. Fossilization destroys the structure of DNA.
 - c. The process of fossilization often destroys anatomical features of the organisms being preserved.
 - d. Fossils only preserve organisms for about 10 million years; older organisms are destroyed by geological processes.
 - e. Only animals, not plants, are fossilized

2. Which of the following characteristic(s) is/are important evolutionary features of the *Tiktaalik* fossil? Choose all of the answers that apply.
 - a. Brain.
 - b. **Scales.**
 - c. **Flat head.**
 - d. Lungs.
 - e. **Fins.**
 - f. None of the above.
 - g. All of the above.

3. The cetaceans (whales, dolphins and porpoises) are marine mammal descendants of land mammals. If you are studying a fossil that is a possible evolutionary link between early cetaceans and land mammals, which of the following characteristic(s) would you expect to find? Choose all of the answers that apply.
 - a. **Fins.**
 - b. Gills.
 - c. Wings.
 - d. Cartilaginous skeleton.
 - e. None of the above.

For questions 4 -6, determine if the statement is true or false. If the statement is false, change one word or phrase to make it true.

4. One of the most important features of the *Tiktaalik* fossil is the presence of the neck.

True.

5. The *Tiktaalik* fossil provides an evolutionary link, or transitional form, between fish and early hominids.

False; ~~hominids~~ tetrapods

6. The study of fossils has helped scientists identify the migratory tendencies of *homo erectus* species.

True.

7. What characteristics do paleontologists look for when they are trying to find a new place to discover fossils?

Rocks of the right age

Rocks of the right type

Rocks that are accessible (expose to the surface)

8. *Archaeopteryx* is a bird-like dinosaur that is thought to be the evolutionary link between non-avian feathered dinosaurs and modern birds.



(Wikipedia:H Raab; Jim, the photographer)

- a. Describe two characteristics that *Archaeopteryx* may have had and why these characteristics suggest that it may be the evolutionary link between non-avian feathered dinosaurs and modern birds.
- i. **Characteristics that resemble dinosaurs (e.g. sharp teeth, three fingers with claws on the wings, bony tail, etc)**
 - ii. **Characteristics that resemble modern birds (e.g. wings, flight feathers)**

- b. If an extremely well preserved example of *Archaeopteryx* was found, what other technique could you use to prove that *Archaeopteryx* is the missing link between non-avian feathered dinosaurs and modern birds?

You could compare the nuclear or mitochondrial DNA between *Archaeopteryx* and members of the non-avian feathered dinosaurs and modern birds species.

9. List two pieces of evidence for evolution, and for each, briefly explain why they provide strong support for this theory.

Five different possibilities for this answer

- a. **Fossils: Fossils are the remains of organisms that lived in the past. We can determine the age of the fossils using relative or absolute dating. These records document the evolutionary history of life on Earth and show transitions between ancestors and modern species.**
- b. **Comparative Anatomy: We can determine the evolutionary relationships of organisms by examining homologous structures (those that have different appearances and functions, but originally came from one common ancestor; for example the fin of a whale and the arm of a human), analogous structures (which are not the result of recent common ancestry, rather, they evolved due to convergent evolution; for example the fin of a whale and the fin of a fish), vestigial traits (those that came from a common ancestor but have reduced or lack of function; for example the wisdom teeth or tailbone).**
- c. **Biogeography: Closely related species are often located in areas that are geographical neighbors because the species may all have evolved from a common ancestor to fill different ecological niches (adaptive radiation).**
- d. **Artificial selection: This is similar to natural selection, but involves the intentional breeding of organisms that have a desired trait, rather than the environment acting on the organism.**
- e. **Molecular Biology: DNA sequences or protein structures are most similar in organisms that share a recent evolutionary history.**

Questions for Part 3:

1. The deer mice that live on Santa Rosa beach have evolved a lighter colored coat than other populations of deer mice. Which of the following options may explain this observation? Choose all of the answers that apply.
- a. Light coat color attracts predators.
- b. Light coat color helps to attract a mate.**
- c. Light coat color provides better camouflage.**
- d. Light coat color is a result of diet.
- e. None of the above.

2. Although deer mice living on the Atlantic and Gulf island evolved from different ancestors, they both evolved to have light coat color. This is an example of
 - a. Mimicry.
 - b. Speciation.
 - c. Convergent evolution.**
 - d. All of the above.
 - e. None of the above.

3. An Amazonian butterfly looks like a poisonous species of spider. This is an example of
 - a. Mimicry.**
 - b. Speciation.
 - c. Convergent evolution.
 - d. All of the above.
 - e. None of the above.

4. The beluga whale and the manatee are mammalian marine species that evolved the same general shape. This is an example of
 - a. Mimicry.
 - b. Speciation.
 - c. Convergent evolution.**
 - d. All of the above.
 - e. None of the above.

5. Divergent evolution is the accumulation of traits that lead to speciation. Which of the following options is an example of divergent evolution? Choose all of the answers that apply.
 - a. Wolf and domestic dog.**
 - b. Shark and dolphin.
 - c. Bats and birds.
 - d. Different species of galapagos island finches.**
 - e. Desert fox and arctic fox.**

For questions 6-8, determine if the statement is true or false. If the statement is false, change one word or phrase to make it true.

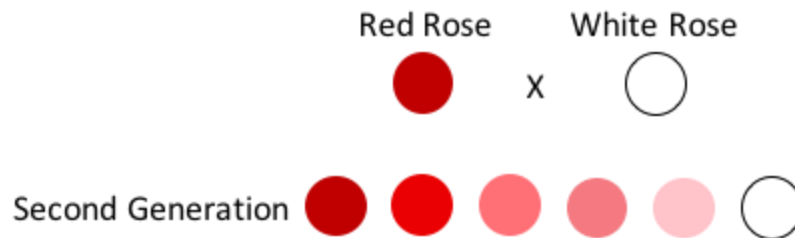
6. The MC1R gene has been linked with coat color in different species of animals.
True.

7. Whale flippers and human hands are an example of analogous evolution.
True.

8. Distantly related organisms have similar embryological structures during late stages of development.

False. Distantly closely

9. Alex is studying a rose species that lives in the south of Puerto Rico. She observes that this rose comes in 2 main colors; red and white. If she breeds a red plant with a white plant, she obtains the result shown below.



- a. Alex argues that this result shows that the flower color is determined by a handful of genes (more than 1, but less than 100). Propose an explanation that supports Alex's hypothesis. (Assume that the red rose and the white rose are homozygous.)

If the flower color was determined by only one gene, she would only observe white and red flowers in the second generation. If the flower color was determined by a lot of genes, the probability of getting a completely red flower and a completely white flower on the second generation is very low. Given that she is able to observe both, red and white flowers, she can hypothesize that the flower gene is determined by only a few genes.

- b. Alex observes that the pollinator spends more time close to the red flower than the white flower. What consequences could this have in the evolutionary path of this flower.

If the pollinator is attracted to the red flower more often, this could give the flowers with the red phenotype a reproductive advantage.

10. For each of the examples listed below, indicate if the organisms evolved due to convergent evolution, or divergent evolution. Briefly explain your answer, and note that more than one answer may be correct.

- a. The Hawaiian silversword 'ohana plant evolved from one species and now comprises 28 different species occupying many different habitats and niches on the different islands. These plants all look very different from each other.

Divergent evolution. The related organisms have different structures and functions based on their habitats.

- b. Antifreeze proteins are found in both Arctic and Antarctic cod. These fish descended from different ancestors which lived in warmer waters.

Convergent evolution. Antifreeze proteins perform a similar function in both fish which must survive in frigid water. However, the cod are not closely related to each other, so these adaptations evolved independently in response to similar environments.