

Session 2: Theory Behind Evolution II

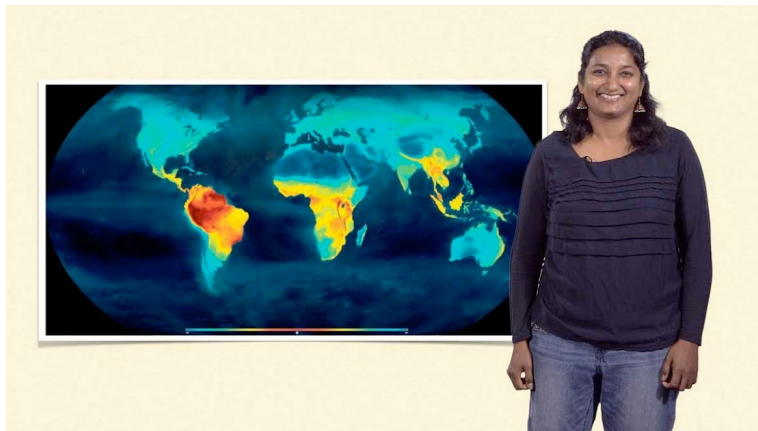
Overview:

This session continues our introduction to evolution. Dr. Ramakrishnan studies how species are distributed across regions. She expands on the concept of speciation and explains why islands and mountain ranges are often regions of increased biodiversity. Dr. Tishkoff investigates the migration of hominids out of Africa and the evolution of modern humans. She defines many key concepts in evolution including genetic drift, neutral evolution, founder effect, and more. She explains how mitochondrial DNA can be used to study relatedness of humans and other populations. Dr. Hadly finishes with a short, clear, explanation of a genetic bottleneck.

First video:

Title: Biogeography: Studying the Distribution of Species Across Space

Speaker: Uma Ramakrishnan



Questions for Part 1:

1. Darwin's theory of evolution suggests
 - a. species are fixed.
 - b. the Earth is 6,000 years old.
 - c. the environment creates favorable characteristics on demand.
 - d. the interaction of organisms with their environment is important in the evolutionary process.
 - e. None of the above.

2. For the following question, choose all of the answers that apply. For a region to have high levels of biodiversity, the region needs to have
 - a. High levels of speciation
 - b. High levels of natural selection.
 - c. Low levels of evolution.
 - d. High levels of evolution.
 - e. Low levels of speciation.
 - f. Low levels of extinction.

3. Which of the following regions is likely to contain the highest level of biodiversity?
 - a. An island in the tropics.
 - b. An island close to Alaska.
 - c. A temperate forest.
 - d. An island in the south of Argentina.
 - e. All of the above have the same level of biodiversity.

4. Which of the following is true? Natural selection
 - a. is more common in the tropics.
 - b. always leads to allopatric speciation.
 - c. is not required for evolution.
 - d. is the most common form of sympatric speciation.
 - e. None of the above.

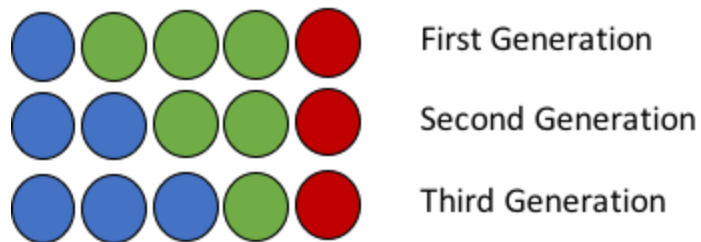
5. Allopatric speciation is
 - a. more likely to occur in small populations.
 - b. caused by a population becoming reproductively isolated in the midst of another population's range.
 - c. caused by a population being on the border of another population.
 - d. rarely a form of speciation.
 - e. due to sexual selection.

6. Sam finds two mice in the wild and she is wondering if these mice belong to the same species. Provide two observations or methods that could help Sam determine if these two mice are the same or different species.

For questions 7-8, determine if the statement is true or false. If the statement is false, change one word to make it true.

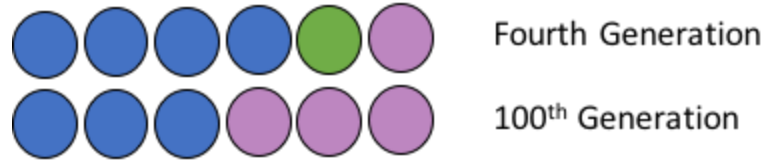
7. Biogeography is the study of the different species in a region.

8. If sympatric speciation increases, the biodiversity in a region will increase.
9. Shannon is studying the biodiversity between adjacent mountains in Puerto Rico. She observes the same species of birds in both mountains, but different species of frogs.
- Provide a hypothesis that explains this observation.
 - Shannon carefully observes two set of birds, one that prefers to live on the top of the mountain and the other one prefers to live near the bottom of the mountain. She discovers that the bird that lives on the top of the mountain is better adapted for high altitudes. Which type of speciation is this?
10. The following diagram represents the evolution of an allele in a species of squirrels that allows them to digest food.



- Using evolutionary terms, explain what could be happening to the green allele.

- b. The red allele mutates into pink, which allow squirres to digest a plant that lives in this ecosystem. The following diagram represents the distribution of the digestive alleles in these squirrels.



If squirrels with the blue and pink alleles are now two different species, is this more likely an example of sympatric or allopatric speciation? Briefly explain.

Second Video:

Title: African Genomics: Human Evolution

Speaker: Sarah Tishkoff

Key Challenges in Human Genomics Research



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



Third video:

Title: Loss of biodiversity in a human-dominated world

Speaker: Elizabeth Hadly



Questions for Part 2 & 3:

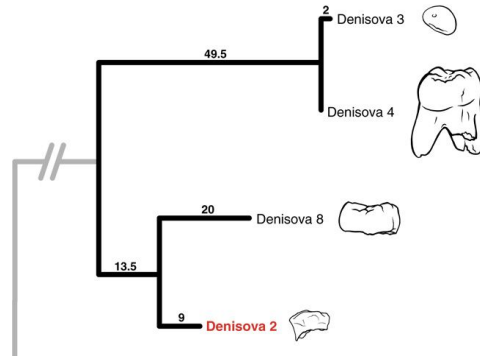
1. Which of the following characteristics did Lucy, the *Australopithecus afarensis* fossil, have that made her a member of the hominin lineage? Choose all of the answers that apply.
 - a. She was bipedal.
 - b. She had a brain.
 - c. She was about 3 foot tall.
 - d. She lived around 3.2 million years ago.
 - e. She was skinny.
2. Choose all of the answers that apply. A drought kills 90% of all species of avocado plants. The surviving plants are an example of:
 - a. Allopatric speciation.
 - b. Sympatric Speciation.
 - c. Neutral evolution.
 - d. Speciation.
 - e. Genetic drift.
3. Choose all of the answers that apply. A flock of birds colonizes an island. This is an example of:
 - a. Neutral evolution.
 - b. Founder effect.
 - c. Genetic drift.
 - d. Neutral evolution.
 - e. Sympatric Speciation.

4. Choose all of the answers that apply. By analyzing the mitochondrial DNA of different species, there is evidence of low levels of gene flow between the homo sapiens and
 - a. Neanderthals
 - b. Chimpanzee
 - c. Gorrillas
 - d. Denisovans
 - e. None of the above.

For questions 5-7, determine if the statement is true or false. If the statement is false, change one word to make it true.

5. According to mitochondrial DNA analyses, modern human's common ancestor comes from Africa.
6. The allele frequency of a small population homogenises at a fast rate.
7. F_{ST} estimates the genetic variation among populations. An F_{ST} of zero implies that there is no overlap in the allele frequency between population A and population B at a specific gene locus.
8. List and briefly describe two strategies that animals have evolved to avoid predation.
9. Compare and contrast the nuclear and the mitochondrial DNA.

10. Analyses of DNA residues from a tooth fossil have allowed scientists to identify a fourth individual of the Denisovans, a sister group of Neanderthals (Viviane Slon, et al. *Sci Adv.* 2017, 3(7):e1700186). Denisovans are thought to have populated Asia, and scientists estimate that their population split from Neanderthals 190 to 470 thousand years ago. Shown below is the phylogenetic tree relating denisovan individuals.



- a. What analysis did scientists performed to classify these fossils as members of the Denisovan species?

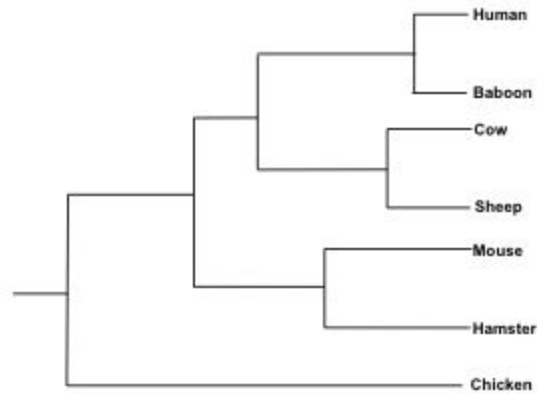
- b. After analysing the nuclear DNA of Denisovan individuals, you discovered very low genetic variation. What could you conclude from this result? Briefly explain.

- c. The DNA of modern humans diverged more from Denisovans than Neanderthals. If these species share a common ancestor, draw a phylogenetic tree that shows the relationship between modern humans, denisovans and neanderthals.

11. Scientists have identified traces of Neanderthal DNA in non-African modern human individuals. Propose an explanation for this observation. Why we do not see traces of Neanderthal DNA in African individuals?

12. Describe three processes that affect the allele frequencies of small populations. What effect does each process have on a population?

13. Shown below is a phylogeny of vertebrates.



Which organisms are more closely related: Hamsters and Sheep, or Cow and Baboons? Briefly explain.

Answers for Session 2:

1. Darwin's theory of evolution suggests
 - a. species are fixed.
 - b. the Earth is 6,000 years old.
 - c. the environment creates favorable characteristics on demand.
 - d. **the interaction of organisms with their environment is important in the evolutionary process.**
 - e. None of the above.

2. For the following question, choose all of the answers that apply. For a region to have high levels of biodiversity, the region needs to have
 - a. **High levels of speciation**
 - b. High levels of natural selection.
 - c. Low levels of evolution.
 - d. High levels of evolution.
 - e. Low levels of speciation.
 - f. **Low levels of extinction.**

3. Which of the following regions is likely to contain the highest level of biodiversity?
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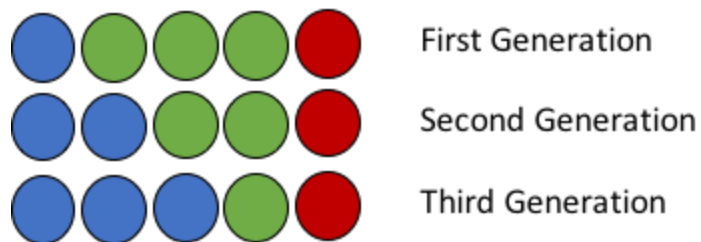
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 - b. always leads to allopatric speciation.
 - c. is not required for evolution.
 - d. is the most common form of sympatric speciation.
 - e. **None of the above.**

5. Allopatric speciation is
 - a. **more likely to occur in small populations.**
 - b. caused by a population becoming reproductively isolated in the midst of another population's range.
 - c. caused by a population being on the border of another population.
 - d. rarely a form of speciation.
 - e. due to sexual selection.

6. Sam finds two mice in the wild and she is wondering if these mice belong to the same species. Provide two observations or methods that could help Sam determine if these two mice are the same or different species.
 - a. **If the mice don't breed in the wild.**
 - b. **Substantial differences in their DNA sequences.**

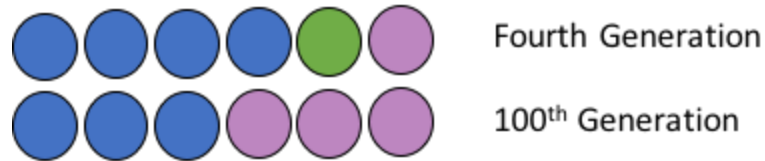
For questions 7-8, determine if the statement is true or false. If the statement is false, change one word to make it true.

7. Biogeography is the study of the different species in a region.
True.
8. If sympatric speciation increases, the biodiversity in a region will increase.
False; will could
9. Shannon is studying the biodiversity between adjacent mountains in Puerto Rico. She observes the same species of birds in both mountains, but different species of frogs.
 - a. Provide a hypothesis that explains this observation.
Birds probably fly between mountains, and therefore populations were not isolated and speciation did not occur. Frogs are less mobile, and therefore physical isolation over time allowed for allopatric speciation to occur.
 - b. Shannon carefully observes two set of birds, one that prefers to live on the top of the mountain and the other one prefers to live near the bottom of the mountain. She discovers that the bird that lives on the top of the mountain is better adapted for high altitudes. Which type of speciation is this?
Sympatric speciation.
10. The following diagram represents the evolution of an allele in a species of squirrels that allows them to digest food.



- a. Using evolutionary terms, explain what could be happening to the green allele.
In this ecosystem there is a negative selective pressure against the green allele that decreases fitness or reproductive success of individuals with the green allele.

- b. The red allele mutates into pink, which allow squirrels to digest a plant that lives in this ecosystem. The following diagram represents the distribution of the digestive alleles in these squirrels.



If squirrels with the blue and pink alleles are now two different species, is this more likely an example of sympatric or allopatric speciation? Briefly explain.

Likely sympatric speciation. For example, if the plant that the pink squirrels can digest is in a different region of the forest from the plants that the blue squirrels eat, only pink squirrels will be attracted to this region. Over time, pink squirrels are more likely to encounter and mate with other pink squirrels resulting in the evolution of two separate species.

Questions for Part 2 & 3:

1. Which of the following characteristics did Lucy, the *Australopithecus afarensis* fossil, have that made her a member of the hominin lineage? Choose all of the answers that apply.
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 - c. Neutral evolution.
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 - e. **Genetic drift.**

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 - b. Founder effect.**
 - c. Genetic drift.**
 - d. Neutral evolution.
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4. Choose all of the answers that apply. By analyzing the mitochondrial DNA of different species, there is evidence of low levels of gene flow between the homo sapiens and
- a. Neanderthals**
 - b. Chimpanzee
 - c. Gorillas
 - d. Denisovans**
 - e. None of the above.

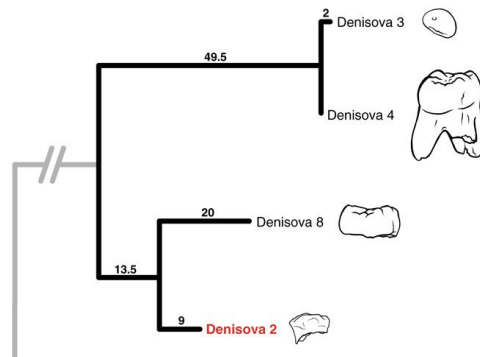
For questions 5-7, determine if the statement is true or false. If the statement is false, change one word to make it true.

5. According to mitochondrial DNA analyses, modern human's common ancestor comes from Africa.
True
6. The allele frequency of a small population homogenises at a fast rate.
True
7. F_{ST} estimates the genetic variation among populations. An F_{ST} of zero implies that there is no overlap in the allele frequency between population A and population B at a specific gene locus.
False; Zero One OR not 100%
8. List and briefly describe two strategies that animals have evolved to avoid predation.
There are several possibilities, including mimicry (avoiding predation by having a phenotype similar to another organism that is dangerous/ toxic to predators), development of secondary toxic compounds that could injure or kill a predator, and crypsis (having a phenotype that allows for camouflage against one's background).

9. Compare and contrast the nuclear and the mitochondrial DNA.

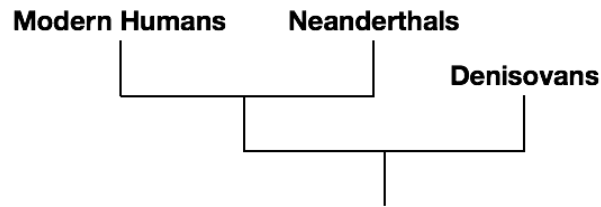
	Nuclear DNA	Mitochondrial DNA
Localization	Nucleus	Mitochondria
Shape	Linear	Circular
Inheritance	Inherited from both parents	Maternally inherited
	Extensive recombination	No Recombination

10. Analyses of DNA residues from a tooth fossil have allowed scientists to identify a fourth individual of the Denisovans, a sister group of Neanderthals ([Viviane Slon, et al. *Sci Adv.* 2017, 3\(7\):e1700186](#)). Denisovans are thought to have populated Asia, and scientists estimate that their population split from Neanderthals 190 to 470 thousand years ago. Shown below is the phylogenetic tree relating denisovan individuals.



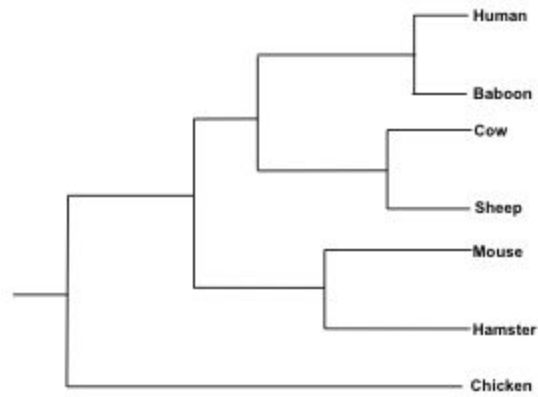
- What analysis did scientists performed to classify these fossils as members of the Denisovan species?
Scientists probably compared the mitochondrial DNA between members of the denisovan species as well as other hominid species.
- After analysing the nuclear DNA of Denisovan individuals, you discovered very low genetic variation. What could you conclude from this result? Briefly explain.
Nuclear DNA allows scientists to study diversity among species and member of the same species. Low genetic variation implies that the Denisovan species was very homogenous, and provides evidence of a possible bottleneck event.

- c. The DNA of modern humans diverged more from Denisovans than Neanderthals. If these species share a common ancestor, draw a phylogenetic tree that shows the relationship between modern humans, denisovans and neanderthals.



11. Scientists have identified traces of Neanderthal DNA in non-African modern human individuals. Propose an explanation for this observation. Why do we not see traces of Neanderthal DNA in African individuals?
Non-African individuals overlapped in time and space with Neanderthals, allowing for low levels of gene flow to occur. This is not observed in African lineages because Non-African lineages diverged from African lineages before this event happened.
12. Describe three processes that affect the allele frequencies of small populations. What effect does each process have on a population?
- Random genetic drift is the change in allele frequencies resulting from chance alone. Random genetic drift causes change in allele frequencies and loss of genetic variation because some alleles are lost as other alleles become fixed.**
 - Founder effect occurs when the population is founded by a small number of individuals. The frequency of alleles is limited due to the fact that the founders carry a small percentage of the overall genetic diversity in the source population.**
 - Bottleneck effect occurs when the population undergoes a drastic reduction in population size. In this situation, alleles will be lost and the surviving population will be more homogeneous.**

13. Shown below is a phylogeny of vertebrates.



Which organisms are more closely related: Hamsters and Sheep, or Cow and Baboons?
Briefly explain.

Cow and Baboons are more closely related. This is because they share a common ancestor more recently than Hamsters and Sheep.