Slide Notes: The Evolution of the Human Pelvis

Slide 1

- **Evolution** describes the process of an accumulation of heritable traits in organisms through time, leading to the development of new species; in other words, evolution is **descent withmodification**.
- Organisms may be born with traits that make them better able to survive in their environment.If they are better able to survive, they are more likely to reproduce and have offspring with those heritable traits. Over long periods of time, these traits, which are under what we call **natural selection**, will become widespread in populations. Over even more time, this descent with modification leads to changes within populations, and this is what we call **evolution.**
- **Phylogenetic trees,** like this very detailed one, are excellent tools to help us visualize the evolutionary relationships of different types of organisms by demonstrating how these groupsevolved from **common ancestors**.

Slide 2

- Here's a much more simplified version of the tree from the last slide.
- This is also a **phylogenetic tree.** It depicts evolutionary relationships (or **phylogenies**) betweengroups of organisms. It also represents time. The further left we go, the older we get.
- The points where these lines branch are called **nodes**. After a node, these lines represent different evolutionary pathways, and result in very different groups of organisms.
- The pattern of branching shows us how groups of organisms evolved from a **common ancestor.**
  The red dots represent the common ancestors (or the nodes)
- A common ancestor and ALL of its descendants form a group called a **clade**. Normally, a trait already existing in a common ancestor is modified through evolution. Allof the descendants share this trait, but they look different because of these modifications. Thisis called a **homologous structure**. For example, everyone in the blue clade has a pelvis, but it looks different between all these species.
- Clades can be different sizes, so long as they include the commonancestor and ALL descendants.
- We can use things like DNA to help us figure out where groups of organisms can go on

this tree.

- We also know that there are organisms that should fall along the lines of these trees, like extinct organisms. We can use fossil evidence and similarities or differences between structures to helpus fill in the gaps.

Slide 3

- Groups that share a more recent common ancestor are more related. This usually, but notalways, means that we share more traits.
- Groups that share a more distant common ancestor, or a less recent common ancestor, are lessrelated and will share fewer traits.
- So, groups of organisms that share a common ancestor more recently, for example, monkeys and apes, will share more traits. Monkeys and apes are pretty similar toeach other because we share a more recent common ancestor. We share traits such as a large brain or long life spans. Our homologous structures often look more similar.
- We share fewer traits with fish, because our common ancestor was along time ago and we've been evolving in different directions for a long time. Our homologous structures look very different
- It's important to remember that we're not MORE evolved than fish. We've just been evolving indifferent directions.

Slide 4

- Another thing to note is that phylogenetic trees can look different but still say the same thing
- All of these trees represent the same evolutionary relationships.
- So long as the nodes (common ancestors) and branches (lineages) are the same, the trees aresaying the same thing.
- That means branches can swap places, but the clades remain the same.
- These three trees are equivalent, even though they look different.
- The common ancestor of mammals is maintained, and the branches show the same evolutionary pathways. The clades are the same.

Slide 5

- So let's test your knowledge of phylogenetic trees.
- Who is the most recent common ancestor of amphibians and apes? A, B, or C?

Slide 6

- Who is the most recent common ancestor of amphibians and rodents? A, B, or C?

Slide 7

- Are apes more closely related to rodents or monkeys?

Slide 8

- Are fish more closely related to amphibians or apes?

Slide 9

- Are reptiles more closely related to amphibians or insects?

Slide 10

- Ok let's move on to a specific part of the phylogenetic tree. The primate phylogenetic tree.
- This is Certainly not all of the phylogenetic tree.
- We share a **common ancestor** with chimpanzees at about 7-13 million years ago
- While we don't know exactly what this common ancestor looked like, we do know that it didn'tlook exactly like modern chimpanzees or modern humans.
- Between the time period of that common ancestor and now, organisms used different traits to adapt to changing environments. Perhaps walking on two legs, called **bipedalism**, was beneficialin an environment that was changing from being densely forested to one with open grasslands, because it freed up the hands or allowed for a wider territory. Traits that help with bipedalism, like a differently shaped pelvis or stiffer feet, would have been under natural selection. These homologous structures were modified.
- Other groups of organisms, perhaps those in the evolutionary lineage of chimpanzees, usedother traits to **adapt to their environment**.
- We don't necessarily know the stages between a common ancestor and now, but we have touse **fossil evidence** to help fill in the gaps.
- When we find **fossil evidence**, we can infer where on these phylogenetic trees they should go,even without DNA evidence that may not be available in older fossils.
- We look at differences and similarities between structures to figure out where these newspecies should go.

Slide 11

- One type of fossil that is incredibly informative is the **pelvis**. The pelvis looks similar across species since it is a homologous structure. It is composed of the same parts. The more closelytwo groups are, chances are the more closely their pelves appear. So the pelvis of a human isgoing to look more similar to that of a monkey than that of a fish.

- The pelvis is an important structure in the modern human
- It is a point of connection between **axial skeleton** (head and trunk) and the **appendicularskeleton** (limbs).
- It aids in weight bearing and weight transfer during locomotion.
- The pelvis physically supports the internal organs of the abdomen.
- Finally, it serves as a passage during childbirth.
- The anatomy of the pelvis reflects these different responsibilities. That means we can tell a lot about an individual just by looking at their pelvis.
- Not just modern humans, either. We can look at the pelvis of an organism and make informeddecisions about lots of things, like how this individual moved around, **since form can reflect function.**

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This is a human pelvis.

- The pelvis is composed of three bones, the **sacrum**, which is an extension of the vertebralcolumn, and a right and left os coxae.
- An important part of the pelvis is the **ilium**. This is what you feel when you put your hands onyour hip.

Slide 13

- If we were to go back to that primate phylogenetic tree, all of these primates have a pelvis thatlook pretty similar. But most of those primates use a different form of locomotion, and that is reflected in the pelvis.
- We can use concepts of **biomechanics** when we look at a pelvis to decide how that individualmoved.
- We'll talk about two types of **locomotion** here that are common in primates, but there areplenty more. This is a simplification.
- **Quadrupedalism** is when an animal walks on four limbs. There are different types ofquadrupedalism.
- We already mentioned **bipedalism**, or walking on two limbs. That's our mode of locomotion. Our ancestors, called hominins, were bipedal too. But we share a

common ancestor with otherprimates, and this common ancestor may have been quadrupedal.

- Bipedalism was an adaptation to changing environments. So, certain aspects of the pelvis had tochange over time to allow for bipedalism
- The hips of hominins are much shorter than that of quadrupeds. This shortening leads to a shorter torso and allows for the **center of mass** of the body to sit overour feet when we're standing up. This makes balancing on two legs much easier. It requires much less work from our hip muscles to keep us from tipping forward.
- If a quadruped, like this chimp. were to stand on two feet, their long hips would place theircenter of mass in front of the feet, making the hip muscles have to work hard to keep the quadruped from tipping forward.
- The hips of modern humans are also turned sideways, so to speak. Now that the hips face outward, muscles that attach to the hip are on the side of thebody. These muscles keep us from tipping sideways when we walk on two legs.
- In quadrupeds, these muscles are on the back of the animal. They act to move the leg backward,which is not as important for walking on two legs as it is for walking on four.
- This is because the hips are facing backwards, like in the bonobo, or mostly backwards for othermammals

*Note: Sometimes the iliac orientation is obvious, like in knuckle walkers (a type of quadrupedalism in some apes). Gorillas, for example, have ilia that face backwards. For other quadrupeds, it may not be soobvious. For example, in dogs, the ilia appear to face sideways, but the orientation of the ilia relative to the **femur** still allows for these muscles to be on the back of the pelvis for hip extension.*

Slide 14

- Here we can see the pelvis in articulation with the rest of the skeleton in a **biped** and a **quadruped** (knuckle walking gorilla).
- We can see that shorter pelvis in the human. This brings the center of mass (purple line) over the feet. If the hip was longer, like in aquadruped, it would shift that center of mass forward.
- The orientation of the hip in humans is **lateral** (to the side). This places certain important hip muscles on the side of the body to helpfrom tipping sideways when we walk.
- On quadrupeds, these muscles are on the back of the body, helping to extend the leg (move theleg backwards), which we don't need so much when we're walking on two

legs.

Note: There's more! But we won't talk about it now.

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- These types of evolutionary changes in the hip make it easy for scientists to determine a mode of locomotion when they find a fossil pelvis. This helps us decide where on the phylogenetic treeit should go.
- Other measurements of the pelvis can also help scientists to make educated guesses aboutthings such as age, height, and weight.
- Refer to this image for help if you need it.

Slide 16

- You're a world-renowned paleoanthropologist who has been flown overseas to help identifyorganisms at an excavation site. They have discovered several pelves from different time periods.
- They all look slightly similar since the pelvis is a **homologous structure**- an anatomical trait that looks similar across multiple species due to **shared ancestry**. You realize that populations of organisms that are more closely related will likely look similar because they share a more recent **common ancestor**. You also realize that knowing certain things about the organisms, likemode of locomotion, might help you identify the species.
- Your job is to figure out the mode of locomotion for these species. Use that knowledge, as wellas the general structure of the pelvis, to sort these organisms into a **phylogenetic tree**.
- Answer the following questions by examining these pelves from MorphoSource.

Slide Notes: Extended

Activity

Slide 1

- The pelvis can be a really important fossil find because it can tell us so much about an organism.We discussed how it can tell us about mode of locomotion, but it can also tell us the sex of an individual.
- *Note: "Male" and "female" here refer to individuals with anatomy commonly assigned to maleand female, respectively. Methods of determining sex are generally inconclusive for intersex individuals, and these methods can make no determination of gender.*
- The human pelvis shows a fair amount of **sexual dimorphism**, which is a difference in size orappearance between males and females.
- This is mainly due to the fact that the child-bearing pelvis in a female must be more spacious toallow for the passage a baby.
- Knowing the sex of an individual is incredibly important for human paleontologists. Since females give birth, knowing if the pelvis belongs to a female will allow scientists to infer other traits, such as how large a baby's head could have been. This, in turn, can help us to decide howbig of a brain the infants of the species had.
- Knowing the sex can also help scientists decide other traits, like height, age, or weight. These can give us clues about life history (how long they lived), or what types of activities they mayhave been engaging in.
- Being able to identify the sex of skeletal remains is also really helpful if you're a forensicanthropologist and you're trying to identify the remains.
- Refer to this image for help if you need it.

Slide 2

- There are a lot of differences between the pelvis of a male and the pelvis of a female.
- Male pelves are more robust, meaning there is generally more bone.
- When viewed from above, the **pelvic inlet** (or the pelvic brim) isthis red dotted line. In males, the pelvic inlet is heart shaped (right) while in females, it is more oval shaped and wider (left). The whole pelvic canal in females is wider and more spacious.
- Because of the wider pelvis, the angle beneath the pubic symphysis, called the **subpubic angle** here in yellow, is wider in females.

Slide 3

- Finally, the **greater sciatic notch** (the wide notch on the ilium on either side of the sacrum) iswider in females than in males. But this is a spectrum.

Slide 4

- You've successfully identified the species in the assemblage. The team now asks you to figure out the sex of each hominin pelvis. The team will be able to use that information to figure out other important things about the organisms, like weight, height, or age.
- Answer the following question by examining these pelves from MorphoSource.