The Teacher Institute for Evolutionary Science (Ties)

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Evolution is AMAZING!!!!

• This guided lesson will take you through the basics of evolutionary biology.

• You will need to answer questions along the way on paper or on a Word/Google Document. Your teacher will let you know how he/she would like you to turn this in.

• All questions to be answered will be in red font.
So what is Evolution?

Evolution is a theory. The word “theory” is really misunderstood. Why?

Have you heard somebody say something like, “I have a theory that my dog is stealing my socks every morning”? People say things like that all of the time, and it’s ok. But that is not what scientists mean when they use the word theory.

Check out this video: Fact vs Theory vs Hypothesis vs Law

Start numbering your document.

#1. What is the difference between how we use the word “theory” in everyday language and what it means in science?

#2. As you watch the video, define the terms Fact, Hypothesis, Theory, and Law.
So now we know that theories are big explanations for something in nature.

What does evolution explain?

It explains two main things:

1. Evolution explains the vast diversity of living things we see on this planet. Scientists estimate there are 8.7 million living things on Earth!!!

2. Evolution explains that all of these living things descend from a common ancestor. We are all related.
Let’s take a look at this vast diversity and some examples of common ancestry.

Go to: The Evogeneao Website and click on the interactive tree of life on the right hand side of the page. The branches represent different living things. The branches that do not make it to the top of the semi-circle represent extinct species.

Click on any species (except humans). See what our most recent common ancestor with this species looked like and how long ago we shared this common ancestor.

• 3. Now click on Lungfish (in aqua blue under “Fish”) What does our most recent common ancestor with the lungfish look like?

• 4. Click reset, top right: Now click on any other living thing in the semi-circle. a. What living thing did you choose? b. What does our most recent common ancestor with this living thing look like? C. How long ago did we split?
Another amazing website to see the vast diversity of life and how we are all related is OneZoom

OneZoom can be a little overwhelming. They are trying to put all 8.7 million species of living things in one tree of life!!

Click on the OneZoom link and zoom all of the way out. You should see this the image on the left.

Keep clicking on the red ladybug to see how this amazing website works. Take your time, look around. Search for your favorite animal in the search box top right.

5. What is your favorite animal?
So how do we know that evolution explains life’s diversity and common ancestry?

What evidence do we have?

And, how did all of these living things change over time?

We need to look at two things:

1. The many types of evidence for Evolution.
2. The mechanism, or the way living things changed over time.
The many types of evidence for Evolution.

Believe it or not, Evolution is the scientific theory with the most evidence backing it up. Think about it, we can study the relatedness of millions of living things. There are many different types of evidence for Evolution.
Let’s start with the one we think about first. Fossils!

Watch this video: What is a fossil?

6. What is the definition of a fossil?

7. a. What is permineralization?
   b. What is more likely to become a fossil, a worm or a snail? Why?

Now watch this video. What's a fossil?

8. List the steps described in the formation of a dinosaur fossil.
Evidence for Evolution #2: Comparative Anatomy

Have a look at your arm. Starting at your shoulder, you have one long bone (humerus), two more long bones (radius and ulna), little round-ish bones in your wrist (carpals), little long bones in your hands (meta-carpals, and more little bits of bones that make up your fingers (phalanges).

Are you the only living thing with this arm or forelimb structure? Nope. Every tetrapod (animal with a backbone and 4 limbs) has this structure. What does that mean?
It means that this forelimb structure was present in the ancestor of all of these related creatures.

9. Compare the forelimbs of the 6 animals in this diagram. How are the structures similar?

10. Compare the forelimbs of the bat and the whale. How are the forelimbs different? (Use the correct names for the bones from the previous slide in your answer).

11. Why do you think the bat has such long phalanges?
How about embryos? Are they similar, too?

Look at these embryos. They are all out of order on purpose.

12. Try to put them in order,
Here’s a hint
Fish
Stage 1 is 8
Stage 2 is 1
Stage 3 is 14
Don’t worry, it’s really hard because they are so similar!
You won’t get marked wrong if you mess this one up.
Evidence for Evolution #3: Vestigial Structures

Check out this video on vestigial structures in humans:
Proof of evolution that you can find in your own body

13. Why do you get goose bumps sometimes?
Rocks are generally deposited horizontally. After one rock layer has been deposited, another is laid down on top of it.

Thus, the rocks on the bottom of the stack are the oldest, and the rocks on the top are the youngest. Once the rocks have been deposited they sometimes get moved around. They can be broken by faults, tilted into mountains, intruded by magma, or cut through by rivers and streams.

By looking at the rock layers and seeing in which order these processes occurred, we can determine how old the rocks are in relation to the rocks around them, as well as the general timing for things like fault ruptures and magmatic intrusion.

This law, proposed by Nicolaus Steno in 1669, is called the Law of Superposition.

This video should help you understand: The Law of Superposition

14. The teacher in the video used a school locker to explain the Law of Superposition. Can you think of another example to explain it?
Give these two examples a try.

15. Study the diagram to the left. Who stole the cookie?
16. Answer the question under the diagram on the right.

From: Who Dunit? and the Law of Superposition
Lisa Wald, U.S. Geological Survey
So how does the Law of Superposition provide Evidence for Evolution?

Because after thousands and thousands of fossil digs and geological studies over hundreds of years, nobody has ever found a fossil out of place.

Look at the diagram to the right.

As you go from older rock to newer rock, you take a tour of how life evolved and got more and more complex.
Evidence for Evolution #5: Artificial Selection

Have you ever seen wild corn? Wild broccoli? How about wild poodles running around the African savannah? No? Why not?

Because just like nature can change living things over time, so can we. It’s called Artificial Selection.

Try one of the games on this website: Artificial Selection and Selective Breeding

17. Name and describe the game you tried. Did you win? What did you have to do to win the game?
Genetics is the study of heredity. Cells contain DNA and DNA is passed on from parent to offspring. As you may have learned in class, DNA contains the instructions for an organism. The more DNA you share in common with another living thing, the more related you are.

How close is the DNA of a human and that of a chimpanzee? Check it out:

Richard Dawkins compares the human and chimpanzee genomes
The DNA in each cell guides the making of proteins, which are made up of amino acids. Scientists can compare DNA or amino acids, to see how related two species are to each other.

In this activity, Comparative DNA, you will be comparing the amino acid sequences of 6 different organisms and the DNA sequences of 9 different organisms.

Use the graph on the next slide to answer questions 18-20.
18. According to the graph, what species are humans furthest related to? How many amino acids differ between humans and this species?
19. As the difference in amino acid number increases, what happens to the genetic relatedness of the two species.
20. With which animal on the graph are humans most closely related? What evidence did you use for this claim?
The graph shows the number of amino acids that differ from a human hemoglobin polypeptide across various species. The species include:

- Human
- Rhesus monkey
- Mouse
- Chicken
- Frog
- Lamprey

The number of amino acid differences decreases as we move from human to lamprey, illustrating evolutionary relationships and divergence.
Use the DNA sequences to answer the following questions. Count the number of differences in nucleotides (letters) between each species. The fewer the differences, the more closely related they are:

<table>
<thead>
<tr>
<th>Animal</th>
<th>Sequence A</th>
<th>Sequence B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>TCGAGCTCTGGCGCGCGCCTCTCTGAGCTCGCGCAG</td>
<td>GAGATCCCATCTCCAGTTCCTCCGGGCAGACCTCTT</td>
</tr>
<tr>
<td>Rhesus monkey</td>
<td>TCGAGCTCTCCCGCGTCGCGGCTCCTCCTCCGAGCGG</td>
<td>GGGATCCCATCCGGTTCCTCCCGGAGACATCT</td>
</tr>
<tr>
<td>Mouse</td>
<td>TCGAGCTCTCCCGCGGTCTGAGCCGTCGCTCCGAG</td>
<td>TTGGTTCCTCCCGGAGACATCT</td>
</tr>
<tr>
<td>Dog</td>
<td>TCGAGCTCTCCCGCGGTCTGAGCCGTCGCTCCGAG</td>
<td>TTGGTTCCTCCCGGAGACATCT</td>
</tr>
<tr>
<td>Horse</td>
<td>TCGAGCTCTCCCGCGGTCTGAGCCGTCGCTCCGAG</td>
<td>TTGGTTCCTCCCGGAGACATCT</td>
</tr>
<tr>
<td>Opossum</td>
<td>TCGAGCTCTCCCGCGGTCTGAGCCGTCGCTCCGAG</td>
<td>TTGGTTCCTCCCGGAGACATCT</td>
</tr>
<tr>
<td>Platypus</td>
<td>TCGAGCTCTCCCGCGGTCTGAGCCGTCGCTCCGAG</td>
<td>TTGGTTCCTCCCGGAGACATCT</td>
</tr>
<tr>
<td>Chicken</td>
<td>TCGAGCTCTCCCGCGGTCTGAGCCGTCGCTCCGAG</td>
<td>TTGGTTCCTCCCGGAGACATCT</td>
</tr>
<tr>
<td>Frog</td>
<td>TCGAGCTCTCCCGCGGTCTGAGCCGTCGCTCCGAG</td>
<td>TTGGTTCCTCCCGGAGACATCT</td>
</tr>
</tbody>
</table>

21. Which animal is most closely related to the human? How many differences in DNA are there?
22. Which animal is least closely related to the human? Explain.
Before we move on, let’s look at the evidence for evolution one more time.

Click here: Evidence for Evolution
So how do we know that evolution explains life’s diversity and common ancestry?

What evidence do we have?

And, how did all of these living things change over time?

We need to look at two things:

1. The many types of evidence for Evolution.
2. The mechanism, or the way living things changed over time.

We covered some of the evidence for evolution. Now let’s look at #2, the mechanism for how living things changed over time.
The primary mechanism for Evolution is **Natural Selection**

Let’s start with a simple, easy explanation here: **Introducing Lithipodius nulla!!**

Answer the following questions as you watch the video:

Here is a

**Time stamp 0:23**
26. What similar traits do the members of the species have?
27. What different traits do the members of the species have?

**Time Stamp 0:46**
28. Which members of the species are more vulnerable to the predator?
29. Which members of the species are more likely to survive?
30. Can you predict what the population will look like over time?

**Time Stamp 1:33**
31. Can you describe natural selection?
32. What is adaptation?
33. a. What will happen to the green individuals in this sandy environment? b. What if the environment changes and gets greener?

**Time stamp 1:49**
34. How does variation play a role in the survival of the species?
The primary mechanism for Evolution is **Natural Selection**

Now let’s dig deeper. Watch this video: Amoeba Sisters: Natural Selection

Download, print, and complete the handout for this video here:

[Amoeba Sisters Natural Selection Video Companion](#)
Let’s jump on the TIES Time Machine!! Click [here](#) to learn more about natural selection and play the game.
This video is just super cool, you can watch it without answering any questions.

The Evolution of Bacteria on a Mega-Plate Petri Dish

This shows antibiotic resistance as described in the last video in a stunning fashion.
Your friend has a dog with fleas. She goes to the pet store and buys over-the-counter flea medicine. It does not work. So she goes to the veterinarian and explains that she just spent $80 on medicine that does not work. The vet casually says, “Oh yeah, that medicine does not work anymore.” Because you now understand natural selection, your friend asks you questions. Answer them with evidence.

32. What caused the fleas to become resistant to the medicine?
33. Do all of the fleas become resistant right away?
34. What do the resistant fleas do that the sensitive fleas do not?
So now, you know a lot more about Evolution!

Do you know who discovered this amazing process?

The concepts of common descent and natural selection were first proposed by Charles Darwin in his famous book, *The Origin of Species* in 1859.

You can learn more about him here: [Who was Charles Darwin](#)

32. Darwin was buried in Westminster Abbey next to Sir Isaac Newton. Describe the significance of this honor.
This slide and the next one are just for fun.
Do you love dogs??
The creator of this unit does!!!!

There is an amazing NOVA special called Dogs Decoded. I recommend the whole thing but you can see an amazing example of artificial selection (one of the types of evidence for Evolution, remember?) stating at time stamp: 35:18. In Siberia, researchers have basically turned foxes into dogs.

Check it out here by scrolling to that time stamp: Scroll to Time Stamp 35:18
We can see our evolutionary history all around us, and also, in our bodies.

You probably have never heard of the recurrent laryngeal nerve but the path it takes from your brain to your throat is pretty weird! This can only be explained in light of evolution.

Check it out: [The Dissection of the Recurrent Laryngeal Nerve in a Giraffe](#)

Warning: This video is graphic and contains images of a dead giraffe being dissected.