Title: "Evidence of Evolution Homologous Structures"

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Abstract:
This lesson plan uses the products of the oVERT project, at the University of Florida, in order to make the Evidence of Evolution section of the Middle School Scope and Sequence both more hands on, and more attractive to students of the technological age. Specifically, it uses the CT (Computed Tomography) scans of vertebrate forelimbs, both as 3D models and as shapefiles, to enhance and illustrate the concepts of homologous structures, and the evolution of anatomical structures as a function of their use (i.e. locomotion, grasping, and burrowing).

Subject, Grade Level:
This lesson is appropriate for middle school science students. It could be used in Integrated Science, Biology, or Environmental Science. It was planned for an advanced/gifted level class with access to a class set of chromebooks, but it could also be used for regular 7th grade classes.

Learning objectives:
By the end of this activity, students will be able to:

1. Recognize that fossil evidence is consistent with the scientific theory of evolution that living things evolved from earlier species.
2. Recognize and explain the ways in which genetic variation and environmental factors contribute to evolution by natural selection and diversity of organisms.

Science Standards:
The Florida Middle School Science Standards used in this lesson are;
SC.7.L.15.1 and SC.7.L.15.2.

Timeframe:
100 mins estimated class time (two 50-minute class periods)

Day 1: Lesson using the worksheet
Day 2: Completing the digital work (Creating you own shapefiles to print specific models, or printing models to create the puzzles will take more time.)

You will want to practice with the software so that you can assist the students in loading the files, and using the measuring tools. I would estimate that you will need a couple of hours of practice before your first use depending on your comfort with technology.

List of materials:

- If you want to use existing forelimb shape files from sketchfab.com, you should download them ahead of time so that they can be sent or saved to the student computers. The shape files have already been post processed so all you need to do is download them.
- If you want to create your own shape files, you will need to download the meshes you want from www.MorphoSource.org. Some of the meshes require permission to download so start early if this is what you want to do.
- Currently, you have to enter the scientific name of the animal scan you are seeking, but a keyword search will be added in the future. Meshes will have to be post processed in MeshLab in order to create the shape file.
- Your class computers will also have to have the 3DView app (for chromebook users), or the MeshLab software (for windows computers, available at MeshLab.net) downloaded to your devices, unless you wish to use the online version of MeshLab which can be found at https://www.rollapp.com › Apps › Graphics.
- Both MeshLab and Sketchfab have the ability to manipulate the models, as well as tools to measure length, width, and thickness of the bones. Meshlab also has the ability to turn specific layers of the file on and off, so that you can use them separately to highlight a specific feature.
- Students will need a notebook, crayons or colored pencils, a laptop or chromebook, and a pencil.

Procedure and general instructions (for instructor):

- Whichever software you decide to use, you will want to practice before the class so that you can tell the students how to load the files, measure the bones, etc. New images are being scanned daily so you may want to do some data mining to see what new items are available.
- Finished shape files can be loaded into 3DView or MeshLab. The mesh files will require post processing in MeshLab in order to create the 3D models for printing and analysis. The models can be printed and then dyed or painted if you wish to highlight a specific feature or features.
- Individual sections of models can also been printed and then have small magnets inserted so that the models can be used like puzzles in the classroom. This is labor intensive and time consuming, but it does create an amazing learning tool. The small magnets can be purchased from Amazon.com.
- 3DView has a user manual included in the software. It is available in the dropdown menu under the Help button. Meshlab also has a tutorial available. It is located …
- Step by step instructions for the digital work will be added later.
- There is an accompanying Slide presentation with an introduction to the concepts, relevant vocabulary terms, and student instructions. There is also a worksheet so the students can color code the homologous structures. I let my students decide what colors to use for the bones, but you may want to stipulate the color for each bone. (see attachments, appear after the procedures for students)

Procedure and general instructions (for students):

- Students will need a notebook, crayons or colored pencils, a laptop or chromebook, and a pencil. They should watch the Slide presentation and write the definitions for homologous structures and analogous structures in their notebook, while they are on the screen.
- Students are then instructed to go online and launch the 3DView app. Once the app has loaded, click on file, then load, which will take you to your folder. Double click on limb comparison and give it time to load. It should come up in 3D view, where you can rotate it and see it from all sides.
- After they have examined the models and pictures, they are to color code the homologous structures on the worksheet. They will also need to make a key that shows which color they used for each type of bone.

Slide Presentation:

Slide 1:

Evidence of Evolution

Homologous Structures

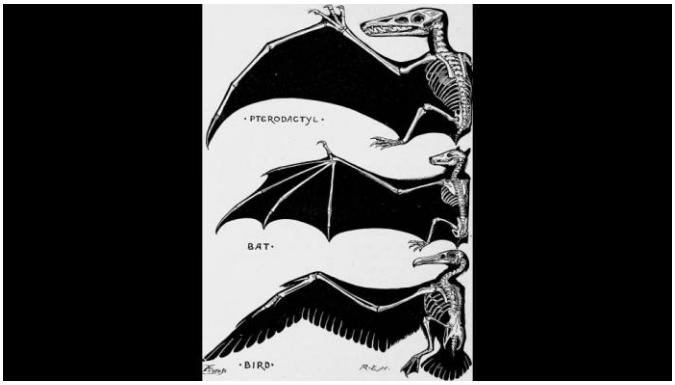
Slide 2:

As much as we all think we are unique, there is a large body of evidence that indicates that many species are descended from common ancestors. Homologous and analogous structures are just one part of that evidence.

Slide 3:

Analogous structures - have **different** evolutionary ancestries but they have the same function. Examples of these types of **structures** are the wings of birds, bats and insects.

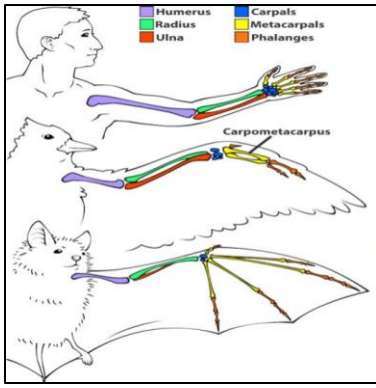
Slide 4:



Slide 5:

Homologous structures - are the opposite of analogous structures in that they may have similar ancestries and common traits but may not have the same function in an organism.

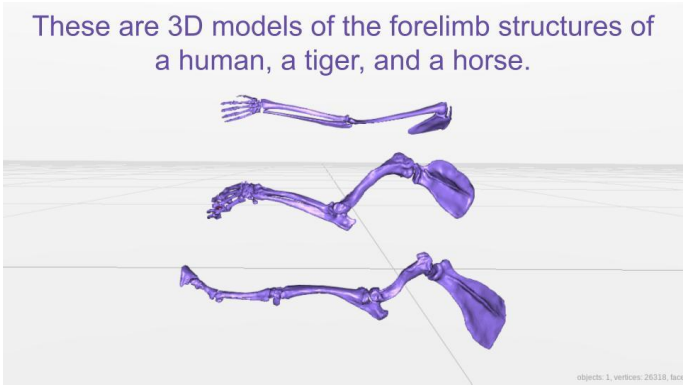
Slide 6:



These are homologous structures in that they are the same structures, but they have been adapted to be used for different functions in each animal.

Slide 7:

These are 3D models of the forelimb structures of a human, a tiger, and a horse.



Slide 8:

You are going to go online and manipulate the models. You can turn them around and see them from all directions. Tomorrow, you will also measure the thickness of the bones so that we can discuss their differences.

Go to apps and click on this icon.

Slide 9:

Once the app loads, click on file and then load which will take you to your folder. Double click on limb comparison and give it time to load. It should come up in 3D view, where you can rotate it and see it from all sides.

Slide 10:

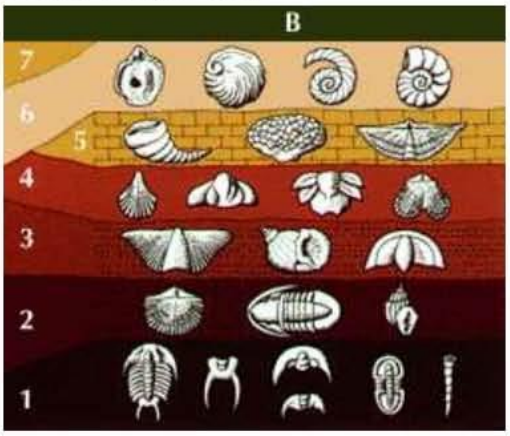
After you have examined the models and pictures, your task will be to color code the homologous structures on your worksheet. You will also need to make a key that shows which color you used for each type of bone.

Name: _____
Period: ____

Evidence of Evolution- PreAP

Background: Much evidence has been found to indicate that living things have evolved or changed gradually during their natural history. The study of fossils as well as work in embryology, biochemistry, and comparative morphology provides evidence for evolution.

Objective: To compare homologous, analogous, and vestigial structures and analyze their significance in evolutionary history.



I. Fossils

Study the figure at right.

1. Which rock layer is the oldest? _____
2. Which rock layer is the youngest? _____
3. Explain what can scientists learn about evolution when comparing different fossils in different rock layers? (Use terms like relatedness, extinction, transition etc.) You must write at least two complete sentences.

II. Homologous Structures

1. Carefully examine the drawings of the bones in Figure 1 on the next page. Look for similarities among the various animals.

i. Color each bone of the human arm a different color. All bones of the wrist (carpals) should be a single color, and the bone groups of the hand (metacarpals and phalanges) should be a another color. Then color the corresponding bones (containing the same pattern) in each of the other animals the same color as the human bone (i.e. if you color the humerus blue in the human, it should be blue in all the other animals).

ii. Describe at least two *functions* of each set of bones below:

Animal	Functions	
Human		
Whale		
Cat		
Bat		
Bird		
Crocodile		

Table 1

iii. Are the bones arranged in a similar way in each animal? _____

These structures on the following page are *formed* in similar ways during embryonic development and share like *arrangements*; however, they have somewhat different forms and functions. They are called *homologous structures*. **What does the prefix "homo" mean?** _____

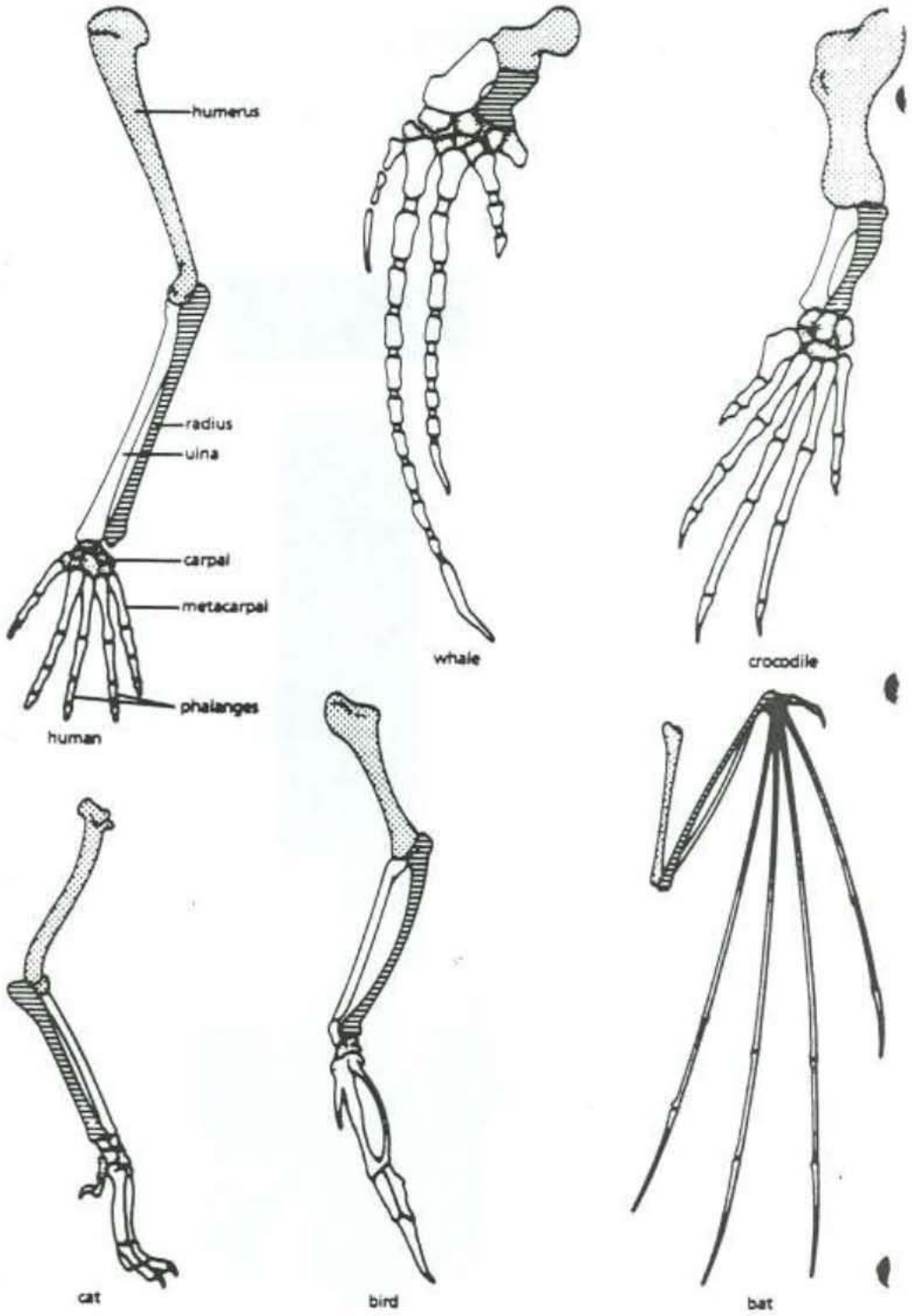


Figure 1

III. Embryology

1. Using complete sentences, describe how comparing early development can help scientists learn about the relatedness of species. Page 385 may give you a start. Give an example!

_____

_____

_____

IV. Analogous structures

1. Examine the butterfly wing and the bird wing shown in Figure 2.

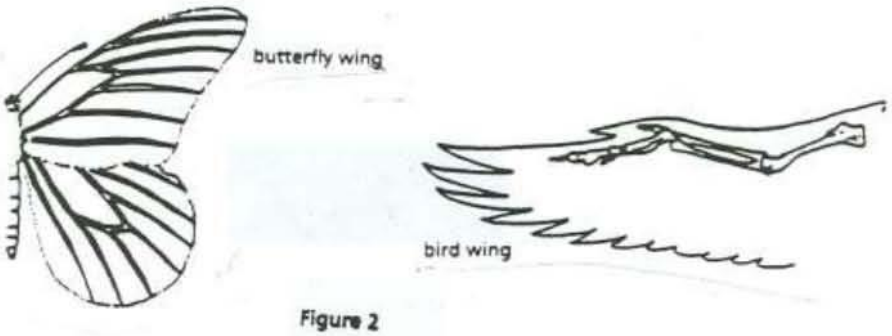


Figure 2

a. What function do these structures share? _____

b. How do the structures differ internally and externally? (give me three)_____
_____
_____

c. Do birds and insects share any structural similarities that would suggest they are closely related in the single tree of life that includes all organisms? Explain.
_____
_____
_____

Some apparently **unrelated** animals have organs with similar functions, yet are very different in structure and form. These structures are called *analogous structures*.

V. Vestigial structures

Gradual changes have occurred through time that have, in some cases, reduced or removed the function of some body structures and organs. The human appendix that is reduced and no longer digests rough vegetation and pelvic bones of snakes that have no legs are examples of this phenomenon.

1. The cave fish and minnow shown in Figure 3 are related, but the cave fish is blind.

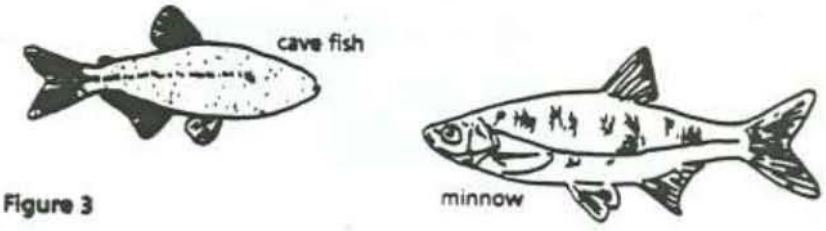


Figure 3

a. Explain why eyesight is not an important adaptation to life in a **cave**.
_____
_____

b. Do the appearance of the cave fish and minnow suggest common ancestry? Explain.
_____
_____

Organs or structures that have lost their function in the organism and have become reduced in size (because of efficiency) are called **vestigial structures**.

2. Read the list of human vestigial structures shown in Table 2. Suggest a possible function for each structure and explain why it became vestigial (why that adaptation became less important for survival). Think about organisms that are closely related to us and the functions they have for those structures (meaning other mammals or specifically other primates). Record your answers in the table. For the second part, analyze why this function is no longer needed (has a different structure taken over that function? Has the environment changed?)

Table 2

Structure	Possible Function(s)	Why it is considered vestigial
Appendix		
Muscles that make hair stand up		
Coccyx (tail bone)		
Muscles that move ears		
Wisdom teeth		

Analysis and Interpretations

1. Explain why the homologous structures in Part II are evidence of evolutionary relationships.

2. Explain the evolutionary relationship between the fin of a fish and the flipper of a whale (a mammal).

3. List two structures (not found in Table 2) that you think are *vestigial* and why. These structures can be from any living organism, not just humans.

4. What is the appendix homologous to in other mammals? What do homologous structures indicate?

5. If a scientist states that two species are closely related based on morphology, what would you expect a comparison of their DNA base sequence to reveal?