From the Teacher: J. Haut
Class: Enhanced Biology & Enhanced SEA Biology
Period: 2, 4, and 5
Assignment: Week 4

If turning in paper packet and work, make sure to include this header information on all pages!

From the Student: Student Name
Teacher Name
Name of class
Period #
Assignment #

Evidence of Evolution

The work in this packet is due 5/15/2020. If working online, you may turn in work digitally before the deadline. I encourage you to turn work in as you complete it. If completing paper packets, attach all work to packet before turning packet in on May 15th. You can also take a picture of paper packet work and email images to me (make sure to write your name in ink on each page). Make sure to have the proper heading on each page to ensure that I receive all of your work. I have broken the work down into daily tasks to help you manage your time.

My office hours are 10AM-12PM, M-F. You can email me at jhaut@tusd.net, post a question in Teams, or call me at (209) 625-9540 with questions. Please continue to check your email regularly.

Wk4:Day 1 (turn in by 5/15/20):
The basic idea of natural selection is that a population of organisms can change over the generations if individual having certain heritable traits leave more offspring than other individuals. The result of natural selection is evolutionary adaptation, a population's increase in the frequency of traits that are suited to the environment. In modern terms, we would say that the genetic makeup of the population has changed over time, and that is one way to define evolution. Evolution leaves observable signs. There are five lines of evidence that support evolution: the fossil record, biogeography, comparative anatomy, comparative embryology, and molecular biology. [Campbell, N.A., Reece, J.B., and Simon, E. (2007). How populations evolve. *Essential biology with physiology*, 2nd edition. (p. 245). San Francisco, CA: Pearson, Benjamin Cummings]

1. Review the different lines of evidence used to support the theory of evolution: Read pgs. 250-253 in your textbook. Take notes as needed.
2. Write 1-2 thoughtful paragraphs about what you now understand about a) how the five lines of evidence support the theory of evolution, b) what still confuses you, and c) what new questions you have.

Wk4: Days 2-4 (turn in by 5/15/20)
Complete the Evidence of Evolution Worksheet (See Assignments in Teams or attached to the back if completing paper packet).

Wk4: Days 5 (turn in by 5/15/20)
1. Review Darwin's theory of natural selection: Read pgs. 253-255 in your textbook. Take notes as needed.
2. Write a 1-2 paragraph reflection explaining a) what you learned from the evidence of evolution worksheet and b) the connections you made with what you learned about Darwin's theory of natural selection and how mutations play an important role in natural selection.

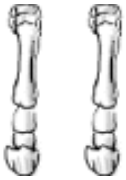
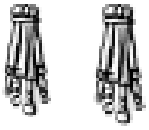
Evidence of Evolution

Background

When Charles Darwin first proposed the idea that all new species descend from an ancestor, he performed an exhaustive amount of research to provide as much evidence as possible. Today, the major pieces of evidence for this theory can be broken down into the fossil record, embryology, comparative anatomy, and molecular biology.

Fossils

This is a series of skulls and front leg fossils of organisms believed to be ancestors of the modern-day horse.

				
				
Equus (modern horse)	Pilohippus	Merychippus	Mesohippus	Eohippus (Dawn Horse)

Source: http://www.iq.poquoson.org

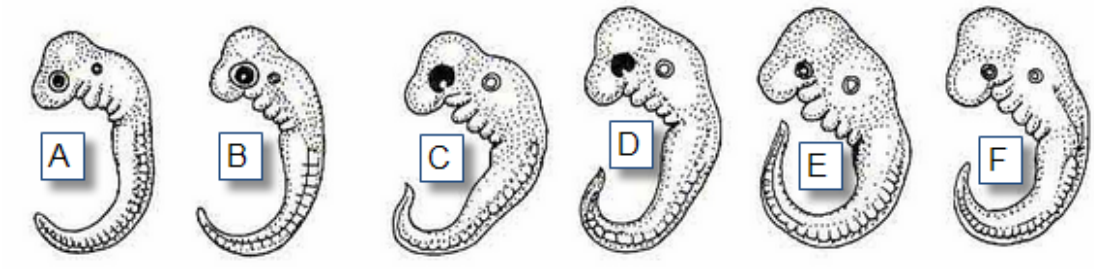
1. Give two similarities between each of the skulls that might lead to the conclusion that these are all related species.

2. What is the biggest change in skull anatomy that occurred from the dawn horse to the modern horse?

3. What is the biggest change in leg anatomy that occurred from the dawn horse to the modern horse?

Embryology

Organisms that are closely related may also have physical similarities before they are even born! Take a look at the six different embryos below:

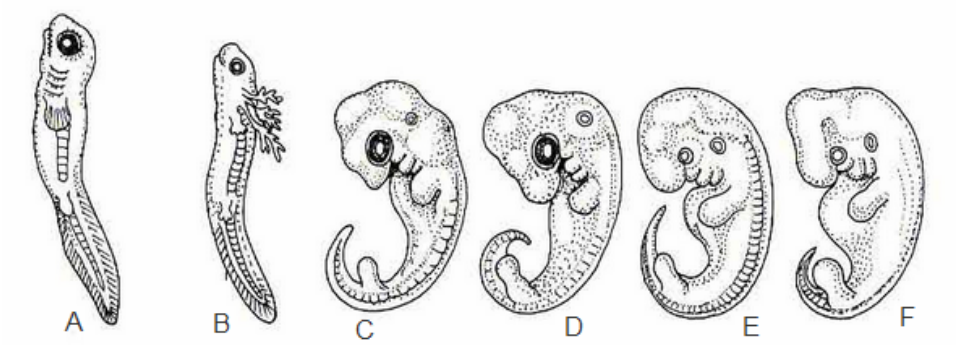


Source: http://www.starlarvae.org

Hypothesize which embryo is from each of the following organisms:

Species	**Embryo**
Human	
Chicken	
Rabbit	
Tortoise	
Salamander	
Fish	

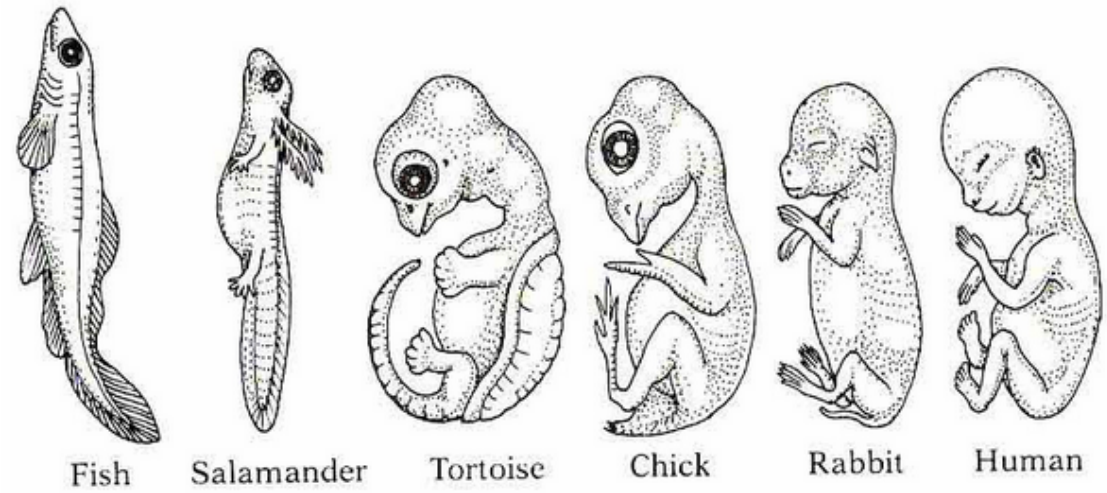
These are older, more developed embryos from the same organisms.



Hypothesize which embryo is from each of the following organisms:

Species	**Embryo**
Human	
Chicken	
Rabbit	
Tortoise	
Salamander	
Fish	

These are embryos at their most advanced stage, shortly before birth.



Describe how the embryos changed for each of these organisms from their earliest to latest stages.

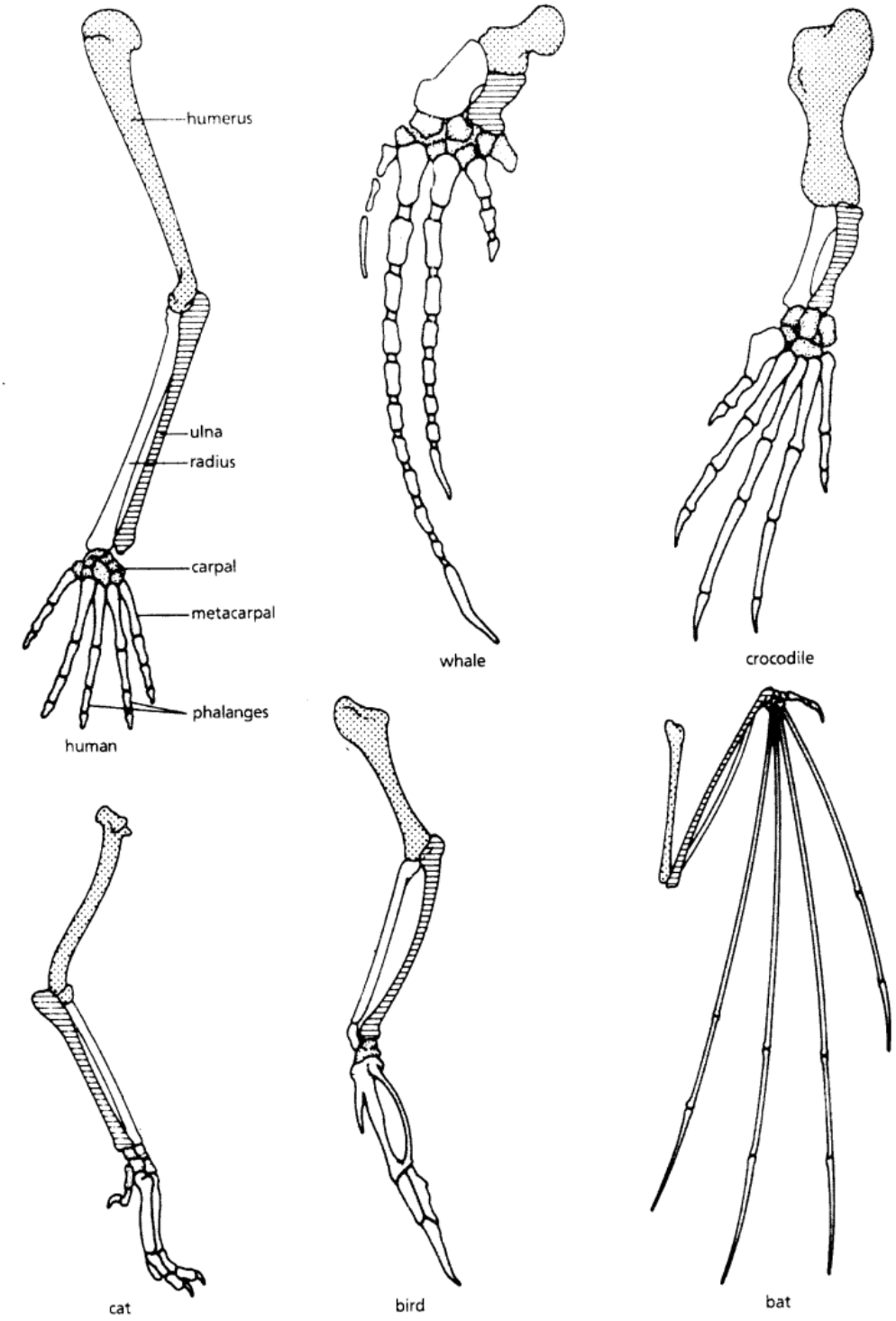
Species	**Anatomical Changes From Early to Late Stages**
Human	
Chicken	
Rabbit	
Tortoise	
Salamander	
Fish	

1. Look again at the six embryos in their earliest stages. Describe the patterns you see. What physical similarities exist between each of the embryos?

2. Does this suggest an evolutionary relationship? Explain how.these embryos can be used as evidence of a common ancestor between each of these six organisms.

Comparative Anatomy

Shown below are images of the skeletal structure of the front limbs of 6 animals: human, crocodile, whale, cat, bird, and bat. Each animal has a similar set of bones shown by shading.



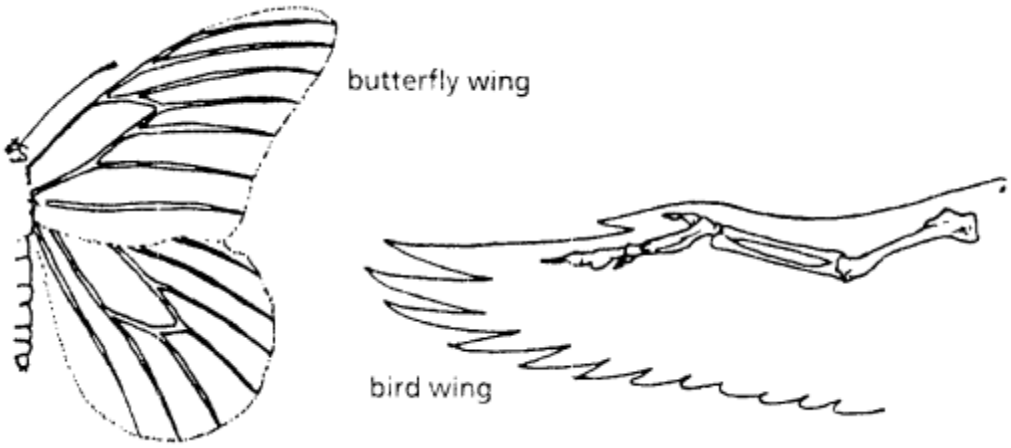
For each animal, indicate what type of movement each limb is responsible for.

Animal	Primary Functions
Human	Using tools, picking up and holding objects
Whale	
Cat	
Bat	
Bird	
Crocodile	

Compare the skeletal structure of each limb to the human arm. Relate the differences you see in *form* to the differences in *function*.

Animal	Comparison to Human Arm in Form	Comparison to Human Arm in Function
Whale	Whale has a much shorter and thicker humerus, radius, and ulna. Much longer metacarpals. Thumb has been shortened to a stub.	The whale fin needs to be longer to help in movement through water. Thumbs are not necessary as the fins are not used for grasping.
Cat		
Bat		
Bird		
Crocodile		

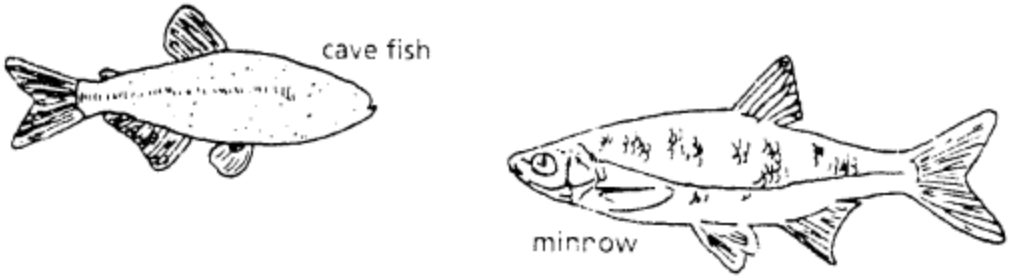
Compare the anatomy of the butterfly and bird wing below.



1. What is the function of each of these structures?

2. How are they different in form? Give specific differences.

Compare the overall body structure of the cave fish and the minnow below.



1. What is the biggest, most obvious difference between the body structure of these two fish?

2. Assume the two fish came from the same original ancestor. Why might the cave fish have evolved without eyesight?

3. What kind of sensory adaptation would you hypothesize the cave fish has to allow it to navigate in a cave, including catching and eating food?

You have now studied three different types of anatomical structures.

- **Homologous structures** show individual variations on a common anatomical theme. These are seen in organisms that are closely related.

1. Give an example of a homologous structure from this activity: _____

- **Analogous structures** have very different anatomies but similar functions. These are seen in organisms that are not necessarily closely related but live in similar environments and have similar adaptations.

2. Give an example of an analogous structure from this activity: _____

- **Vestigial structures** are anatomical remnants that were important in the organism's ancestors but are no longer used in the same way.

3. Give an example of a vestigial structure from this activity: _____

4. Below are some vestigial structures found in humans. For each, **hypothesize** what its function may have been.

Structure	**Possible function?**
Wisdom teeth	
Appendix	
Muscles for moving the ear	
Body hair	
Little toe	
Tailbone	

5. How are vestigial structures an example of evidence of evolution?

Molecular Biology

Cytochrome c is a protein found in mitochondria. It is used in the study of evolutionary relationships because most animals have this protein. Cytochrome c is made of 104 amino acids joined together.
Below is a list of the amino acids in part of a cytochrome protein molecule for 9 different animals. Any sequences exactly the same for all animals have been skipped.

For each non-human animal, take a highlighter and mark any amino acids that are different than the human sequence. When you finish, record how many differences you found in the table on the next page.

	42	43	44	46	47	49	50	53	54	55	56	57
Human	Q	A	P	Y	S	T	A	K	N	K	G	I
Chicken	Q	A	E	F	S	T	D	K	N	K	G	I
Horse	Q	A	P	F	S	T	D	K	N	K	G	I
Tuna	Q	A	E	F	S	T	D	K	S	K	G	I
Frog	Q	A	A	F	S	T	D	K	N	K	G	I
Shark	Q	A	Q	F	S	T	D	K	S	K	G	I
Turtle	Q	A	E	F	S	T	E	K	N	K	G	I
Monkey	Q	A	P	Y	S	T	A	K	N	K	G	I
Rabbit	Q	A	V	F	S	T	D	K	N	K	G	I

	58	60	61	62	63	64	65	66	100	101	102	103	104
Human	I	G	E	D	T	L	M	E	K	A	T	N	E
Chicken	T	G	E	D	T	L	M	E	D	A	T	S	K
Horse	T	K	E	E	T	L	M	E	K	A	T	N	E
Tuna	V	N	N	E	T	L	R	E	K	A	T	S	-
Frog	T	G	E	E	T	L	M	E	S	A	C	S	K
Shark	T	Q	Q	E	T	L	R	I	K	T	A	A	S
Turtle	T	G	E	E	T	L	M	E	D	A	T	S	K
Monkey	T	G	E	D	T	L	M	E	K	A	T	N	E
Rabbit	T	G	E	D	T	L	M	E	K	A	T	N	E

Animal	Number of Amino Acid Differences Compared to Human Cytochrome C	Animal	Number of Amino Acid Differences Compared to Human Cytochrome C
Horse		Shark	
Chicken		Turtle	
Tuna		Monkey	
Frog		Rabbit	

Molecular Biology – Summary Questions

1. Based on the Cytochrome C data, which organism is most closely related to humans?

2. Do any of the organisms have the same number of differences from human Cytochrome C? In situations like this, how would you decide which is more closely related to humans?

Conclusion

1. Charles Darwin published his book *On the Origin of Species* in 1859. Of the different types of evidence that you have examined, which do you think he relied upon the most, and why?

2. Given the amount of research and evidence available on evolution, why is it still classified as a theory?