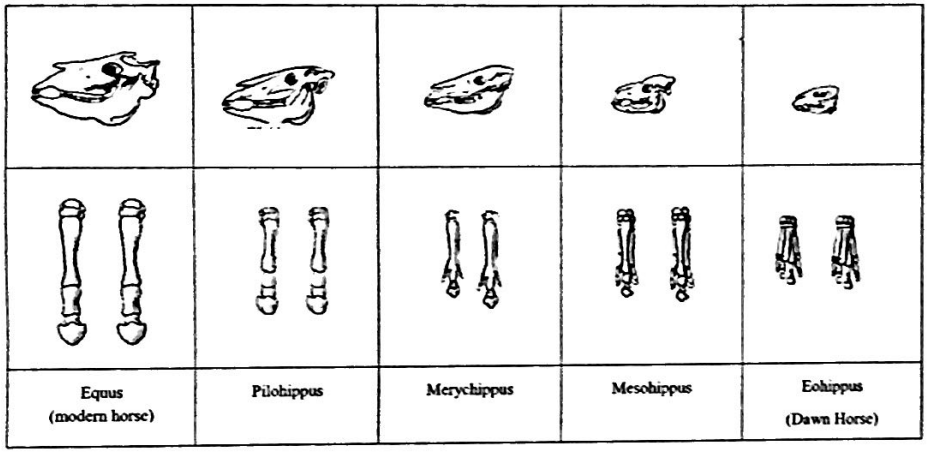
Evidence of Evolution

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)	Pliohippus	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. -Same jaw shape -Same eye shape -Same teeth shape -Same nose shape

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

The skull got bigger

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

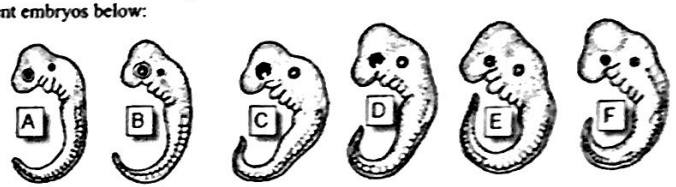
-Toes fused together

-got longer

Name: Key Class: _____ Date: _____

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:

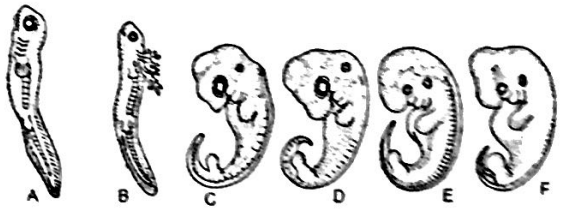


Source: http://www.starlarvae.org

Hypothesize which embryo is from each of the following organisms:

Species	Embryo
Human	
Chicken	
Rabbit	Varies
Tortoise	
Salamander	
Fish	

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

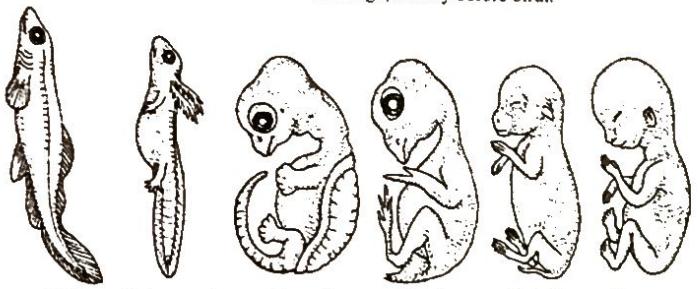


Hypothesize which embryo is from each of the following organisms:

Species	Embryo
Human	
Chicken	
Rabbit	Varies
Tortoise	
Salamander	
Fish	

Name: _____ Class: _____ Date: _____

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



Fish Salamander Tortoise Chick Rabbit Human

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	early stage had a tail, late doesn't
Chicken	early stage had no beak + longer tail
Rabbit	early stage had longer tail
Tortoise	early stage had no shell
Salamander	early stage missing external gills
Fish	early stage no fins

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?

They all have a similar shape → long tail, no limbs, etc.

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.

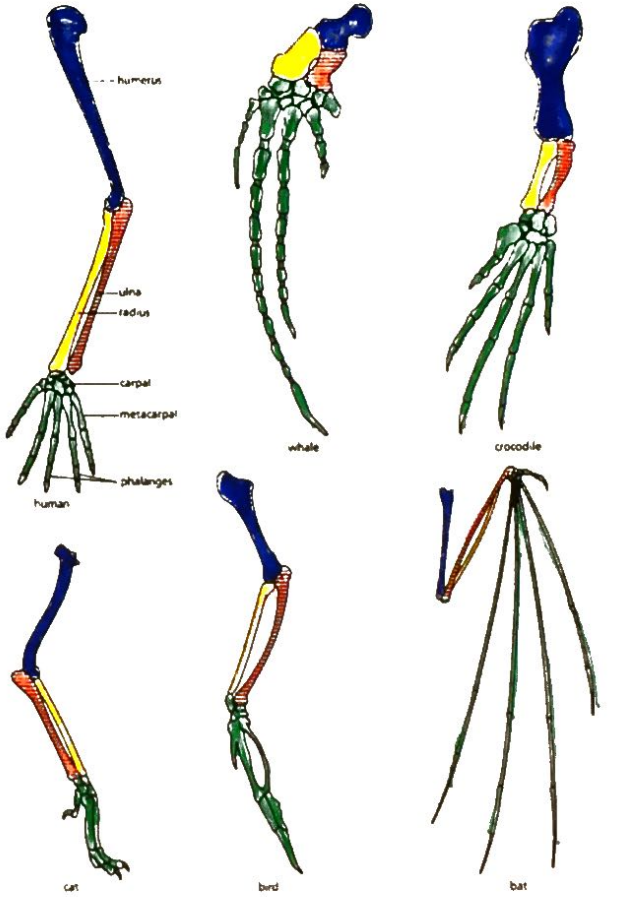
yes, we all begin the same

Name: _____ Class: _____ Date: _____

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. Color code each of the bones according to this key:

Humerus [ ] **Carpals** [ ]
Ulna [ ] **Metacarpals** [ ] } green
Radius [ ] **Phalanges** [ ]



Name: _____ Class: _____ Date: _____

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

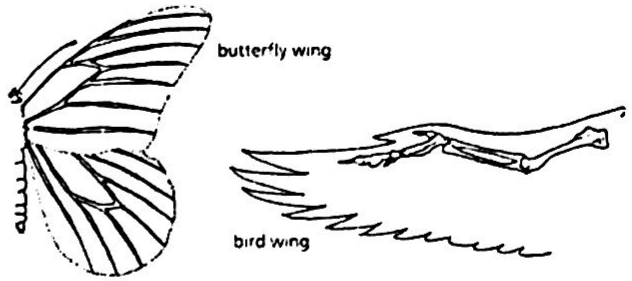
Animal	Primary Functions
Human	Using tools, picking up and holding objects
Whale	swimming
Cat	walking
Bat	flying
Bird	flying
Crocodile	walking

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	smaller carpals, metacarpals & phalanges	they walk on their paws
Bat	much longer phalanges, thumb shortened	increase wing area
Bird	carpals, metacarpals & phalanges close together	creates a surface for standing / perching
Crocodile	larger humerus & longer phalanges	used to swim & push self up

Name: _____ Class: _____ Date: _____

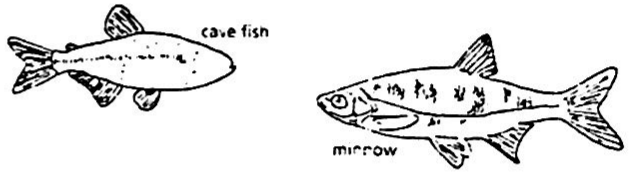
Compare the anatomy of the butterfly and bird wing below.



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

2. How are they different in form? Give specific differences.
butterfly = no bones
bird = bones, feathers

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?
cave fish has no eye

2. Assume the two fish came from the same original ancestor. Why might the cave fish have evolved without eyesight? it didn't need it → lives in the dark

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?
better hearing, sonar, echo location

Name: _____ Class: _____ Date: _____

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	Chewing or eating (most likely veggies)
Appendix	Part of digestion
Muscles for moving the ear	move ears to hear better
Body hair	keep warm
Little toe	stand, stability
Tailbone	a tail

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

Our ancestors once had them but over time we stopped using them as we adapted

Name: _____ Class: _____ Date: _____

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	(D)	A	T	N	E
Tuna	V	N	N	E	T	L	R	E	(E)	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	5	Shark	14
Chicken	7	Turtle	8
Tuna	11	Monkey	1
Frog	9	Rabbit	4

Name: _____ Class: _____ Date: _____

Molecular Biology – Summary Questions

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

Monkey → least # of differences

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?

No (unless I missed one ...)
use anatomical comparison or other evidence

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?

Anatomical comparison →
He didn't have access to other evidence

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

- Gaps within information (fossils)
- Disagreements among scientists regarding connections between org.
- Complexity of cells/DNA/living systems.