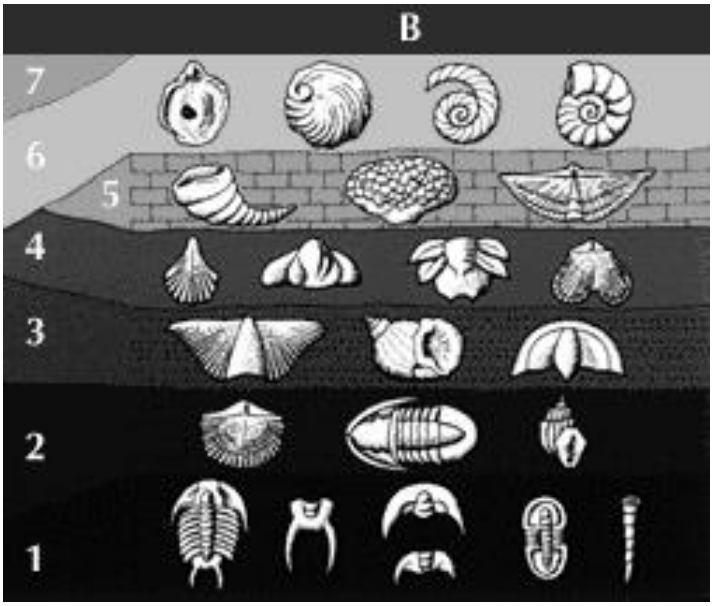
Name: _____

Evidence of Evolution: Fossils, Embryology, and Molecular Record

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.

I. Fossils

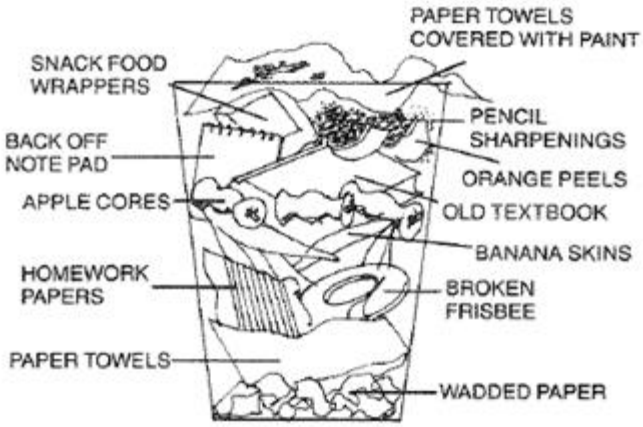
Study the figure at right.



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. Law of Superposition

Examine the contents of the wastebasket pictured to the right. The wastebasket is emptied everyday after school. The contents of the wastebasket have been collected during a single school day.



1. Identify one item that was discarded early in the morning. Explain how you know.
2. Identify one item that was discarded around noon. Explain how you know.
3. Identify one item that was discarded near the end of the day. Explain how you know.
4. **Summarize the law of superposition.**

COMPARATIVE EMBRYOLOGY: THE VERTEBRATE BODY

Even before Darwin proposed the theory of evolution through natural selection, Ernst von Baer claimed that the more closely related any two species are, the more similar their development. His treatise (1828) set the stage for linking the study of ontogeny, the development of the individual through a single life cycle, to phylogeny, the relatedness of species through descent from a common ancestor. When Darwin brought together the diverse lines of evidence to demonstrate that new species arose from previous species, he included the findings from studies on embryos.

Von Baer, who discovered the mammalian egg as part of his detailed studies on animal development, observed that vertebrate animals, during the early stages of their embryological development, seem to have a common design, whereas the adult forms show difference. Arm buds from different species, for example, are virtually indistinguishable when they first form on the embryo, yet they may develop into a wing, an arm, or a flipper.

In the early stages of growth when vital organs originate, the developmental sequences, or ontogeny, of all vertebrates are very similar. As the fertilized egg transforms into an adult, the general vertebrate plan is modified during growth as each species acquires its adult species pattern.

The fertilized eggs (a), or zygotes, are very similar, though they differ slightly in the size of the cell nucleus. The orderly division of the single-celled zygote into a multicelled blastocyst is referred to as cleavage. By the late cleavage stage (b), the embryos look very similar and differ only in their cleavage patterns, which vary due to the presence of differing amounts of yolk in the egg.

As the body segments form (c), all three mammals remain almost identical. Notice the ancestral gill slits, which in the mammals will later develop into parts of the ear and pharynx. The mammals possess an umbilical cord that leads to the placenta. In contrast, the salamander and the chicken are nourished by yolk.

The early forelimbs begin as buds (d). By the late fetal stage (e), limbs take on their adult shapes. The striking similarities in the late fetal stage between monkey and human reflect their close phylogenetic relationship. The main difference lies in the absence of a tail in the human fetus. (If an ape fetus were substituted for this monkey, it too would lack a tail). The chicken has developed its spe-

All vertebrate embryos follow a common developmental plan due to having a set of genes that gives the same instructions for development. As each organism grows, it diverges according to its species way of life. Human embryonic development is similar to that of other vertebrates, more like that of other mammals than nonmammals, and most similar to that of other primates. From the study of ontogeny, we discover clues about the transformation of species through evolutionary change.

1. **What did Von Baer discover about the comparisons of vertebrate embryos?**

2. **As the embryos grow and body segments form how do the mammals compare?**

3. **What feature turns into the ear and pharynx in mammals?**

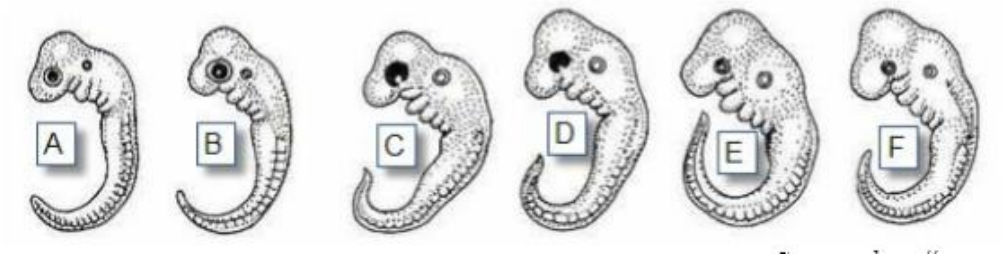
4. **What is the main difference between other mammal embryos and the human embryo?**

5. **Do humans have a tail in the early stages of their embryo development?**

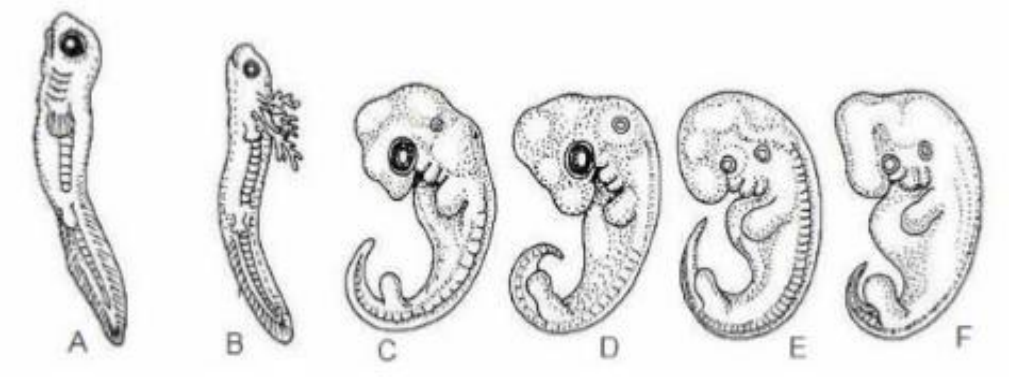
III. Embryology

Organisms that are closely related may also have physical similarities before they are even born. Take a look at the six vertebrate embryos below as they progress through the stages of gestation.

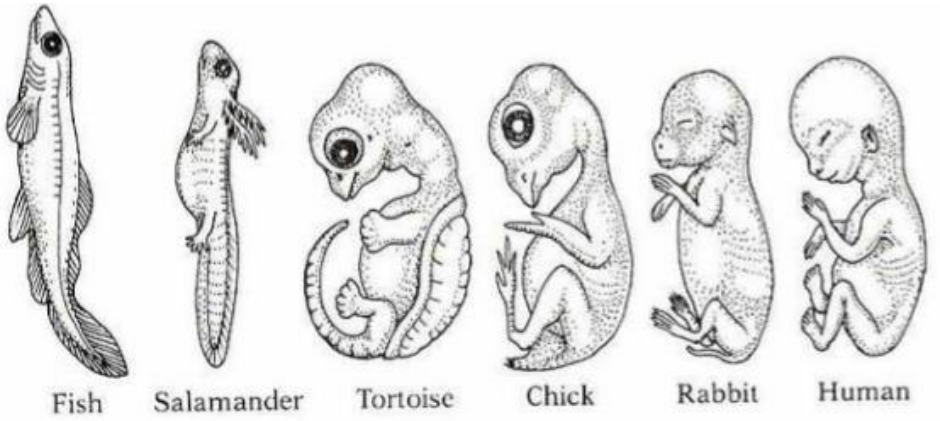
4 weeks gestation



10 weeks gestation



20 weeks gestation



1. Can you easily identify which embryo is the human and which is the salamander just by observing the embryos at 4 weeks gestation? Explain why or why not.

2. Look at the embryos at 4 weeks gestation and describe any patterns that you see. What physical similarities do you observe between the embryos?

3. 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.

IV. Molecular Record

Scientists can examine the amino acid sequences of particular protein molecules found in vertebrates to determine the degree of similarity between vertebrate species. Even organisms that appear to have few physical similarities may have similar sequences of amino acids in their proteins and be closely related through evolution. Scientists believe that the greater the similarity in the amino acid sequences of two organisms, the more closely related they are in an evolutionary sense. Cytochrome-c is a protein found in the mitochondria that is used in cellular respiration. This protein consists of a chain of 104 amino acids. The chart below shows the amino acid sequence of nine vertebrates. The letters identify the name of the amino acid.

Animal	Amino Acid Sequences in Cytochrome-c																					
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Horse	gln	pro	phe	thr	thr	ala	lys	asn	lys	thr	lys	glu	glu	thr	leu	met	glu	lys	ala	thr	asn	glu
Chicken	gln	glu	phe	ser	thr	asp	lys	asn	lys	thr	gly	glu	asp	thr	leu	met	glu	lys	ala	thr	ser	lys
Tuna	gln	glu	phe	ser	thr	asp	lys	ser	lys	val	asn	asn	asp	thr	leu	met	glu	ser	ala	thr	ser	--
Frog	gln	ala	phe	ser	thr	asp	lys	asn	lys	thr	gly	glu	asp	thr	leu	met	glu	ser	ala	cys	ser	lys
Human	gln	pro	tyr	ser	thr	ala	lys	asn	lys	ile	gly	glu	asp	thr	leu	met	glu	lys	ala	thr	asn	glu
Shark	gln	gln	phe	ser	thr	asp	lys	ser	lys	thr	gln	gln	glu	thr	leu	arg	ile	lys	thr	ala	ala	ser
Turtle	gln	glu	phe	ser	thr	glu	lys	asn	lys	thr	gly	glu	asp	thr	leu	met	glu	asp	ala	thr	ser	lys
Monkey	gln	pro	tyr	ser	thr	ala	lys	asn	lys	thr	gly	glu	asp	thr	leu	met	glu	lys	ala	thr	asn	glu
Rabbit	gln	val	phe	ser	thr	asp	lys	asn	lys	thr	gly	glu	asp	thr	leu	met	glu	lys	ala	thr	asn	glu

DATA

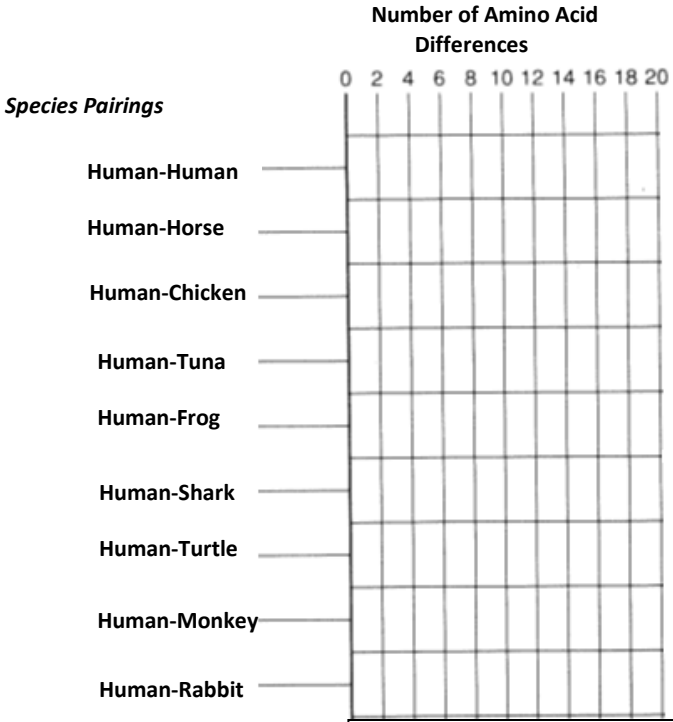
Compare the amino acid sequence of human cytochrome-c with that of the other eight vertebrates. For each vertebrate, count the number of amino acids that differ from those in the human and write the number in the chart to the right.

TABLE 1

Number of Amino Acid Differences from Human Cytochrome-c	
Species	**Number Differences**
Human	0
Horse	
Chicken	
Tuna	
Frog	
Shark	
Turtle	
Monkey	
Rabbit	

Graphing

In the space below construct a bar graph comparing the amino acid differences for the different organisms.



1. Based on the data gathered, which organisms appear to be most closely related to humans? Explain your answer.

2. Among the organisms compared, which one appears least closely related to humans? Explain your answer.

3. If the amino acid sequence in the proteins of two organisms is similar, why will their DNA also be similar?

4. Check the pair of organisms that appears to be most closely related to one another.

_____ chicken- tuna
_____ chicken-frog
_____ chicken-turtle

Explain your answer.

Get signed off before moving on. _____