Name: _____ **Period:** _____

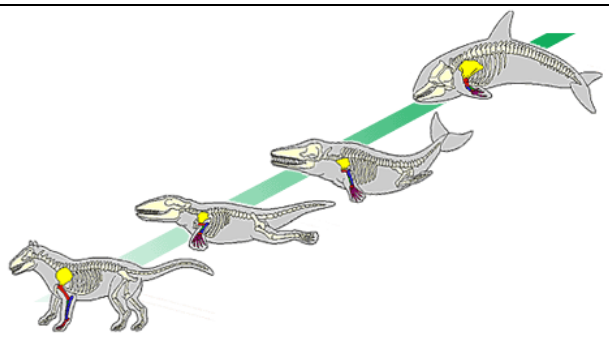
Evidence for Evolution

Part I. Introduction

Two of the most important ideas in evolution are as follows:

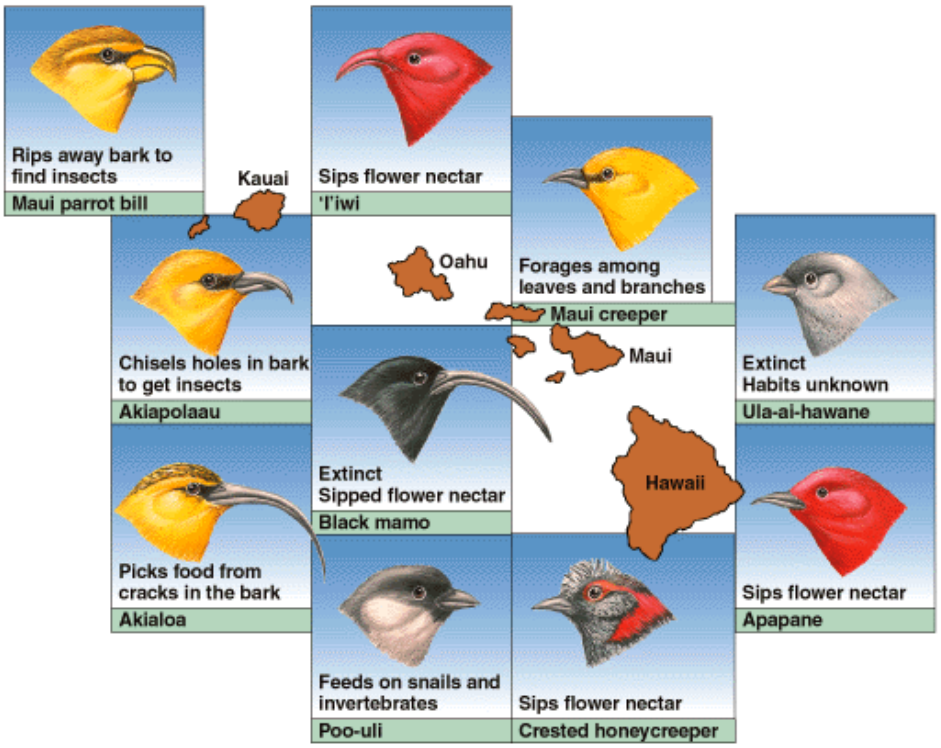
1) Every species is a modified (changed) descendant of a species that existed before. In other words, the species we see today weren't created in their current form. Rather, they evolved into their current form. Darwin called this "*Descent with Modification.*"

You can see this in the diagram on the right. The ancestors of whales, which are mammals, lived on land. The series shows evidence of descent with modification because key features are retained (overall skeletal organization, way of moving the spine when moving, mammalian traits) while structures have been modified for life in the water (reduction and loss of hind limbs, movement of nostrils to the top of the head, loss of hair, etc).



2) Somewhere back in time, any two currently existing species are connected by a common ancestor. Walk back in time through your own ancestry and you pass from humans, to pre-human ancestors, to ape-like ancestors, to monkey-like ancestors, to rodent-like ancestors. Stop at those rodent-like ancestors and move forward through time to the line that leads to modern day squirrels. You can represent this as is shown in the diagram to the left.

We didn't evolve *from* squirrels: we share a *common ancestor* with squirrels. Nor did we evolve from monkeys. Rather, humans and monkeys share a common ancestor.



When one ancestral species evolves into two or more descendants, each adapted for a different type of environment, it's called *adaptive radiation*. In this context, "radiation" means "spreading out." For example, based on body size and DNA evidence, it's clear that all of the birds that belong to the honeycreeper family on the Hawaiian islands are closely related. The key features that the modern species share in common are called *homologous features*. They started out the same, but then end up different. This happens on two levels.

The first is developmental. When these birds are embryos, in their eggs, their beaks start out identically. But then different genes are expressed, or the timing of expression is different, leading to longer and shorter beaks, beaks with different shapes, etc.

The other timescale is evolutionary. Way back in time, a single species of honeycreeper arrived at these islands. Over time, processes like geographic isolation, genetic drift, and geographic isolation led these birds to evolve into separate species.

Checking Understanding:

1. When one line of organisms changes over time, this is called _____ with _____.
2. When one line of organisms branches into several descendant species, it's called _____ _____.
3. Structures that related species share that have evolved to have different functions are called _____ _____.
4. We use the same word, *homologous*, to describe the matching (but not identical) chromosomes we inherit from our parents. It makes sense to use the same word to describe the beaks of honeycreepers because …

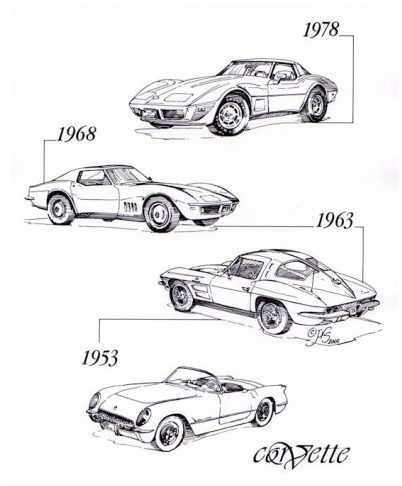
Part 2: Writing and talking about the evidence for evolution

The evidence for evolution is written into the fabric of nature as two patterns: 1) patterns that show descent with modification; and 2) patterns that show adaptive radiation with the homologous features that result. Often, you can see both patterns. We'll start with two cultural examples of evolution.

Here's what you're going to look for and write about for evidence from descent with modification:

The _____ shows evidence of evolution because of the clear pattern of descent with modification. Over time, key features that were preserved in this evolutionary line were….At the same time, the _____ changed over time with new features such as…

Example 1: *The Evolution of the Chevy Corvette*



(hint: look for descent with modification in a lineage)

The evidence for evolution in the design of the corvette is …

Example 2: *The Evolution of Language.*

This example shows evidence from both descent with modification AND adaptive radiation with homologous features. Here's how to write about the later:

The relationship between _____,_____, and _____ is evidence for linguistic evolution because of the pattern of **adaptive radiation.** From a common ancestor, there was differentiation into multiple forms such as _____, _____, and _____. You can see this in the homologies between _____, _____, and _____. For example….

I am a man in four languages

Latin: ego sum homo		
Spanish:	*Italian:*	*French:*
yo soy un hombre	io sono un uomo	je suis un homme

Similarities in these four languages include:

	Latin	Spanish	Italian	French
I				
am				
man				

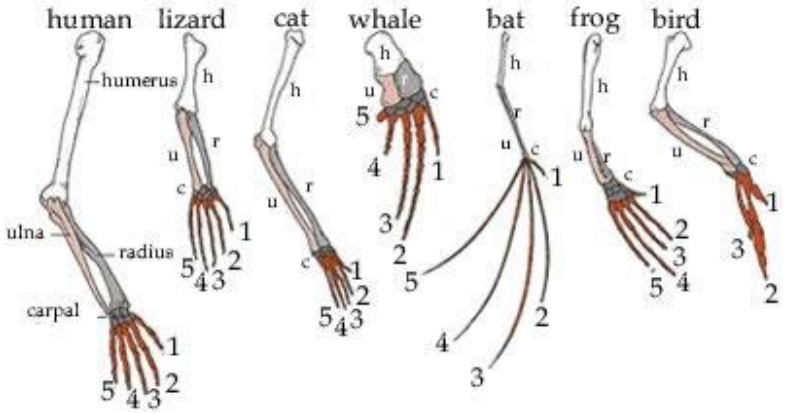
(hint: look for descent with modification, adaptive radiation, and homologous features).

The evidence for evolution in the relationship between Latin, Spanish, Italian, and French …

Part 3: Examining the Evidence for Evolution

Exhibit 1: Forelimbs in Vertebrates.

The image below shows the forelimbs of seven different species. Bones that similarly labeled and shaded originate from the same embryonic tissue (and are referred to by the same name). Choose about three of these, and describe how this diagram provides evidence for evolution.



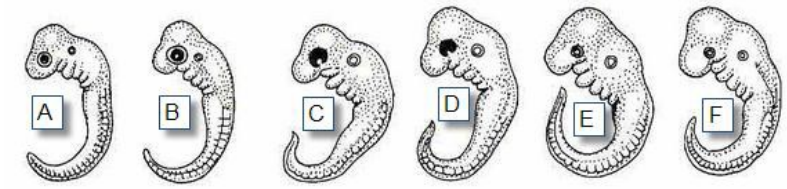
GUIDE

The relationship between _____,_____, and _____ is evidence for evolution because of the pattern of _____. From a common ancestor, there was differentiation into multiple forms such as _____, _____, and _____. You can see this in the homologies between the _____, _____, and _____. For example….

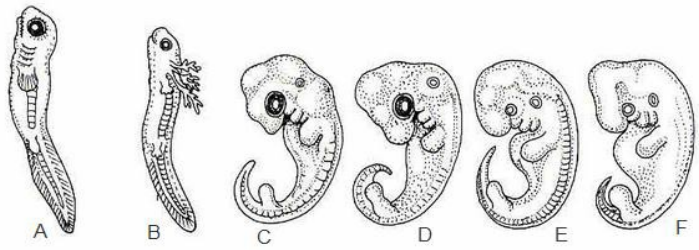
YOU WRITE IT OUT:

Exhibit 2: Embryos

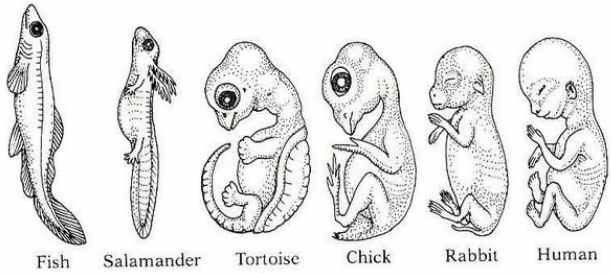
Take a look at the six different embryos below:



Early embryos



later in development



…even later

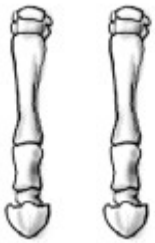
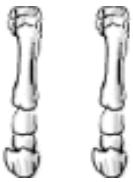
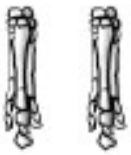
GUIDE

The relationship between _____,_____, and _____ is evidence for evolution because of the pattern of _____. From a common ancestor, there was differentiation into multiple forms such as _____, _____, and _____. You can see this in the homologies between the _____, _____, and _____. For example….

YOU WRITE IT OUT:

III. Fossils: Horse Evolution

This is a series of skulls and front leg bones from fossils of organisms thought to be the ancestors of the modern--day horse. Drawings are not shown to true scale, but are shown in terms of relative size.

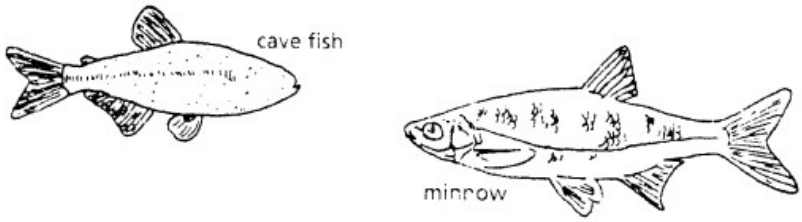
SKULL					
LOWER LEG and DEVELOPING HOOF					
Notes	*Equus* (modern horse) 3.5 million years ago to present day 160 centimeters tall	*Pliohippus* 12 million years ago 125 centimeters tall	*Merychippus* 15 million years ago 100 centimeters (one meter) tall	*Mesohippus* 40 million years ago 61 centimeters tall	*Eohippus* (Dawn Horse) 52 million years ago 40 centimeters tall

GUIDE: The _____ shows evidence of evolution because of the clear pattern of descent with modification. Over time, key features that were preserved in this evolutionary line were….At the same time, the _____ changed over time with new features such as…

YOU WRITE IT OUT:

IV. Comparative Anatomy: Vestigial Structures

A "vestige" is "something left behind." Compare the overall body structure of the cave fish and the minnow below.



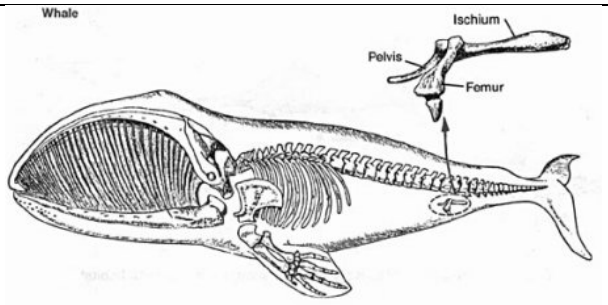
1. What is the biggest, most obvious difference between the body structure of these two fish?

2. While you can't see the cave fish's eyes in the diagram, some of the tissues and structures of the eye are still there (though covered by skin). In other words, the eye is a *vestigial structure*. Assume the two fish came from the same original ancestor. Why, over the course of evolution, might the line that led to cave fish have evolved smaller and smaller eyes, until the eyes are practically gone?

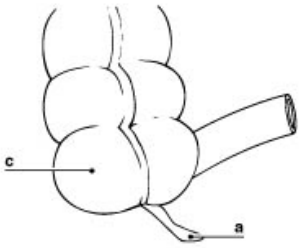
Vestigial Structures, Continued

GUIDE: The [**trait or feature]** of **[species]** show evidence of evolution because they're a clear example of a vestigial structure. In this case the **[trait or feature]** was once an adaptation for **[original function].** As the descendants **[describe what happened],** the **[feature]** became unnecessary, and mutations accumulated. Over time the **[feature]** lost its function and **[describe how else it changed]**.

3. Whales have no hind legs, yet, inside their bodies, they have a tiny pelvis and hind limb structures. During the whaling era of the 1800s, there were reports of small numbers of captured whales having tiny hind legs. Fossils of animals thought to be the ancestors of modern whales (dug up in the Sahara desert, which was once a sea floor) had small external hind legs.
Explain



4. The appendix is a small pouch near the junction of the small and large intestine. In plant eaters, it allows for the digestion of plant matter such as cellulose. In humans, the appendix sometimes becomes inflamed and requires removal. One can live perfectly well without it. Explain!



5. Humans and other apes (chimps, gorillas, orangutans, and gibbons) lack a tail. Yet all have a tailbone, a small group of vertebrae called a *coccyx* (shown at letter b to the right). The *coccyx*, in humans, is a _____ organ. Explain!

VI. Molecular Homologies

Cytochrome c is a protein found in mitochondria, an organelle found in the cells of every animal. 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. Each letter stands for a different amino acid. Numbers are missing because some sequences that were exactly the same for all of the animals listed below have been skipped.

For each non-human animal, mark any amino acids that are different than the human sequence. When you finish, record how many differences you found in the table below.

	42	43	44	46	47	49	50	53	54	55	56	57	58	60	61	62	63	64	65	66	100	101	102	103	104
human	Q	A	P	Y	S	T	A	K	N	K	G	I	I	G	E	D	T	L	M	E	K	A	T	N	E
Chicken	Q	A	E	F	S	T	D	K	N	K	G	I	T	G	E	D	T	L	M	E	D	A	T	S	K
Horse	Q	A	P	F	S	T	D	K	N	K	G	I	T	K	E	E	T	L	M	E	K	A	T	N	E
Tuna	Q	A	E	F	S	T	D	K	S	K	G	I	V	N	N	E	T	L	R	E	K	A	T	S	-
Frog	Q	A	A	F	S	T	D	K	N	K	G	I	T	G	E	E	T	L	M	E	S	A	C	S	K
Shark	Q	A	Q	F	S	T	D	K	S	K	G	I	T	Q	Q	E	T	L	R	I	K	T	A	A	S
Turtle	Q	A	E	F	S	T	E	K	N	K	G	I	T	G	E	E	T	L	M	E	D	A	T	S	K
Monkey	Q	A	P	Y	S	T	A	K	N	K	G	I	T	G	E	D	T	L	M	E	K	A	T	N	E
Rabbit	Q	A	V	F	S	T	D	K	N	K	G	I	T	G	E	D	T	L	M	E	K	A	T	N	E

Animal	Horse	Chicken	Tuna	Frog	Shark	Turtle	Monkey	Rabbit
Number of amino acid differences with Human cytochrome C								

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

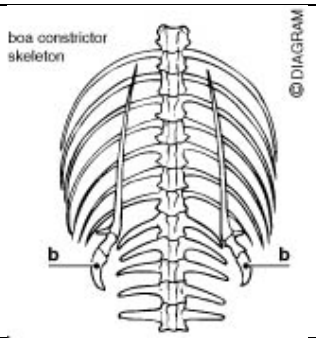
2. Do any of the organisms have the same number of differences from human Cytochrome C? In situations like this, how would you decide which is more closely related to humans?

3. How is this cytochrome C data evidence for evolution? Choose a language frame, and write out your response below.

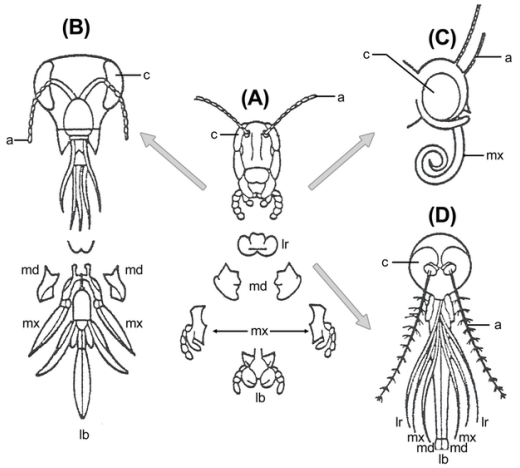
Part 4: Application

Apply what you've learned. The diagrams below could show homologous structures, vestigial structures, molecular homologies, and/or embryological similarities. Some of the diagrams are explained by adaptive radiation. All show evidence of descent with modification. USE THE APPROPRIATE CONCEPT(S) IN YOUR EXPLANATIONS.

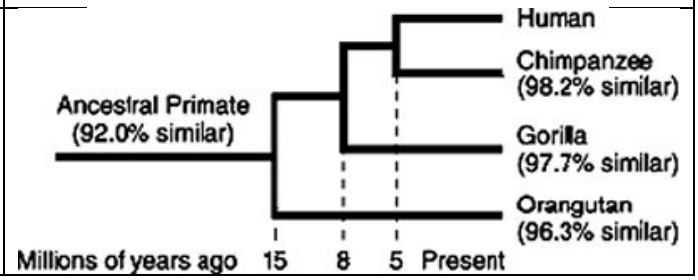
1. Snakes lack legs, but possess the remnants of a pelvis and leg bones (b). Identify the category of evidence for evolution, and explain how this is evidence for descent with modification:



2. The basic structures of all insect mouth parts are the same. In some insects these structures are enlarged and modified; in others, they are reduced and lost. In the grasshopper, they've been modified for biting and chewing. In the honeybee (B), they're for biting and chewing wax. In the butterfly, (C) they're for sipping nectar. In mosquitos (D), they've evolved into a tube for piercing skin. and sucking blood
Identify the category of evidence for evolution, and explain how this is evidence for evolution.



3. DNA similarities among primates. Identify the category of evidence for evolution, and explain how this is evidence for descent with modification:

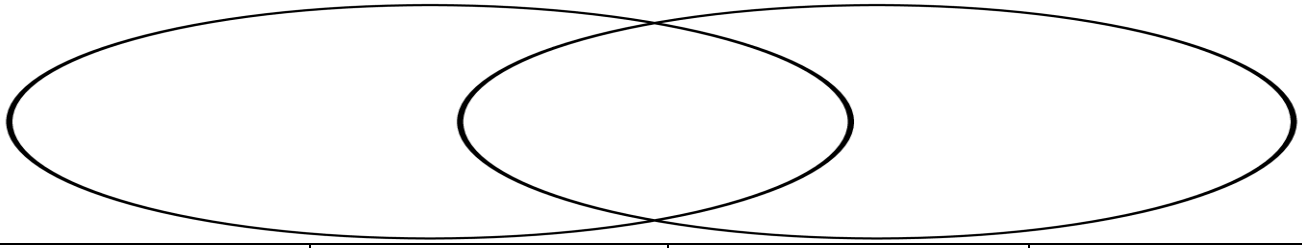


4. Charles Darwin published his book On the Origin of Species in 1859. Of the different types of evidence that you have examined, which do you think he relied upon the most, and why?

5. Given the amount of research and evidence available on evolution, why is it classified as a theory (as opposed to a hypothesis)

Part V. Checking Understanding

1. Compare and contrast **homologous** and **vestigial** structures



• *are similar because* • *have in common* • *difference between* • *on the other hand*	• *just like* • *in contrast* • *compared to* • *as opposed to*	• *a distinction between* • *share common attributes* • *synonymous with*	• *just as* • *whereas* • *by comparison*

Part VI. Conclusion

You've been hired by a local science museum to write an opinion piece explaining the evidence for evolution. Write your piece below.