

ACTIVITY

SCREEN 1

MAKING A CLADOGRAM

HOW DOES COMPARATIVE ANATOMY SHED LIGHT ON RELATIONSHIPS AND EVOLUTION?

For each animal below, **if** you think that animal **has** a particular set of traits, find that set in the “Box of Traits”, click on that set, and drag it to the animal. Repeat this for every trait listed that you think is found in that animal. If you want a **clue** for any **trait** or **animal**, just double click on it. If a set of traits does NOT belong to an animal, it will bounce back to the Box of Traits.

Repeat this for every animal. Click on “**Done**” when you feel you have made all possible matches. If you have overlooked any trait-animal matches, those animals will start flashing until you drag the missing traits to them.

Kangaroo	Lamprey	Rhesus Monkey	Snapping Turtle	Human	Bullfrog	Tuna Fish
----------	---------	------------------	--------------------	-------	----------	-----------

BOX OF TRAITS

<u>Set 1:</u> Dorsal nerve cord, Notochord	<u>Set 2:</u> Paired appendages, Backbone	<u>Set 3:</u> Paired legs, Five toes & fingers	<u>Set 4:</u> Amnion
<u>Set 5:</u> Mammary glands, Three ear-bones	<u>Set 6:</u> Placenta	<u>Set 7:</u> Foramen magnum forward	

DONE

When all animals have their respective sets of traits properly matched, the animals will re-sort so that the animal with the most matching traits will be first, and the animal with fewest matching traits will be last, according to the following chart.

SETS	TRAITS	Human	Rhesus	kangaroo	Turtle	Bullfrog	Tuna	Lamprey
1	Dorsal nerve cord, notochord	X	X	X	X	X	X	X
2	Paired appendages spinal column	X	X	X	X	X	X	
3	Paired legs, five fingers and toes	X	X	X	X	X		
4	Amnion, different types of teeth	X	X	X	X			
5	Mammary glands, 3 ear bones	X	X	X				
6	Placenta	X	X					
7	Foramen magnum forward	X						

HOT LINKS FOR PREVIOUS PAGE

Hot Links with clues to animals and traits: If an animal or set of traits is clicked, the following clues and information will appear in a sidebar box, as appropriate.

ANIMALS:

Kangaroo: A mammal that does not produce a placenta with its embryo, so the embryo is born prematurely, and must continue its development in its mother's pouch outside her body.

Lamprey: A long snake-shaped animal, with no appendages (no fins or legs). Lives and swims, mostly in lakes.

Rhesus Monkey: A placental mammal; walks and climbs on all four legs.

Snapping Turtle: A reptile, which lays soft-shelled eggs, as most reptiles do.

Human: A placental mammal which walks erect (so its head sits directly on top of its spinal column).

Bullfrog: An amphibian, with four legs and 5-fingered toes; lays jelly-coated eggs in water ponds.

Tuna: A fish, with paired pectoral and pelvic fins for swimming in the ocean.

TRAITS:

Set 1: Dorsal Nerve Cord: A spinal cord that runs down the back of an animal, attached to its brain at one end.
Notochord: A stiffening rod made of cartilage which runs down the back of an animal embryo; eventually replaced by the spinal column (vertebrae) in most animals.

Set 2: Paired Appendages: Limbs (arms, legs, fins, wings) are found in pairs.
Backbone: The spinal column (made of a series of boney vertebrae) which runs down the back.

Set 3: Paired Legs: Limbs (at least one pair) are used for walking/running on land.
Five-Fingers/Toes: Each appendage ends in 5 digits (at least in the embryo).

Set 4: Amnion: A membranous sac which surrounds an embryo (in a shelled egg, or in the uterus)

Set 5: Mammary Glands: Glands which secrete milk to nourish the newborn.
Three Ear Bones: In each ear, the 3 bones which transfer sound waves to the inner ear.

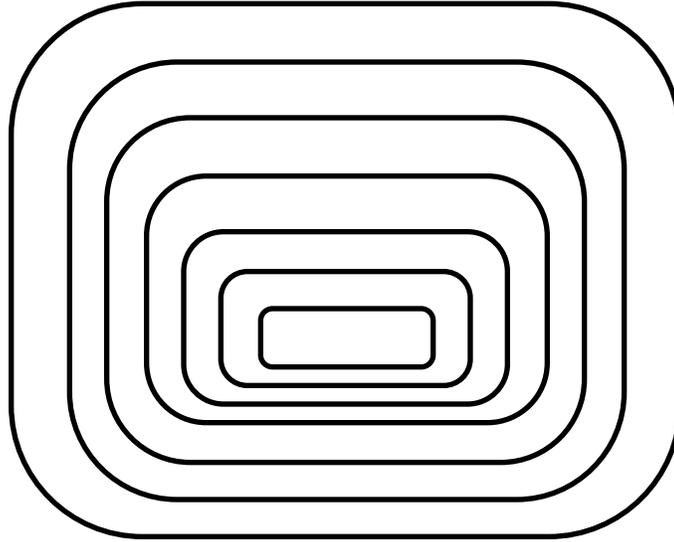
Set 6: Placenta: A mass of tissue produced by an embryo and its mother through which nourishment and oxygen are exchanged with wastes from the embryo.

Set 7: Foramen Magnum Forward: The large opening in the base of the skull through which the spinal cord passes, and to which the spinal column attaches; forward position is well underneath the skull rather than to the rear (back) of the skull.

SCREEN 2

A. From this sorted list, it should be easy to place the animals in their proper places in a Venn diagram, showing that the animal in the **innermost** circle has **all** the traits of the others, plus one more trait **not** shared with the others. Click and drag the name of that animal to the **inner** circle.

Human Monkey Kangaroo Turtle Bullfrog Tuna Fish Lamprey



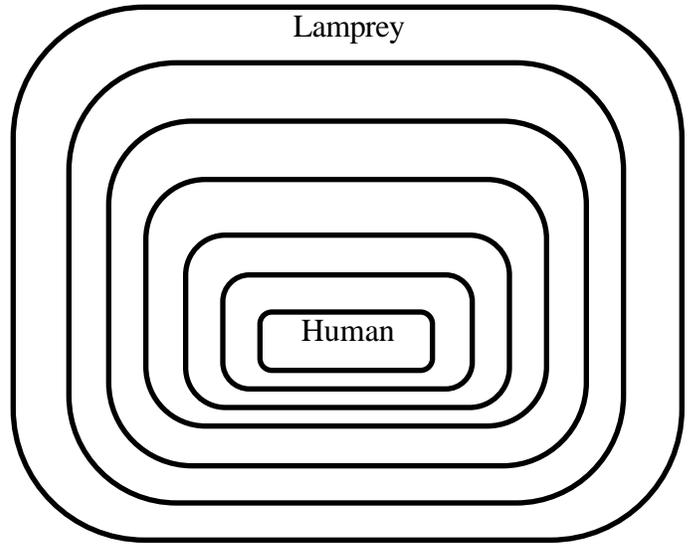
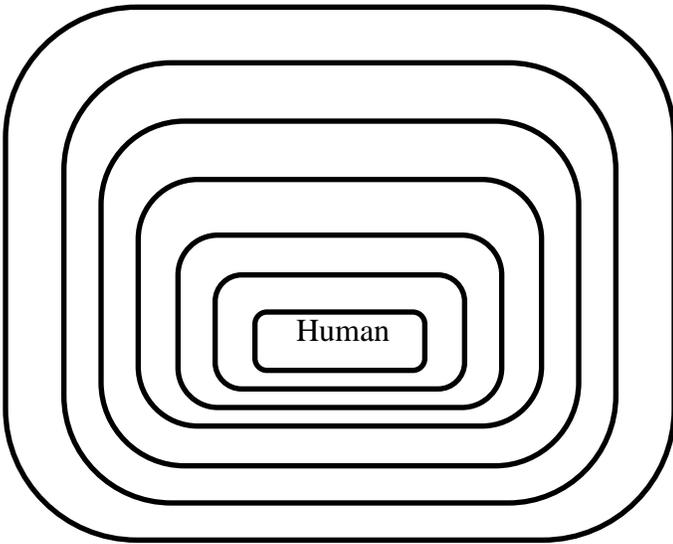
B. The animal in the **outermost** circle has only **one** trait shared with all the others, and **none** of the other traits. Drag that animal to the **outer** circle, so it is not in any of the other rings.

C. Click and drag the name of each remaining animal to its appropriate ring.

These are the results expected with each step of the instructions above:

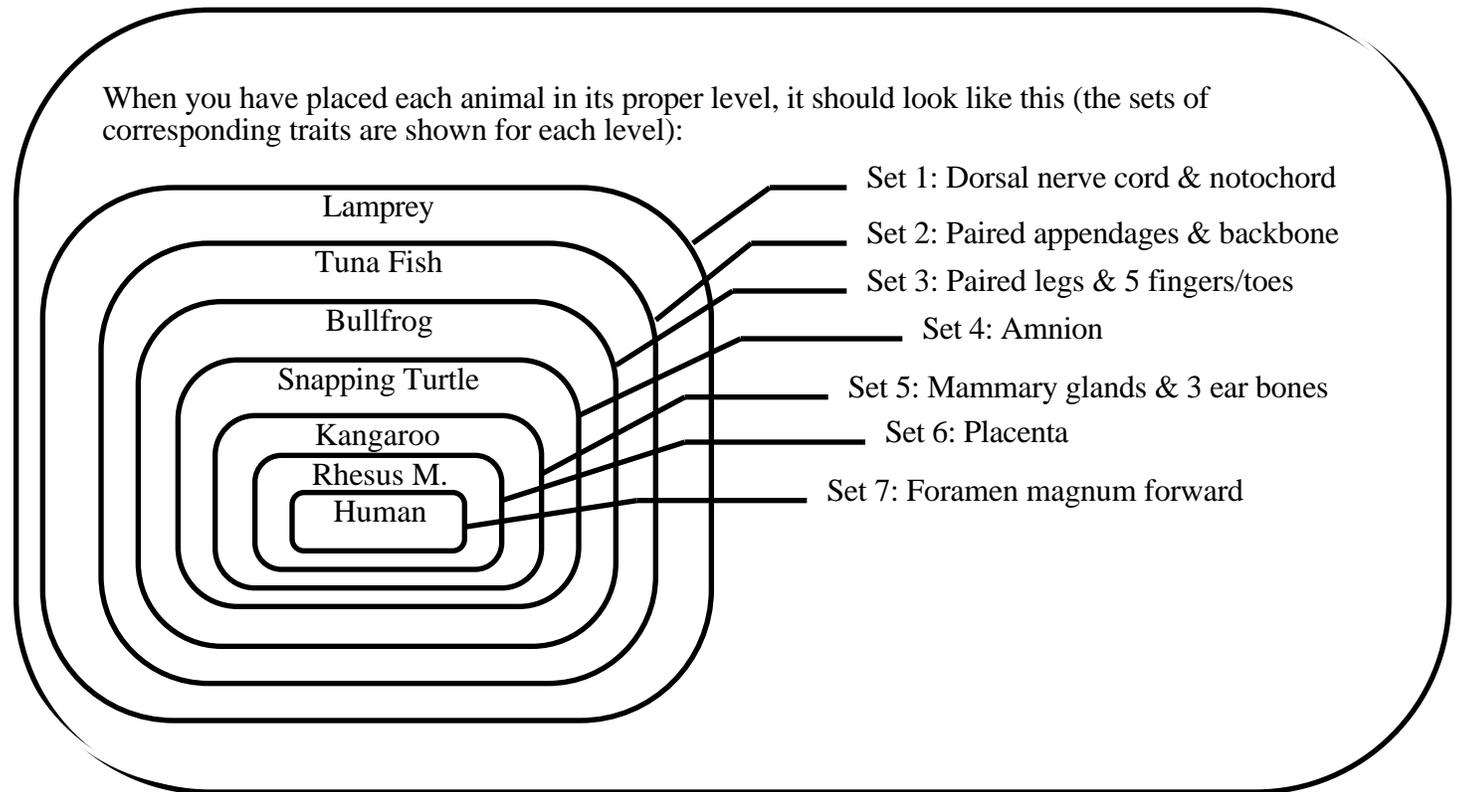
A.

B.



SCREEN 3

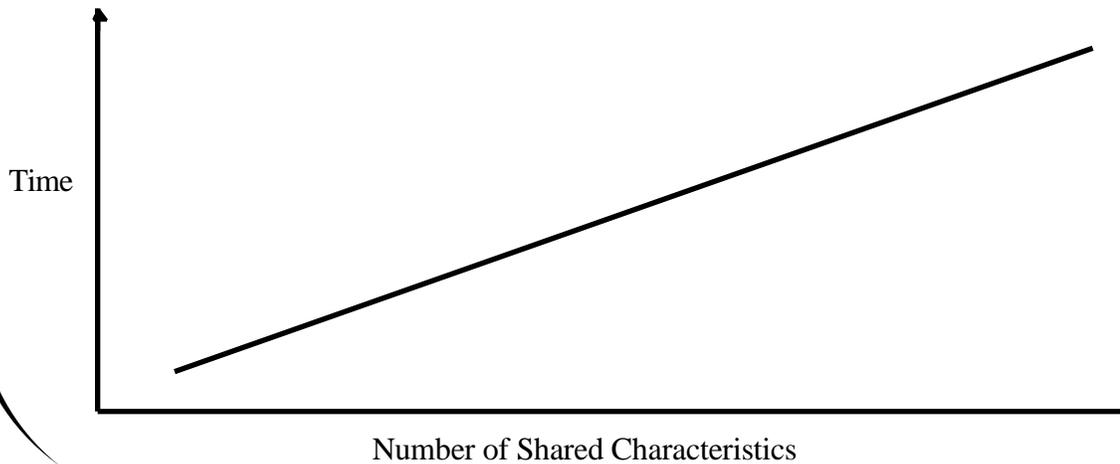
When you have placed each animal in its proper level, it should look like this (the sets of corresponding traits are shown for each level):



SCREEN 4

Biologists typically show these same relationships in a simple branching tree diagram called a **cladogram**. The cladogram summarizes the sequence in which selected traits first appeared, and indicates when particular combinations of traits gave rise to groups we recognize today as major groups, with those traits as their definitive hallmark.

A cladogram is generally formed by first drawing a diagonal line rising from left to right (representing **time** moving closer to the present as it rises, and increasing numbers of shared characteristics accumulating from left to right)...like this:



SCREEN 5

Beginning with the **most highly represented** trait (or set of traits), drag the box with those traits so that its arrow points to a point near the **lower** left end of the diagonal. This will place a small square dot representing the first appearance of that trait or set of traits on the diagonal at that point. Now drag the box with the **least represented** traits so it points to a point just short of the **upper** end of the line. In like manner, click and drag each of the remaining boxes of traits to their relative positions between the two extreme points which reflect the relative number of animals possessing each set of traits. Try to space them out as evenly as you can.

<-- Set 1. Dorsal nerve cord, notochord

<-- Set 5. Mammary glands, 3 ear bones

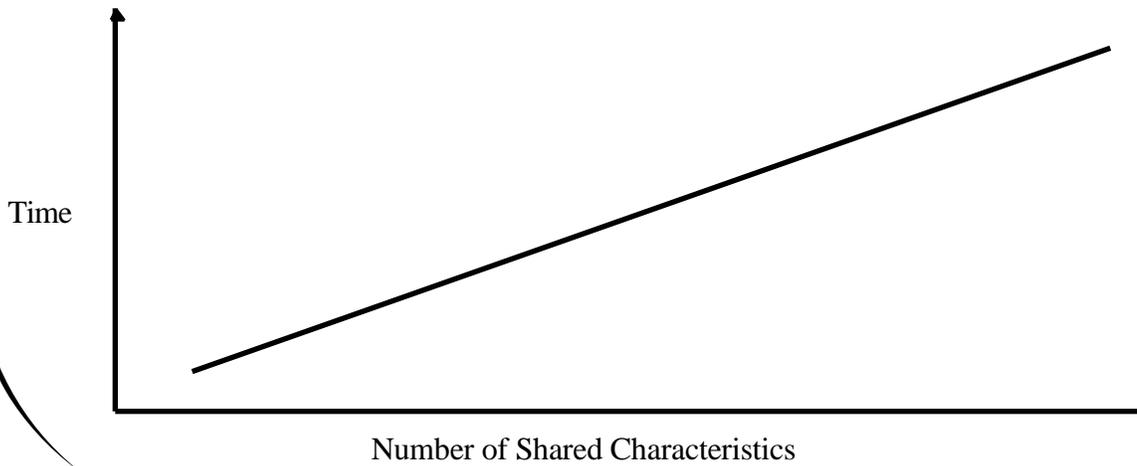
<-- Set 2. Paired append., backbone

<-- Set 6. Placenta

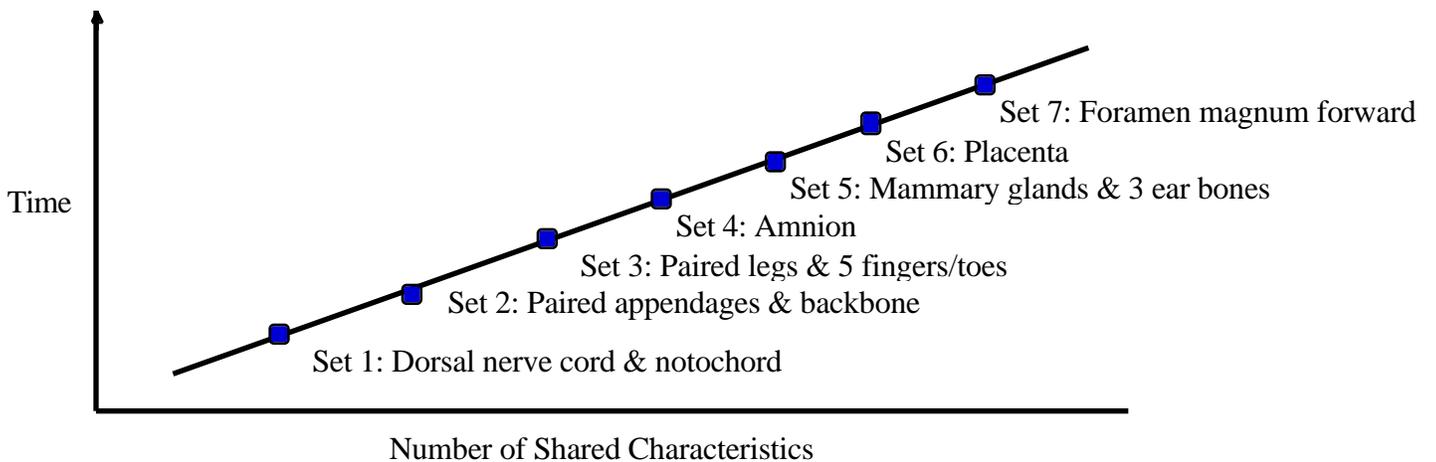
<-- Set 3. Paired legs, 5 fingers/toes

<-- Set 7. Foramen magnum forward

<-- Set 4. Amnion



This is what the cladogram should look like at this point:



SCREEN 6

Finally, we infer from this that each of the animals (or actually the group to which each belongs) branched off this diagonal at a point just **after** the set of traits that group possesses first appeared, and **before** the first appearance of the next set of traits (which it does NOT possess).

Human

Monkey

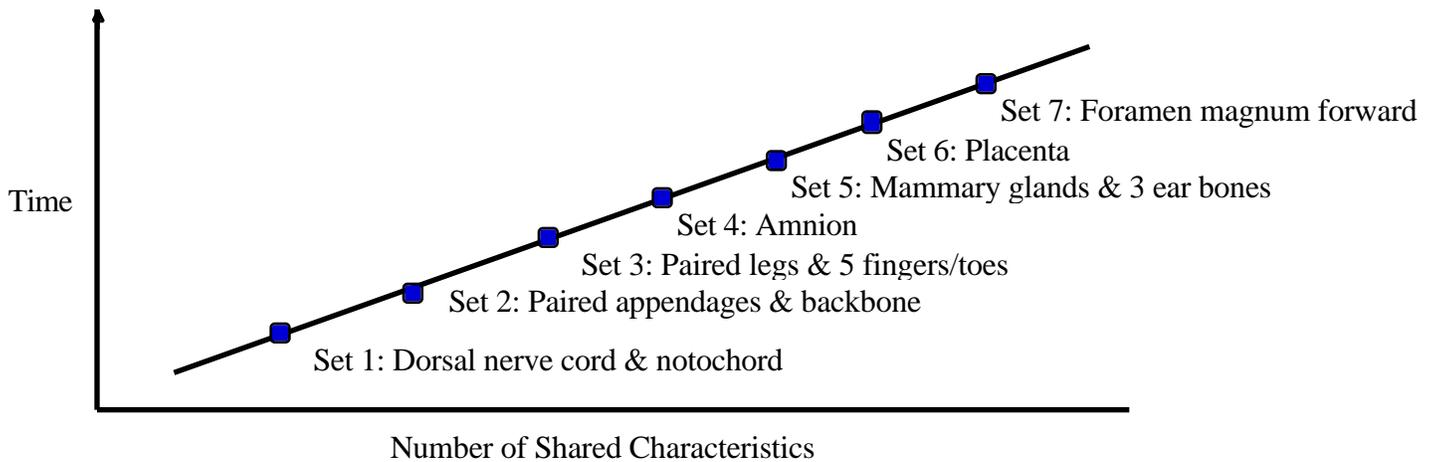
Kangaroo

Turtle

Bullfrog

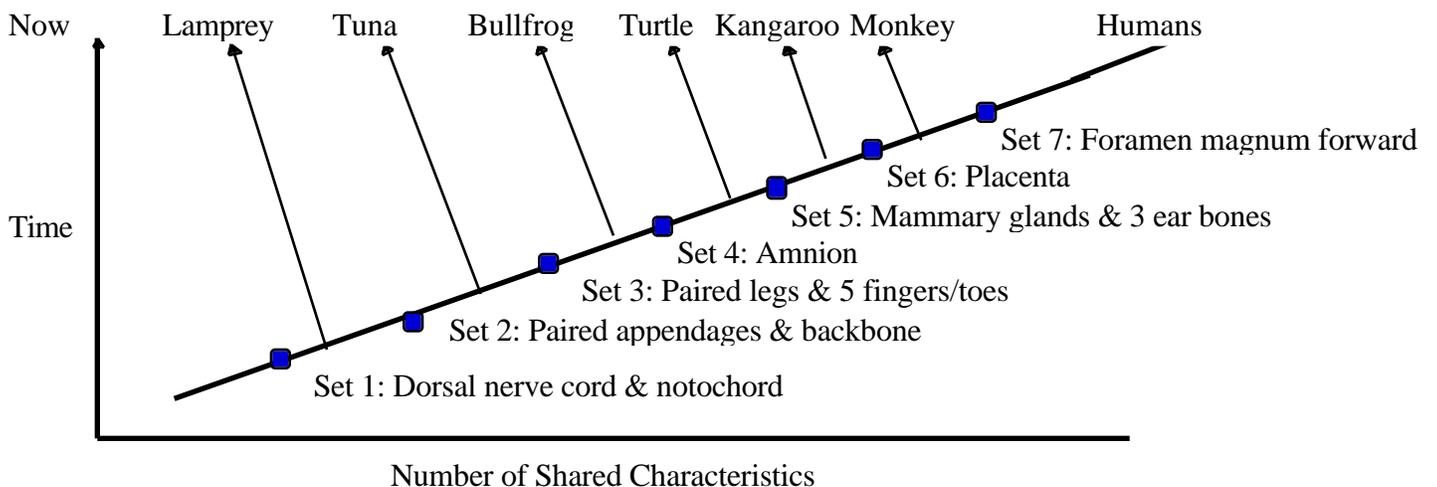
Tuna Fish

Lamprey



To show this, drag each animal box to its appropriate location on the diagonal. If you've dropped it in the proper space, you will see a line grow up from that point to a position at the "now" level in time.

When completed, it will look like this:



[PROGRAMMING NOTE: As each animal name is dragged to its position on the line, it should bounce up to the position shown here, and an arrow grows up from the diagonal to meet it, as shown here.]

SCREEN 7

CHECK YOUR UNDERSTANDING:

1. What types of information can be obtained from a cladogram?:
 - A) probable relationships;
 - B) probable sequence of origins;
 - C) shared derived characters;
 - D) when each trait or group of traits first appeared;
 - E) all the above;
 - F) all but D;
 - G) none of these
2. If the cladogram just constructed is correct, the **fossil** record should show that **different** groups of vertebrate animals...
 - A) first appeared at different times, each with new traits added to earlier existing traits
 - B) first appeared at different times, each with totally new combinations of traits
 - C) appeared at different times, with no particular pattern of trait appearance
 - D) all appeared at about the same time; the cladogram simply exaggerates that time frame
 - E) all appeared at about the same time, each with its own unique traits

CLICK HERE FOR THE FINAL CHECK QUESTION

The answer to #1 is F.

If F is selected, respond with "Very perceptive...nice going!"

If A, B, or C are selected, respond with "Partly....try again"

If E is selected, respond with "Not quite....try again"

If G is selected, respond with "Way off...give it another shot"

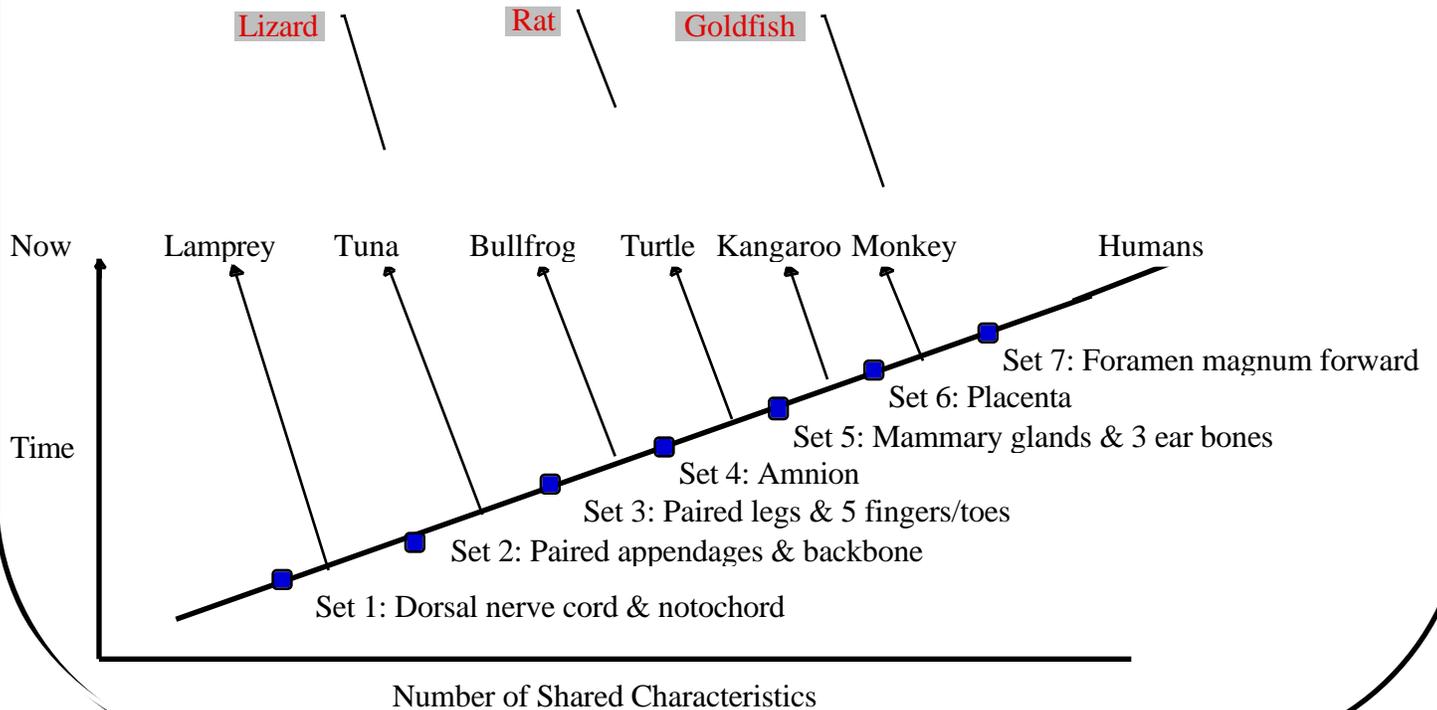
The answer to #2 is A

If A is selected, respond with "You've got it....and the fossil record, clearly and consistently, does show this."

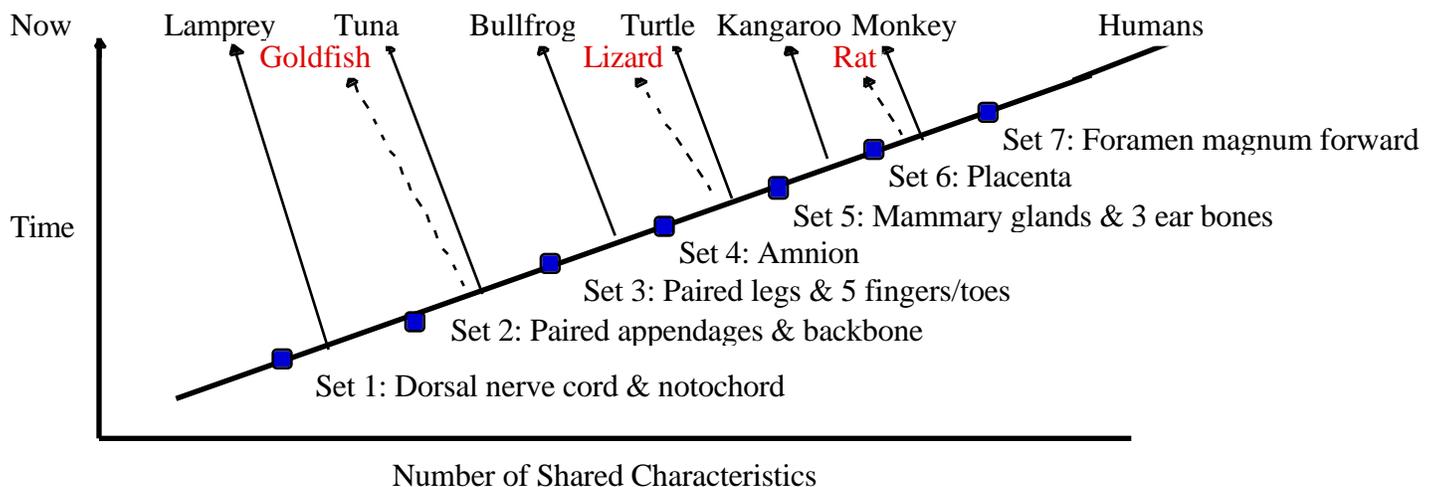
If any other item is selected, respond with "Not really....try again"

SCREEN 8

3. **Extension:** Three previously unknown vertebrates have been discovered in a rain forest in South America. One animal is similar to an iguana **lizard**. The second animal resembles a large **rat**. The third looks like a **goldfish**. These three “discoveries” are shown below. To check your understanding of the cladogram concept, click on each animal in turn, and drag it to a position on the cladogram where you think it should branch. If it “bounces” back, try again, at another location on the main diagonal.



Expected Results of Doing #3:



The “Goldfish” line could branch anywhere between Set 2 and Set 3 traits, or even from the line leading to “Tuna”. This is because a goldfish has the same basic “fish” traits as a tuna.

The “Lizard” line could branch anywhere between Set 4 and Set 5 traits, or even from the line leading to “Turtle”. This is because a lizard has the same basic “reptile” traits as a turtle.

The “Rat” line could branch anywhere between Set 6 and Set 7 traits, or even from the line leading to “Monkey”. This is because a rat has the same basic “placental mammal” traits as a monkey.