Norfolk Public Schools
Science Learning in Place Plan: Biology Lessons

Week 4: April 6 – 10, 2020

Monday	Tuesday	Wednesday	Thursday	Friday
Structural Similarities & Fossil Rock Interpretation Assignments: • **Read** the article entitled, "Evidence for Evolution Part 1" • **Use** *Critical Reading Strategies* to make note of the key points in the passage.	**Structural Similarities & Fossil Rock Interpretation** Assignments: • **Reread** the article entitled, "Evidence for Evolution Part 1" • **Complete** the Evidence for Evolution graphic organizer provided. **Add** 2 new words you did not know from the passage to the organizer as well.	**Structural Similarities & Fossil Rock Interpretation** Assignments: • **Read** the article entitled, "Humanity on the Record" • **Answer** the six "Humanity on the Record Reading Comprehension Questions"	**Structural Similarities & Fossil Rock Interpretation** Assignments: • **Reread** the article entitled, "Humanity on the Record" • **Answer** the three questions on Lesson Review A in complete sentences and support your response with specific details from the text.	**Structural Similarities & Fossil Rock Interpretation** Assignments: • **Review** this week's articles • **Answer** the four questions on Lesson Review B and justify each.

Week 5: April 13 – 17, 2020

Monday	Tuesday	Wednesday	Thursday	Friday
Spring Break				

Week 6: April 20 – 24, 2020

Monday	Tuesday	Wednesday	Thursday	Friday

Developmental Stages
Assignments:
• **Read** the article entitled, "Evidence for Evolution Part 2"
• **Use** Critical Reading Strategies to make note of the key points in the passage.
	Developmental Stages
	Assignments:
	• **Reread** the article entitled, "Evidence for Evolution Part 2"
	• **Complete** the Evidence for Evolution graphic organizer provided. **Add** 3 new words you did not know from the passage to the organizer as well.
		Developmental Stages
		Assignments:
		• **Read** the article entitled, "How Does Embryology Provide Evidence for Evolution?"
		• **Create** a 6-question multiple choice quiz and quiz a member of your family after they read the article. It should include:
		  ○ 4 answer choices for each question with one right answer
		  ○ At least one question for each section of the text
			Developmental Stages
			Assignments:
			• **Reread** the article entitled, "How Does Embryology Provide Evidence for Evolution?"
			• **Write** a claim to support the evidence for evolution you think is the most valuable for understanding the past.
			  ○ Why is this evidence valuable?
			  ○ What have you or the world gained from using this evidence?
			• Support your response with specific details from the texts you've read the last two weeks and your own research if possible.
				Developmental Stages
				Assignments:
				• **Review** this week's articles
				• **Answer** the four questions on How Does Embryology Provide Evidence for Evolution? Lesson Review and justify each.

CRITICAL READING *strategies*

Marking the Text

- # Number the paragraphs
- Circle key terms
- Underline essential info
  (...based on the reading purpose)
- Box new vocab words
  (...and define them in the margins)

Additional Ways to Mark the Text

- [Bracket] information
  (when underlining has been used for another purpose)
- Write labels in the margins
  (double underline labels to stand out from other marks)

Evidence of Evolution - Part 1

Introduction

Evolution is a key unifying principle in biology. As Theodosius Dobzhansky once said, “Nothing in biology makes sense except in the light of evolution. But what, exactly, are the features of biology that make more sense through the lens of evolution? To put it another way, what are the indications or traces that show evolution has taken place in the past and is still happening today?

Evolution happens on large and small scales

Before we look at the evidence, let's make sure we are on the same page about what evolution is. Broadly speaking, **evolution** is a change in the genetic makeup (and often, the heritable features) of a population over time. Biologists sometimes define two types of evolution based on scale:

- **Macroevolution**, which refers to large-scale changes that occur over extended time periods, such as the formation of new species and groups.
- **Microevolution**, which refers to small-scale changes that affect just one or a few genes and happen in populations over shorter timescales. Microevolution and macroevolution aren’t really two different processes. They’re the same process – evolution – occurring on different timescales. Microevolutionary processes occurring over thousands or millions of years can add up to large-scale changes that define new species or groups.

The evidence for evolution

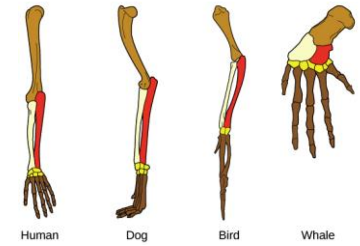
In this article, we'll examine the evidence for evolution on both macro and micro scales. First, we'll look at several types of evidence (including physical and molecular features, geographical information, and fossils) that provide evidence for, and can allow us to reconstruct, macroevolutionary events.

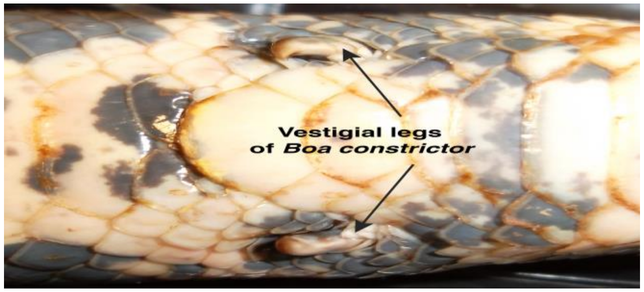
Homologous features

If two or more species share a unique physical feature, such as a complex bone structure or a body plan, they may all have inherited this feature from a common ancestor. Physical features shared due to evolutionary history (a common ancestor) are said to be **homologous**.

To give one classic example, the forelimbs of whales, humans, birds, and dogs look pretty different on the outside. That's because they're adapted to function in different environments. However, if you look at the bone structure of the forelimbs, you'll find that the pattern of bones is very similar across species. It's unlikely that such similar structures would have evolved independently in each species, and more likely that the basic layout of bones was already present in a common ancestor of whales, humans, dogs, and birds.

The similar bone arrangement of the human, bird, and whale forelimb is a structural homology. Structural homologies indicate a shared common come homologous structures can be seen only in embryos. For instance, all vertebrate embryos (including humans) have gill slits and a tail during early development. The developmental patterns of these species become more different later on (which is why your embryonic tail is now your tailbone, and your gill slits have turned into your jaw and inner ear). Homologous embryonic structures reflect that the developmental programs of vertebrates are variations on a similar plan that existed in their last common ancestor.





The small leg-like structures of some snake species, like the *Boa constrictor* , are vestigial structures. These remnant features serve no present purpose in snakes but did serve a purpose in the snakes' tetrapod ancestor (which walked on four limbs). Sometimes, organisms have structures that are homologous to important structures in other organisms but that have lost their major ancestral function. These structures, which are often reduced in size, are known as **vestigial structures**. Examples of vestigial structures include the tailbone of humans (a vestigial tail), the hind leg bones of whales, and the underdeveloped legs found in some snakes.

Analogous features

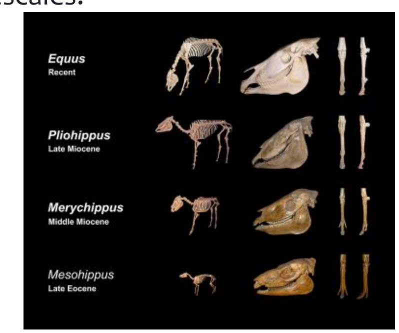
To make things a little more interesting and complicated, not all physical features that look alike are marks of common ancestry. Instead, some physical similarities are **analogous**: they evolved independently in different organisms because the organisms lived in similar environments or experienced similar selective pressures. This process is called **convergent evolution**. (To *converge* means to come together, like two lines meeting at a point). For example, two distantly related species that live in the Arctic, the arctic fox and the ptarmigan (a bird), both undergo seasonal changes of color from dark to snowy white. This shared feature doesn't reflect common ancestry – i.e., it's unlikely that the last common ancestor of the fox and ptarmigan changed color with the seasons. Instead, this feature was favored separately in both species due to similar selective pressures. That is, the genetically determined ability to switch to light coloration in winter helped both foxes and ptarmigans survive and reproduce in a place with snowy winters and sharp-eyed predators.

Determining relationships from similar features

In general, biologists don't draw conclusions about how species are related on the basis of any single feature they think is homologous. Instead, they study a large collection of features (often, both physical features and DNA sequences) and draw conclusions about relatedness based on these features as a group. We will explore this idea further when we examine phylogenetic trees.

Fossil record

Fossils are the preserved remains of previously living organisms or their traces, dating from the distant past. The fossil record is not, alas, complete or unbroken: most organisms never fossilize, and even the organisms that do fossilize are rarely found by humans. Nonetheless, the fossils that humans have collected offer unique insights into evolution over long timescales.



Earth's rocks form layers on top of each other over very long time periods. These layers, called strata, form a convenient timeline for dating embedded fossils. Strata that are closer to the surface represent more recent time periods, whereas deeper strata represent older time periods.

How can the age of fossils be determined? First, fossils are often contained in rocks that build up in layers called **strata**. The strata provide a sort of timeline, with layers near the top being newer and layers near the bottom being older. Fossils found in different strata at the same site can be ordered by their positions, and "reference" strata with unique features can be used to compare the ages of fossils across locations. In addition, scientists can roughly date fossils using radiometric dating, a process that measures the radioactive decay of certain elements.

Fossils document the existence of now-extinct species, showing that different organisms have lived on Earth during different periods of the planet's history. They can also help scientists reconstruct the evolutionary histories of present-day species. For instance, some of the best-studied fossils are of the horse lineage. Using these fossils, scientists have been able to reconstruct a large, branching "family tree" for horses and their now-extinct relatives^66start superscript, 6, end superscript. Changes in the lineage leading to modern-day horses, such as the reduction of toed feet to hooves, may reflect adaptation to changes in the environment.

Evidence of Evolution - Part 1

Graphic Organizer			
Evidence of Evolution	Definition/Notes	Picture	Multiple Choice Question
Homologous features			
Analogous features			
Fossil record			
New Word #1 ______________			
New Word #2 ______________			

Humanity on the Record

In the summer of 2012, paleontologists working on a fossil excavation in Kenya announced that the human race, as we know it, was never alone. Scientists unveiled pieces of skull and bone that are approximately 2 million years old. Their discovery confirmed what earlier fossil findings had introduced as a possible piece of the human origin story: that humankind is merely one of a number of human-like species, each with its own lifespan. Every other species has been long extinct, making *Homo sapiens*, our species, the sole surviving member of the extended human family. Indeed, these findings have confirmed that the family was bigger than anyone had previously imagined.

In conversations about prehistoric evolution, whether humans evolved from apes, is a common but misleading question. Evolution, at its core, is a process that spawns a diversity of species. Some are quite similar and some are quite different. Some strains of evolution take place over millions of years, while other strains (for example, microorganisms that pass through multiple generations in the span of a day) take place over a number of months, even weeks. To track the evolution of various organisms over time is to reveal the natural world's knack for never putting all of its bones in one basket, so to speak.

**Dating Prehistoric Man:
Not as Awkward as It Sounds**

A more revealing question, then, is scientists' inquiry into multiple branches of the *Homo* genus. Assembling a "fossil record" over the course of two centuries, scientists have amassed enough evidence to date the earliest known appearance of *Homo sapiens* to about 200,000 years ago. Their research has also proven that a number of human-like species preceded and accompanied *Homo sapiens* on the prehistoric timeline.

The creation and preservation of an accurate fossil record is no easy task. Bones dug up from the ground don't often offer much information about their own age, so paleontologists have developed several methods to analyze the earth surrounding those bones instead. By inspecting the proximity of a fossil, one can figure out approximately (sometimes precisely) when the fossil itself was actually a living organism.

Radiometric dating—the use of technology to detect radioactive elements to identify the age of whatever those elements are in—is a precise but limited technique for determining the age of a fossil. The precision of radiometric dating comes from the fact that radioactive elements have clear, well-documented decay times (or how long it takes for traces of an element to disintegrate). Using this technique, scientists can narrow down the age of a fossil, even one that's over 50 million years old, to a very close estimate. Unfortunately, radiometric dating only works when radioactive elements were present in the first place.

The alternative method of dating fossils is stratigraphy. Based in the geographic study of layers of sediment that have stacked on top of each other for ages, stratigraphy includes a host of techniques for analyzing these various layers to determine the age of objects found wedged within them. Simply put: If people find a fossil between two layers of dirt, and they know how old those layers of dirt are, they can then say the fossil was part of a living creature between those dates. Stratigraphy can be difficult to execute in the study of fossils, since dirt doesn't always stack up in neatly preserved layers. There are often interruptions in the layers or portions of sediment that ended up being mixed together or eroded. Furthermore, the precision of this technique is said to be relative. Every estimate based on stratigraphic analysis depends on a comparison between other samples and other estimates.

Yet, by reviewing each other's evidence and sharing their findings, researchers are able to make reasonable confirmations of the global fossil record. Radiometric dating and stratigraphic dating are used to establish prehistoric records of fossils. Those records are then used to build a logical timeline for the evolution of many species. When new fossils are dug up, a fossil record spanning the ages is there to help scientists figure out where their new discoveries fit into the stories of the earth.

To Err Is Human; to Evolve Is Much More

One of the most fascinating stories, of course, is the prehistory of the human race. The National Museum of Natural History puts it eloquently: "While people used to think that there was a single line of human species, with one evolving after the other in an inevitable march towards modern humans, we now know this is not the case. Fossil discoveries show that the human family tree has many more branches and deeper roots than we knew about even a couple of decades ago."

Presenting an interactive display of humanity's prehistory, the museum identifies over 15 different species related to humankind. The fossil record reaches back over 6 million years, marking the earliest known appearance of a primate species that walked upright. Two million years later, the record proves the existence of *Australopithecus Anamensis*, a bipedal species that was equally adept at walking upright and climbing trees.

Homo habilis, whose fossils date back 2 million years ago, was the earliest known species of the *Homo* genus. The age of *Homo habilis* closely follows the first known appearance of stone tools. It also coincides with the existence of at least three other human-like species, ape-like creatures that also walked upright. The stone tools discovered from these years were likely used by all of the species, following evolutionary paths that were similar but far from identical.

Even *Homo sapiens*, the species encompassing every human being on the planet right now, were accompanied by similar species. To be exact, at least four other human species have been added to the fossil record for the past million years. The simultaneous existence of *Homo erectus* and *Homo heidelbergensis*, *Homo floresiensis* and *Homo neanderthalensis* covers a period when the human races developed much larger brains and began to form the basis for modern civilization.

One by one, the other races have gone extinct. The hypothesized reasons range from an inability to adapt to climate change to murder at the hands of more advanced humans. Disease, physical disadvantages, and natural disaster have been discussed as possible causes. Some scientists argue that Neanderthals may have bred with early populations of modern humans, changing the record of their extinction to one of possible assimilation.

Thus, precise causes for the ascendency of *Homo sapiens* have yet to be proven. The fact that fossils represent less than 5% of all known living species in the history of the world makes it very difficult for even the brightest paleontologists to gather enough evidence to answer all the questions they have about the origins of man. What the world has gained through their work, though, is less a story of primates transforming into humans than it is the story of humanity's many extinguished flames. At the moment, our human race carries the torch for millions of years of evolution—among species, across continents, and through the ages.

Humanity on the Record

Reading Comprehension Questions

1. What are Homo sapiens? **A.** the use of technology to detect radioactive elements **B.** a fossil record that covers two centuries **C.** our species, the human race **D.** a species that has gone extinct	**2. What is this passage mostly about?** **A.** the appearance and behavior of Homo heidelbergensis **B.** the question of whether humans evolved from apes **C.** the use of radiometric dating to determine the age of fossils **D.** the development and fossils of prehistoric humans
3. Fossils can provide information about the history of humankind. What evidence from the passage supports this statement? **A.** "Assembling a 'fossil record' over the course of two centuries, scientists have amassed enough evidence to date the earliest known appearance of Homo sapiens to about 200,000 years ago." **B.** "At the moment, our human race carries the torch for millions of years of evolution among species, across continents, and through the ages." **C.** "Some scientists argue that Neanderthals may have bred with early populations of modern humans, changing the record of their extinction to one of possible assimilation." **D.** "The simultaneous existence of Homo erectus and Homo heidelbergensis, Homo floresiensis and Homo neanderthalensis covers a period when the human races developed much larger brains and began to form the basis for modern civilization."	**4. Read the following sentence: "If people find a fossil between two layers of dirt, and they know how old those layers of dirt are, they can then say the fossil was part of a living creature between those dates." What does the word fossil mean in the sentence above?** **A.** the slow development of a species over time **B.** part of a living thing that has died and remained in the ground for a long time **C.** a method that scientists use to determine the age of bones they find in the ground **D.** an early human-like species that walked upright and probably used stone tools
5. What sequence of events does this passage describe? **A.** This passage describes the daily routine of Homo neanderthalensis and Homo heidelbergensis. **B.** This passage describes the appearance and disappearance of different species related to humans. **C.** This passage describes the steps that paleontologists took to find pieces of human skull and bone in Kenya. **D.** This passage describes the assembly of a fossil record that dates Homo sapiens to about 200,000 years ago.	**6. Imagine that a group of scientists has just dug up a fossil. What would probably give them the most information about the age of that fossil?** **A.** the fossil itself **B.** the earth around the fossil **C.** the air around the fossil **D.** the water around the fossil

Humanity on the Record
Lesson Review

Lesson Review A

Directions: Answer the following questions in complete sentences.

1. What did scientists discover on a 2012 fossil excavation in Kenya?

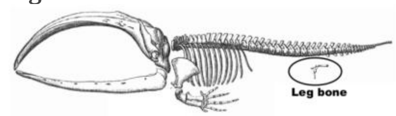
2. What did this discovery tell scientists?

3. Explain how fossils can teach scientists about the development of humans. Support your answer with an example from the passage.

Lesson Review B

Directions: Please justify your answers by providing the specific details from the passages you read this week.

1. What best describes the hind leg bones seen in the whale?

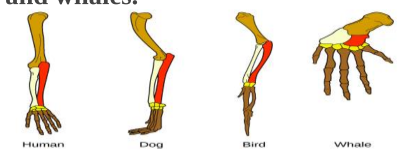


A. Vestigial structures that had a function in an ancestor
B. Fossil structures from an extinct ancestor
C. Analogous structures to the fins of living fish
D. Homologous structures to the wings of butterflies

2. How do fossils support evolution?

A. The fossil record provides evidence that organisms have changed over time.
B. Individual species disappear and reappear in the fossil record over time.
C. Organisms in the fossil record are identical to living organisms.
D. The fossil record provides evidence that all organisms developed at the same time.

3. Some organisms have features that have different functions, but similar structures. One example is the forelimb of humans, dogs, birds, and whales.



A. They are analogous.
B. They are embryological.
C. They are vestigial.
D. They are homologous.

4. Some snakes, like boa constrictors, have small non-functional leg bones near their tail ends. What term best describes the leg bones found in these snakes?

A. Vestigial structures
B. Homologous structures
C. Fossil structures
D. Analogous Structures

Evidence for Evolution Part 2

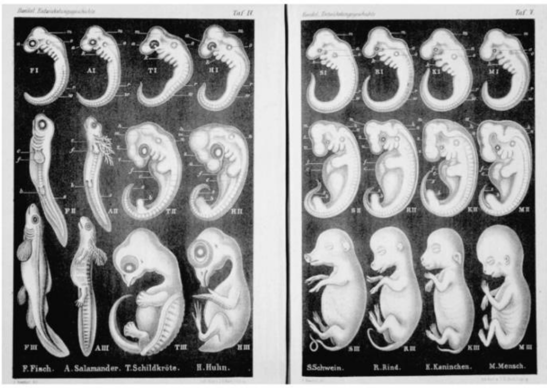
Key points:
Evidence for evolution comes from many different areas of biology:

- **Anatomy.** Species may share similar physical features because the feature was present in a common ancestor (**homologous structures**).
- **Molecular biology.** DNA and the genetic code reflect the shared ancestry of life. DNA comparisons can show how related species are.
- **Biogeography.** The global distribution of organisms and the unique features of island species reflect evolution and geological change.
- **Fossils.** Fossils document the existence of now-extinct past species that are related to present-day species.
- **Direct observation.** We can directly observe small-scale evolution in organisms with short lifecycles (e.g., pesticide-resistant insects).

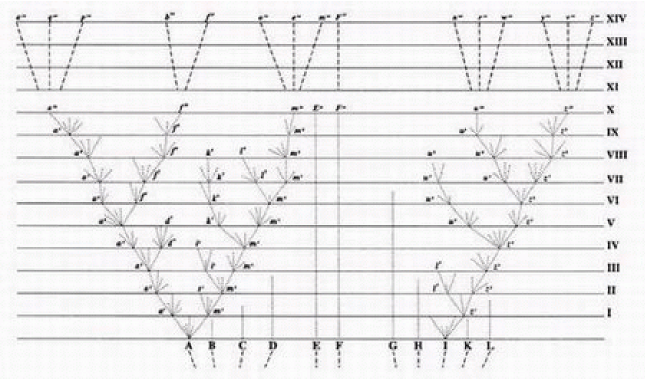
The evidence for evolution continued

Anatomy and embryology

Embryology, the study of the development of the anatomy of an organism to its adult form, provides evidence for evolution as embryo formation in widely-divergent groups of organisms tends to be conserved. Structures that are absent in the adults of some groups often appear in their embryonic forms, disappearing by the time the adult or juvenile form is reached. For example, all vertebrate embryos, including humans, exhibit gill slits and tails at some point in their early development. These disappear in the adults of terrestrial groups, but are maintained in adults of aquatic groups, such as fish and some amphibians. Great ape embryos, including humans, have a tail structure during their development that is lost by birth. Another example, all vertebrate embryos, from humans to chickens to fish, have a tail during early development, even if that tail does not appear in the fully developed organism.



Darwin thought of **evolution** as "descent with modification," a process in which species change and give rise to new species over many generations. He proposed that the evolutionary history of life forms a branching tree with many levels, in which all species can be traced back to an ancient common ancestor.



Branching diagram that appeared in Charles Darwin's *On the origin of species*, illustrating the idea that new species form from pre-existing species in a branching process that occurs over extended periods of time. In this tree model, more closely related groups of species have more recent common ancestors, and each group will tend to share features that were present in its last common ancestor. We can use this idea to "work backwards" and figure out how organisms are related based on their shared features.

Evidence of Evolution - Part 2

Graphic Organizer			
Evidence of Evolution	Definition/Notes	Picture	Multiple Choice Question
Embryology			
New Word #1 __________________			
New Word #2 __________________			
New Word #3 __________________			

How Does Embryology Provide Evidence for Evolution?

Updated May 28, 2019

By Dr. Mary Dowd

Evolution is the study of how different types of living organisms adapt and change over time. New species continually emerge while others go extinct in response to fluctuating environmental conditions. **Embryology** and evolution evidence work in tandem to support the theory that all life evolved from a common ancestor, possibly answering questions like why you had a tail before you were born.

Embryology and Evolution Questions

In the mid-1800s, **Charles Darwin** and **Alfred Wallace** independently concluded that inherited variations in traits, such as a bird's beak shape, may provide better odds of survival in a given niche. Organisms without the advantageous variation are less likely to survive and pass on their genes. Since the heyday of Darwinism, considerable scientific evidence has emerged supporting the theory of evolution, including embryology, although the mechanisms of mutation and change are more complex than previously understood.

Understanding the Theory of Evolution

Theories, such as the theory of evolution, are evidence-based ideas widely held by the scientific community. According to Charles Darwin in *Origin of the Species*, organisms descend and diversify from one common ancestor. Organisms change and adapt over time as a result of inherited physical and behavioral characteristics that are passed down from parent to offspring.

Through the process of natural selection and survival of the fittest, certain traits are more likely to be inherited than other traits.

What Is Embryology?

Embryology is the study and analysis of embryos. Evidence of an evolutionary common ancestor is seen in the similarity of embryos in markedly different species. Darwin used the science of embryology to support his conclusions. Embryos and the development of embryos of various species within a class are similar even if their adult forms look nothing alike. For instance, chicken embryos and human embryos look similar in the first few stages of embryonic development. These early similarities are attributed to the 60 percent of protein-coding genes that humans and chickens inherited from a common ancestor.

Embryology and Evolution History

Evolutionary developmental biology ("evo-devo") dates back to **Alexander Kowalevsky**'s discovery in the 19th century that embryonic stages of development aid in the classification of organisms. Kowalevsky suggested that sea squirts called tunicates should be classified as chordates instead of mollusks because tunicate larvae have notochords and form neural tubes, making them more like chordates and vertebrate embryos. DNA analysis of the tunicate genome has since proven Kowalevsky correct. German scientist **Ernest Haeckel** is known for the ideas of "biogenetic law" and "ontogeny recapitulates phylogeny." Haeckel's drawings of embryos suggested that an organism recapitulates (repeats) stages of its evolutionary history during embryonic stages of development. Haeckel's controversial comparative embryology drawings released in 1874 showed a developing human embryo passing through stages that resembled different animals, such as embryonic fish, chickens and rabbits. The notion of recapitulation drew plenty of critics, notably **Karl von Baer**, who also took a disliking to Darwin's ideas. Embryologist von Baer stressed the differences between vertebrate and invertebrate embryonic development that refuted Haeckel's conclusions. Modern evo-devo experts like **Michael Richardson** agree there are similarities in the embryonic development of related species, but mainly at the molecular level.

Embryology Evolution Evidence

Darwin's theory of biological evolution noted that all vertebrates have gill slits and tails in early stages of embryo formation, even though these features may be lost or modified in the adult-form phenotype. For instance, human embryos have a tail that becomes the tail bone. This pattern indicates that all vertebrates stem from a common ancestor that developed that way, and everything diverged from there.

Embryology Evolution Examples

Many embryology and evolution questions can be answered through the study of comparative anatomy. Homologous structures in embryonic development suggest that ancestral structure was maintained as things diversified.

Examples found in comparative anatomy include the forelimbs of humans and the flippers of a whale, which supports the idea of common descent. Although a human arm and bat wing look different, the process of embryonic development is similar.

How Does Embryology Provide Evidence for Evolution?
Lesson Review

Directions: Justify your answers to the following questions:

1. The presence of gill slits in a human embryo suggests that

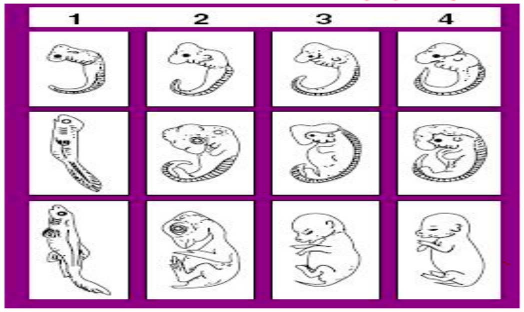
- **A.** humans and fish shared a common ancestor.
- **B.** humans once lived in the seas.
- **C.** humans once used gills to breathe.
- **D.** all of the above.

2. ___________ is the study of embryos to see how their similarities and differences indicate an evolutionary relationship.

- **A.** Paleontology
- **B.** Homologous structure
- **C.** Common ancestry
- **D.** Embryology

3. The above chart shows vertebrate embryo development. Which of these would be least related to the others?

- **A.** 1
- **B.** 2
- **C.** 3
- **D.** 4



4. The most recent ancestral form or species from which two different species evolved is known as ____________________.

- **A.** a common ancestor.
- **B.** an embryonic stage.
- **C.** development.
- **D.** evolution.