Task 1: Prediction

Learning Target: I can create a timeline for the history of life on Earth indicating the beginning of life.

The study of life is known as biology. Scientists who study life, biologists, have noticed that most living things on Earth have similarities. However life has not always looked the way it does today. Fish fossils are found in desert sands, and large fossilized skeletons tell us about dinosaurs that roamed the Earth millions of years ago. Where and how did life begin? Why did it change? We can look at life and fossils today and organize them into a timeline, a History of Life on Earth.

In your group, you will first make a prediction about the sequence of events by arranging the environment and organism cards in order. Place earlier events on the left-hand side and later events on the right hand side. Provide a justification for your choices.
Record your timeline sequence and provide a justification for your group's sequence of events.

History of Life on Earth

Earliest ------------------------------------→ Latest

1	2	3	4	5	6	7	8	9	10	11	12

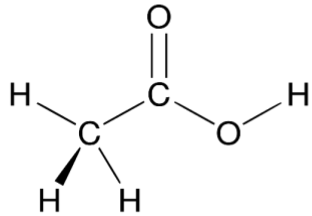
a. **Identify the items you are most certain about and the items you are not sure about.**
b. **List 3 specific questions that will help you better complete the timeline.**

LE Standards: 1.1.1; 4.4.1; 4.3.1

A. Atmosphere with

Little to no oxygen and high amounts of carbon dioxide

B. Organic molecules

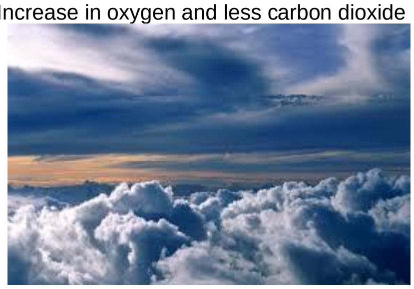


C. Ocean

D. Energy

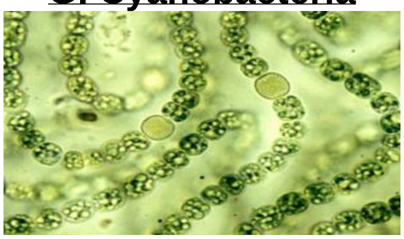
E. Atmosphere with

Increase in oxygen and less carbon dioxide

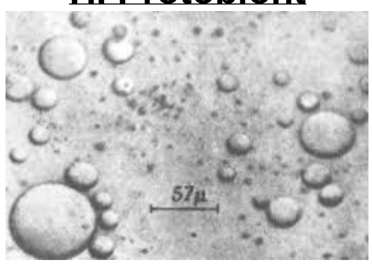


F. Big Bang

G. Cyanobacteria



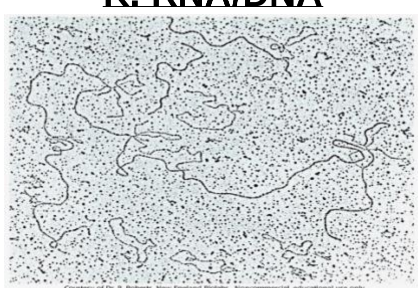
H. Protobiont



I. Unicellular Eukaryote

J. Colonial Algae

K. RNA/DNA



L. Multicellular Organisms


Task 2: Characteristics of Life

Learning Target: I can describe characteristics of life for various living and nonliving specimens.
LE Standards: 4.1.3

Without chemical reactions, there could be no life...Or could there?

It was a long-standing problem. Early in planning Wildfire, the question had been posed: How do you study a form of life totally unlike any you know? How would you even know it was alive?

This was not an academic matter. Biology, as George Wald had said, was a unique science because it could not define its subject matter. Nobody had a definition for life. Nobody knew what it was, really. The old definitions-- an organism that showed ingestion, excretion, metabolism, reproduction, and so on-- were worthless. One could always find exceptions.

The group had finally concluded that energy conversion was the hallmark of life. All living organisms in some way took in energy-- as food, or sunlight-- and converted it to another form of energy, and put it to use. (Viruses were the exception to this rule, but the group was prepared to define viruses as nonliving.)

For the next meeting, Leavitt was asked to prepare a rebuttal to the definition. He pondered it for a week, and returned with three objects: a swatch of black cloth, a watch, and a piece of granite. He set them down before the group and said, "Gentleman, I give you three living things."

He then challenged the team to prove that they were not living. He placed the black cloth in the sunlight; it became warm. This, he announced, was an example of energy conversion-radiant energy to heat.

It was objected that this was merely passive energy absorption, not conversion. It was also objected that the conversion, if it could be called that, was not purposeful. It served no function.

"How do you know it is not purposeful?" Leavitt had demanded.

They then turned to the watch. Leavitt pointed to the radium dial, which glowed in the dark. Decay was taking place, and light was being produced.

The men argued that this was merely release of potential energy held in unstable electron levels. But there was growing confusion; Leavitt was making his point.

Finally, they came to the granite. "This is alive," Leavitt said. "It is living, breathing, walking, and talking. Only we cannot see it, because it is happening too slowly. Rock has a lifespan of three billion years. We have a lifespan of sixty or seventy years. We cannot see what is happening to this rock for the same reason that we cannot make out the tune on a record being played at the rate of one revolution every century. And the rock, for its part, is not even aware of our existence because we are alive for only a brief instant of its lifespan. To it, we are like flashes in the dark."

He held up his watch.

His point was clear enough, and they revised their thinking in one important respect. They conceded that it was possible that they might not be able to analyze certain life forms. It was possible that they might not be able to make the slightest headway, the least beginning, in such an analysis.
(Excerpt from The Andromeda Strain)

1.Describe how a cloth, watch, and granite exhibit characteristics of living things.

<u>What Is Life?</u>

Not all scientists agree exactly about what makes up life. Many characteristics describe most living things. However, with most of the characteristics listed below we can think of one or more examples that would seem to break the rule, with something non-living being classified as living or something living being classified as non-living.

There is not just one distinguishing feature that separates a living thing from a non-living thing. A cat moves but so does a car. A tree grows bigger, but so does a cloud. A cell has structure, but so does a crystal. Biologists define life by listing characteristics that living things share. Something that has all of the characteristics of life is considered to be alive. An individual living creature is called an **organism**. There are many characteristics that living organisms share.

Response to the Environment

All living things detect changes in their environment and respond to them. What happens if you step on a rock? Nothing; the rock doesn't respond because it isn't alive. But what if you think you are stepping on a rock and actually step on a turtle shell? The turtle is likely to respond by moving—it may even snap at you!

Growth and Development

All living things grow and develop. For example, a plant seed may look like a lifeless pebble, but under the right conditions it will grow and develop into a plant. Even the smallest bacteria must grow. This bacteria will reproduce by dividing into two separate bacterium. If the parent bacterium does not grow, then each subsequent generation will just be smaller than the previous generation. Eventually the bacteria will be too small to function properly.

Reproduction

All living things are capable of <u>reproduction</u>. **Reproduction** is the process by which living things give rise to offspring. Reproducing may be as simple as a single **cell** dividing to form two daughter <u>cells</u>. Generally, however, it is much more complicated. Nonetheless, whether a living thing is a huge whale or a microscopic bacterium, it is capable of <u>reproduction</u>.

Complex Chemistry

All living things—even the simplest life forms—have a complex chemistry. Living things consist of large, complex molecules, and they also undergo many complicated chemical changes to stay alive. Thousands (or more) of these chemical reactions occur in each cell at any given moment. **Metabolism** is the accumulated total of all the <u>biochemical reactions</u> occurring in a cell or organism. Complex chemistry is needed to carry out all the functions of life.

Maintain Homeostasis

All living things are able to maintain a more-or-less constant internal environment. They keep things relatively stable on the inside regardless of the conditions around them. The process of maintaining a stable internal environment is called **homeostasis**. Human beings, for example, maintain a stable internal body <u>temperature</u>. If you go outside when the air temperature is below <u>freezing</u>, your body doesn't freeze. Instead, by shivering and other means, it maintains a stable internal temperature.

Cells

All forms of life are built of at least one cell. A **cell** is the basic unit of the structure and function of living things. Living things may appear very different from one another on the outside, but their <u>cells</u> are very similar.

Evolution and Passing on Traits to Offspring

An **adaptation** refers to the process of becoming adjusted to an environment. Adaptations may include structural, physiological, or behavioral traits that improve an organism's likelihood of survival, and thus, reproduction. In a given population, favorable traits are often passed on to offspring.

For each of the following items, describe if it is living or nonliving.

Candle https://www.youtube.com/watch?v=nGdbA0LyIpE	☐ Living ☐ Non-living	Reasoning:
Tornado https://www.youtube.com/watch?v=EdPhSJG3mHc	☐ Living ☐ Non-living	Reasoning:
Plant Phototropism https://www.youtube.com/watch?v=zHe7y8cy-7Y	☐ Living ☐ Non-living	Reasoning:
White) Blood Cell http://annex.exploratorium.edu/imaging_station/research/blood/story_blood1.php	☐ Living ☐ Non-living	Reasoning:
Seeds inside a sealed packet	☐ Living ☐ Non-living	Reasoning:
Viruses	☐ Living ☐ Non-living	Reasoning:

2. <u>How will the information gained from TASK 2 help you revise your timeline and decide when life first began?</u>

Task 3: Cell Theory LT: I can use Cell Theory to describe the history of life on Earth.

The three tenants to cell theory are as described below:

1. All living organisms are composed of one or more cells.
2. The cell is the basic unit of structure and organization in organisms.
3. Cells arise from pre-existing cells.

If cells come from cells that already exist, many ask… "Well, where did the first cell come from?"

It appears that life first emerged at least 3.8 billion years ago, approximately 750 million years after Earth was formed by the "Big Bang." According to the Big Bang theory, the Universe began about 13.7 billion years ago. Everything that is now in the Universe was squeezed into a point. It was all in a single, hot, chaotic mass. Then an enormous explosion—a big bang—took place. How life originated and how the first cell came into being are matters of speculation, since these events cannot be reproduced in the laboratory.

At the time life arose, the atmosphere of Earth is thought to have contained little or no free oxygen, instead consisting principally of carbon dioxide and nitrogen. Scientists think that lightning sparked chemical reactions in Earth's early atmosphere leading to simple organic molecules forming and combining to produce proteins, nucleic acids, lipids and carbohydrates. The early atmosphere was rich in water vapor from volcanic eruptions and comets. When Earth was cool enough, water vapor condensed and rain began to fall. Over millions of years enough precipitation collected that the first oceans could have formed.

1. ***List/explain information that will help you revise your timeline.***

Comparing Prokaryotic and Eukaryotic Cell Types

The first cells to appear on Earth were prokaryotic cells. A prokaryote is an organism made of a single prokaryotic cell. Bacteria are the most common types of prokaryotes. They are very small cells with a simple structure. Prokaryotes do not have a nucleus. This means that their RNA/DNA is not enclosed in a membrane inside the cell. Instead, prokaryotes have a single loop of DNA that floats in the cell's cytoplasm. Protein-making bodies called ribosomes also form part of the cytoplasm. Like all cells, prokaryotes have a cell membrane. All prokaryotes also have a cell wall surrounding the cell membrane. The cell wall helps provide support and protection for the cell. An additional layer encloses some prokaryotes; this layer is called the capsule. The capsule has a sticky surface area, so it allows prokaryotes to cling to surfaces, such as your skin and your teeth, and pretty much any surface for that matter.

Because there was virtually no oxygen in the atmosphere at the beginning of time, one of the earliest and most simple prokaryotes is thought to be cyanobacteria. Cyanobacteria are able to use the process of photosynthesis to convert the energy from sunlight and use carbon dioxide to generate organic molecules, such as glucose. During the process of photosynthesis, oxygen is released as a waste product enriching the atmosphere with precious oxygen. Cyanobacteria also use the process of cellular respiration to convert organic molecules, such as glucose, into cellular energy called ATP.

Eukaryotic cells are more complex than prokaryotic cells. They all have a cell membrane, ribosomes, and DNA as prokaryotic cells do. However, the DNA of eukaryotic cells does not float freely in the cytoplasm. Instead, it is found in the nucleus, an internal compartment bound by a cell membrane. The nucleus is one kind of organelle found in eukaryotic cells. Organelles are structures that perform specific functions. Most organelles are surrounded by a membrane. Some organelles have membranes that form channels, which help transport substances from one part of the cell to another part of the cell.

2. ***List/explain information that will help you revise your timeline.***

The Evolution of Eukaryotic Cells

Eukaryotes are organisms made of one or more eukaryotic cells. The earliest eukaryotes, like the first prokaryotes, were single-celled organisms. They arose about 1 billion years later than the earliest prokaryotes. Later, multicellular eukaryotes arose. Every type of multicellular organism that exists is made up of eukaryotic cells.

Before plants were made up of many cells, or multi-cellular, they were single- celled organisms similar to algae that lived in the water. Algae evolved from single-celled organisms (made up of one cell) to colonial (made up of many individual cells living together) to multi-cellular (many specialized cells working together in one organism).

“The critical point,” says Karl Niklas, a biologist that studies plant evolution, “is that the evolution of multicellular organisms occurred multiple times and involved different developmental ‘motifs,’ such as the ‘glue’ that allow cells to stick together.”

However, there are certain sets of requirements that must be met in order for multicellularity to evolve. These include that:

- Cells must adhere (stick) to each other
- Cooperate with each other
- Specialize in their functions (that not all cells do exactly the same things, otherwise they would just be a group of cells or a colony).

In order to make these things happen, cells must not reject each other. In other words, they must be genetically compatible to some extent—analogous to how our human bodies reject foreign items that are not recognized by our cells.

Interestingly, the first step in this process requires that the organism start from one cell. This is necessary so that all subsequent cells share similar genetic material.

The second step requires that cells work together for a common goal of reproducing more cohesive units, or individuals, like themselves.

How exactly steps such as cell-to-cell adhesion or communication were achieved in plants, animals, fungi, and algae differs among the major eukaryotic groups, yet an important aspect is that these multicellular organisms all went through a similar series of steps on their way to becoming multicellular, functional organisms.

These stages can be mapped on to theoretically possible body plans, illustrating the most plausible series of evolutionary steps—unicellular to colonial to multicellular—that is seen in algae, land plants and animals.

Niklas states, “My attention is on ‘cooperation’ because multicellularity requires cells to work together. Cheating cells cannot be tolerated over the long run because, like cancer, they can gain the upper hand and kill a multicellular organism.”

Edited for length and content from: American Journal of Botany. “From one cell to many: How did multicellularity evolve?”. ScienceDaily. ScienceDaily, 25 January 2015. Accessed on 12 July 2017 from <www. https://www.sciencedaily.com/releases/2014/01/140125172414.htm

Original article: K.J., Niklas. (2013). The evolutionary developmental origins of multicellularity. American Journal of Botany, 101, 6-25. doi:10.3732/ajb.1300314

3. ***List/explain information that will help you revise your timeline.***

It's Just a Theory

In everyday speech, people use the word theory to mean an opinion or speculation not necessarily based on facts. But in the field of science, a theory is a well-established explanation based on extensive experimentation and observation. Scientific theories are developed and verified by the scientific community and are generally accepted as fact.

The first cell membrane was not the first cell:

Protobionts are believed to be the very first form of a cell membrane. Protobionts are described to be sphere-shaped/lipid-based bubble molecules that can spontaneously self-assemble into droplets that enclose a watery solution and maintain a chemical environment different from their surroundings. Protobionts do not produce or use energy, do not reproduce or contain RNA or DNA, and do not contain organelles.

There is compelling evidence that mitochondria and chloroplasts were once free-living organisms.

Evidence supports the idea that eukaryotic cells are actually the descendants of separate prokaryotic cells that joined together in a symbiotic union. In fact, the mitochondrion itself seems to be the "great-great-great-great-great-great-great-great-great granddaughter" of a free-living bacterium that was engulfed by another cell, perhaps as a meal, and ended up staying as a sort of permanent houseguest. The host cell profited from the chemical energy the mitochondrion produced, and the mitochondrion benefited from the protected, nutrient-rich environment surrounding it. This kind of "internal" symbiosis — one organism taking up permanent residence inside another and eventually evolving into a single lineage — is called endosymbiosis.

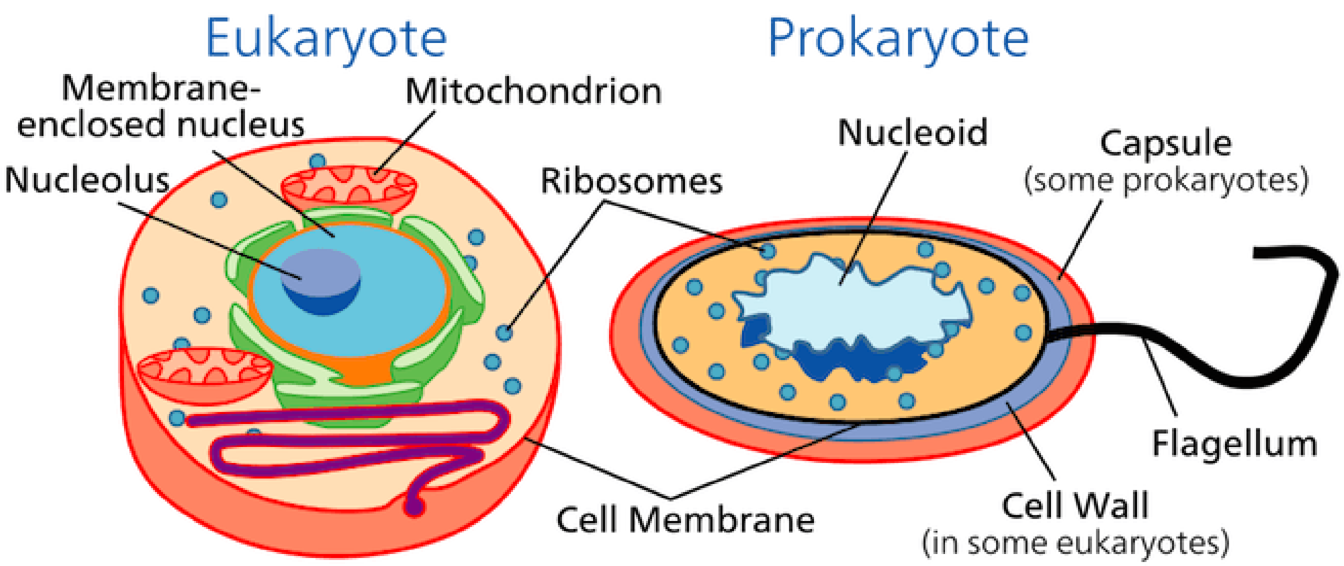
It turns out that many lines of evidence support this idea. Most important are the many striking similarities between prokaryotes (like bacteria) and mitochondria.
-Membranes: Mitochondria have their own cell membranes, just like a prokaryotic cell does.
-DNA: Each mitochondrion has its own circular DNA genome, like a bacteria's genome, but much smaller. This DNA is passed from a mitochondrion to its offspring and is separate from the "host" cell's genome in the nucleus.
-Reproduction: Mitochondria multiply by pinching in half — the same process used by bacteria. Every new mitochondrion must be produced from a parent mitochondrion in this way; if a cell's mitochondria are removed, it can't build new ones from scratch.

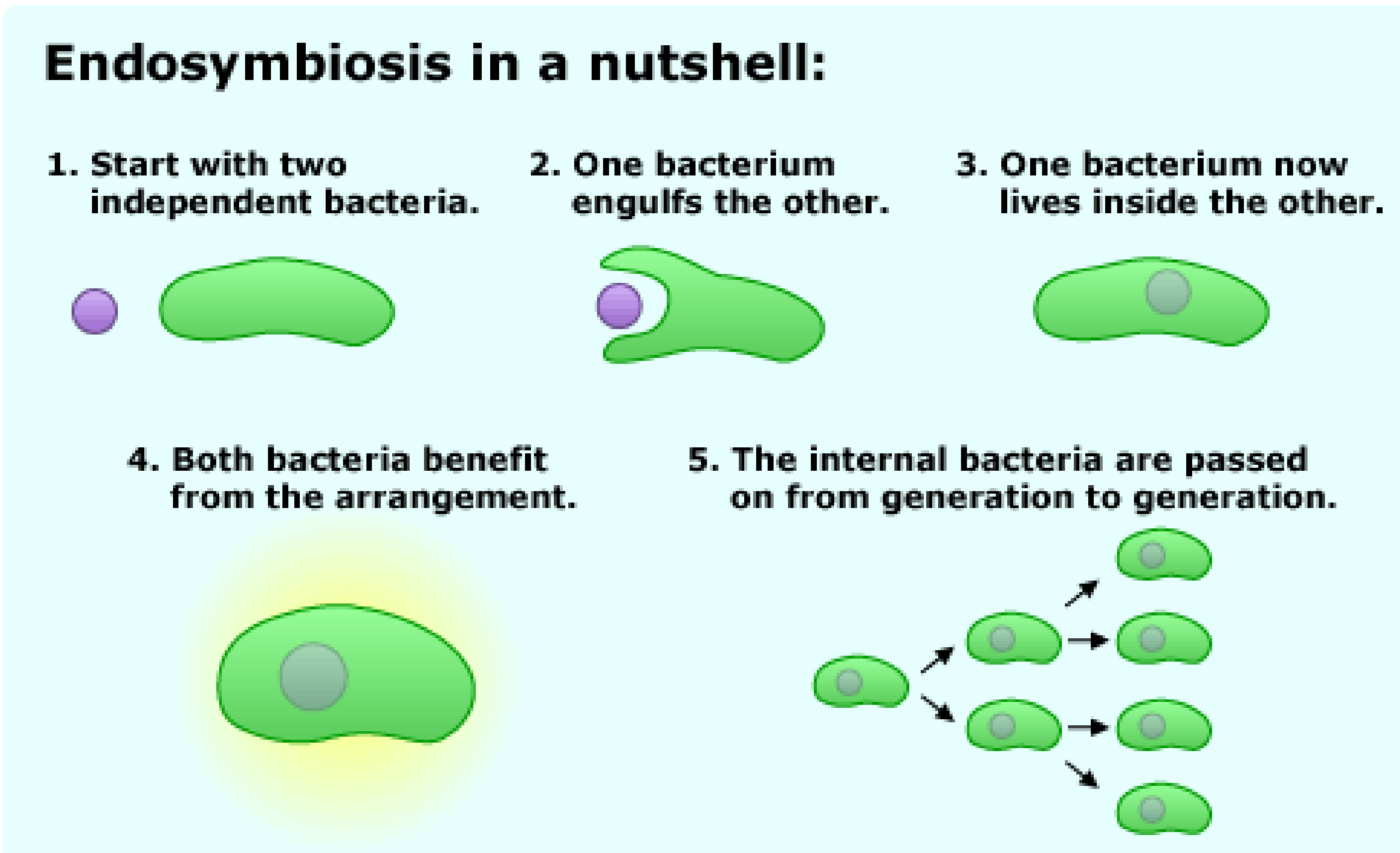
When you look at it this way, mitochondria really resemble tiny bacteria making their livings inside eukaryotic cells! Based on decades of accumulated evidence, the scientific community now supports endosymbiosis theory as the best explanation for the evolution of the eukaryotic cell. How did this theory get its name? Symbiosis occurs when two different species benefit from living and working together. When one organism actually lives inside the other it's called endosymbiosis.

What's more, the evidence for endosymbiosis applies not only to mitochondria, but to other cellular organelles as well. Chloroplasts are like tiny green factories within plant cells that help convert energy from sunlight into sugars, and they have many similarities to mitochondria. The evidence suggests that these chloroplast organelles were also once free-living bacteria.

The endosymbiotic event that generated mitochondria must have happened early in the history of eukaryotes, because all eukaryotes have them. Then, later, a similar event brought chloroplasts into some eukaryotic cells, creating the lineage that led to plants.

Over millions of years of evolution, mitochondria and chloroplasts have become more specialized and today they cannot live outside the cell.





4. List/explain information that will help you revise your timeline.

LE Standards: 4.1.3; 4.1.2f; 4.3.1;

Final Task and Reflection

Directions: Individually respond to the following prompts on a separate sheet of paper.

1. Make a final timeline that shows a consensus on the sequence of events in the history of life on Earth.

2. On your timeline, have you placed the atmosphere card that indicates an increase in oxygen before **or** after the emergence of cyanobacteria? Support your choice using your understanding of biology.

3. On your timeline, have you placed the emergence of eukaryotic organisms before **or** after the emergence of prokaryotic organisms? Support your choice using your understanding of biology.

4. Look back at all of the organism event cards, which do you consider as alive and which do you consider not alive? Support your choices using your understanding of biology.

5. What conditions were necessary for life on Earth to develop? Explain your answer.

6. Reflect on the process of working with your group. What went well? What were the challenges? How could you improve the process to be more effective for the next group task?

Additional Resources Include:

https://www.bighistoryproject.com/chapters/3#extinctions

https://evolution.berkeley.edu/evolibrary/article/evotext_13

https://www.ncbi.nlm.nih.gov/books/NBK9841/

https://www.nytimes.com/2016/07/26/science/last-universal-ancestor.html?hp&action=click&pgtype=Homepage&clickSource=story-heading&module=second-column-region&region=top-news&WT.nav=top-news&_r=1

	3	2	1
Timeline	The timeline is complete, accurate and creative. All events are described and provide insight into why they were placed in that order.	The timeline is mostly complete, accurate and creative. Most events are described and provide insight into why they were placed in that order.	The timeline is mostly incomplete, inaccurate or not creative. Few events are described and provide insight into why they were placed in that order.
Reflection	The reflection is thorough and detailed. Text evidence supports decisions in arranging events in order from first to last. The decision and group process reflection is unique and detailed.	The reflection includes general text evidence that supports decisions in arranging events in order from first to last. The decision and group process reflection is general.	The reflection includes general text evidence that is incomplete or does not support decisions in arranging events in order from first to last. The decision and group process reflection is incomplete.