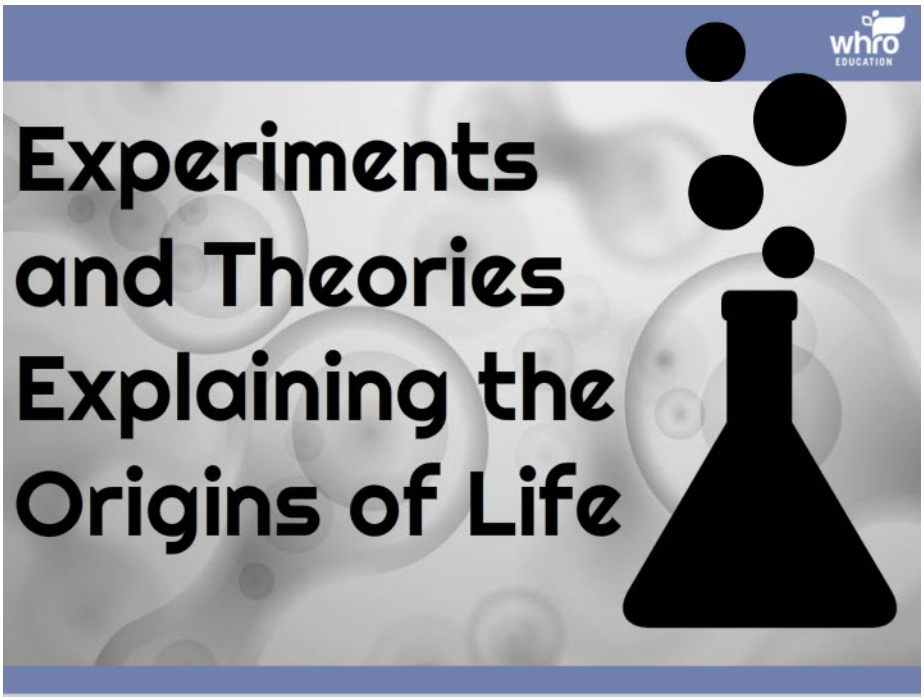
Module 3: Cell Biology - Structure and Function

Topic 2 Content: Experiments and Theories Explaining the Origins of Life Notes

Introduction



Experiments and Theories Explaining the Origins of Life.

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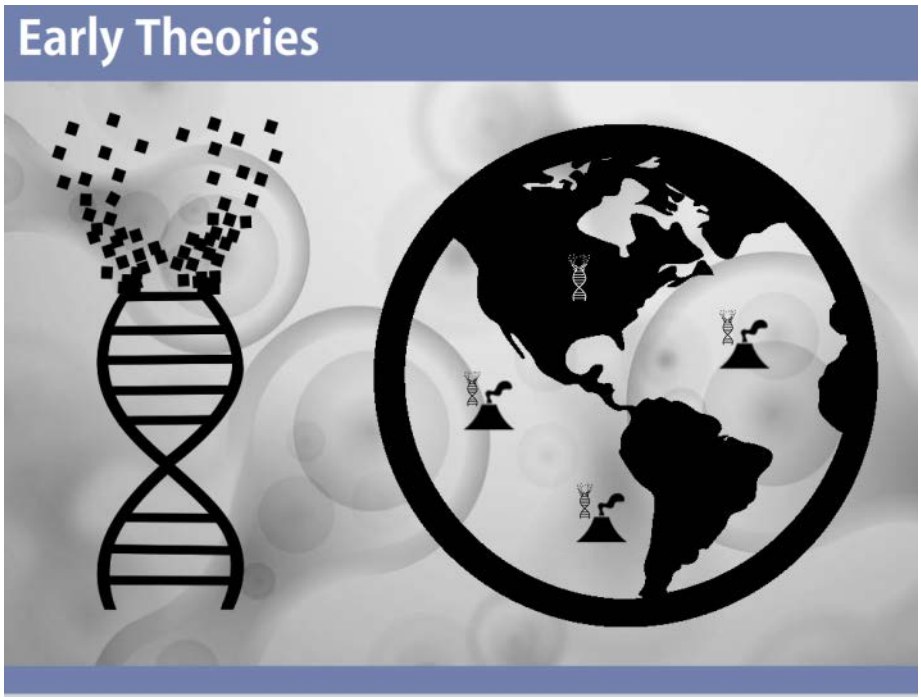
Early Theories



There have been many hypotheses and ideas related to how life originated on Earth. Early scientists believed that life originated spontaneously. Some scientists theorized that the organic material responsible for life was brought to Earth by meteorites, or it could have originated near deep-sea vents. In this interactivity, learn about the different experiments and theories that attempted to explain how life originated on Earth.

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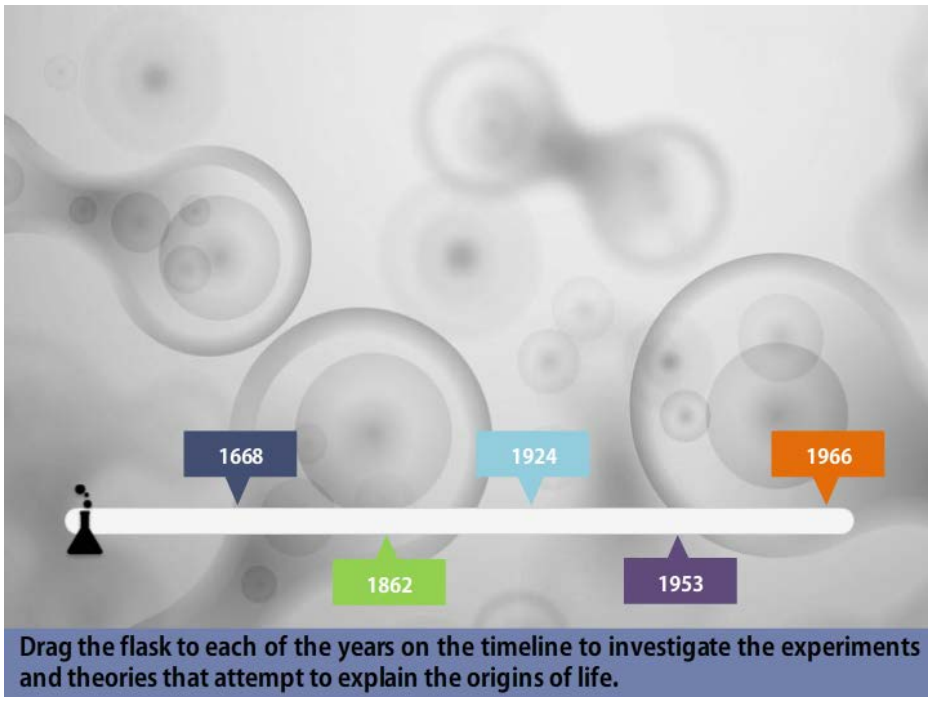
Instructions



Drag the flask to each of the years on the timeline to investigate the experiments and theories that attempt to explain the origins of life.

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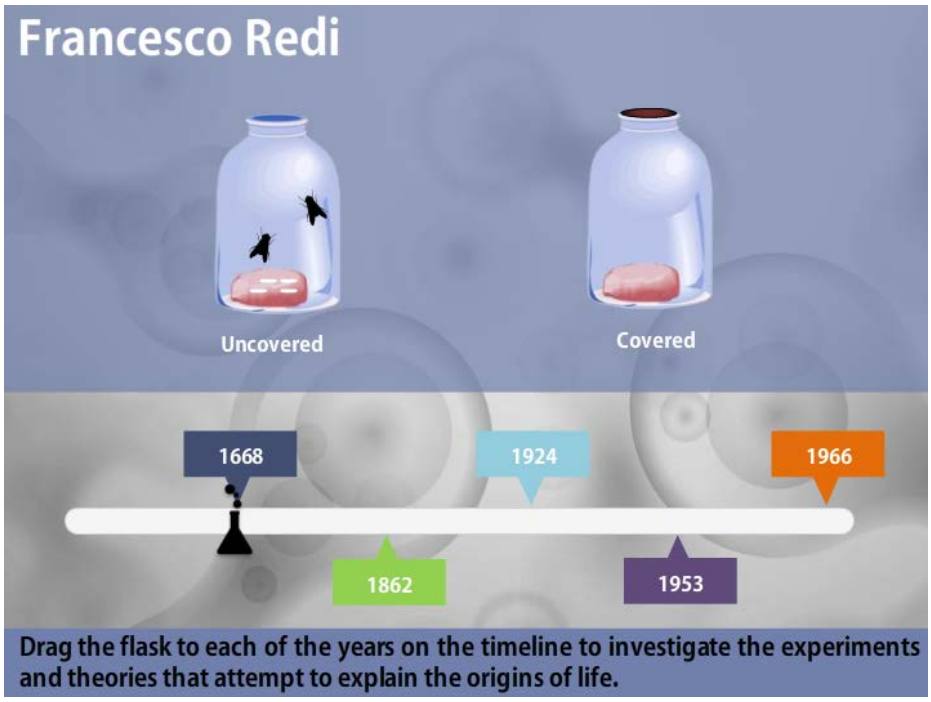
Francesco Redi - 1668



One of the first experiments that attempted to prove how life originated was conducted by Francesco Redi. He tested the hypothesis that flies, and not rotting meat, gave rise to maggots. Redi placed a piece of meat into a flask that was left uncovered, and another piece of meat in a flask that was covered. He observed that maggots only formed on the meat on which flies were able to land. The meat that was in the covered flask did not have any maggots.

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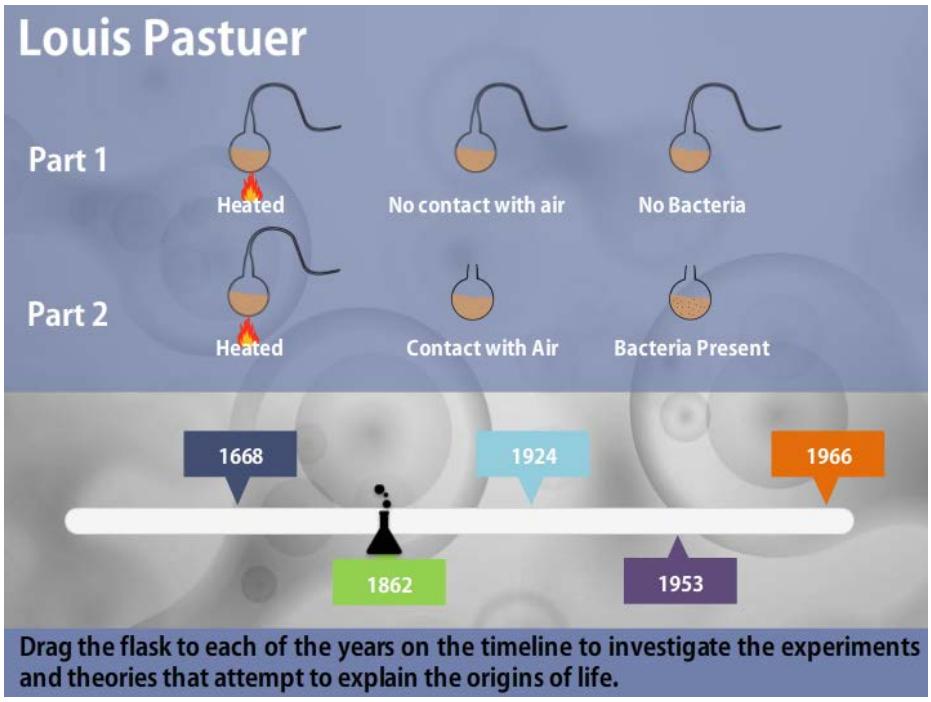
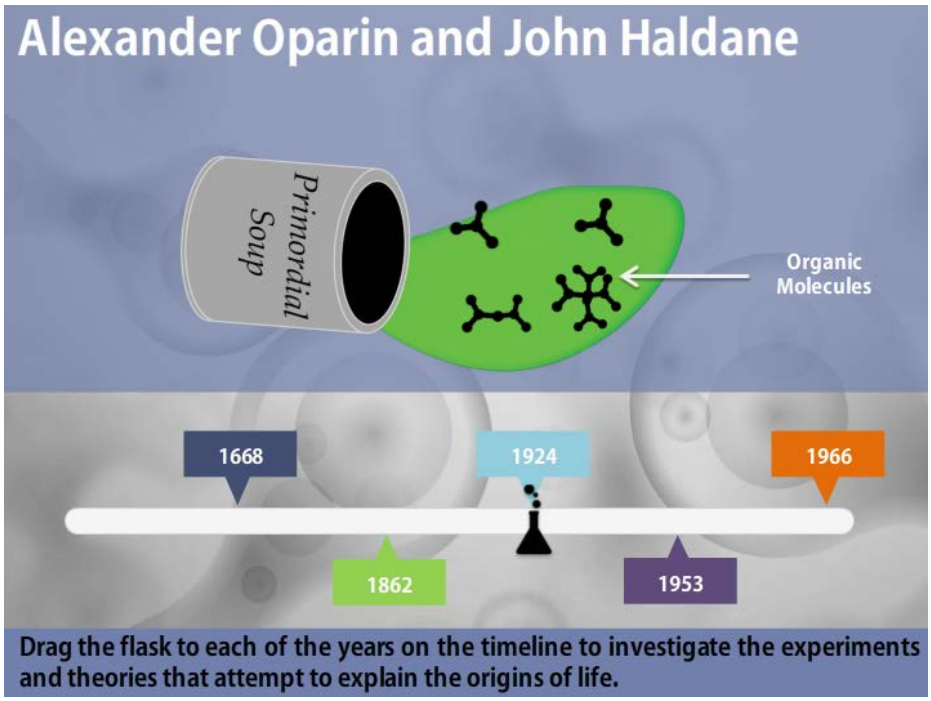
Louis Pastuer - 1862



In an experiment similar to Redi's, Louis Pasteur demonstrated that spontaneous generation was not realistic for microbial organisms. In his experiment, he placed the same amount of sterile nutrient broth into two different flasks. In one flask, air was able to contact the broth, while in the other flask, no air was able to come in contact with the broth. Microorganisms only grew in the flask in which the air was in contact with the broth. This showed that microorganisms did not just appear.

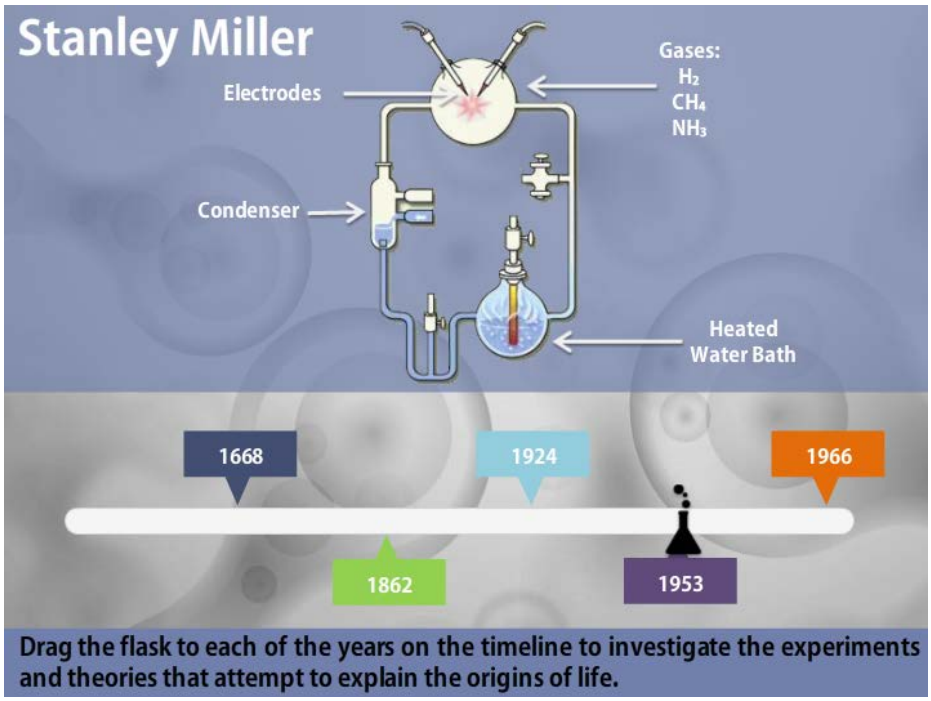
The experiments by Pasteur and Redi helped to debunk the idea of spontaneous generation, and replaced it with the Theory of Biogenesis. The Theory of Biogenesis states that only living organisms can give rise to other living organisms. But, if life can only arise from other life, how did the first organisms appear on Earth 3.5 billion years ago?

Alexander Oparin and John Haldane - 1924



Soviet biologist Alexander Oparin and British geneticist John Haldane proposed the Oparin-Haldane Theory of the Origin of Life, in 1924. These scientists believed that simple organic molecules could be made from the reaction of the gases in the Earth's early oceans and atmosphere. This idea is referred to as the Primordial Soup Hypothesis.

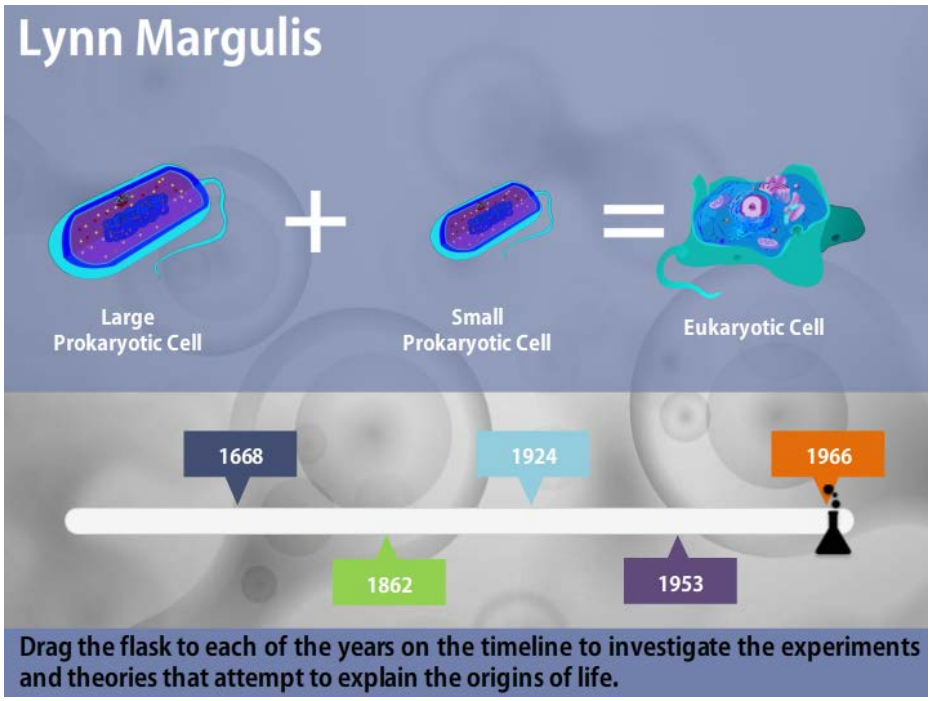
Stanley Miller - 1953



In 1953, a scientist named Stanley Miller performed an experiment that showed how amino acids could be generated under conditions like those present of Earth billions of years ago. Miller's experimental set up included a heated water bath that represented the primordial soup, and another flask that contained the gases hydrogen, methane, and ammonia, along with water vapor. These gases represented the mixture Miller believed composed Earth's early atmosphere. Electrodes in the flask with the gas mixture produced sparks to mimic lightening. A condenser cooled and condensed the water vapor and gas mixture, causing it to precipitate from the flask. When the precipitate was tested, Miller found that organic compounds, including amino acids, had formed. This supported the idea that, under the right conditions, organic compounds could form from inorganic elements.

No matter how the first organic molecules originated on Earth, organic life would not form if the subunits could not be organized into stable proteins or other macromolecules. In Miller's experiment, the amino acids that formed would just as easily separate because there were no enzymes to catalyze a reaction and form a stable bond.

Lynn Margulis - 1966



The addition of oxygen to the atmosphere created an environment hospitable to the evolution of the eukaryotic cell. Recall that the eukaryotic cell is larger than the prokaryotic cell, and that it contains many membrane-bound organelles, including mitochondria, and in plants, chloroplasts. Fossil records show that eukaryotic cells evolved from prokaryotic cells about 1.8 billion years ago, but scientists are unsure why this evolution took place.

One idea is called the endosymbiosis theory. This theory was developed in 1966 by a biologist named Lynn Margulis. The endosymbiosis theory states that eukaryotic cells were formed when large prokaryotic cells engulfed smaller prokaryotic cells. These smaller cells remained undigested, and eventually the relationship between the two cell types became mutually beneficial.

There are several pieces of evidence that support the endosymbiosis theory. First, the mitochondria and chloroplasts of eukaryotic cells contain their own unique DNA, suggesting that these organelles once existed as separate prokaryotic cells. Likewise, the existence of double membranes found around mitochondria and chloroplasts of eukaryotic cells also supports the idea that prokaryotic cells, whose intracellular structures do not have membranes, were absorbed into other cells and eventually became mitochondria or chloroplasts. Lastly, the ribosomes of eukaryotic cells closely resemble those of prokaryotic cells, which strengthens the link between the origin of eukaryotic cells and the existence of prokaryotic cells.