Biology 1305
Modern Concepts in Bioscience (ICB Textbook)
Hello and welcome to the weekly resources for BIO-1305 - Biology 1

This week is Week 7 of class, and typically in this week of the semester, your professors are covering the topics below. If you do not see the topics your particular section of class is learning this week, please take a look at other weekly resources listed on our website for additional topics throughout the semester.

We also invite you **to look at the group tutoring chart on our website to see if this course has a group tutoring session offered this semester.**

If you have any questions about these study guides, group tutoring sessions, private 30 minute tutoring appointments, the Baylor Tutoring YouTube channel, or any tutoring services we offer, please visit our website www.baylor.edu/tutoring or call our drop in center during open business hours (M-Th 9am8pm on class days at 254-710-4135).

KEYWORDS: **Abiotic Origins, Prehistoric, Amino Acids, Vesicles, Amphiphilic**

TOPIC OF THE WEEK

Abiotic Origins of Living Systems

As we have seen in previous chapters, the four major groups of macromolecules which are essential for life are **proteins, lipids, amino acids, and nucleic acids.** Please watch the following video for a quick overview of the structure and function of each of these molecules.

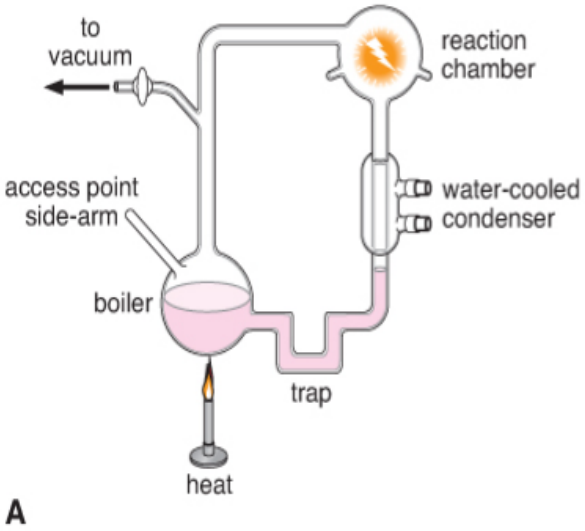
https://youtu.be/V5hhrDFo8Vk

It may also be helpful to review the sections of past chapters which discuss characteristics of these molecules; some important things you will need to know include their **molecular structure, the roles they play in the cell, polarity and charges, and their monomer components (monosaccharides, amino acids, etc).**

Now that we understand how these molecules work, let's look at some experiments that were designed to study the origins of these molecules on earth before life as we know it existed.

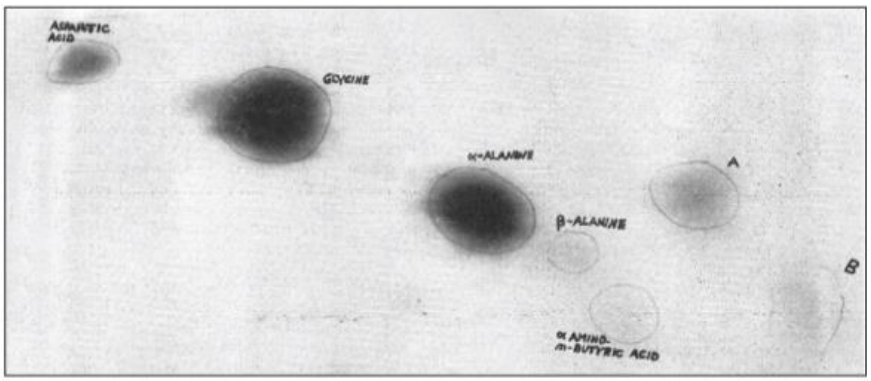
Stanley Miller wanted to understand if **amino acids**, which are the building blocks of proteins, were able to form **abiotically,** or without life, in primitive earth environmental conditions. By this point, scientists knew that the atmosphere of the early earth was made of the gases **methane, hydrogen, and ammonia.** These gases and water were added to a self-contained apparatus which simulated the atmosphere of the primitive earth. "Modern air," which is made up of a mixture of oxygen, carbon dioxide, nitrogen, and other gases which were not present in the atmosphere at the time of the early earth, were removed.

Miller then applied heat to the flask, causing steam to rise and move to a reaction chamber where electrical sparks were produced. This steam then condensed in a cooling chamber to form liquid, which then returned to the boiling flask. As you can see based on the labeled chambers in the figure, the reaction moved in a clockwise direction. This cycle repeated itself throughout the simulation. The production of electrical stimulation, which drove the reaction, was meant to simulate the lighting storms which would have occurred in the prehistoric earth environment.



After a week, the red liquid was removed, dried, and analyzed through two dimensional thin layer chromatography. This is a method which allows for different molecular components in a mixture to be separated based on their affinity for a known material. After the chromatography step was completed, Miller sprayed the entire paper with a stain so he could visualize the different molecules that the mixture was composed of.

Based on the results below, was it possible for amino acids to be generated abiotically in the environment of the prehistoric earth?

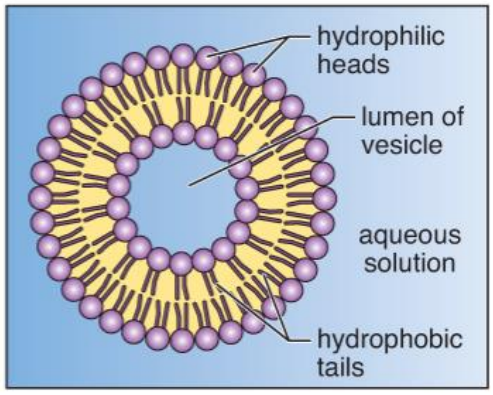


Yes!

The different spots on the TLC plate were labeled by Miller as Aspartic Acid, Glycine, and Alanine; these are all different types of amino acids.

Miller's experiment demonstrated that amino acids could be synthesized in the conditions of the prehistoric earth, before life existed on our planet.

Miller's experiment encouraged many new ways of visualizing and simulating abiotic formation of biological molecules. One example of this is when NASA scientists attempted to replicate the synthesis of lipids in an outer space environment. They did this by shining ultraviolet light (which is abundant in space) on a mixture of inorganic gases which make up interstellar ice in outer space. By doing this, the scientists were able to create **amphiphilic** molecules which could assemble into membrane fragments and lipid bilayers, forming three dimensional membrane spheres called **vesicles.**



B

An amphiphilic molecule has both hydrophobic and hydrophilic segments. In this diagram of a vesicle, the lipid membrane is formed by two layers of amphiphilic molecules. The vesicle has assembled in an aqueous solution, which contains water. The round "heads" of these molecules are hydrophilic, so they face outwards, while the "tails" are hydrophobic, so they face inwards away from the aqueous solution. This lipid bilayer is very similar to the cell membranes of cells in living organisms.

The NASA experiments showed that lipid bilayers and vesicles can be synthesized in abiotic conditions, which makes it more likely that they could have been created in the conditions of the prehistoric earth.

HIGHLIGHT #1: Natural Selection

Evolution is the change in the allele frequency of a population over time. Essentially, the proportion of individuals with certain characteristics in a population changes over time. Remember that evolution happens over time and it affects **populations**, not individual organisms.

The primary mechanism of evolution is **natural selection.** This is the process by which organisms which are better adapted for their environment have a higher chance of surviving in that environment, reproducing, and passing on their traits to their offspring. The five basic tenets of natural selection, as defined by your ICB textbook are:

1. *Overproduction*: Each generation of an organism produces more offspring than nature can support.
2. *Variation*: With each new generation, individuals have slight differences in characteristics, which means they have slightly different abilities.
3. *Competition*: Overproduction of offspring results in competition for limited resources, such as water, food, and shelter.
4. *Selective advantage*: Variation results in some individuals who have an advantage over others, depending on the circumstances. Variations in strength, acquiring energy, stress resistance, and so on allows a subset of individuals to out-compete others for the limited resources. Those with the advantage continue living.
5. *Reproduction*: Those who survive the competition are able to reproduce and pass on to the next generation the genetic information that enabled them to out-compete others. The next generation exhibits additional variation based on the successful trait that they inherited from their parents.

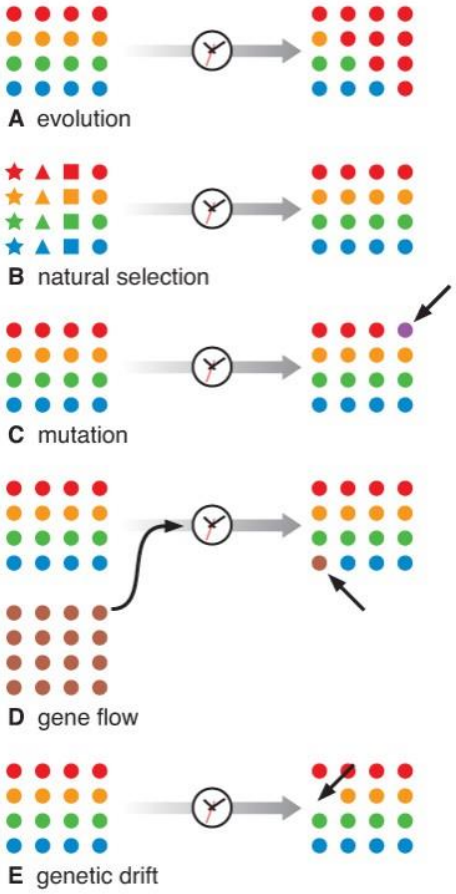
HIGHLIGHT #2: Mechanisms of Evolution

Natural selection is only one of four mechanisms of evolution. The other three are **mutation, genetic drift,** and **gene flow.**

Mutation: a change in DNA sequence; can happen with erroneous replication of DNA by DNA polymerase

Gene flow: an individual from one population transmits a new allele to one or more individuals in another population.

Genetic Drift: allele frequency in a population changes due to random events; these random events can be environmental or due to overrepresentation or underrepresentation of an allele when gametes are produced during meiosis



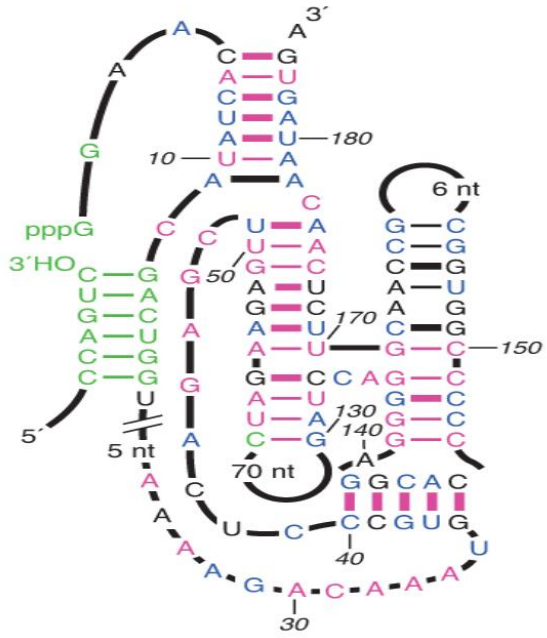
This figure provides a visual of how each of the mechanisms of evolution may affect the frequency of alleles before and after in a population. Each circle (or other shape) represents an individual in a population.

Figure A: Depicts **Evolution;** the circles represent individuals in a population with different alleles (colors). The frequency of alleles changes over time.
Figure B: **Natural selection** favors circles, which are able to reproduce, over other shapes. The new population consists only of circles.
Figure C: **Mutation** is the random appearance of a new allele through DNA change
Figure D: **Gene flow** is the arrival of a new allele from a different (brown) population.
Figure E: **Genetic drift** is shown as the random loss of an allele through a process not related to natural selection. This is just one example of a mechanism of genetic drift

HIGHLIGHT #3: Sequence Conservation

When scientists studied the ribozyme's ability to catalyze reactions, they wanted to know which base pairs were being conserved in the most effective ribozymes that they produced. Remember that in biology, structure determines function! Therefore, base pairs which are **conserved** across all or most of the ribozymes were likely very important for the function of the ribozymes.

When we say a base pair or sequence is **conserved**, this means that it is so unique or essential to the function of the organism that changes to that location of the genome either were lethal, resulting in no organisms passing on that mutation, or the gene gave the organism a very strong selective advantage which allowed organisms with that exact sequence to survive and reproduce over organisms with a difference base pair at that location.



This figure is a diagram of a ribozyme, with thick dashes indicating base pairs in which when one base was changed, the other base also changed in order to maintain the base pair and prevent a mutation at that location. We can assume that these base pairs which are connected by a thicker dash are evolutionarily conserved, and they are essential to the function of the ribozyme or increase its effectiveness in some way.

CHECK YOUR LEARNING

(Answers below)

1) A person decides he wants to improve his health by exercising and improving his diet. This makes him healthier and improves his chances of living longer and surviving illnesses. Is this an example of evolution? Why not?
2) What does it mean for a molecule to be hydrophobic or hydrophilic?
3) What was Stanley Miller trying to test? Why did he use ammonium, methane, and hydrogen for the “atmosphere” in his experiment?
4) If the mutation rate in the directed rate (ribozyme) experiment was 0.2, what is the probability that a base pair is conserved (not mutated)? What is the probability of two base pairs being conserved? Given two base pairs, what is the probability that only one base pair is conserved?

THINGS YOU MAY STRUGGLE WITH

- Remember that evolution is a change in the frequency of alleles over time in a population. It does NOT happen to individual organisms over their lifetime.
- When we say a base pair is conserved, that does not happen to an individual organism in its lifetime. We are talking about the larger evolutionary timeline. The more types of organisms that a gene or sequence is conserved across, the more likely it is that the base pair is crucial for an important or basic function that is essential for life
- Natural selection is not the same thing as evolution. **Natural selection, genetic drift, mutation,** and **gene flow** are all mechanisms of evolution. This means they all result in a change in allele frequency in populations over time.

ANSWERS

1) No, because these changes cannot be passed on to the next generation. Evolution can't happen to one organism. It occurs in a population.
2) If a molecule is hydrophilic, it has a high affinity for water. Hydrophobic molecules are repelled by water.
3) Miller wanted to see if amino acids and other biologically important molecules could be formed in the abiotic conditions of the early earth. He used these gases because that is what the atmosphere of the early earth was composed of.
4) a) 1 - 0.2 =0.8 b) 0.8*0.8= 0.64 c) 0.8*0.2= 0.16 (please review probability rules and the **multiplication rule** if needed)

Thanks for checking out these weekly resources! Don't forget to check out our website for group tutoring times, video tutorials and lots of other resources: www.baylor.edu/tutoring! Answers to Check your Learning questions are below!