<u>STUDY GUIDE</u> - *Ch. 4.1 - Organic Chemistry is Key to the Origin of Life.* **NAME: ________________________**

- **<u>PHYSICALLY PRINT OUT</u> this PDF and <u>HANDWRITE</u> (with a black or blue pen) your answers directly on this PDF.** *Typed or digitally-written work is **<u>not</u>** be accepted. Do **<u>not</u>** answer questions on separate paper.*
- **Importantly, study guides are <u>NOT GROUP PROJECTS</u>!!!** *You, and you alone, are to answer the questions as you **<u>read</u>** your assigned textbook. You are **<u>not</u>** to share answers with other students. You are **<u>not</u>** to copy any answers from any other source, including the internet.*
- **Get in the habit of writing <u>LEGIBLY</u>, neatly, and in a <u>medium-sized font.</u>** *AP essay readers and I will skip grading anything that cannot be easily read so start perfect your handwriting, and don't write so large you can't add all the relevant details and key elaborations in the space provided.*
- **<u>SCAN</u> physical documents in color and with good resolution. Then, upload your final work as <u>PDFs</u> to Archie.** *Avoid uploading dark, shaded, washed out, side ways, or upside down scans of homework. Keep completed physical study guides organized in your biology binder to use as future study and review tools.*
- **<u>READ FOR UNDERSTANDING</u> and not merely to complete an assignment.** *<u>**First**</u>, read a section quickly to get an overview of the topic covered. Then, read it a **<u>second</u>** time slowly, paraphrasing each paragraph **<u>out loud</u>** and analyzing every figure. Finally, read it a **<u>third</u>** time as you answer the study guide questions if assigned and to start building your memory. Try to write answers out in your own words when possible and to purposefully and accurately use all new terminology introduced.*

KEY CONCEPTS

- Carbon is one of the key elements around which living matter is organized and core biological processes have evolved.
- Carbon plays a **<u>vital role in the capture, use, and storage of the energy needed to support life</u>**.
- Carbon serves as the **<u>backbone around which a great diversity of biomolecules are synthesized and/or degraded as carbon cycles through the environment</u>**.

UNDERSTANDING THE USE & MOVEMENT OF CARBON & ENERGY IN ECOSYSTEMS

Organic carbon (carbons that are part of organic molecules) enter the biosphere through the action of **<u>PRODUCERS</u>** - photosynthetic organisms ***(like plants, certain protists, and certain bacteria)***, which use **<u>SOLAR ENERGY</u>** to transform atmospheric **<u>CO_2</u>** into the **<u>CARBON-BASED MOLECULES OF LIFE</u>**. The solar energy thus is converted into **<u>CHEMICAL ENERGY</u>**, the potential energy stored in the bonds of organic molecules. Organic (carbon-based) molecules are then passed along to non-photosynthetic organisms, known as and **<u>CONSUMERS</u>** ***(animals, certain bacteria, certain protists, fungi)*** and **<u>DECOMPOSERS</u>** ***(bacteria and fungi)***, which feed on other organisms and which <u>cannot</u> capture the radiant energy from the sun directly, but still need **energy to perform the work of life** and also **need carbon to build their own necessary organic molecules**. **<u>CO_2</u>** is returned to the atmosphere through a process called cellular respiration (and in some organisms fermentation) in which the **<u>CARBON-BASED MOLECULES OF LIFE</u>** are broken down, releasing the chemical energy stored in certain high-energy chemical bonds. This energy is used to do work with in the cell, the energy eventually being lost to the environment as **<u>HEAT</u>** *(**THERMAL ENERGY** - the energy that causes the random motion of particles in substances - that transfers from an area of higher to lower temperature).*

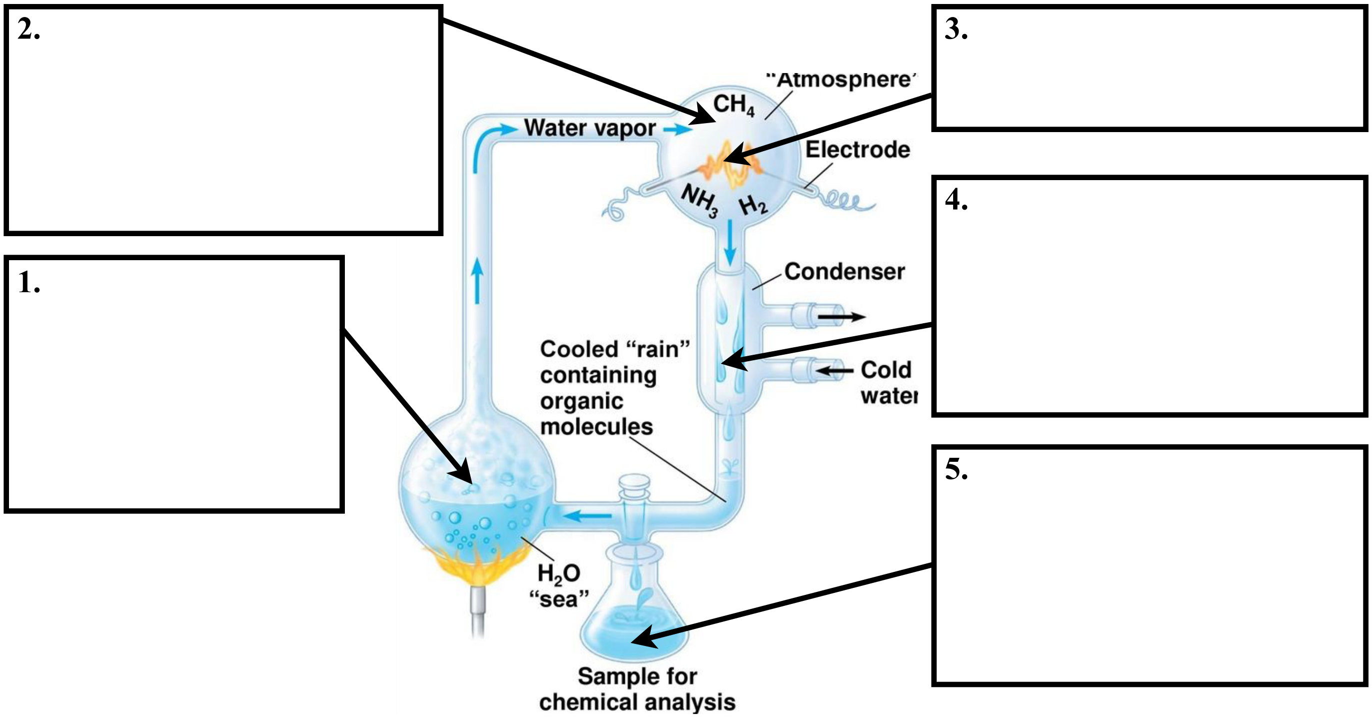
1. Carbon is unparalleled in its ability to form molecules that are large, complex, and diverse. What do we call the **<u>branch of chemistry that studies carbon-based molecules</u>**?

2. Why do the **<u>major elements of life (C, H, O, N, S, P) reflect the common evolutionary origin of all of life</u>** (*the idea that all life today is descendant from a common ancestor*)?

3. How many other atoms can a **<u>carbon atom form a covalent bond with</u>**?

4. How does **<u>carbon allow for the existence of different species and variations between individuals within a species</u>**?

5. a Read & study Figure 4.2. Describe the **Urey-Miller Experiment,** which attempted to **simulate conditions on early Earth**, by filling in the boxes below, indicating what occurred in the various parts of the apparatus used.



b. This experiment was incredibly important. Study the results of the experiment. Which **synthesized organic molecules were collected from the sample for chemical analysis?**

c. What was *the* **important conclusion** Miller drew from the results of his experiment?

d. Remember, **chemical products are formed from chemical reactions.** During a chemical reaction the original covalent bonds between the atoms in reactants are broken, allowing the atoms to rearrange, forming new covalent bonds and partnerships, resulting in products that are different from the starting reactants. According to the **Law Conservation of Mass**, during a chemical change, the total mass of the products remains equal to the total mass of the reactants. *(Atoms cannot just appear appear or disappear. All the atoms in the reactants must be accounted for in the products).*

i. How do you think the relative amounts of products HCN versus CH_2O would differ had Miller increased the concentration of NH_3 in the experiment.

ii. **WHY** did you predict what you did above? *(Check your answer for accuracy by going to the* ***Ch.4 Figure Question*** *answer in Appendix A of your textbook)*

e. Miller also carried out a **controlled experiment without discharging sparks** and found **no** organic compounds. What explains these results? *(Check your answer for accuracy by going to the **Ch.4 Concept Check Question** answer in Appendix A)*

6. Let's try the **Scientific Skills Exercise**: Working with Moles & Molar Ratios.

After you read the introductory paragraphs, take time to truly understand the information in the table, especially that third column that shows you the **Molar ratio RELATIVE to Glycine.** You will find data often reported as a ratio in this way, **A relative to B.**

Molarity (M) is a unit of concentration. **1 M = 1 mol / 1 L**

- A **liter (L)** is a unit of volume.
- A **mole (mol)** refers to a particular quantity of items just like a dozen does. 1 dozen eggs = 12 eggs. 1 mole of eggs = $6.02214076 \times 10^{23}$ eggs (which is a *LOT* of eggs or 602,214,076,000,000,000,000,000 eggs).

Relative to something means with reference to it or in comparison with it. In this table, molar ratio refers to the ratio between the M of one compound and the M of another compound. **How do you calculate a ratio of one item relative to another? Well a ratio is a fraction and a fraction is a division. So, 2/8 is really 2 divided into 8 equal units or 2 divided by 8, which is 0.25 each or 1/4. When asked to compare A relative to B, A is always the numerator and B is always the denominator in your fraction (A/B).**

In this case, the scientists took the Molarity (concentration) of glycine and divided that by the Molarity of glycine in order to produce the molar ratio of glycine to glycine. The units cancel our hence the ratio (the results of the division) has no units. Of course, dividing one number by the same number results in a value of 1 (or 1.0), which is reported in the first row of the table. No matter what the concentration was of Glycine, when you divide the concentration of Glycine by the concentration of Glycine, the value you get is 1.0. For example: 1.5 M of Glycine / 1.5 M of Glycine = 1.0 ; 50.0 M of Glycine / 50.0 M of Glycine = 1.0 etc... **Here both A and B referred to the concentration of Glycine in your ratio or fraction or division.**

If we look at the second row, the row for Serine, they took the Molarity (concentration) of Serine and divided it by the Molarity (concentration) of Glycine, Glycine being, in this case, the amino acid they set as the standard to compare other compounds to. They are comparing, therefore **the concentration of Serine (A) relative to the concentration of Glycine (B), so you will set the concentration of Serine as the numerator and the concentration of Glycine as the denominator in your ratio or fraction.**

So, there was a certain concentration of Serine, which was divided by a certain concentration of Glycine. The units (M) cancelled out, but the numerical calculation didn't end up being 1.0 this time because it turns out the value of the numerator was **not** the same value as the denominator. Instead of B/B = 1.0 (where B is the molar concentration or Molarity of Glycine), as was the case in the first row, in the second row, A/B = 3.0×10^{-2} or 0.03 (where A is the molar concentration of Serine).

As you know, 0.03 is smaller than 1.0. So does this mean that there was a higher or lower concentration of Serine RELATIVE to the concentration of Glycine?????

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Hopefully, you answered lower. Actually, there is (0.03/1.0) x 100 = **3%** of the concentration of Serine **compared to** or **RELATIVE TO** the concentration of Glycine.

Now that you understand the data as reported in the table, try to answer the questions posed to you in this Skills Exercise:

1. a.

   b.

   c.

2. a.

   b. *(Be careful, they are asking about* <u>*number*</u> *molecules not the concentration of these molecules)*

3. a.

   b.

   c.

   d. Part 1.

   d. Part 2.

4. a.