

STUDY GUIDE - Ch. 10.4 - The Calvin cycle uses ATP and NADPH to convert CO₂ to sugar NAME: _____

- Ch. 10.5 - Alternative mechanisms of carbon fixation have evolved in hot, arid climates

- Ch. 10.6 - Photosynthesis is essential for life on Earth

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

The Calvin Cycle is a metabolic pathway in which each step is catalyzed by an enzyme, much like the Citric Acid (Krebs) Cycle from cellular respiration.

However, keep in mind that the Calvin Cycle uses energy (in the form of ATP and NADPH) to synthesize carbohydrates (simple sugars) and is, therefore, **anabolic**.

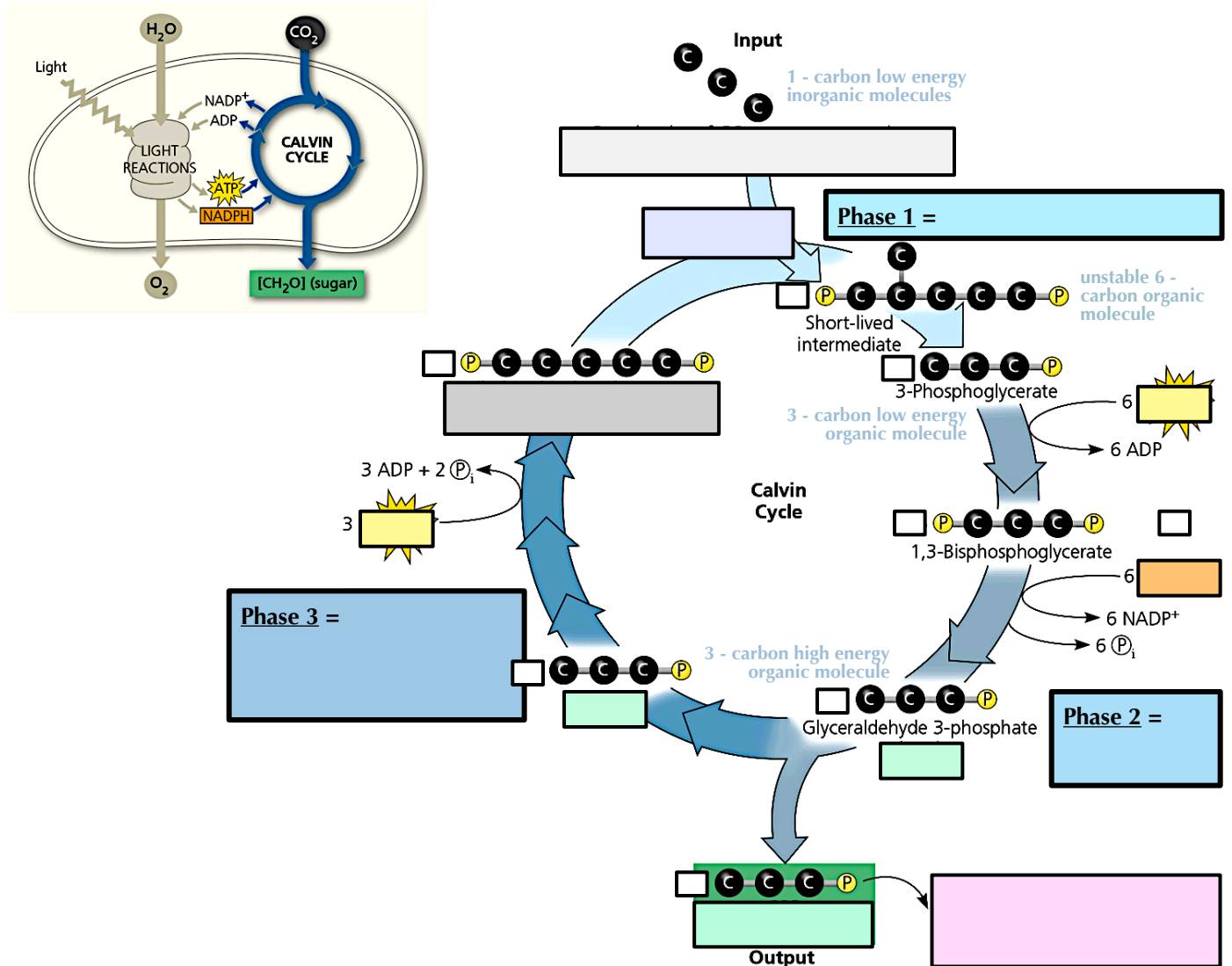
In contrast, cellular respiration is **catabolic**, breaking down carbohydrates (simple sugars) in order to release energy that is used to drive the production of ATP.

1. Where does the Calvin Cycle of Photosynthesis take place in photosynthetic eukaryotes?
2. What is oxidized in the Krebs Cycle inside the Mitochondria during Cellular Respiration?
3. What is reduced in the Calvin Cycle inside the Chloroplast during Photosynthesis?
4. What does the term Carbon Fixation refer to?
5. What is the overall purpose of the Calvin Cycle in Photosynthesis?
6. The carbohydrate produced directly from the Calvin cycle is **not glucose**, but the three-carbon compound _____. Each turn of the Calvin Cycle fixes **one** molecule of CO₂. Therefore, it will take _____ turns of the Calvin Cycle to **net one** (three-carbon) **G3P** (sugar).
7. Name and then describe the key events that occur in each of the **three phases of the Calvin Cycle**.
Phase 1 of Calvin Cycle = _____

Phase 2 of Calvin Cycle = _____

Phase 3 of Calvin Cycle = _____

8. Label and study the diagram below of the Calvin Cycle.



9. a. To review, the **enzyme responsible for carbon fixation in Phase One** of the Calvin Cycle, and possibly the most abundant protein on Earth, is _____.
 - b. In **Phase Two**, the reduction stage, the energy and phosphates of _____ will be added to the low-energy organic acid 3-phosphoglycerate to form a reactive, phosphorylated 1, 3-bisphosphoglycerate.
 - c. In **Phase Two**, the reduction stage, the reducing power of _____ will donate high-energy electrons to the lower-energy acid 1, 3-bisphosphoglycerate to form the three-carbon, high-energy sugar _____.
 - d. The net production of one G3P thus requires _____ molecules of ATP and _____ molecules of NADPH.
 - e. **To synthesize one (6-carbon) glucose molecule**, the Calvin cycle uses _____ molecules of CO₂, _____ molecules of ATP and _____ molecules of NADPH. *(Check your answers to #9.d. by going to the Ch.10.4 Concept Check Question #1 in Appendix A of your textbook)*
10. *Let's tally those carbons!* The figure in #8 above shows the **production of one net 3-carbon G3P molecule of sugar**. This means the Calvin cycle must be turned _____ times since in each turn one inorganic carbon is fixed into one organic carbon. Each turn will require a starting molecule of _____, a five-carbon compound. Since we must perform the Calvin Cycle three times before one 3-carbon G3P is made, which the cell will use to synthesize other carbohydrates (glucose, fructose, sucrose, starches, cellulose), lipids, amino acids, proteins, glycoproteins, nucleotides, and nucleic acids etc from, we start with _____ total carbons distributed in three RuBPs. After fixing three inorganic carbon dioxide molecules using the enzyme Rubisco, the Calvin Cycle forms six G3Ps containing a total of _____ carbons. At this point, the net gain of carbons is a three-carbon _____ or one net G3P molecule, the other _____ number of G3P molecules being used to regenerate _____ number of five-carbon RuBPs. Since RuBP, the starting reactant, is used up temporarily, but then is reformed again, we call this biochemical pathway a cycle.
 11. *Think* = Consider a poison that inhibits an enzyme of the Calvin cycle. Do you think such a poison will also inhibit the light reactions? Explain your reasoning. *(Check your answers to #11 by going to the Ch.10.4 Concept Check Question #3 in Appendix A of your textbook)*
12. The photosynthesis so far discussed is called **C3 Photosynthesis** since the net product of the process is a 3-carbon G3P sugar. Some plants live in extremely hot, dry (*arid*) environments, where dehydration is an even larger threat than it would be in moister environments. Here, to prevent too much water loss via transpiration from the pores in the leaves, C3 plants would need to close their stomates for longer periods of time, which negatively impacts photosynthesis rates and, thus, the biological fitness of the plant. Over time, special adaptations, modifications to C3 Photosynthesis, called **C4 Photosynthesis** and **CAM Photosynthesis**, have evolved to help plants maximize photosynthetic rates while still minimizing water loss in these very hot or dry locations. Please carefully **read Section 5 of the textbook, studying both adaptations in detail, including key terms and all figures.**
 13. Then **read Section 6** to summarize Photosynthesis, after which you should **try to answer the multiple-choice questions in the TEST YOUR UNDERSTANDING section at the end of the chapter.**