STUDY GUIDE - *Ch. 9.5 - Fermentation & Anaerobic Respiration Enable Cells to Produce ATP WITHOUT the Use of Oxygen*
- Ch. 9.6 - Glycolysis & the Citric Acid Cycle Connect to Many Other Metabolic Pathways

NAME: _____

- **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.*

1. **Some organisms or cell types can oxidize glucose, in order to produce some ATP** *without using **Oxygen***. The two ways that have evolved to do so are called **Anaerobic Cellular Respiration** or **Fermentation.** What is the main **difference** between these two processes?

2. a. What is the **final electron acceptor** of bacteria that engage in **Aerobic Respiration**?

   b. How does the **final electron acceptor** used at the conclusion of the Electron Transport Chain in "sulfate-reducing" bacteria, for example, which engage in **Anaerobic Respiration**, differ from that of aerobically-respiring bacteria?

   c. What is the final product that forms in the aerobically-respiring bacteria when the final electron acceptor is reduced with the electrons leaving the ETC

   d. What is the final product that forms in the "sulfate-reducing" anaerobically-respiring bacteria when the final electron acceptor is reduced with the electrons leaving the ETC

3. In Aerobic Cellular Respiration, glucose is oxidized into two pyruvate through **Glycolysis**, pyruvate is oxidized into Acetal CoA through **Pyruvate Oxidation**, and Acetyl is oxidized into CO_2s in the **Citric Acid (Krebs) Cycle**. A few ATPs were made in glycolysis and the Citric Acid Cycle. High-energy electrons collected during Glycolysis, Pyruvate Oxidation, and the Citric Acid Cycle are then passed through the **Electron Transport Chain** so their energy can be extracted, stored in a proton gradient, and the energy used by **ATP Synthase** to construct much more ATP as ATP Synthase allows the proton gradient to dissipate. **These same steps are used by bacteria that engage in full anaerobic cellular respiration using an Electron Transport Chain and ATP Synthase in the absence of O_2.** Though all cells can conduct Glycolysis, not all cells, which can survive in anaerobic (O_2-lacking) conditions, can make the enzymes needed to conduct the Citric Acid Cycle and can ETC. Others cannot use their ETC when O_2 is absent.

   What does the two-part process - known as **fermentation** - consist of, which certain bacteria and yeast cells engage in when O_2 is absent ?

   1.

   2.

4 a. **Fermentation allows for the production of ATP *without* O_2 and *without* using the Electron Transport Chain and ATP Synthase (so *without* oxidative phosphorylation).** What is the net ATP yield per molecule of glucose oxidized (broken down) during fermentation?

b. **Without a supply of oxidized ("empty") NAD^+ electron carriers (types of coenzymes), glycolysis will not be able to occur.** As you know, in Glycolysis, NAD^+s are reduced into NADH. Unless NADH can loose the high-energy electrons they accepted (unless it gets oxidized again), the cell will soon run out of available NAD^+. What would be the **consequence** to a cell trying to perform fermentation if all electron carriers exist as NADH instead of NAD^+?

5. To review, how does a cell engaging in Aerobic Cellular Respiration recycle (oxidize) NADH back into NAD^+?

6. **Without Oxygen though, electrons cannot be removed from the Electron Transport Chain** (in organism that can build one). If electrons don't flow through the ETC, but get stuck on the ETC, their energy isn't extracted and thus no proton can be pumped by the complexes of the ETC to build a proton gradient (the proton motive force). With **no proton gradient**, there would be **no stored energy** and no protons would diffuse down a nonexistent concentration gradient through ATP Synthase (even if the cell could build this enzyme). So **no ATP could be made with the help of the ETC and ATP Synthase** without some final electron acceptor like Oxygen in Aerobic Cellular Respiration (or another electronegative atom in Anaerobic Cellular Respiration). Cells that thus engage in Fermentation (which does not use the ETC and ATP Synthase) need a different way to recycle NADH back into NAD^+.

   a. Read your text and study Figure 9.16 well. What do the cells that engage in **ALCOHOL FERMENTATION**, therefore, use as a **final electron acceptor**?

   b. Explain the details of **what happens in the two chemical steps of Alcohol Fermentation**, which follow Glycolysis?

      1.

      2.

   c. Which types of organisms/cells carry out alcohol fermentation?

   d. Read your text and study Figure 9.16 well. What do the cells that engage in **LACTIC ACID FERMENTATION**, therefore, use as a **final electron acceptor**?

   e. Explain the details of **what happens in the one chemical step of Lactic Acid Fermentation**, which follows Glycolysis?

   f. Which types of organisms/cells carry out alcohol fermentation?

7. a. A glucose-fed yeast cell is moved form an aerobic to an anaerobic environment. For the cell to continue producing ATP at the same rate, how would its rate of glucose consumption need to change? Circle: **YES** or **NO**

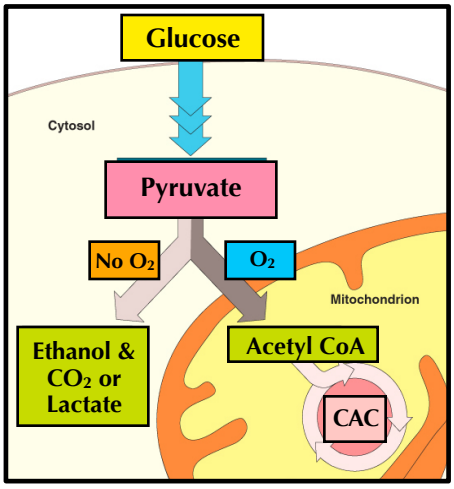
b. Explain **WHY** you circled what you did. *(Check your answer by going to the **Ch.9.5 Concept Check Question #2** answer in Appendix A)*

8. **TIP**: On the AP exam, you may be asked to *compare and contrast* two processes. When you get such a prompt, treat it literally. You are expected to **first compare** (describe similarities) **AND then to contrast** (describe differences).
   a. Describe two **similarities** among **(compare)** **fermentation, anaerobic respiration,** & **aerobic respiration**.
      1.
      2.
   b. Describe two **differences** between **(contrast)** **fermentation, anaerobic respiration,** & **aerobic respiration**.
      1.
      2.

9. What is the difference between an **obligate anaerobe** and a **facultative anaerobe**?
   Obligate anaerobe =

   Facultative anaerobe =

10. Using the figure to the right, explain why **pyruvate is a key juncture in catabolism for facultative anaerobes**.



11. What will happen in a human muscle cell that has used up its supply of oxygen and ATP? This scenario occurs during strenuous exercise where oxygen cannot diffuse into the cell fast enough to keep up with **metabolic (cellular respiration) demands** (the amount of cellular respiration that has to happen per minute) ? *(Check your answer by going to the **Ch.9.6 Concept Check Question #3** answer in Appendix A)*

12. List **two evidences** that exists for **glycolysis** being the **first metabolic process used** by living organisms to **generate ATP**, being sure to explain *why* each evidence is seen as such.

    1.

    2.

13. a. How long ago did the first cells, which used glycolysis too, evolve on Earth?

    b. When did significant amounts of O_2 gas start to appear in the atmosphere?

    c. What is the reason for the "sudden" increase in O_2 ?

14. a. What three organic **macromolecules are often utilized** (as energy sources) **to make ATP through cellular respiration**?

    1. _____ 2. _____ 3. _____

    b. Explain how **carbohydrate macromolecules and disaccharides can be used as fuel** to produce ATP.

15. Explain how **proteins can be used as fuel**. *Be sure to discuss the deamination process as part of your answer.*

16. a. Explain how the two components of **fats can be used as fuel**. *Be sure to discuss the beta oxidation process as part of your answer.*

b. Why do **fats provide a little more than twice as many calories per gram as compared to carbohydrates**?
Hint: Think of the output per cycle of the Citric Acid Cycle.

17. Why are only **8 amino acids considered essential** to have in the human diet even though **humans need 20 amino acids in total** to make all proteins.

18. How can **cells use intermediates from the catabolic cellular respiration pathways to instead construct (synthesize)**...
    a. glucose?

    b. fatty acids *(for phospholipid or fat construction for example)*?

19. Under what circumstances might your body synthesize fat molecules. *(Check your answer by going to the **Ch.9.6 Concept Check Question #2** answer in Appendix A)*

20. a. What **key enzyme helps control the rate of cellular respiration**?

    b. Where is this enzyme located in the cells of prokaryotes?

    c. Where is this enzyme located in the cells of eukaryotes?

    d. Study well **figure 9.19**. What three substances affect the **rate of phosphofructokinase (PFK) activity** and **how**?

        1. _____ =

        2. _____ =

        3. _____ =

e. Is the fact that high concentrations of ATP inhibit PFK, but high concentrations of AMP (signaling low concentrations of ATP), stimulate PFK, an example of positive or negative feedback inhibition? First define properly both negative and then positive feedback inhibition, by revisiting Ch.1.1. Then use the definitions to determine and explain your answer.

Definition of **Negative Feedback Inhibition**:

Definition of **Positive Feedback Inhibition**:

Your Determination as to the **Type of Feedback Regulation Exhibited by Phosphofructokinase** & why:

Think: Why does it make sense that regulation of this enzyme has evolved so that it is influenced by concentration of ATP and AMP this way?

f. Why would **phosphofructokinase** being allosteric in character be an advantage to the **synchronization of glycolysis and the citric acid cycle**?

21. Remember the **First Law of Thermodynamics**: Energy Cannot Be Created or Destroyed.

Therefore, the ENERGY that keep us alive (that allows cells to do work) is _____ ,

NOT _____ by cellular respiration (or fermentation in some organisms).

22. Proceed to the TEST YOUR UNDERSTANDING section at the end of the chapter. **Study your chapter sections and all Ch.9 study guides first!** Then, do your best to try to answer these from memory first in order to test how well you grasped the material before. If you are unsure, return to the relevant section of your chapter and restudy any pertinent material to refresh your memory. *(Check some of your answers by going to the Ch.9 Test Your Understanding answers in Appendix A)*

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____

9.

12. *(Draw neatly & explain clearly)*

13. Remember, a **hypothesis is an explanatory statement.** Before answering this question **review Ch.6.5** and the **Theory of Endosymbiosis**, to make sure you remember exactly **HOW** it explains the origin of 1. eukaryotic cells and 2. their mitochondria and chloroplast organelles.

    a.

    b.

14. When you explain, be sure to do so **logically, step-by-step, describing *why* you make each claim you do**. *(So, what happens when you make the inner mitochondrial membrane leaky to protons? Because of that, what activity of the membrane will no longer occur? What are then the consequences of that activity no longer occurring to the cell? How would the body respond to this new reality that would lead the body to loose weight? And why might death occur?)*