STUDY GUIDE - *Ch. 8.3 - ATP Powers Cellular Work by Coupling Exergonic Reactions to Endergonic Reactions*

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. List and describe the **three main kinds of cellular work done by ATP**.

   i.

   ii.

   iii.

2. a. Define the term **Energy Coupling**

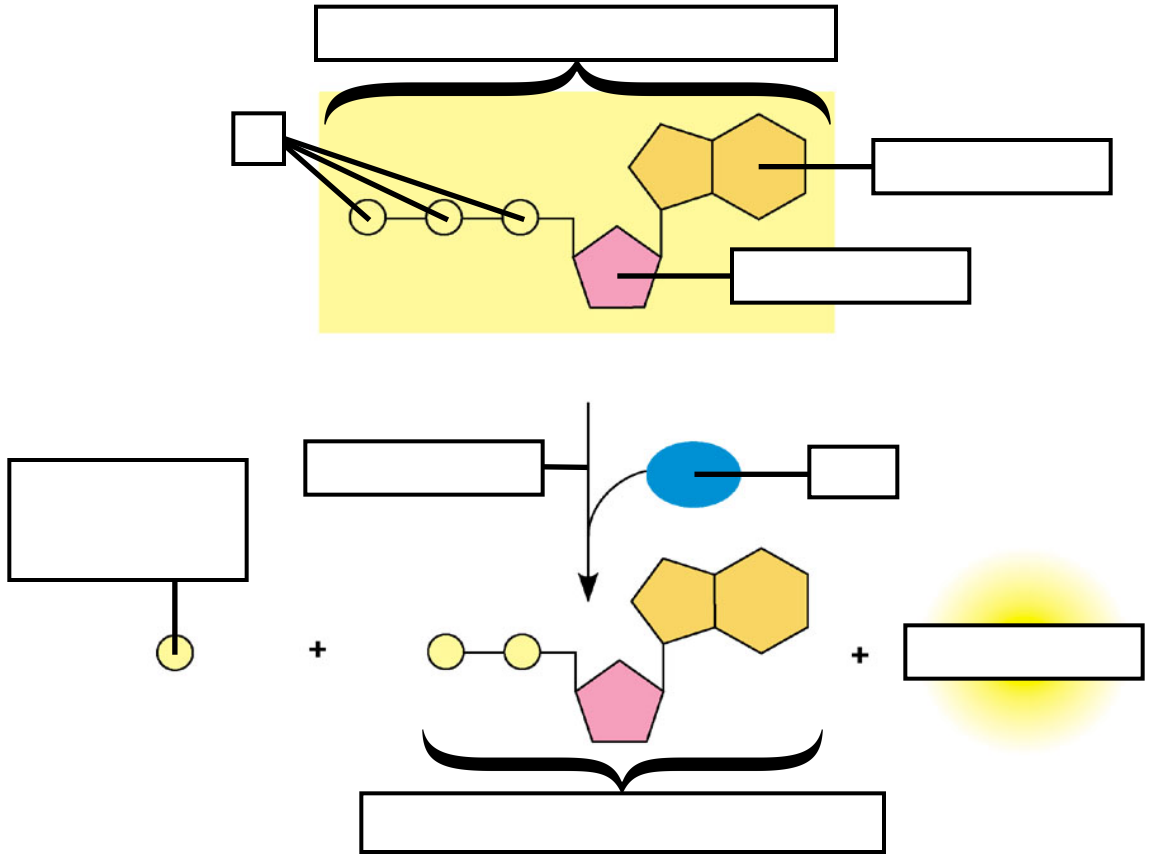
   b. What is **the role ATP plays in Energy Coupling**.

3. a. What does the acronym **ATP** stand for?

   b. What **components make up a molecule of ATP**?

   c. Besides being a molecule that can store and release energy, where else is ATP used in the cell?

4. Label the diagram below showing the **structure of ATP** & **how ATP helps cellular work get done**.



5. a. What type of chemical reaction allows for a terminal phosphate bond to be released from the ATP molecule?

b. As you see above, when the terminal phosphate-to-phosphate bond is broken in ATP, a molecule of ADP and a molecule of inorganic phosphate **P_i** form and energy is _____.

c. Is the **hydrolysis of ATP** exothermic or endothermic?

d. What is the **ΔG** for the reaction **ATP → ADP +P_i**? *(Under standard conditions)*.

e. What is the **ΔG** for the reaction **ATP → ADP +P_i**? *(Under actual cellular conditions)*.

f. ATP is useful as it releases more energy during hydrolysis than other molecules often can. **Why does ATP hydrolysis release the energy** it does?

6. a. By the way, based on your understanding now of some biochemistry (Ch.8.2), if hydrolysis reactions can convert ATP into ADP + P_i, **what kind of reaction do you think must be done to convert ADP + P_i back into ATP**? *(Hint: It's the reverse of the process depicted in Question #4)*

b. Given $\Delta G = G_{final\ state} - G_{initial\ state,}$ would the reaction, **ADP + P_i → ATP**, be **endergonic or exergonic**?!

c. Would the reaction, **ADP + P_i → ATP**, have a positive or negative calculated **ΔG**?

7. Let's return to the exergonic reaction of ATP hydrolysis (**ATP → ADP +P_i**) ...
   a. **What do cells do with the energy released from ATP hydrolysis**? *(The answer involves proteins).*

   b. *How* does ATP play a role in helping drive endergonic reactions by **coupling endergonic reactions to the exergonic reaction of ATP hydrolysis**?

   c. What does it mean when a molecule gets **phosphorylated**?

8. a. Describe how the **phosphorylation of reactants by ATP helps in driving chemical reactions**?

   b. Study Figure 8.10. Draw a series of three images showcasing the process you explained in 8.a for two reactants **A** and **B** as they undergo an **endergonic reaction** in order to be converted into product **C**, C being a product that is higher in free energy than the reactants A and B were. *The **1st** image should show the starting reactants and product. The **2nd** image should show the intermediate stage of the reaction, when a phosphorylated intermediate has formed with the help of ATP. The **3rd** stage should show the ending status of the reaction **and ATP hydrolysis**.*

1.

2.

3.

*(**Note:** Since the reverse reaction, C → A + B, is exergonic, the product - C - being lower in free energy than the reactants - A + B - , **NO** additional net energy - from ATP - would be needed for the reaction to occur and so **NO** phosphorylated intermediate would be observed)*

c. Describe how the **phosphorylation of membrane transport proteins by ATP drives transport work** that takes place when a transport protein moves solutes across a membrane.

d. Study 8.11. Let's see if you can visualize what occurs. Draw a series of images showcasing the process you explained in 8.c for **solute A that is being pumped actively across a membrane by a carrier transport protein**. *The **1st** image should show the starting state with an empty carrier and solute A in a region of lower solute A concentration compared to the region of higher solute A concentration. The **2nd** image should show an intermediate stage of the transport activity, with solute A bound to the binding site on the carrier as it is being carried across the membrane, the carrier having been phosphorylated. The **3rd** image should show the carrier de-phosphorylated again, back to its original shape, the solute A on the side of higher solute A concentration.* Don't forget to include ATP, ADP, &/of P_i as relevant in each figure.

1.	2.	3.

e. Describe how **ATP and ATP Hydrolysis drives mechanical work** that takes place when a **motor protein** *(like dynein or myosin)* **moves vesicles along the cytoskeleton**? *Notice that this process does not involve the motor protein getting phosphorylated though ATP still releases energy that causes the protein to change shape!*

f. Draw a series of images showcasing the process you explained in 8.e for a transport vesicle, carrying substance B, that is being actively pulled along a microtubule by a motor protein of dynein. *The **1st** image should show the motor protein's starting position, interacting with a membrane protein of a vesicle filled with copies of solute B. The **2nd** image should show ATP docked onto one of the motor protein's "feet", which causes the motor protein to take one step forward. The **3rd** image should show ATP having been hydrolyzed, the products of that hydrolysis having fallen off the motor protein, the release of energy from ATP and the dislodging of ATP from the motor protein causing it to take a second step, returning in its shape to the that which it had initially.*

1.	2.	3.

9. Study Figure 8.12. Draw and explain the **ATP cycle**?

Illustrated ATP Cycle	**Explanation of the ATP Cycle**

10. Where does the required **energy** comes from **used to phosphorylate ADP and produce new ATP molecules** *(an endergonic process that results in a product - ATP - with more Gibbs Free Energy than both reactants initially had)*?

11. Review Figure 8.10. Which of the following combination of substances has more free energy combined: Glutamic acid + ammonia + ATP **or** glutamine + ADP + P_i? Explain the details of why you claim what you claim. *(Check your answer by going to the **Ch.8.3 Concept Check Question #2** answer in Appendix A)*