Biology 1305 – Modern Concepts in Bioscience – ICB Textbook
Week of November 2nd, 2020
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Hello everyone!! I hope you are all enjoying the Biology ICB class. We are a few weeks away from finals and hopefully everyone is in good standing and ready to tackle the material that's left in the class. If you need an extra hand, remember that we continue to have group tutoring for this class each week. If you cannot make it to Group Tutoring, also know that these resources are available to you in the tutoring center website. If you wish to attend group tutoring, make sure you reserve a spot via the tutoring center website.

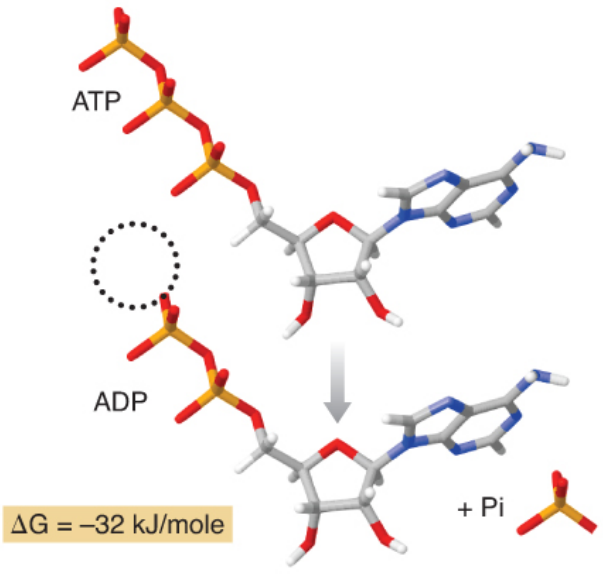
Our Group Tutoring sessions will be every Tuesday from 6:00 – 7:00 PM. You can reserve a spot at https://baylor.edu/tutoring. I hope to see you there!

Last week, we went over experimental details about multicellular organisms, and looked at the role of molecular structure in cellular functioning and signal transduction pathways using the epinephrine example.
That resource can be found here:
https://www.baylor.edu/support_programs/index.php?id=967950

This week, we will jump into chapter 10 and review the most important concepts related to: **how molecules carry energy and how food is converted to molecular energy.**

The first question to tackle in this chapter is: **how do biomolecules carry energy?** For this, we need to know the **laws of thermodynamics** and the different types of energy in terms of bioenergetics: Total energy of the system (H), free energy available (G), and Entropy (S).

$$\Delta G = \Delta H - \Delta S \times T$$



Converting ATP to ADP releases energy. The terminal phosphate (P_i) is removed from ATP and produces ADP. The products have less energy due to the two electrons lost in the broken bond. **Total amount of energy from ATP hydrolysis is -32 kJ/mole.** Other very important molecules known as energy carriers include NADH, $FADH_2$, and biomolecules that are involved in bioenergetics: oxygen, pyruvate, glucose.

Next, we will answer: **how does food get converted into energy?** In other words, how does glucose is metabolized to produce ATP? The following videos about glucose metabolism and ATP production should help in getting the details about these important processes.

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Glycolysis: (https://www.youtube.com/watch?v=hIzNDdcboSA&list=PLYjFOc4FIyikoVfco6z-axMx5_CDDHj2m&index=15

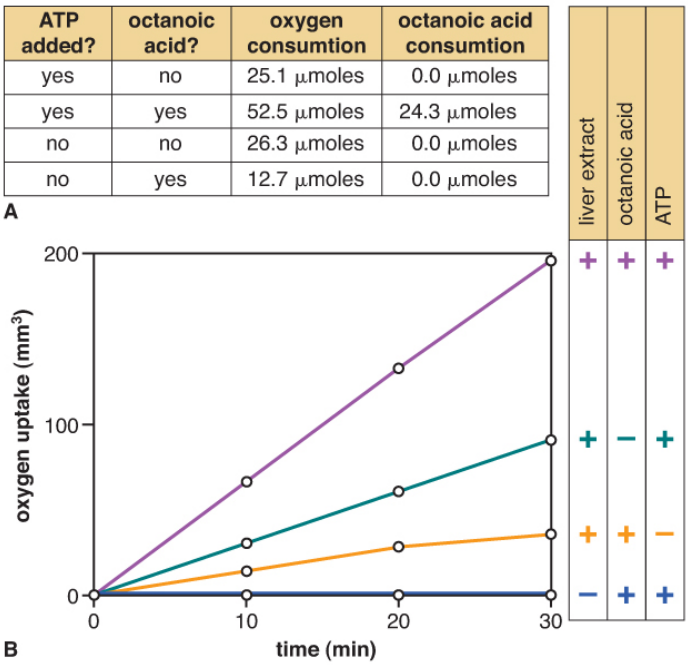
Pyruvate oxidation, the citric acid cycle:
https://www.youtube.com/watch?v=SuUa8SKkVf4&list=PLYjFOc4FIyikoVfco6z-axMx5_CDDHj2m&index=17

Electron transport chain:
https://www.youtube.com/watch?v=bWoFrP4D1GQ&feature=youtu.be

Another topic related to energy production is **lipid metabolism**, so how do organisms produce energy from lipids? Let's look at some experimental data to investigate this further. The figure below shows the biochemical requirements for beta oxidation of an 8-carbon lipid, octanoic acid. **A,** Liver cell extract was incubated with ATP and octanoic acid as indicated for 30 minutes before oxygen and fatty acid consumption were measured. **B,** Rate of oxygen consumption by liver cell extracts over 30 minutes when octanoic acid and ATP were added as indicated. These were part of a series of experiments known as the Lehninger experiments.

ATP added?	octanoic acid?	oxygen consumtion	octanoic acid consumtion
yes	no	25.1 μmoles	0.0 μmoles
yes	yes	52.5 μmoles	24.3 μmoles
no	no	26.3 μmoles	0.0 μmoles
no	yes	12.7 μmoles	0.0 μmoles

A



The Lehninger experiment found that ATP, oxygen, and fatty acids were consumed during beta oxidation. Of course, cell extracts can do more than just beta oxidation, which is why they consumed oxygen in all four conditions. Only when ATP, oxygen, and octanoic acid were combined with the cytoplasm of liver cells could Lehninger measure the consumption of fatty acid and oxygen, which explains why fatty acid degradation is called **beta *oxidation.***

Next, we want to understand protein metabolism and how pH affects protein function. In other words, **how can an enzyme digest proteins when the pH is so low that most proteins cannot function?** The figures below show protease activity for digesting proteins. **A,** Humans produce all three proteases tested, but each enzyme has a different pH sensitivity. **B,** Pepsin was incubated with three different protein substrates, and their degradation was monitored over 4 hours.

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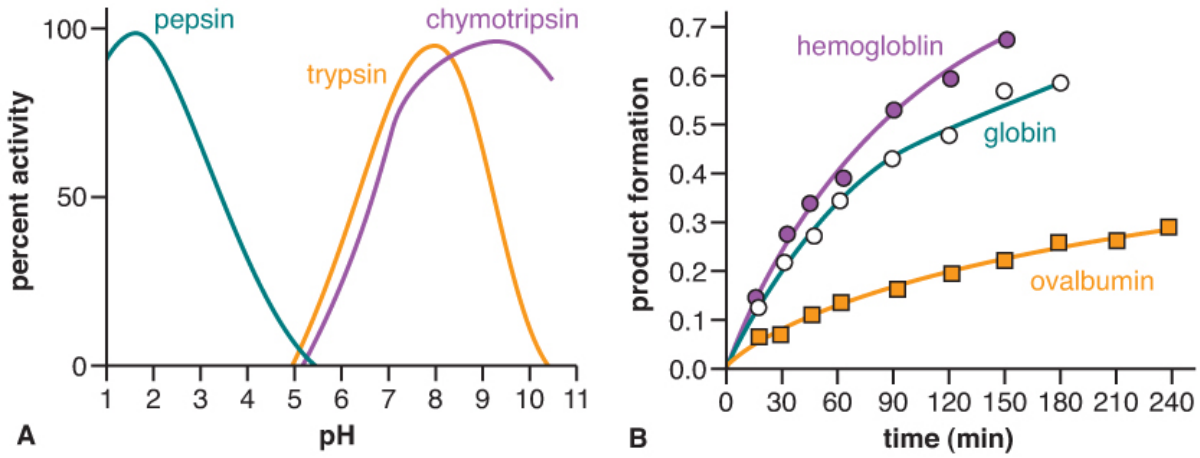
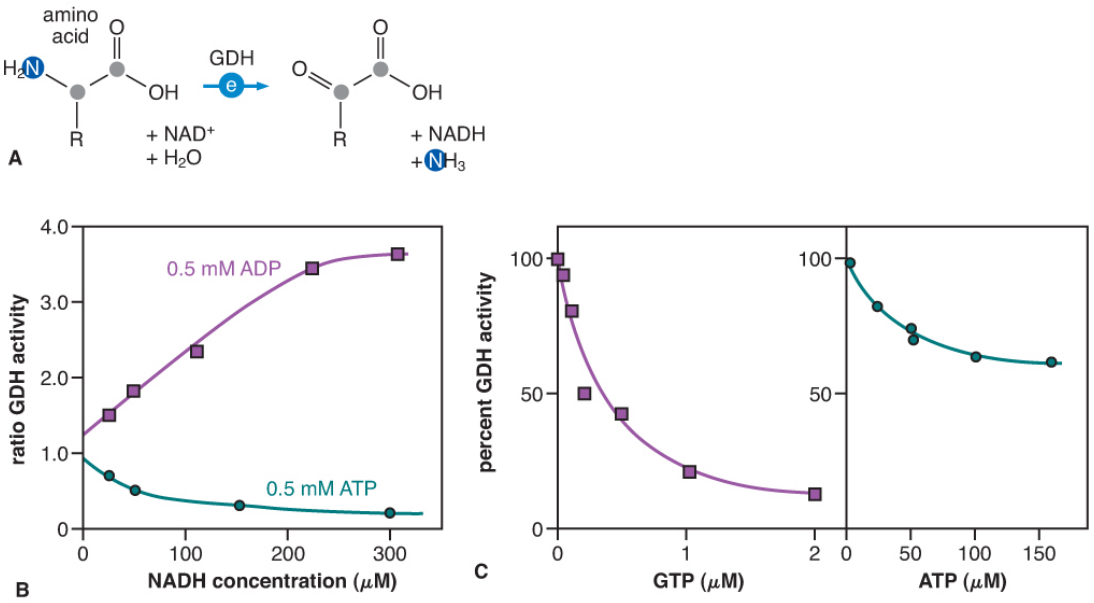


Once the proteases have digested complex proteins into individual amino acids, **the molecular components of cellular respiration take control of converting amino acids into forms that are more easily converted to ATP.** One way to use amino acids that you consume is to recycle them by making new proteins directly from these amino acids. However, if you need to extract energy from a protein food source such as mother's milk, your cells have the ability to break amino acids into two parts. For example, glutamate is one of the 20 amino acids and glutamate dehydrogenase (GDH) is an important enzyme in cellular respiration of proteins. GDH consumes one amino acid and one NAD^+ to produce an ammonia molecule, one NADH, and the oxidized amino acid lacking its nitrogen atom.

The figure below represents deamination of amino acids. **A,** GDH removes the amine and produces ammonia and NADH as well as a 2-carbon acetyl group. The light blue circle labeled "e" represents an enzymatic reaction. **B,** GDH activity is modulated by ATP and ADP over a range of NADH concentrations. The ratio of activity compares GDH with and without the indicated nucleotide. **C,** GTP and ATP alter GDH activity differently at 85 µM NADH.



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Let's check your understanding!

1. What does ATP stand for?
2. What does it mean when ATP is hydrolized?
3. What other molecules are known to be energy carriers?
4. What is required for beta-oxidation?
5. Why is the protein pepsin more active at low pH while other proteins are not?

Answers!!

1. Adenosine tri-phosphate
2. A phosphate group is removed from the ATP molecule, producing ADP.
3. NADH and $FADH_2$
4. The combination of ATP, oxygen, and octanoic acid with the cytoplasm of cells.
5. Because it breaks down proteins in the stomach during digestion, when gastric juice (highly acidic) is also released.

That's it this week. Please reach out if you have any questions and don't forget to visit the Tutoring Center website for further information.

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