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AP Biology Insta-Review

Unit 3: Cellular Energetics

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AP Biology

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Today’s Plan:

Enzymes

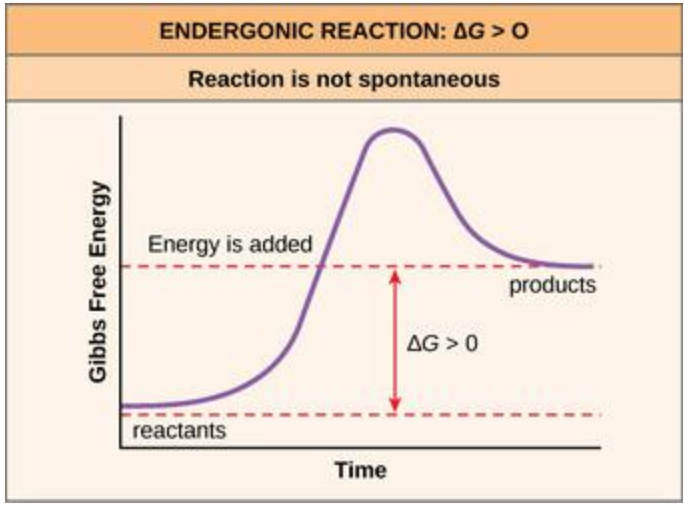
Cellular Respiration

Photosynthesis

Practice Questions

Unit 3 Q&A

Endergonic Reaction



- Not spontaneous
- ABSORB energy
- Example: ADP + P_i → ATP

- Spontaneous
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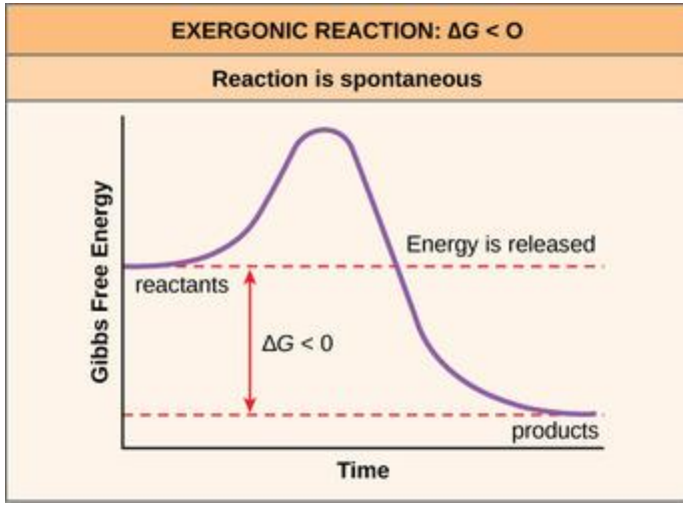


Exergonic Reaction

Gibbs Free Energy & Reactions

What is Gibbs Free Energy?

- Energy available to do work

$$\Delta G = \Delta G_f - \Delta G_i$$

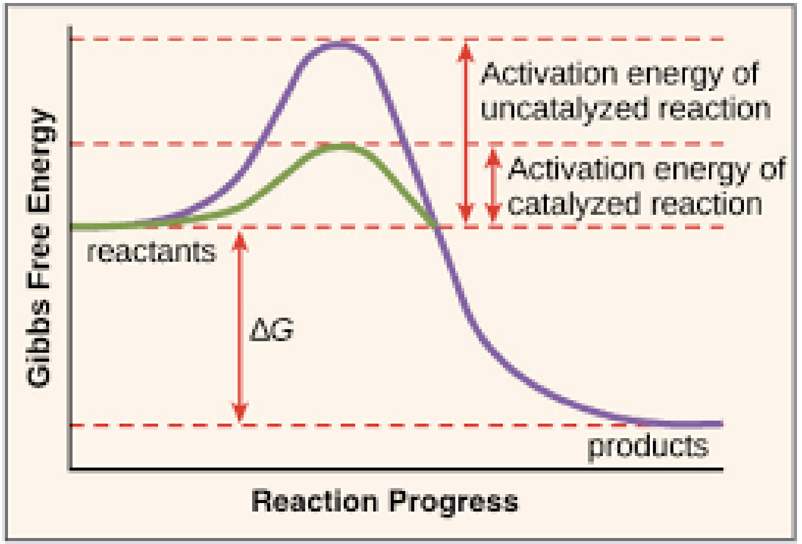
$$\Delta G = \Delta H - T\Delta S$$

- ΔG: Change in Gibbs Free Energy
- ΔH: Change in Enthalpy
- T: Temperature (K)
- ΔS: Change in Entropy

Enzymes

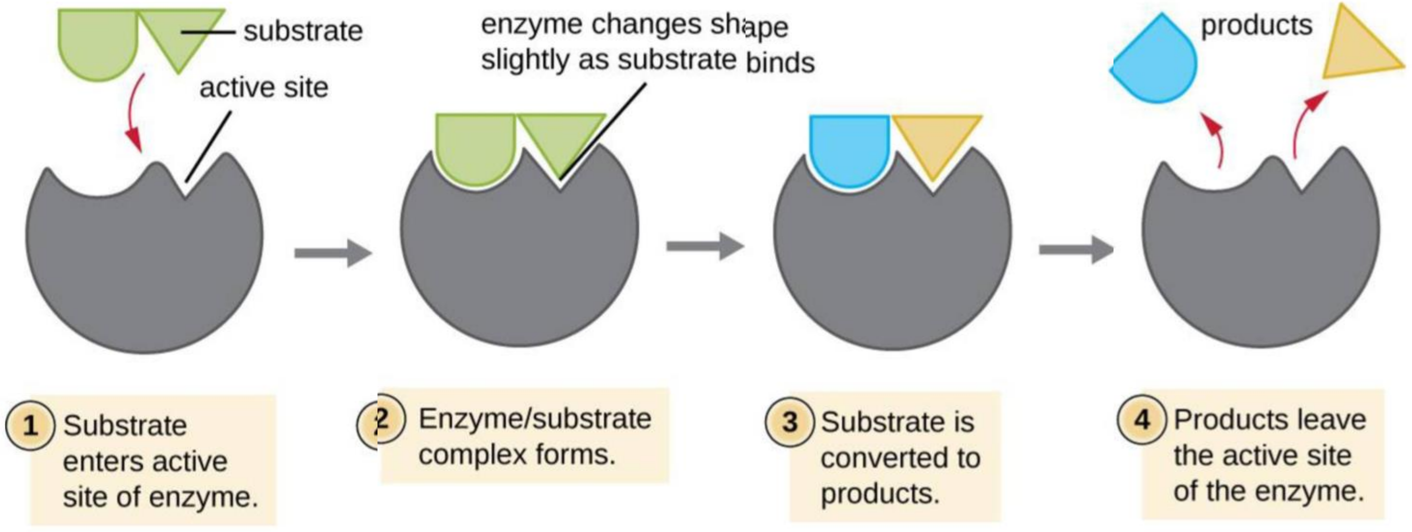
Functions

- Biological catalyst
- Speeds up chemical reactions
- Reduces the activation energy



Important Notes:

- Enzymes are PROTEINS
- Are NOT consumed by the reaction
- Have no effect on the change in Gibbs Free Energy



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Competitive:

- Binds to active site

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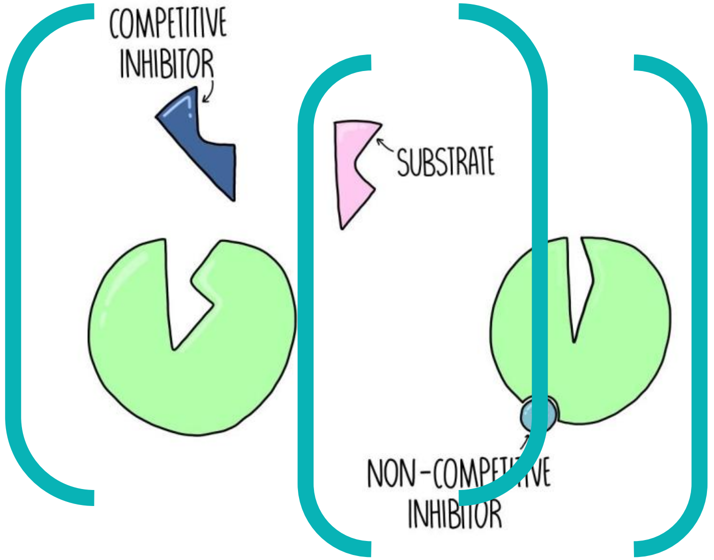

Denaturation

Environmental Temperatures
pH
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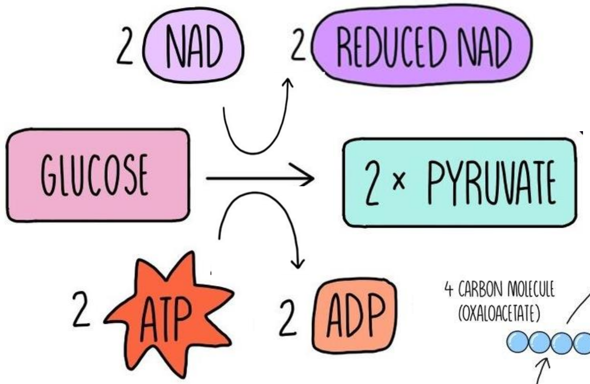
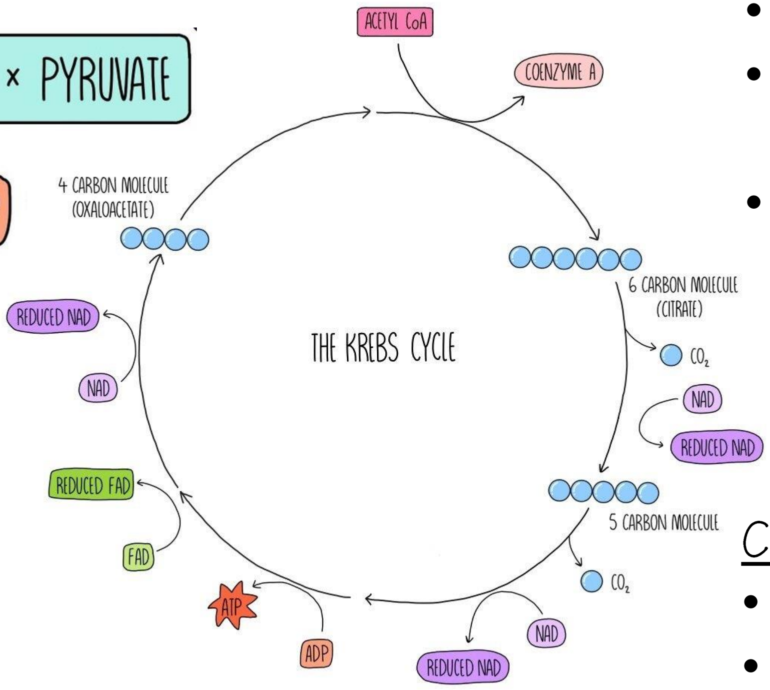
Cellular Respiration

Glycolysis

- Location: Cytosol
- Starting Material:
  Glucose
- Products:
  2 Pyruvate
  2 NADH
  2 ATP





Krebs Cycle

- Location: Mitochondrial Matrix
- Staring Material:
  Acetyl CoA
- Products:
  2 CO_2
  3 NADH
  1 $FADH_2$
  1 ATP

Chemiosmosis

- ATP Synthase uses proton gradient
- Synthesizes ATP

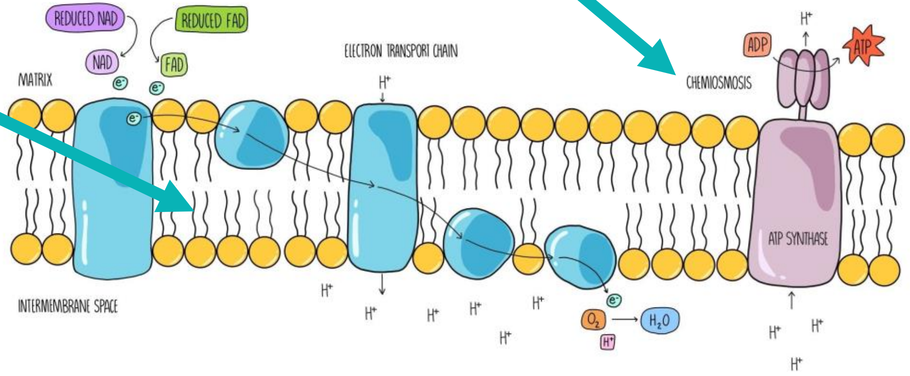
Oxidative Phosphorylation

- Location: Mitochondrial Cristae
- Starting Material:
  NADH/$FADH_2$ (electrons)
- Product:
  ATPs
- Two Parts:

Electron Transport Chain & Chemiosmosis

Electron Transport Chain

- Protons pumped into IM space
- Generates proton gradient
- Final electron acceptor: OXYGEN



Cellular respiration includes the metabolic pathways of glycolysis, the Krebs cycle, and the electron transport chain, as represented in the figures. In cellular respiration, carbohydrates and other metabolites are oxidized, and the resulting energy-transfer reactions support the synthesis of ATP.

(a) Using the information above, describe ONE contribution of each of the following in ATP synthesis.

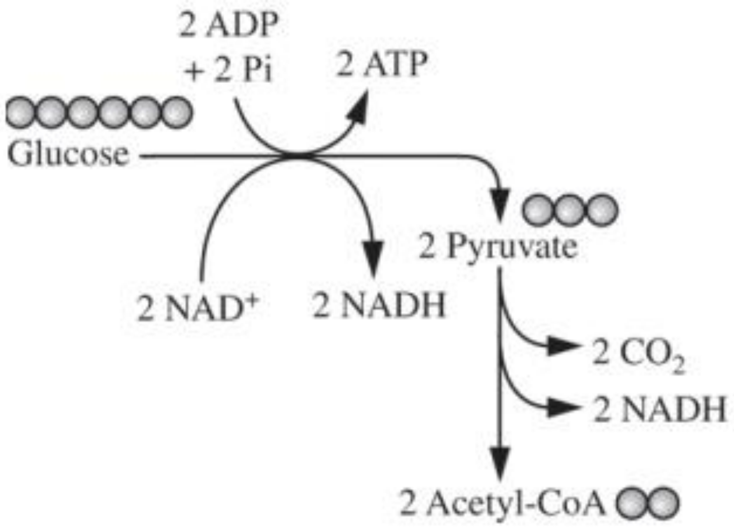


Figure 1. Glycolysis and pyruvate oxidation

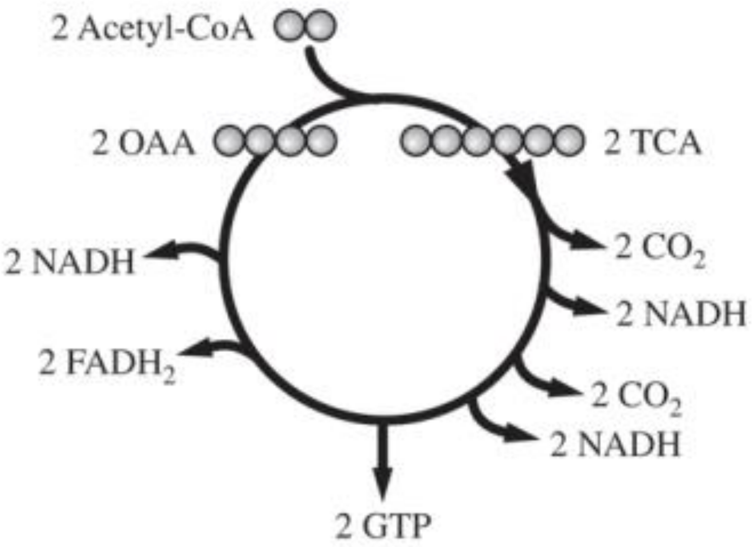


Figure 2. Krebs cycle

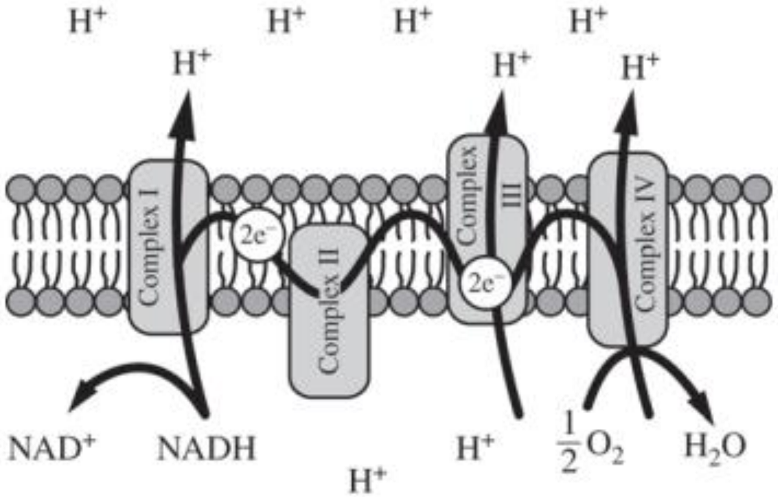


Figure 3. Electron transport chain

Catabolism of glucose in glycolysis and pyruvate oxidation

- Produces NADH for use in ETC
- Produces acetyl-CoA for entry into Krebs cycle
- Provides energy for (substrate level) phosphorylation of ADP

Oxidation of intermediates in the Krebs cycle

- Produces NADH or FADH2 for use in ETC
- Releases high energy electrons for use in ETC
- Provides energy to pump protons against their concentration gradient
- Produces GTP for (substrate level) phosphorylation of ADP

Formation of a proton gradient by the electron transport chain

- The flow of protons through membrane-bound ATP synthase generates ATP
- Provides energy for (oxidative) phosphorylation of ADP

Photosynthesis

Light Reactions

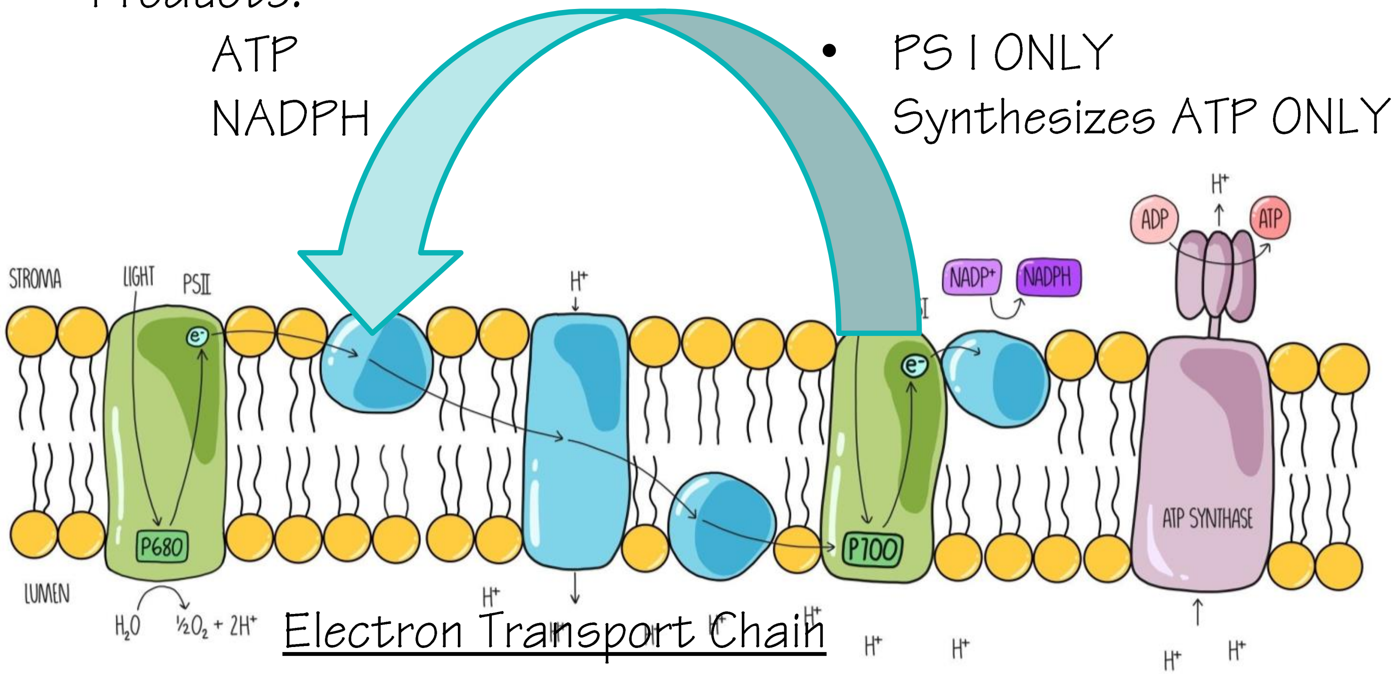
- Location: Thylakoid Membrane
- Starting Material:
  - Water (electrons)
  - Photons (energy)
- Products:
  - ATP
  - NADPH

Linear Electron Flow

- PS I & PS II
- Synthesizes ATP & NADPH

Cyclic Electron Flow

- PS I ONLY
- Synthesizes ATP ONLY

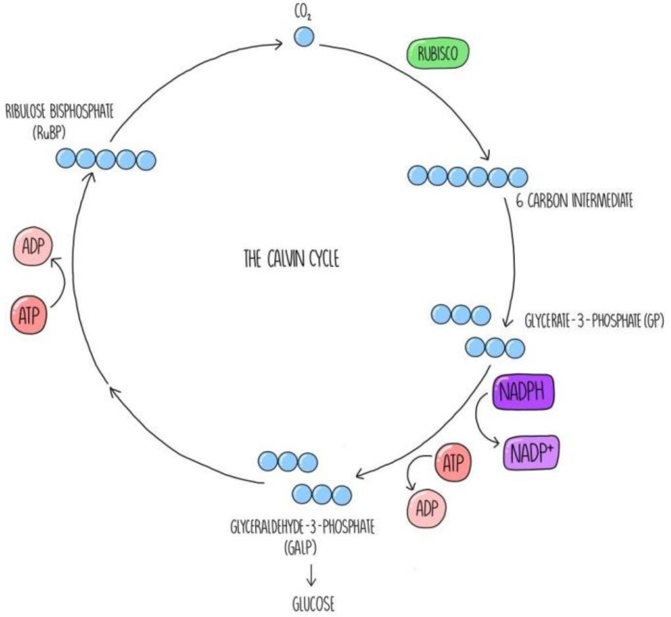


__Electron Transport Chain__

- Protons are pumped into the thylakoid space

Calvin Cycle

- Location: Stroma
- Starting Material:
  - 3 CO_2
  - 9 ATP
  - 6 NADPH
- Products:
  - G3P



Multiple Choice Practice

The chemical reaction for photosynthesis is

$$6\ CO_2 + 12\ H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$$

If the input water is labeled with a radioactive isotope of oxygen, ^{18}O, then the oxygen gas released as the reaction proceeds is also labeled with ^{18}O. Which of the following is the most likely explanation?

a. During the light reactions of photosynthesis, water is split, the hydrogen atoms combine with the CO_2, and oxygen gas is released.

b. During the light reactions of photosynthesis, water is split, removing electrons and protons, and oxygen gas is released.

c. During the Calvin cycle, water is split, regenerating NADPH from $NADP^+$, and oxygen gas is released.

d. During the Calvin cycle, water is split, the hydrogen atoms are added to intermediates of sugar synthesis, and oxygen gas is released.

Organism	Temperature (°C)	Average respiration ($mL\ O_2/g/min$)
Mouse	10	0.0518
Mouse	25	0.0321
Cricket	10	0.0013
Cricket	25	0.0038

An experiment to measure the rate of respiration in crickets and mice at 10°C and 25°C was performed using a respirometer, an apparatus that measures changes in gas volume. Respiration was measured in mL of O_2 consumed per gram of organism over several five-minute trials and the following data were obtained.

According to the data, the mice at 10°C demonstrated greater oxygen consumption per gram of tissue than did the mice at 25°C. This is most likely explained by which of the following statements?

a. The mice at 10°C had a higher rate of ATP production than the mice at 25°

b. The mice at 10°C had a lower metabolic rate than the mice at 25°C.

c. The mice at 25°C weighed less than the mice at 10°C.

d. The mice at 25°C were more active than the mice at 10°C.

Free Response Practice:

Researchers hypothesize that the plant compound resveratrol improves mitochondrial function. To test this hypothesis, researchers dissolve resveratrol in dimethyl sulfoxide (DMSO). The solution readily passes through cell membranes. They add resveratrol solution to mammalian muscle cells growing in a nutrient-rich solution (culture medium) that contains glucose. They measure ATP production at several time points after the addition of the resveratrol solution and find an increase in ATP production by the muscle cells.

(a) **Describe** the primary advantage for a mammalian muscle cell in using aerobic respiration over fermentation.

- More ATP (per glucose molecule) is produced by aerobic respiration.

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(b) **Identify** an appropriate negative control for this experiment that would allow the researchers to conclude that ATP is produced in response to the resveratrol treatment.

Accept one of the following:

- The researchers must run the experiment without adding resveratrol.
- The researchers must treat the cells with DMSO alone.

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(c) **Predict** the effect on short-term ATP production when resveratrol-treated mammalian muscle cells are grown in a culture medium that lacks glucose or other sugars.

Accept one of the following:

- No ATP production
- Reduced ATP production

Free Response Practice:

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(d) The researchers find that resveratrol stimulates the production of components of the electron transport chain. The researchers claim that treatment with resveratrol will also increase oxygen consumption by the cells if glucose is not limiting. **Justify** this claim.

- More electrons can be transferred so that more oxygen is required as the final electron acceptor.

Q & A

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Gibbs Free Energy & Reactions

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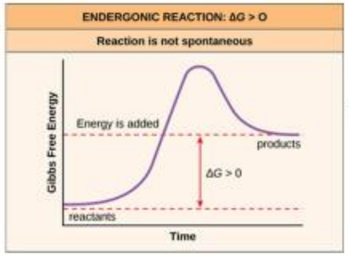

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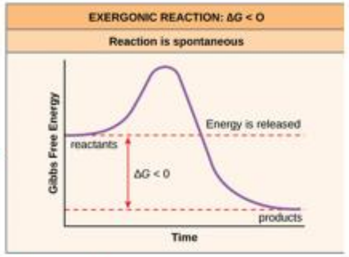

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Exergonic Reaction

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

- Change in Gibbs Free Energy (ΔG)
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- Temperature (K) (T)
- Change in Entropy (ΔS)

What is Gibbs Free Energy?

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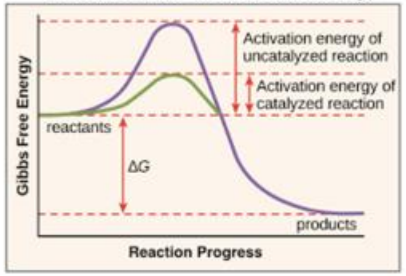

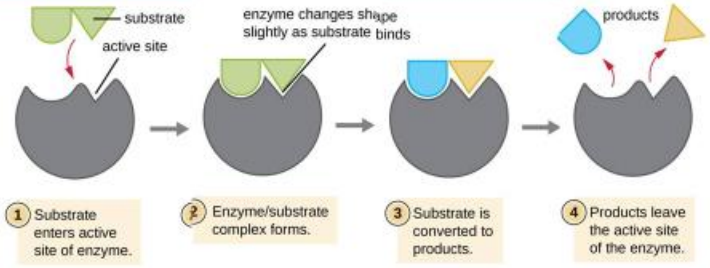

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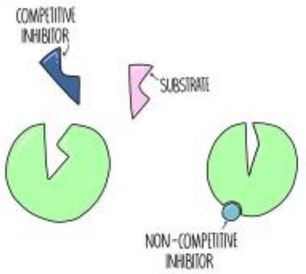

Denaturation

Environmental Temperatures
pH
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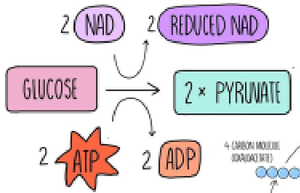
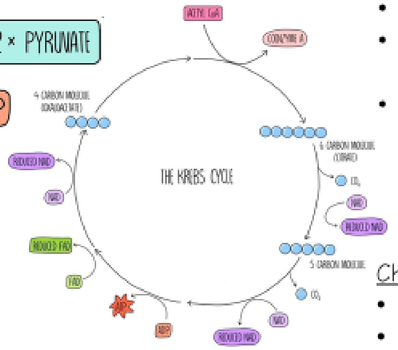
Salinity

Cellular Respiration

Glycolysis

- Location: Cytosol
- Starting Material: Glucose
- Products:
  - 2 Pyruvate
  - 2 NADH
  - 2 ATP





Krebs Cycle

- Location: Mitochondrial Matrix
- Staring Material: Acetyl CoA
- Products:
  - 2 CO_2
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Oxidative Phosphorylation

- Location: Mitochondrial Cristae
- Starting Material: NADH/$FADH_2$ (electrons)
- Product: ATPs
- Two Parts: Electron Transport Chain & Chemiosmosis

Chemiosmosis

- ATP Synthase uses proton gradient
- Synthesizes ATP

Electron Transport Chain

- Protons pumped into IM space
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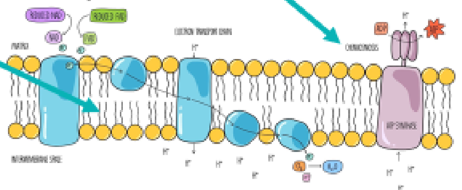
- Final electron acceptor: OXYGEN



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Light Reactions

- Location: Thylakoid Membrane
- Starting Material:
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- Products:
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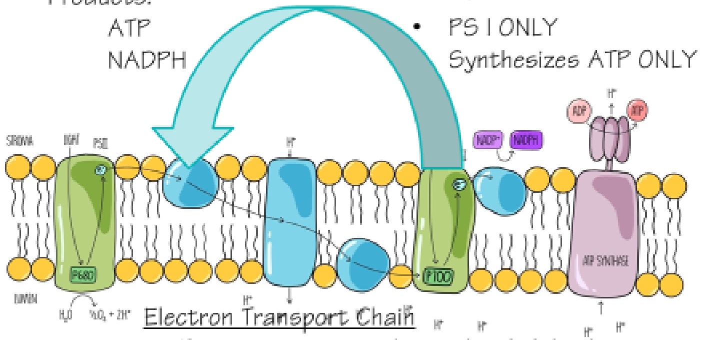

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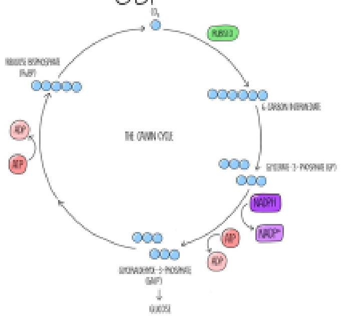

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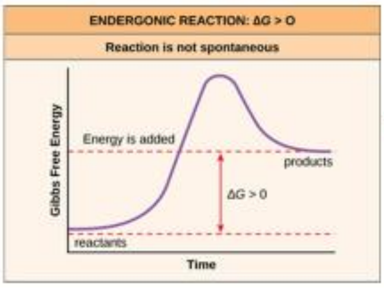

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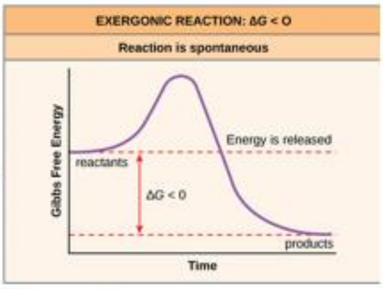

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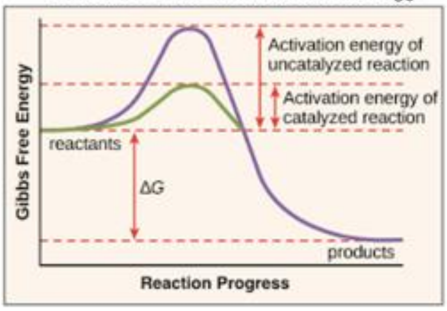

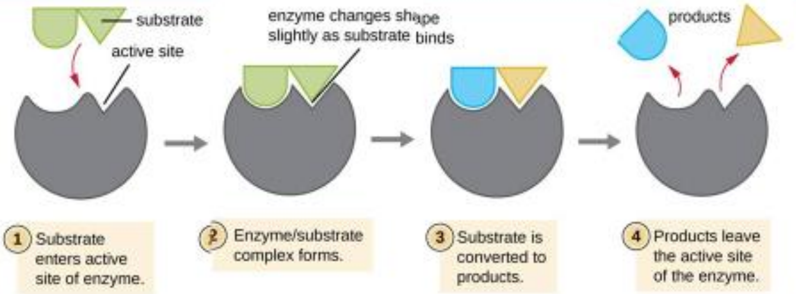

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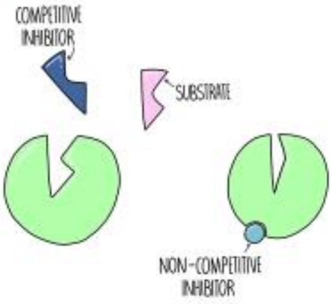

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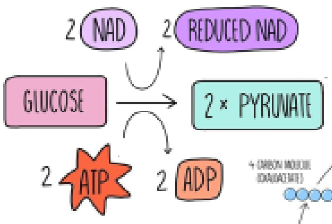

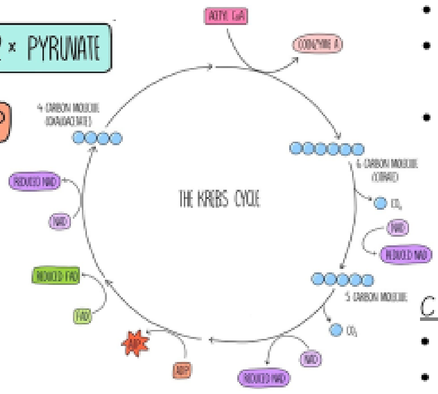

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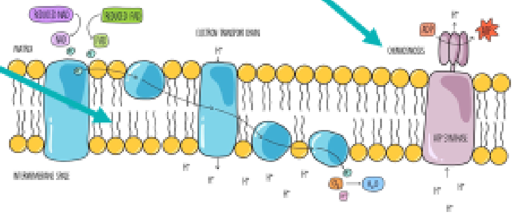

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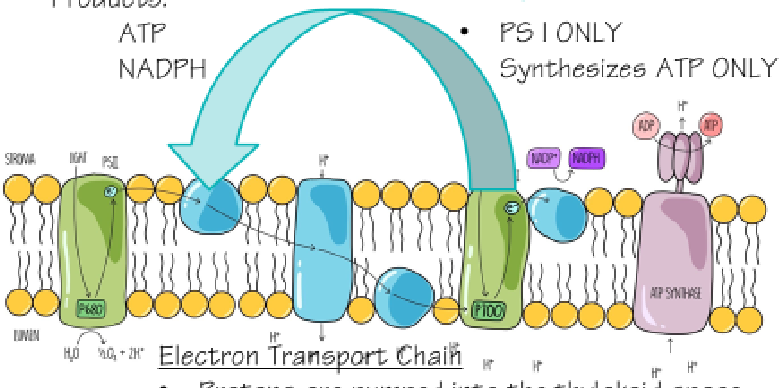

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