Topic 2.8 Cell Respiration

Essential idea: Cell respiration supplies energy for the functions of life.

Understandings:

- 2.8.U1 Cell respiration is the controlled release of energy from organic compounds to produce ATP. [Details of the metabolic pathways of cell respiration are not needed but the substrates and final waste products should be known.]
- 2.8.U2 ATP from cell respiration is immediately available as a source of energy in the cell.
- 2.8.U3 Anaerobic cell respiration gives a small yield of ATP from glucose.
- 2.8.U4 Aerobic cell respiration requires oxygen and gives a large yield of ATP from glucose.

Application:

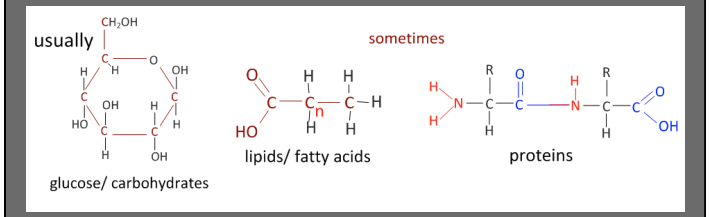
- 2.8.A1 Use of anaerobic cell respiration in yeasts to produce ethanol and carbon dioxide in baking.
- 2.8.A2 Lactate production in humans when anaerobic respiration is used to maximize the power of muscle contractions.

Skills:

- 2.8.S1 Analysis of results from experiments involving measurement of respiration rates in germinating seeds or invertebrates using a respirometer.

I. Release of Energy by Cell Respiration

A. Cell respiration is the controlled release of energy from organic compounds to produce ATP-
   1. Almost all organic compounds can be broken down to release energy to be harvested as ATP.



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II. ATP is a Source of Energy

A. ATP from cell respiration is immediately available as a source of energy in the cell-

$C_6H_{12}O_6$

Glucose
An organic molecule

II. ATP is a Source of Energy

$C_6H_{12}O_6 + 6O_2$

Oxygen
Aerobic respiration gives a higher yield of ATP

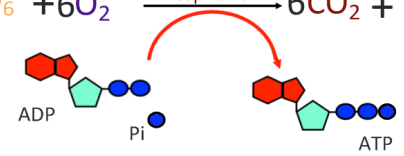
II. ATP is a Source of Energy

$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{respiration}} 6CO_2 + 6H_2O$

Many enzymes facilitate the reactions

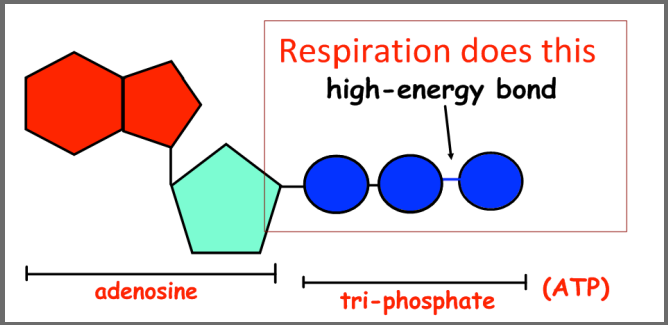
II. ATP is a Source of Energy

$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{respiration}} 6CO_2 + 6H_2O$



II. ATP is a Source of Energy

2. ATP (adenosine triphosphate) can power cell processes.



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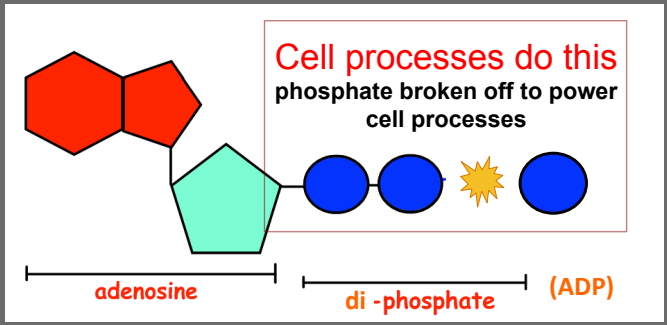
II. ATP is a Source of Energy

3. ADP (adenosine diphosphate) is a "rechargeable" molecule that can reenergized through cell respiration.



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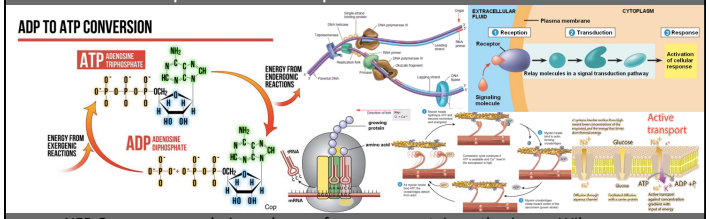
II. ATP is a Source of Energy

B. ATP powers:
   1. DNA and RNA replication
   2. Synthesis of DNA, RNA and proteins
   3. Active transport
   4. Muscle contrition
   5. Cell signaling
   6. Transport of cell components

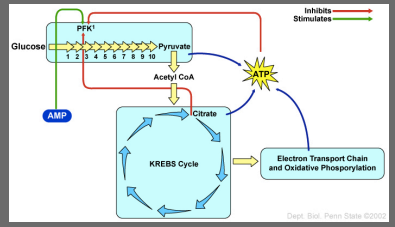
The energy transfer that occur with ATP/ADP are not 100% efficient. Where is this energy lost to?



NFP Gear; reasonandscience.heavenforum.org; proteinsynthesis.org; Wiley; Pearson Education

II. ATP is a Source of Energy

C. Energy is released in a controlled manner:
   1. Enzymes make intermediates throughout the production of ATP in metabolic pathways and cycles (glycolysis, Kreb's cycle and the electron transport chain).
      a. The step-wise process of harvesting energy from the changing of chemical bonds intermediate maximizes ATP yield.
   2. ATP is an end-product inhibitor that regulates itself through negative feedback.



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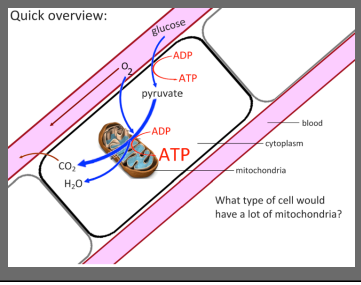
III. Aerobic Respiration

A. Aerobic respiration requires oxygen and give a large yield of ATP from glucose-
   1. One molecule of glucose can potentially yield 36 to 38 ATP molecules when oxygen is present.
   2. Metabolic water and carbon dioxide waste are also produced.

How much ATP is needed by the cell to meet its metabolic needs?



If oxygen is not present (anaerobic conditions), how will the cell meets is metabolic needs?

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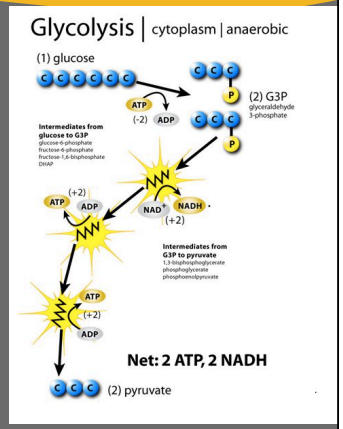
IV. Anaerobic Respiration

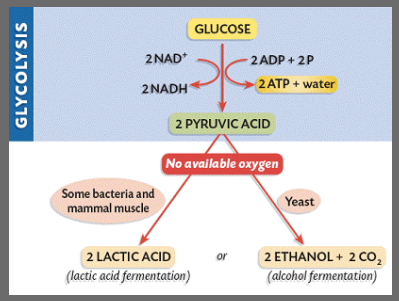
A. Anaerobic cell respiration gives a small yield of ATP from glucose-
   1. The first step of glucose breakdown is completed utilizing glycolysis which does not require oxygen.
   2. Glycolysis is important:
      a. for quick, but short production of ATP.
      b. when oxygen supplies have run out.
      c. anaerobic environments.



Sharyl Fleming

IV. Anaerobic Respiration

3. Pyruvate is used to convert NADH (an electron carrier to be discussed later…) to continue glycolysis.
4. The products of anaerobic respiration are toxic and either must be removed or limited in quantity.



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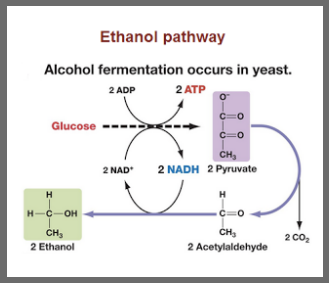
IV. Anaerobic Respiration

B. Anaerobic respiration in yeast and plants:
   1. Glucose is converted to pyruvate and ATP.
   2. Pyruvate is processed into ethanol and carbon dioxide.



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2.8.A1 Use of anaerobic cell respiration in yeasts to produce ethanol and carbon dioxide in baking.

Bread is made by adding **water** to **flour**, kneading the mixture to make dough and then baking it. Usually an ingredient is added to the dough to create bubbles of gas, so that the baked bread has a lighter texture (e.g. **yeast**).

After kneading (mixing) the dough is kept **warm** to encourage the yeast to respire.

Yeast can respire aerobically or anaerobically, but oxygen in the dough is soon used up so the yeast is forced to **respire anaerobically**.

The **carbon dioxide produced** by anaerobic cell respiration cannot escape from the dough and **forms bubbles** causing the dough to **swell** and **rise**.

Ethanol is also produced by anaerobic cell respiration, but it **evaporates** during baking.

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2.8.A1 Use of anaerobic cell respiration in yeasts to produce ethanol and carbon dioxide in baking.

Bioethanol (ethanol produced by organisms) is a renewable energy source.

Most bioethanol is produced from **sugar cane** and **maize**, using **yeast**.

Starch and **cellulose** in the plant material are broken down by **enzymes** into sugars.

Fermenters are used to keep the yeast in optimum conditions.

When yeast carry out **anaerobic respiration** the **sugars** in the plant material are converted to **ethanol** and carbon dioxide.

The ethanol produced by the yeasts is purified by distillation and water is removed to improve combustion.

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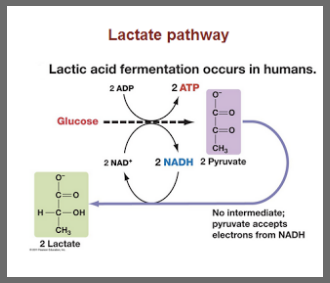
IV. Anaerobic Respiration

C. Anaerobic respiration in mammals and some bacteria:
   1. Glucose is converted to pyruvate and ATP.
   2. Pyruvate is processed into lactate.



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2.8.A2 Lactate production in humans when anaerobic respiration is used to maximize the power of muscle contractions.

Certain human activities require **anaerobic respiration** such as **weight lifting** and **sprinting**.

Aerobic respiration generates a much greater yield of ATP, but anaerobic respiration can **supply ATP very rapidly**, as oxygen is not required.

Rapid generation of ATP enables us to **maximize the power of muscle contractions**.

Anaerobic cell respiration **produces lactate**. There is a **limit** to the **concentration** of lactate that the body can **tolerate** and this limits how much or how long anaerobic respiration can be done for.

Afterwards lactate must be **broken down**. This involves the use of oxygen. It can take several minutes for enough oxygen to be absorbed for all lactate to be broken down. The demand for oxygen that builds up during a period of anaerobic respiration is called the **oxygen debt**.

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