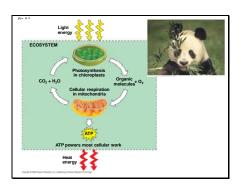


Slide 2

Metabolism

- Thermodynamics says that the flow of chemical energy into a system is equal to:
 - the energy used as work
 - the energy lost as heat
 - the chemical potential energy stored
 - true for ecosystems, organisms, tissues, cells

Slide 3



Metabolic pathways

 Catabolic pathways <u>release energy</u> (exergonic) by breaking down complex molecules into simpler compounds

> Free energy available for work

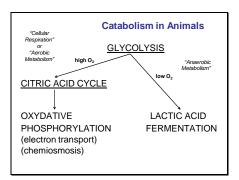
Heat energy lost to the organism

- Work pathways couple the energy derived from exergonic reactions to perform an endergonic activity – together the whole is always exergonic
 - Anabolic pathways
- Mechanical work

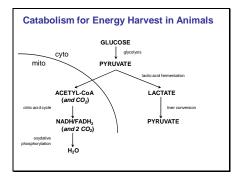
More heat energy

- Transport work

Slide 5



Slide 6



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Other Catabolic Pathways

- Fermentation is a partial degradation of sugars that occurs (with/without) O₂
 - Alcohol fermentation Saccharomyces cerevisiae
 - Lactic acid fermentation Lactobacillus acidophilus
 - Acetic acid fermentation Escherichia coli
- Anaerobic respiration is similar to aerobic respiration but consumes compounds other than ${\rm O}_2$
 - Sulfate-reducing bacteria and archaea

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Slide 8

 Although carbohydrates, fats, and proteins are all consumed as fuel, it is helpful to trace cellular respiration with the sugar glucose:

$$C_6H_{12}O_6 + 6 O_2$$

$$\downarrow \\ 6 CO_2 + 6 H_2O$$

Energy (ATP + heat)

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Slide 9

The Principle of Redox

How does the breakdown of glucose yield energy?

- The <u>transfer of electrons</u> during chemical reactions releases energy stored in organic molecules
- Chemical reactions that transfer electrons between reactants are called oxidation-reduction reactions
 - or redox reactions

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The Principle of Redox

- In oxidation, a substance loses electrons, or is oxidized
- In reduction, a substance gains electrons, or is reduced.

an oxidized reactant is more (+) a reduced reactant is less (+)

- The <u>electron donor</u> is called the **reducing agent**
- The <u>electron receptor</u> is called the **oxidizing agent**

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Slide 11

Oxidation of Organic Fuel Molecules During Cellular Respiration

During cellular respiration, the fuel (such as glucose) is _______;

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + Energy$$

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Slide 12

Electrons are transferred to ${\rm O_2}$ when glucose bonds are broken and ${\rm H_2O}$ bonds are formed

 Oxygen attracts electrons and electrons lose potential energy when they move to oxygen



Can't see electrons moving, but can see H atoms redistributing

Oxidation of Organic Fuel Molecules During Cellular Respiration

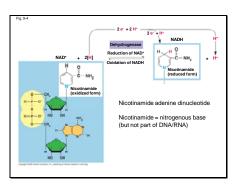
Electrons travel with a proton (in the form of a H atom)

H atoms are not transferred directly to oxygen, but first to an electron carrier, the coenzyme NAD+

Dehydrogenases remove H atoms from the substrate

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Slide 14



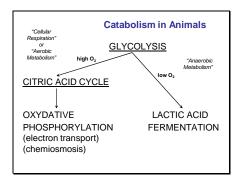
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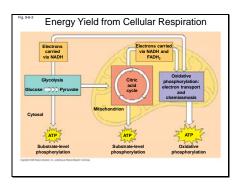
Oxidation of Organic Fuel Molecules During Cellular Respiration

- If NAD+ is an electron acceptor, is it an oxidizing or reducing agent?
- Each NADH (the ______ form of NAD+) represents stored energy that is tapped to synthesize ATP

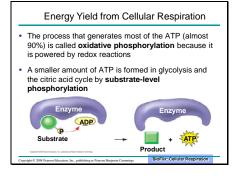
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Slide 16





Slide 18



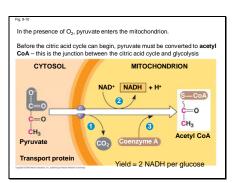
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Energy Yield from Cellular Respiration

Glucose — glycolysis 2 Pyruvate

- Steps 1 and 3 cost a single ATP
- Step 6 pays out 2 NADH
- Step 7 pays out 2 ATP (phosphoglycerokinse)
- Step 10 pays out 2 ATP (pyruvate kinase)

Slide 20



Slide 21

Energy Yield from Cellular Respiration

2 Ac-CoA Krebs Cycle
8 enzymatic steps 4 CO₂

- Steps 3, 4, 8 pay out 1 NADH per Ac-CoA
- Step 6 pays out 1 FADH₂ per Ac-CoA
- Step 5 pays out 1 ATP per Ac-CoA (SLP)

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Energy Yield from Cellular Respiration

 $\frac{\text{glycolysis, Ac-CoA, Krebs}}{\text{21 enzymatic steps}} \rightarrow 6 \text{ CO}_2$

- Total cost 2 ATP
- Total pay out 6 ATP (SLP)
- Total pay out 10 NADH
- Total pay out 2 FADH₂
