

Cell Respiration Notes Guide- General Biology

Objective 1: Explain the process of Cellular Respiration

- Cellular Respiration is the process of breaking down organic molecules into energy forms (_____) which we can use to build and maintain our bodies.
- Energy is stored in organic molecules such as carbohydrates, fats, proteins
 - Animals/heterotrophs eat these organic molecules with food which digest organic molecules to get...
 - raw materials for synthesis
 - fuels for energy
 - controlled release of energy
 - “burning” fuels in a series of step-by-step enzyme-controlled reactions

Harvesting stored energy we use glucose as the model of _____ to produce ATP



Glucose + Oxygen gas ----Forms----> ATP (Energy) + Water + Carbon Dioxide gas

How do we harvest energy from fuels?

- Digest large molecules into smaller ones
- break bonds & move electrons from one molecule to another
- as electrons move they “carry energy” with them
- that energy is stored in another _____, released as heat or harvested to make ATP

What is the point? The point is to make _____!

Overview of cellular respiration

- 4 metabolic stages
 1. Glycolysis - Anaerobic respiration (respiration without O₂) which occurs in cytosol
 2. Pyruvate oxidation - Aerobic respiration (respiration using O₂) which occurs in mitochondria
 3. Krebs cycle - Aerobic respiration (respiration using O₂) which occurs in mitochondria
 4. Electron transport chain - Aerobic respiration (respiration using O₂) which occurs in mitochondria

Glycolysis

- Breaking down _____ which means “glyco – lysis” (splitting sugar)
- Its an ancient pathway which harvests energy where energy transfer first evolved
- transfer energy from organic molecules to ATP
- Its still is starting point for ALL cellular respiration but it’s inefficient
- Glycolysis generates only _____ for every 1 glucose
- it occurs in cytosol (cytoplasm in cell)

Evolutionary perspective

- Prokaryotes were the first cells which had no organelles
- Lived in anaerobic atmosphere
- Life on Earth first evolved without free _____ (O_2) in atmosphere
- Energy had to be captured from organic molecules in absence of O_2
- Prokaryotes that evolved glycolysis are ancestors of all modern life
- _____ cells still utilize glycolysis

Overview

10 reactions in Glycolysis

- Those convert glucose (6C) to 2 pyruvate (3C)
- produces: 4 ATP & 2 NADH
- consumes: 2 ATP
- net yield: _____ & _____

Glycolysis summary

Needs: _____ invest some ATP

Releases: _____ harvests a little ATP and a little NADH

Net Yield: 2 ATP and 2 NADH

But can't stop there!

- Going to run out of _____ without regenerating NAD^+ , energy production would _____!
- another molecule must accept H from NADH
- so NAD^+ is freed up for another round

How is NADH recycled to NAD^+ ?

Another molecule must accept H from NADH

Option 1: Fermentation (anaerobic) using Bacteria, yeast

- Alcohol Fermentation- Pyruvate is broken down into ethanol and CO_2
- Lactic Acid Fermentation-Pyruvate is broken down into lactic acid

The goal of fermentation is to recycle NADH to _____ so it can be used in glycolysis again.

Pyruvate is a branching point

Pyruvate can be broken down in fermentation (no oxygen) or mitochondria (with oxygen)

Cellular Respiration- Stage 2 & 3: Oxidation of Pyruvate and Krebs Cycle

Fate of Pyruvate

- 2 Pyruvates are made in Glycolysis
- Each pyruvate enters mitochondrial matrix

- A carbon is broken off the 3 carbon pyruvate and binds with oxygen. It releases 2 CO₂.
- reduces 2 NAD⁺ to form 2 NADH (moves e⁻) and produces 2 acetyl CoA
- Acetyl CoA enters _____ cycle

Count the electron carriers!

How many NADH (PINK PIGS) are there in 1 turn of the Krebs Cycle? _____

How many FADH₂ (BLUE PIGS) are there in 1 turn of the Krebs Cycle? _____

How many ATP are made in 1 turn of the Krebs Cycle? _____

Electron Carriers = Hydrogen Carriers!

Krebs cycle produces large quantities of electron carriers such as NADH and FADH₂. They go to the Electron Transport _____!

Energy accounting of Krebs cycle

Net gain (1 glucose) = 2 ATP
 = 8 NADH + 2 FADH₂

Stripping H from Electron Carriers

Electron carriers pass electrons & H⁺ to ETC

-H cleaved off NADH & FADH₂

-electrons _____ from H atoms and split into H⁺ (protons) and e⁻ (electrons)

-electrons passed from one electron carrier to next in mitochondrial membrane (ETC)

-flowing electrons = energy to do work

-transport proteins in membrane pump H⁺ (protons) across inner membrane to intermembrane space

Electrons flow downhill

-Electrons move in steps from carrier to carrier downhill to _____

-each carrier more electronegative

-controlled oxidation

-controlled release of energy

We did it!

-Set up a H⁺ gradient

-Allow the protons to flow through ATP synthase

-Synthesizes (makes) ATP

ADP + Pi → ATP

Each NADH can produce up to _____ ATP

Each FADH₂ can produce up to _____ ATP.

Cellular Respiration:

2 ATP from Glycolysis, 2 ATP from Krebs, _____ ATP from ETC

A total of _____ ATP from 1 Glucose molecule.

Objective 2: Explain what molecules are used and what is produced in the process of Cellular Respiration



Glucose + Oxygen gas ----Forms--- $\square$ ATP (Energy) + Water + Carbon Dioxide gas
(glycolysis) + (Oxidation of pyruvate) ---- $\square$ (glycolysis, Krebs, ETC) + (ETC) + (Oxidation of pyruvate/ETC)

Cellular Respiration Summary:

-Glycolysis:

-Used: 2 ATP and 2 NAD⁺

-Made: 4 ATP and 2 NADH

-Oxidation of Pyruvate

-Used: 2 Pyruvate

-Made: 2 Acetyl CoA and 2 NADH

Krebs Cycle:

-Used: 2 Acetyl CoA and Oxygen Gas

-Made: 2 ATP, 8 NADH and 2 FADH₂

Electrons Transport Chain:

-Used: 10 NADH and 2 FADH₂

-Made: 28 ATP

Summary of cellular respiration



Glucose + Oxygen gas ----Forms--- $\square$ ATP (Energy) + Water + Carbon Dioxide gas
(glycolysis) + (Oxidation of pyruvate) ---- $\square$ (glycolysis, Krebs, ETC) + (ETC) + (Oxidation of pyruvate/ETC)

-Where did the glucose come from?

-Where did the O₂ come from?

-Where did the CO₂ come from?

-Where did the CO₂ go?

-Where did the H₂O come from?

-Where did the ATP come from?

-What else is produced that is not listed in this equation?

-Why do we breathe?