UNIT 2

THE WORKING CELL
ENERGY AND THE CELL

5.10 Cells transforms energy as they perform work
Energy is defined as

Life depends on the fact that energy can be converted from one form to another
Two basic forms of energy
  Kinetic energy
  Potential energy

5.11 Two laws govern energy transformations
  Thermodynamics is

  The First Law of Thermodynamics

  The Second Law of Thermodynamics

5.12 Chemical reactions either store or release energy
  Endergonic reactions

  Yield products rich in potential energy
  Exergonic reactions

What is metabolism?

  Not just breaking down of substances (ex. Food)
  Energy coupling
    Energy coupling uses

5.13 ATP shuttles chemical energy and drives cellular work
  ATP (adenosine triphosphate) powers nearly all forms of cellular work
  ATP is composed of
The energy in an ATP molecule lies in the bonds between its phosphate groups
ATP powers cellular work through coupled reactions
The bonds connecting the phosphate groups are broken by ____________,
an exergonic reaction
Hydrolysis is coupled to an endergonic reaction through ________________
A phosphate group is transferred from ATP to another molecule
Cellular work can be sustained, because ATP is a renewable resource that cells
regenerate
The ATP cycle involves continual

HOW ENZYMES FUNCTION
5.14 Enzymes speed up the cell's chemical reactions by lowering energy barriers

Energy of activation

Enzymes
Proteins that function as ________________________________
________________________ the rate of a reaction without themselves being changed
An enzyme can ______________________ the energy of activation needed to begin a reaction
5.15 A specific enzyme catalyzes each cellular reaction
Each enzyme has a unique three-dimensional shape that determines which

The cellular environment affects enzyme activity
Physical factors influence enzyme activity
  Temperature, salt concentration, pH
Some enzymes require nonprotein ____________________________
Metal ions, organic molecules called ____________________________

HOW CELLS HAREST CHEMICAL ENERGY
INTRODUCTION TO CELLULAR RESPIRATION
6.1 Photosynthesis and cellular respiration provide energy for life

Photosynthesis converts energy from the sun to ________________ and ______
Cellular respiration breaks down glucose and

6.2 Breathing supplies oxygen to our cells and removes carbon dioxide

6.3 Cellular respiration banks energy in ATP molecules
6.4 The human body uses energy from ATP for all its activities
6.5 Cells tap energy from electrons “falling” from organic fuels to oxygen
   The energy available to a cell is contained in the arrangement of electrons in chemical bonds
   Electrons lose potential energy when they

Each step of the “fall” involves paired ____________________________ (redox) reactions

**Oxidation:**

**Reduction:**

The redox reactions of cellular respiration
Glucose loses electrons (in H atoms) and becomes __________________________
O₂ gains electrons (in H atoms) and becomes __________________________
Along the way, the

The redox reactions that break down glucose involve an enzyme and a coenzyme
The enzyme __________________________ removes electrons (in H atoms) from fuel molecules (oxidation)
The electrons are transferred to the coenzyme _______________, which is converted to ________________ (reduction)
NADH passes electrons to an electron transport chain

The energy released is used by the cell to make ______

**STAGES OF CELLULAR RESPIRATION & FERMENTATION**
6.6 Overview: Cellular respiration occurs in three main stages
   Stage 1: **Glycolysis**
      Occurs in the __________________________

   Stage 2: **The citric acid cycle**
      Takes place in the __________________________

      Supplies the third stage of cellular respiration with electrons
   Stage 3: **Oxidative phosphorylation**
      Occurs in the __________________________
6.7 Glycolysis harvests chemical energy by oxidizing glucose to pyruvate

Glycolysis _________ sugar molecules in the cytoplasm

Starts with a single __-carbon molecule of ______________________

Ends with two __-carbon molecules of ______________________

Produces two molecules of _______ in the process and 2 ____________

6.8 Pyruvate is chemically groomed for the citric acid cycle

A large, multienzyme complex catalyzes three reactions in the mitochondrial matrix

A carbon atom is removed from pyruvate and released in ___________

The remaining two-carbon compound is oxidized, and a molecule of

________________________ joins with the 2-carbon group to produce _________

6.9 The citric acid cycle completes the oxidation of organic fuel, generating many NADH and FADH$_2$ molecules

For each turn of the citric acid cycle

6.10 Most ATP production occurs by oxidative phosphorylation

An electron transport chain in the mitochondrial membrane creates a H$^+$ gradient

Electrons from NADH and FADH$_2$ travel down the chain to __________, which picks up H$^+$

___________ is formed as a product

6.12 Review: Each molecule of glucose yields many molecules of ATP

Glycolysis and the citric acid cycle together yield

Oxidative phosphorylation, using electron transport and chemiosmosis, yields

These numbers are maximums

Some cells may lose a few ATP to NAD$^+$ or FAD shuttles

6.13 Fermentation enables cells to produce ATP without oxygen

Fermentation

Muscle cells use ____________________________ fermentation

NADH is oxidized to NAD$^+$ as pyruvate is reduced to lactate

Alcohol fermentation occurs in brewing, wine making, and baking

NADH is oxidized to NAD$^+$ while converting pyruvate to CO$_2$ and ____________

6.15 Cells use many kinds of organic molecules as fuel for cellular respiration

Cells use three main kinds of food molecules to make ATP

The fuel for respiration ultimately comes from photosynthesis
PHOTOSYNTHESIS: USING LIGHT TO MAKE FOOD

Plant Power

Photosynthesis makes

Carried out by plants, algae, and some bacteria
The ultimate source of all food eaten by animals
A major source of heat, light, and fuel
Using photosynthesis to meet growing energy demands
Energy plantations of trees

AN OVERVIEW OF PHOTOSYNTHESIS

7.1 Autotrophs are the producers of the biosphere

Autotrophs

Photoautotrophs

7.2 Photosynthesis occurs in chloroplasts

In plants, photosynthesis occurs primarily in __________________

__________________________ are the site of photosynthesis

Chloroplast structure

Stroma

Thylakoids

7.3 Plants produce O$_2$ gas by splitting H$_2$0

Experiments have made it possible to follow all the atoms in photosynthesis

The O$_2$ liberated by photosynthesis is made from the

7.4 Photosynthesis is a redox process, as is cellular respiration

Photosynthesis

Cellular respiration
7.5 Overview: Photosynthesis occurs in two stages linked by ATP and NADPH

Light reactions

Calvin cycle

THE LIGHT REACTIONS: CONVERTING SOLAR ENERGY TO CHEMICAL ENERGY

7.6 Visible radiation drives the light reactions

Sunlight is _______________________, or _______________________________

Sunlight
- Radiation travels as waves and the distance between waves is a _______________
- Visible light is only a small part of the electromagnetic spectrum
- Light also behaves as discrete _______________________

What happens to light when it strikes an object?
How is light absorbed?

Photosynthetic pigments

Types of pigments

Chlorophyll \( a \)
- Absorbs blue-violet and red light, reflects green light

Chlorophyll \( b \)
- Absorbs blue and orange light, reflects yellow-green

Carotenoids
- Yellow-orange pigments that absorb mainly blue-green light

Light also behaves as photons
- A fixed quantity of _______________________
- Specific amounts of energy in photons absorbed by different pigments
7.7 Photosystems capture solar power
The thylakoid membrane contains two types of **photosystems**, which consist of

Photosystems

- A chlorophyll *a* molecule
- A primary electron acceptor molecule
  - That will transfers them to an ____________

7.8 In the light reactions, electron transport chains generate ATP and NADPH

**Photosystem II**
1. Pigment molecules ________________ which then excites electrons from P680
2. ________________ is then captured by the primary electron acceptor, then to an electron transport chain
3. Water is _______, replacing electrons lost by P680 and releasing ________
4. Electrons shuttle down the chain from photosystem II to photosystem I, providing energy to make ________

**Photosystem I**
5. A photon is absorbed and excites an electron of chlorophyll P700
6. The excited electron passes through a short electron transport chain, reducing

**THE CALVIN CYCLE: CONVERTING CO₂ TO SUGARS**
7.10 ATP and NADPH power sugar synthesis in the Calvin cycle
The Calvin cycle makes sugar in the chloroplast
**HOW?**
**Inputs**

**Output**

**PHOTOSYNTHESIS REVIEWED AND EXTENDED**
7.11 Review: Photosynthesis uses light energy to make food molecules
7.12 C₄ and CAM plants have special adaptations that save water
  - What happens when the environment is hot and dry?
  - **Photorespiration** will occur
C₃ plants
Corn, soybeans, wheat, rice
Use
Rate of photosynthesis decreases in dry weather
Stomata
Calvin cycle diverted to ______________

C₄ plants
Include corn and sugarcane

Enables plant to continue making sugar
Prevents photorespiration and water loss

CAM plants
Pineapple, cactus, succulents
Adapted to very dry climates

Let’s describe some reasons why photosynthesis is important to you.
7.13 Photosynthesis moderates global warming
The greenhouse effect

Excess greenhouse gases in the atmosphere contribute to global warming

7.14 Mario Molina talks about Earth's protective ozone layer
Nobel Prize winner Mario Molina has studied how pollutants are affecting Earth's ozone layer

The ozone layer shields organisms on Earth's surface from damaging UV radiation
CFCs have caused dangerous thinning of the ozone layer
International restrictions on CFC use are allowing a slow recovery