

UNIT FOUR: PHOTOSYNTHESIS

Upon completion of this unit you will be able to:

1. Identify and name component parts of the electromagnetic spectrum.
2. Distinguish between ionizing and non-ionizing radiation.
- 3. Write the general chemical equation for photosynthesis.**
- 4. List several requirements for photosynthesis.**
5. Identify the portions of the electromagnetic spectrum most instrumental in the process of photosynthesis.
6. List and provide the functions of the accessory pigments.
- 7. Characterize the events in the light-dependent and light-independent reactions of photosynthesis.**
8. List the things a plant can do with the product of photosynthesis.
- 9. Define compensation point and describe the activities of a plant when it is above or below this point.**
- 10. List and describe environmental conditions that effect the rate of photosynthesis (temp., CO₂, light intensity, etc.)**
- 11. Explain the Green House effect and explain how green plants are able to curtail the greenhouse effect.**
- 12. Identify the palisade layer, spongy parenchyma (mesophyll) and epidermis layers of a leaf and describe their role in photosynthesis.**
13. Explain the mechanism and significance behind the opening and closing of stomata.
- 14. Identify the roles of grana and matrix within the chloroplast.**
- 15. Describe how radiant energy is converted to chemical energy in the chloroplasts. Relate to the photooxidation of a chlorophyll molecule.**
16. Define photon and fluorescence.
17. Define transpiration and evapotranspiration.
18. Identify sites on planet earth where most photosynthetic productivity occurs.
19. Relate photosynthesis to life on earth.

Unit References: [Text Chapter 7](#) www.mhhe.com/enger13
[An Online Biology Text Book](#)

35mm slides - The Light and Dark Reactions of Photosynthesis
Video - Photosynthesis

Check Out:

[Arizona State University Photosynthesis Center](#)

[PLANTS, PHOTOSYNTHESIS](#)

[biology4kids: Photosynthesis](#)

[What is Photosynthesis](#)

[YouTube: Photosynthesis Song](#)

UNIT FOUR: PHOTOSYNTHESIS

ELECTROMAGNETIC SPECTRUM (Objective #1) (Text pg 139)

Sun emits long and short wave energy

short wave length (High energy) Gamma waves, X-rays, UV waves	Visible	long wave length (Low energy) Infrared, radiowaves, microwaves
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1. Energy inversely proportional to wavelength
2. UV, X-ray, Gamma rays- dangerous (Objective #2) IR, micro-, radiowaves do not damage cells
3. -Ionizing vs. Non-ionizing
Ionizing radiation- forms ions (free radicals) by knocking electrons away from atoms (Gamma and X-rays are ionizing forms of radiation)

Check Out:

[Electromagnetic Spectrum: Introduction](#)

[The Electromagnetic Spectrum](#)

[Wikipedia: Electromagnetic Spectrum](#)

Radiation can come in waves (from sun) or as particles (radioactive or isotopic decay)

**most highly effected tissues or systems are those undergoing constant active division
-skin, blood, gastrointestinal, reproductive (males)

**also why this is effective treatment of cancers

Photosynthesis uses visible light (Text pg 139)

Visible light contains the rainbow: red, orange, yellow, green, blue, indigo, violet (ROY G BIV)

There are two kinds of organisms in the world: (Text pg 146)

AUTOTROPHS- producers, Plants, those that can make their own food
HETEROTROPHS- consumers, those that must consume foods that others make

BRIEF HISTORY-

-Ancient Greeks ---> "soil eaters"

-Jean Baptiste Von Helmont

5lb. willow tree into 200 lbs soil, Five years pass, 170 lb tree and

Conclusion???

****By the end of the 19th Cent** $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{Carbohydrate} + \text{O}_2$

GENERAL REACTION $6\text{CO}_2 + 6\text{H}_2\text{O} + \text{SUN} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ (Objective #3)
(Text pg 137) accomplished by green plants (w/exceptions)

RAW MATERIALS: (Objective #4)

Carbon dioxide (CO_2)- .03% of atmospheric gases!

Water (H_2O)

Light- absorbed by chlorophyll

Chlorophyll- $\text{C}_{55}\text{H}_{72}\text{O}_5\text{N}_4\text{Mg}$

Enzymes and Carrier molecules (NAD)

VISIBLE LIGHT (Objective #5) (Text pg 139)

Part of Electromagnetic Spectrum

White (visible) light ----> **prism** ----> ROY G BIV (Red LONGEST; Violet SHORTEST)

IR 760 Red 647 Orange 586 Yellow 535 Green 492 Blue 432 Violet 390 UV
(wavelengths in nm)

Reflection/Absorption

Two things happen to light when it hits a surface

- 1. It is reflected**
- 2. It is absorbed**

-We see reflected light, what we don't see is most likely absorbed or "drowned out"

White light -----> white rabbit ---> all reflected, none absorbed

-----> black panther --> none reflected, all absorbed

-----> red corvette, green leaf?

**Question: Does photosynthesis utilize green wavelengths?

Does photosynthesis utilize all wavelengths of white?

**Remember, we see reflected light

Absorption spectrum: measures which wavelengths are being absorbed/reflected

(text pg 139)

Lab: Spectrophotometer

% absorbance

nm 390 422 492 535 586 647 660 760

Pigments: provide reflective surfaces, the colors reflected are seen (Objective #6)

green- chlorophyll a and b; a and b together produce higher rates

orange/yellow- carotenoids, prevalent in fall but, always present (carotenes- orange; xanthophylls- yellow)

red/violet- phycobins

*pigments other than chlorophylls are **accessory pigments**, compliment or enhance

Check Out: [Chemistry of Autumn Colors](#)

[The Carotenoids Page](#)

[Molecule of the Month: Chlorophyll](#)

Photosynthesis has two parts:

Some Key Players in the process of Photosynthesis are [Text pgs 136-145](#)

ATP- Adenosine Triphosphate - by splitting one phosphate away to make ADP provides

energy for CO₂ conversion

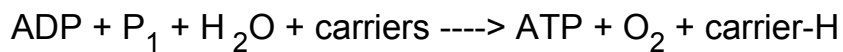
NADP- carrier of hydrogen and electrons between light conversion and CO₂ conversion reactions.

PGAL (Objective #8) - Phosphoglyceraldehyde- 3 carbon carbohydrate; Plant uses PGAL to make: glucose ---> starch and other complex carbohydrates, fats (fatty acids), protein (amino acids), Rubber, Terpenes (oils), Saps, Balsam, etc

*****Please note that there are multiple descriptions of this topic in your book, each with an increasing level of complexity but essentially describing the same process**

Part I: Light-energy conversion stage (=light reaction = light dependent reaction)- (Objective #7) light energy converted to chemical energy, "Battery Charger"

Two actions in part one ; Collection of usable source of energy (the sun) and conversion into a more useful commodity (ATP)



Light Dependent Reactions (light reactions) (Objective #7)

1. Requires light for energy
2. very rapid 1/100,000 sec to 1/10,000,000sec
3. Temperature independent
4. ****H₂O broken down** (hydrogen carried to next part for assembly)
5. ****O₂ released**
6. ****ATP produced** (energy carried to light independent react.)

Part II: Carbon dioxide conversion stage (=dark reaction = light independent reaction) (Objective #7) carbon dioxide used to build carbohydrates (Uses battery energy)

*****Again please note multiple descriptions of this in your book**



Light Independent Reaction (dark reaction) (Objective #7)

1. does not require light, uses ATP to drive reaction

2. slower (relatively speaking)
3. Temp. Dependent (remember NAD is an enzyme)
4. ****CO₂ trapped and hydrogen** received for assembly
5. ****carbohydrate synthesized/produced** (PGAL/glucose)

PHOTOSYNTHESIS VS. RESPIRATION (energy production vs. energy usage) (text pg 116-117, 146-147) (Objective #9)

-plants first produce energy for their own needs, then store as starch, protein, etc.

Compensation point- the intensity of light when photosynthetic rate is equal to respiration rate
(energy produced = energy used)

*Below this point- growth limited {energy use > energy produced} ex. fall/winter

*Above this point- growth exceeds needs {energy produced > energy used} ex. spring/summer

Light availability dictates seasons

Check Out:

Seasons

The Seasons: Science U

FACTORS EFFECTING PHOTOSYNTHETIC RATE (Objective #10)

Carbon Dioxide - sole source of carbon for plants

enters leaf through stomata ---> dissolves in water ---> enters as carbonic acid

-increase of CO₂ increases rate of photosynthesis (~10%+ however, is toxic)

-increase of CO₂ can only be beneficial if light intensities increase also

**our world would be in pretty good shape w/ increased CO₂, only problem is that we're also destroying the organisms that use it!!

Light intensity- increased light intensities mean more light energy to power light reaction

-at a point, however, photosyn levels off because enzyme controlled reactions

(light independent) are not benefiting, Already at max. rate.
-Seasons

Temperature- at high light intensities, temp. increases rate of photo. until ~ 35-40C^o .
Past that heat will begin to denature enzymes

Why do our plants (temperate regions) decrease or curtail photosynthesis in fall?

- decreased temp
- decreased CO₂
- decreased light intensities

C! Enzyme lab showed that cold does not hamper enzyme action, nor does it decrease CO₂

Winter Wheat does pretty good in the Winter!

Greenhouse Effect (Objective #11)

-CO₂ (and others) retain heat near surface, sunlight gets through but heat can't escape (blanket)

-burning of fossil fuels most responsible (cars worst)

-Cloudy vs clear nights

-theoretically increased CO₂, increased temps., wide climatic changes or onset of next ice age

-logically, more plants, less CO₂ (deforestation adding to problem)

Check Out: [Global Warming Information](#)

Sites of Photosynthesis (Objective #12) Text pgs 140-141 pg 492

Leaves- most concentrated source of chloroplasts and chlorophyll although any green part has them.

upper epidermis- lacks chloroplasts, waxy, reduces H₂O loss

Palisade layer- highest concentration of chloroplasts

Spongy mesophyll

-space between cells allows
gas exchange between
atmosphere and plant

Lower epidermis- contains
STOMATA, no chloroplasts

Check Out:

Leaves

Leaves and fall colors

STOMATA (Objective #13) (Text pg. 140, pg 492) - openings that allow gases and water to move into spongy layer. Guard cells regulate opening and closing .

Dependent upon plant requirements and environment

-must be open long enough to allow max. CO₂ to enter leaf

but not long enough to allow H₂O loss (transpiration).

-open or close in response to turgor pressure in guard cells
-regulation not entirely understood, timing key

-one side of cell has thicker in lower pressures, cells lose water & cell wall;
when cell swells, cell shrinks slightly causing closure, one side bends

Check Out:

Stomata

What's a Stomata

Stoma

CHLOROPLASTS (Objective #14) (Text pg 141) - primary site of photosynthesis;
organelle of green plant cells and some algae

-double membrane surrounds large central space called the STROMA or
MATRIX that contains enzyme rich solution. Site of dark reaction.

-membrane of stroma forms GRANA, stacks of flat pancake-like discs. Individual disc is a THYLAKOID (lamelle). Site of light reaction and pigments

Check Out: [What the Heck is a Chloroplast?](#)

Photooxidation of chlorophyll (Objective #15, 16) **Text pages 142, :** Photosystems

Photon (light) -----> chlorophyll

-electrons excited: 1. will help bind third phosphate to ADP or be accepted by NADPH
2. if not used to do work they mellow and return to previous state
- will give off energy in return (FLOURESENCE)
3. additional energy is used to break hydrogen from water

-Photosystem: Antenna

-Reaction center

-Primary electron acceptor

-Acceptance of electron first step in light reaction

Occurrence of Photosynthesis: Where in the World does this work best?? (Objective #18)

Productivity- energy accumulation by photosynthesis usually measured as dry weight

-dependent upon: nutrients, water, limits on temp., light intensity

Areas w/ highest productivity

-intertidal zones, flood plains, forests, swamps, marshes, estuaries, coral reefs, (crops not usually on list but rice and sugar cane fit)

*intertidal kelp/sea palm community net production exceeds 14,000 gm (~31lbs) per m²/year

-A little less: most temperate forests, agricultural crops, lakes, streams, grasslands

~1000-2000 grams/ m² / year

-Least: tundra, alpine regions, deserts, open ocean

~70-200 grams/ m² / year

[Back to General Biology at WNCC](#)