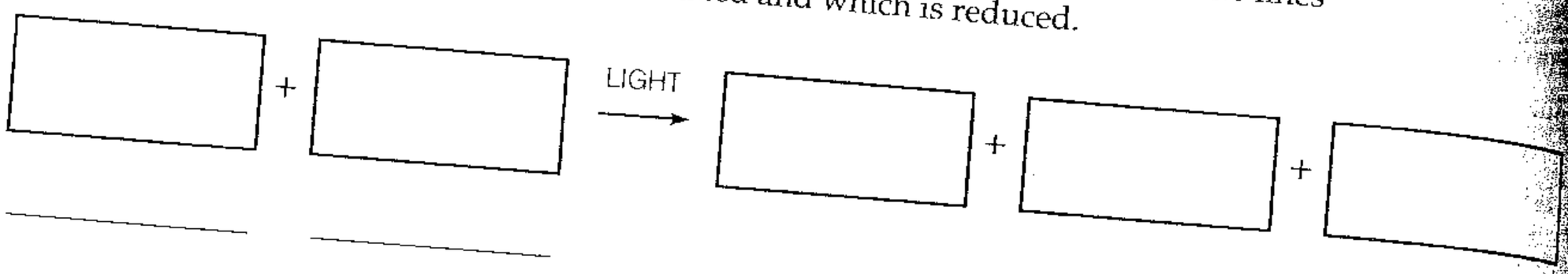
PACKET 7

Exercise 3 (Modules 7.3 – 7.4)

Write the overall equation for photosynthesis in the boxes below. Show the substances used on the left, and those produced on the right. Use different colors for carbon, hydrogen, oxygen in carbon dioxide, and oxygen in water, and then use your color code to show where atoms of C, H, and O on the left end up in the products on the right. On the lines under the substances used, state which is oxidized and which is reduced.

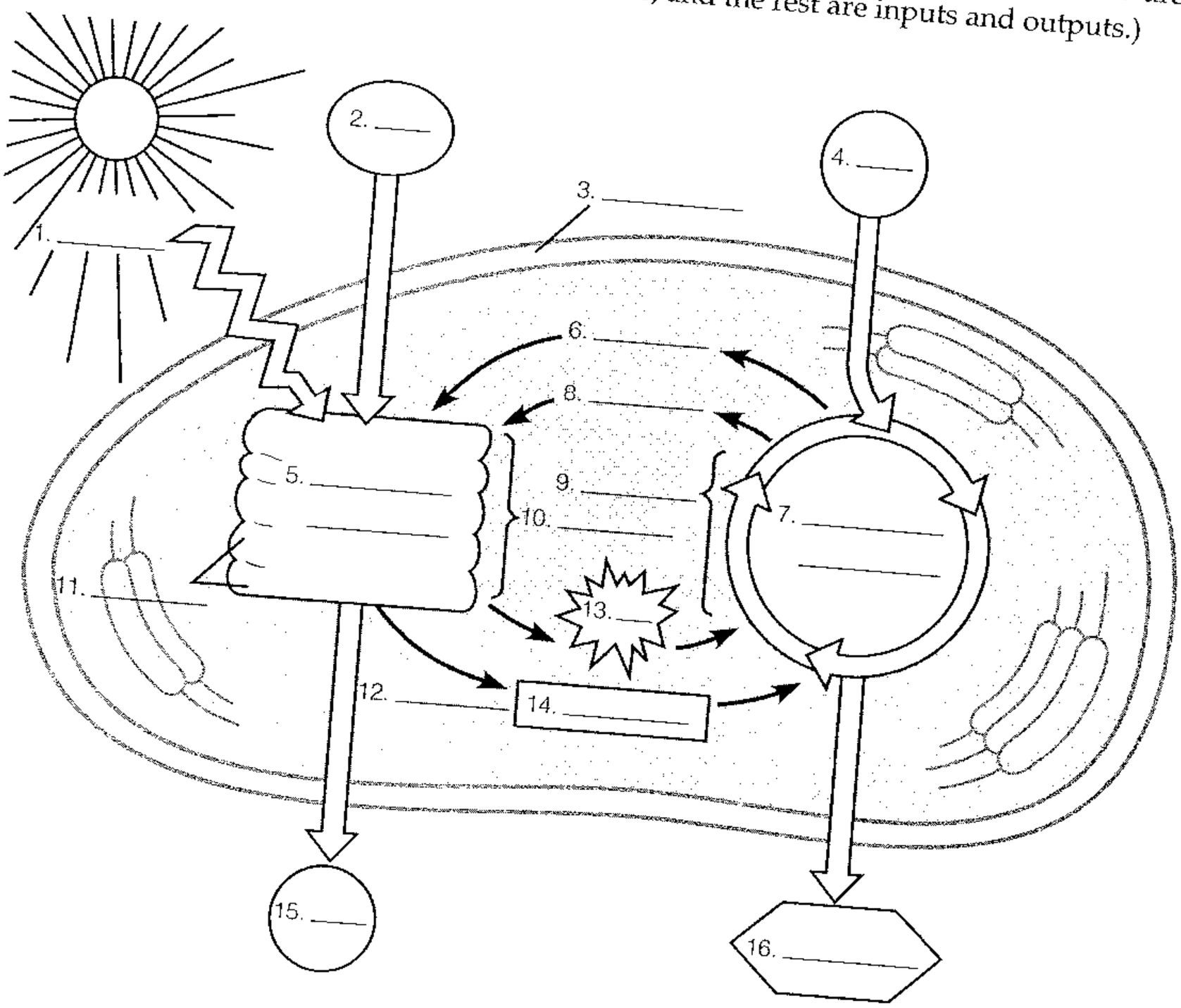


_____ _____

Exercise 4 (Modules 7.3 – 7.5)

Web/CD Activity 7B *Overview of Photosynthesis*

Label this diagram summarizing the two stages of photosynthesis. Include **outer membrane of chloroplast, thylakoids, granum, stroma, light reactions, Calvin cycle, light, H_2O, O_2, electrons, NADPH, ATP, CO_2, sugar, ADP + P,** and **$NADP^+$.** (Note: 5 and 7 are processes, 3, 9, 10, and 11 are places or structures, and the rest are inputs and outputs.)



Exercise 5 (Modules 7.3 – 7.5)

Web/CD Activity 7B *Overview of Photosynthesis*

Refer to the equations and diagrams in the modules to match each of the phrases on the left with one of the ingredients or products of photosynthesis listed on the right.

_____ 1. Oxidized in light reactions
_____ 2. Reduced in Calvin cycle
_____ 3. Carries H and electrons from light reactions to Calvin cycle
_____ 4. Food produced by photosynthesis
_____ 5. Source of H and electrons in glucose
_____ 6. Source of O atoms in glucose
_____ 7. Where O atoms from water end up
_____ 8. Oxidized in Calvin cycle
_____ 9. Reduced in light reactions
_____ 10. Supplies energy to Calvin cycle
_____ 11. Where C and O atoms in carbon dioxide end up
_____ 12. Recycled from Calvin cycle to make ATP
_____ 13. Supplies energy to light reactions
_____ 14. Gas produced by reactions in the thylakoids
_____ 15. Gas consumed by reactions in the stroma
_____ 16. Source of carbon for carbon fixation
_____ 17. Source of H for the Calvin cycle
_____ 18. Picks up energized electrons from reactions in the thylakoids

A. Carbon dioxide, CO_2
B. Water, H_2O
C. Glucose, $C_6H_{12}O_6$
D. Oxygen, O_2
E. ADP + P
F. ATP
G. $NADP^+$
H. NADPH
I. Light

Exercise 6 (Modules 7.6 – 7.7)

Web/CD Activity 7C *Light Energy and Pigments*

Order the following forms of electromagnetic energy from the shortest wavelength (1) to the longest (9). At which wavelength do photons have the most energy? Which are used by plants in photosynthesis?

_____ a. Green light
_____ b. Radio waves
_____ c. X-rays
_____ d. Red light
_____ e. Ultraviolet light
_____ f. Infrared
_____ g. Microwaves
_____ h. Blue light
_____ i. Gamma rays

Exercise 7 (Modules 7.7 – 7.11)

Web/CD Activity 7D *The Light Reactions*
Web/CD Activity 7E *The Calvin Cycle*

To review photosynthesis, fill in the blanks in the following story.

The next time you eat an apple, reflect on the apple tree's ability to make the sugars it contains, using sunlight to assemble simple substances from air and soil. This process is called [1] _____, and it takes place in structures called [2] _____ in cells of tissues called the [3] _____ inside the leaves of the apple tree. Photosynthesis actually consists of two processes: In the [4] _____ reactions, [5] _____ molecules in membranes called [6] _____ in the chloroplast capture light energy. In the [7] _____ cycle, which takes place in the [8] _____ surrounding the thylakoids, this energy is used to make sugar, a process called [9] _____ fixation.

Chlorophyll molecules absorb [10] _____ packets of light energy. Chlorophyll absorbs only certain wavelengths, or colors, of light, mainly in the [11] _____ and [12] _____ parts of the spectrum. It reflects [13] _____ light. Other pigments, such as [14] _____, can absorb colors that chlorophyll cannot use directly, and transfer this energy to chlorophyll. Chlorophyll and other pigments are clustered on the thylakoid membranes in groups called photosystems. All the pigment molecules in a photosystem pass their energy along to a single chlorophyll molecule, called the [15] _____, in the middle of the photosystem. There are two kinds of photosystems, photosystem I and photosystem II, which absorb slightly different colors of light.

Most bacteria and all [16] _____ and algae power the production of [17] _____ through a process that starts when photons energize a chlorophyll molecule in photosystem I. This raises the chlorophyll's [18] _____ to an excited state. The excited electrons are passed to the chlorophyll at the reaction center, which passes them to a protein called the [19] _____. From here, the electrons travel along an [20] _____ chain and end up as high-energy electrons in a molecule called [21] _____.

In the cells in the leaves of an apple tree, photosystem II replaces the electrons lost by photosystem I. A chlorophyll molecule of photosystem II absorbs [22] _____ and ejects [23] _____. These pass to a primary electron acceptor and on to an electron transport chain. The electrons pass down the chain and eventually end up replacing the electrons lost by the chlorophyll of [24] _____. On their way down the electron transport chain, the electrons perform important work. One of the electron carriers in the chain uses the energy released by the electrons to transport [25] _____ ions from the [26] _____ into the space inside the [27] _____. This creates a buildup of H^+ ions, a concentration [28] _____ of H^+ across the membrane. The H^+ ions then diffuse through the membrane via a protein complex called [29] _____, which captures their energy to make [30] _____. In photosynthesis, this chemiosmotic production of ATP is called [31] _____. How does photosystem II replace its lost electrons? It gets them by splitting [32] _____. When the electrons of

photosystem II are jarred loose, the reaction center develops a strong attraction for electrons. It obtains them by breaking apart a molecule of [33]_____. This leaves two H^+ ions (which pass into the thylakoid space) and an [34]_____ atom. This atom combines with another from another water molecule to form a molecule of [35]_____ gas, which diffuses out of the leaf—a product of photosynthesis important to us and other animals.

At this point, the cells of the apple leaf have captured the energy of the sun in molecules of NADPH and ATP, but so far they have made no sugar. The NADPH and ATP are used, and sugar is made, in the [36]_____ cycle, the second portion of [37]_____ that takes place in the [38]_____ of the chloroplast, around the thylakoids. Using carbon from [39]_____ obtained from the air, energy from [40]_____, and hydrogen and high-energy electrons carried by [41]_____, the enzymes of the Calvin cycle construct [42]_____, a high-energy sugar molecule. In a series of steps, these molecules are combined to form the important six-carbon sugar [43]_____ and other organic compounds, in the leaves and in other parts of the plant.

The cellulose that gives an apple its crunch and the sugar that gives it its sweet taste are made from the glucose made in photosynthesis. In your intestine, the sugars enter your blood and are transported to your body cells. There the chemical pathways of cellular [44]_____ release the energy in the sugar molecules and use it to build [45]_____, which is in turn used to power cellular work. Energy from the sun, captured by the apple and passed on to you, enables you to see, to move, and to contemplate this amazing story.

Exercise 8 (Module 7.12)

Web/CD Activity 7F *Photosynthesis in Dry Climates*

Plants employ a variety of ways of fixing CO_2 and saving water. State whether each of the following statements relates to **C_3** plants, **C_4** plants, or **CAM** plants.

_____ 1. May waste energy on photorespiration on a hot day
_____ 2. Trap carbon in four-carbon compound, which donates it to Calvin cycle
_____ 3. Corn and sugarcane
_____ 4. Open stomata and trap CO_2 at night
_____ 5. Most plants
_____ 6. Soybeans, oats, wheat, rice
_____ 7. Can grow in hot, dry climates
_____ 8. Also can grow in hot, dry climates
_____ 9. Pineapple and many cacti
_____ 10. Calvin cycle uses CO_2 directly from the air