Nutrient Cycling
I. A. Photosynthesis
   B. Respiration
   C. Production
      Primary productivity
      Gross Production
      Net Production
II. Types of photosynthesis
    A. C3, B. C4, C. CAM
    D. Comparisons
III. General Carbon Cycle:
     Inputs and Outputs
     Human Impact

PHOTOSYNTHESIS
Conversion of light energy to chemical energy, or the production of carbohydrates from carbon dioxide and water in the presence of chlorophyll.

\[6\text{CO}_2 + 6\text{H}_2\text{O} + \text{(light)} = C_6\text{H}_{12}\text{O}_6 + 6\text{O}_2\]
What is Photosynthesis?
Photosynthesis is the process by which plants, some bacteria, and some protists use the energy from sunlight to produce sugar, which cellular respiration converts into ATP, the "fuel" used by all living things. The conversion of unusable sunlight energy into usable chemical energy, is associated with the actions of the green pigment chlorophyll. Most of the time, the photosynthetic process uses water and releases the oxygen. We can write the overall reaction of this process as:

$$6\text{H}_2\text{O} + 6\text{CO}_2 \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$$

Photosynthesis

$$6\text{H}_2\text{O} + 6\text{CO}_2 \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$$

Green plants (w/chlorophyll) absorb light energy and use it to produce glucose from carbon dioxide and water releasing oxygen as a byproduct.

Six molecules of water plus six molecules of carbon dioxide produce one molecule of sugar plus six molecules of oxygen.
The raw materials of photosynthesis, water and carbon dioxide, enter the cells of the leaf, and the products of photosynthesis, sugar and oxygen, leave the leaf.

Plants are the only photosynthetic organisms to have leaves (and not all plants have leaves). A leaf may be viewed as a solar collector crammed full of photosynthetic cells.

**RESPIRATION:**

The rate at which energy is used to do work in an ecosystem, or the process by which organic compounds are transformed into gaseous CO2.  

\[ C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O + \text{usable energy(heat)} \]
Types of Photosynthesis

C3 photosynthesis

C4 photosynthesis

CAM photosynthesis

C3 - most widely distributed type of photosynthesis. Includes all algae and most vascular plants. C3 plants are best adapted to cool moist, moderate light conditions.

C4 occurs only in vascular plants, mostly grasses. C4 plants are best adapted to hot, dry sunny conditions. Commonly found in tropics.
CAM—crassulacean acid metabolism. Assimilation of CO2 occurs at night, and includes both C3 and C4 processes. CAM plants often have a reverse “stomatal rhythm” where their stomates are open at night and closed during the day. Water loss is minimal.

Comparisons between photosynthetic strategies

- C3, C4 photosynthesize during day
- CAM at night
- Amount of photosynthesis depends on temperature: C3 cooler temperatures does best, C4 hotter climates does best
- C4 can take advantage of high light intensity, C3 levels out

PRODUCTION: the process of energy input and storage in ecosystems.

Gross Production: \( (\text{PG}) \) -- the energy input into the ecosystem. (total amount of carbohydrate produced)

Net Production: \( (\text{PN}) \) -- the energy storage in an ecosystem, or the rate of growth in the system. (the amount of carbohydrate remaining after respiration)

PN can be figured by the following formula: \( \text{PN} = \text{PG} - \text{R} \)
Primary Productivity of Ecosystems

**Net primary productivity (NPP)**

- Estuaries
- Swamps and marshes
- Tropical rain forest
- Tropical savanna
- Northern coniferous forest (taiga)
- Agricultural land
- Woodland and shrubland
- Temperate grassland
- Lakes and streams
- Continental shelf
- Open ocean
- Tundra (arctic and alpine)
- Desert

Average net primary productivity (kcal/m²/yr)

Fig. 4.25, p. 88

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Earth's gross primary productivity

Fig. 4.24, p. 87

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Carbon cycle
Carbon cycle in the Ocean

The Carbon Cycle (Aquatic)

Coral Reefs In Peril
Nutrient Cycling

I. Plants are large component of the carbon cycle
   A. Photosynthesis
      \[ 6\text{H}_2\text{O} + 6\text{CO}_2 \xrightarrow{\text{light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \]
   B. Respiration
      \[ (\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 = 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{usable energy(heat)} \]
   C. Production
      Primary productivity
      Gross Production - respiration = Net Production

II. Types of photosynthesis
   A. C3 (common), C4 (grasses), CAM (deserts)
   D. Comparisons

III. General Carbon Cycle: Inputs and Outputs
     Human Impact (terrestrial and aquatic)