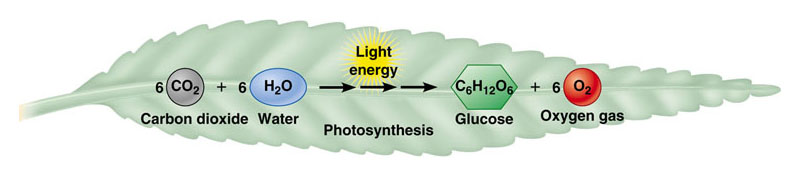
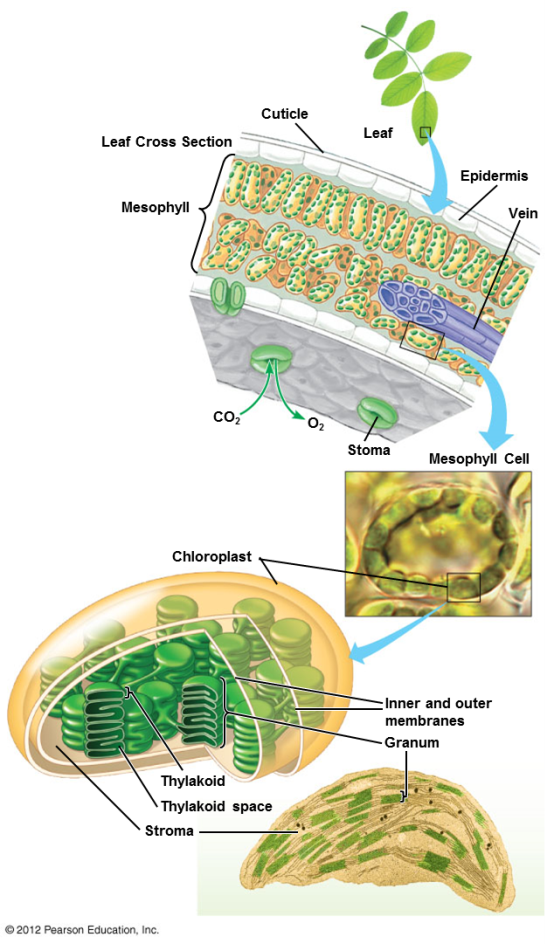
Chapter 7 Test Study Guide

*Photosynthesis: Using Light to Make Food*

**7.1 – Autotrophs are the producers of the biosphere**

* **Autotrophs** (self-feeders)
  + Photoautotrophs: light energy, photosynthesis
    - Producers
    - Plant products: paper, wood, medicine, etc.
  + Chemoautotrophs: inorganic molecules
* **Heterotrophs** (other eaters)
  + Consumers (that’s us!)



**7.2 – Photosynthesis occurs in chloroplasts in plant cells**

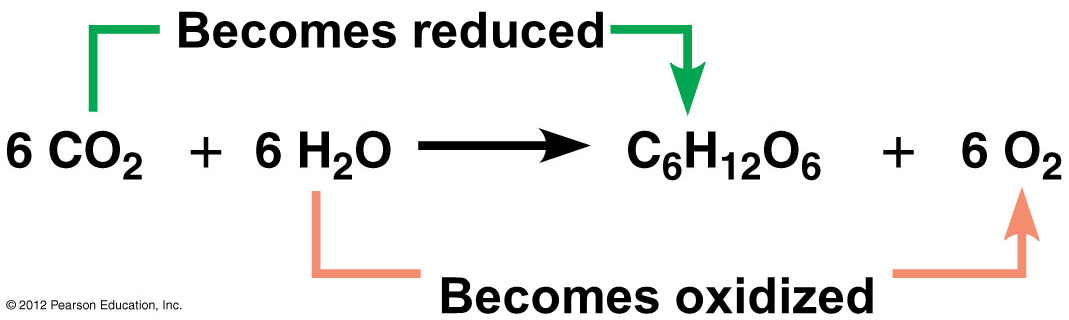
* Chloroplasts are major sites of photosynthesis in green plants
* **Chlorophyll:**
  + Light-absorbing pigment in chloroplasts
  + Responsible for the green color of plants
  + Central role in converting solar energy to chemical energy

**7.3 – SCIENTIFIC DISCOVERY: Scientists traced the process of photosynthesis using isotopes**

* Scientists have known since the 1800s that plants produce O2; they didn’t know if oxygen came from carbon dioxide or water
  + Research using a heavy isotope of oxygen, 18O, showed that oxygen produced by photosynthesis comes from H2O (Neil)
* Experiment 2: 6 CO2 + 12 H2**O** → C6H12O6 + 6 H2O + 6 **O2**
* Photosynthesis produces billions of tons of carbohydrate a year. Where does most of the mass for this huge amount of organic matter come from? Answer: carbon dioxide

**7.4 – Photosynthesis is a redox process, as is cellular respiration**

* Photosynthesis is a redox process (like cellular respiration!)
  + CO2 becomes reduced to sugar **as electrons** & hydrogen ions from water **are added**
  + Water molecules are **oxidized** when they **lose electrons** and hydrogen ions

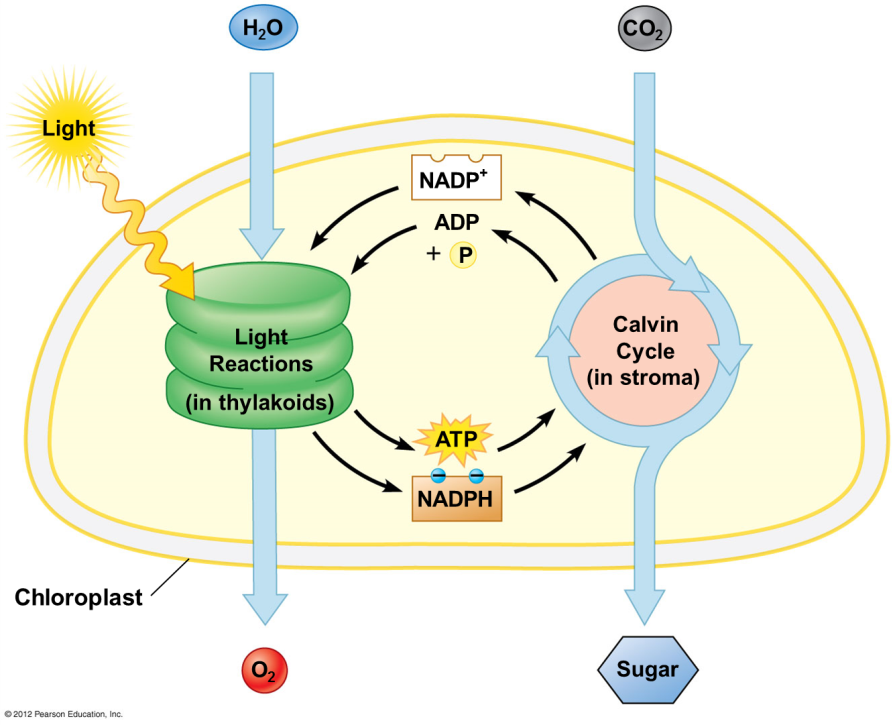


Photosynthesis Summary:

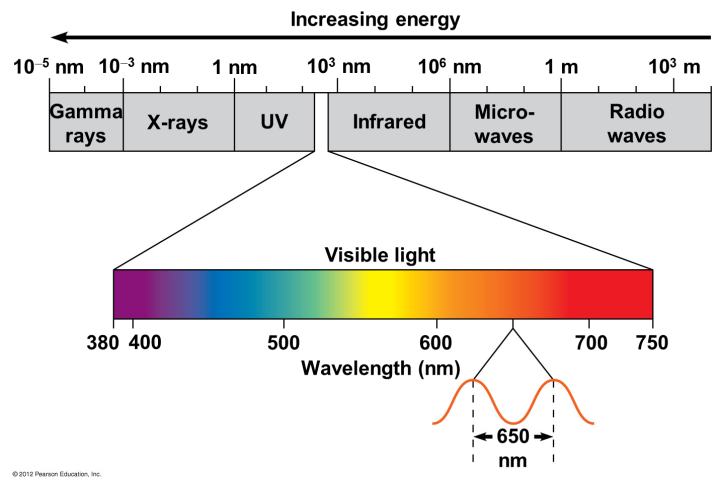
* Requires energy (light)
  + Endergonic
* Light energy is captured by chlorophyll molecules to boost the energy of electrons
* **Light reactions**: light energy is converted to chemical energy
* **Calvin cycle**: chemical energy is stored in the chemical bonds of sugars

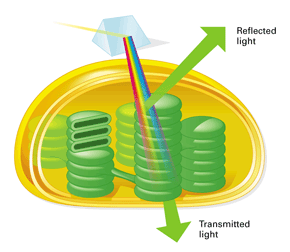
**7.5 – Overview: The two stages of photosynthesis are linked by ATP and NADPH**

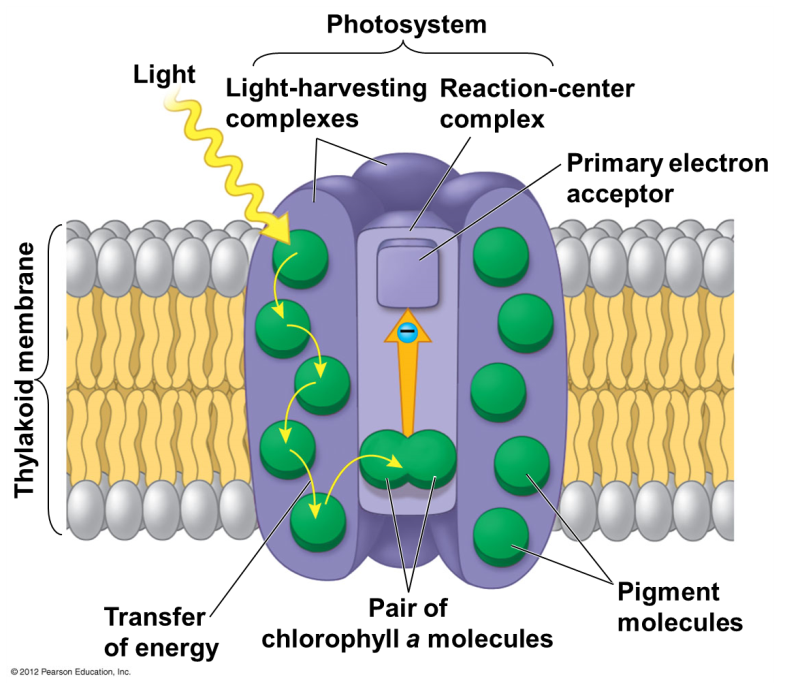
* Photosynthesis occurs in two metabolic stages
  1. The **light reactions** occur in the thylakoid membranes. In these reactions
     + water is split, providing a **source of electrons** and giving off **oxygen as a by-product**
     + **ATP is generated**
     + **NADP+** is reduced to NADPH
     + **ATP and NADPH** are used in the **Calvin cycle**
  2. The second stage is the **Calvin cycle**, which occurs in the stroma of the chloroplast
     + The Calvin cycle is a cyclic series of reactions that assembles sugar molecules using CO2 and the energy-rich products of the light reactions. (ATP and NADPH)
     + CO2 is incorporated into organic compounds in a process called **carbon fixation**
     + Also called the “light independent reactions” or “dark reactions”



**7.6 – Visible radiation absorbed by pigments drives the light reactions**

* Sunlight contains energy called electromagnetic energy/radiation
  + Electromagnetic energy travels in waves
    - **Wavelength:** distance between the crests of two adjacent waves
* Light behaves as discrete packets of energy called photons
  + **Photon:** a fixed quantity of light energy
  + Shorter wavelength = greater energy (of the photon)



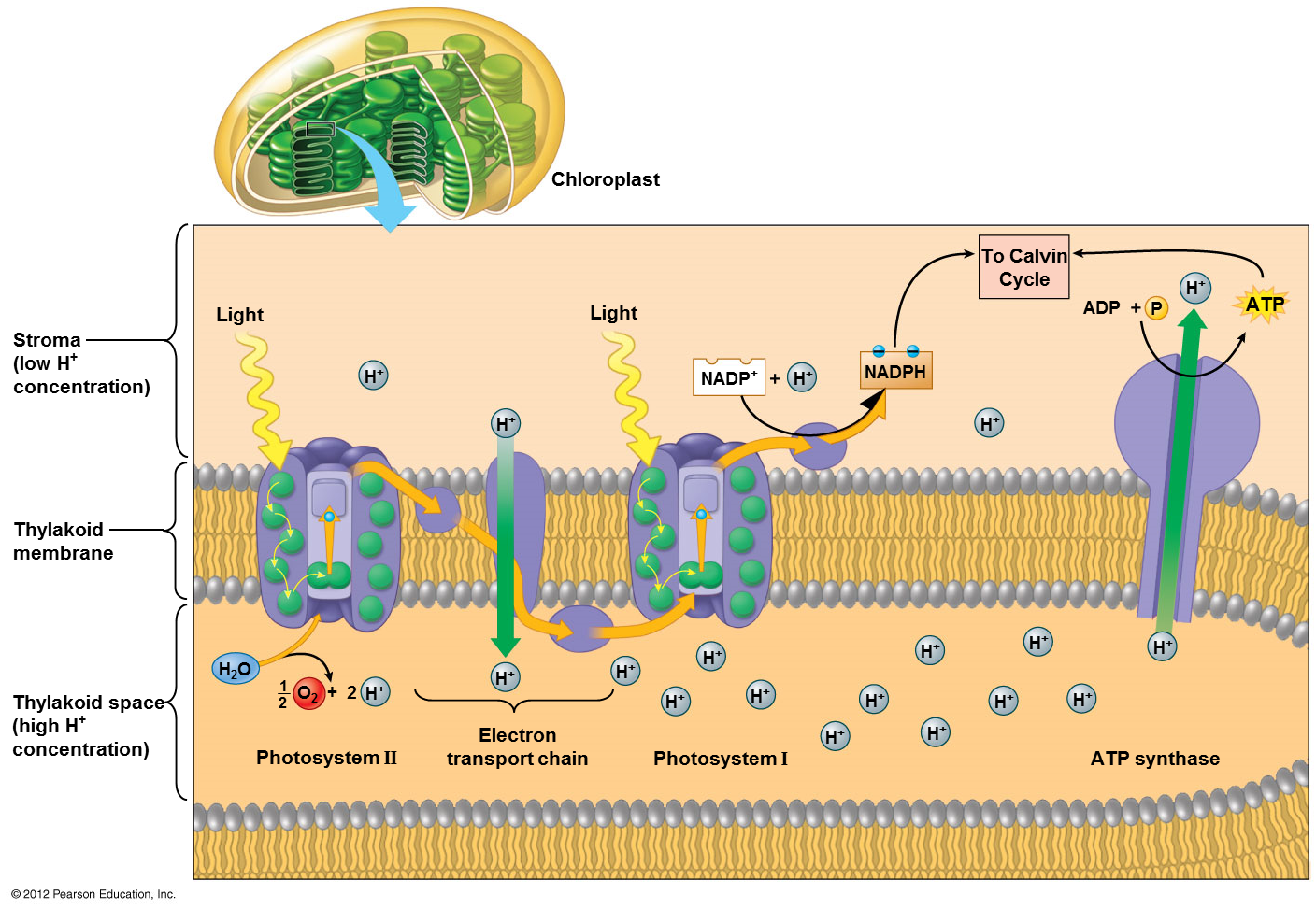
* Plant pigments
  + Light-absorbing molecules
  + Built into the thylakoid membranes
  + Blue green and red orange absorbed
  + Absorb light *energy*
* Chloroplasts contain several different pigments
  + **Chlorophyll *a*** absorbs blue-violet and red light and reflects green
  + Chlorophyll *b* absorbs blue and orange and reflects yellow-green
  + Carotenoids
    - broaden the spectrum of colors that can drive photosynthesis
    - provide photoprotection
      * *Antioxidant in cells*

**7.7 – Photosystems capture solar energy**

* In the thylakoid membrane, chlorophyll molecules are organized along with other pigments and proteins into **photosystems**
* Photosystem: light-harvesting complexes surrounding a reaction-center complex
  + Photosystem ll: P680
  + Photosystem l: P700

**7.8 – Two photosystems connected by an electron transport chain generate ATP and NADPH**

* In the light reactions, light energy is transformed into the chemical energy of ATP and NADPH
* To accomplish this, electrons are
  + removed from water
  + passed from photosystem II to photosystem I
  + accepted by NADP+, reducing it to NADPH
* Between the two photosystems, the electrons
  + move down an electron transport chain
  + provide energy for the synthesis of ATP



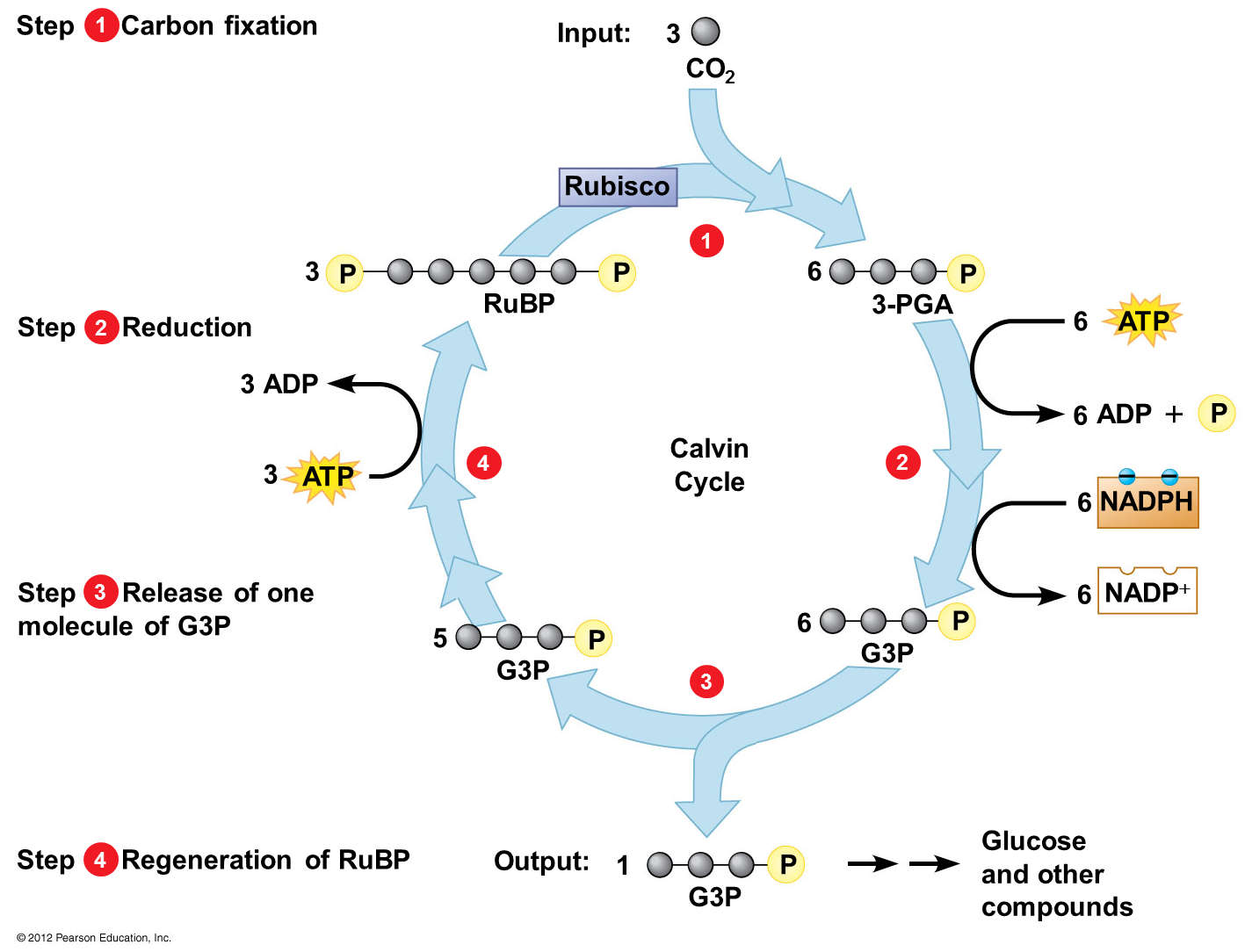
* Products of light reactions:
  + NADPH
  + ATP
  + Oxygen
  + Light energy to chemical energy
  + Why doesn’t photosynthesis stop here?
    - Glucose is needed both to store this energy and for use as plant material

**7.9 – Chemiosmosis powers ATP synthesis in the light reactions**

* Chemiosmosis:
  + Involved in oxidative phosphorylation in mitochondria
  + Generates ATP in chloroplasts
* ATP is generated because the electron transport chain produces a concentration gradient of hydrogen ions across a membrane
* In **photophosphorylation**, using the initial energy input from light,
  + Electron transport chain pumps H+ into the thylakoid space
  + Resulting concentration gradient drives H+ back through ATP synthase, producing ATP

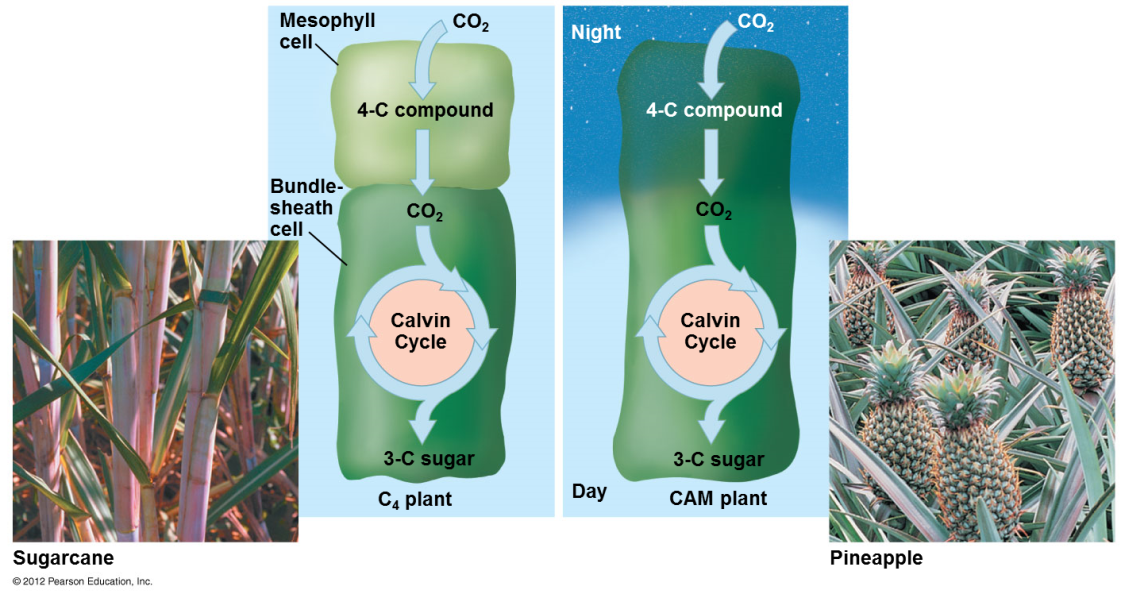
**7.10 – ATP and NADPH power sugar synthesis in the Calvin cycle**

* Steps of the Calvin cycle:
  1. Carbon fixation
  2. Reduction
  3. Release of G3P
  4. Regeneration of the starting molecule – ribulose bisphosphate (RuBP)



**7.11 – EVOLUTION CONNECTION: Other methods of carbon fixation have evolved in hot, dry climates**

* **C3 plants**
  + First product of carbon fixation is a *three carbon* compound 3-PGA
  + Close their stomata in hot dry weather in order to prevent dehydration
  + **Photorespiration** occurs
    - Oxygen builds up, rubisco adds O2 instead of CO2 to RuBP resulting in a 2-carbon product which is broken down in the cell **using ATP**
  + **What will happen if this process continues for too long?** Answer: plant death
* **C4 plants** have evolved a means of
  + carbon fixation that saves water (closed stomata) during photosynthesis
* C4 plants first fix CO2 into a *four-carbon* compound
  + With the help of an enzyme
* The 4-carbon compound “shuttles” the carbon to the Calvin cycle
* **CAM plants** conserve water by opening their stomata and admitting CO2 only at night
  + CO2 is fixed into a four-carbon compound
    - Banks CO2 at night
    - Releases CO2 to the Calvin cycle during the day
  + CAM plants include pineapples and cacti



Needed for photosynthesis:

* CO2 – Calvin cycle – carbon fixation: glucose
* H2O – light reactions – split: 2H + 2e- + ½O2
* Light – light reactions – energy
* Chlorophyll – light reactions – absorbs light energy