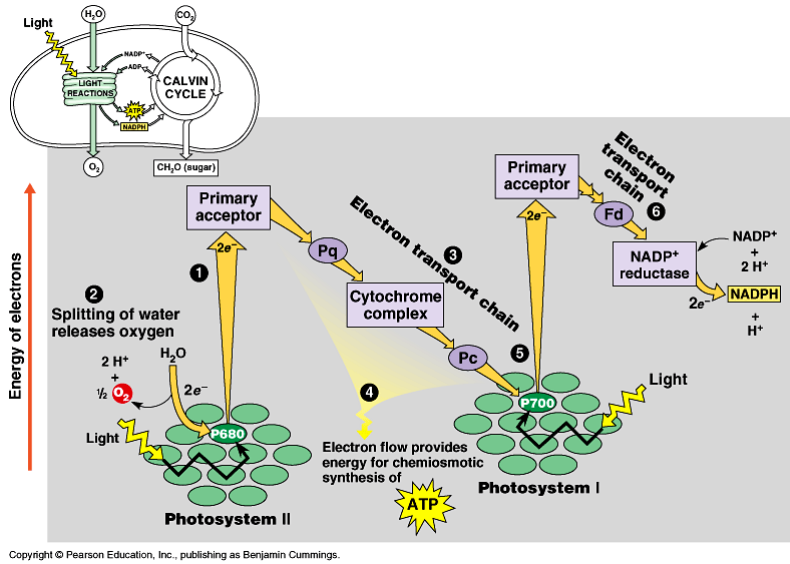
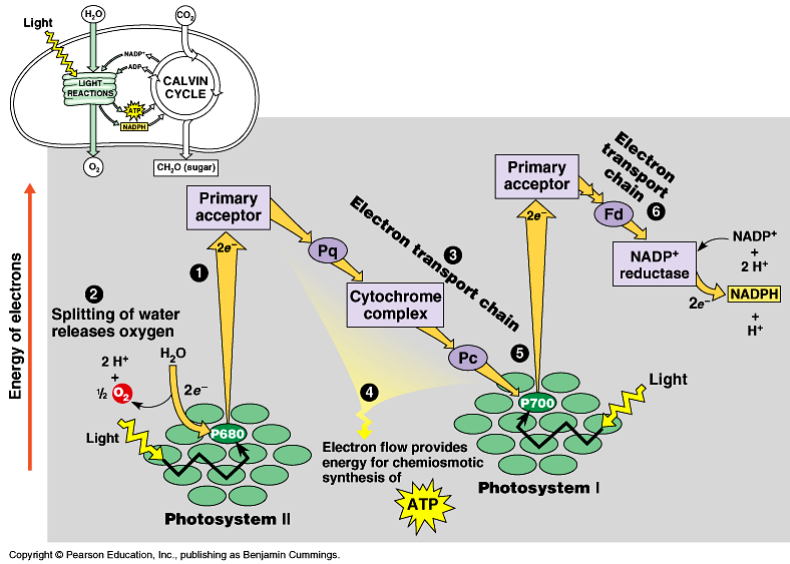
Photosystems I & II

- 2 photosystems occur in thylakoid membranes with photosystem I having a chlorophyll a molecule that absorbs best wavelengths of 700 nm & photosystem II chlorophyll a absorbing best at 680 nm
- Difference due to associated proteins in photosystem not to different chlorophyll a molecules



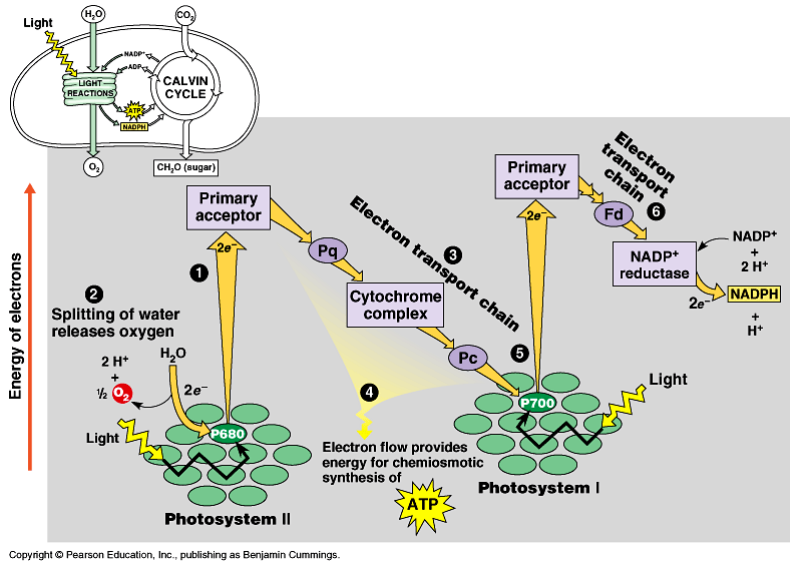
Photosystems

- Noncyclic electron flow through photosystems – 1) photosystem II absorbs light energy & electron is excited & passed to reaction center chlorophyll a which passes the electron to primary electron acceptor



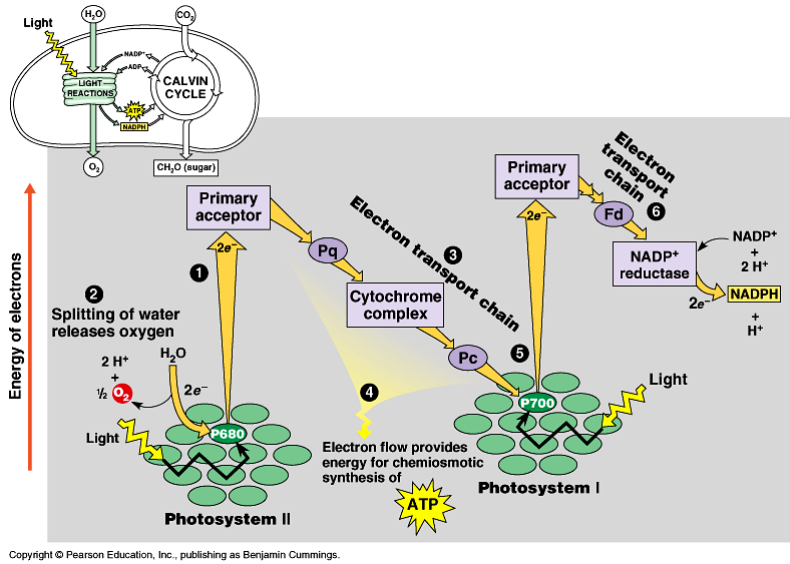
Photosystems

- Oxidized chlorophyll a molecule is very strong oxidizing agent which needs to replace the excited electron
- Enzyme extracts electrons from water & supplies to P680 so water is split and O_2 is formed so called water splitting step of photosynthesis that releases oxygen



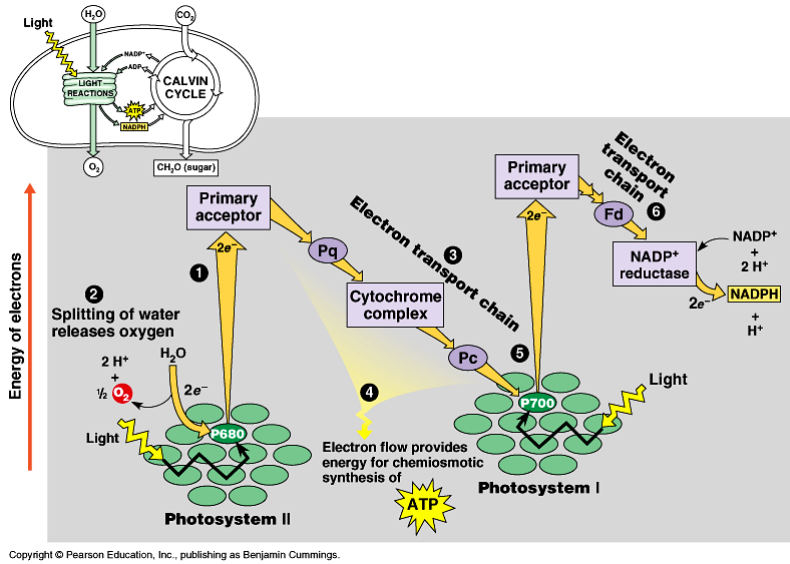
Photosystems

- Photoexcited electron passed from primary electron acceptor of photosystem II to photosystem I through an electron transport system consisting of plastoquinone, a complex of 2 cytochrome proteins, & a copper containing protein called plastocyanin



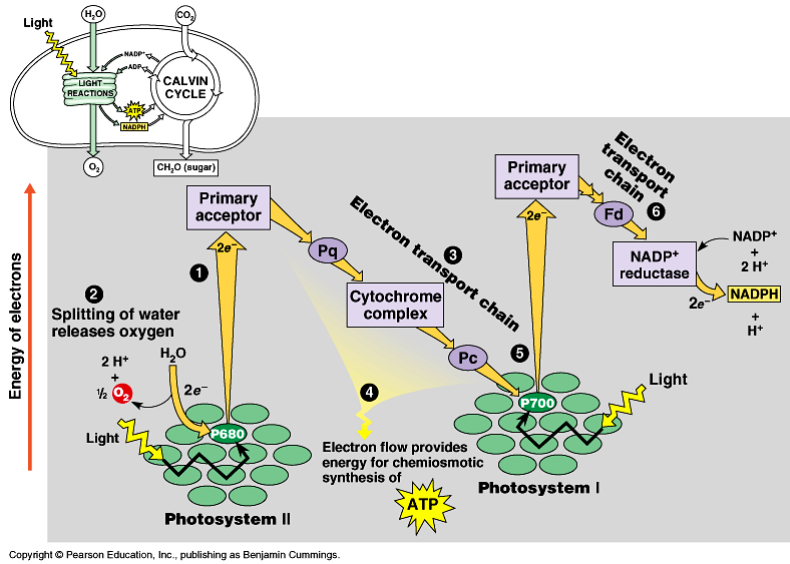
Photosystems

- Electrons ‘fall’ down electron transport chain they lose energy which is used to form a hydrogen ion gradient across thylakoid membrane which also has an ATP synthase complex which uses the potential energy in the gradient to form ATP



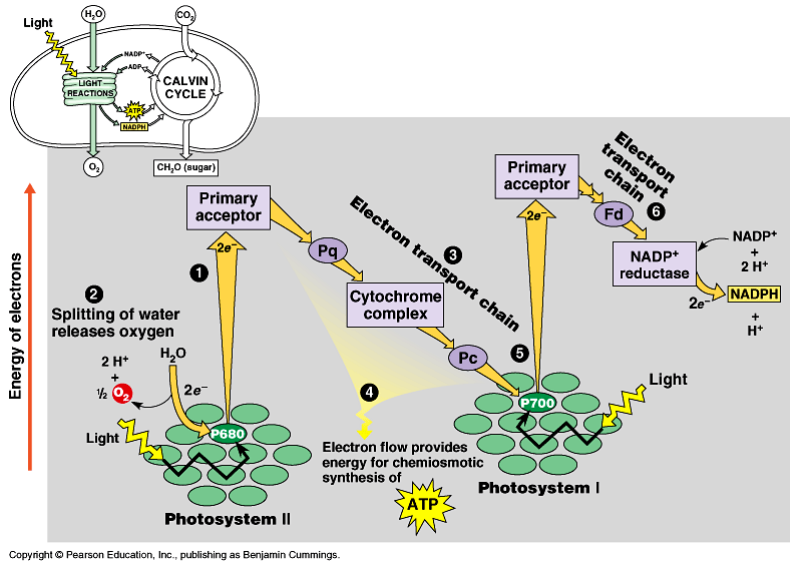
Photosystems

- In noncyclic photophosphorylation when electron gets to bottom of electron transport chain of photosystem II it fills ‘hole’ in chlorophyll a molecule of photosystem I



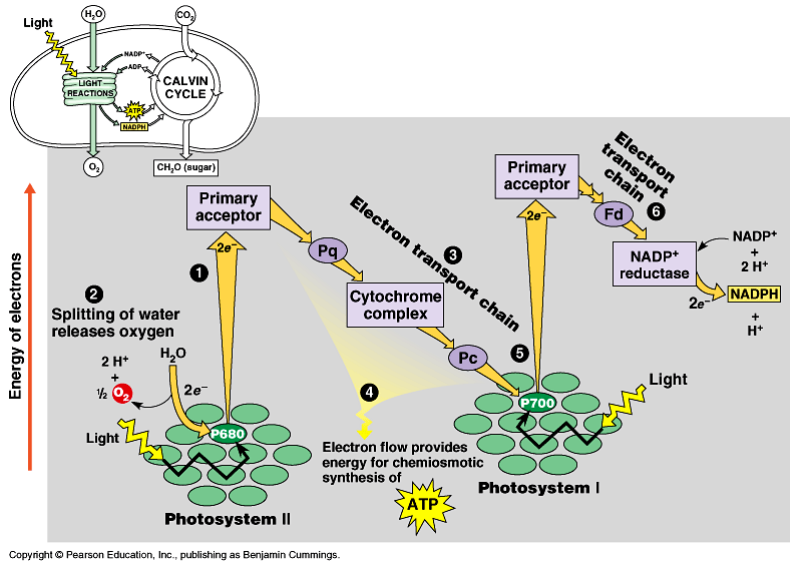
Photosystems

- Photosystem I works the same as photosystem II
- Sunlight absorbed by pigment which passes excited electron to reaction center chlorophyll a molecule which passes it to primary electron acceptor which passes the excited electron to another electron transport chain which transfers it to ferredoxin, an iron containing protein



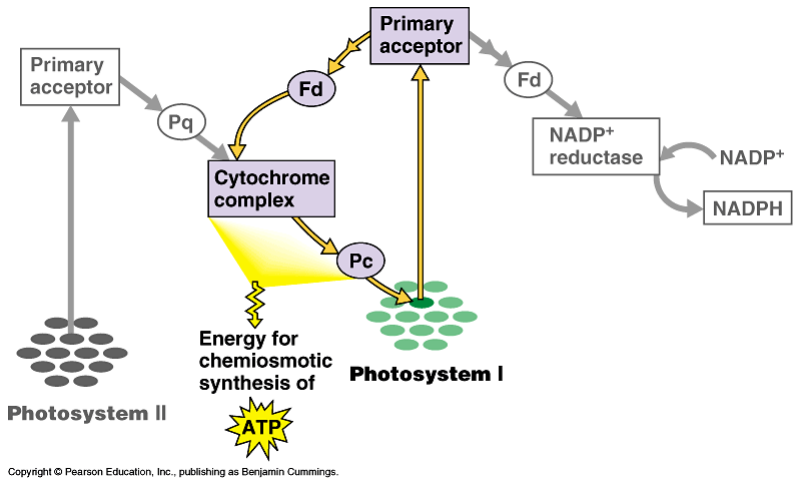
Photosystems

- Enzyme called NADP+ reductase passes excited electron to NADP+ forming NADPH – redox reaction storing high energy electrons in NADPH
- Light reactions form ATP and NADPH



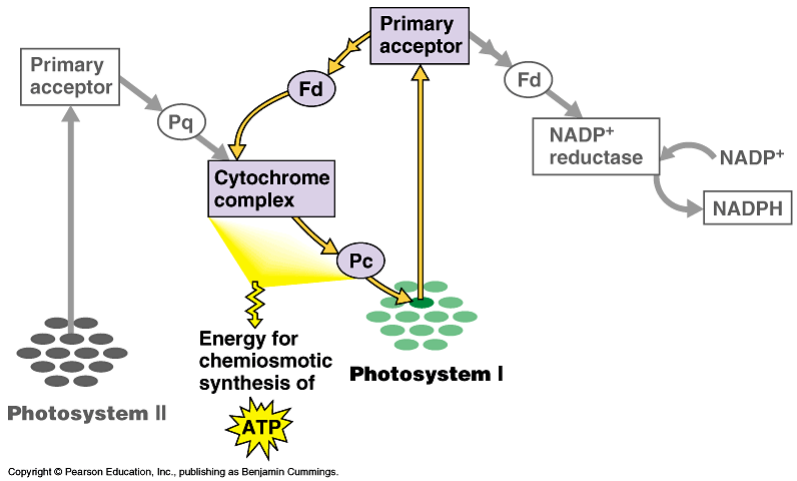
Photosystems

- Can have cyclic flow of electrons where excited electron of photosystem I is transferred to ferredoxin which passes it to cytochrome complex of photosystem II



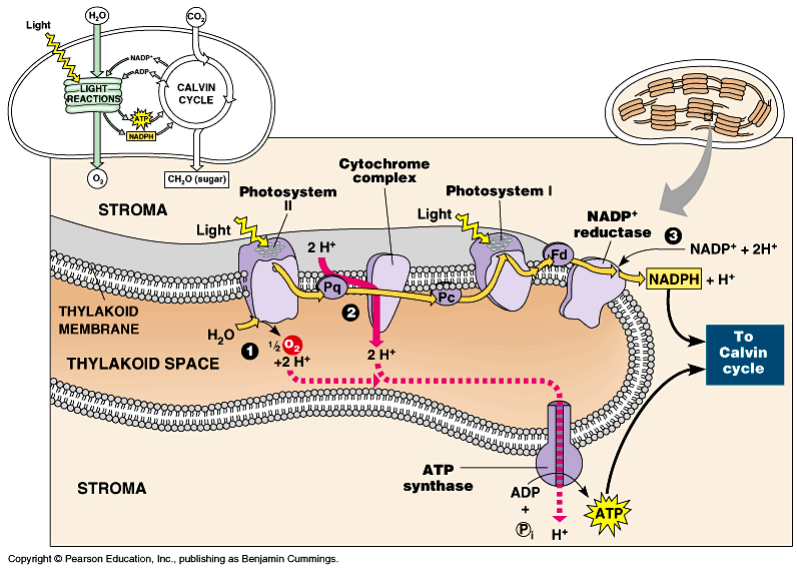
Photosystems

- Why ? Noncyclic photophosphorylation produces about equal amounts of ATP & NADPH but Calvin cycle uses more ATP than NADPH so cyclic electron flow sends electrons through electron transport chain which makes extra ATP



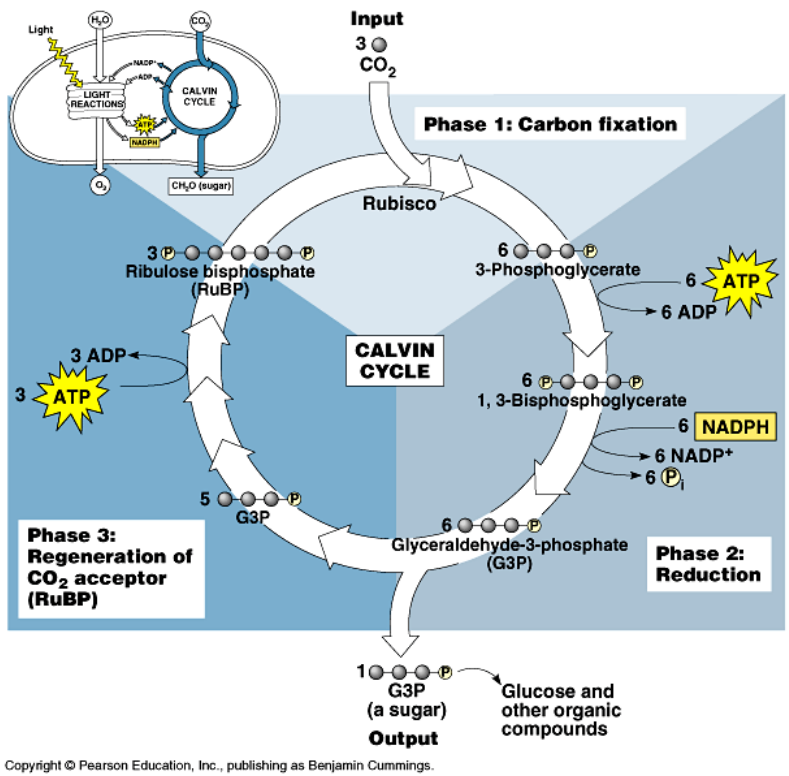
Light reactions - Review

- All systems are built into the thylakoid membrane



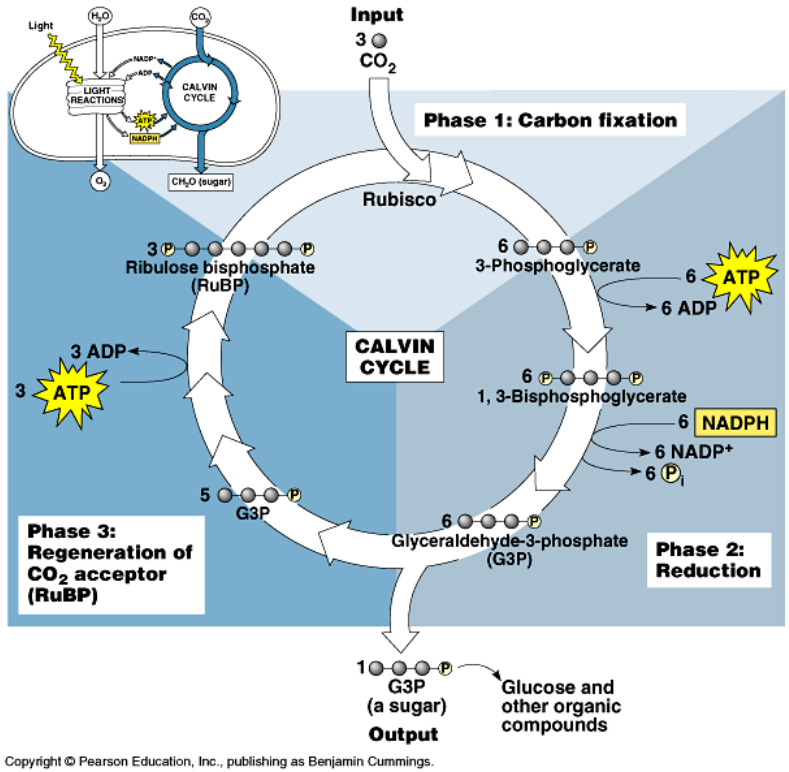
Calvin Cycle

- Calvin cycle uses energy molecules formed in light reactions ATP & NADPH in combination with carbon dioxide to form sugar called glyceraldehyde-3-phosphate (G3P)
- Calvin cycle has 3 phases or parts



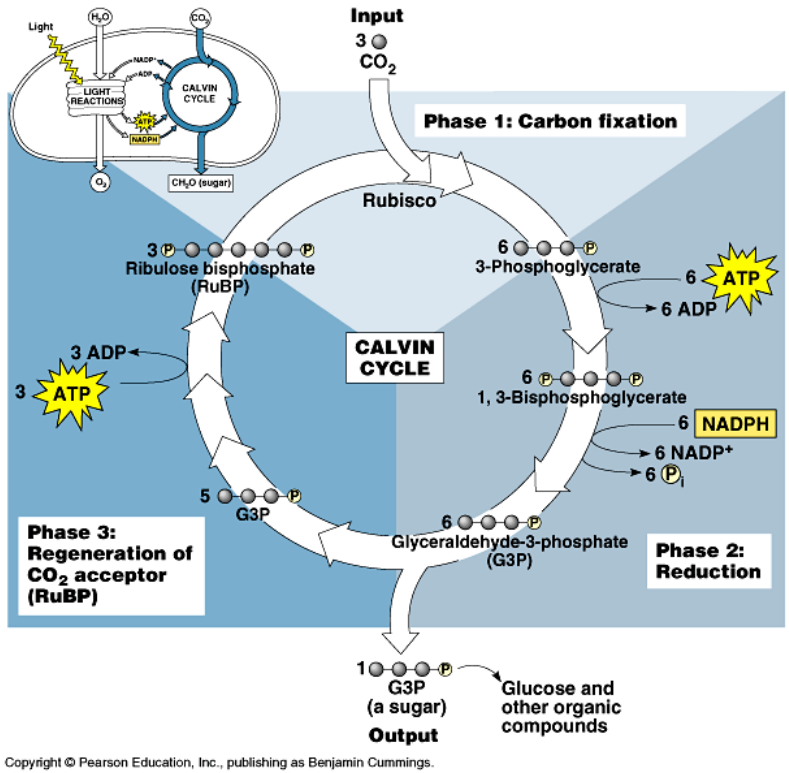
Calvin Cycle cont.

- Phase 1 – carbon fixation – carbon dioxide attached to 5 carbon sugar called ribulose bis-phosphate catalyzed by RuBP carboxylase or rubisco
- Forms unstable 6 carbon intermediate which splits into 2 3-carbon molecules of 3-phosphoglycerate



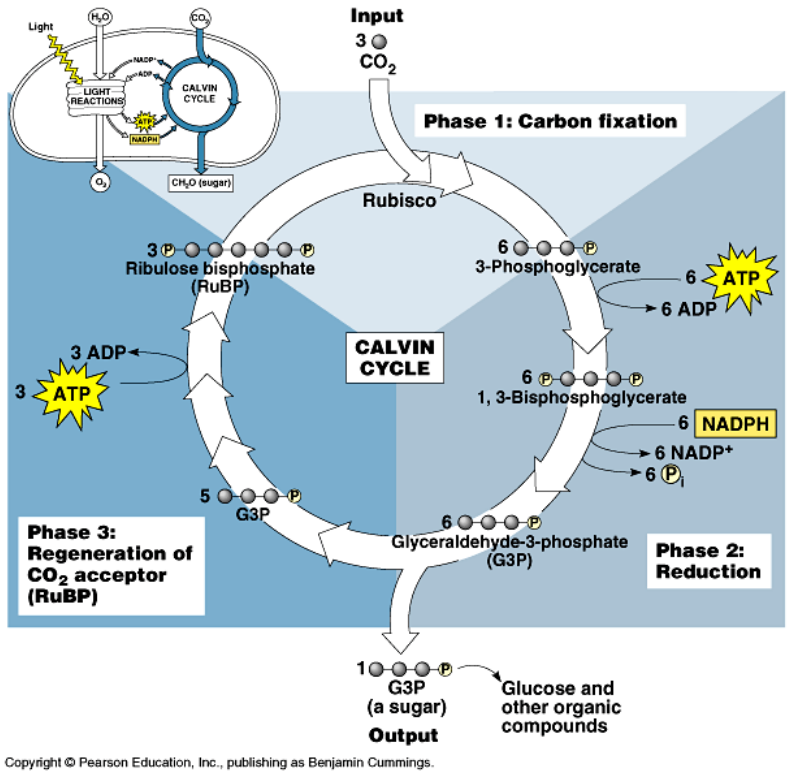
Calvin Cycle cont.

- Phase II – each molecule of 3-phosphoglycerate gets a phosphate group from ATP forming 1,3-bisphosphglycerate then electrons donated by NADPH reduce 1,3 bisPG to G3P – same 3 carbon sugar formed in glycolysis by splitting glucose



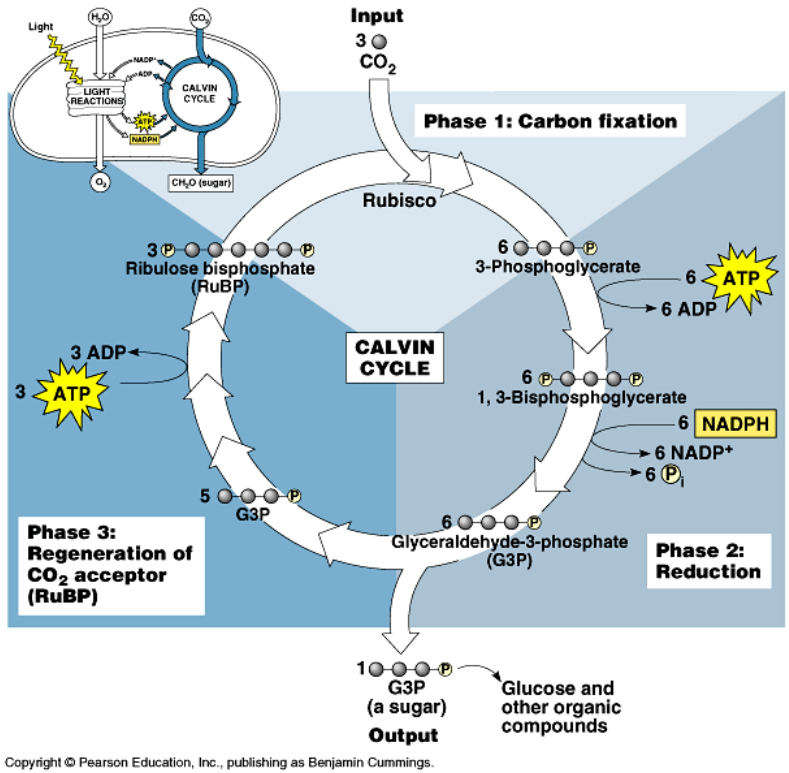
Calvin Cycle cont.

- Phase 3 – regeneration of carbon dioxide acceptor – complex series of reactions changes 5 molecules of G3P to 3 molecules of RuBP requiring use of 3 more molecules of ATP



Calvin Cycle cont.

- Change from 3-PG to G3P uses same amount of ATP & NADPH but phase 3 uses additional ATP so get this extra ATP from the cyclic electron flow of the light reactions



Calvin Cycle cont.

- G3P is then converted into glucose and other organic molecules
- Direct product of Calvin cycle is G3P not glucose
- ATP & NADPH from light reactions used to convert 3-PG to G3P in reduction phase (phase II) & additional ATP needed to regenerate CO_2 acceptor