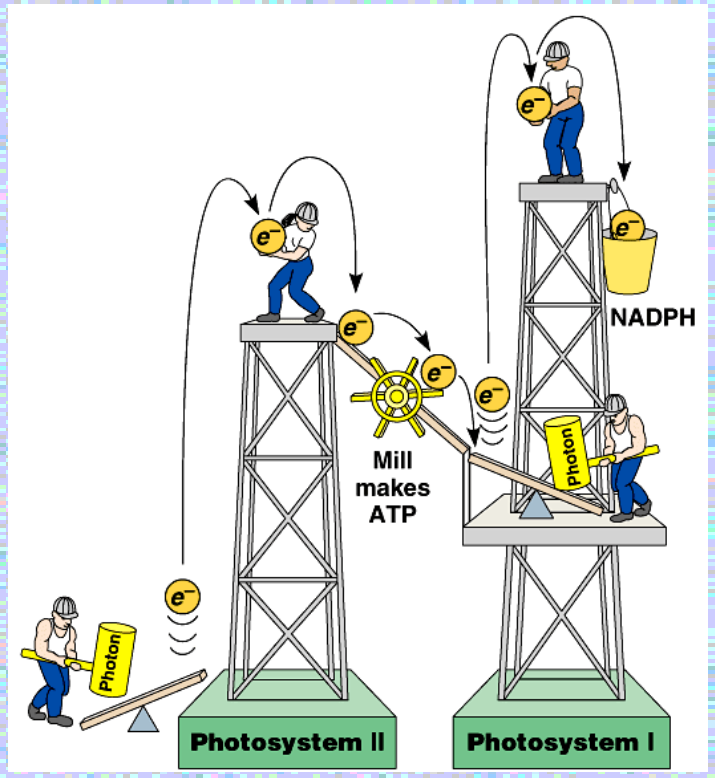
Aim: What is noncyclic photophosphorylation?

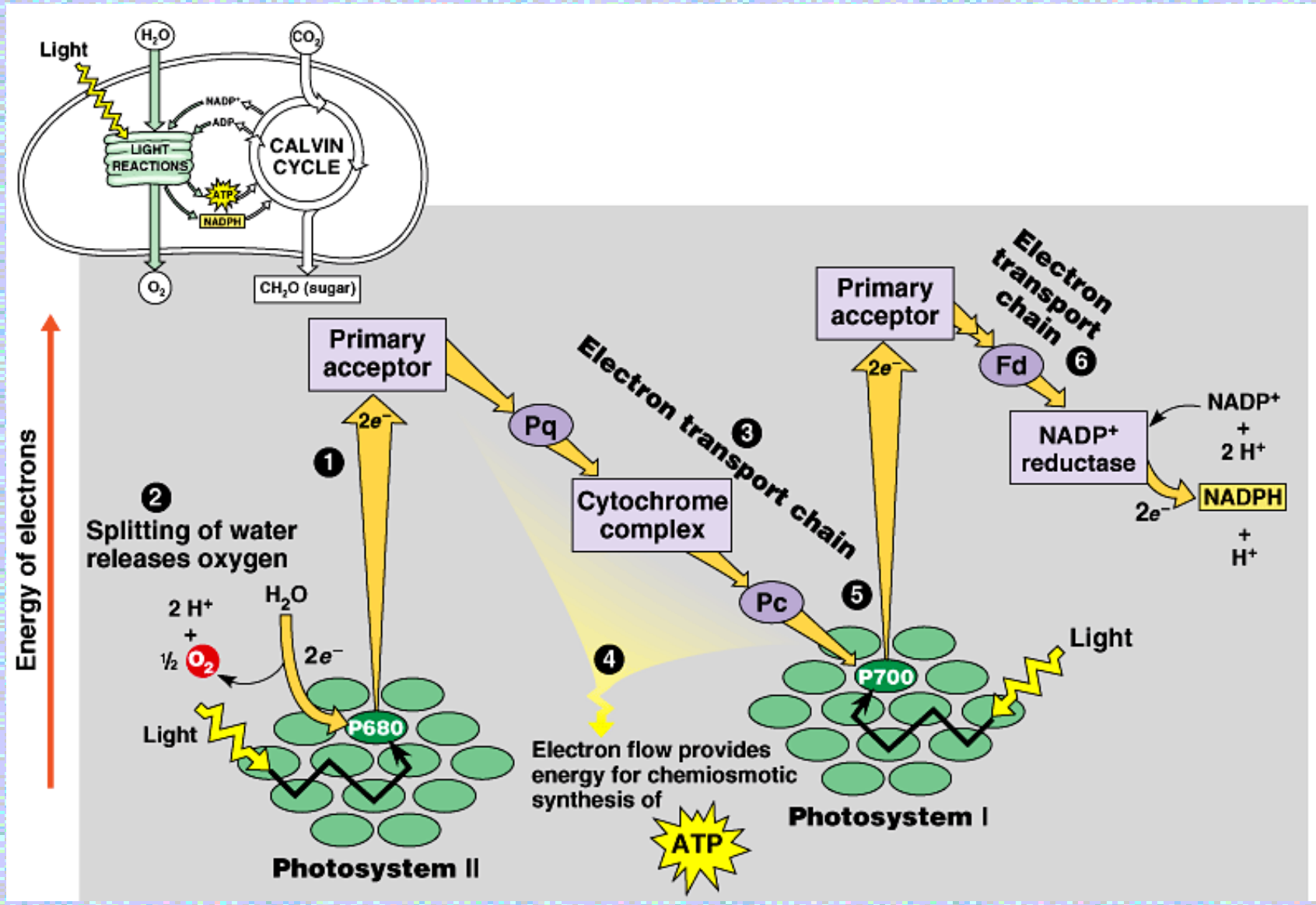


Steps involved with the noncyclic flow of electrons

- **Noncyclic electron flow**, produces both ATP and NADPH.
- 1. When photosystem II absorbs light, an excited electron is captured by the primary electron acceptor, leaving the reaction center oxidized

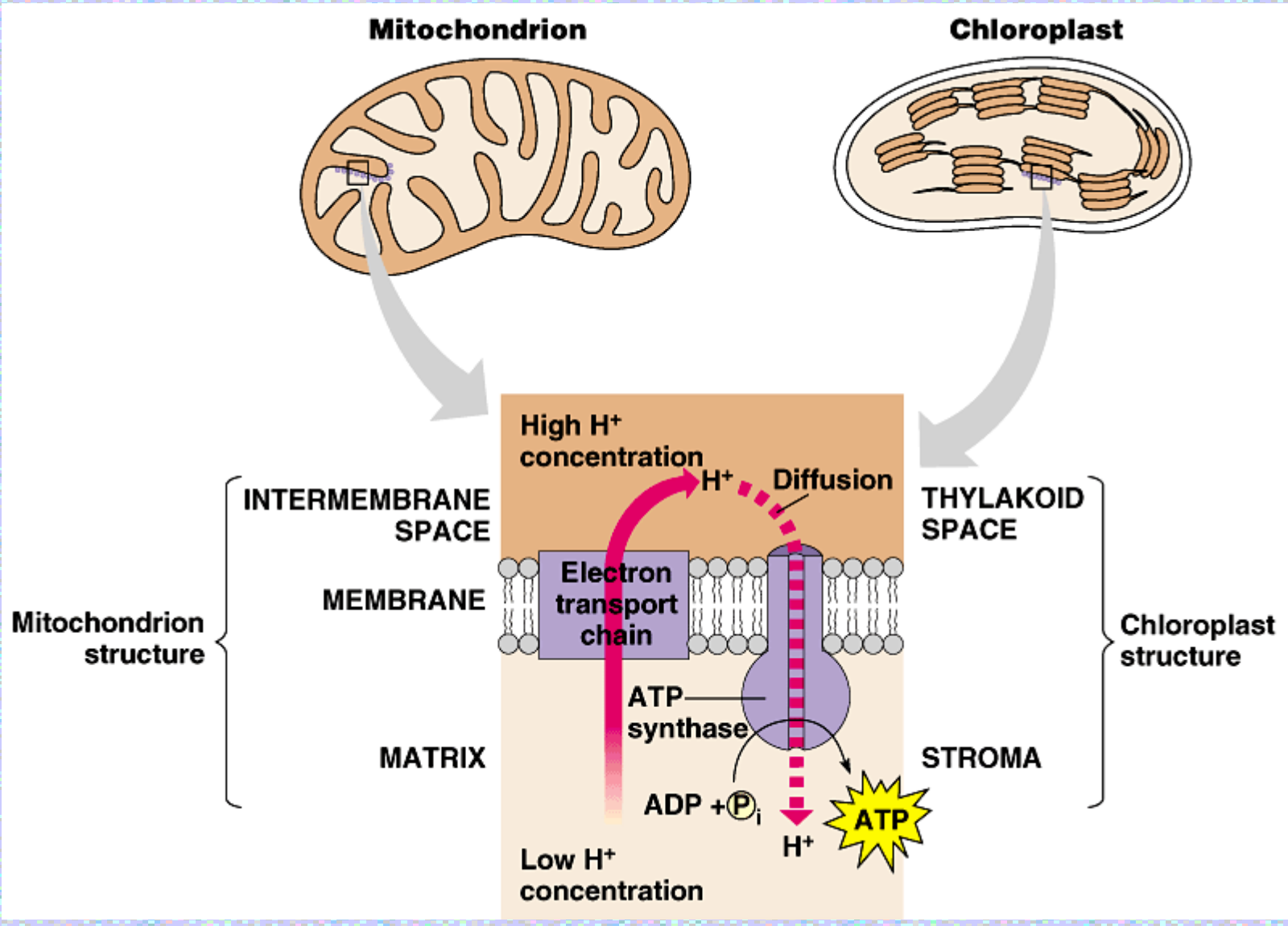
2. An enzyme extracts electrons from water and supplies them to the oxidized reaction center.
   - This reaction splits water into two hydrogen ions and an oxygen atom which combines with another to form O_2.

3. Photoexcited electrons pass along an electron transport chain before ending up at an oxidized photosystem I reaction center.
4. As these electrons pass along the transport chain, their energy is harnessed to produce ATP.
   - The mechanism of **noncyclic photophosphorylation** is similar to the process on oxidative phosphorylation

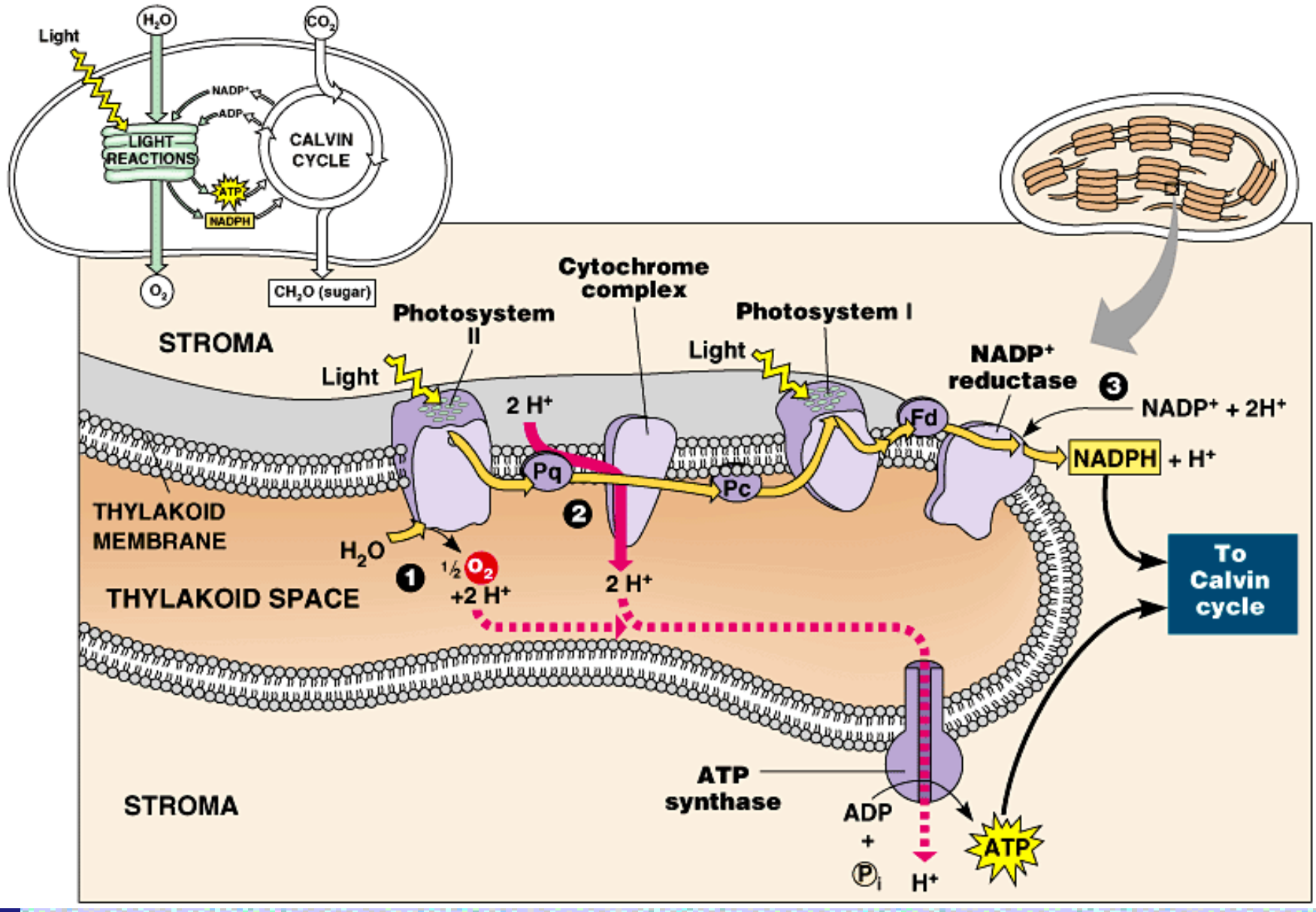

Light
H_2O
CO_2
NADP+
ADP
LIGHT REACTIONS
CALVIN CYCLE
ATP
NADPH
O_2
CH_2O (sugar)
Energy of electrons
Primary acceptor
Pq
Cytochrome complex
Pc
Primary acceptor
Fd
Electron transport chain
6
NADP+ reductase
NADP+ + 2 H+
NADPH + H+
2e−
1
2e−
3
Electron transport chain
5
2e−
2
Splitting of water releases oxygen
2 H+ + ½ O_2
H_2O
2e−
Light
P680
4
Electron flow provides energy for chemiosmotic synthesis of
ATP
Light
P700
Photosystem II
Photosystem I

5. At the bottom of this electron transport chain, the electrons fill an electron "hole" in an oxidized P700 center.
6. This hole is created when photons excite electrons on the photosystem I complex.
    - The excited electrons are captured by a second primary electron acceptor which transmits them to a second electron transport chain.
    - Ultimately, these electrons are passed from the transport chain to $NADP^+$, creating NADPH.
        - NADPH will carry the reducing power of these high-energy electrons to the Calvin cycle.

- Chloroplasts and mitochondria generate ATP by the same mechanism: chemiosmosis.
  - An electron transport chain pumps protons across a membrane as electrons are passed along a series of more electronegative carriers.
  - This builds the proton-motive force in the form of an H^+ gradient across the membrane.
  - ATP synthase molecules harness the proton-motive force to generate ATP as H^+ diffuses back across the membrane.
- Mitochondria transfer chemical energy from food molecules to ATP and chloroplasts transform light energy into the chemical energy of ATP.


Mitochondrion
Chloroplast
High H+ concentration
H+
Diffusion
INTERMEMBRANE SPACE
THYLAKOID SPACE
Mitochondrion structure
MEMBRANE
Electron transport chain
Chloroplast structure
ATP synthase
MATRIX
STROMA
ADP + Pi
ATP
H+
Low H+ concentration

- The proton gradient, or pH gradient, across the thylakoid membrane is substantial.
  - When illuminated, the pH in the thylakoid space drops to about 5 and the pH in the stroma increases to about 8, a thousandfold different in H+ concentration.
- The light-reaction "machinery" produces ATP and NADPH on the stroma side of the thylakoid.


Light
H_2O
CO_2
NADP+
ADP
LIGHT REACTIONS
CALVIN CYCLE
ATP
NADPH
O_2
CH_2O (sugar)
STROMA
Photosystem II
Cytochrome complex
Photosystem I
Light
Light
NADP+ reductase
3
NADP+ + 2H+
Fd
NADPH + H+
2 H+
Pq
Pc
2
THYLAKOID MEMBRANE
H_2O
1
½ O_2
+2 H+
2 H+
THYLAKOID SPACE
To Calvin cycle
ATP synthase
ADP + Pi
H+
ATP
STROMA

- Noncyclic electron flow pushes electrons from water, where they are at low potential energy, to NADPH, where they have high potential energy.
  - This process also produces ATP.
  - Oxygen is a byproduct.
- Cyclic electron flow converts light energy to chemical energy in the form of ATP.