**Topic 8.3: Photosynthesis**

**Essential Idea: Light energy is converted into chemical energy.**

**Statements & Objectives:**

**8.3.U1 Light-dependent reactions take place in the intermembrane space of the thylakoids.**

State the location of the light dependent reactions of photosynthesis.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

State that the light dependent reactions of photosynthesis include:

* Photoactivation
* Photolysis
* Electron transport
* Chemiosmosis
* ATP synthesis
* ​Reduction of NADP to NADPH + H+

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U2 Light –independent reactions take place in the stroma.**

State that the light dependent reactions convert light energy into chemical energy in the form of ATP and NADH.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U3 Reduced NADP and ATP are produced in the light-dependent reactions.**

State the location of the light independent reactions of photosynthesis.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

State that the light independent reactions of photosynthesis include:

* Carbon fixation
* Carboxylation of RuBP
* Production of triosphosphate
* ATP and NADPH as energy sources
* ATP used to regenerate RuBP
* ATP used to produce carbohydrates​

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U4 Absorption of light by photosystems generates excited electrons.**

Define photosystem and reaction center.

(**Define** Give the precise meaning of a word, phrase, concept or physical quantity.)

State that the light dependent reactions of photosynthesis begin at Photosystem II.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

Outline process of photoactivation of the reaction center chlorophyll.

(**Outline** Give a brief account or summary.)

State that in photoactivation at Photosystem II, the reaction center chlorophyll is oxidized and the plastoquinone (Pq) is reduced.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U5 Photolysis of water generates electrons for use in the light-independent reactions.**

State that to replace the electrons lost during photoactivation, the reaction center chlorophyll takes electrons by splitting water.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U6 Transfer of excited electrons occurs between carriers in thylakoid membranes.**

Draw a cross section of the thylakoid membrane to show the path of transfer of excited electrons, inclusive of Photosystem II, ATP synthase, an electron transport chain (with Pq first) and Photosystem II.

(**Draw**: Represent by means of a labeled, accurate diagram or graph, using a pencil. A ruler(straight edge) should be used for straight lines. Diagrams should be drawn to scale. Graphs should have points correctly plotted(if appropriate) and joined in a smooth curve. )

**8.3.U7 Excited electrons from Photosytem II are used to contribute to generate a proton gradient.**

State that electrons pass from plastoquinone (Pq) through a chain of electron carrier molecules.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

State that the energy released by the movement of electrons is used to pump protons across the thylakoid membrane, from the stroma into the thylakoid lumen.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

State that the result of the electron transport chain is a proton gradient, with a high concentration of protons in the thylakoid lumen.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U8 ATP synthase in thylakoids generates ATP using the proton gradient.**

State that in chemiosmosis, ATP is generated as protons move down their concentration gradient through ATP synthase.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U9 Excited electrons from Photosytem I are used to reduce NADP.**

State that photoactivation of the reaction center chlorophyll in photosystem I excites electrons which pass through a different electron transport chain.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

State that the electrons of Photosystem I are used to reduce NADP+ to form NADPH.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

State that NADPH is an electron carrier molecule.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

State that the electrons from the Photosystem II electron transport chain are used to replace the electrons lost during photoactivation of Photosystem I.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U10 In the light-independent reaction a carboxylase catalyzes the carboxylation of ribulose-bisphosphate.**

Define carbon fixation and carboxylation.

(**Define** Give the precise meaning of a word, phrase, concept or physical quantity.)

State that carbon fixation occurs in the chloroplast stroma.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

State that the 5-carbon molecule ribulose bisphosphate (RuBP) is carboxylated by CO2, forming 2 3-carbon molecules called glycerate-3-phosphate (G3P).

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

State that the enzyme that catalyzes the carboxylation of RuBP is called ribulose bisphosphate carboxylase (rubisco).

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U11 Glycerate 3-phosphate is reduced to triose phosphate using a reduced NADP and ATP.**

State that ATP (from the light dependent reaction) provides the energy for NADPH (from the light dependent reaction) to reduce G3P, forming a three carbon carbohydrate, triose phosphate. ​

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U12 Triose phosphate is used to regenerate RuBP and produce carbohydrates.**

State that in the Calvin Cycle, triose phosphate is used to regenerate RuBP and create glucose.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

State that six turns of the Calvin Cycle are needs to produce one molecule of glucose.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U13 Ribulose bisphosphate is reformed using ATP.**

State that ATP is used to regenerate RuBP from triose phosphate.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.U14 The structure of the chloroplast is adapted to its function in photosynthesis.**

Outline how chloroplast structure could evolve through natural selection.

(**Outline** Give a brief account or summary.)

State evidence that suggests chloroplast were once free living prokaryotes.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.A1 Calvin’s experiment to elucidate the carboxylation of RuBP.**

Outline Calvin’s “lollipop” experiment, including the role of:

* Radioactive carbon-14
* Green algae
* Air with CO2
* Light
* Varying the time of light exposure
* Heated alcohol
* Chromatography
* Autoradiography

(**Outline** Give a brief account or summary.)

**8.3.S1 Annotation of a diagram to indicate the adaptations of a chloroplast to its function.**

Draw and label a diagram of the chloroplast.

(**Draw**: Represent by means of a labeled, accurate diagram or graph, using a pencil. A ruler(straight edge) should be used for straight lines. Diagrams should be drawn to scale. Graphs should have points correctly plotted(if appropriate) and joined in a smooth curve. )

State the function of the following chloroplast structures: double membrane, thylakoids, pigment molecules, thylakoid lumen, and stroma.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**8.3.NOS Developments in scientific research follow improvements in apparatus- sources of 14C and autoradiography enabled Calvin to elucidate the pathways of carbon fixation**.

State that the discovery of the radioactive 14C isotope allowed Calvin to determine the pathway of the light independent reactions of photosynthesis.

(**State** Give a specific name, value or other brief answer without explanation or calculation.)

**Key Terms**

​ Photosynthesis

​Light-dependent reactions

light dependent reactions

​ATP

triosphosphate

​Photosystem I

photolysis

electron transport chain

​triose phosphate

 autoradiography

chloroplast

photoactivation

synthesis

​light energy

photosystem

Calvin Cycle

​ATP synthesis

​carbon fixation

​prokaryotes

​thylakoid lumen

photolysis

​grana

​NADP

photon

​reaction center

​photoactivation

​pigments

carboxylation

carbon-14

stroma

electron transport

 NADPH

 carbon fixation

RuBP

plastoquinone (Pq)

​proton gradient

​G3P

​light waves

thylakoid

chemiosmosis

​ADP

carboxylation

​Photosystem II

​electrons

​carboxylase

​rubisco

chromatography