4. Noncyclic electron flow and cyclic electron flow are two major pathways of the light-dependent reactions of photosynthesis. In noncyclic electron flow, electrons pass through photosystem II, then components of a chloroplast electron transport chain, and then photosystem I before finally reducing $NADP^+$ to NADPH. In cyclic electron flow, electrons cycle through photosystem I and some components of the electron transport chain (Figure 1).

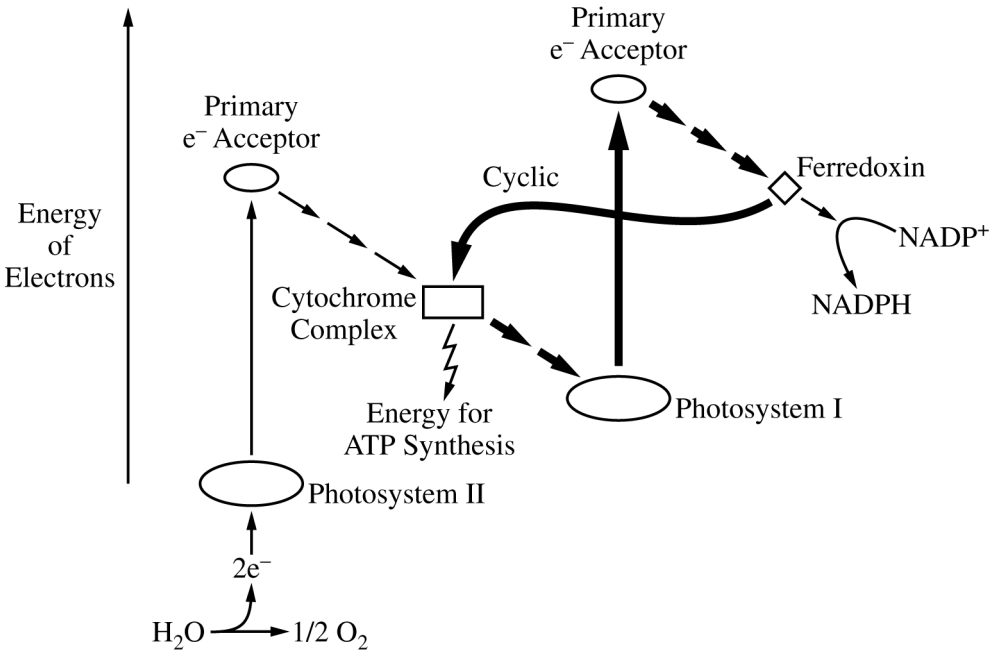


Figure 1. The pathways of noncyclic and cyclic (heavy arrows) electron flow. The cytochrome complex is a component of the electron transport chain between the two photosystems.

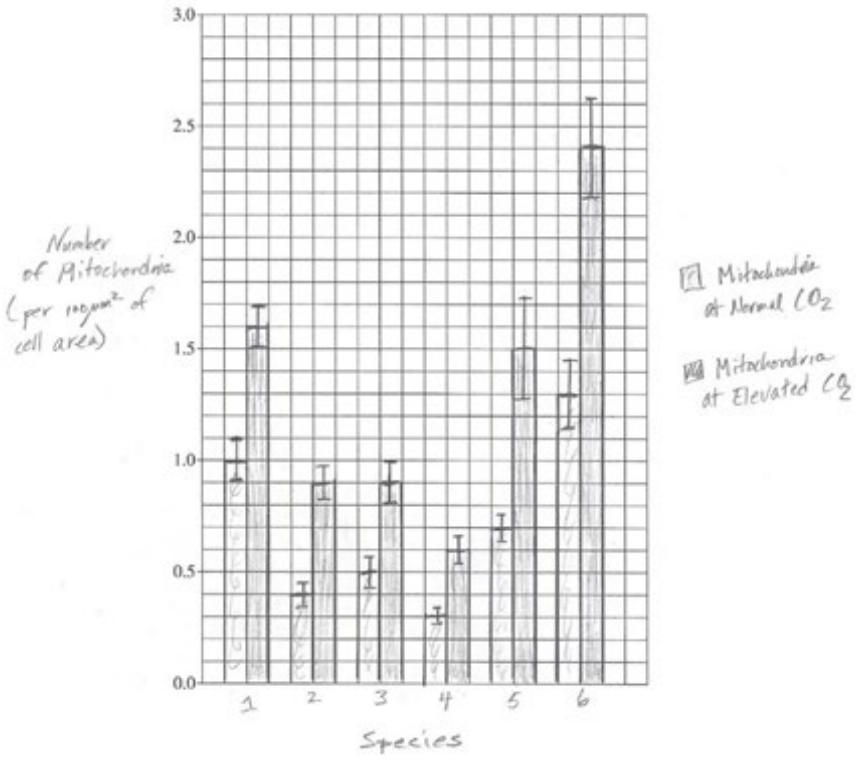
(a) **Describe** the role of chlorophyll in the photosystems of plant cells.

(b) Based on Figure 1, **explain** why an increase in the ratio of NADPH to $NADP^+$ will cause an increase in the flow of electrons through the cyclic pathway.

(c) Using rice plants, scientists examined the effect of a mutation that results in the loss of the protein CRR6. CRR6 is a part of the photosystem I complex, and its absence reduces the activity of photosystem I. **Predict** the effect of the mutation on the rate of biomass (dry weight) accumulation.

(d) **Justify** your prediction in part (c).

Write your responses to this question only on the designated pages in the separate Free Response booklet.

(b)	Using the template in the space provided for your response, **construct** an appropriately labeled graph that represents the data in Table 1. Sample response:  • Appropriate labelling	**1 point**
	Using the template in the space provided for your response, **construct** an appropriately labeled graph that represents the data in Table 1. • Data are represented in a bar/modified bar graph.	**1 point**
	Using the template in the space provided for your response, **construct** an appropriately labeled graph that represents the data in Table 1. • Data points and error bars are correctly plotted.	**1 point**
	Determine which species show(s) a difference in the number of mitochondria between normal and elevated levels of CO_2. • All of the species	**1 point**
		Total for part (b) 4 points
(c)	Based on the data in Table 1, **describe** the relationship between the level of CO_2 and the average number of mitochondria per unit area of a cell. Accept one of the following: • The number of mitochondria is greater under conditions of elevated CO_2 (than under normal CO_2). • It is a positive relationship/correlation.	**1 point**

Question 4: Conceptual Analysis — 4 points

Noncyclic electron flow and cyclic electron flow are two major pathways of the light-dependent reactions of photosynthesis. In noncyclic electron flow, electrons pass through photosystem II, then components of a chloroplast electron transport chain, and then photosystem I before finally reducing $NADP^+$ to NADPH. In cyclic electron flow, electrons cycle through photosystem I and some components of the electron transport chain (Figure 1).

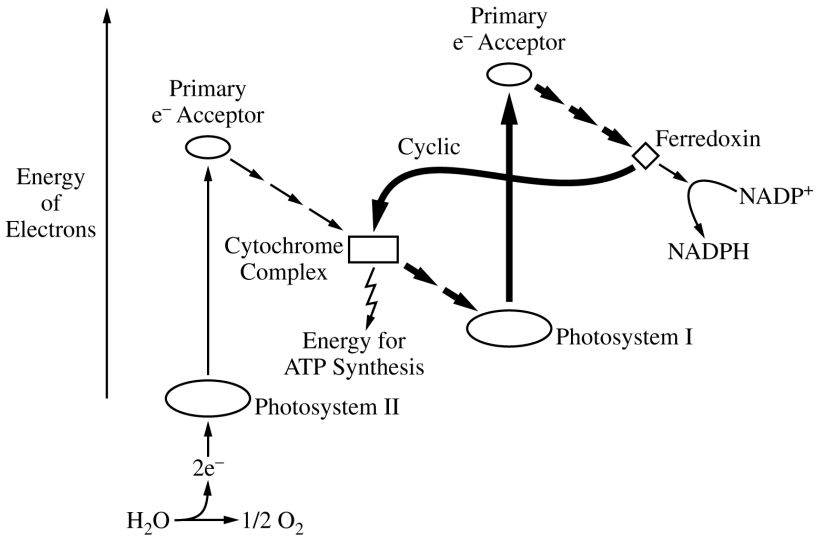


Figure 1. The pathways of noncyclic and cyclic (heavy arrows) electron flow. The cytochrome complex is a component of the electron transport chain between the two photosystems.

(a)	**Describe** the role of chlorophyll in the photosystems of plant cells. Accept one of the following: • Chlorophyll captures/absorbs light (energy). • Chlorophyll receives electrons (from water)/receives electrons (from an electron transport chain)/transfers electrons (to an electron transport chain).	**1 point**
(b)	Based on Figure 1, **explain** why an increase in the ratio of NADPH to $NADP^+$ will cause an increase in the flow of electrons through the cyclic pathway. • There is less/no $NADP^+$ to accept the electrons, so the electrons pass (instead) to the cyclic pathway/from ferredoxin to the cytochrome complex.	**1 point**
(c)	Using rice plants, scientists examined the effect of a mutation that results in the loss of the protein CRR6. CRR6 is a part of the photosystem I complex, and its absence reduces the activity of photosystem I. **Predict** the effect of the mutation on the rate of biomass (dry weight) accumulation. • The rate (of biomass accumulation)/Biomass/It will be lower (in comparison with plants without the mutation).	**1 point**
(d)	**Justify** your prediction in part (c). • There will be insufficient ATP/NADPH produced for the synthesis of carbohydrates/the Calvin cycle.	**1 point**
	Total for question 4	**4 points**