

Limiting Factors affecting Photosynthesis

Learning Targets

21a. I can identify the factors that affect the rate at which photosynthesis occurs.

21b. I can identify the factors that cause photorespiration to occur.

You will use your textbook as needed to complete the following activity about the limiting factors affecting photosynthesis. Start by defining the term *limiting factor* below:

I. Rate of Photosynthesis and CO₂ concentration

The data below shows how the rate of photosynthesis depends on CO₂ concentration. The rate of photosynthesis is measured here by the amount of CO₂ uptake, in units of *milli-mol per square meter per second* [$\text{mmol}/(\text{m}^2 \text{ s})$], where the unit *mol* is used in chemistry to measure the amount of a substance. Concentration of CO₂ is measured in *parts-per-million* (*ppm*). **Graph the data (be sure to LABEL your graph/axes) and then answer the analysis questions that follow.**

Which is the independent and which is the dependent variable?

Rate of photosynthesis: CO ₂ uptake [$\text{mmol}/(\text{m}^2 \text{ s})$]	Ambient CO ₂ concentration (ppm)
0.0	0
11.5	200
13.0	400
13.9	600
14.5	800
15.0	1000



(1) Describe how CO_2 concentration affects the rate of photosynthesis

(2) Give an explanation for the shape of the curve

II. Rate of Photosynthesis and Light Intensity

Below is data showing the rate of photosynthesis as a function of the intensity of light on the plant (same units as above). Irradiance is measured as light intensity per unit area of leaf (Light intensity is measured in candelas, abbreviated as cd)

Graph the data and answer the analysis questions.

Rate of CO ₂ uptake [mmol/(m ² s)]	Irradiance (cd/m ²)		Rate of CO ₂ uptake [mmol/(m ² s)]	Irradiance (cd/m ²)
-5.0	0		18.5	6
0	1		19.2	7
5.0	2		19.6	8
10.0	3		19.8	9
15.0	4		20.0	10
17.0	5			



(1) Describe the effect of light intensity on the rate of photosynthesis

(2) Give an explanation for the shape of the curve. Your answer should involve the term *photoinhibition*. Label the *light saturation point* on the graph and explain the significance of this point.

(3) Sketch and explain the expected shape of the graph if the concentration of CO_2 was increased, compared to the curve you drew above (you should have two curves on the same graph - one for lower and one for higher CO_2 concentration).

(4) Suggest why the net rate of CO_2 uptake has a negative value at zero irradiance

III. Temperature and Rate of Photosynthesis

Below is data showing the rate of photosynthesis as a function of temperature. Graph the data and answer the analysis questions.

Rate of CO_2 uptake [mmol/(m ² s)]	Temperature (°C)		Rate of CO_2 uptake [mmol/(m ² s)]	Temperature (°C)
11.0	10		19.0	35
15.0	15		12.0	40
18.0	20		7.0	45
18.5	25		0.0	50
20.2	30			



(1) Describe the dependence of the rate of photosynthesis on temperature. Is there an *optimum temperature* that maximizes the photosynthesis rate? If so, what is that temperature?

(2) Give an explanation for the shape of the curve. How can you explain the existence of an optimum temperature for photosynthesis?

(Hint: Are enzymes involved in photosynthesis? If so, can you use this information to explain why the rate of photosynthesis may depend on temperature in this way? Think back to the Netlogo Enzyme activity.)

IV. Photorespiration

Read through the beginning of section 4.6 in your textbook and sketch the graph shown in figure 4.18 showing the rate of photosynthesis as a function of O_2 concentration. Explain this graph and summarize in your own words what photorespiration is and how it competes with photosynthesis. What determines whether photosynthesis or photorespiration will win?