# Photosynthesis Investigation Study Guide

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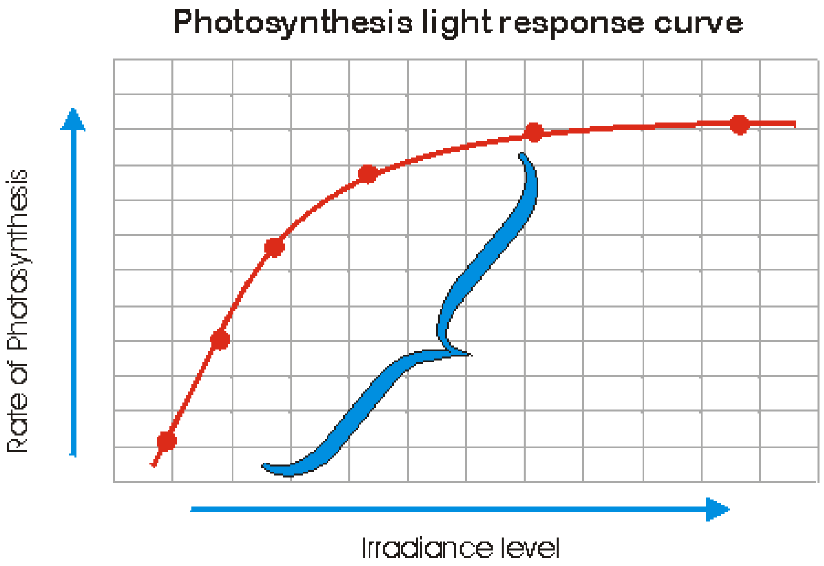
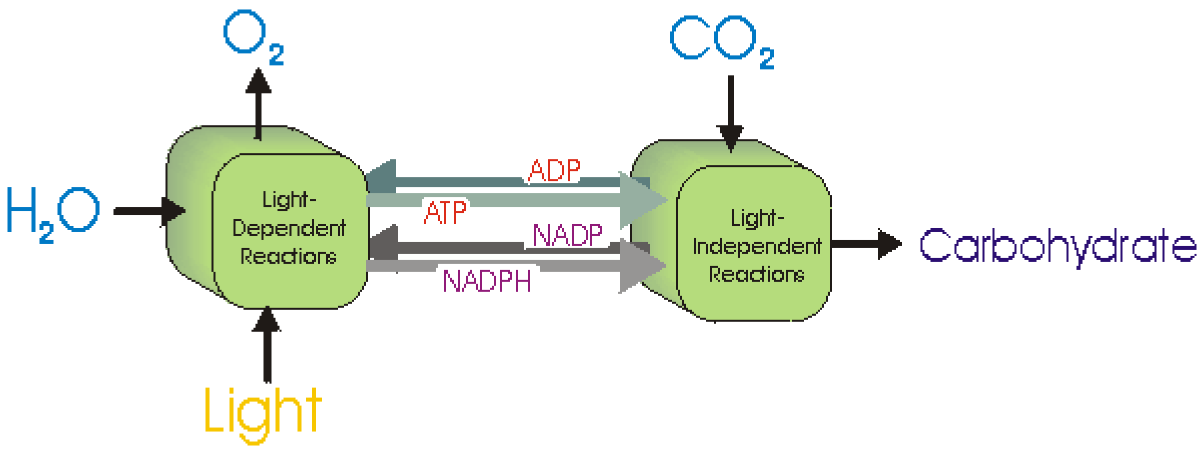
*This resource is made from selected pages from:*
*[http://www.marietta.edu/~spilatrs/biol103/photolab/part1rev.html](http://www.marietta.edu/~spilatrs/biol103/photolab/part1rev.html)*

**What process limits the rate of photosynthesis at low light levels?**




Remember, in C3 and C4 plants, the light-dependent and the light-independent reactions operate in unison, as shown in the following diagram. The rate of the 'slower' reaction will determine ('limit') the overall rate of photosynthesis.




**What factors determine the rates of metabolic processes, such as the light-dependent and light-independent reactions?**

One factor is the maximum potential speed of **physical processes** (such as enzyme activity and electron transport) and the **concentrations of the reactants** (e.g., light, water, $O_2$, $CO_2$, ATP, ADP, NADP and NADPH) and **temperature**. Generally, physical processes only operate at their maximum potential rate when there is a large excess of the reactants. Under normal conditions, a shortage of one reactant or another usually creates the proverbial 'bottleneck' that slows the overall process. <u>Under low light levels, the available light is insufficient to support the maximal potential rate of the light-dependent reactions, and thus limits the overall rate of photosynthesis.</u>

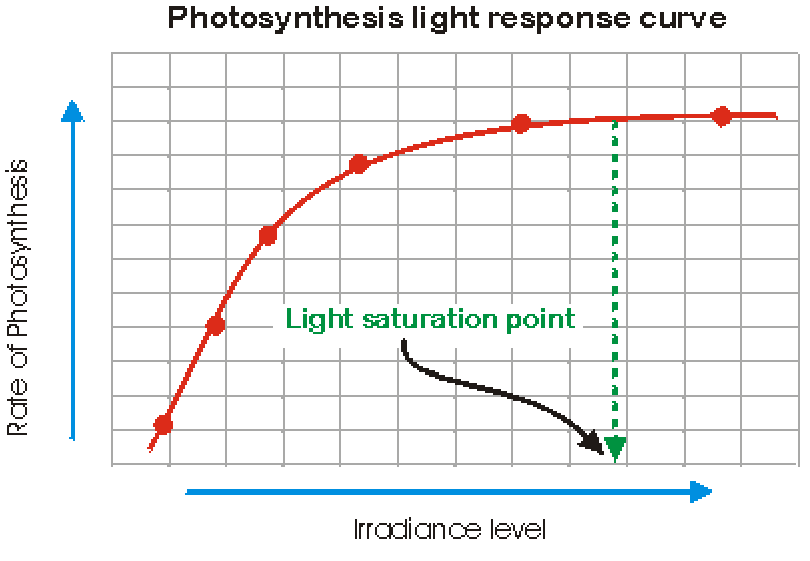
Reactants: Chemicals you start with before a chemical reaction
Products: Chemicals you are left with after the reaction finishes

As light levels are increased, more ATP and NADPH are produced, and the overall rate of photosynthesis increases. This pattern will continue until some other reactant becomes limiting. This is what happens when the light response curve begins to level off at the "light saturation point."

*Is water ever limiting for the light-dependent reactions?* Probably not. In the aqueous environment inside a cell, availability of water is essentially limitless.

## What happens at the light saturation point?

As light intensity is increased, eventually an intensity is reached above which light no longer is the factor limiting the overall rate of photosynthesis. We say that a process is 'saturated' for a particular reactant when adding more of it does not increase the rate, just as a sponge becomes saturated with water when it can't hold any more. At the light saturation point, increasing the light no longer causes an increase in photosynthesis.

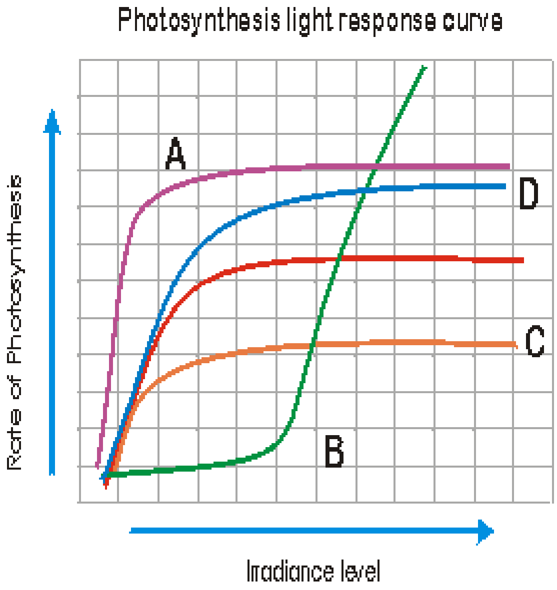



Above the light saturation point, the light-dependent reactions are producing more ATP and NADPH than can be used by the light-independent reactions for $CO_2$ fixation.

*What limits the rate of photosynthesis above the light saturation point?* Under normal conditions, availability of $CO_2$ is the limiting factor. The concentration of $CO_2$ in the atmosphere is relatively low. At approximately 0.035%, the amount of $CO_2$ in the atmosphere is much less than that of $O_2$ or $N_2$, which are approximately 20% and 70%, respectively.

Burning of fossil fuels and forest destruction has caused $CO_2$ in the atmosphere to increase approximately 25% (from 0.029% to 0.035%) in the last one hundred years. Many scientists fear that elevated atmospheric $CO_2$, a major contributor to global warming, will lead to dramatic changes in global climate patterns. Some plant physiologists have pointed out that elevated temperature and $CO_2$ levels will increase photosynthesis rates and possibly increase crop yields.

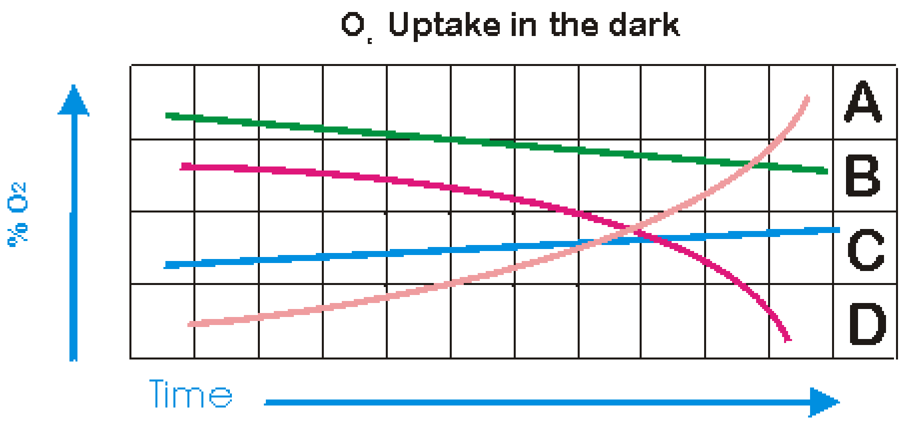
**How would we expect elevated $CO_2$ concentrations to affect the light saturation curve of a plant? In the diagram below the red line is the original response curve.**




'D' is the correct answer since it shows an increase in the light saturation point and maximal rate of photosynthesis. With more $CO_2$ available, photosynthesis can take advantage of higher light levels. The light compensation point and maximal rate of photosynthesis are higher.

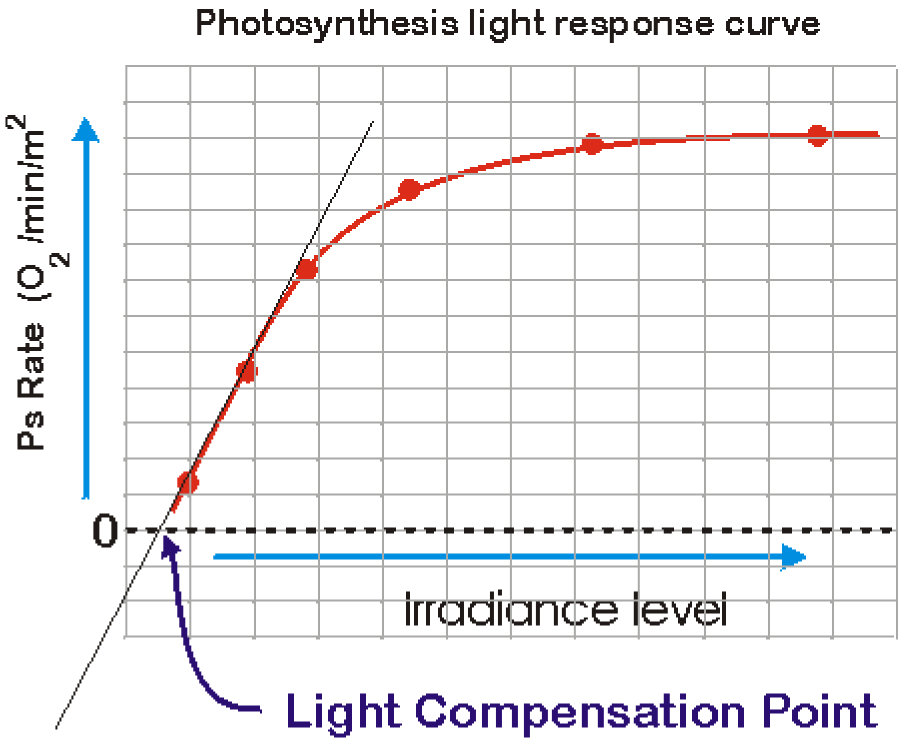
Some people might mistakenly select 'A'; however, a careful analysis shows this to be incorrect. Higher $CO_2$ levels will only affect the rate of photosynthesis at the highest light levels. Curve 'A' shows photosynthesis rate is also increased at low light levels. This would not be expected, since at low light levels the overall rate of photosynthesis will be determined, as before, by the availability of light.

## How would an oxygen uptake curve appear for a leaf held in complete darkness?



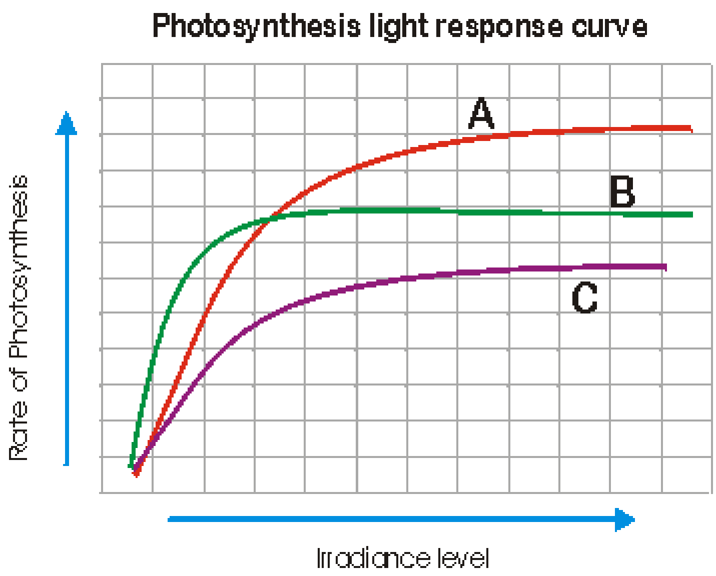

We would expect a gradual decline in the amount of $O_2$ in the leaf chamber over time (Line B), the result of $O_2$ uptake by cellular respiration. While line D is not necessarily incorrect, we have no reason to expect the rate of $O_2$ uptake to increase over time.

**Why doesn't the light response curve pass through the origin?**




Processes occur in leaves that cause an uptake of $O_2$ from the air. One of these processes is cellular respiration. *(What other process related to photosynthesis also utilizes $O_2$?)* Under 'normal' light conditions, the rate of photosynthesis greatly exceeds that of $O_2$ uptake processes, and we see a net release of $O_2$. However, under very low light conditions, the amount of $O_2$ being taken up exceeds that produced by photosynthesis, and we see no net $O_2$ evolution-- even a slight net uptake.

**Which of these curves corresponds with the highest photosynthetic efficiency?**




Leaf B has the highest efficiency because the slope of the response curve at low light levels is greater than for the other two leaves. Note that when describing the photosynthetic efficiency, we are only concerned with the slope of the line, not the maximal rate of photosynthesis. Thus, although leaf A has a lower efficiency, it can sustain higher maximum rates of photosynthesis than leaf B.