

This is the **Higher Combined** version — includes Higher Tier content. Some Separate-only details are omitted.

The rate of photosynthesis is controlled by limiting factors. The factor in shortest supply at any given time limits the rate, regardless of how much of the other factors are present.

**Required Practical: Investigating effect of light intensity on photosynthesis using pondweed. Use different distances from lamp. Add  $\text{NaHCO}_3$  to ensure  $\text{CO}_2$  is not limiting. Control temperature with a water bath.**

- Three main limiting factors: light intensity,  $\text{CO}_2$  concentration, temperature.
- Light intensity: more light  $\rightarrow$  more energy available  $\rightarrow$  faster rate. Above a point, another factor becomes limiting.
- $\text{CO}_2$  concentration:  $\text{CO}_2$  is a reactant. More  $\text{CO}_2$   $\rightarrow$  faster rate up to a limit.
- Temperature: higher temp  $\rightarrow$  enzymes more active  $\rightarrow$  faster reactions. But above  $\sim 45^\circ\text{C}$ , photosynthesis enzymes DENATURE  $\rightarrow$  rate drops sharply.
- ★ **HT Inverse square law:**  $\text{light intensity} \propto 1/\text{distance}^2$ . Double the distance  $\rightarrow$  quarter the light intensity.
- Greenhouse growers control all three factors: artificial lighting,  $\text{CO}_2$  generators, heating — to maximise year-round yield.

### Key Terms

<b>Limiting factor</b>	The factor in shortest supply that controls the rate of a reaction — increasing other factors has no effect
<b>Light intensity</b>	Amount of light per unit area — proportional to $1/\text{distance}^2$ from a light source

■ **Exam Tip:** In a graph where rate plateaus: the plateau means ANOTHER factor is now limiting, not the one being changed. You must identify what that other factor is. Common mistake: saying "maximum rate reached" without specifying the new limiting factor.