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## **A Comparative Study of Gas Exchange in the Giant Cockroach (*Blaberus gigantean*) and the Faba Bean (*Vicia faba*) in Light and Dark Environments**

### **Introduction**

Gas exchange is a process that occurs in all living organisms however, the mechanism for its regulation varies greatly between organisms. The Faba bean, which is representative of plants, utilizes microscopic pores on the surface of the leaves called stomata in the exchange of CO<sub>2</sub> and O<sub>2</sub> (see figure 1). Guard cells flank each stoma and control the size of the stomata opening (Campbell 1996). A variety of factors influence the guard cells and the subsequent size of stomata opening including, CO<sub>2</sub> and O<sub>2</sub> concentrations, environmental stress, or light (Raven 1986).

Giant cockroaches in contrast have 10 pairs of spiracles that are used for respiration. Cockroaches use the spiracles for “efficient modulation of gas flux rates both into and out of the tracheal system (Lighton 1996).” Respiration occurs through a discontinuous gas-exchange cycle so that oxygen intake and CO<sub>2</sub> release are not constant but rather come in bursts.

### **Hypotheses**

As it has been previously established that stomata in plants open in response to light cues, this also suggests a possible connection between light and respiration rates within plants. An increase in energy available to the plant from the photons of light would also suggest an increase in respiration as the plant converts the available light energy into ATP, a useable form of energy

for the plant. It is therefore predicted that respiration in plants will increase in the presence of light.

Due to a general trend in all organisms, the expectation is to also see an increase in the respiration of the cockroach due to light exposure.

## **Methods**

DCMU, a photosynthetic inhibitor, was applied to the leaves of the plant prior to measuring the respiration rate of the plant. This was done in order to measure only the rate of respiration, independent of photosynthesis.

In the dark, the stomata of most plants are closed. Therefore, in order to measure the rate of respiration occurring in the dark, fusicoccin was used to maintain open stomata.

## **Results**

Plant respiration was found to remain relatively constant despite manipulation of the exposure of the plant to light (see attached graphs). The CO<sub>2</sub> concentration respired by the plant in the absence of light fluctuated throughout the course of the trial between 357.7 ppm and 353.1 ppm, a difference of only 4.6 ppm. In the presence of light, the plant maintained a similarly constant CO<sub>2</sub> concentration merely fluctuating 4.1 ppm, between 351.6 ppm and 347.5 ppm. A similar result was found when a single plant was exposed to both light and dark conditions within the scope of a single trial. The graph shows the CO<sub>2</sub> concentration to hover throughout the trial around the 350-ppm mark with the finding of maximum and minimum concentrations of 359.4 ppm and 349.5 ppm respectively. Throughout all the trials, the %O<sub>2</sub> showed no fluctuation but remained at a constant level.

As expected, in trials run with the cockroach a discontinuous gas-exchange cycle was found to occur. An increased respiration level under one condition versus the other however, was not found to occur. In the absence of light, the minimum CO<sub>2</sub> concentration was 349.9 ppm while the maximum was 621.5 ppm. When exposed to light the minimum CO<sub>2</sub> concentration was 373.5 ppm and the maximum recorded was 520.4 ppm. Once again the %O<sub>2</sub> was sustained at a constant level.

### **Interpretation**

In this study, evidence was produced which supports the idea that respiration in both plants and cockroaches occurs in both light and dark environments. However, the difference in light intensity between these two conditions has no observable effect on respiration rate as noted by CO<sub>2</sub> concentrations.

In the plants, while it was necessary to inhibit photosynthesis to insure that only changes in respiration were measured, it is possible that this also had an effect on the respiration rate. CO<sub>2</sub> is one of the products of respiration and it might be that the inhibition of photosynthesis, preventing the use of CO<sub>2</sub> and resulting in the presence of high CO<sub>2</sub> concentrations, led to a suppression of respiration that can be attributed to Le Chatlier's principle.

As with the plant, the respiration rate of the cockroach seemed unaffected by light intensity. The slightly higher minimum and lower maximum CO<sub>2</sub> concentrations in graph 5 compared with the values of graph 4 are thought to be due to the discontinuous gas-exchange cycle. The time frame of the trial happened to occur during an exchange cycle which extended beyond the scope of measurements recorded, contributing to the difference in CO<sub>2</sub> concentrations noted.

The slightly different trend in the respiration of the cockroach exposed to light might also be due to an increased level of activity in the cockroach that was observed. When the cockroach was exposed to light, it attempted to find dark cover. While an attempt was made to inhibit the movement of the cockroach as much as possible, increased activity was not eliminated.

## Works Cited

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- Lighton J. 1996. Discontinuous Gas Exchange in Insects. *Annual Review of Entomology* 41: 309-324
- Raven P, Evert R, Eichhorn S. 1986. *Biology of Plants*. New York, NY: Worth Publishers, Inc. 775 p.

**Figure 1:** SEM images of a) open and closed plant stomata, b) cockroach spiracle.