Investigating the factors affecting the breathing rate of a locust

The purpose of this activity is:

* to practice handling a living organism while observing its behaviour
* to observe the effect of changing oxygen and carbon dioxide concentration on the ventilation movements (breathing) of a locust
* to test and decide between these two hypotheses:

1: An animal breathes faster as the concentration of oxygen in its environment decreases

2: An animal breathes faster as the concentration of carbon dioxide in its environment increases.

### Procedure

SAFETY:

Take care using the chemicals used to generate gases for this practical or when using gas from cylinders

### Investigation

1. Place a living locust in a 20 cm3 clear plastic syringe as shown in the diagram. Insert the piston and push it in gently so that the locust has no room to move. Do not squash the animal.



1. Count the number of pumping movements of the abdomen which occur in thirty seconds. Record the results of three such counts.
2. Attach a piece of plastic tubing to the syringe nozzle. Remove the piston and replace it with a loose plug of cotton wool. Exhale gently through the tube for 10 to 15 seconds (so that your exhaled air goes into the syringe barrel, but you inhale from your surroundings). Remove the cotton wool and replace the piston.
3. Count the locust’s breathing rate for three successive periods of 30 seconds.
4. Move the piston to and fro about ten times to replace the exhaled air with laboratory air. Allow the locust time to acclimatize to atmospheric air. (If its breathing rate returns to the original rate it has acclimatized.)
5. Remove the piston and put back the cotton wool plug. Pass pure oxygen gently into the syringe barrel for 10 to 15 seconds. Then replace the piston and push it as close to the locust as possible without crushing it at all. Record the breathing movements of the animal for three periods of thirty seconds.
6. Prepare a 20 cm3 syringe with a short extension tube on its nozzle and fill with carbon dioxide.
7. Link the syringe containing carbon dioxide to the nozzle of the locust’s syringe and transfer 1 cm3 of carbon dioxide into the locust’s atmosphere. (Move the pistons of both syringes to prevent a change in pressure.)
8. Record breathing movements for three further periods of thirty seconds.
9. Add another 1 cm3 of carbon dioxide to the locust’s atmosphere and record the breathing rate.
10. Repeat step **j** once more if possible.
11. Return the locust to its cage.
12. Tabulate your records to show mean breathing rates for each part of the investigation.
13. Calculate as accurately as possible the volume of the atmosphere surrounding the locust. (Assume that the locust has a volume of 4 cm3.)
14. Assume that the atmosphere started as 100% oxygen and you added pure carbon dioxide each time. Calculate the percentage of both oxygen and carbon dioxide in the locust’s atmosphere during each recording period in steps **h** to **j**.

### QUESTIONS

1. Were the locust’s ventilation movements affected by the changing conditions during the procedure?
2. When you breathed into the syringe barrel, which conditions in the atmosphere around the locust would have changed?
3. How could you modify this stage of the procedure to reduce the number of variable factors associated with exhaled air?
4. From your results, which factor seems to control ventilation rate?
5. Which of the two hypotheses do your results support?
6. What improvements, if any, would you like to make to this procedure if you were to repeat the investigation?

### ANSWERS

1. If the students have observed no change to the locust’s ventilation movements, there are no data to discuss. If it was too hard to keep the locust still, or if they couldn’t see any activity – this is the time to record it.
2. When you breathed into the syringe barrel, the conditions of gas composition, temperature and humidity in the atmosphere would have changed.
3. To reduce the number of variable factors associated with exhaled air you could collect and dry exhaled air (using a desiccant such as silica gel) and allow it to equilibrate to room temperature. Then add it to the syringe in the same way as the carbon dioxide and oxygen. Or you could breathe through a longer tube with some desiccant in it, and some temperature equilibrating device around it.
4. From our results, each time, two factors change – the amount of carbon dioxide and the amount of oxygen. It seems that the ventilation rate varies from around 7 movements per 30 seconds to around 50 (a factor of about 7). The factor that seems most significant is carbon dioxide concentration.
5. The sample results support the hypothesis that “An animal breathes faster as the concentration of carbon dioxide in its environment increases” – at least over a range of increasing carbon dioxide.
6. The ideal would be to have a system in which you could change only oxygen or carbon dioxide concentration, rather than both at once. Perhaps with a more sophisticated gas production system, and using a gas that is known to be inert (nitrogen, or helium?) you could set up changing concentration of oxygen at a mid-range concentration of carbon dioxide and vice versa. So you might have mixtures as in the table below. Then you could compare the effect of changing carbon dioxide at a fixed concentration of oxygen and vice versa.

|  |  |  |
| --- | --- | --- |
| Volume of inert gas per 100 cm3 | Volume of carbon dioxide per 100 cm3 / percentage carbon dioxide | Volume of oxygen per 100 cm3 / percentage oxygen |
| 95 | 0 | 5 |
| 90 | 0 | 10 |
| 85 | 0 | 15 |
| 80 | 0 | 20 |
| 93 | 2 | 5 |
| 88 | 2 | 10 |
| 83 | 2 | 15 |
| 78 | 2 | 20 |
| 91 | 4 | 5 |
| 86 | 4 | 10 |
| 81 | 4 | 15 |
| 76 | 4 | 20 |