

How insects breathe

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Larvae of Culex Mosquitoes forming dense groups in standing water. Photo by: James Gathany/CDC. Photo by: James Gathany/CDC.

Insects require oxygen to live and produce carbon dioxide as a waste product, just as humans do. That is where the commonality between the insect and human respiratory systems essentially ends.

Insects do not have lungs, nor do they transport oxygen through their circulatory systems. Instead, the insect respiratory system relies on a simple gas exchange system to bathe the insect's body in oxygen and to expel carbon dioxide waste.

Insect Respiratory System

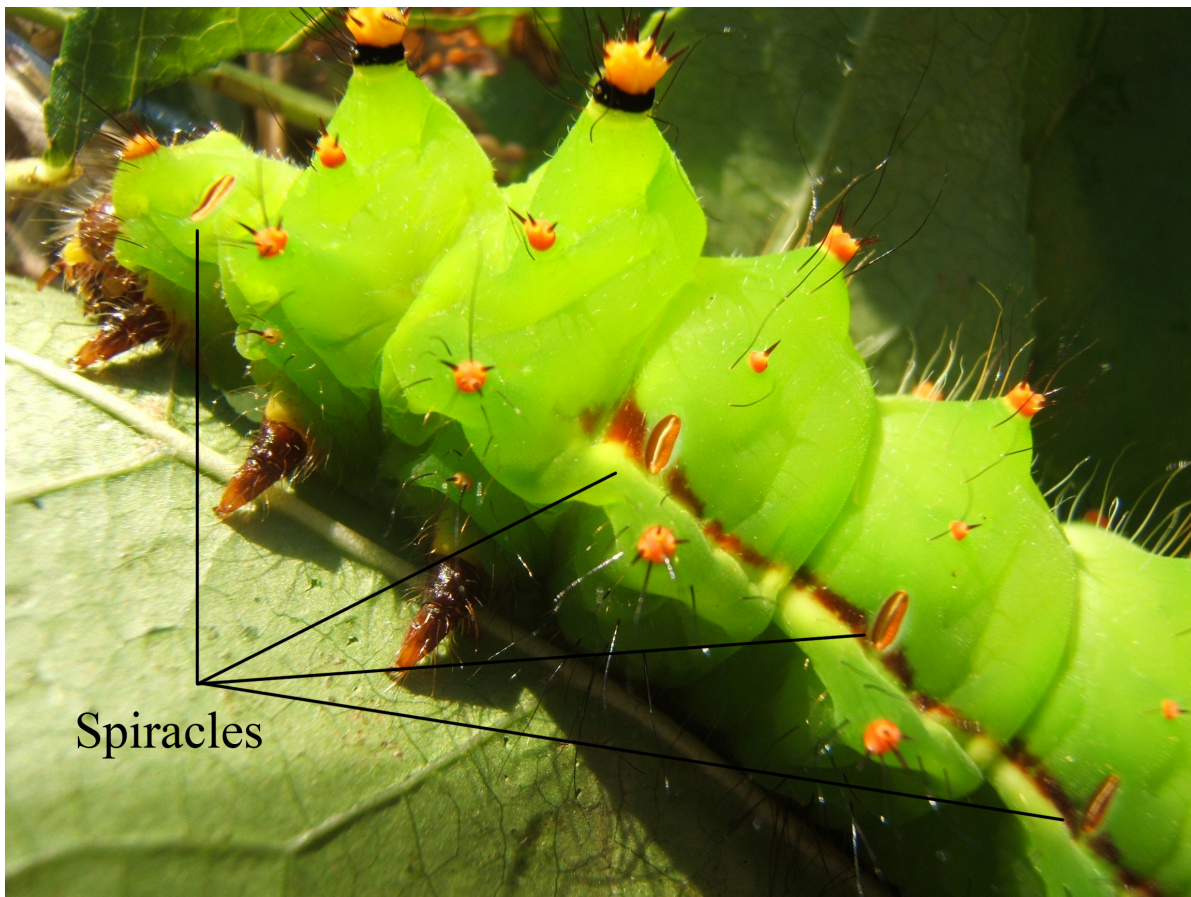
Air enters the respiratory systems of insects through a series of external openings called spiracles. These external openings, which act as muscular valves in some insects, lead to the internal respiratory system, a densely networked array of tubes called tracheae.

To simplify the insect respiratory system, it acts like a sponge. The sponge has small holes that let water into it, moistening the sponge. Similarly, the spiracle openings allow air into the interior tracheal system, bathing the insect's tissues with oxygen. Carbon dioxide, a metabolic waste, exits the body through the spiracles.

The spiracles can be opened and closed in an efficient manner to reduce water loss. This is done by contracting muscles surrounding the spiracle. In order to open, the muscle relaxes.

How Can Insects Control Respiration?

Insects can control respiration to some degree. An insect can open and close its spiracles using muscle contractions.



For example, an insect living in a dry, desert environment can keep its spiracle valves closed to prevent moisture loss.

Also, insects can pump muscles in their bodies to force air down the tracheal tubes, thus speeding up the delivery of oxygen. In cases of heat or stress, insects can even vent air by alternately opening different spiracles and using muscles to expand or contract their bodies.

Still, the rate of gas diffusion, or flooding the inner cavity with air, cannot be controlled. As long as insects breathe using the spiracle and tracheal system, they are not likely to get much larger than they are now.

How Do Aquatic Insects Breathe?

While oxygen is plentiful in air (200,000 parts per million in the air), it is considerably less accessible in water (15 parts per million in cool, flowing water). Despite this respiratory challenge, many insects live in water during some stages of their life cycles.

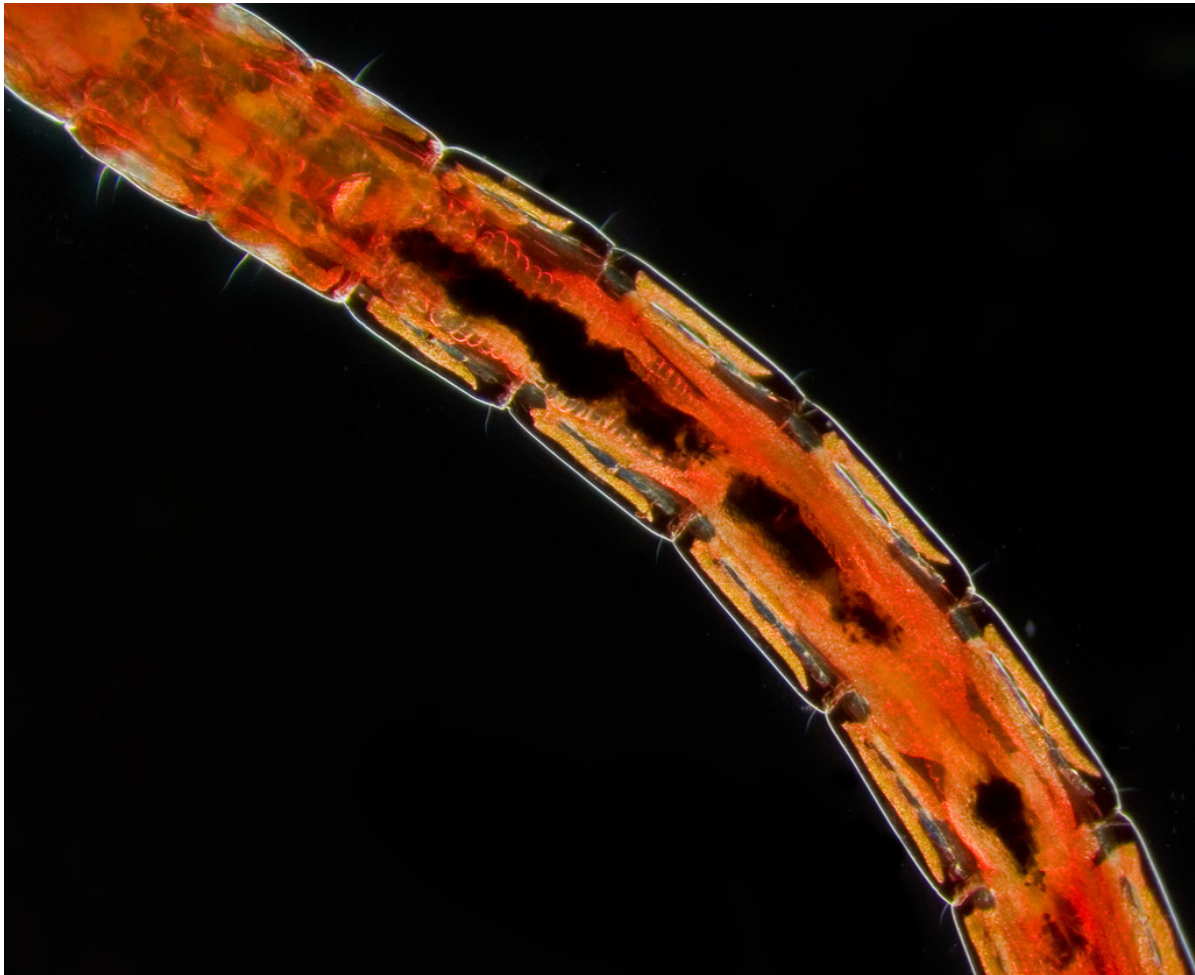
How do aquatic insects get the oxygen they require while submerged? To increase their oxygen uptake in water, all but the smallest aquatic insects employ innovative structures that can get oxygen in and carbon dioxide out — such as using gill systems and structures similar to human snorkels and scuba gear.

Insect Aquatic Gills

Many water-dwelling insects have tracheal gills, which are layered extensions of their bodies that enable them to take more oxygen from the water. These gills are most often located on the abdomen, but in some insects, they are found in odd and unexpected places. Some stoneflies, for example, have anal gills that look like a cluster of filaments extending from their hind ends.

Dragonfly nymphs have gills inside their rectums.

Hemoglobin Can Trap Oxygen



Hemoglobin can facilitate the capture of oxygen molecules from the water. Non-biting midge larvae from the Chironomidae family and a few other insect groups possess hemoglobin, much like vertebrates do. Chironomid larvae are often called bloodworms because the hemoglobin gives them a bright red color. Bloodworms can thrive in water with exceptionally low oxygen levels. They undulate their bodies in the muddy bottoms of lakes and ponds to saturate the hemoglobin with oxygen. When they stop moving, the hemoglobin releases oxygen, enabling

them to breathe in even the most polluted aquatic environments. This backup oxygen supply may only last a few minutes, but it is usually long enough for the insect to move into more oxygenated water.

Snorkel System

Some aquatic insects, like rat-tailed maggots, maintain a connection with air on the surface through a snorkel-like structure. A few insects have modified spiracles that can pierce the submerged portions of aquatic plants, and take oxygen from air channels within their roots or stems.

Scuba Diving

Certain aquatic beetles and true bugs can dive by carrying a temporary bubble of air with them, much like a scuba diver carries an air tank. Others, like riffle beetles, maintain a permanent film of air around the bodies. These aquatic insects are protected by a meshlike network of hairs that repels water, providing them with a constant airspace from which to draw oxygen. This airspace structure, called a plastron, enables them to remain permanently submerged.

Quiz

- 1 The following sentences from the article support the conclusion that insects' respiratory processes are adapted to their environments.

1. *For example, an insect living in a dry, desert environment can keep its spiracle valves closed to prevent moisture loss.*
2. *Many water-dwelling insects have tracheal gills, which are layered extensions of their bodies that enable them to take more oxygen from the water.*
3. *When they stop moving, the hemoglobin releases oxygen, enabling them to breathe in even the most polluted aquatic environments.*

Which additional detail from the article creates the MOST COMPLETE understanding that insects' respiratory processes are adapted to their environments?

- (A) These external openings, which act as muscular valves in some insects, lead to the internal respiratory system, a densely networked array of tubes called tracheae.
- (B) The spiracles can be opened and closed in an efficient manner to reduce water loss. This is done by contracting muscles surrounding the spiracle.
- (C) They undulate their bodies in the muddy bottoms of lakes and ponds to saturate the hemoglobin with oxygen.
- (D) A few insects have modified spiracles that can pierce the submerged portions of aquatic plants, and take oxygen from air channels within their roots or stems.

- 2 Read the paragraph from the section "How Can Insects Control Respiration?"

Still, the rate of gas diffusion, or flooding the inner cavity with air, cannot be controlled. As long as insects breathe using the spiracle and tracheal system, they are not likely to get much larger than they are now.

What conclusion can be drawn from this paragraph?

- (A) Insects that are larger have a harder time maintaining oxygen levels than the tiniest insects.
- (B) Insects would need to evolve a more sophisticated respiratory system to increase in size.
- (C) Insects developed their current respiratory system as a result of their comparatively small size.
- (D) Insects will eventually develop a respiratory system more similar to humans and other animals.

- 3 Read the first two paragraphs in the article.

Why does the author choose to begin the article with these paragraphs?

- (A) to highlight the sophistication of the insect respiratory system through a comparison
- (B) to emphasize the uniqueness of the insect respiratory system through a contrast
- (C) to praise insect respiration as a rare solution to the problem of carbon dioxide waste
- (D) to illustrate insect respiration as a process requiring many distinct steps

- 4 Which of the following provides the BEST analysis of the article's conclusion?

- (A) The conclusion describes a strategy used by certain insects to draw oxygen, but does not summarize or provide conclusions related to the article as a whole.
- (B) The conclusion develops the comparison between certain insects respiratory strategies and those of humans, but does not explain the effects of the strategy.
- (C) The conclusion illustrates the causes of a certain respiratory process in insects, and summarizes how they can be contrasted with other insect species.
- (D) The conclusion indicates that insect species can affect their surroundings with their respiratory processes, and explains how these insects relate to the article as a whole.