

- 5 Read the passage below and answer the questions that follow, which relate to this passage.

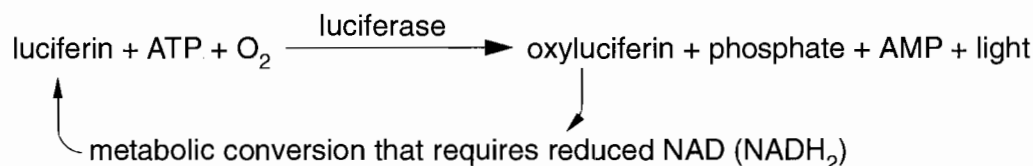
### How fireflies light up

Fireflies are insects which have organs producing flashes of light. Fireflies are active at night and the light flashes are an important part of their sexual behaviour.

Within their light-producing organs are tubes, filled with air, called tracheae. These tracheae supply oxygen to light-producing cells. Fig. 5.1 on an insert shows the arrangement of light-producing cells around a trachea.

Light is produced by organelles situated well away from the surfaces of the cells nearest the trachea.

The reaction that produces light requires **both** oxygen **and** ATP.



When the organ is not producing any light, the numerous mitochondria use oxygen very fast. These mitochondria lie between the tracheae and the light-producing organelles, just under the cell membrane, so that no oxygen is available for the oxidation of luciferin.

A flash of light is produced when nerve impulses stimulate the walls of the tracheae and the cytoplasm of the light-producing cells, to produce nitrous oxide. Nitrous oxide diffuses rapidly through the cells. It enters mitochondria and inhibits oxidative phosphorylation, so the oxygen concentration increases in the cytoplasm of the light-producing cells.

Nitrous oxide is very unstable and breaks down quickly, so its effects are temporary.

An extract of crushed fireflies was found to be an extremely sensitive test for the presence of ATP in foods, such as milk and meat. The more bacteria there are in the food, the more light is produced, provided the mixture of food and firefly extract is well oxygenated.

Fortunately for fireflies, luciferin can be synthesised artificially and luciferase has been produced by gene technology, using methods similar to those for producing human insulin.

- (a) Different species of firefly often live in the same habitat. The frequency with which a firefly flashes its light organ on and off, is a characteristic of a species.

Suggest an advantage, for fireflies, of flashing at a characteristic frequency.

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 ..... [1]

- (b) (i) State the process by which oxygen reaches the light-producing organelles.

..... [1]

- (ii) Explain why the light-producing organelles are located well away from the plasma (cell surface) membrane.

..... [1]

- (c) Suggest why it is important for the effects of nitrous oxide to be temporary.

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 ..... [2]

- (d) Light-producing cells in fireflies do not divide. State **three** ways in which these cells might use ATP **other** than in the production of light.

1 .....  
 2 .....  
 3 ..... [3]

- (e) If a firefly is suddenly crushed, for example by hitting a car windscreen, it produces a prolonged and unusually bright flash of light after which all light production ceases.

Suggest an explanation for these observations.

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 ..... [3]

- (f) A solution containing luciferin, luciferase and oxygen glows when painted onto the surface of meat contaminated by live bacteria, but not if the meat is contaminated by dead bacteria.

Explain this observation.

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..... [1]

- (g) What substance would be extracted and purified from light-producing cells of fireflies in order to produce luciferase by gene technology?

..... [1]

[Total: 13]

**END OF QUESTION PAPER**