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BREATHING IN FISHES

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Breathing or respiration is the process by which oxygen is supplied to, and carbon dioxide removed from, the blood and, eventually, the various cells of the body.

Fundamentally, this process is the same in fishes and in man, or any animal, but, in most fishes as in many other aquatic forms, special provision has been made for breathing under water. Because of this, it is not necessary for the typical fish to come to the surface for air, as it is necessary for whales and porpoises, water turtles and some aquatic insects. Indeed, for most fishes it is useless, or nearly so, to come to the surface for air. If they cannot obtain the necessary oxygen from the water, they die.

The most important provision by means of which the fish breathe under water is, of course, that of gills. Gills are of various sorts, but those of fish, and of other vertebrates such as salamanders and tadpoles, are of the general type known as blood gills. In such structures the blood flows in fine streams which are separated from the water only by thin and highly permeable membranes, through which carbon dioxide is given up by the blood and oxygen taken in. It is their blood, of course, that makes gills normally red. Pale gills, therefore, indicate an anemic condition.

Although the gills of fish differ greatly in points of structure and arrangement, in all cases they can function effectively only if bathed by a current of water containing sufficient dissolved oxygen. In most fishes the current is produced by water being drawn into the mouth with the gill covers closed, and then forced out through the gills under the opened gill covers, in an intermittent manner comparable to the inhalation and exhalation of air by mammals, for example. This process is facilitated in some fishes (e.g., the cod and the wrasse) by the presence of special skin folds in the mouth, known as breathing valves. Thus the wrasse, which

possesses breathing valves breathes about 15 times a minute; the little stickleback, which does not possess them, almost 10 times as frequently.

In addition to gills, oxygen is obtained from the water by some fish by means of highly vascular fins (young of Embiotocids) and parts of the alimentary canal (loaches and others).

Besides this "water breathing" or utilization of oxygen dissolved in water, some fish come to the surface to gulp air, and thus obtain a greater or lesser portion of the needed oxygen.

In the simplest cases (some Clupeids and others), the air is confined above ordinary gills. Further developments are found in the more or less lung-like air sacs (Saccobranchus, Amphipnous). The highest development for air breathing in fishes is found in the Dipnoi or lungfish of South America, Africa, and Australia. The Dipnoi, besides gills, possess a lung or lungs (1 or 2 per fish) very much like the lungs of the higher vertebrates. The South American and African forms are able to live for months in mud at the bottom of lakes which have become waterless in the long dry season.

As noted, in order for fish, except for air breathers, to obtain sufficient oxygen, there must be sufficient oxygen dissolved in the water in which they live. Exact limits cannot be set, because an active fish adapted to life in cool, well-aerated water (e.g., the trout) requires more oxygen than a sluggish fish which normally dwells in muddy and more or less stagnant water. Moreover, as the temperature of the water rises, the oxygen requirements, of a given type of fish, increases.

Low oxygen may be brought about in various ways. Increased temperature reduces the capacity of water to hold oxygen. Fish, other aquatic animals, plants (in the absence of sunlight) and organic decay utilize dissolved oxygen and may dangerously reduce or even eliminate it. Besides such natural means, there is the great offender, pollution. This may be domestic sewage or industrial wastes of very many sorts. The great danger from industrial waste may, of course, be due to some poisonous property rather than to a high oxygen demand, but this latter property, of using up oxygen, is a harmful characteristic of many industrial discharges.

The dissolved oxygen of water is obtained by absorption at the surface, by mechanical mixing of air and water (as by waterfalls and waves or by artificial aerators) and by the action of plants in the presence of sunlight.

Except for such amounts as may be brought in by streams or retained from the days before the cover was formed, (amounts which may, of course, be ample, especially in deep, well-aerated lakes) the oxygen of lakes or ponds completely covered by ice is attributable to the action of sunlight on plants, either planktonic forms such as diatoms or higher plants. Light penetration through thick ice is poor, especially if the ice is rough, contains many bubbles or is covered with a thick layer of snow. Therefore, especially if the organic content of the water is high or if many fish are present, it is not surprising that the oxygen content of such lakes becomes low and fish loss high in winter. Rather, it is remarkable that so often there is sufficient oxygen to keep fish, and other aquatic forms, in health.