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Standard and Active Metabolism

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Animals need chemical energy to carry out their various functions, and their overall use of chemical energy is often referred to as their *energy metabolism*

Animals obtain energy mostly through the oxidation of foodstuffs, and their consumption of oxygen can therefore be used as measure of their energy metabolism. Some animals can live in the absence of free oxygen

Such animals meet their energy needs through *anaerobic metabolism*



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The energy-requiring processes and reactions in the living organism use a common source of energy, *adenosine triphosphate (ATP)*

ATP is formed at the various energy-yielding steps in the oxidation of foodstuffs



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Metabolic Rate

Metabolic rate refers to the energy metabolism per unit time.

The measure that can be used to determine the metabolic rate is the amount of oxygen used in oxidation processes

The reason oxygen can be used as a practical measure of metabolic rate is that the amount of heat produced for each liter of oxygen used in metabolism remains nearly constant



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The amount of oxygen needed to oxidize 1 g fat is more than twice the amount needed for oxidation of carbohydrate or protein

ratio between the carbon dioxide formed in metabolism and the oxygen used

This ratio, known as the *respiratory quotient (RQ)*

The RQ gives information about the fuel used in metabolism



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Effect of oxygen concentration on metabolic rate

At relatively high oxygen tension the oxygen uptake of goldfish is independent of the available oxygen, lower oxygen tensions there is a linear relationship

- **Acclimation to low oxygen levels**
- Many fast-swimming, active fish are quite sensitive to low oxygen in the water
- If the fish has been kept in relatively oxygen-poor water, it becomes more tolerant to low levels of oxygen



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Anaerobic metabolism

Animals that tolerate prolonged exposure to zero oxygen must of necessity obtain their metabolic energy from nonoxidative reactions

This holds true for many intestinal parasites

Animals that can intermittently survive long periods of anoxic conditions are called facultative anaerobic organisms

One common process for obtaining energy under anaerobic conditions is the breakdown of carbohydrate into lactic acid



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ATP is the immediate source of energy for nearly every energy-requiring process in the living organism

Glycogen is a polymer of glucose, and the single glucose unit in the polymer is called a glycosyl unit

The anaerobic metabolism of fish has an interesting consequence that is related to the low carbon dioxide concentration in fish blood



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- The addition of large amounts of lactic acid would therefore severely disturb the normal acid-base balance of the poorly buffered blood
- A trout that was made to swim vigorously for 15 minutes showed a considerable increase in the lactic acid concentration in the blood
- Among the fish studied, warm-bodied species such as tuna had the greatest buffering capacities
- Deep-sea fishes and shallow-living fishes with sluggish swimming habits and low buffering capacities



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Goldfish tolerate anoxia very well and can survive for several days in the absence of oxygen, especially if the temperature is low

The amount of glycolysis, as indicated by a increase in lactic acid in muscle and blood, to support the metabolic rate is insufficient

The ethanol is easily removed from the body because it readily diffuses out through the gills



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Transformation of lactate to ethanol, which is readily lost to the water, apparently serves as a means of avoiding acidosis, although the fish pays for this privilege in the form of excessive loss of metabolic fuel

A human who has a blood alcohol level of 0.25% ethanol is intoxicated, and in many countries (but not all) the legal limit for automobile driving is one-fifth of this, or 0.05%



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- Most of the world's oceans contain, at intermediate depth, zoned where the oxygen content is very low
- There is a large such area in the northeastern tropical Pacific, which is known as the oxygen minimum layer
- During the day, when the fish are at depth, it seems likely that they must obtain energy by anaerobic pathways
- Their blood has a low oxygen capacity and their hemoglobin such a strikingly low affinity for oxygen that no more than 1% of the hemoglobin would be oxygenated while the fish are at depth (Douglas *et al.*, 1976)



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Energy Utilization

Energy metabolism difference from that of an animals and birds by two aspects

Fish don't expend energy to maintain the body temperature different from that of their environment