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Energy and Nutrient Status of Food

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Introduction

Energy necessary for the varied activities of life is generated in a series of chemical reactions referred to as cellular metabolism or respiration. Cellulose is broken down to $+O_2$ and CO_2 .

In respiration the chemical energy contained in carbohydrates, fats, and proteins is transformed into a more labile and directly useful form of energy.

The FAs and some of AAs join also form pyruvic acid and join the cycle other AAs join at other stages as shown in fig.



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- This energy in turn is used for animal activities such as remove muscular movement, biosynthesis, secretion, heat (and sometimes light and electricity) etc.
- For example the phosphorylation of glucose is an exchange reaction.
- The reactions involved in tissue respiration are chemical in nature and can be represented as
- $A+B \rightleftharpoons C+D$



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At equilibrium, in accordance with the law of mass action the product of the concentrations of the substances formed (C&D) divided by the product of the reactants (A&B) is a constant known as the equilibrium constant K .



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Nutrition and metabolism in fish

Nutrition is the process of nourishing the individual cells of the body N- to a layman -> just requirements of nutrients of flour supply.

Digestion is the break down of complex consumed food into simple assimilated forms.

The ingested food of any origin cannot be taken as such to cells for energy production – need by cells. In higher animals all cells cannot take up – directly from dig. syst.



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Digestive System

- The structural components of a fish's digestive system include the mouth, teeth and gill rakers, esophagus, stomach, pylorus, pyloric caeca, pancreatic tissue (**exocrine** and **endocrine**), liver, gall bladder, intestine and anus.
- In predatory (carnivorous) fishes, the mouth is usually large for engulfing prey whole, or in large chunks, and teeth are present on the jaws (e.g. maxillary and dentary) and tongue.



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In omnivorous and **planktivorous** fishes, the mouth is smaller and is usually devoid of teeth except for pharyngeal teeth that may be blunt and flat for grinding or sharp and long for shredding.

The esophagus, which is lubricated by mucus, leads to the stomach.

The pylorus is a sphincter that prevents premature movement of the food **bolus** out of the stomach.



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The role of pyloric caeca in digestion has been widely speculated upon.

- As in all vertebrates, the pancreas has two digestive functions.
- It is the source of: 1) exocrine secretion of digestive enzymes (**proteases**, **lipases**, and **carbohydrases**) into the intestine and 2) endocrine secretion of the hormones insulin and glucagon that act to lower and raise blood sugar.



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Bile contains waste products of liver activity which pass out of the fish in the feces. Bile has a digestive function in that it **emulsifies** lipids, greatly increasing their absorption in the intestine.

The liver is key in the **anabolism** and **catabolism** of amino acids absorbed during digestion and is also the site of storage of food energy in the form of **glycogen**.

Most absorption of nutrients occurs in the intestine.



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The large protein, fat, and starch molecules in food that have been broken into smaller molecules by gastric acid and digestive enzymes move by diffusion or active transport (ATPase pumps) into the network of capillaries surrounding the gut.



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Metabolic Rate - Temperature Effects

Animals get the energy to sustain life by oxidizing reduced carbon compounds in food, therefore metabolic rate can be measured experimentally by determining an animal's rate of oxygen consumption ($\text{mg O}_2/\text{kg body weight/hr}$).

Basal metabolic rate (BMR) in mammals is the rate of oxygen consumption at a resting state.

The concept of BMR is not appropriate for fish because the metabolic rate in a resting fish will vary depending on the ambient temperature.



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Oxygen Effects

Over a broad range of dissolved oxygen (DO) concentrations at a given temperature and activity level, a fish has a constant metabolic rate. There is a critical point of DO.



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Activity Effects

In all animals, a higher rate of physical activity (exercise) oxidizes more calories.

In fish, whose metabolic rate is affected by the oxygen content of the water, the oxygen effect interacts with the activity effect.



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At any given level of temperature, oxygen and activity, two different species may have different metabolic rates.

For example, a carp and a trout have different hemoglobin oxygen dissociation curves (**See Ch. IIE**) and different tissue tolerances for hypoxia.



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Fish can have feed conversion ratios (dry weight of feed fed/dry weight of gain) of less than 2, which are some of the highest feed conversion ratios in animal agriculture.

This efficiency in the conversion of food to flesh is advantageous.



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Effects of the Aquatic Habitat

All animals create ammonia during the catabolism of proteins.

Ammonia is toxic and its accumulation in the body cannot not be tolerated.

Urea is water soluble and mammals excrete it in the urine.

Since fish have constant exchange with water at the gill, they can excrete ammonia directly, without conversion, as soon as it is created.



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When carbohydrate or fat is metabolized, about 5% of the assimilated energy is used in changing the structure of the food molecules into forms the body can use and the remaining 95% can be used for maintenance and growth.



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Nitrogenous Compounds



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Effects of Poikilothermy

Mammals and birds use energy constantly to keep their body heat up.

In cold temperatures this is fairly substantial.

So, poikilothermy and a lack of a penalty for protein consumption are the reasons that fish can have high feed conversion ratios.



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Effects of Carnivory

Fish that are more fully omnivorous, e.g. tilapia, are less commonly produced in the U.S., but commonly imported from tropical countries.

All the essential amino acids are present in plant protein and they are all present in animal protein, but the percentage of individual amino acids tends to differ between animal and plant sources and less total protein needs to be fed if the amino acid profile of the feed is similar to the body of the animal.



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The best protein source for carnivorous fish is fish meal, which means feeding fish flesh to grow fish flesh.