Nutrition and Biochemistry of Parasites

1. The parasitic advantage

Parasites have the unique advantage over free-living animals in that they live entirely surrounded by their food. The methods of feeding have been adapted to the parasites habitat. In most cases the food has already been digested into a soluble form available for absorption. Hence some of the helminthes groups have dispensed with a gut together (the cestodes) and absorb their nutrients through the outer covering (the tegument). Others have a gut also absorb food through the tegument (the trematodes), while there are some (the nematodes) that only absorb food via their mouths.

The direct uptake of soluble molecules through either a tegument or a membrane is a physiological process similar to that of the uptake of solutes by mammalian gut epithelial cells. The process of absorption centers round the following mechanisms:

Simple diffusion:

Molecules are absorbed passively through the membrane a process regulated by the movement of molecules **from a higher concentration into the parasite's cells or tissues with a lower concentration.**

Active transport:

Absorption whereby molecules pass into the parasite against a Concentration gradient. This process requires **energy** and can be inhibited by substances that interfere with or inhibit respiration. This system may involve a carrier' molecule and the simulatenous movement of sodium.

Facilitated or mediated diffusion:

Movement into the parasite by molecules first conjugated to **carrier molecule** and then absorbed through the membrane. The solute is released once it has crossed the membrane. **The carrier is a locus on the membrane to which the solute binds to and is then released on the other side of the membrane where the concentration is lower.**

Pinocytosis (endocytosis and exocytosis):

Large molecules such as **proteins** are transported into the tissues within **membrane-bound vesicles.**

Contact digestion:

There is evidence to show that absorption of nutrients involves **enzymes**. These are either **intrinsic** ie of parasite origin, or **extrinsic** ie of host origin.

2. Uptake of nutrients

A number of studies on the kinetics of the uptake of nutrients have been carried out using two species of adult tapeworm, namely *Hymenolepis diminuta* and *H. microstoma*. Both of these worms can be removed from the gut of their host, a rat and mouse respectively, the uptake of nutrient was followed.

The results obtained from those experiments indicate that the uptake of nutrients by those parasites follow similar pathways to the manner in which nutrients are absorbed into the gut epithelial cells. Parameters such as pH, temperature, oxygen, carbon dioxide and enzymes can all be influential in the absorption of soluble nutrients.

* Transport kinetics reveal that the uptake of carbohydrates is dependent on the molecular shape and structure of the carbohydrate molecule and often there is competition for the identical transport locus (competitive inhibition).

* **Glucose** absorbed by active transport in the presence of galactose or fructose may lead to competitive inhibition of the uptake of compounds, particularly if one of them is at a higher concentration.

2.1 Uptake of amino acids

Amino-acids, from the gut amino-acid pool, are absorbed by tapeworms The amino acids enter the worms via **mediated transport systems** and accumulate against a concentration gradient.

- **The cestodes** unlike mammals, **require sodium and chloride ions coupled to the amino-acid transport system.**
- The cestodes have an equal affinity for the absorption of both **D and L amino-acids**. However apparently a two way process is in operation. Moelcules leak from as well as enter the parasite. A pool exists within the tissues of the parasite.
- The movement of amino-acids in and out of the parasite maintains an equilibrium between the amino-acids pool in the host's gut lumen and the pool within the parasite.

2.2 Energy storage

All parasites need a supply of energy to maintain and regulate their metabolism. It has been established that many parasitic helminthes can function for limited periods under anaerobic conditions. All require a source of reduced organic compounds and a mechanism for the release and capture of energy. In most helminthes the energy is stored as glycogen and, in the protozoan Plasmodium and Trypanosoma, carbohydrate is the main energy store whereas in *Entamoeba* spp. it is probably glycogen.

The parasites investigated from a biochemical point of view indicate that they conform to most of the established biochemical pathways. All of the parasites observed oxidize glucose by the same glycolytic pathway as that encountered in free-living organisms. The oxidation pathway that produces phosphoenol pyruvate (PEP) is common to nearly all parasites but the conversion of PEP to pyruvate and further degradations are not common. Some follow the mammalian patterns, other do not. In mammals PEP is converted to pyruvate and them normally passes to the tricarboxylic acid cycle. This cycle is far less active in parasites and when it does operate, it does so at a very low level and appears to be far less important to parasites than to mammals. One of the reasons for this is that parasites do not expend much energy in their search for food.

2.2.1 Energy for reproduction

The helminthes have, in general, complex sets of reproductive organs that produce numerous eggs with protective sets of membranes and shells. In many of the namatodes the females give birth to live larvae. Adult cestodes, trematodes and nematodes have a high fecundity rate and some of the metacestodes reproduce a sexually. Most energy production, whether it be from an aerobic or anaerobic source, is required to fuel the reproductive process. In addition there are added demands such as the production of hatching enzymes and penetrating enzymes.

* Many of the passive stages such as cysts, metacercaria and eggs require the appropriate external stimulus before they develop any further.*Schistosome eggs need a temperature lower than of the host, together with both light and water in order to hatch.

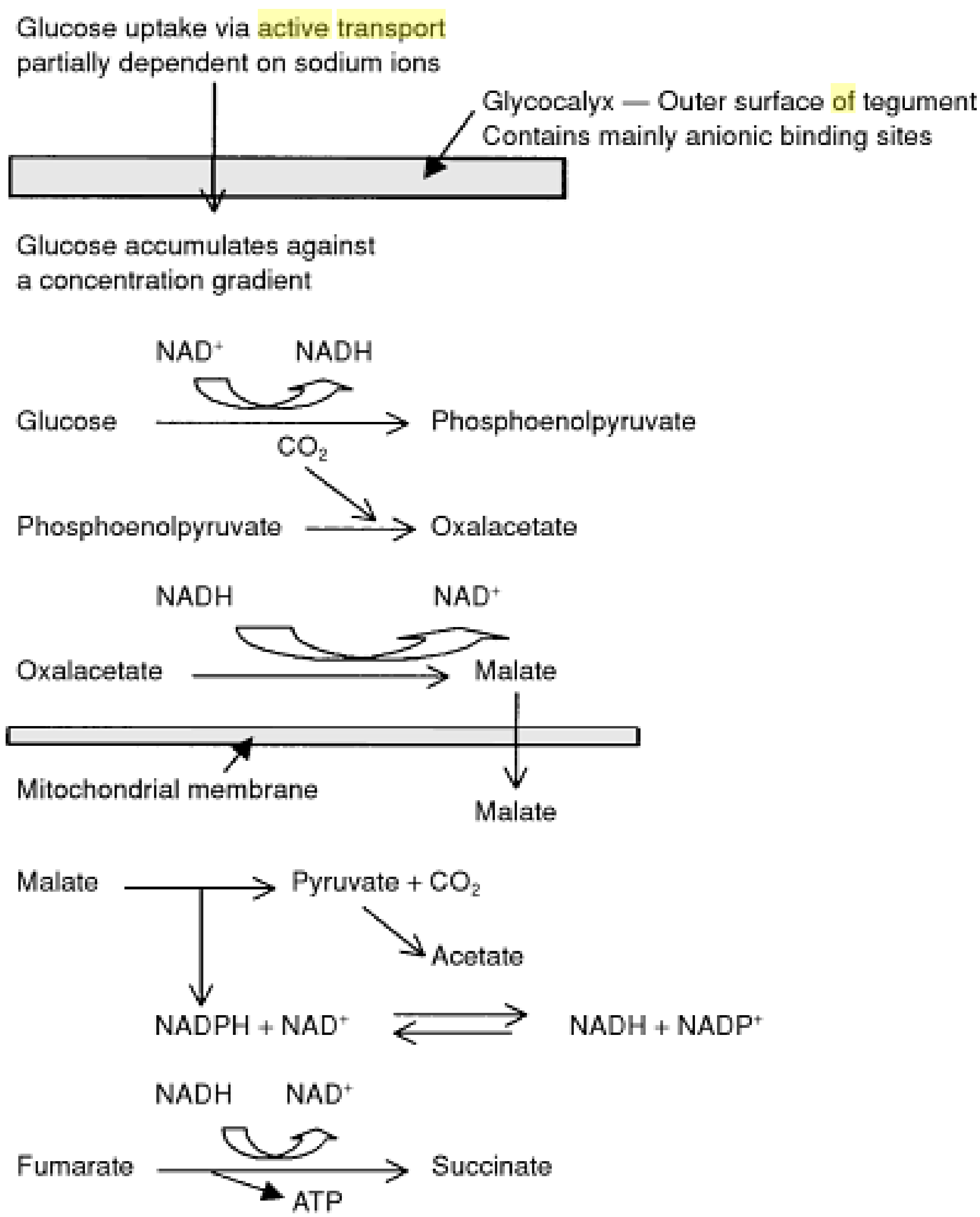

Fig.(1): The capture storage and active transport of energy in parasitic helminthes.

In parasitic platyhelminthes glucose is absorbed from an exogenous source mainly by a process of active transport. Having passed through the tegument the glucose is stored mainly as glycogen within the parenchyma cells.

When glucose is required the glycogen is converted into glucose.

The glucose is then converted into malate and lactate via phosphaoenoplyruvate and oxalacetate. The malate is absorbed through the mitochondria membrane and broken down into acetate and lactate via phosphoenolpyruvate and oxalacetate. Malate is broken down into acetate and succinate. The later reaction produces the energy rich compound ATP.

NAD = nicotinamide adenine trinucleotide; NADH = the reduced of NAD; ATP = adenosine triphosphate – an energy rich compound.

*Eimeria cysts only release their sporozoites after they have been subjected to the conditions of first the mammalian stomach and then the small intestine.

*Cestode eggs only hatch once inside the appropriate host and the larvae normally require the gut’s digestive enzymes, particualrlty bile to develop into the next stage.

3. Basic physiology and metabolic pathways

Each individual parasite has evolved and adapted basic physiological and metabolic pathways for its own needs. Some of the more important features of parasites in relation to their metabolism and physiology are:

- The cestodes and trematodes are triplobastric without a body cavity. They are aceolomate and all movement of solutes by diffusion from cell to cell or through the mesodermal matrix.

- The nematodes have a body cavity, the pseudocoelome, which is filled with pseudocoelomic fluid. The osmotic pressure of the fluid is equivalent to 0.2 M NaCl, the pH is between 6.2-6.4; and within the fluid proteins, fats, carbohydrates, enzymes, organic acids and small quantities of haemoglobin are stored.

• The role of haemoglobin in nematodes is not clear and the haemoglobin does not deoxygenate at low pressures. In Ascaris the body haemaglobin deoxygenates slowly under aerobic conditions.

• Among the carbohydrates are glucose (trace quantities), the disaccharide trehalose and glycogen. Glycogen is the main polysaccharide and is stored in the body wall and muscle tissues.

• Keratin, sclerotin and collagen are the main structural proteins. The collagen exists in two forms: (1) basement membrane collagen; and (2) cuticular collagens.

All classes of neutral lipid and phospholipid have been identified in different nematode species. In eggs and in the reproductive tract of female ascris a unique series of α-glycosides have been isolated.

The protein, lipid and carbohydrate composition in cestodes is different from most invertebrates. The glycogen (carbohydrate) level is relatively high and the protein level relatively low. Investigations have shown that metacestodes contain the highest levels of glycogen.

The body structure of both trematodes and cestodes contains **calcareous corpuscles** ranging in size of over 12-32 µm. These structures are made from both organic base and inorganic material. The corpuscles originate intracellularly one per cell which is eventually destroyed. The role of these structures is the subject of much speculation. One view is that they acts as a buffer for acids produced by anaerobic respiration and another is that they act as reserves of phosphates, other organic ions and carbon dioxide.