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Sodium Ion and Potassium Ion Transport and Permeability: a Comparison between Squid Giant Axons and *Ascaris* Muscle Fibres

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Although squid giant axons and the muscle fibres of the pig roundworm *Ascaris lumbricoides* are both invertebrate systems, the ion-transport phenomena associated with them illustrate many points that are relevant to transport in mammalian systems and micro-organisms. Na⁺ and K⁺ transport in squid axons takes place at the same temperature as that in many micro-organisms, and shows many similarities to that in mammalian erythrocytes. Na⁺ and K⁺ transport in *Ascaris* muscle on the other hand takes place at the same temperature as that in mammalian systems, but shows many unusual features.

Na⁺ transport in squid axons is diminished by removal of extracellular K⁺ (Hodgkin & Keynes, 1955) and by inhibitors of the sodium-pump enzyme system described by Skou (1957), e.g. ouabain (Caldwell & Keynes, 1959). It is also diminished by metabolic inhibitors (Hodgkin & Keynes, 1955). Many features of this transport can be interpreted in terms of models for the coupled transport of Na⁺ and K⁺ that also hold for mammalian erythrocytes (e.g. see Caldwell, 1968; Stone, 1968).

Electrochemical considerations suggest that Na⁺ transport must also take place from *Ascaris* muscle, but the system involved is very different since it is unaffected by the removal of extracellular K⁺ and the action of inhibitors such as ouabain (Caldwell & Ellory, 1968). The permeability properties of the *Ascaris* muscle membrane are also unusual. Although the membrane shows an appreciable permeability to radioactive Cl⁻ and K⁺, the resting membrane potential is not very sensitive to changes in the external concentration of these ions (Brading & Caldwell, 1964; del Castillo *et al.*, 1964). This is in contrast with squid giant axons, the resting membrane of which shows a high permeability towards K⁺ and the resting potential a high sensitivity to changes in extracellular K⁺. Some of the unusual behaviour of the *Ascaris* muscle membrane can be explained in terms of electrogenic sodium-pump mechanisms in which the outward movement of Na⁺ is not coupled to the movement of another ion.

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The Transport of Metabolites across the Mitochondrial Membranes

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It is now fairly well accepted that at least seven anion-transporting systems are present in liver mitochondria (Chappell, 1968, 1969; Klingenberg, 1970). Lehninger (1972) has provided convincing evidence for the existence of a specific carrier for L-ornithine, which must enter the mitochondria during the process of urea synthesis. It is reasonably well established that most mitochondrial anion-transporters are exchange-diffusion carriers or antiporters (Mitchell, 1966). Thus the dicarboxylate-carrier exchanges dicarboxylate anion for dicarboxylate anion or phosphate (or arsenate), and the tricarboxylate-carrier exchanges tricarboxylate anion (e.g. citrate) for dicarboxylate anion (e.g. L-malate), and in the case of the 2-oxoglutarate carrier a similar mechanism is apparently involved, i.e. oxoglutarate is exchanged for malate. It is not known whether the phosphate carrier is an antiporter, in which case it would permit phosphate-OH⁻ exchange, or a symporter, in which case phosphate would enter in association with a proton.

The existence of an ATP/ADP-carrier, the so-called adenine nucleotide translocase, is also well documented. This carrier catalyses an obligatory 1:1 exchange between internal and external adenine nucleotides. Of the naturally occurring nucleotides only the adenine derivatives are active. The specificity of the exchange in both directions has been studied in great detail by using radiochemical methods. External ADP exchanges rapidly for internal ADP and ATP. External ATP can exchange for internal ADP under certain conditions. The ATP-ATP exchange is relatively slow, and AMP is not exchanged at a significant rate.

The adenine nucleotide translocase is inhibited by two naturally occurring compounds, namely atractyl-loside and bongkreic acid. The mechanism of