

16. The conquest of land –animals

Moving of animals on dry land is also a great puzzle. Why animals should move to such a hostile environment, while oceans offer such a perfect living conditions?

When animals moved from water to land they would have to face similar problems to plants. First animals to venture onto land were the arthropods such as spiders and centipedes. In early land animals the control of water loss was achieved by the exoskeleton having a composite multilayer structure in which the outermost layer was waxy and waterproof. This waterproofing was achieved by a complex system of internal canals providing wax to the outer surface.

Another source of water loss in organisms is excretion. When animals digest proteins, excess nitrogen is produced and is usually released in the form of ammonia which is a toxic compound that requires dilution or removal. Dilution demands a lot of water and is thus unsuitable for terrestrial organisms. Thus arthropods converted ammonia into a more complex yet less toxic compound such as uric acid which removed with the aid of special organs.

Another major issue with life on land is that of respiration, or gas exchange. This cannot be done through increasing the permeability of the exoskeleton, which would cause significant water loss. The solution to this problem is that arthropods had specialized gas exchange structures which had a very complex mechanism.

Another less apparent issue is that of reproduction. In the marine environment releasing eggs and sperm into the sea for external fertilization is a workable solution. This is not possible on dry land, therefore internal fertilization was necessary. This required a wide range of complex sperm transfer techniques for safe fertilization.

The next problem to overcome was gravity. In water, bodies are supported from all sides by water pressure therefore they do not need strong skeletons to hold internal organs. To swim in water animals need some sort of fins which do not support the animal's weight, so the muscles used for propulsion do not have to be very strong. Another advantage of living in water is buoyancy which reduces the weight of the body, therefore animals use limbs more for movement than support.

Bodies of land animals are normally, with a few exceptions such as worms, snakes and snails, supported by legs which must be strong enough to carry all their weight. Such legs must be joined with a strong skeleton and must have powerful muscles. To move on land, animals use much more energy than needed to swim in water therefore their metabolism must be improved. The largest animal on Earth is a whale because only an aquatic environment can support such a large body.

The bodies of most animals function in a limited temperature range, from zero up to 40°C. Land masses are much more exposed to large temperature variations than water therefore land animals must have developed additional temperature control systems. Cold blooded animals would have had a problem living on land, exposed to the cold at night and the sun during the day. They would have needed a hiding place which could provide some protection against the cold and heat.

The first animals appeared on land about 430 million years ago, but what is interesting is that their body structures which enabled them to do so were designed during the Cambrian explosion about 100 million years earlier.

Before animals moved onto land they had to be adapted to the new environment . The development of these animals took place whilst still living in water. For example, the earliest four legged vertebrates, known as tetrapods, which emerged from the water about 385 million years ago, looked like fish but already had lungs and strong shoulders and hips capable of supporting the body's weight on land. How evolution would know in advance what changes were needed to adapt water based animals for land living?