Name______________________________ Class__________________ Date ______________

Summary

29–1 Invertebrate Evolution

Paleontologists have identified microscopic fossils from between 610 and 570 million years ago. From the same time period, they have identified trace fossils, which are tracks and burrows made by soft-bodied animals. The fossils of some of the earliest and most primitive animals known were discovered in the Ediacara Hills of Australia. The Ediacaran animals, which lived between 575 and 543 million years ago, were flat and plate-shaped. They lived on the bottom of shallow seas and were made of soft tissues. They were segmented and had bilateral symmetry. However, the fossils show little evidence of cell specialization or a front and back end. The Cambrian Period, which began 544 million years ago, is marked by the abundance of different fossils. One of the best-known sites of Cambrian fossils is the Burgess Shale of Canada. In just a few million years, animals had evolved complex body plans. Because of the extraordinary growth in animal diversity, events of the early Cambrian Period are called the Cambrian Explosion. The anatomies of Burgess Shale animals typically had body symmetry, segmentation, some type of skeleton, a front and a back end, and appendages adapted for many functions.

The appearance of each animal phylum in the fossil record represents the evolution of a successful and unique body plan. Modern sponges and cnidarians have little internal specialization. As larger and more complex animals have evolved, specialized cells join together to form tissues, organs, and organ systems. All invertebrates except sponges exhibit some type of body symmetry. Cnidarians and echinoderms exhibit radial symmetry—body parts extend from the center of the body. Worms, mollusks, and arthropods exhibit bilateral symmetry—they have mirror-image right and left sides.

The evolution of bilateral symmetry was accompanied by the trend toward cephalization, which is the concentration of sense organs and nerve cells in the front of the body. Invertebrates with cephalization can respond to the environment in more sophisticated ways than can simpler invertebrates.

Most complex animals are coelomates, with a true coelom that is lined with tissue derived from mesoderm. A coelom is a body cavity. Flatworms are acoelomates—they don't have a coelom. Roundworms are pseudocoelomates—their coelom is only partially lined with mesoderm.

In most invertebrates, the zygote divides to form a blastula. In protostomes, the blastopore develops into a mouth. In deuterostomes, the blastopore develops into an anus. Worms, arthropods, and mollusks are protostomes. Echinoderms (and chordates) are deuterostomes.

29–2 Form and Function in Invertebrates

In many ways, each animal phylum represents an "experiment" in the adaptation of body structures to carry out the essential functions of life. Biologists can learn a great deal about the nature of life by comparing body systems among the various living invertebrates.

The simplest animals—sponges—break down food primarily through intracellular digestion, which is the process of digesting food inside cells. More complex animals—mollusks, annelids, arthropods, and echinoderms—use extracellular digestion, which is the process of breaking down food outside the cells in a digestive cavity or tract. Complex animals digest food in a tube called the digestive tract. Food enters the body through the mouth and leaves the body through the anus.

All respiratory systems share two basic features. (1) Respiratory organs have large surface areas that are in contact with the air or water. (2) For diffusion to occur, the respiratory surfaces must be moist. Aquatic animals naturally have moist respiratory surfaces. Aquatic mollusks, arthropods, and many annelids exchange gases through gills. In terrestrial animals, surfaces are covered with water or mucus. Such covering prevents water loss from the body and also moistens air as it travels through the body to the respiratory surface.

All cells require a constant supply of oxygen and nutrients. Also, cells must remove wastes. The smallest and thinnest animals accomplish these tasks by diffusion between their bodies and the environment. Most complex animals move blood through their bodies using one or more hearts. Some use an open circulatory system, in which blood is only partially contained within blood vessels. The blood moves through vessels into a system of sinuses, where the blood directly contacts tissues. In a close circulatory system, a heart or heart-like organ forces blood through vessels that extend throughout the body.

Multicellular animals must control the amount of water in their tissues. But they also have to get rid of ammonia, a poisonous nitrogen-containing wasted produced as a result of metabolism. Most animals have an excretory system that rids the body of metabolic wastes while controlling the amount of water in the tissues. Many land animals convert ammonia into a compound called urea, which is eliminated from the body through urine.

Invertebrates show three trends in the evolution of the nervous system: centralization, cephalization, and specialization. The more complex an animal's nervous system is, the more developed its sense organs are.

Invertebrates have one of three main kinds of skeletal systems. (1) Some—annelids and certain cnidarians—have a hydrostatic skeleton, in which muscles surround a fluid-filled body cavity that supports the muscles. (2) Arthropods have an exoskeleton, which is an external skeleton. (3) Echinoderms have an endoskeleton, which is structural support located inside the body.

Most invertebrates reproduce sexually during at least part of their life cycle. Depending on environmental conditions, however, many invertebrates may also reproduce asexually. In external fertilization, eggs are fertilized outside the female's body. In internal fertilization, eggs are fertilized inside the female's body.