Chapter 1 - The Ocean as a Habitat

Chapter Summary

To understand any marine biological processes, we have to start with an understanding of the ocean as a habitat that can potentially support a tremendous diversity of life. The oceans are ancient and have an incredible geologic, physical, chemical and biologic history. If we want to become students of marine biology, we can't ignore the other aspects of ocean science because all areas of ocean science are interrelated. Geologic, chemical, and physical processes in the ocean all directly determine the distribution of marine organisms.

The Earth is thought to be about 5.0 billion years old and, throughout this long history, the continents and the world oceans have been changing due to dynamic physical, geologic, and chemical processes. After the Earth formed, numerous volcanoes spewed out a primitive atmosphere. Atmospheric gases and dissolved minerals contributed to the formation of seawater. The production of free oxygen by photosynthetic cells resulted in aerobic respiration becoming a dominant metabolic strategy. Most marine phyla had appeared by 500 million years ago. Abundant oxygen in the upper atmosphere was converted to ozone, a process that prevents much of the sun's lethal ultraviolet radiation from reaching the earth's surface. Concurrently, seafloor spreading and plate tectonics have wrought impressive changes on the shapes and sizes of the ocean basins. Today, we view the world ocean as a huge body of seawater that covers more than 70% of the surface of the earth to an average depth of 3,800 m.

Water is a polar molecule that forms hydrogen bonds with other polar water molecules giving water many unique properties that ultimately affect the diversity and distribution of marine organisms. Some of these properties include solvent capabilities, high heat capacity, density-temperature relationships, and increased viscosity. Seawater differs from fresh water in that it contains many dissolved constituents such as salts. Seawater also contains many nutrients (necessary for primary productivity), gases, and buffering substances. All of the components of seawater are necessary in the maintenance of well-balanced marine ecosystems.

Marine organisms face environmental stresses that are unique to life in the ocean. We can identify ecological and evolutionary adaptations in marine organisms that enable them to accommodate not only to the physical environment but also to ensure successful reproduction. Two environmental stresses are salinity and temperature fluctuations. To deal with salinity effects, an organism can have (1) body fluids of the same chemical composition as the ambient seawater (isosmotic), (2) body fluids that have a greater salt concentration than surrounding seawater (hyperosmotic), or (3) body fluids with a salt concentration less than that of ambient seawater (hypoosmotic). In terms of temperature regulation, most marine organisms are poikilothermic ectotherms; they lack physiological mechanisms to regulate body temperature and hence their internal temperature fluctuates with and is primarily controlled by ambient temperatures. On the other hand, marine birds and mammals are homeothermic endotherms; they have constant body temperatures that are internally controlled by physiological mechanisms.

The ocean is a very dynamic 3D environment that is in constant motion. In general, the world
ocean is set into motion by global and local winds that are ultimately caused by the unequal heating of the Earth by the Sun. Major and minor currents move the water in predictable patterns around the Earth. Other than currents, the sea also is set into motion by tides, waves, and vertical water movements. Most areas of the ocean are defined biologically by the combination of water movements, both horizontal and vertical, in a given area. A good example of this is seen in upwelling areas where entire ecosystems are dependent upon nutrient-rich waters that are upwelled from deeper waters.

In general, we think of the marine environment as being divided up into several specific regions called physiographic provinces. Each province is unique and the organisms that live there have evolutionary adaptations that enable them to survive and succeed in their particular environment. These provinces are defined based on physical properties such as depth, light availability, proximity to a continent, or tidal flux. The four fundamental realms of the world ocean are the seaside neritic vs. the oceanic provinces, and the benthic organisms of the sea floor vs. those that inhabit the water column in the pelagic realm.

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