Environmental Physiology

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ADHYAYA
Publishers & Distributors
DELHI (INDIA)

Published by

ADHYAYA

Publishers & Distributors

Corporate Office : A-108, Street No. 1/3, Kausal Puri
Delhi-110094 (INDIA),
Phone No.: 9968628081, 9643620664
E-mail : adhyayapublishers@gmail.com, adhyayapublishers@yahoo.com
Website : www.adhyayabooks.com

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© **Saaduz Zafar Ali, Dr. Shayiesta Zulfeqar**

First Edition 2021
ISBN 978-93-91284-08-4

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Printed in India

Published by Virendra Kumar Yadav for Adhyaya Publishers & Distributors. Cover Designed and Laser Typesetting at VM Graphic and Printed at Aarna Enterprises, Delhi.

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Preface

Environmental Physiology is concerned with the environment's influence on the physiological function and performance of living organisms.

The development of adaptations is studied by isolating an organism from individual environmental factors (controlled cultivation and rearing) and by comparing the parameters of physiological reactions in species that are taxonomically similar but that have different ecological specialization, such as arctic, tropical, desert, terrestrial, and semiaquatic organisms with different levels of muscle activity. In research on sensory systems, signalization, echolocation and ranging (bats, birds, fish), and chemical links (pheromones) between organisms, environmental physiology depends upon biophysical and biochemical data.

A structural adaptation is a change involving a physical aspect of an organism. The physical change is often related to a change in the organism's physical environment. For example, an ecosystem suddenly becoming forested might cause the animals living there to develop suction pads or climbing claws, which would convey a distinct advantage over species that did not change. Other examples of structural changes include developing wings for flight, fins for swimming or powerful legs for jumping.

Homeostasis is a key concept in understanding how our body works. It means keeping things constant and comes from two Greek words: 'homeo,' meaning 'similar,' and 'stasis,' meaning 'stable.' A more formal definition of homeostasis is a characteristic of a system that regulates its internal environment and tends to maintain a stable, relatively constant, condition of properties.

Endotherms generate most of the heat they need internally. When it's cold out, they increase metabolic heat production to keep their body temperature constant. Because of this, the internal body temperature of an endotherm is more or less independent of the temperature of the environment.

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Osmoregulation is the process of maintaining salt and water balance (osmotic balance) across membranes within the body. The fluids inside and surrounding cells are composed of water, electrolytes, and nonelectrolytes. An electrolyte is a compound that dissociates into ions when dissolved in water. A nonelectrolyte, in contrast, does not dissociate into ions in water. The body's fluids include blood plasma, fluid that exists within cells, and the interstitial fluid that exists in the spaces between cells and tissues of the body. The membranes of the body (both the membranes around cells and the "membranes" made of cells lining body cavities) are semipermeable membranes. Semipermeable membranes are permeable to certain types of solutes and to water, but typically cell membranes are impermeable to solutes.

In electrochemistry, the Nernst equation is an equation that relates the reduction potential of an electrochemical reaction (half-cell or full cell reaction) to the standard electrode potential, temperature, and activities (often approximated by concentrations) of the chemical species undergoing reduction and oxidation. It was named after Walther Nernst, a German physical chemist who formulated the equation.

This book is an endeavour to make aware the young workers with allied techniques comprising destructive and non-destructive methods for extending relevant research incessantly in the years to come to gain further information of both basic and applied significance.

This book simultaneously addresses big questions in organismal biology at small levels of biological organization to provide explanations of how biochemical machinery working at the cellular level results in organisms with different distributions and lifestyles, especially in the context of their environment.

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Dr. Shayiesta Zulfeqar

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1

Adaptation and Environment

In evolutionary theory, adaptation is the biological mechanism by which organisms adjust to new environments or to changes in their current environment. Although scientists discussed adaptation prior to the 1800s, it was not until then that Charles Darwin and Alfred Russel Wallace developed the theory of natural selection.

Wallace believed that the evolution of organisms was connected in some way with adaptation of organisms to changing environmental conditions. In developing the theory of evolution by natural selection, Wallace and Darwin both went beyond simple adaptation by explaining how organisms adapt and evolve. The idea of natural selection is that traits that can be passed down allow organisms to adapt to the environment better than other organisms of the same species. This enables better survival and reproduction compared with other members of the species, leading to evolution.

Organisms can adapt to an environment in different ways. They can adapt biologically, meaning they alter body functions. An example of biological adaptation can be seen in the bodies of people living at high altitudes, such as Tibet. Tibetans thrive at altitudes where oxygen levels are up to 40 percent lower than at sea level. Breathing air that thin would cause most people to get sick, but Tibetans' bodies have evolved changes in their body chemistry. Most people can survive at high altitudes for a short time because their bodies raise their levels of hemoglobin, a protein that transports oxygen in the blood. However, continuously high levels of hemoglobin are dangerous, so increased hemoglobin levels are not a good solution to high-altitude survival in the long term. Tibetans seemed to have evolved genetic mutations that allow them to use oxygen far more efficently without the need for extra hemoglobin.

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Organisms can also exhibit behavioral adaptation. One example of behavioral adaptation is how emperor penguins in Antarctica crowd together to share their warmth in the middle of winter.

Scientists who studied adaptation prior to the development of evolutionary theory included Georges Louis Leclerc Comte de Buffon. He was a French mathematician who believed that organisms changed over time by adapting to the environments of their geographical locations. Another French thinker, Jean Baptiste Lamarck, proposed that animals could adapt, pass on their adaptations to their offspring, and therefore evolve. The example he gave stated the ancestors of giraffes might have adapted to a shortage of food from short trees by stretching their necks to reach higher branches. In Lamarck's thinking, the offspring of a giraffe that stretched its neck would then inherit a slightly longer neck. Lamarck theorized that behaviors aquired in a giraffe's lifetime would affect its offspring. However, it was Darwin's concept of natural selection, wherein favorable traits like a long neck in giraffes suvived not because of aquired skills, but because only giraffes that had long enough necks to feed themselves survived long enough to reproduce. Natural selection, then, provides a more compelling mechanism for adaptation and evolution than Lamarck's theories.

LEVELS OF ADAPTATION

Adaptation, in biology, the process by which a species becomes fitted to its environment; it is the result of natural selection's acting upon heritable variation over several generations. Organisms are adapted to their environments in a great variety of ways: in their structure, physiology, and genetics, in their locomotion or dispersal, in their means of defense and attack, in their reproduction and development, and in other respects.

The word *adaptation* does not stem from its current usage in evolutionary biology but rather dates back to the early 17th century, when it indicated a relation between design and function or how something fits into something else. In biology this general idea has been coopted so that *adaptation* has three meanings. First, in a physiological sense, an animal or plant can adapt by adjusting to its immediate environment—for instance, by changing its temperature or metabolism with an increase in altitude. Second, and more commonly, the word *adaptation* refers either to the process of becoming adapted or to the features of organisms that promote reproductive success relative to other possible features. Here the process of adaptation is driven by genetic variations among individuals that become adapted to—that is, have greater success in—a specific environmental context. A classic example is shown by the melanistic (dark) phenotype of the peppered moth (*Biston betularia*), which increased in numbers in Britain following the Industrial Revolution as dark-coloured moths appeared cryptic against soot-darkened trees and escaped predation by birds. The process of adaptation occurs

through an eventual change in the gene frequency relative to advantages conferred by a particular characteristic, as with the coloration of wings in the moths.

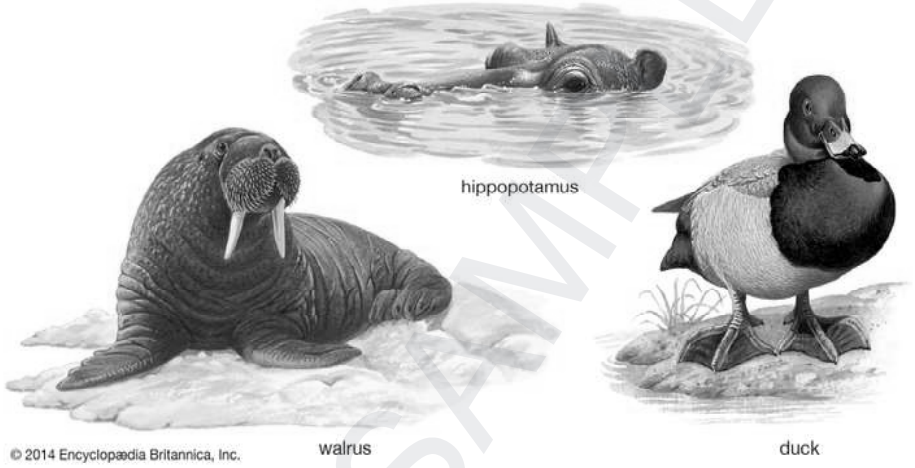


A light gray peppered moth (Biston betularia) and a darkly pigmented variant rest near each other on the trunk of a soot-covered oak tree. Against this background, the light gray moth is more easily noticed than the darker variant.



Against the background of a lichen-covered oak tree, a darkly pigmented peppered moth (*Biston betularia*) stands out, while the light gray moth (left) remains inconspicuous.

The third and more popular view of adaptation is in regard to the form of a feature that has evolved by natural selection for a specific function. Examples include the long necks of giraffes for feeding in the tops of trees, the streamlined bodies of aquatic fish and mammals, the light bones of flying birds and mammals, and the long daggerlike canine teeth of carnivores.



The habitat adaptations of walruses (thick skin to protect against cold conditions), hippopotamuses (nostrils on the top of the snout), and ducks (webbed feet).

All biologists agree that organismal traits commonly reflect adaptations. However, much disagreement has arisen over the role of history and constraint in the appearance of traits as well as the best methodology for showing that a trait is truly an adaptation. A trait may be a function of history rather than adaptation. The so-called panda's thumb, or radial sesamoid bone, is a wrist bone that now functions as an opposable thumb, allowing giant pandas to grasp and manipulate bamboo stems with dexterity. The ancestors of giant pandas and all closely related species, such as black bears, raccoons, and red pandas, also have sesamoid bones, though the latter species do not feed on bamboo or use the bone for feeding behaviour. Therefore, this bone is not an adaptation for bamboo feeding.

The English naturalist Charles Darwin, in *On the Origin of Species by Means of Natural Selection* (1859), recognized the problem of determining whether a feature evolved for the function it currently serves:

The sutures of the skulls of young mammals have been advanced as a beautiful adaptation for aiding parturition [birth], and no doubt they facilitate, or may be indispensable for this act; but as sutures occur in the skulls of young birds and reptiles, which only have to escape from a broken egg, we may infer that this structure has arisen from the laws of growth, and has been taken advantage