ESSENTIAL PUBLIC HEALTH

Series Editor: Richard Riegelman

Essentials of Public Health Biology

Biologic Mechanisms of Disease and Global Perspectives

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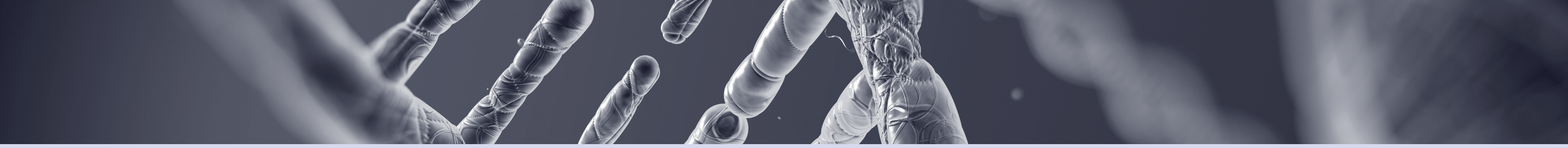

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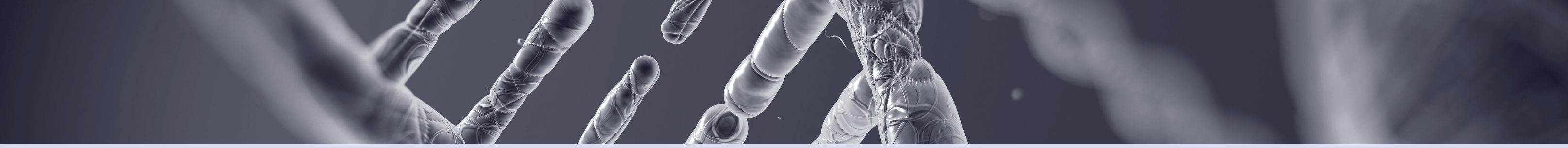


Prologue

Public health biology provides a critical foundation for the study of public health. In recent years, it has become increasingly clear that public health students at all levels need to understand the biologic basis for public health. New developments in genetics, immunology, and brain function require a basic understanding of biology. New preventive, diagnostic, and therapeutic technologies cannot be successfully applied without such an understanding of underlying biology.

Essentials of Public Health Biology starts by introducing students to basic concepts of cellular biology, immunology, and physiology, which are key to appreciating the connections between biology and public health. The authors build on these concepts to discuss the biologic aspects of important public health problems from communicable and noncommunicable diseases to aging, nutrition, environmental exposures, and injuries.

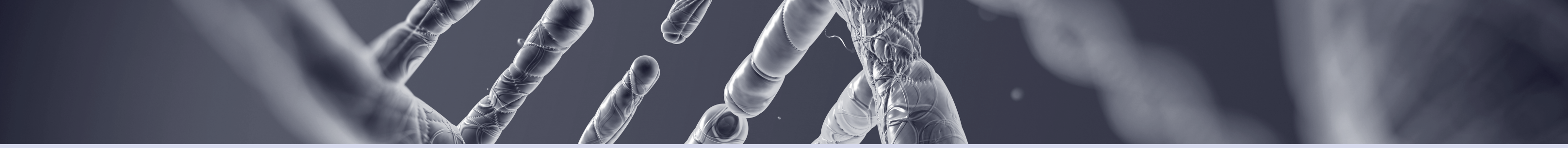
Essentials of Public Health Biology is unique in its focus on populations. It emphasizes the population as well as the individual implications of biology. The population perspective is key to understanding the biology of epidemic disease and immunizations as well as issues of environmental risk. The text does not assume that students have had previous biology courses. It starts with the fundamentals and leads the students to appreciate the implications of the biology for public health.

The lead authors of the text have worked together to offer on-site as well on online course work emphasizing public health biology. Their diverse disciplinary backgrounds and complementary areas of interest provide a strong basis for a comprehensive text. The authors utilize graphics, case studies, and in-depth examples to provide an engaging curriculum well designed for use as a textbook.

The text is organized into two sections beginning with fundamental concepts and followed by extensive applications to current public health issues. This step-by-step approach should help students understand and apply biology to current and future public health issues. The text provides the basis for course work that addresses the Council on Education for Public Health expectations for accreditation as well as preparing students for the certifying examination in public health.

The text's emphasis on basic concepts and applications to current public health issues should serve students well for many years to come. I'm very pleased that *Essentials of Public Health Biology* is part of the Essential Public Health series.

Richard Riegelman, MD, MPH, PhD
Series Editor—Essential Public Health



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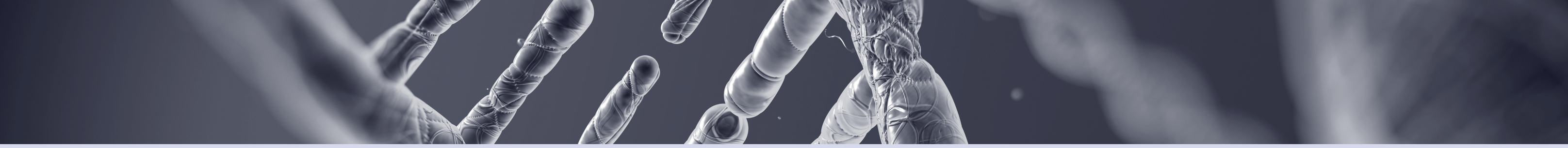

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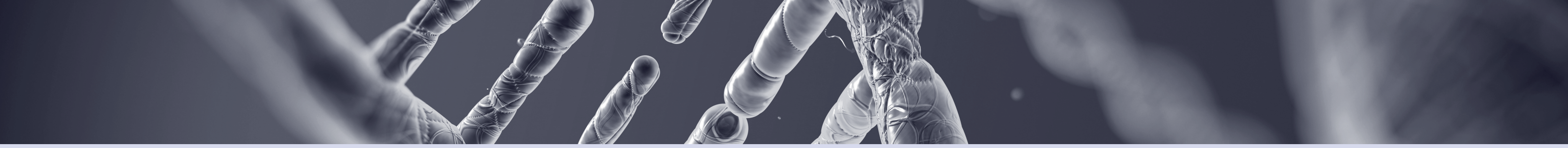

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Introduction

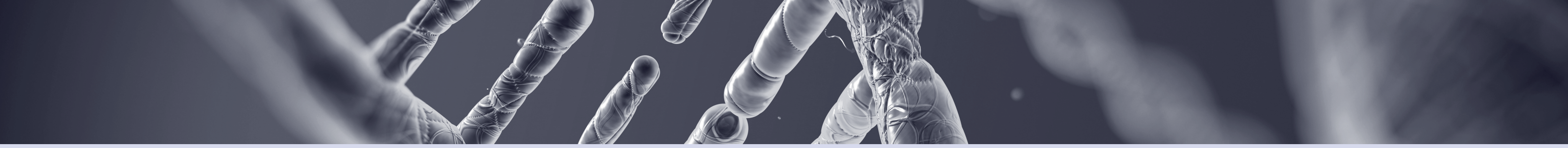
Essentials of Public Health Biology is designed as an introductory text for undergraduates and as part of the Master of Public Health core that aims to (1) provide an overview of current knowledge about the biologic mechanisms of diseases that are major causes of death and disability in both developed and developing countries; (2) understand and interpret the reciprocal relationships of genetic, environmental, and behavioral determinants of health and disease within an ecologic context; and (3) provide opportunities to analyze, discuss, and communicate biologic principles of disease across the biologic and the public health spectra.

The Public Health Core Competencies Addressed by This Text

After using this textbook, students will be able to:

1. Apply fundamental biologic concepts of the disease process as they relate to important communicable and noncommunicable diseases that are observed globally in public health.
2. Integrate these fundamental concepts with regard to their relation to exposures and disease outcomes across the public health spectrum.
3. Identify the role of host and environmental factors in determining susceptibility and resistance to disease.
4. Explain the multidisciplinary nature of contemporary public health issues and the role that various professionals play in addressing these issues.
5. Summarize the social, legal, ethical, economic, and political context of contemporary public health problems.

—Richard Riegelman, MD, MPH, PhD
Series Editor—Essential Public Health



Overview of Public Health Biology

Loretta DiPietro, Julie A. DeLoia, and Victor K. Barbiero

Introduction

The World Health Organization defines public health as "the art and science of preventing disease, prolonging life and promoting health through the organized efforts of society."[1] This includes all organized public or private measures to prevent disease, promote health, and prolong life at the population level. Public health efforts intend to provide physical, social, and political conditions that can empower people to gain control over the determinants of their own health. One obvious goal of public health is disease prevention and control—an effort that demands collaboration among scientists in several different disciplines. Sound public health practice requires knowledge and understanding of health- and disease-related terminology, concepts and processes spanning the biologic spectrum (cell, tissue, organ, system, and whole-body levels). The purpose of this textbook is to help students understand fundamental concepts of the disease process as they relate to important communicable and noncommunicable diseases that are observed globally. Moreover, students will apply these fundamental biologic concepts to exposures and disease outcomes across the public health spectrum in order to recognize optimal time points and strategies for successful intervention.

Basic Principles of Challenge and Homeostasis

Stress is a common and adaptive component of our interaction with the environment, and the human body has evolved over the millennia to adapt to various environmental stressors. A stressor can be defined as any type of challenge to the body's basal function. This challenge will result in an increased demand on physiologic function and a consequent disruption in *homeostasis*. In order to regain homeostasis, the body needs to adapt to the particular challenge by undergoing either transient or long-term adjustments. For example, simply standing up from a chair and walking across the room is a challenge to basal function and requires a series of adjustments in heart rate and blood pressure to ensure adequate blood flow to working muscles and to the brain to support even this minimal activity.

Cellular and tissue functions are controlled within narrow limits, and therefore, to maintain homeostatic control, the human body must be able to detect deviations in the internal environment. Once detected, the body must then be able to control the appropriate factors responsible for adjusting these deviations back to the basal state. For instance, when core body temperature drops too low, a number of alterations will occur automatically. Blood flow will shift away from the skin toward the central organs (resulting in "goose bumps" on the skin surface) and rapid, involuntary muscle contractions (shivering) will begin to generate heat. "Negative feedback" occurs when a deviation in a controlled function triggers a response that opposes that deviation, thereby restoring function in the opposite direction back to normal (**FIGURE 1**).

In public health, we can identify myriad exposures that challenge, perturb, or stress basal function. These can be beneficial exposures, like exercise and work activity, or they can be harmful, such as exposure to cigarette smoking or toxic chemicals. Our ability to respond and adjust to these challenges in a timely and appropriate manner relies on both the *plasticity* and *resiliency* of our physiology. Plasticity (or compliance) refers to the amount of expansion and recoil that occurs in certain types of tissues or organs in response to increased physiologic demands. In cardiovascular function, for instance, plasticity is a reflection of both the structure and functional properties of

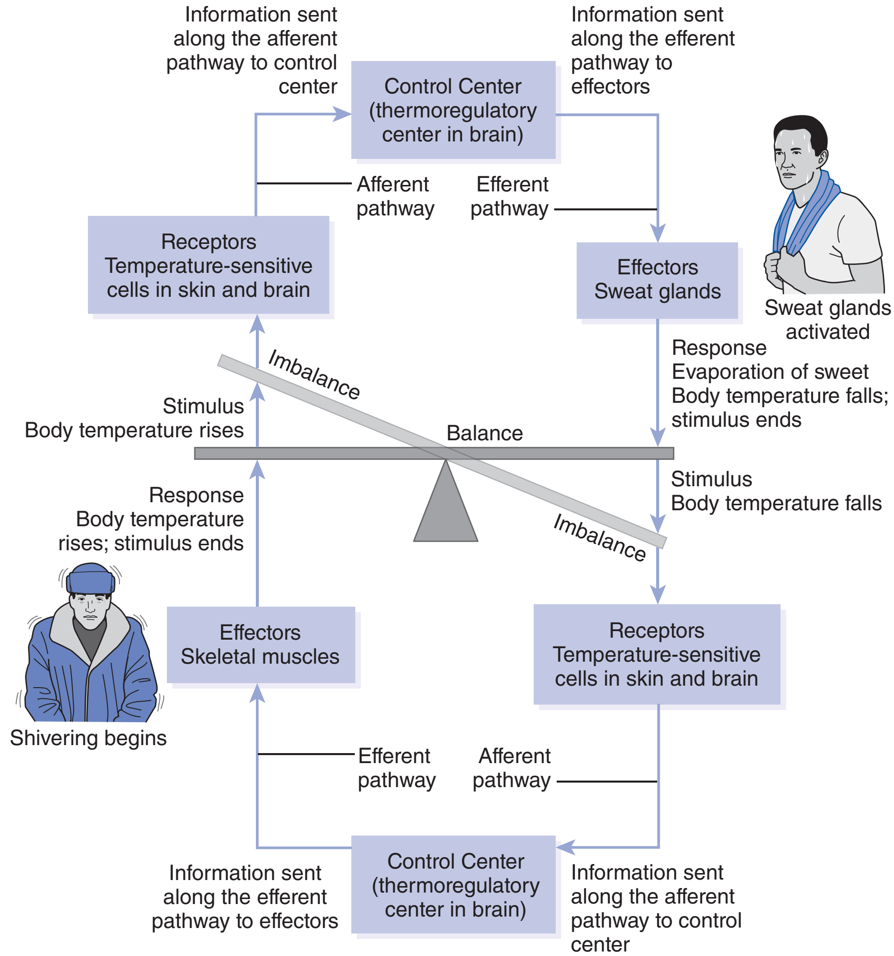


FIGURE 1 Homestasis and Temperature Control

the circulatory system. Resiliency (or *allostasis*) refers to the timely ability to regain normal homeostatic function following a given environmental challenge through the activation of neural, neuroendocrine, and neuroendocrine immune responses. Indeed, a near-collision in an automobile can double heart rate within 3 to 5 seconds and blood pressure within 10 to 15 seconds. Normally, heart rate and blood pressure would return to resting levels several minutes after the "threat" has disappeared, thereby indicating resiliency. In some people, however, this *fight-or-flight* response is exaggerated beyond the level of threat and remains long after the threat has dissipated. This exaggerated response also may occur in reaction to multiple other threats, such as occupational, financial, or interpersonal stressors. The *allostatic load* refers to the accumulated physiologic burden (wear and tear) to repeated cycles of allostasis. When the allostatic load is greater than the body's ability to compensate, errors or injuries will occur in the cells, tissues, organs, systems, or whole body, thereby initiating and promoting the disease process.

The Natural History of Disease in Public Health

The natural history of disease refers to the manner in which a disease progresses in the absence of any medical or public health intervention. Public health practitioners rely on available knowledge about the stages, mechanisms, and causes of disease to determine the most appropriate time and manner to intervene. The goal of any intervention is to alter the natural history of a disease in a favorable way—either by preventing it entirely, delaying its onset, or by reversing it.

A disease develops over time and can be divided into three stages: pre-disease, latency, and symptomatic. The pre-disease stage precedes any pathologic process and is the ideal time to intervene, as stopping the disease before it causes damage may be the most cost-effective path. Early efforts to prevent exposures to harmful factors and thus prevent the disease process from even starting are termed *primary prevention*. When the disease process has begun but the person is not yet symptomatic is called the latency stage—or incubation period. In order to prevent the progression to the next stage, screening and early treatment may be necessary. This level of early detection and treatment is referred to as *secondary prevention*. Once disease symptoms become evident (symptomatic stage), efforts to slow or even reverse the progression of disease are called *tertiary prevention*. Examples of tertiary prevention include cardiac or physical rehabilitation and bariatric surgery.

Models of Disease Transmission

Public health divides disease into those that are communicable (e.g., influenza, measles, polio, human immunodeficiency virus/acquired immune deficiency syndrome) and those that are noncommunicable (e.g., heart disease, cancer, diabetes). The *etiology* of most diseases involves an interactive triad of factors: the agent, the host, and the environment. For many communicable diseases, a fourth factor is added: the vector or vehicle.

An *agent of disease* is a necessary initiator of that disease; for instance, without the agent, there is no disease. Biologic agents include bacteria, viruses, allergens, toxins, and even foods (those high in trans fats, for example); chemical agents include toxins such as lead, arsenic, or asbestos; physical agents include radiation, uncontrolled mechanical energy (the factor in vehicular injuries and bullet wounds), heat, cold, micro-gravity, and a chronic positive energy balance (the agent of obesity). *Host factors* are those traits that affect one's susceptibility to the disease agent. Host resistance is influenced by genotype, age, sex, immune response, and behavior. Several host factors can work synergistically to influence resistance or susceptibility to disease. For example, frail, older people often are undernourished and have other comorbid conditions, thereby making them particularly susceptible to diseases like influenza. The *environment* influences the probability of contact between the agent and the host. Poor sanitation, poverty, laws pertaining to firearm access, the political environment, urban design, and crowded schools are all examples of environmental factors that influence disease causation. Vectors of disease are those factors that transmit or spread the disease among populations. These can include insects, animals, and water; however, the definition also could apply more broadly to people (drug dealers) or objects (contaminated needles, elevators, guns). To be an effective transmitter of disease, the vector must have a specific relationship to the agent, the host, and the environment. For example, the vector in malaria transmission is the *Anopheles* mosquito, which carries the agent for malaria (e.g., *Plasmodium vivax*) in its salivary glands. When the mosquito feeds on human blood, this parasite is transferred to the host. The warm, humid climate of central Africa is a particularly friendly environment for this species of mosquito, thereby enhancing the contact between humans, mosquitos, and the parasite in that geographic area.

More recent epidemiologic models of noncommunicable disease transmission embrace a multifactorial model of causation, which describes the interactions among a variety of agent, host, and environmental factors. The sufficient–component model (**FIGURE 2**) illustrates how different combinations of various risk factors may work together to

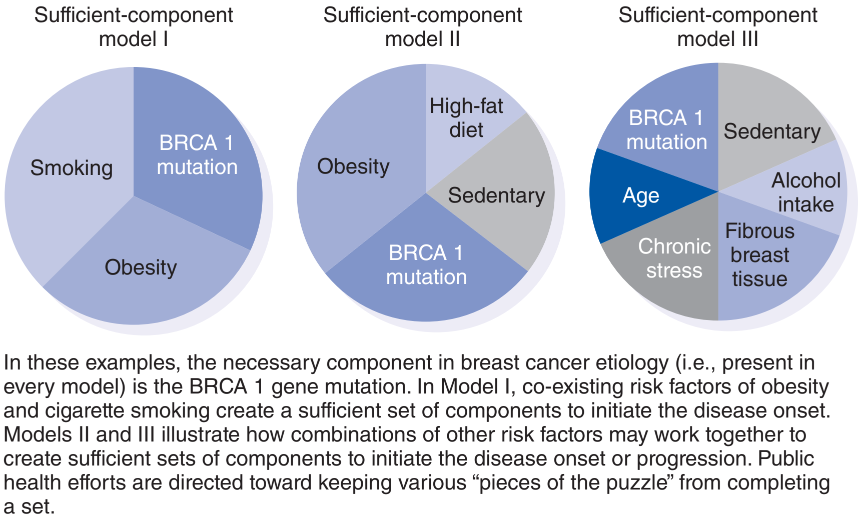


FIGURE 2 Sufficient-Component Model

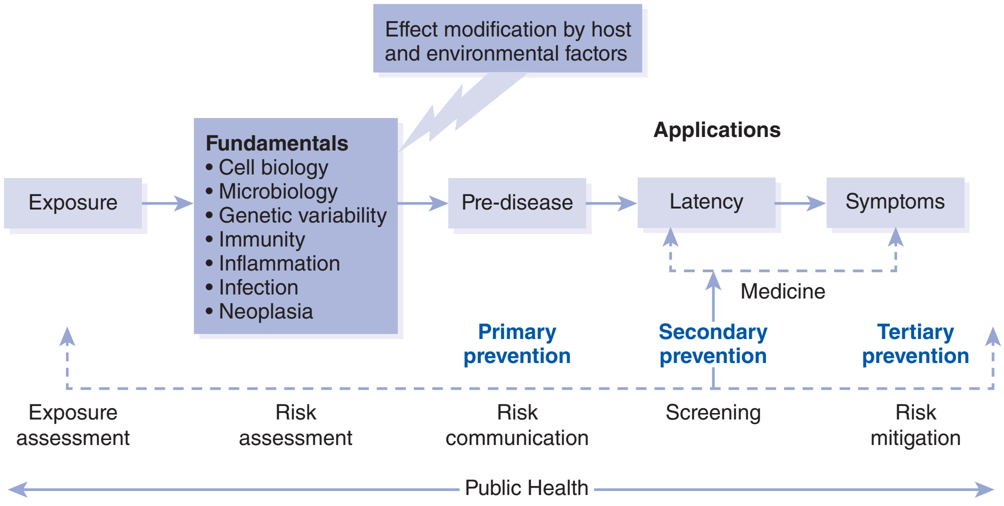


FIGURE 3 Paradigm for Relating Foundation Topics to Pervasive Health Issues Across the Biologic and Public Health Spectra

cause certain diseases. This model emphasizes that while a given risk factor may be a *necessary* component for a particular disease, in many cases that one factor may not be *sufficient* by itself to result in the disease. Rather, this necessary factor must be accompanied by a particular combination of other risk factors, and when a sufficient set of components is in place, disease onset occurs. Public health efforts can be directed toward blocking other risk components (e.g., hypertension, smoking, obesity) from completing the "sufficient set." Efforts and resources are best directed toward risk components that are easily modifiable either by behavior change, medication, or by policy.

The Paradigm

As stated previously, the overarching goal of this textbook is to help students understand and apply fundamental biologic concepts of the disease process as they relate to globally observed communicable and noncommunicable diseases. Within the biologic spectrum, we discuss cell anatomy and physiology, microbiology, immunity, inflammation, and genetic variation because they are the fundamental elements of human disease. We next apply these fundamental concepts and functions across the disease spectrum (pre-disease, latency, symptomatic) to illustrate how public health can affect the natural course of disease in the most cost-effective manner. The public health spectrum refers to primary, secondary, and tertiary levels of intervention with regard to disease prevention and management, but it involves the prevention and management of risk exposures as well. Indeed, sound public health practice requires that the disciplines of exposure assessment, risk assessment, risk communication, and risk mitigation work together to protect the health of the population (**FIGURE 3**).

Reference

1. World Health Organization. Public health services. Available at http://www.euro.who.int/en/health-topics/Health-systems/public-health-services. Accessed November 27, 2017.