Chapter 1

Why This Book?

"...diseases entrenched in natural foci are old in nature and 'new' only in relation to the time and conditions of their appearance in man and still more 'new' when one considers the time at which the physician learned to diagnose correctly."(Pollitzer)[1]

Photo by Milton Friend

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Bolded words within the text indicate terms that are defined in the Glossary.

Chapter 1

Why This Book?

Overview

The appearance and diagnosis in humans of various infectious diseases is a dynamic situation involving "new" diseases that continue to arise and challenge humankind, along with fluctuating levels of established diseases. Some of the agents causing these diseases originate in humans and others in animals. As a group, the **zoonoses** (diseases transmissible between animals and humans) are of special concern because of the close associations people have with domesticated species and **free-ranging wildlife**. In many areas of the world, those associations with wildlife have become greater during recent years, especially as the increasing human population results in wildlife and people sharing more of the same space (Fig. 1.1). In addition, the popularity of outdoor recreation and **ecotourism** results in millions of humans entering "wild places" (Fig. 1.2). During 2001, 39 percent of the USA population 16 years old and older participated in activities related to fish and wildlife. These activities generated 1.1 percent of the Nation's gross domestic product ($110 billion).[2] Because of these factors, zoonoses are the dominant type of infectious disease in the current era of disease emergence and reemergence, a situation that is likely to continue for the foreseeable future (see Chapter 2). Not only can humans contract diseases from wildlife (Fig. 1.3), but humans can introduce diseases that jeopardize wildlife.[3,4] Wildlife populations that become infected by **pathogens** typically considered to cause human disease may then become **enzootic** foci for those infections. Recent infection of African wildlife with the human strain of tuberculosis (*Mycobacterium tuberculosis*) has been attributed to the expansion of ecotourism and is but one example of disease introduced into wildlife populations associated with human encroachment into remote areas.[4–7]

Photo by Milton Friend

Figure 1.1 Urban and suburban environments are important habitats for some wildlife. The potential for transfer of zoonotic diseases amplifies the need to actively manage the health of wildlife populations within human environments.

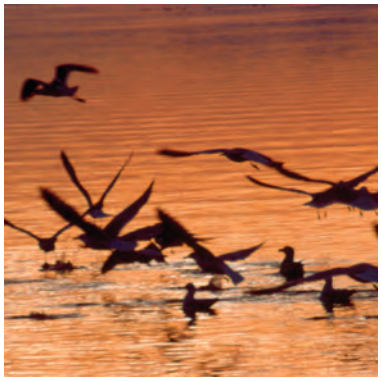
Three basic factors can minimize the potential for diseases present in nature, such as **AIDS**, from becoming established as new diseases of humans, and can help to protect humans from long established zoonoses, such as rabies: 1) knowing the natural history of animal diseases transmitted to humans, 2) raising public awareness about the diseases they may encounter, and 3) implementing sound practices and public policy to address those diseases. Minimizing the introduction

National Parks | National Forests | State Parks

Photos by Milton Friend

Figure 1.2 Outdoor recreational visitor use associated with USA parks and forests in 2000 (data from T. Jordan, National Park Service; L. Warren, National Forest Service; D.D. McLean, Indiana State University).

Hydatid disease



Ornithosis

Trichinosis

Toxic tissue secretons

Leptospirosis

Plague

Mycobacterium infections

West Nile fever

Salmonellosis

Bovine tuberculosis

Baylisascariasis

Erysipeloid

Crow photo courtesy USGS; all others by Milton Friend

Figure 1.3 Examples of diseases potentially acquired from various wildlife species groups.

of typically human infections into wildlife populations is complicated because less is known about disease **transmission** from humans to free-ranging wildlife. A better understanding of the dynamics involved is essential for identifying mechanisms for limiting wildlife exposures to those infections.[4] In addition to human illness and death, zoonoses are a threat to the sustainability of wildlife populations and impose heavy economic, social, and institutional costs.

Background

Another Emerging Diseases Publication

Many published works have addressed emerging diseases; however, these publications often are directed towards scientific audiences within the human and animal health fields (Box 1–1). Nondisease specialists and the general public are also in need of information about these diseases, thus this book is directed towards them. In contrast to the previous "Field Manual of Wildlife Diseases,"[8] also developed by the National Wildlife Health Center, this publication does not address the pathology, ecology, and control for specific diseases. Instead, the focus is on concepts associated with disease emergence in wildlife, the general importance of wildlife as sentinels for disease emergence, and the importance of wildlife as sources for **zoonotic** disease. Forthcoming publications will provide in-depth coverage for many of the diseases identified here. The extensive literature citations in this publication expand the information base for disease specialists and others by providing scientific literature sources about specific diseases and associated subject areas. Noninfectious diseases and the full spectrum of infectious diseases are not addressed here.

Compared with general knowledge about diseases transmitted to humans by **domestic animals**, the public knows less about acquiring diseases from wildlife populations, especially diseases associated with the changing pattern of wildlife/human interactions. Because of this lack of knowledge, response to zoonoses transmitted by wildlife is often crisis-oriented rather than based on preventive strategies. Our intent is to enhance the basic understanding about disease ecology and disease transmission from wildlife to humans, especially those who are more at risk because of their contact with wildlife (Fig. 1.4). We also highlight the human role in disease emergence in wildlife.

Disease Emergence in a Changing World

Many factors associated with disease emergence and resurgence (see Chapter 2), such as human-induced landscape and seascape changes, worldwide travel, urbanization, changing environmental conditions, and changes in human behavior, provide new opportunities for **microbes** and parasites to infect humans, animals, and arthopod vectors of disease. Evolutionary processes favor the disease agents[9] and are providing an increasing number of "wake-up calls" in response to human ignorance and arrogance towards disease processes.[10] **HIV** infection is a well-known consequence of human behavior and conveys lessons relative to how human/wildlife interactions, in combination with human mobility and behavior, can result in the establishment of new disease foci.[11] Therefore, it is prudent to consider diseases of wildlife from a global perspective rather than from just a local, regional, or even national perspective (Box 1–2).

Disease Ecology

By examining the history of long-standing diseases and how their ecology has changed in response to changes in environmental conditions and human behavior, we can understand more about current and future disease risks. For example, the history of rabies, a long-standing **zoonosis**, is lost in antiquity. The first recorded presence for this disease is from the days of the **Asclepiadae**, 124 – 40 BC .[12] Despite this extended history, "with few exceptions, the disease is no less a worldwide problem than it was centuries ago".[13] In part, the stature of rabies as a dreaded disease has been maintained by its diverse ecology. Rabies transmitted to humans by nonvampire bats has provided new dimensions for this disease within North America since the early 1950s.[14] However, rabies virus in a nonvampire **bat** was first identified in 1916 in a Brazilian fruit-eating bat. Since then, rabies in nonvampire bats has also been documented in Europe and Asia in addition to South and North America.[15] Several different strains of rabies associated with specific wildlife species have been recognized, leading to a greater understanding of rabies ecology. The ecology of **arthropod**-vectored disease, such as West Nile fever and dengue fever, can be even more complex than that of rabies.

Humans can become infected and contract the same zoonoses through multiple routes (Fig. 1.5). Therefore, to prevent exposure to pathogens, it is important to know the different routes of exposure (Table 1.1) and to be aware of other factors, such as the environmental persistence of the causative agents. For example, animal hides with hair have been the source of human cases of anthrax from curios purchased by tourists.[16] Fish and wildlife law-enforcement personnel involved with port-of-entry inspections and other activities may encounter animal hides and other materials imported illegally. Safeguards against the transport of pathogens from the country of origin have been compromised in those situations and the law-enforcement personnel must quickly evaluate potential risks and deal with the situation without compromising their health or that of others. Important factors to consider are knowledge of the types of disease agents that might be encountered in animal hides and products made from them, the countries that pose substantial risks from those diseases, and routes for human exposure (e.g., aerosol vs. contact).

Postmortem photo by James Runningen; cave photo by William Zanwell; other photos by Milton Friend

Figure 1.4 Enhanced contact with animals and animal components associated with some types of work-related and recreational activities results in increased potential for exposure to zoonotic diseases. Recognition of inherent risks provides a basis for actions to minimize risks that may exist.

Infectious Disease Publications: Past and Present *Box 1–1*

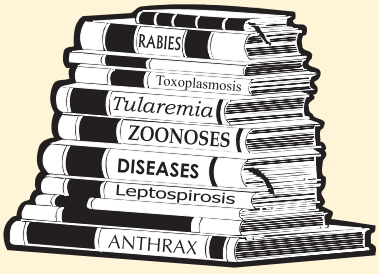
Keeping up with the continual publication of new scientific literature can be a challenge. An unfortunate result of focusing primarily on the newest literature is that the historic literature is often forgotten. Consequently, insights that might spring from reexamining past perspectives along with present knowledge do not emerge. Also, for some, the historic literature may hold greater interest than current literature because of the richness of concepts, discovery, and insights of early investigators prior to the development of current technologies and expanded knowledge of specific diseases.

- Before modern theories and technology were highly developed, publications on diseases were rich in descriptive detail of the observations being made at the gross level and the conclusions being drawn from those observations. The general wisdom and powers of deduction displayed, despite the technical limitations of those times, are impressive (see quote from **Hippocrates** on page 11).

- Descriptive epidemiology provides a foundation for many correlations and hypotheses that have been converted to important scientific discovery with the advent and application of enhanced technology and scientific methods. A classic example of descriptive epidemiology leading to disease control is John Snow's quantitative investigation of cholera in London during 1854, many years prior to the 1883 identification of the causative agent. He determined that the mortality rates in houses supplied by a specific water company were between eight and nine times greater than those in homes supplied by another water company, and also were much greater than in the remainder of London. Those findings, along with his investigation of the Broad Street Pump cholera **epidemic**, resulted in his inference of the existence of a "cholera poison" transmitted by polluted water, and led to legislation mandating that all of the water companies in London filter their water by 1857.[18] Numerous other diseases have been described as distinct clinical entities and the primary sources for human infection correctly identified prior to the isolation and identification of the causative agents.

- The historic accounts of disease are also an important part of the history of human civilization because the two are so intimately intertwined (see Chapter 2). For example, it has been suggested that **domestic pigs** brought to the New World in 1539 by the Spanish explorer Hernando de Soto were the source of epidemic disease that decimated Native American populations in the Mississippi Valley following disease transfer from the pigs to wildlife.[19] Historic publications on **epizootics** affecting wildlife that involve zoonoses often provide a wealth of information about animal populations, habitat conditions, environmental changes, and human activities during the time period of the publication. The "descriptive naturalist" approach by some of the field biologists conducting those investigations provides an enhanced vision of the field conditions associated with the specific disease events.

Current knowledge about infectious diseases is essential for combatting these diseases. Nevertheless, there will always be value in taking the time to "dust off" historic accounts of disease to appreciate the contributions made, and perhaps, to gain some new insights from the wisdom of past investigators. Chapter 7 (*How to Find and Access Published Information on Emerging Infectious Diseases*) provides guidance for access to historic and current information on emerging infectious diseases.



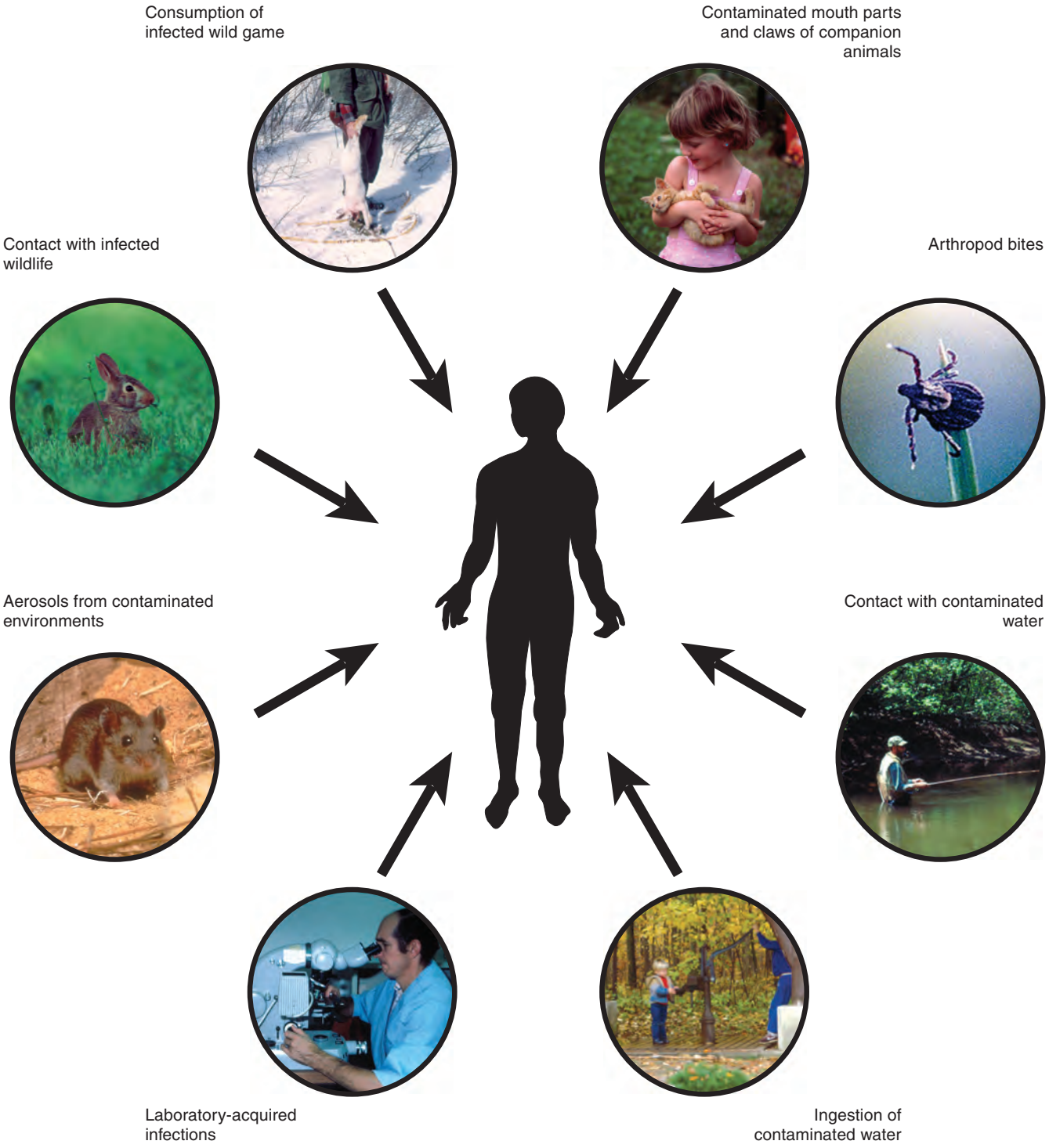


Figure 1.5 Principal routes of human exposure to infectious agents. (Mouse and tick photos courtesy of the Centers for Disease Control; microscope photo by James Runningen; other photos by Milton Friend.)

Although zoonoses are diseases transmitted between animals and humans, humans are not essential for the maintenance of most zoonotic disease agents. In many instances, the disease is not transmissible from human to human nor do human cases of the disease result in the transfer of the disease to other species. In those situations, humans are a "dead-end host," regardless of whether disease culminates in death. Nevertheless, humans greatly influence the establishment, maintenance, and occurrence of many zoonoses and other diseases. Serious consequences can arise from instances where significant human diseases are introduced into wildlife populations, which then serve as reservoirs for human infections. This dimension of disease emergence has received little attention.

Regardless of the disease, three basic factors are involved for disease to occur. Environmental conditions must be such that the disease agent can exist in a viable state; **hosts** must be susceptible to that agent; and the host and agent must have sufficient interaction for disease to occur (Fig. 1.6). Environmental conditions are often the driving force that cause host-agent relations that result in disease.

The basic disease cycle of host, agent, and environment has many permutations. These differences are primarily associated with how various types of infectious disease agents (Table 1.2) are maintained in nature and transmitted to susceptible hosts (Fig. 1.6). Understanding these processes can help minimize the potential for exposure to the pathogens that cause infectious disease. This aspect of "landscape ecology" is not a new concept.

Many people move freely and rapidly between cities, nations, and continents "in which we are a stranger." Also, our love for nature frequently takes us into environs that are even less familiar. Familiarity with disease risks before we visit a place can help guard against the diseases that may be present in those places. For example, multiple reports of outbreaks of acute **schistosomiasis** have been documented since 1975 among European and American tourists returning from various African countries.[17] In addition, a greater understanding of the potential that humans, **companion animals**, and agricultural activities have for introducing disease into wildlife populations can help in minimizing the establishment of those diseases.

This Book in Perspective

This book provides a foundation for why diseases of wildlife deserve greater attention and how lack of attention can in some instances result in those diseases becoming important zoonoses. *Disease Emergence and Resurgence* (Chapter 2) discusses the current state of emerging and reemerging diseases of wildlife and humans. *The Wildlife Factor* (Chapter 3) discusses the changing patterns of wildlife–human interactions and how those changes affect the potential for disease emergence and resurgence. *Zoonoses and Travel* (Chapter 4) provides information to expand awareness about zoonoses that may be encountered during travel and useful information for interacting with the medical community. *Is This Safe to Eat?* (Chapter 5) provides general commentary on the consumption of fish and game and addresses some of the questions commonly asked of wildlife disease specialists. *Biowarfare, Bioterrorism, and Animal Diseases as Bioweapons* (Chapter 6) focuses on the concepts, concerns, and potential for utilizing wildlife as vehicles for the introduction and transmission of infectious disease. *How to Find and Access Published Information on Emerging Infectious Diseases* (Chapter 7) provides insights and guidance for negotiating the information maze of scientific literature and staying current with advances in knowledge. Following the chapters, supplemental information ranging from a glossary of terms, scientific names of species, and other useful data are included. Literature citations provide sources for further exploration. In some instances, historical or other interests are the basis for the citation. Collectively, the contents of this book provide a wealth of information in a format that should be highly readable and informative for individuals with different levels of interest and knowledge in zoonoses and other infectious diseases of wildlife.

Milton Friend

Centuries ago, Hippocrates, in his treatise *On Airs, Waters, and Places*, c. 400 B.C., noted the linkage between environmental conditions and disease prevention and control in humans.

"When one comes into a city in which he is a stranger, he ought to consider its situation, how it lies as to the winds and the rising of the sun; for its influence is not the same whether it lies to the north or to the south, to the rising or to the setting sun. These things one ought to consider most attentively, and concerning the waters which the inhabitants use, whether they be marshy and soft, or hard and running from rocky elevations, and then if saltish and unfit for cooking; and the ground whether it be naked and deficient in water, or wooded and well-watered, and whether it lies in a hollow, confined situation, or is elevated and cold.... From these things he must proceed to investigate everything else. For if one knows all these things well, or at least the greater part of them, he cannot miss knowing, when he comes into a strange city, either the diseases peculiar to the place, or the particular nature of the common diseases, so that he will not be in doubt as to the treatment of the diseases, or commit mistakes, as is likely to be the case provided one had not previously considered these matters. And in particular, as the season and the year advance, he can tell what epidemic disease will attack the city, either in the summer or the winter, and what each individual will be in danger of experiencing from the change of regimen."

Box 1–2 Human Activities and Zoonoses

Humans interact with wildlife in many ways including cultural and subsistence use by native peoples, recreation, economic pursuits, and as a result of employment activities. Too often, the potential for disease transfer is either not considered or inadequately addressed (see Chapter 2). Increased consideration of disease can reduce human risks and still provide for the continued enjoyment and traditional uses of wildlife.

All photographs by Milton Friend

- Ecotourism—Increasing numbers of people visit "exotic places" and enter into habitat that may expose them to microbes and parasites not present in their home environment. Physical contact with wildlife often is not required because arthropod vectors, contact with contaminated waters, or cultural food habits may be the primary means for disease transmission. For example, about one-third of 26 members of a whitewater rafting expedition in Costa Rica contracted leptospirosis from the river water during their expedition.[20] Another example involves a cluster of African trypanosomiasis (sleeping sickness) in travelers to Tanzanian National Parks. Those cases are thought to represent a change in the local epidemiology of this disease.[21] Travelers can minimize their potential exposure to disease agents by learning about the status of significant diseases and taking appropriate precautions.

- **Companion Animals**—An estimated 68 million **dogs** and 73 million cats are kept as pets in the USA.[22] While outdoors, the dog or **cat** may encounter and consume wildlife such as small **rodents** that are either diseased or **carriers** of disease agents that cause zoonoses. They may also encounter **ticks** and other arthropods infected with disease agents.

  Many people also have wildlife as companion animals. Several cases of rabies resulting in substantial numbers of human exposures within the USA have been associated with pet skunks.[23] Salmonellosis has often been contracted from pet **turtles**, and Easter ducklings and chicks[24,25] and during recent years unusual *Salmonella* **serotypes** (strains) have been isolated from people having direct or indirect contact with lizards, **snakes**, or turtles.[26] Ornithosis (chlamydia) outbreaks originating from pet shops[27] and human cases associated with **birds** kept in the home[28] are other examples of zoonoses acquired from companion animals.

- **Wildlife Rehabilitation**—The strong bonds that exist between many people and wildlife have resulted in increasing involvement in efforts to save and rehabilitate injured and diseased wildlife, such as the cleaning of wildlife coated with spilled oil. In many instances, the individuals involved are not specialists in animal disease, and the clinical signs in the affected animals are too general to identify the presence of serious zoonoses. Also, the facilities where the animals are cared for, and the

management of animals within them, are rarely adequate to minimize the potential for disease transmission among animals or between the animal patients and humans. For example, an attempt to assist a sick wild baby **rabbit** resulted in tularemia affecting an eye (Parinaud's oculoglandular syndrome) of the individual attempting to provide assistance.[29] As more wildlife rehabilitators become aware of particular zoonoses and gain more knowledge about species that are likely to harbor disease agents, they will be able to better judge risks involved with individual animals brought into the rehabilitation facility (chlamydiosis and West Nile fever are two **avian** diseases of increasing importance). To reduce risks from disease, training for individuals and certifying wildlife rehabilitation facilities is essential.

- Wildlife Harvests—Many people hunt, trap, and fish; these activities result in humans having direct contact with a broad spectrum of wildlife. Nevertheless, those involved in the harvest of wildlife may have little knowledge of what disease agents may be harbored by the species they are pursuing or how humans become infected by those agents. Trichinosis infections of individuals consuming wild game meat[30,31] and a recent case of *Escherichia coli* O157:H7 from **deer** meat[32] are examples of diseases generally associated with **livestock**. Unlike domestic animals, there are no health inspections for wildlife harvested for personal consumption. Timely, objective information on wildlife diseases should be fully integrated within the framework for licensing, methods for take, and promotion of these activities. However, to better inform the public about disease risks, more wildlife-disease surveillance is needed.

- Other—Numerous other human activities have the potential to result in exposure to zoonoses. For example, 9 members of a 34-person humanitarian group from Oregon that traveled to Swaziland to participate in a construction project returned to the USA with African tick-bite fever.[33] Similar humanitarian activities in Mexico have resulted in church group members from Pennsylvania and from Washington State returning with cases of the fungal disease coccidioidomycosis.[34] People have commonly acquired Lyme disease from ticks while hiking, and have become infected with hantavirus from exposure to contaminated environments while camping.

Trapping photo courtesy of the Centers for Disease Control; all others by Milton Friend

These examples are not reasons for avoiding the activities noted. Instead, they indicate the need for greater awareness of zoonotic diseases so that people can minimize their potential risks. For example, because of the potential contact with bats, since the 1960s it has been recommended that cavers receive rabies vaccination. Nevertheless, a recent survey of cavers indicated a general under-appreciation of the risk for rabies from bat bites.[35] Similarly, recent fatal cases of yellow fever in unvaccinated travelers to the Amazon also reflect under-appreciation of the risks involved from this disease.[36,37]

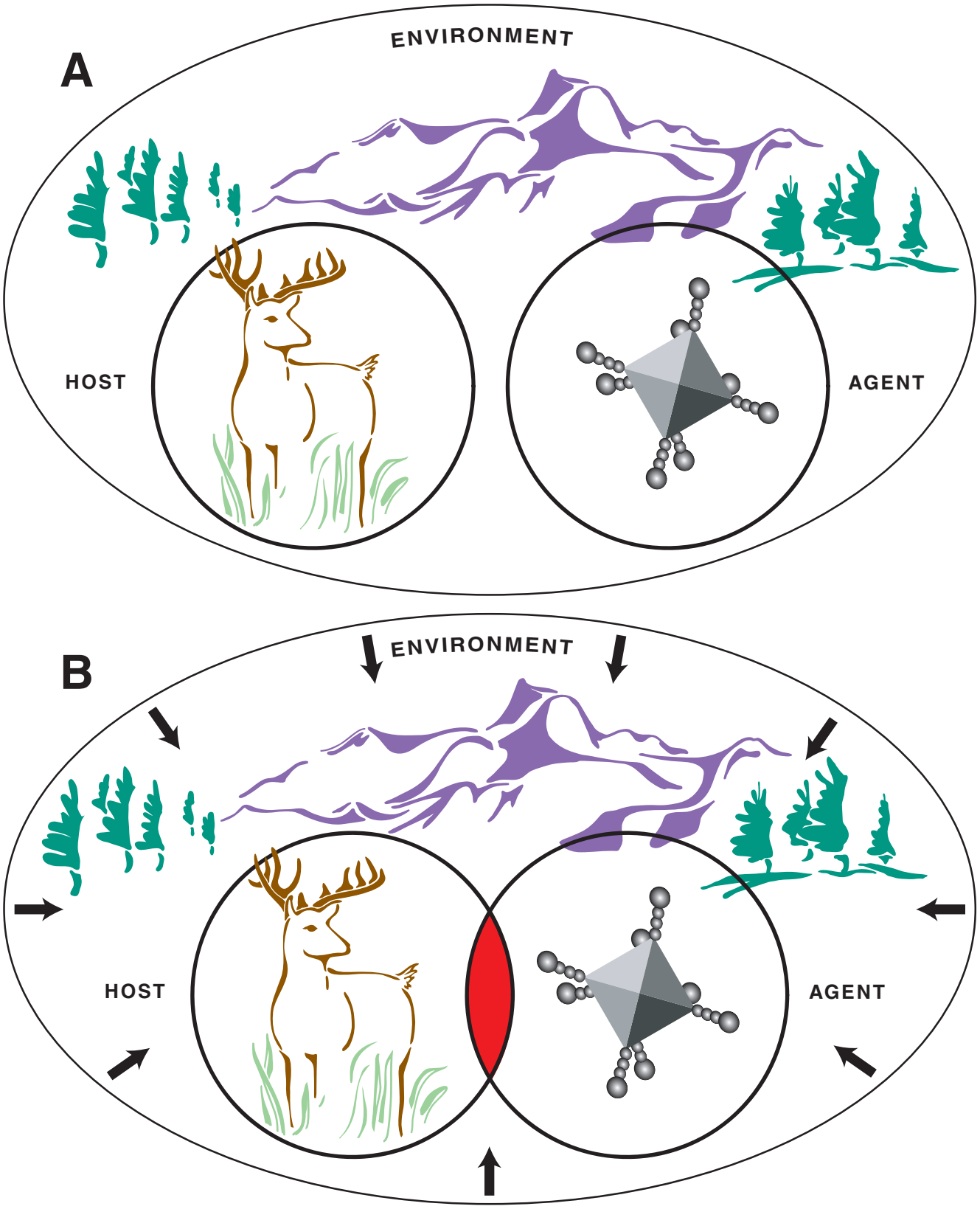


Illustration by Jennifer Rodriguez and Frances J. Bergmann

Figure 1.6 (A) Primary factors involved in the occurrence of disease: susceptible hosts; agents capable of causing disease; environmental conditions that facilitate the presence of disease agents; (B) Environmental conditions facilitate host-agent interactions in a manner that results in disease.

Table 1.1 Routes for human exposure to infectious disease agents harbored by wildlife.

Route of exposure	General circumstances (examples)
Animal bite	• Diseased animal has agent present in saliva and inoculates human through a bite wound (rabies). • Healthy animal commonly has agent present in mouth and transfers the agent through a bite wound (pasteurellosis). • Healthy animal has contaminated mouthparts from recent feeding on diseased animal and transfers the agent through a bite wound (tularemia).
Direct contact	• Individual harvesting, processing, or handling wildlife with bare hands, contact with infectious agents present within animal tissues, organs, and fluids, and in some instances on contaminated body surfaces (tuberculosis). Contaminated hands may also transfer agent to eyes (tularemia).
Indirect contact	• Swimming or otherwise immersing bare body parts in waterbodies contaminated by infectious agents able to survive within those environments. Entry of the pathogen is through small abrasions in the skin, conjunctiva of the eye, or by invasion of infectious parasites ("swimmers' itch"). • Contact with soil and other components of the terrestial environment that have been contaminated with infectious agents by rodent feces and urine (hantavirus).
Arthropod bite	• Arthropods that either become infected and harbor those infectious agents or have contaminated body parts and fluids as a result of recent feeding on an infected host transmit the disease agent when feeding on humans (West Nile fever).
Aerosol	• Individuals investigating various aspects of infectious diseases in confined areas (scientists and other laboratory workers), workers processing animals and crop harvests in production facilities, and individuals cleaning animal facilities have become infected by a variety of infectious agents present in the animals, their body discharges, or by water contaminated at other locations. The infectious agents become airborne in water sprays and by other means, are inhaled, and establish infection with the human host. In some instances, entry may occur through the conjunctiva of the eye (Newcastle disease). • Contaminated hides used for curios for the tourist trade and hides processed for the leather industry and other purposes have been a source for human infections. The infectious agents become airborne during handling and are inhaled (anthrax). • Fungal spores present in soil and in bird and bat guano become airborne when soil is disturbed. Human exposure to the fungal pathogens results from inhalation (histoplasmosis).
Ingestion	• Healthy-looking infected wildlife (including fish) are harvested and consumed without being cooked long enough or at a sufficiently high temperature to kill disease agents present (trichinosis). In some instances, the wildlife (especially fish) is consumed raw (anisakiasis).

Table 1.2 Types of infectious disease agents causing zoonoses.

Agent type (examples)	Characteristics
Virus Rabies (RNA virus); herpesvirus infections (DNA viruses)	• Organisms usually too small to be seen by light microscopy • Use the functions of living host cells of other species to replicate • Able to reproduce with genetic continuity and the possibility of mutation • Virus particle, or virion, primarily consists of either a DNA or an RNA (nucleic acid) core enclosed within a protein shell or capsid
Bacteria Salmonellosis	• Unicellular organisms, other than blue-green alga, visible by light microscopy; reproduction is commonly by cell division • Typically, the bacterial cell is contained within a cell wall
Rickettsia Rocky Mountain spotted fever	• A specialized type of bacteria that typically occurs within the cytoplasm of cells or within the gut of insects that transmit these organisms to vertebrates, including humans
Chlamydia Chlamydiosis (ornithosis, psittacosis)	• Another specialized type of bacteria that is classified as a separate group • Reproduction is only within the cytoplasm of vertebrate host cells • Reproduction is by a unique, complex developmental cycle involving attachment and penetration of the host cell by infectious elementary bodies, which undergo further transformations before developing into additional elementary bodies that are released when the dead cell is ruptured as part of the reproductive process • Do not have a cell wall
Fungi imperfecti Histoplasmosis	• Heterogeneous group of fungi with a body not differentiated into discretely recognized components for reproduction and other functions; some develop into two forms depending on the conditions for their growth (dimorphic); budding is a common form of growth • Systemic mycoses are the group most commonly involved in zoonoses of concern and are generally pulmonary in origin
Protozoa Toxoplasmosis	• "Animal-like" unicellular organisms that range in size from submicroscopic to macroscopic • Approximately 10,000 of the 35,000 species within this group are parasitic • Reproduction typically involves asexual and sexual stages
Metazoan parasites Hydatid disease (echinococcosis)	• Multicellular parasitic organisms with a body composed of cells differentiated into tissues and organs; usually with a digestive cavity lined with specialized cells • Generally macroscopic, but some are microscopic • Life cycles often involve different host species for each of the developmental stages of the parasite; a mixture of invertebrate and vertebrate intermediate (developmental) hosts is common for completion of the life cycle
Prions "Mad cow disease"	• An aberrant form of the normal cellular prion protein; causes neurodegenerative disease • An emerging disease issue about which too little is known to clearly understand the processes involved in transmission or zoonotic status

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