14.3A: Penetrating Host Defenses

Learning Objectives

- Recognize the ways a host can be infected by, and resist, pathogens

The human microbiome (or human microbiota) is the aggregate of microorganisms that reside on the surface and in deep layers of skin, in the saliva and oral mucosa, in the conjunctiva, and in the gastrointestinal tracts. They include bacteria, fungi, and archaea. Some of these organisms perform tasks that are useful for the human host. However, the majority have no known beneficial or harmful effect. Organisms that are expected to be present, and that under normal circumstances do not cause disease, but participate in maintaining health, are deemed members of the normal flora.

Many of the bacteria in the digestive tract, collectively referred to as the gut flora, are able to break down certain nutrients such as carbohydrates that humans otherwise could not digest. The majority of these commensal bacteria are anaerobes, meaning they survive in an environment with no oxygen. Normal flora bacteria can act as opportunistic pathogens at times of lowered immunity. *Escherichia coli* (*E. coli*) is a bacterium that lives in the colon. It is an extensively studied model organism. Certain mutated strains of these gut bacteria do cause disease. An example is *E. coli* O157:H7.
Figure: **Escherichia coli O157:H7**: Topographical images of colonies of *E. coli* O157:H7 strains (A) 43895OW (curli non-producing) and (B) 43895OR (curli producing) grown on agar for 48 h at 28°C. Escherichia coli O157:H7 is an enterohemorrhagic strain of the bacterium Escherichia coli and a cause of food borne illness. Infection often leads to hemorrhagic diarrhea and occasionally to kidney failure, especially in young children and elderly persons. Transmission is via the fecal-oral route. Most illness has been associated with eating under cooked, contaminated ground beef or ground pork, swimming in or drinking contaminated water, or eating contaminated vegetables.

Infection is the invasion of a host organism’s bodily tissues by disease-causing organisms, their multiplication, and the host’s reaction to these organisms and the toxins they produce. Infections are caused by pathogens such as viruses, prions, bacteria, and viroids, and larger organisms like macroparasites and fungi.

It is important to keep in mind that although the immune system has evolved to be able to control many pathogens, pathogens themselves have evolved ways to evade the immune response. An example already mentioned is in *Mycobacterium tuberculosis*, which has evolved a complex cell wall that is resistant to the digestive enzymes of the macrophages that ingest them, and thus persists in the host, causing the chronic disease tuberculosis. This section briefly summarizes other ways in which pathogens can “outwit” immune responses. But keep in mind, although it seems as if pathogens have a will of their own, they do not. All of these evasive “strategies” arose strictly by evolution, driven by selection.

Bacteria sometimes evade immune responses because they exist in multiple strains, such as different groups of *Staphylococcus aureus*. *S. aureus* is commonly found in minor skin infections, such as boils, and some healthy people harbor it in their nose. One small group of strains of this bacterium, however, called methicillin-resistant *Staphylococcus aureus*, has become resistant to multiple antibiotics and is essentially untreatable. Different bacterial strains differ in the antigens on their surfaces. The immune response against one strain (antigen) does not affect the other; thus, the species survives.

Another method of immune evasion is mutation. Because viruses’ surface molecules mutate continuously, viruses like influenza change enough each year that the flu vaccine for one year may not protect against the flu common to the next. New vaccine formulations must be derived for each flu season.

Genetic recombination—the combining of gene segments from two different pathogens—is an efficient form of immune evasion. For example, the influenza virus contains gene segments that can recombine when two different viruses infect the same cell. Recombination between human and pig influenza viruses led to the 2010 H1N1 swine flu outbreak.

Pathogens can produce immunosuppressive molecules that impair immune function, and there are several different types. Viruses are especially good at evading the immune response in this way, and many types of viruses have been shown to suppress the host immune response in ways much more subtle than the wholesale destruction caused by HIV.

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**Key Points**

- Infections are caused by pathogens such as viruses, prions, bacteria, and viroids, and larger organisms like macroparasites and fungi.
- Mammalian hosts react to infections with an innate response, often involving inflammation, followed by an adaptive response.
- Pathogens can evade the body’s immune responses through means that include specialized adaptations, mutation, evolved resistance to treatments, genetic recombination, and the production of immunosuppressive molecules that...
impair immune function.

Key Terms

• **Human microbiome**: The aggregate of microorganisms that reside on the surface and in deep layers of skin, in the saliva and oral mucosa, in the conjunctiva, and in the gastrointestinal tracts.