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Microbiology

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Textbook of Diagnostic Microbiology (Mahon, Textbook of Diagnostic Microbiology), Connie R. Mahon MS, Donald C. Lehman EdD MLS(ASCP)cm SM(NRCM), George Manuselis Jr. MA MT(ASCP)

Jawetz Melnick & Adelbergs Medical Microbiology, Stefan Riedel (Author), Stephen Morse (Author), Timothy Mietzner (Author), Steve Miller.

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Microbiology

Microbiology (Greek: mīkros small; bios life), it primarily deals with organisms too small for the naked eye to see, encompasses the study of organisms that cause disease, the host response to infection and ways in which such infection may be prevented. So the microbiology is the study of microorganisms, a group of microscopic organisms that are as single cells or clusters; it also includes viruses, which are microscopic but not cellular.

The current understanding based on their genetic relatedness is that all forms of life fall into three domains: Archaea, Bacteria and Eucaryotic. Note that taken together, Archaea and Bacteria are also known as prokaryotes. Viruses are not included in this classification as they are unique, acellular, metabolically inert organisms and therefore replicate only within living cells**.**

Types of microbial interaction.

Positive interaction: mutualism, commensalism.

Negative interaction: Ammensalism (antagonism), parasitism, predation, competition.

Mutualism (Symbiosis): It is defined as the relationship in which each organism in interaction gets benefits from association. It is an obligatory relationship in which mutualism and host are metabolically dependent on each other.

Commensalisms: is a unidirectional relationship between populations in which one population benefits & the other one is unaffected; such as one species of organism uses the body of a larger species as its physical environment.

Amensalism (Antagonism): When one microbial population produces substances that is inhibitory to other microbial population then this inter population relationship is known as Ammensalism or Antagonism. It is a negative relationship. The first population which produces inhibitory substances are unaffected or may gain a competition and survive in the habitat while other population get inhibited. This chemical inhibition is known as antibiosis**.**

Competition: The competition represents a negative relationship between two microbial population in which both the population are adversely affected with respect to their survival and growth. Competition occurs when both population uses same resources such as same space or same nutrition, so, the microbial population achieve lower maximum density or growth rate.

Parasitism: It is a relationship in which one population (parasite) get benefited and derive its nutrition from other population (host) in the association which is harmed. Ectoparasite: when the parasite lives outside host cell while other parasite lives inside host cell, known as endoparasite.

Predation: It is a wide spread phenomenon when one organism (predator) engulf or attack other organism (prey).The prey can be larger or smaller than predator and this normally results in death of prey. Normally predator-prey interaction is of short duration.

Synergism: in which both populations benefit from the relationship but that the association is not obligatory. Both populations are capable of surviving independently, although they both gain advantage from the synergistic relationship.

Pathogenesis of bacterial infections:

The pathogenesis of bacterial infection includes initiation of the infectious process and the mechanisms that lead to the development of signs and symptoms of disease. The biochemical, structural, and genetic factors that play important roles in bacterial pathogenesis.

Characteristics of bacteria that are pathogens include transmissibility, adherence to host cells, persistence, invasion of host cells and tissues, toxigenicity, and the ability to evade or survive the host's immune system. Resistance to antimicrobials and disinfectants can also contribute to virulence, or an organism's capacity to cause disease. Many infections caused by bacteria that are commonly considered to be pathogens are in apparent or asymptomatic. Disease occurs if the bacteria or immunologic reactions to their presence cause sufficient harm to the person.

Bacterial virulence factors:

There are some factors that help microbes to be harmfull to human.

1-Adherence Factors

Adherence is the first step in the infectious process, is followed by development of microcolonies and subsequent steps in the pathogenesis of infection. When bacteria enter the body of the host, they must adhere to cells of a tissue surface. If they did not adhere, they would be swept away mucus

and other fluids that bathe the tissue surface. Many bacteria have pili, thick rod like appendages or fimbriae, shorter “hair like” structures that extend from the bacterial cell surface and help mediate adherence of the bacteria to host cell surfaces.

After adherence occurs, conformational changes in the host cell ensue that can lead to cytoskeletal changes allowing organism uptake by the cell. Sometimes, changes in the adhesion molecule after attachment may trigger activation of virulence genes that promote invasion or that result in other pathogenic changes.

2-Invasion of Host Cells and Tissues

Invasion is the term commonly used to describe the entry of bacteria into host cells and for many disease-causing bacteria, invasion of the host’s epithelium is central to the infectious process.

When inside the host cell, bacteria may remain enclosed in a vacuole composed of the host cell membrane, or the vacuole membrane may be dissolved and bacteria may be dispersed in the cytoplasm. Some bacteria multiply within host cells, but other bacteria do not. Toxin production and other virulence properties are generally independent of the ability of bacteria to invade cells and tissues.

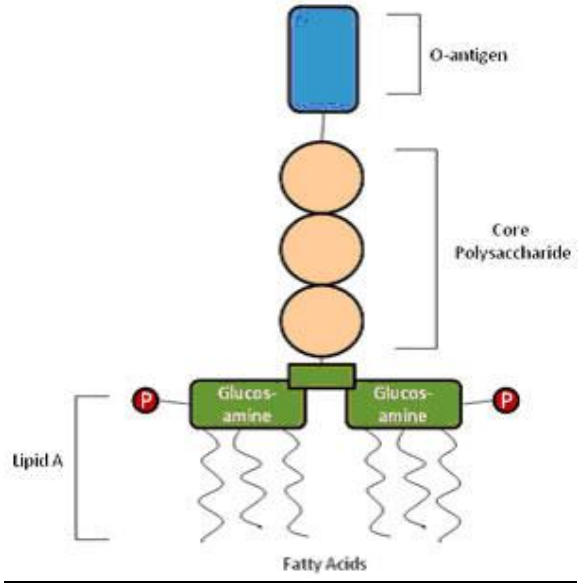
Toxins

A. Exotoxins

Many gram-positive and gram-negative bacteria produce exotoxins of considerable medical importance.

Endotoxins

The LPS (endotoxin) of gram-negative bacteria are bacterial cell wall components that are often liberated when the bacteria lyse. They have three main regions. The lipid A domain is the region recognized by the immune system and is the component that is responsible for cytokine stimulation. The other two components are an oligosaccharide core and an outermost O-antigen polysaccharide.



Exotoxins	**Endotoxins**
Excreted by organisms, living cell	Integral part of cell wall
Found in both Gram positive and Gram Negative bacteria	Found mostly in Gram Negative Bacteria
It is polypeptide	It is lipopolysaccharide complex.

heat labile (60°C)	heat tolerant
Highly antigenic	Weakly immunogenic
Toxoids can be made by treating with formalin	Toxoids cannot be made
Highly toxic, fatal in µg quantities	Moderately toxic
Usually binds to specific receptors	Specific receptors not found
Not pyrogenic usually, Toxin Specific	Fever by induction of interleukin 1 (IL-1) production, Shock
It has mostly enzymatic activity	It has no enzymatic activity
Its molecular weight is 10KDa	Its molecular weight is 50-1000KDa
On boiling it get denatured.	On boiling it cannot be denatured.

Enzymes

A.Tissue-Degrading Enzymes

Many bacteria produce tissue-degrading enzymes. The roles of tissue-degrading enzymes in the pathogenesis of infections is clear.

B.Proteases

The bacterial proteases have the potential to destroy the structural and functional proteins that constitute host tissues as well as to destroy proteins important in host defense.

C.Antiphagocytic Factors:

Impeding or preventing the action of the phagocytes. Some bacterial pathogens are rapidly killed after they are ingested by polymorphonuclear cells or macrophages. Some pathogens evade phagocytosis or leukocyte microbicidal mechanisms by adsorbing normal host components to their surfaces. A few bacteria produce soluble factors or toxins that inhibit chemotaxis by leukocytes and thus evade phagocytosis by a different mechanism.

D.Intracellular Pathogenicity

Most microorganisms are destroyed by the host tissues through processes which usually involve phagocytosis and lysosomal disruption. However, some organisms are capable of growing inside macrophages and avoiding destruction. The bacteria use several mechanisms: they may avoid entry into phagolysosomes and live within the cytosol of the phagocyte; they may prevent phagosome–lysosome fusion and live within the phagosome.

E.Antigenic Heterogeneity

Antigenic alteration refers to the mechanism by which an infectious agent such as a protozoan, bacterium or virus alters the proteins or carbohydrates on its surface and thus avoids a host immune response. It is related to phase variation. Antigenic variation not only enables the pathogen to avoid the immune response in its current host, but also allows re-infection of previously infected hosts.

F.Iron Requirement

Iron is perhaps the most important micronutrient required for bacteria to proliferate and cause disease. Iron has several roles within a bacterial cell. It is required to render active many different proteins and enzymes involved in a variety of metabolic processes. The ability of a microbial pathogen to efficiently obtain iron from the host environment is critical to its ability to cause disease. For ex. *C. diphtheriae* that carry the lysogenic bacteriophage and low iron availability, there is increased production of diphtheria toxin and potentially more severe disease

G.Bacterial Biofilms

Bacterial biofilms are clusters of bacteria that are attached to a surface and/or to each other and embedded in a self-produced matrix. The biofilm matrix consists of substances like proteins, polysaccharide, as well as eDNA. In addition to the protection offered by the matrix, bacteria in biofilms can employ several survival strategies to evade the host defense systems. By staying dormant and hidden from the immune system, they may cause local tissue damage and later cause an acute infection. Within the biofilm, the bacteria adapt to environmental anoxia and nutrient limitation by exhibiting an altered metabolism, gene expression, and protein production, which can lead to a lower metabolic rate and a reduced rate of cell division**.**