HOST-PARASITE RELATIONSHIP

NATURE OF HOST-PARASITE
Bacteria are consistently associated with the:
1) Body surfaces
2) Mucus membranes
3) Intestinal linings of humans
There are many more bacterial cells on the surface and the gastrointestinal tract of a human than there are human cells that make up the body

Normal Flora
bacteria and other microbes that are consistently associated with the body (Symbiosis)
Symbiosis is defined as:
"life together"
two organisms live in an association with one another
Three types of relationships based on the quality of the relationship for each member of the symbiotic association
Mutualism
Commensalism
Parasitism

MUTUALISM
Both members of the association benefit
A classic mutualistic association is that of the lactic acid bacteria that live on the vaginal epithelium of a woman
The bacteria are provided habitat with a constant temperature and supply of nutrients (glycogen) in exchange for the production of lactic acid
Bacteria produced lactic acid protects the vagina from colonization and disease caused by yeast and other potentially harmful microbes

COMMENSALISM
There is no apparent benefit or harm to either member of the association
Staphylococcus epidermidis, a consistent inhabitant of the skin exhibits a commensal relationship with humans
Staphylococcus epidermidis produces lactic acid that protects the skin from colonization by harmful microbes that are less acid tolerant
Some research has shown that other metabolites that are produced by the bacteria are a contributing factor of body odors and possibly associated with certain skin cancers

PARASITISM
An organism that grows, feeds and is sheltered on or in a different organism while contributing nothing to the survival of its host
parasites are capable of causing damage to the host
Parasitism may become pathogenic if the damage to the host results in disease
Some parasitic bacteria live as normal flora of humans while waiting for an opportunity to cause disease
Other non-indigenous parasites generally cause disease

PATHOGENICITY
A pathogen is a microorganism that is able to produce disease
Pathogenicity is the ability of a microorganism to cause disease in another organism, namely the host for the pathogen
Pathogenicity may be a manifestation of a host-parasite interaction
Some of the normal bacterial flora are potential pathogens that live in a commensal or parasitic relationship without producing disease
Staphylococcus aureus
Streptococcus pneumoniae
These normal flora do not cause disease in their host unless they have an opportunity brought on by a compromise or weakness in the:
- Host's anatomical barriers
- Tissue resistance
- Immunity

**OPPORTUNISTIC PATHOGENS**
Bacteria which cause a disease in a compromised host which typically would not occur in a healthy host
A member of the normal flora can cause an opportunistic infection, but so can an environmental organism
Classic opportunistic infections in humans are caused by normal flora of the oral cavity:
- dental caries
- periodontal disease

**INFECTION**
The blood and internal tissues are sterile and void of bacteria
If a bacterium, whether or not a component of the normal flora, breaches one of these surfaces, an infection is said to have occurred
Infection does not necessarily lead to infectious disease
Factors that play a role in determining the outcome of infection and lead to disease are:
- Route of entry
- The number of infectious bacteria
- The status of the host defenses (most important)

**VIRULENCE**
Virulence is the degree of pathogenicity
Pathogenic bacteria are able to produce disease because they possess traits that render them pathogenic or virulent:
- Structural
- Biochemical
- Genetic
The sum of the characteristics that allow a given bacterium to produce disease are the pathogen's determinants of virulence
Some pathogens may rely on a single determinant of virulence to cause damage to their host
- Such as toxin production
*Clostridium tetani* and *Corynebacterium diphtheriae* are able to produce disease despite possessing few invasive characteristics
Symptoms of disease depend on a single genetic trait in the bacteria:
- the ability to produce a toxin
Pathogens, such as *Staphylococcus aureus*, *Streptococcus pyogenes* and *Pseudomonas aeruginosa*, maintain a large repertoire of virulence determinants
Consequently they are able to produce a more complete range of diseases that affect different tissues in their host

**HOST DEFENSES**
The bacterial parasite has its determinants of virulence that allow it to invade and damage the host and to resist the defenses of the host
The host has various degrees of resistance to the parasite in the form of the host defenses
A healthy animal can defend itself against pathogens at different stages in the infectious disease process
The host defenses may be of such a degree that infection can be prevented entirely
If infection does occur:
- the defenses may stop the process before disease is apparent
the defenses that are necessary to defeat a pathogen may not be effective until infectious disease is well into progress.

Typically the host defense mechanisms are divided into two groups:

1) Constitutive Defenses
2) Inducible Defenses

**CONSTITUTIVE DEFENSES**
Provide general protection against invasion also referred to as "natural" or "innate" resistance, since they are inherent to the host.

**INDUCIBLE DEFENSES**
Generally quite specifically directed against an invading pathogen.

Constitutive defenses, by themselves, may not be sufficient to protect the host against pathogens.

Such pathogens that evade or overcome the nonspecific constitutive defenses are usually susceptible to the more specific inducible defenses, once they have developed.

The inducible defenses are a function of the immunological system and the immune responses.

The inducible defenses must be triggered in a host and initially take time to develop.

**ACQUIRED IMMUNITY**
The type of resistance thus developed in the host is called *acquired immunity*.

Acquired immunity, itself, is sometimes divided into two types, based on how it is acquired by the host.

- **Active**
- **Passive**

**ACTIVE IMMUNITY**
The host undergoes an immunological response and produces the cells and factors responsible for the immunity.

- Antibodies
- Lymphocytes

Active immunity can persist a long time in the host, up to many years in humans.

**PASSIVE IMMUNITY**
Acquisition of immune factors which were produced in another animal.

- the host receives antibodies and/or lymphocytes originally produced in another animal.

Typically persists only a few weeks or months.

**ANTIGENS**
Antigens are chemical substances that stimulate the immune response in animals.

Bacteria are composed of various macromolecular components that are antigens or "antigenic" in their host.

Bacterial antigens interact with the host immunological system in a variety of ways.

**NATURAL ANTIBODIES**
Studies on germ-free animals show that bacterial flora in the intestinal tract are required for development of immunological tissues in the intestine.

The interaction between these immune tissues and intestinal bacteria results in the production of antibodies that are directed against bacterial antigens.

These antibodies probably help protect the host from invasion by its own normal flora.

They can also react with related pathogens.

- Ex: antibodies against normal *E. coli* could react with related pathogenic *Shigella dysenteriae*.

These type of antibodies are called natural antibodies.

**BACTERIAL ANTIGENS**
Bacterial antigens that are the components or products of pathogens are the substances that induce the immune defenses of the host to defend against, and to eliminate, the pathogen or disease.
In the laboratory, these bacterial antigens can be manipulated so that they will stimulate the immune response in the absence of infection

**ACTIVE IMMUNIZATION**
These isolated or modified antigens are the basis for active immunization (vaccination) against bacterial disease
A modified form of the tetanus toxin which has lost its toxicity but retains its antigens, is used to immunize against tetanus
Antigenic parts of the whooping cough bacterium can be used to induce formation of antibodies that will react with the living organism and prevent infection

**ANTIMICROBIAL AGENTS**
One line of defense against infection is with antimicrobials such as antibiotics
Originally, a group of soil bacteria, the *Streptomyces*, were the most innovative producers of antibiotics
- Streptomycin
- Tetracycline
- Erythromycin
- Chloramphenicol

Bacteria have the capability to evolve rapidly toward resistance
bacteria can exchange genes for antibiotic resistance, and because of misuses of antibiotics, many pathogens are emerging as resistant to antibiotics
There are infections caused by *Enterococcus*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* that are resistant to all known antibiotics
Bacterial resistance to antimicrobial agents has become part of a pathogen's determinants of virulence
The body heals itself
- most antibiotics just stop bacterial growth, and the host must rely entirely on its native defenses to accomplish the neutralization of bacterial toxins or the elimination of bacterial cells

**HOST FACTORS**
1) Skin
2) Mucosal surfaces
   - oropharynx
   - respiratory tract
   - intestinal tract
   - urinary tract
3) Sub-epithelium

**SKIN**
first barrier against organisms unless:
- its physically compromised
- the immune system is depressed

The epithelial layer of the skin is continuously being replaced
has inhibitory activity to growth of organisms
- low moisture
- low pH
- lactic acid from sweat glands

Most microorganisms are associated with sweat glands and hair follicles because of the moist and nutritious environment
Urea, amino acids, salts, lactic acids, and lipids are secreted through the skin and provide microorganisms with what they need to grow
Some of the most commonly found microorganisms on the skin are:
- *Corynebacterium diptheriae*
Staphylococcus aureus
Micrococcus luteus
Staphylococcus epidermis
Pityrosporum ovale

Most bacteria are beneficial to the skin because they prevent colonization of the skin by pathogens.
But if a cut is present, these bacteria can enter the body and cause damage.

**MUCOSAL SURFACES**

slgA
prevents the binding of some pathogens

Commensals
create an environment that prevents noncommensals from colonizing

Mucins
prevent adherence of organisms and toxins

Enzymes which aid in defense
- Lysozyme
- Lactoferrin
- Peroxidases

**OROPHARYNX**

Saliva contains inhibitors of some organisms
- lysozyme
- secretory antibodies (slgA)

**RESPIRATORY TRACT**

slgA is secreted in mucus that traps and inhibits foreign agents

Cilia on the trachea sweep mucus with foreign agents to the throat

There are macrophages in the alveoli for phagocytosis

**INTESTINAL TRACT**

cells secrete products that can destroy some organisms
- *Acid* in the stomach
- *bile salt*
- *gastric and pancreatic enzymes*
- *hydrolytic acid* in the intestine
- *Mucus* lining the intestine trap and inhibit organisms which are removed by peristaltic action

**UROGENITAL TRACT**

Urine from the bladder is normally sterile

In females lactic acid prevents the growth of some organisms

Passage of urine has a flushing effect and along with low pH tend to inhibit microbial growth

**SUBEPITHELIUM**

has antimicrobial factors

Tissue fluid contains antibodies and serum factors that are bactericidal (Properdin)

Lymph system has phagocytes

local phagocytes at the site where organisms entered the body

**MICROBIAL FACTORS**

factors which enhance pathogenicity
- adherence
- invasiveness
- toxins
- avoidance
- iron

**ADHERENCE**
Organisms must have adhesin to bind to the host but the host must have receptors for the adhesin

Types of adhesins
- Pili
- Lipoteichoic acid
- Capsules

**INVASIVENESS**
The ability of organisms to penetrate tissues

**TOXINS**

Exotoxin
- A protein that is antigenic and produced mostly by gram positive organisms
- Composed of 2 subunits, a part that binds to the cell surface and facilitates entry of the second subunit that is toxic

Endotoxin
- Found in the cell wall of some gram negative organisms and is bound to lipid A which is toxic

**AVOIDING THE HOST DEFENSE**

Capsules
- allow some organisms to avoid phagocytosis and digestion

Changing the antigenic determinants
- Some organisms can avoid the immune system

Similar proteins
- Others avoid the host defense by coating themselves with proteins similar to that coating red blood cells

Special proteins
- M protein of some organisms affects the binding of complement and therefore prevent opsonization

**IRON**

Most bacteria require iron for certain enzymes to function

In humans
- iron forms a complex with iron-binding proteins that are bacteriostatic
  - transferrin in blood
  - lactoferrin in milk
- this bacteriostatic effect is lost when these molecules are saturated with iron

Some bacteria secrete Siderophores
- Remove iron from the host for their growth and enhance their virulence

Examples of siderophores are
- Aerobactin
- Enterobactin

**END HOST-PARASITE RELATIONSHIP**