Host Microbe Interactions

Part 1: The Good - Resident Biota

Normal biota:

- Large and diverse collection of microbes living on and in the body
- Resident or indigenous biota
- Include bacteria, fungi, protozoa and viruses
  - These organisms have a profound effect on human biology

The Human Microbiome Project

http://www.npr.org/blogs/health/2013/11/18/244526773/gut-bacteria-might-guide-the-workings-of-our-minds

Preliminary results:

- 10 X more microbes that human cells
- Human cells contain 22,000 protein encoding genes; microbes that inhabit humans contain 8 million
- Most are good
- All healthy people harbor potentially dangerous pathogens, but in low numbers

Acquiring Resident Biota – Table 13.1

Acquiring Resident Biota – Table 13.2

Acquiring Resident Biota

Benefits of normal biota:

- Influence the development of organs
- Prevent the overgrowth of harmful microorganisms

Microbial antagonism:

- The general antagonistic effect "good" microbes have against intruder microorganisms
- Microbes in a steady, established relationship are unlikely to be displaced by incoming microbes

The Importance of Gut Biota

Intestinal biota can influence many facets of your overall health.

Have been associated with risk for:

- Heart disease
- Asthma
- Autism
- Rheumatoid arthritis
- Even thoughts, moods, and propensity for mental illness

Endogenous infections:

- Caused by normal flora
- Normal flora introduced into sterile areas
  - Example: *Escherichia coli* entering the bladder, resulting in a UTI

Initial Colonization of the Newborn

Microbiota may be introduced *in utero*.

- Important for healthy full term pregnancies and healthy newborns

Also acquired during birth and shortly afterwards

Continued through diet:

- Breast milk contains around 600 species of bacteria and sugars that babies cannot digest
  - Sugars used by healthy gut bacteria
  - Breast milk may be necessary for maintaining a healthy gut microbiome in

the baby
Indigenous Biota – Table 13.4 of Specific Regions

Part 2: The Bad: Colonization, Infection, Disease

Infection:
Pathogenic microorganisms penetrate host defenses, enter the tissues, and multiply
Pathologic state:
Cumulative effects of infection damage
Disruption of tissues and organs
Results in **disease**
Disease:
Any deviation from health
Factors that cause disease:
Infections
Diet
Genetics
Aging
Infectious disease:
Disruption of tissues or organs caused by microbes or their products
The Progress of Infection
Pathogen:
A microbe whose relationship with its host is parasitic
Results in infection and disease
Type and severity of infection depend on both the pathogenicity of the organism and the condition of the host
Pathogenicity:
Describes an organism's potential to cause infection or disease
True pathogens:
Capable of causing disease in healthy persons with normal immune defenses
Opportunistic pathogens:
Cause disease when:
The host's defenses are compromised
When they become established in a part of the body that is not natural to them
The Progress of Infection
Virulence:
The relative severity of the disease caused by a particular microorganism
Virulence factor:
Any characteristic or structure of the microbe that contributes to toxin production or induction of an injurious host response
Biosafety Levels (BSL):
A system of biosafety categories adopted by the Centers for Disease Control and Prevention (CDC)
Based on the general degree of pathogenicity and the relative danger in handling these pathogens
The Progress of Infection – Table 13.5
Becoming Established: Step One – Portals of Entry
Portal of entry:

A characteristic route taken by a microbe to initiate infection
Usually through skin or mucous membranes
Exogenous: originating from outside the body
The environment, another person, or animal
Endogenous: already existing in the body
Normal biota or a previously silent infection

Skin

Sites of entry:
- Nicks
- Abrasions
- Punctures
- Conjunctiva

Intact skin - very tough barrier

The Gastrointestinal Tract

Entry through
- food
- drink
- other ingested substances

Adapted to survive digestive enzymes and abrupt pH changes

Respiratory System

Openings to the respiratory tract:
- Oral cavity
- Nasal cavity

Continuous mucous membrane
- Upper respiratory tract, sinuses, and auditory tubes.
- Microbes often transferred from one site to another

Urogenital System

Sexually transmitted infections (STIs):
- Account for 4% of infections worldwide
- 13 million new cases in the U.S. each year

Entry points through the skin or mucosa of:
- Penis
- External genitalia
- Vagina
- Cervix
- Urethra

Urogenital Portals of Entry – Table 13.6

Pathogens That Infect During Pregnancy and Birth

The placenta is an exchange organ:
- Maternal and fetal tissues
- Separates mother and baby's blood
- Permits diffusion of dissolved nutrients and gases to the fetus
- A few microbes cross the placenta and are spread by the umbilical vein into the fetal tissues.
- Pathogens can be transmitted perinatally as the child passes through the birth canal.

TORCH: common infections of the fetus and neonate.
- **T**oxoplasmosis
- **O**ther diseases: syphilis, coxsackievirus, varicella-zoster virus, AIDS, chlamydia
- **R**ubella

Cytomegalovirus
Herpes simplex virus

The Size of the Inoculum

Infectious dose (ID): a minimum number of microbes required for an infection to proceed

Determined experimentally for many microbes
Microbes with a smaller infectious dose have greater virulence

Becoming Established: Step Two – Attaching to the Host

Adhesion:

Microbes - stable foothold on host tissues
Binding between specific molecules on both the host and pathogen
A particular pathogen is limited to only those cells and organisms to which it can bind
Once attached, a pathogen can invade body compartments

Attaching to the Host – Table 13.7

Becoming Established: Step 3 – Surviving Host Defenses

Phagocytes:

White blood cells that engulf and destroy pathogens

Antiphagocytic factors:

Used by pathogens to avoid phagocytes
Leukocidins
Capsules
Survive after engulfed

Step Four: Causing Disease

Virulence factors:

Structures, products, or capabilities that allow a pathogen to cause infection in the host
Adaptations that a microbe uses to invade and establish itself in a host
Determine the degree of tissue damage that occurs

Extracellular Enzymes

Exoenzymes:

Secreted by pathogenic bacteria, fungi, protozoa, and worms
Break down and inflict damage on tissues
Dissolve host's defense barriers and promote the spread of microbes into deeper tissues

Mucinase
Keratinase
Collagenase
Hyaluronidase

Bacterial Toxins: A Potent Source of Cellular Damage

Toxin:

Poisonous substance

Exotoxin:

Secreted by a living bacterial cell to the infected tissues
Many types

Endotoxin:

Shed from the outer membrane when microbe is damaged
Only found in gram-negative bacteria

Bacterial Toxins – Table 13.8

Inducing an Injurious Host Response

Many cases of microbial diseases are the result of indirect damage.

Host's excessive or inappropriate response to a microorganism
Pathogenicity is a trait not solely determined by microorganisms
Consequence of an interplay between microbe and host

The Process of Infection and Disease

Microbes settle in a target organ and cause damage at the site.
Type and scope of injuries account for:
Typical stages of infection
Patterns of the infectious disease
Manifestation in the body

Patterns of Infection

Localized infection:
Microbe enters the body and remains confined to a specific tissue
Boils
Fungal skin infections
Warts
Systemic infection:
When an infection spreads to several sites and tissue fluids, usually in the bloodstream.
Viral: measles, rubella, chickenpox, AIDS
Bacterial: brucellosis, anthrax, typhoid fever, syphilis
Fungal: histoplasmosis, cryptococcosis
Infectious agents can travel by means of nerves or cerebrospinal fluid
Focal infection:
Exists when the infectious agent breaks loose from a local infection and is carried to other tissues
Examples:
Tuberculosis
Streptococcal pharyngitis: scarlet fever
Toxemia: infection remains localized, toxins are carried through the blood to the target tissue
Mixed infection:
Several agents establish themselves simultaneously at the infection site
In synergistic infections, microbes cooperate in breaking down tissue
In other mixed infections, one microbe creates an environment that enables another microbe to invade
Primary infection:
Initial infection
Secondary infection:
Occurs when a primary infection is complicated by another infection caused by a different microbe
Acute infections:
Come on rapidly
Have short-lived effects
Chronic infections:
Progress and persist over a long period of time

Signs and Symptoms: Warning Signals of Disease

Sign:
Any objective evidence of disease as noted by an observer
Symptom:
Subjective evidence of disease as sensed by the patient

Syndrome:

A disease identified or defined by a certain complex of signs and symptoms

Signs and Symptoms: Table 13.6 Signs and Symptoms of Disease

Signs and Symptoms of Inflammation

Inflammation:

Earliest symptom of disease

Edema:

Accumulation of fluid in afflicted tissue

Granulomas and **Abscesses:**

Walled-off collections of inflammatory cells and microbes in the tissues

Lymphadenitis:

Swollen lymph nodes

Signs of Infection in the Blood

Leukocytosis:

Increase in the level of white blood cells

Leukopenia:

Decrease in the level of white blood cells

Septicemia:

General state in which microbes are multiplying in the blood and are present in large numbers

Bacteremia:

Small numbers of bacteria are present in the blood but not multiplying

Viremia:

Presence of viruses in the blood, whether or not they are actively multiplying

Infections That Go Unnoticed

Asymptomatic, subclinical, or **inapparent** infections:

Host is infected but does not show symptoms of disease

Vacating the Host: Step Five – Portals of Exit

Portal of exit:

Pathogens exit the host

- Secretion
- Excretion
- Discharge
- Sloughed tissue

Respiratory and Salivary

Escape media for pathogens that infect the upper and lower respiratory tract:

- Mucus
- Sputum
- Nasal drainage
- Moist secretions

Skin Scales

The outer layer of skin and scalp is constantly being shed

- Household dust is composed of skin cells
- A single person can shed several billion skin cells a day

Fecal Exit

Some intestinal pathogens cause irritation in the intestinal mucosa that increases the motility of the bowel.

- Diarrhea - rapid exit for the pathogen
- Helminth worms - release eggs and cysts through the stool
- Feces containing pathogens creates a public health problem

Urogenital Tract

Agents involved in STIs leave the host in vaginal discharge or semen.
Source of neonatal infections during birth.

- Herpes simplex
- *Chlamydia*
- *Candida albicans*

Blood

Pathogen is released when blood is removed or released through vascular puncture.
Blood-feeding animals are the most common transmitters of pathogens:

- Ticks
- Fleas
- Mosquitoes

The Persistence of Microbes and Pathologic Conditions

Latency:

- A dormant state of an infectious agent
- Microbe can become active and produce recurrent disease

Sequelae:

- Long-term or permanent damage to organs and tissues

What Happens in Your Body

Incubation period:

- The time from initial contact with the infectious agent to the appearance of first symptoms

Prodromal period:

- When the earliest notable symptoms of infection appear

Period of invasion:

- Infectious agent multiplies at high levels and exhibits greatest virulence

Convalescent stage:

- Patient responds to infection and symptoms decline

Reservoirs: Where Pathogens Persist

Reservoir:

- A permanent place for an infectious agent to reside

Source:

- Individual or object from which the infection is acquired

Carrier:

- An individual who *inconspicuously* shelters a pathogen and can spread it to others without knowing

Living Reservoirs – Figure 13.12

Vector:

- A live animal that transmits an infectious agent from one host to another
- Majority of vectors are arthropods:
  - **Biological vector:**
    - Actively participates in a pathogen's life cycle
    - Serves as a site in which it can multiply or complete its life cycle
  - **Mechanical vectors:**
    - Not necessary to the life cycle of an infectious agent
    - Merely transport it without being infected

Animals as Reservoirs and Sources

Zoonosis:

- An infection indigenous to animals but naturally transmissible to humans
- Human does not contribute to the natural persistence of the microbe
- Spread of disease is promoted by close associations of humans with animals

Animals as Reservoirs and Sources – Table 13.10

Nonliving Reservoirs

Microbes have adapted to nearly every habitat in the biosphere.

- Soil, water, and air
- Most are saprobic and cause little harm to humans
- Some are opportunists
- A few are regular pathogens

The Acquisition and Transmission of Infectious Agents

Communicable disease:

- Occurs when an infected host can transmit the infectious agent to another host and establish infection in that host

Contagious:

- The agent is highly communicable, especially through direct contact

Noncommunicable:

- Does **not** arise through transmission of the infectious agent from host to host

Patterns of Transmission in Communicable Diseases

Direct Contact

- Touching
- Kissing
- Sexual Intercourse
- Vertical Transmission
  - Prenatal – across placenta
  - Perinatal – during childbirth

Indirect Spread by Vehicles: Fomites

Vehicle:

- Any inanimate material commonly used by humans that can transmit infectious agents

Fomite:

- An inanimate object that harbors and transmits pathogens
- Not a continuous source of infection

Indirect Spread by Vehicles

Oral-fecal route:

- Fecal carrier with inadequate personal hygiene contaminates food during handling, and an unsuspecting person ingests it
  - Hepatitis A
  - Amoebic dysentery
  - Shigellosis
  - Typhoid fever

Water, Soil, and Air as Vehicles

Water and soil may harbor pathogens:

- Can also become temporarily contaminated with pathogens that come from humans

Air:

- Indoor air can serve as a support medium for the suspension and dispersal of respiratory pathogens via droplet nuclei and aerosols

Droplet nuclei:

- Dried microscopic residues created when microscopic pellets of mucus and saliva are ejected from the mouth and nose

Aerosols:

- Suspensions of fine dust or moisture particles in the air that contain live pathogens

Healthcare-Associated Infections

Healthcare-associated infections (HAIs):

- Nosocomial Infections
- Infectious diseases that are acquired or develop during a hospital stay or stay in another health care facility
- Rates of HAIs can range from 0.1 – 20% of all admitted patients

Medical asepsis:

- Goal: limit the spread of infectious agents from person to person

Surgical asepsis:

- Ensuring all surgical procedures are conducted under sterile conditions

Infection control officer:

- Implements proper practices and procedures throughout the hospital
- Charged with:
  - Tracking potential outbreaks
  - Identifying breaches in asepsis
  - Training other healthcare workers in aseptic technique

Universal Precautions

Universal Precautions (UPs):

- Barrier precautions
- Needlestick precautions
- Precautions with dental handpieces
- Decontamination after hands and surfaces have been contaminated with blood and other fluids
- Healthcare workers with active, draining skin or mucous membrane lesions must refrain from handling patients

Using Koch's Postulates to Determine Etiology

Essential aim of the study of infection and disease is determining the **etiologic agent** (causative agent).

Robert Koch:

- Developed a standard for determining causation of disease that stood the test of scientific scrutiny
- Determined the causative agent of anthrax
- **Koch's postulates:**
  - A series of proofs that established the principal criteria for etiologic studies

Koch's Postulates – Figure 13.17

TOOLKIT CREDITS:
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WEBSITE:
http://www.coexploration.org/C-DEBI/toolkits_biology.html