**Infectious Diseases: Skin**

**Structure of the Skin**

- **Functions of the skin**
  - Prevents excessive water loss
  - Important to temperature regulation
  - Involved in sensory phenomena
  - Barrier against microbial invaders
- **Composed of two main layers**
  - Dermis
  - Epidermis
Skin

• Epidermis
  – Stratum corneum (dead cells are sloughed off)
    • Keratin (protein)
      – Waterproof the skin
      – Protects from microbial invasion
    – Replaced every 25-45 days
    – No nerve endings or blood vessels

Skin continued

• Dermis
  – Source for epidermis cells
  – Connective tissue (fibers)
  – Nerves, blood vessels, lymphatic
  – Hair follicles, glands (sebum, lysozyme)
• Subcutaneous layer

Normal Flora of the Skin

• normally harmless microbes able to survive on the skin
  – Cannot be completely removed through cleansing
  – various microbes
    • The yeast, Malassezia
    • The bacteria, S. epidermidis, Micrococcus, and the diphtheroids
  – Can produce disease (especially if penetrate epidermis or suppressed immune system)
Wounds

- Trauma to any tissue of the body
  - Cuts, scrapes, surgery, burns, bites, etc.
- Allow microbes to infect the deeper tissues of the body
- In most cases other body defenses eliminate the infection
- Can result in severe or fatal diseases

Folliculitis

- Signs and symptoms
  - Infection of the hair follicle
  - Often called a pimple
  - Called a sty when it occurs at the eyelid base
  - Spread of the infection into surrounding tissues can produce furuncles
  - Carbuncles occur when multiple furuncles grow together

Folliculitis

- Pathogen and virulence factors
  - Most commonly caused by *Staphylococcus*
    - Bacteria that are facultatively anaerobic, gram-positive cocci, arranged in clusters
    - Salt tolerant
    - Tolerant of desiccation
  - Two species commonly found on the skin
    - *Staphylococcus epidermidis*
    - *Staphylococcus aureus*
Staphylococcus & folliculitis

Staph Virulence Factors

<table>
<thead>
<tr>
<th>Table 19.1</th>
<th>Comparison of Virulence Factors of Two Staphylococcal Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virulence Factor</td>
<td>S. aureus</td>
</tr>
<tr>
<td>Enzymes</td>
<td>+</td>
</tr>
<tr>
<td>Coagulase</td>
<td>+</td>
</tr>
<tr>
<td>Staphylokinase</td>
<td>+</td>
</tr>
<tr>
<td>Lipase</td>
<td>+</td>
</tr>
<tr>
<td>β-Lactamase</td>
<td>Present in 30% of strains</td>
</tr>
<tr>
<td>Factors That Inhibit Phagocytosis</td>
<td></td>
</tr>
<tr>
<td>Fibrinogen-like layer</td>
<td>+</td>
</tr>
<tr>
<td>Protein A on cell surface</td>
<td>+</td>
</tr>
<tr>
<td>Teasles</td>
<td>+</td>
</tr>
<tr>
<td>Capsular toxins</td>
<td>+</td>
</tr>
<tr>
<td>Leukocidin</td>
<td>+</td>
</tr>
<tr>
<td>Exfoliative toxin</td>
<td>Present in some strains</td>
</tr>
<tr>
<td>Toxic shock syndrome toxin</td>
<td>Present in some strains</td>
</tr>
</tbody>
</table>

Example Staph aureus diseases

<table>
<thead>
<tr>
<th>Table 19.2</th>
<th>Some Diseases Caused by Staphylococcus aureus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease</td>
<td>Discussed on Page</td>
</tr>
<tr>
<td>Skin disease: folliculitis, sty, furuncle, carbuncle</td>
<td>554</td>
</tr>
<tr>
<td>Staphylococcal scalded skin syndrome</td>
<td>566</td>
</tr>
<tr>
<td>Impetigo</td>
<td>557</td>
</tr>
<tr>
<td>Staphylococcal toxic shock syndrome</td>
<td>Chapter 24</td>
</tr>
<tr>
<td>Bacteremia</td>
<td>Chapter 21</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>Chapter 21</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>Chapter 22</td>
</tr>
<tr>
<td>Food poisoning</td>
<td>Chapter 23</td>
</tr>
</tbody>
</table>
Staphylococcal Toxic Shock Syndrome

Staphylococcus aureus

- Associated with a number of diseases, including impetigo, sss, folliculitis, food poisoning, Toxic Shock, Endocarditis, Pneumonia, Osteomyelitis
- Enzymes
  - Coagulase
  - Hyaluronidase
  - Staphylokinase
  - Lipases
- Most studied non-spore forming pathogen
- Rx: Methycillin, Vancomycin for MRSA

Folliculitis

- Diagnosis
  - Detection of Gram-positive bacteria in grapelike arrangements isolated from pus, blood, or other fluids
- Treatment
  - Dicloxacillin (semi-synthetic form of penicillin) is the drug of choice for staphylococcal infections
  - Vancomycin used to treat resistant strains
- Prevention
  - Hand antisepsis
  - Also, proper cleansing of wounds and surgical openings, aseptic use of catheters or indwelling needles, and appropriate use of antiseptics
Staphylococcus scalded skin syndrome (SSSS)

- Bacterial infection
- Affects mostly newborns and babies
- Bullous lesions
- Desquamation (loss of protective keratinized layer)

Staphylococcus Exfoliative toxin causes the major signs and symptoms of SSSS.

Staphylococcal Scalded Skin Syndrome (SSS)
- Pathogen and virulence factors
  - Some Staphylococcus aureus strains
  - One or two different exfoliative toxins cause SSSS
- Pathogenesis
  - No scarring because dermis is unaffected
  - Death is rare but may occur due to secondary infections
- Epidemiology
  - Disease occurs primarily in infants
  - Transmitted by person-to-person spread of bacteria
Staphylococcal Scalded Skin Syndrome

- Diagnosis, treatment, and prevention
  - Diagnosed by characteristic sloughing of skin
  - Treated by administration of antimicrobial drugs
  - Prevention is difficult due to the widespread occurrence of *S. aureus*

Impetigo (Pyoderma) and Erysipelas

- Pathogens and virulence factors
  - Most cases caused by *S. aureus*
  - Some cases caused by *Streptococcus pyogenes* (often called Group A *Streptococcus*)
    - Gram-positive coccus, arranged in chains
    - Virulence factors similar to those of *S. aureus*
      - M protein interferes with phagocytosis
      - Hyaluronic acid acts to camouflage the bacteria
      - Pyrogenic toxins stimulate fever, rash, and shock

Features of impetigo caused by either *Strep. pyogenes* or *Staph.*
Impetigo (Pyoderma) Example

Erysipelas Example

Impetigo (Pyoderma) and Erysipelas

- Pathogenesis
  - The bacteria invade where the skin is compromised

- Epidemiology
  - Transmitted by person-to-person contact or via fomites
  - Impetigo occurs most in children, whereas erysipelas can also occur in the elderly
Impetigo (Pyoderma) and Erysipelas (cont.)

- Diagnosis, treatment, and prevention
  - The presence of vesicles is diagnostic for impetigo
  - Treatment is with penicillin and careful cleaning of the infected areas
  - Proper hygiene and cleanliness help prevent impetigo and erysipelas

Necrotizing Fasciitis

- Pathogen and virulence factors
  - Caused by *S. pyogenes*
  - Various enzymes facilitate invasion of tissues
  - Exotoxin A and streptolysin S are also secreted
- Pathogenesis and epidemiology
  - *S. pyogenes* enters through breaks in the skin
  - Usually spread person-to-person
- Diagnosis, treatment, and prevention
  - Difficult to diagnose in the early stages because the symptoms are nonspecific and flulike
  - Treatment is with clindamycin and penicillin

Blister Necrotizing Fasciitis Example
Acne

- Bacterial infection
- Follicle-associated lesion
- Types
  - Comedo
  - Whitehead
  - Blackhead
  - Pustule
  - Cystic

Acne

- Pathogen and virulence factors
  - Commonly caused by *Propionibacterium acnes*
    - Gram-positive, rod-shaped diphtheroids
    - Commonly found on the skin
- Epidemiology
  - Propionibacteria are normal microbiota
  - Typically begins in adolescence but can also occur later in life
Acne Tissue Reaction

Acne (cont.)

- Diagnosis, treatment, and prevention
  - Diagnosed by visual examination of the skin
  - Treatment is typically with antimicrobial drugs and drugs that cause exfoliation of dead skin cells
  - Accutane is used to treat severe acne
  - A new treatment uses a blue light wavelength to destroy *P. acnes*

Cat Scratch Disease

- Pathogen and virulence factors
  - Caused by the Gram-negative bacteria *Bartonella henselae*
  - Endotoxin is the primary virulence factor

- Pathogenesis and epidemiology
  - Transmitted by cat bites or scratches

- Diagnosis, treatment, and prevention
  - Diagnosed with serological testing and treated with antimicrobials
Pseudomonas Infection
- Pathogen and virulence factors
  - *Pseudomonas aeruginosa* is the causative agent
    - Found in soil, decaying matter, moist environments
  - Virulence factors include various adhesins, toxins, and a polysaccharide capsule
- Pathogenesis
  - Infection can occur in burn victims
    - Bacteria grow under the surface of the burn
  - The bacteria kills cells, destroys tissue, and triggers shock

Pseudomonas Infection Example

Pseudomonas Infection (cont.)
- Pseudomonas Infection
  - Epidemiology
    - *P. aeruginosa* is rarely part of the microbiota
    - *P. aeruginosa* can cause infections throughout the body once inside
  - Diagnosis, treatment, and prevention
    - Diagnosis can be difficult though pyocyanin discoloration indicates massive infection
    - Treatment is difficult due to the resistance of *P. aeruginosa* to multiple drugs and disinfectants
    - *P. aeruginosa* is widespread and thus infections are not easily prevented though they typically don't occur in healthy individuals
Rocky Mountain Spotted Fever (cont.)

- Signs/symptoms – non-itchy spotted rash on trunk and appendages
- Pathogen and Virulence Factors
  - Caused by *Rickettsia rickettsii*
  - Pathogen avoids digestion in phagosome
- Pathogenesis – due to damage to blood vessels
- Epidemiology – transmitted via bite of infected tick
- Treatment – with various antimicrobials
Gas Gangrene

- Bacterial infection
- Anaerobic
- Toxins
- Gas formation
- Two forms
  - Localized
  - Diffused (myonecrosis)
Example Myonecrosis (Group A Strep) (also see handout):

- Initial presentation of the foot w/ extensive cyanotic skin changes and bullae formation

- Intra-operative photo of the plantar incision and drainage showing extensive myonecrosis with minimal bleeding.

Over the next six days the patient underwent two subsequent debridements involving the removal of necrotic digits 2, 3, and 4.

After four surgical debridements w/amputation, there is now viable bleeding tissue that is free from infection and necrosis.

An example of the gas-filled spaces produced by Clostridium perfringens in gas gangrene

Features of gas gangrene.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause</td>
<td>Clostridium perfringens, other species</td>
</tr>
<tr>
<td>Mode of Transmission</td>
<td>Vehicle (soil), ingestion, transfer from skin, G.I. tract, reproductive tract</td>
</tr>
<tr>
<td>Pathology</td>
<td>Alpha toxin, endotoxin, enzymes, gas formation</td>
</tr>
<tr>
<td>Signs/Symptoms</td>
<td>Gas, edema, abdominal dissection, X ray, clinical picture</td>
</tr>
<tr>
<td>Prevention</td>
<td>Clean wounds, distal free tissue</td>
</tr>
<tr>
<td>Treatment</td>
<td>Copious aspirations, surgical removal, oxygen therapy</td>
</tr>
</tbody>
</table>
Hansen's Disease (Leprosy)

- Bacterial infection
- Chronic and progressive
- Skin and nerve disease
  - Tuberculoid leprosy
  - Lepromatous leprosy (LL)

Tuberculoid leprosy is less severe, and can be treated effectively.

Lepromatous leprosy--a more severe lesion, associated with disfigurement (lepromas).
Viral Diseases of the Skin and Wounds

- Many viral diseases are systemic in nature
  - can result in signs and symptoms in the skin

Diseases of Poxviruses

- Poxviruses that cause human diseases
  - Smallpox
  - Orf, cowpox, and monkeypox infect humans rarely
- Smallpox first human disease eradicated
- Diseases due to the poxviruses progress through a series of stages
Skin Lesion Types

Diseases of Poxviruses (cont)
- Pathogens and virulence factors
  - Caused by Orthopoxvirus (variola virus)
- Pathogenesis
- Epidemiology
  - Increase in monkeypox cases over the past decade
- Diagnosis, treatment, and prevention
  - Treatment requires immediate vaccination
  - Vaccination discontinued in 1972

Small Pox Lesions
Viral Diseases of the Skin and Wounds

<table>
<thead>
<tr>
<th>Table 19.3</th>
<th>Comparative Epidemiology and Pathology of Herpes Simplex Types 1 and 2 Infections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HSV 1</td>
</tr>
<tr>
<td>Herpes</td>
<td>HSV 2</td>
</tr>
<tr>
<td>Mode of</td>
<td>Mode of</td>
</tr>
<tr>
<td>transmission</td>
<td>transmission</td>
</tr>
<tr>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Receptive</td>
<td>Receptive</td>
</tr>
<tr>
<td>Site of</td>
<td>Site of</td>
</tr>
<tr>
<td>infection</td>
<td>infection</td>
</tr>
<tr>
<td>Oral cavity</td>
<td>Oral cavity</td>
</tr>
<tr>
<td>Mucous</td>
<td>Mucous</td>
</tr>
<tr>
<td>membranes</td>
<td>membranes</td>
</tr>
<tr>
<td>Site of</td>
<td>Site of</td>
</tr>
<tr>
<td>infection</td>
<td>infection</td>
</tr>
<tr>
<td>Oral cavity</td>
<td>Oral cavity</td>
</tr>
<tr>
<td>Mucous</td>
<td>Mucous</td>
</tr>
<tr>
<td>membranes</td>
<td>membranes</td>
</tr>
<tr>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>complications</td>
<td>complications</td>
</tr>
<tr>
<td>Oral cavity</td>
<td>Oral cavity</td>
</tr>
<tr>
<td>Mucous</td>
<td>Mucous</td>
</tr>
<tr>
<td>membranes</td>
<td>membranes</td>
</tr>
</tbody>
</table>

Herpes Infections

- **Epidemiology**
  - Spread between mucous membranes of mouth and genitals
  - Herpes infections in adults are not life-threatening
- **Diagnosis, treatment, and prevention**
  - Diagnosis made by presence of characteristic lesions
  - Immunoassay reveals presence of viral antigens
  - Chemotherapeutic drugs help control the disease but do not cure it

Warts

- Benign growths of the epithelium on the skin or mucous membranes
- Can form on many body surfaces
- Various papillomaviruses cause warts
  - Transmitted via direct contact and fomites
- Diagnosed by observation
- Various techniques to remove warts, though new warts can develop due to latent viruses
- Include: Papillomas & Molluscum contagiosum
Papillomas

- Viral infection
- Benign
- Nearly everyone is infected
- Different virus types
  - Plantar warts (HPV-1)
  - Flat warts (HPV-3,10,28,49)

Wart Examples

(a) = seed wart
(b) = plantar wart
(c) = flat wart

Shingles (*varicella zoster*)
Rubella (ssRNA)

Includes congenital defects in unborn fetus

Rubella vaccination

Early measles sign

Koplik’s spots

“salt” grains
Measles vaccination

Comparing Measles & Rubella

| Table 19.4: A Comparison of Measles and Rubella |
|-----------------|----------------|-----------------|-----------------|
| Disease         | Cause          | Primary Symptom | Complications   | Skin Rash       | Birthmark       |
| Measles         | Erythema infectiosum | Respiratory disease | Measles         | Present | Absent |
| Rubella         | Rubella virus  | Cervicofacial   | Measles         | Present | Absent |

Viral Rashes

- Erythema infectiosum
  - Erythrovirus of family Parvoviridae
  - Respiratory disease → manifests as a rash
  - "fifth disease"

- Roseola
  - Human herpesvirus 6 (HHV-6)
  - Characterized by a rose-colored rash

- Coxsackievirus infection
  - Coxsackie A viruses
  - Lesions like herpes infections
  - Also causes hand-foot-and-mouth disease
Mycoses of the Hair, Nails, and Skin

- Mycoses are diseases caused by fungi
- Most are opportunistic pathogens
- Mycoses are classified by infection location
  - Superficial – occur on the hair, nails, and outer skin layers; most common fungal infections
  - Subcutaneous – in the hypodermis and muscles
  - Systemic – affect numerous systems

Superficial Mycoses

- Pathogens and virulence factors
  - Piedra
    - Caused by *Piedraia hortae* (black piedra) and *Trichosporon beigeli* (white piedra)
  - Pityriasis
    - Caused by *Malassezia furfur*
- Pathogenesis and epidemiology
  - Superficial fungi produce keratinase, which dissolves keratin
  - Fungi are often transmitted via shared hair brushes and combs
Superficial Mycoses (cont.)

- **Piedra:**
  - firm, irregular nodules of hyphae
  - 2 kinds - black & white
  - diagnosed by appearance and treated by shaving infected hair

- **Pityriasis:**
  - Hypo or hyper pigmented scaley skin (affect melanin prod.)
  - identified by green color under ultraviolet light and treated with topical or oral drugs

---

[Black piedra example](#)

---

[Pityriasis example](#)

Notice pigmentation changes
Cutaneous Mycoses

- Some fungi that grow in the skin manifest as cutaneous lesions
- Dermatophytoses are cutaneous infections caused by dermatophytes
  - Cell-mediated immune responses damage deeper tissues

Ringworm

- Fungal infection (mycosis)
  - dermatophyte
- Conditions name – tinea
  - Scalp (tinea capitis)
  - Beard (tinea barbae)
  - Body (tinea corporis)
  - Groin (tinea cruris)
  - Foot (tinea pedis)
  - Hand (tinea poniis)
  - Nail (tinea unguium)
An example of body ringworm

Examples of ringworm of the feet and nails.

Athlete’s Foot – Fungal Mycosis Example
Common Dermatophytes

<table>
<thead>
<tr>
<th>Disease</th>
<th>Agent</th>
<th>Common Signs</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tinea pedis</td>
<td><em>T. mentagrophytes</em></td>
<td>Red rash between the toes and athlete's foot</td>
<td>Human transmission via walking, contact, or soil</td>
</tr>
<tr>
<td>Tinea manuum</td>
<td><em>T. rubrum</em></td>
<td>Small, red patches on the hands</td>
<td>Human transmission via touching, contact, or soil</td>
</tr>
<tr>
<td>Tinea corporis</td>
<td><em>T. rubrum</em></td>
<td>Large, red patches on the body</td>
<td>Human transmission via touching, contact, or soil</td>
</tr>
<tr>
<td>Tinea cruris</td>
<td><em>T. rubrum</em></td>
<td>Red rash between the legs, typically in folds</td>
<td>Human transmission via walking, contact, or soil</td>
</tr>
</tbody>
</table>

Common cutaneous mycoses

- **Diagnosis, treatment, and prevention**
  - Diagnosed by clinical observation
  - KOH preparation of skin or nail samples confirms diagnosis
  - Treat limited infections with topical agents
  - Treat widespread infections with oral drugs

**So- What is Wound Mycoses?**

- Some fungi grow in deep tissues but do not become systemic
- Fungi eventually grow into the epidermis to produce skin lesions
Wound Mycoses

- Chromoblastomycosis
  - Caused by four species of ascomycete fungi
  - Painless lesions that progressively worsen
- Phaeohyphomycosis
  - Caused by over 30 genera of fungi
  - Acquired when spores enter wounds

Chromoblastomycosis

Wound Mycoses

- Mycetomas
  - Caused by several genera of soil fungi
  - Tumorlike lesions on skin, fascia, and bones
- Sporotrichosis
  - Caused by a dimorphic ascomycete
  - Subcutaneous infection usually limited to the arms and legs
  - Occurs as fixed cutaneous sporotrichosis or lymphocutaneous sporotrichosis
Mycetoma (Madurella mycetomatis)

Mycetoma: tumor-like infection of skin, fascia, bones by soil inhabitants

Lymphocutaneous Sporotrichosis

Nocardia and Actinomyces

- Nocardia asteroides
  - Common inhabitant of soils rich in organic matter
  - Produces opportunistic infections in numerous sites
    - Pulmonary infections
      - Develop from inhalation of the bacteria
    - Cutaneous infections
      - Result from introduction of the bacteria into wounds
        - May produce a mycetoma
    - Central nervous system infections
      - Result from spread of bacteria in the blood
  - Prevention involves avoiding exposure to bacterium in soil
A Nocardia infection

Nocardia and Actinomyces

- **Actinomyces**
  - Member of the surface microbiota of human mucous membranes
  - Opportunistic infections
    - Respiratory, gastrointestinal, urinary, and female genital tracts
  - Actinomycosis
    - Results when bacteria enter breaks in the mucous membrane
    - Formation of abscesses connected by channels in skin or mucous membranes
  - Diagnosis difficult
    - Other organisms cause similar symptoms

Actinomyces examples
Parasitic Infestations of the Skin

**Leishmaniasis**

- **Signs and symptoms**
  - Cutaneous – produce large painless skin lesions
  - Mucocutaneous – Occur when skin lesions enlarge to encompass the mucous membranes
  - Visceral – parasite spread by macrophages can lead to death in untreated cases
- **Pathogen and virulence factors**
  - *Leishmania* is the causative agent
    - Flagellated protozoan transmitted to humans by female sand flies

Mucocutaneous Leishmaniasis

Leishmaniasis

- **Pathogenesis and epidemiology**
  - Chemicals released by infected macrophages stimulate inflammatory responses
  - Leishmaniasis is endemic to regions of the tropics and subtropics
- **Diagnosis, treatment, and prevention**
  - Diagnosed by microscopic identification of the protozoa
  - Most cases heal without treatment though antimicrobials are needed for severe infections
  - Prevention involves reducing exposure to the reservoir host
Features of leishmaniasis and cutaneous anthrax pustular lesions

<table>
<thead>
<tr>
<th>Category</th>
<th>Leishmaniasis</th>
<th>Cutaneous Anthrax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease</td>
<td>Leishmaniasis</td>
<td>Cutaneous Anthrax</td>
</tr>
<tr>
<td>Microorganism(s)</td>
<td>Leishmania</td>
<td>Bacillus anthracis</td>
</tr>
<tr>
<td>Most Common Mode of Transmission</td>
<td>Nutritional</td>
<td>Direct contact with anthrax</td>
</tr>
<tr>
<td>Virulence Factors</td>
<td>Multiplication within macrophages</td>
<td>Endospores formation, spores, lethal factor alleles</td>
</tr>
<tr>
<td>Colonic Trajectory</td>
<td>Culture of proteus, microscopic visualization</td>
<td>Culture on blood agar sensitivity: PCR performed by CDC</td>
</tr>
<tr>
<td>Prevention</td>
<td>Develolpment and fly</td>
<td>Avoid contact, wash hands after use</td>
</tr>
<tr>
<td>Treatment</td>
<td>Permethrin</td>
<td>Cycl desperation, dapsone, penicillin</td>
</tr>
<tr>
<td>Differentiating Features</td>
<td>Mucocutaneous and systemic forms</td>
<td>Can be fatal</td>
</tr>
<tr>
<td>Appearance of Lesions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scabies

- Intense itching and localized rash at infection site
- *Sarcoptes scabiei* (mite)
- Transmission is via prolonged bodily contact such as sexual activity
- Treatment requires use of miticide lotions and cleaning contaminated clothes, towels, etc.