Microbial Diseases of the Skin and Wounds
Structure of the Skin

• Composed of two main layers
  – Dermis
  – Epidermis

• Functions of the Skin
  – Prevents excessive water loss
  – Regulates temperature
  – Involved in sensory phenomena
  – Barrier against microbial invaders
Figure 19.1 The skin-overview

- Hair
- Nails
- Skin
- Sweat pores
- Hair shaft
- Epidermis
- Dermis
- Hypodermis
- Nerve
- Sweat gland
- Microbiota in sweat gland
- Pressure receptor
- Blood vessels
- Oil gland
- Microbiota in hair follicle
- Hair root
- Hair follicles
- Stratum corneum
- Stratum granulosum
- Stratum spinosum
- Stratum basale
- Melanocyte
- Basal cell
- Dendritic cell
- Microbiota in stratum corneum

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• 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 infection
    – Can result in severe or fatal diseases
Normal Microbiota of the Skin

- Skin microbiota are normally harmless microbes present on the skin
  - Cannot be completely removed through cleansing
  - Made up of various microbes
    - Yeast
      - Malassezia
    - Bacteria
      - Staphylococcus, Micrococcus, and the diphtheroids
- May produce disease
  - If penetrate epidermis or if immune system is suppressed
*Staphylococcus aureus*، *Acinetobacter spp*، *Bacillus spp*، *Candida albicans*،

*Corynebacterium spp*، *Corynebacterium parvum*

• *Enterobacter cloacae*، *Epidermophyton floccosum*، *Micrococcus spp*،

*Micrococcus luteus*، *Neisseria spp*

• *Mycobacterium spp*، *Peptostreptococcus spp*، *Pityrosporum ovale*،

*Propionibacterium spp*، *Propionibacterium acnes*

• *Pseudomonas aeruginosa*، *Sarcina spp*، *Staphylococcus epidermidis*،

*Staphylococcus haemolyticus*

• *Streptococcus viridans*، *Trichophyton spp*
• **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 infection into surrounding tissues can produce furuncles
    – Carbuncles occur when multiple furuncles grow together
Bacterial Diseases of the Skin and Wounds

• Folliculitis
  – Pathogen and virulence factors
    – Most commonly caused by *Staphylococcus*
    – Two species commonly found on the skin
      – *Staphylococcus epidermidis*
      – *Staphylococcus aureus*
Figure 19.2 *Staphylococcus*
### Table 19.1 Comparison of Virulence Factors of Two Staphylococcal Species

<table>
<thead>
<tr>
<th>Virulence Factor</th>
<th>S. aureus</th>
<th>S. epidermidis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enzymes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coagulase</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Staphylokinase</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Lipase</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>β-Lactamase</td>
<td>Present in 90% of strains</td>
<td>–</td>
</tr>
<tr>
<td><strong>Factors That Inhibit Phagocytosis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polysaccharide slime layer</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Protein A on cell surface</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td><strong>Toxins</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cytolytic toxins</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Leukocidin</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Epidermal cell differentiation inhibitor</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Exfoliative toxin</td>
<td>Present in some strains</td>
<td>–</td>
</tr>
<tr>
<td>Toxic shock syndrome toxin</td>
<td>Present in some strains</td>
<td>–</td>
</tr>
</tbody>
</table>
Bacterial Diseases of the Skin and Wounds

- **Folliculitis**
  - Diagnosis
    - Isolation of Gram-positive bacteria in grapelike clusters from pus
  - Treatment
    - Dicloxacillin (semisynthetic penicillin) is the drug of choice
    - Vancomycin used to treat resistant strains
  - Prevention
    - Hand antisepsis
    - Proper procedures in hospitals to minimize MRSA infections
Bacterial Diseases of the Skin and Wounds

• **Staphylococcal Scalded Skin Syndrome**
  – 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 be due to secondary infections
  – Epidemiology
    – Disease occurs primarily in infants
    – Transmitted by person-to-person spread of bacteria
Figure 19.3 Staphylococcal scalded skin syndrome
Bacterial Diseases of the Skin and Wounds

- **Staphylococcal Scalded Skin Syndrome**
  - Diagnosed by characteristic sloughing (السلخ) of skin
  - Treated by administration of antimicrobial drugs
  - Widespread presence of *S. aureus* makes prevention difficult
Bacterial Diseases of the Skin and Wounds

- Impetigo (Pyoderma) and Erysipelas
  - Pathogens and virulence factors
    - Most cases are caused by *S. aureus*
    - Some cases are caused by *Streptococcus pyogenes*
      - Gram-positive cocci, arranged in chains
      - Virulence factors similar to those of *S. aureus*
        - M protein
        - Hyaluronic acid
        - Pyrogenic toxins
Figure 19.4 Impetigo
• 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
    – Erysipelas can also occur in the elderly
Bacterial Diseases of the Skin and Wounds

• **Impetigo (Pyoderma) and Erysipelas**
  – Diagnosis, treatment, and prevention
    – The presence of vesicles is diagnostic for impetigo
    – Treat with penicillin and careful cleaning of infected areas
    – Prevent with proper hygiene and cleanliness
Necrotizing Fasciitis

- Pathogen and virulence factors
  - Most cases caused by \textit{S. pyogenes}
  - Various enzymes facilitate invasion of tissues
  - Exotoxin A and streptolysin S are also secreted
- Pathogenesis and epidemiology
  - \textit{S. pyogenes} enters through breaks in the skin
  - Usually spread person-to-person
- Diagnosis, treatment, and prevention
  - Early diagnosis is difficult because symptoms are nonspecific
  - Treat with clindamycin and penicillin
Figure 19.6 Necrotizing fasciitis
Bacterial Diseases of the Skin and Wounds

• 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 occur later in life
Figure 19.7 The development of acne

1. **Normal skin**
   Oily sebum produced by glands reaches the hair follicle and is discharged onto the skin surface via the pore.

2. **Whitehead**
   Inflamed skin swells over the pore when bacteria infect the hair follicle, causing the accumulation of colonizing bacteria and sebum.

3. **Blackhead**
   Dead and dying bacteria and sebum form a blockage of the pore.

4. **Pustule formation**
   Severe inflammation of the hair follicle causes pustule formation and rupture, producing cystic acne, which is often resolved by scar tissue formation.
Bacterial Diseases of the Skin and Wounds

- **Acne**
  - Diagnosis, treatment, and prevention
    - Diagnosed by visual examination of the skin
    - Treated with antimicrobial drugs and drugs that cause exfoliation of dead skin cells
    - Accutane is used to treat severe acne
    - New treatment uses blue-light wavelength to destroy bacteria

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Cat Scratch Disease

- Pathogen and virulence factors
  - Caused by the Gram-negative bacterium *Bartonella henselae*
  - Endotoxin is the primary virulence factor
- Pathogenesis and epidemiology
  - Transmitted by cat bites or scratches
  - Diagnosed with serological testing
  - Treated with antimicrobials
Bacterial Diseases of the Skin and Wounds

- **Pseudomonas Infection**
  - Pathogen and virulence factors
    - *Pseudomonas aeruginosa* is the causative agent
      - Found in soil, decaying matter, moist environments
    - Virulence factors
      - 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

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Figure 19.8 *Pseudomonas aeruginosa* infection
Bacterial Diseases of the Skin and Wounds

• Pseudomonas Infection
  – Epidemiology
    – *P. aeruginosa* is rarely part of the microbiota
      – Can cause infections throughout the body once inside
  – Diagnosis, treatment, and prevention
    – Diagnosis can be difficult
      – Pyocyanin discoloration indicates massive infection
    – Difficult to treat due to multidrug resistance of *P. aeruginosa*
      – *P. aeruginosa* is widespread, but infections typically don’t occur in healthy individuals
• Rocky Mountain Spotted Fever
  – Signs and symptoms
    – Non-itchy spotted rash on trunk and appendages
  – Pathogen and virulence factors
    – Caused by *Rickettsia rickettsii*
    – Pathogen avoids digestion in phagosome
  – Pathogenesis
    – Disease follows damage to blood vessels
Rocky Mountain Spotted Fever

- Epidemiology
  - Transmitted via bite of infected tick
- Diagnosis, treatment, and prevention
  - Diagnosed with serological testing
  - Treated with various antimicrobials
  - Prevented with the use of tick repellents and avoidance of tick-infested areas
Figure 19.9 Number of cases of Rocky Mountain spotted fever in the U.S., 1999-2009
• **Cutaneous Anthrax**
  – Caused by *Bacillus anthracis*
  – Characterized by an eschar
    – Black, painless, ulcer
  – Treated with antimicrobial drugs
  – Prevention requires control of the disease in animals
Gas Gangrene

- Signs and symptoms
  - Blackening of infected muscle and skin
  - Presence of gas bubbles
- Pathogens and virulence factors
  - Caused by several *Clostridium* species
  - Bacterial endospores survive harsh conditions
  - Vegetative cells secrete 11 toxins
• **Gas Gangrene**
  – Pathogenesis and epidemiology
    – Traumatic event must introduce endospores into dead tissue
    – Mortality rate exceeds 40%
  – Diagnosis, treatment, and prevention
    – Appearance is usually diagnostic
    – Rapid treatment is crucial
      – Surgical removal of dead tissue
      – Administration of antitoxin and penicillin
    – Prevent with proper cleaning of wounds
Many viral diseases are systemic in nature
  – These diseases can result in signs and symptoms in the skin
Diseases of Poxviruses

- Poxviruses that cause human diseases
  - Smallpox
  - cowpox, and monkeypox (rare)
- Smallpox first human disease eradicated
- Signs and symptoms
  - Diseases progress through a series of stages
Figure 19.10 The stages of lesions in poxviral skin infections—overview

1. Macule
   - Epidermis
   - Dermis

2. Papule

3. Vesicle
   - Fluid
   - 1 cm

4. Pustule
   - Pus

5. Crust

6. Scar
Diseases of Poxviruses

- Pathogens and virulence factors
  - Caused by *Orthopoxvirus* (variola virus)

- Pathogenesis
  - Infection occurs by inhalation of virus

- Epidemiology
  - Increase in monkeypox cases over the past decade

- Diagnosis, treatment, and prevention
  - Treatment requires immediate vaccination
  - Vaccination discontinued in 1980s
Viral Diseases of the Skin and Wounds

- **Herpes Infections**
  - **Signs and symptoms**
    - Slow spreading skin lesions
    - Recurrence of lesions is common
  - **Pathogen and virulence factors**
    - Caused by human herpesviruses 1 and 2
    - Produce various proteins that act as virulence factors
  - **Pathogenesis**
    - Painful lesions caused by inflammation and cell death
    - Cause fusion of cells to form syncytia
Figure 19.11 Oral herpes lesions
Figure 19.12 Sites of events in herpesvirus infections

- Trigeminal (V) nerve ganglion
  - Site of viral latency
- Brachial ganglia
  - Site of viral latency
- Sacral ganglia
  - Site of viral latency
- Ophthalmic branch
- Ocular herpes
- Maxillary branch
- Mandibular branch
- Fever blisters
- Genital herpes
- Whitlow
• 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 epithelial growths on the skin or mucous membranes
    – Can form on many body surfaces
  – Various papillomaviruses cause warts
  – Most warts are harmless
  – Transmitted via direct contact and fomites
  – Diagnosed by observation
  – Various techniques to remove warts
    – New warts can develop due to latent viruses
Figure 19.13 Various kinds of warts--lesions caused by papillomaviruses-overview
• **Chickenpox and Shingles**
  – Signs and symptoms
    – Chickenpox characterized by lesions on the back and trunk that spread across body
    – Shingles lesions localized to skin along an infected nerve
  – Pathogen
    – Varicella-zoster virus (VZV) causes both diseases
  – Pathogenesis
    – Infected dermal cells cause rash characteristic of chickenpox
    – Virus becomes latent in nerve ganglia
    – Reactivated VZV causes shingles
• **Chickenpox and Shingles**
  – Epidemiology
    – Chickenpox occurs mostly in children
      – Disease is more severe in adults
    – Risk of shingles increases with age
  – Diagnosis, treatment, and prevention
    – Diagnosis based on characteristic lesions
    – Treatment based on relief of symptoms
    – Vaccine available against chickenpox
Rubella

- Children develop a mild rash
- Congenital infection can result in birth defects or death of fetus
- Caused by rubella virus
  - Spread by respiratory secretions
  - Infects only humans
- Diagnosis made by observation of rash and serological testing
- Vaccine is available
  - Aimed at preventing rubella infections in pregnant women
Figure 19.14 The efficacy of immunization against rubella

Attenuated vaccine licensed

Year

Cases

Cases (thousands)

1966 '72 '78 '84 '90 '96 '02 '06 '09

2001 '02 '03 '04 '05 '06 '07 '08 '09

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Viral Diseases of the Skin and Wounds

• **Measles (Rubeola)**
  – Signs and symptoms
    – Characterized by Koplik’s spots
    – Subacute sclerosing panencephalitis is rare complication
  – Pathogen and virulence factors
    – Caused by measles virus
    – Adhesion and fusion proteins help virus avoid immune recognition
  – Pathogenesis
    – Immune response to infected cells causes most symptoms
Viral Diseases of the Skin and Wounds

- **Measles (Rubeola)**
  - Epidemiology
    - Measles is highly contagious
    - Spread via respiratory droplets
    - Humans are the only host
  - Diagnosis, treatment, and prevention
    - Diagnosis based on signs of measles
    - No treatment is available
    - Measles immunization available as part of MMR vaccine
Figure 19.15 Measles cases in the United States since 1950

- **Attenuated vaccine licensed**
  - Cases (thousands)
  - Year

Cases (thousands):
- 1950: 800
- 1955: 600
- 1960: 400
- 1965: 200
- 1970: 0

Year:
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009

Increase in cases in 2008 and 2009 due to nonvaccination.
• Other Viral Rashes
  – Erythema infectiosum
    – Caused by an erythrovirus of family Paroviridae
    – Respiratory disease that manifests as a rash
    – Also referred to as fifth disease
  – Roseola
    – Caused by human herpesvirus 6 (HHV-6)
    – Characterized by a rose-colored rash
  – Coxsackievirus infection
    – Caused by coxsackie A viruses
    – Produces lesions like those from herpes infections
    – Also causes hand-foot-and-mouth disease
Figure 19.16 A case of erythema infectiosum (fifth 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

- Signs and symptoms
  - Piedra
    - Irregular nodules on the hair shaft
  - Pityriasis versicolor
    - Hypo- or hyperpigmented patches of scaly skin
- Pathogens and virulence factors
  - *Piedraia hortae* causes black piedra
  - *Trichosporon beigelii* causes white piedra
  - Pityriasis caused by *Malassezia furfur*
Figure 19.18 Pityriasis versicolor
Superficial Mycoses

- Pathogenesis and epidemiology
  - Superficial fungi produce keratinase, which dissolves keratin
  - Fungi often transmitted via shared hair brushes and combs
- Diagnosis, treatment, and prevention
  - Piedra diagnosed by appearance and treated by shaving infected hair
  - Pityriasis identified by green color under ultraviolet light and treated with topical or oral drugs
• **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
Figure 19.19 Dermatophytosis (ringworm)
Figure 19.20 Athlete’s foot
# Table 19.5 Common Dermatophytoses

<table>
<thead>
<tr>
<th>Disease</th>
<th>Agents</th>
<th>Common Signs</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tinea pedis (&quot;athlete’s foot&quot;)</td>
<td><em>Trichophyton rubrum</em>; <em>T. mentagrophytes var. interdigitale</em>; <em>Epidermophyton floccosum</em></td>
<td>Red, raised lesions on and around the toes and soles of the feet; webbing between the toes is heavily infected</td>
<td>Human reservoirs in toe webbing; carpeting holding infected skin cells</td>
</tr>
<tr>
<td>Tinea cruris (&quot;jock itch&quot;)</td>
<td><em>T. rubrum</em>; <em>T. mentagrophytes var. interdigitale</em>; <em>E. floccosum</em></td>
<td>Red, raised lesions on and around the groin and buttocks</td>
<td>Usually spreads from the feet</td>
</tr>
<tr>
<td>Tinea unguium (onychomycosis)</td>
<td><em>T. rubrum</em>; <em>T. mentagrophytes var. interdigitale</em></td>
<td>Superficial white onychomycosis: patches or pits on the nail surface; Invasive onychomycosis: yellowing and thickening of the distal nail plate, often leading to loss of the nail</td>
<td>Humans</td>
</tr>
<tr>
<td>Tinea corporis</td>
<td><em>T. rubrum</em>; <em>Microsporum gypseum</em>; <em>M. canis</em></td>
<td>Red, raised, ringlike lesions occurring on various skin surfaces (tinea corporis on the trunk, tinea capitis on the scalp, tinea barbae of the beard)</td>
<td>Can spread from other body sites; can be acquired following contact with contaminated soil or animals</td>
</tr>
<tr>
<td>Tinea capitis</td>
<td><em>M. canis</em>; <em>M. gypseum</em>; <em>T. equinum</em>; <em>T. verrucosum</em>; <em>T. tonsurans</em>; <em>T. violaceum</em>; <em>T. schoenleinii</em></td>
<td>Ectothrix invasion: fungus develops arthroconidia on the outside of the hair shafts, destroying the cuticle; Endothrix invasion: fungus develops arthroconidia inside the hair shaft without destruction; Favus: crusts form on the scalp, with associated hair loss</td>
<td>Humans; can be acquired following contact with contaminated soil or animals</td>
</tr>
</tbody>
</table>
• **Cutaneous Mycoses**
  – Diagnosis, treatment, and prevention
    – Diagnosed by clinical observation
    – KOH preparation of skin or nail samples confirms diagnosis
    – Limited infections treated with topical agents
    – Widespread infections treated with oral drugs
• **Wound Mycoses**
  – Some fungi grow in deep tissues but do not become systemic
  – Fungi eventually grow into the epidermis to produce skin lesions
Mycoses of the Hair, Nails, and Skin

- **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

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Figure 19.21 A leg with extensive lesions of chromoblastomycosis
Mycoses of the Hair, Nails, and Skin

• **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 or lymphocutaneous sporotrichosis
Figure 19.22 A mycetoma of the ankle
Figure 19.23 Lymphocutaneous sporotrichosis on the arm
Parasitic Infestations of the Skin

• **Leishmaniasis**
  – Signs and symptoms
    – Cutaneous: Produces large painless skin lesions
    – Mucocutaneous: Skin lesions enlarge to encompass mucous membranes
    – Visceral: Parasite is spread by macrophages throughout body
  – Pathogen and virulence factors
    – *Leishmania* is the causative agent
      – Protozoan transmitted to humans by female sand flies
Figure 19.24 Mucocutaneous leishmaniasis
Parasitic Infestations of the Skin

• **Leishmaniasis**
  – Pathogenesis and epidemiology
    – Infected macrophages stimulate inflammatory responses
    – Leishmaniasis endemic in parts of the tropics and subtropics
  – Diagnosis, treatment, and prevention
    – Diagnosed by microscopic identification of the protozoa
    – Most cases heal without treatment
    – Antimicrobials are needed for severe infections
    – Prevention involves reducing exposure to the reservoir host
• **Scabies**
  – Characterized by intense itching and rash at infection site
  – The mite *Sarcoptes scabiei* is the causative agent
  – Transmitted via prolonged bodily contact
  – Epidemics occur among people in crowded conditions
  – Treated with mite-killing lotions and cleaning of contaminated items
  – Prevented only by good personal hygiene
Figure 19.25 Scabies mites