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Learning Objectives

- Describe the structure of the skin
- Provide examples of normal skin microbiota
- Differentiate staphylococci from streptococci, & name several skin infections caused by each
- List the causative agent, mode of transmission, & clinical symptoms of *Pseudomonas* infections

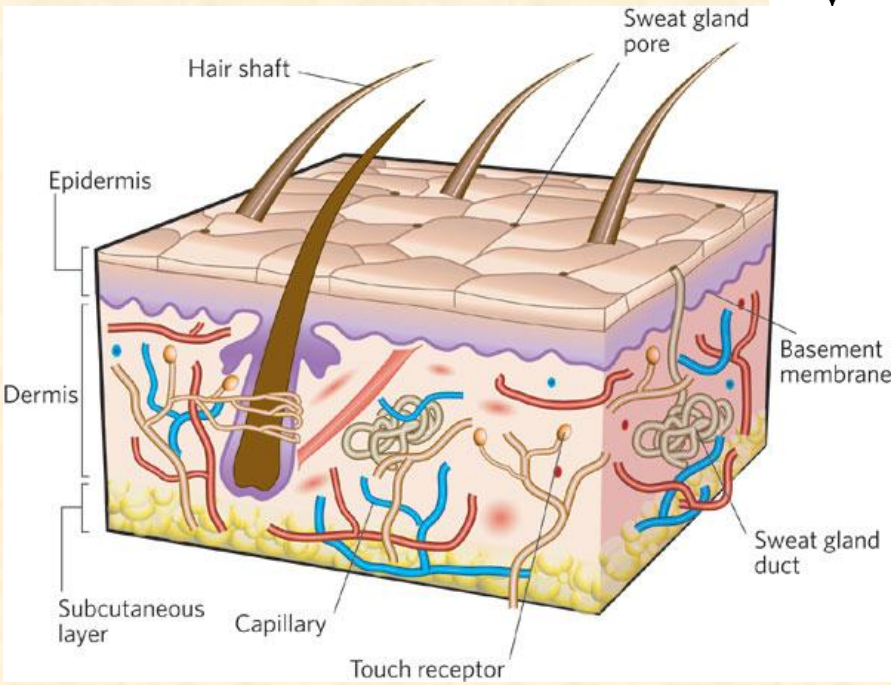
Structure of the Skin

Functions of the Skin

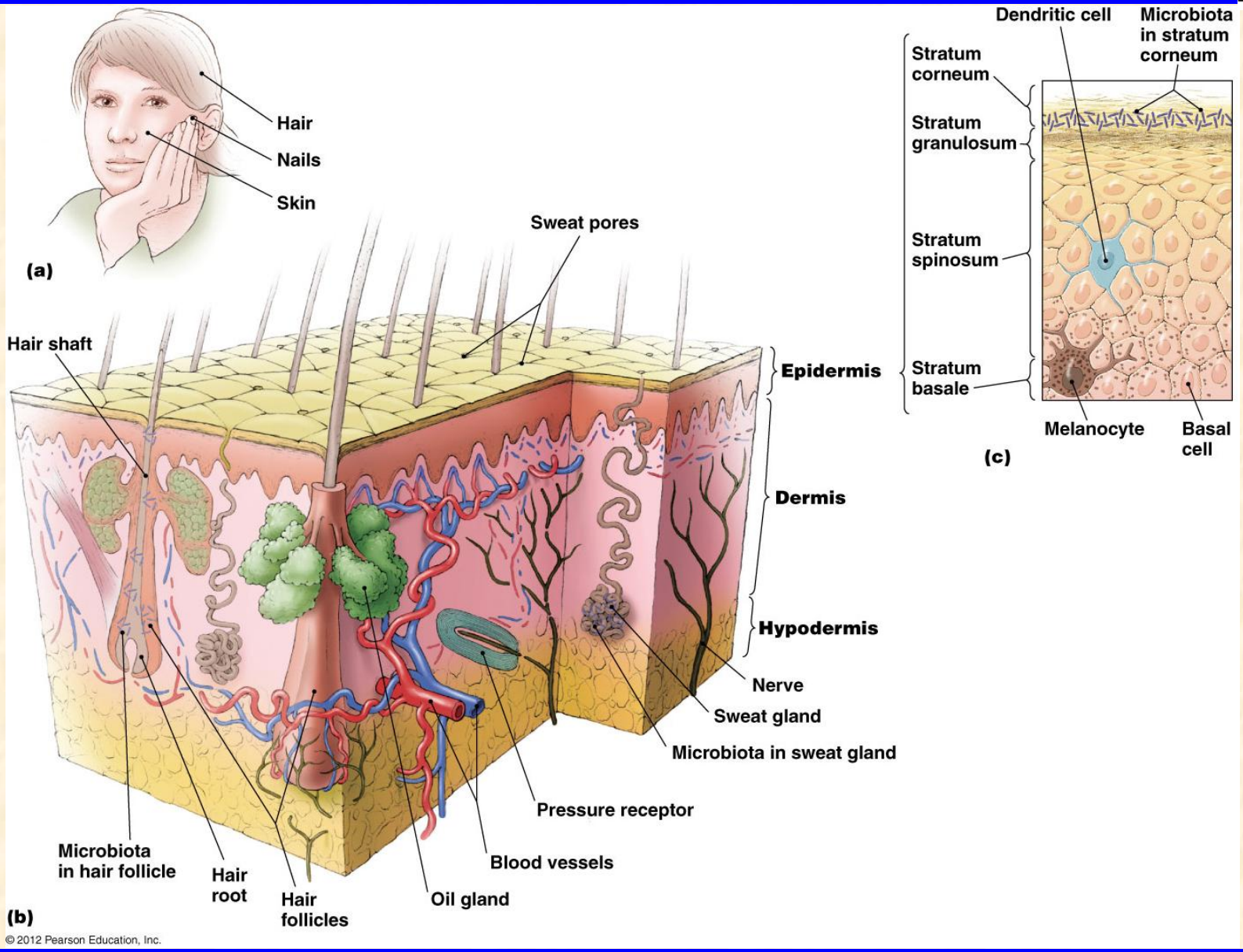
- Prevents excessive water loss
- Regulates temperature
- Involved in sensory phenomena
- Barrier against microbial invaders

Skin layers

- Epidermis : Keratin
- Dermis: Collagen, Elastin
- Fat layer



The skin-overview



Structure of the Skin

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 Flora of the Skin

- Skin flora are normally harmless microbes present on the skin
- Must be able to live in dry, salty conditions
- Cannot be completely removed through cleansing
- Made up of various microbes
- May produce disease

  If penetrate epidermis or if immune system is suppressed

Normal Flora of the Skin

Resident Flora	Transient flora
Propionibacterium acnes	*S. aureus*
Staphylococcus epidermidis	*Streptococcus pyogenes*
Micrococci	*Haemophilus influenzae*
Anaerobic Gram positive cocci	Clostridium Spp.
Aerobic Gram negative bacilli (low numbers)	*Francisella tularensis*
	Pseudomonas aeruginosa
	Burkholderia cepacia
	Mycobacterium marinum

Exogenous Infections

Disease	Organisms
Folliculitis	Staphylococci, Pseudomonas species
Carbuncles, Furuncles	Staphylococci
Impetigo	Streptococci, Staphylococci
Erysipelas	Streptococci
Cellulitis	Streptococci, Staphylococci, Haemophilus influenzae
Synergistic cellulitis	Streptococci, enteric bacteria, anaerobes
Gas gangrene	Clostridia
Necrotizing fasciitis	Streptococci, enteric bacteria, anaerobes

Endogenous Infections

Direct extension	Hematogenous infections
Osteomyelitis: draining sinus	Bacteremia: Meningococci
Septic arthritis: draining sinus	Endocarditis
Tuberculosis	Rickettsioses

Bacterial Diseases of the Skin & Wounds

Folliculitis

Signs & 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 & Wounds

Folliculitis

Pathogen & virulence factors

- Most commonly caused by *Staphylococcus*
- Facultatively anaerobic, Gram-positive bacteria
- Cocci typically arranged in clusters
- Tolerant of salt & desiccation
- Two species commonly found on the skin
- *Staphylococcus epidermidis*
- *S. aureus*

Bacterial Diseases of the Skin & Wounds

Folliculitis

Diagnosis

Isolation of G $^{+}$ 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 & Wounds

Staphylococcal Scalded Skin Syndrome

Pathogen & virulence factors

- Some *Staphylococcus aureus* strains
- One or two different exfoliative toxins

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

Bacterial Diseases of the Skin & Wounds

Staphylococcal Scalded Skin Syndrome

Diagnosis, treatment, & prevention

- Diagnosed by characteristic sloughing of skin
- Treated by administration of antimicrobial drugs
- Widespread presence of *S. aureus* makes prevention difficult

Bacterial Diseases of the Skin & Wounds

Impetigo (Pyoderma)

Pathogens & virulence factors

- Most cases are caused by *S. aureus*
- Some cases are caused by *Streptococcus pyogenes*

Bacterial Diseases of the Skin & Wounds

Erysipelas

Pathogens & virulence factors

- Are caused by *S. pyogenes*
- Gram-positive coccus, arranged in chains
- Hemolysins
- Streptokinase
- Hyaluronidase
- Pyrogenic toxins
- M protein

  (prevents complement activation)

Bacterial Diseases of the Skin & Wounds

Impetigo (Pyoderma) & 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 & Wounds

Impetigo (Pyoderma) & Erysipelas

Diagnosis, treatment, & prevention

- The presence of vesicles is diagnostic for impetigo
- Treat with penicillin and careful cleaning of infected areas
- Prevent with proper hygiene and cleanliness

Bacterial Diseases of the Skin & Wounds

Necrotizing Fasciitis

Pathogen & virulence factors

- The presence of vesicles is diagnostic for impetigo
- Treat with penicillin and careful cleaning of infected areas
- Prevent with proper hygiene and cleanliness

Bacterial Diseases of the Skin & Wounds

Necrotizing Fasciitis

Pathogens & virulence factors

- Most cases caused by *S. pyogenes*
- Various enzymes facilitate invasion of tissues
- Exotoxin A & streptolysin S are also secreted

Pathogenesis & epidemiology

- *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 & penicillin

Bacterial Diseases of the Skin & Wounds

Acne

Pathogen & 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

Bacterial Diseases of the Skin & Wounds

Acne

Diagnosis, treatment, & prevention

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

Comedonal Acne

Inflammatory Acne

Nodular Cystic Acne

Bacterial Diseases of the Skin & Wounds

Classifications of Acne

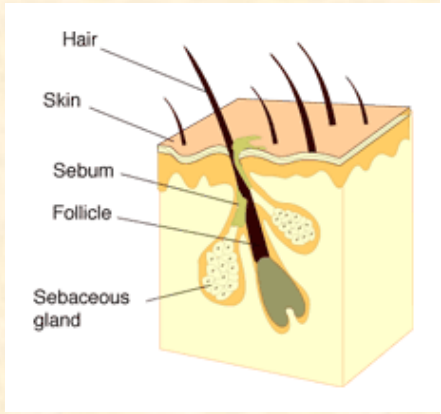
Comedonal (mild) acne

Sebum channels blocked with shed cells

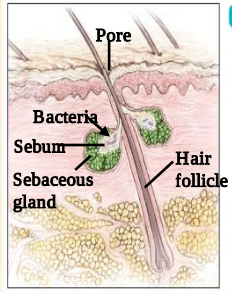
Inflammatory (moderate) acne

Propionibacterium acnes

Nodular cystic (severe) acne

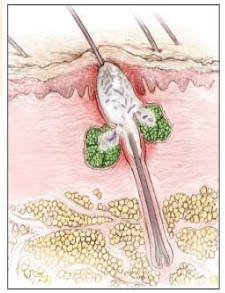


Whiteheads (comedo) vs. blackheads (comedons or open comedos)



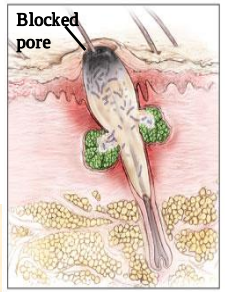
1 Normal skin

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



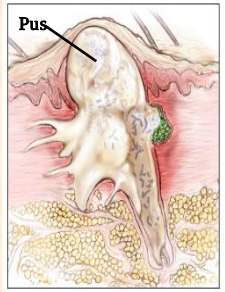
2 Whitehead

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 & Wounds

Cat Scratch Disease

Pathogen & virulence factors

- Caused by the Gram-negative bacterium *Bartonella henselae*
- Endotoxin is the primary virulence factor

Pathogenesis & epidemiology

- Transmitted by cat bites or scratches

Diagnosis, treatment, & prevention

- Diagnosed with serological testing
- Treated with antimicrobials

Bacterial Diseases of the Skin & Wounds

Pseudomonas Infection

Pathogen & virulence factors

- ***Pseudomonas aeruginosa*** **is the causative agent**
- **Found in soil, decaying matter, moist environments**

Virulence factors

- **Adhesins, toxins, & a polysaccharide capsule**

Pathogenesis

- **Infection can occur in burn victims**
- **Bacteria grow under the surface of the burn**
- **The bacteria kills cells, destroys tissue, & triggers shock**

Bacterial Diseases of the Skin & Wounds

Pseudomonas Infection

Epidemiology

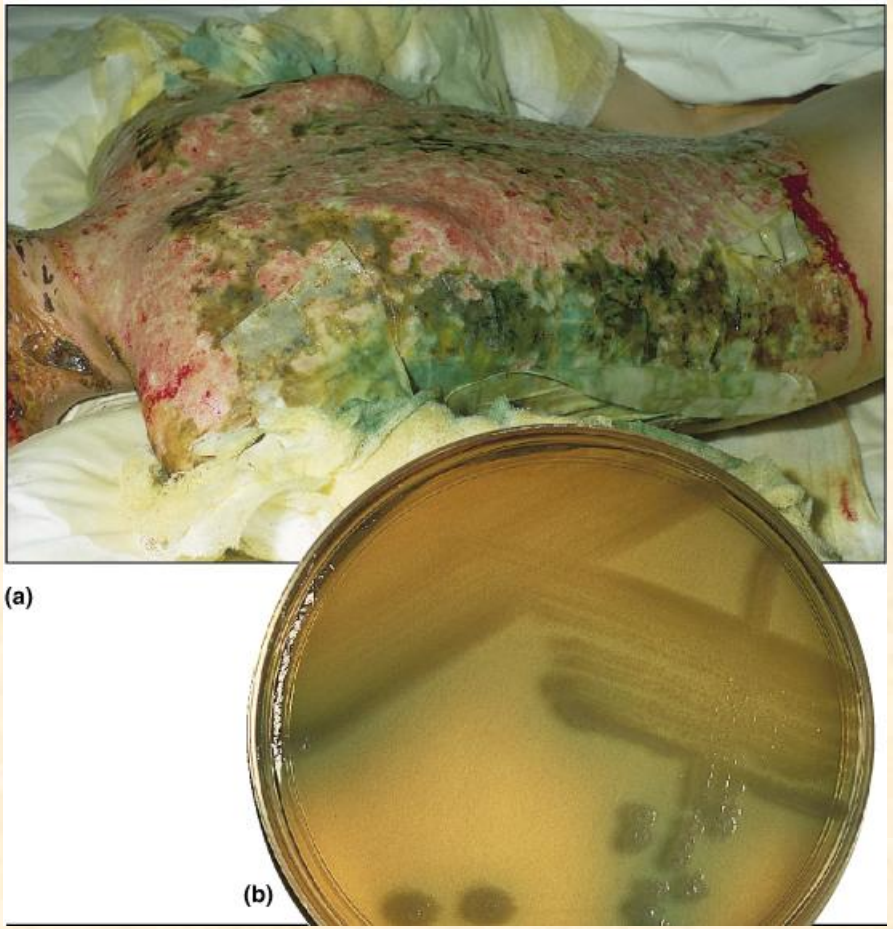
- *P. aeruginosa* is rarely part of the microbiota
- Can cause infections throughout the body once inside

Diagnosis, treatment, & 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

Bacterial Diseases of the Skin & Wounds

***Pseudomonas aeruginosa* infection**



Bacterial Diseases of the Skin & Wounds

Rocky Mountain Spotted Fever

Signs & symptoms

- Non-itchy spotted rash on trunk & appendages

Pathogen & virulence factors

- Caused by *Rickettsia rickettsii*
- Pathogen avoids digestion in phagosome

Pathogenesis

- Disease follows damage to blood vessels

Bacterial Diseases of the Skin & Wounds

Rocky Mountain Spotted Fever

Epidemiology

- Transmitted via bite of infected tick

Diagnosis, treatment, & prevention

- Diagnosed with serological testing
- Treated with various antimicrobials
- Prevented with the use of tick repellents & avoidance of tick-infested areas

Bacterial Diseases of the Skin & Wounds

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

Courtesy of James H. Steele/CDC

Bacterial Diseases of the Skin & Wounds

Gas Gangrene


Courtesy of Dr. Jack Poland/CDC

Signs & symptoms

- Blackening of infected muscle and skin
- Presence of gas bubbles

Pathogens & virulence factors

- Caused by several *Clostridium* species
- *Clostridium perfringens*
- Bacterial endospores survive harsh conditions
- Vegetative cells secrete 11 toxins

Bacterial Diseases of the Skin & Wounds

Gas Gangrene

Pathogenesis & epidemiology

- Traumatic event must introduce endospores into dead tissue
- Mortality rate exceeds 40%

Diagnosis, treatment, & prevention

- Appearance is usually diagnostic
- Rapid treatment is crucial
- Surgical removal of dead tissue
- Administration of antitoxin & penicillin
- Prevent with proper cleaning of wounds

Case

Ms. W., a 27-year-old emergency medical technician, was evaluated by a physician for a slight infection around the nail of her left index finger (called a **paronychia**). The physician drained the lesion, and a culture of the pus grew a group A β-hemolytic streptococcus (*S. pyogenes*). Ms. W. was not given antimicrobial therapy because the physician thought that drainage was sufficient. Five days later, Ms. W. complained of fever and severe pain in the forearm, which had become swollen and red (erythematous). Her temperature was 40.2°C, and she was sweaty and hot. A patchy rash extended from her left upper arm to her shoulder. Lymph nodes in the axilla were enlarged and tender. Ms. W. was admitted to the hospital with a diagnosis of **streptococcal cellulitis.** She was treated successfully with high doses of penicillin. Blood cultures obtained before starting antimicrobial therapy also yielded *S. pyogenes.*

1. What risk factors predisposed Ms. W. to the development of cellulitis?
2. What virulence determinants are expressed by *S. pyogenes*?
3. What antibiotic should have been administered at the time of the incision and drainage?