CHAPTER 6: SKIN AND THE INTEGUMENTARY SYSTEM

INTRODUCTION

The integumentary system is the first body system studied. Before we begin any study of a body system, we will first think about the organs/tissues that work together to perform the function(s) of that system.

The integumentary system consists of a major organ, skin, and many epidermal derivatives (accessory organs), which include hair follicles, sebaceous glands, sweat glands, and nails.

In addition, the organs of the integumentary **system** are composed of many different tissues that perform common functions. These tissues include stratified squamous epithelium, glandular epithelium, dense irregular CT, smooth muscle tissue, adipose tissue, and nervous tissue. The functions that these tissues collectively perform are many. Functions of the skin include protection, excretion, regulation of body temperature, sensory reception, immunity, synthesis of Vitamin D, and blood reservoir.

II. **SKIN AND ITS TISSUES** (Cutaneous Membrane)

A. **General Structure**:

1. Two distinct regions or layers compose the skin:
   a. **Epidermis** = outermost layer;
      - keratinized stratified squamous ET.
   b. **Dermis** = inner layer;
      - keratinized epithelium (hair follicles),
      - glandular epithelium (sweat, sebaceous glands),
      - dense irregular CT (collagen),
      - smooth muscle tissue (arrector pili muscles),
      - nervous tissue (Meissner's & Pacinian Corpuscles), and
      - blood vessels.
2. **Subcutaneous layer** = adipose tissue;
   distinct layer beneath skin
   also called **hypodermis**

II. **SKIN AND ITS TISSUES** (Cutaneous Membrane)

B. **Skin Functions**

1. **Protection**:
   - **Physical barrier**
     a. from water loss;
     b. from injury;
     c. from chemicals and microorganisms.
   - **Chemical barrier**
     a. pH or 5-6
     b. prevents microorganism growth
   - **Biological barrier**
     a. Langerhan's cells (epidermis)
     b. Macrophages and mast cells (dermis)

2. **Excretion** (minimal, most through kidneys!):
   - urea;
   - uric acid.

3. **Regulation of body temperature**:
   Review negative-feedback mechanisms from Ch. 1.

4. **Cutaneous Sensation**:
   - Light touch detection = **Meissner's Corpuscle's**;
     a. egg-shaped;
     b. located in dermal papillae;
     c. populate areas in the fingertips, palms, soles, eyelids, tip of tongue, nipples, clitoris, tip of penis.

   - Pressure detection = **Pacinian Corpuscle's**;
     a. onion-shaped;
     b. located in deep dermis and subcutaneous regions;

5. **Vitamin D Synthesis**:
   - UV rays in sunlight activate its synthesis;
   - Vitamin D is required for bone homeostasis.

6. **Blood Reservoir**:
   - The dermis houses about 10% of the body's blood vessels.
   - Skin only requires 1-2% of the body's blood

7. **Immunity**:

- Langerhan's cells (macrophages);
- interact with T-helper cells in immune responses.

II. **SKIN AND ITS TISSUES** (Cutaneous Membrane)

C. **Epidermis**:

1. Structure = **keratinized stratified squamous epithelium**;

a. **Four distinct layers** determined by the extent of keratinization in the epithelial cells:

1. **Stratum corneum** = outermost layer.

- composed of dead epithelial cells filled with the protein keratin;

*** **Stratum lucidum** = translucent layer cells separating s. corneum from s. granulosum.

- extra layer only in thick skin of soles & palms;

2. **Stratum granulosum** is composed of 3-5 layers of flattened granular cells (filled with keratin granules);

3. **Stratum spinosum** is composed of many layers of spiky cells with large nuclei;

4. **Stratum basale** (germinativum)= innermost layer;

- directly above basement membrane;
- composed of a single row mitosing cuboidal epithelial cells and
- composed of melanocytes.

a. specialized cells that produce the pigment melanin.

2. Main Function = **Protection** (keratin):

a. prevents moisture loss (waterproof);
b. prevents injury by penetration;
c. prevents microorganisms/chemicals entry

II. **SKIN AND ITS TISSUES** (Cutaneous Membrane)

C. **Epidermis**:

3. Pigment = **Melanin**:

a. determines **skin color**:
b. is produced by melanocytes in stratum basale (germinativum);

D. **Dermis**: inner layer of skin;
binds epidermis to underlying tissues.

1. Structure:

a. **two distinct layers**:
1. **papillary layer** (20%) is below epidermis:
- composed of loose areolar CT;
- surface forms dermal papillae (finger-like projections into the epidermis) that form fingerprints in thick skin
- **Meissner's Corpuscles** (sensory receptor for light touch).

2. **reticular layer** (80%) = dense irregular CT;
- bundles of collagen fibers,
- elastic fibers, and
- reticular fibers which give skin its
- strength and resiliency.
- Pacinian corpuscles –sensory receptors for deep pressure

b. The dermis houses epidermal derivatives or accessory organs (see below).

2. Main Function = **nourishment** of epidermis.

E. **Subcutaneous Layer (hypodermis)** = beneath skin.
1. Structure = adipose tissue & blood vessels;
2. Function = insulation.

III. ACCESSORY ORGANS OF THE SKIN (Epidermal Derivatives)

A. Hair Follicles:

1. Structure:
   a. root or base in deep dermis;
   b. follicle throughout dermis;
   c. hair shaft in epidermis.

2. Keratinization
   a. cells are epithelium;
   b. cells in root = active mitosis;
   c. cells in follicle = maturing & accumulating keratin;
   d. cells in epidermis = dead epithelial cells; full of keratin = exposed hair or hair shaft.

3. **Pigment = Melanin**

4. **Arrector Pili Muscle** = a bundle of smooth muscle associated with every hair follicle.
   a. causes hair to stand on end ("goose bumps") when frightened or cold.

B. Nails:

1. Epithelium undergoing keratinization (active mitosis in lunula).
2. Functions:
   a. manipulation;
   b. protection of digit ends.

C. Sebaceous Glands:

1. holocrine gland (simple cuboidal epithelium);

2. associated with every hair follicle;

3. Secretion (holocrine) = sebum (i.e. oil).
   a. fat
   b. cellular material

4. Sebum is secreted into hair follicle;

5. Function: Sebum keeps skin & hair soft, pliable and virtually waterproof!

6. Disorders:

a. acne (hypersecretion of sebum; ducts clog & inflame);
b. seborrhea (hyperproduction of sebum; oily scales)

III. ACCESSORY ORGANS OF THE SKIN (Epidermal Derivatives)

D. Skin Glands (Sweat Glands or Sudoriferous Glands)

1. Two types (based on glandular secretion):
   a. **Merocrine (Eccrine) Glands**:
      - Structure:
        1. coil in deep dermis
        2. duct in dermis
        3. pore at surface
      - Characteristics:
        1. respond to elevated temperature / exercise
        2. no odor in secretion
        3. function throughout life
        4. not associated with hair follicles
        5. Location: forehead, neck, back
      - Secretion (merocrine) = water plus
        1. salts and
        2. wastes (urea and uric acid)

   b. **Apocrine glands**:
      - Structure: ducts terminate into hair follicles
      - Characteristics:
        1. respond to stress / emotions
        2. odor in secretion
        3. begin to function at puberty & continue through life
        4. associated with hair follicles
        5. Location: armpits, groin
      - Secretion (apocrine) = sweat above plus
        1. oil and
        2. cellular debris.
      - Modified Apocrine Glands
        1. **Ceruminous glands** = external ear; secretion = earwax;
        2. **Mammary glands** = breasts; milk.

***Note that the above structures under III. **ACCESSORY ORGANS OF THE SKIN (Epidermal Derivatives)** are epithelial in nature and are actually specialized parts of the epidermis, even though their location is within the dermis.

IV. REGULATION OF BODY TEMPERATURE – normally near 98.6 F set point

A. Heat production and loss.

1. **Heat production** is mostly a by-product of cellular metabolism.

2. **Heat loss** is controlled by regulating dermal blood flow.
   a. Vasodilation – increases dermal blood flow, which also increases heat loss
   b. Vasoconstriction – decreases derma blood flow which decreases heat loss

3. Heat loss is by four methods
   a. **Radiation**
      - most heat loss by this mode
      - infrared heat rays move from area of high heat (i.e. the blood) to areas of low heat (i.e. the environment)
   b. **Conduction**
      - less heat loss
      - heat moves by physical contact
      - the reason the seat you sit in is warm when you stand up
   c. **Convection**
      - heat loss to surrounding air
      - increases as air movement increases, that is why turning on a fan cools your body
   d. **Evaporation**
      - heat loss varies
      - if heat increases our sweating increases, so we lose more heat by evaporating the sweat on the surface of our skin

4. Low body temperatures require heat loss to be minimized
   a. The **Hypothalamus** signals for sweating to decrease (decreasing heat loss by evaporation) and dermal vasoconstriction (decreasing heat loss by radiation)
   b. Usually this brings the body temperature back to normal

5. If the **body temperature remains low** after the above action
   a. Heat must be produced
   b. **Shivering** occurs and the tiny muscle contractions involved produce heat

IV. REGULATION OF BODY TEMPERATURE

B. Problems in Temperature Regulation

1. **Hyperthermia** – elevated body temperature
   a. Two common causes
      - humid air decreases evaporation
      - air temperature exceeds body temperature, thus heat is gained not lost

2. **Hypothermia** – low body temperature
   a. very dangerous if core body temperature drops below 94 F
   b. limbs can withstand about 65 F because they contain no vital organs
   c. cause is intentional during some surgical procedures

V. SKIN COLOR

A. Genetic Factors

1. People of different races have essentially the same # of melanocytes, but the amount of melanin produced varies (determined by **DNA**);

B. **Environmental Factors** affect melanin production: by affecting gene expression

1. UV rays,
2. chemicals,
3. drugs (antihistamines & antibiotics);

C. **Physiologic Factors** may affect skin color (but not melanin production):

1. Carotene may accumulate in s. corneum = orange;
2. Hemoglobin (Hb) in dermal blood vessels = pink;
3. Lack of Hb in dermal blood vessels = blue (cyanosis.)
4. Inability to breakdown Hb (liver problems) = yellow (jaundice)

VI. HEALING OF WOUNDS AND BURNS

Inflammation – process that involves blood flow changes and chemical signaling leading to healing.

A. **Cuts**

1. **Epidermal cuts** are closed by increased cell division in the stratum basale

2. **Deep cuts** involve blood vessel damage resulting in:

   a. Inflammation
   b. Blood clotting
   c. Scab formation
   d. Fibroblast infiltration and repair
   e. Scab falls off
   f. Scar may or may not remain

B. **Burns**

1. Superficial partial-thickness burns **(1st degree)**

   a. Epidermis only
   b. Reddening due to increased blood flow
   c. Mild pain
   d. Common in sunburn
   e. Heals in a few days-2 weeks

2. Deep partial-thickness burns **(2nd degree)**

   a. Epidermis and some dermal damage
   b. Reddening and blistering caused by blood vessel damage
   c. Moderate pain
   d. Common to physical contact with hot objects
   e. Heals in 2-6 weeks without scars unless infected

3. Full-thickness burns **(3rd degree)**

   a. Epidermis, entire dermis, and potentially subcutaneal damage
   b. Dry, leathery tissue with red or black color
   c. Severe pain
   d. Caused by prolonged heat or chemical contact
   e. Healing rarely occurs due to lack of surviving skin cells, skin replacements (grafts) are usually needed, usually extensive scarring
      - Autograft – transplant from undamaged area of yourself
      - Homograft – temporary transplant from cadaver
      - Skin substitutes

VI. **HEALING OF WOUNDS AND BURNS**

B. **Burns**

4. Body Surface affected

a. Estimated by “rule of nines”
b. Important for determining treatment and prognosis

VII. LIFE SPAN CHANGES

A. Aging skin exhibits:
1. wrinkling
2. sagging
3. age spots or liver spots

B. Efficient regulation of body temperature declines with age.
1. The number of sweat glands changes.
2. Capillary beds in the skin shrink.

C. Synthesis of vitamin D declines as skin ages, which affects skeletal health.

VIII. HOMEOSTATIC IMBALANCES OF THE SKIN

Throughout the text of each chapter, your authors present selected imbalances, disorders, and diseases of each system. Although you may only discuss some major disorder in class, these disorders and diseases are very interesting to learn about. You are strongly encouraged to study them.

A. Epidermolysis bullosa.
B. Psoriasis.
C. Contact dermatitis.
D. Rashes.
E. Skin Cancer = carcinoma.
F. Folliculitis.
G. Hair loss.
H. Acne.
I. Hypothermia.
J. Albinism.
K. Elevated body temperature.
L. Jaundice.