Integumentary System Lecture Notes

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I. Skin

In adults, the skin represents 16% of the total body weight, and is the largest organ of the body.

A. Epidermis

1. Cells

Keratinocytes

90% of epidermal cells are keratinized
contains keratin (fibrous protein)
protects and waterproofs the skin

Melanocytes

8% of the epidermal cells
produces melanin
contributes to skin color and absorbs UV light

Langerhans cells

Arise from red bone marrow and migrate to the epidermis
Constitute small portion of epidermal cells
Participate in immune responses
Easily damaged by UV light

Merkel cells

Least numerous of the epidermal cells
Found in the deepest layer of the epidermis
Along with tactile discs, they function in sensation of touch
2. Layers

Stratum basale
Also referred to as stratum germinatum because this is where new cells are formed
Deepest layer of the epidermis
Single row of cuboidal or columnar keratinocytes

Stratum spinosum
Located above the stratum basale
8-10 layers of keratinocytes
Some cells retain their ability for cell division
Cells have spindleshape projections (bundles of filaments of the cytoskeleton)
Tightly joins cells to each other.
Provides skin both strength and flexibility

Stratum granulosum
Located above the stratum spinosum
3-5 layers of flattened keratinocytes undergoing apoptosis
Organelles begin to disintegrate
Becomes non-living cells
Marks the transition between deeper metabolically active strata and the dead cells of the superficial strata.
Contains lamellar granules
Secretes lipid-rich secretion that acts as a water sealant

Stratum lucidum
Present only in thin skin
3-5 layers of clear, flat, dead keratinocytes
dense packed intermediate filaments
Thick plasma membranes

Stratum corneum
25-30 layers of dead flat keratinocytes
Shed continuously and replaced by cells from the deeper strata
Serves as a water, microbe, injury barrier

3. Growth
Newly formed cells in the stratum basale undergo keratinization as they are pushed to the surface.
They accumulate more keratin during the process
They then undergo apoptosis
Eventually they slough off and are replaced
The process takes about 4 weeks
Rate of cell division in the stratum basale increases during injury
B. Dermis
Second deepest part of the skin
Blood vessels, nerves, glands and hair follicles are embedded here
Composed mainly of connective tissues (collagen and elastic fibers)
Collagen fibers make up 70% of the dermis and give structural toughness and strength. Elastin fibers are loosely arranged in all directions and give elasticity to the skin.

Can be divided into 2 regions
  Papillary region
    Superficial portion of the dermis
    Consist of areolar connective tissue containing elastic fiber
    Surface area is increased due to projections called dermal papillae
    Contains capillaries or tactile receptors
    Epidermal ridges conforms to the dermal papillae
  Reticular region
    Deeper portion of the dermis
    Consist of dense irregular connective tissue containing collagen/elastic fibers
    Provides skin with strength and elasticity
    Contains hair follicles, nerves, sebaceous and sudoriferous glands

C. Hypodermis
Lies below the dermis
Not part of the skin
Contains areolar connective tissue and adipose tissues
Attaches the skin to underlying organs and tissues.
II. Skin Color

3 pigments responsible for skin color
melanin, carotene, hemoglobin

Melanin
Located mostly in epidermis
Melanocytes are plentiful in:
Mucous membranes, penis, nipple area, face, and limbs
Number of melanocytes are about the same in all races
Difference in skin color is due to the amount of pigment that melanocytes produce and disperse to keratinocytes.
Freckles are caused by the accumulation of melanin in patches
Liver spots are also caused by the accumulation of melanin
Melanocytes synthesize melanin from an amino acid called tyrosine along with an enzyme called tyrosinase. All this occurs in the melanosome which is an organelle in the melanocyte.
UV light increases enzymatic activity in the melanosomes and leads to increased melanin production.
A tan is achieved because the amount of melanin has increased as well as the darkness of the melanin.
The melanin provides protection from the UV radiation but prolonged exposure may cause skin cancer.

Carotene
(carot = carrot)
yellow-orange pigment
precursor for Vitamin A which is used to make pigments needed for vision
found in stratum corneum and fatty areas of dermis and hypodermis layer

Hemoglobin
Oxygen-carrying pigment in red blood cells

Epidermis appears translucent when there is little melanin or carotene
White skin appears pink to red depending on amount and oxygen content of blood moving in the capillaries of the dermis.

Albinism
Inherited trait
Can’t produce melanin
Have melanocytes but unable to make tyrosinase.
Missing melanin in their hair, eyes, and skin.
Skin color as diagnostic clues for medical conditions

Cyanotic (cyan = blue)
- Ex: someone who has stopped breathing
- Skin appears bluish
- Hemoglobin is depleted of oxygen

Jaundice (jaund = yellow)
- Buildup of bilirubin (yellow pigment) in the blood
  - Bilirubin is produced when red blood cells get old and are broken down by the body. Normally it is processed in the liver and then deposited in the intestine so it can come out in the stool.
- Yellowish appearance of eyes and skin
  - Indicates liver disease

Erythema (ery = red)
- Engorgement of capillaries in the dermis
- Indicates skin injury, infection, heat exposure, inflammation, allergies

III. Accessory Structures of the Skin

A. Hair

- Shaft: portion of hair that projects from skin surface
  - Straight hair has a round shaft
  - Curly hair is oval

- Root: portion of hair deep to the shaft penetrating the dermis

  3 layers:
  - medulla: contains pigment granules and air spaces
  - cortex: middle layer
    - in dark hair contains pigment
    - in gray or white hair contains air bubbles
  - cuticle: outer layer
    - heavily keratinized cells that lie like shingles

- Base of the hair follicle
  - Bulb: houses the papilla which contains the blood vessels that nourishes the growing hair follicle.
  - Matrix: responsible for hair growth and produces new hair

- Arrector pili: smooth muscle
  - Extends from the dermis to the side of hair follicle.
  - Hair grows at an angle to the surface of the skin
  - Arrector pili muscles contract and pulls hair straight causing goosebumps.

- Hair root plexus
  - Dendrites of neurons that are sensitive to touch
1. Growth

Every hair follicle goes through a growth cycle consisting of a growth stage and a resting stage.

Each hair on your body grows from its own individual hair follicle. Inside the follicle, new hair cells form at the root of the hair shaft. As the cells form, they push older cells out of the follicle. As they are pushed out, the cells die and become the hair we see.

A follicle will produce new cells for a certain period of time depending on where it is located on your body. This period is called the growth phase. Then it will stop for a period of time (the rest phase), and then restart the growth phase again.

When the hair follicle enters the rest phase, the hair shaft breaks, so the existing hair falls out and a new hair takes its place. Therefore, the length of time that the hair is able to spend growing during the growth phase controls the maximum length of the hair.

The cells that make the hairs on your arms are programmed to stop growing every couple of months, so the hair on your arms stays short. The hair follicles on your head, on the other hand, are programmed to let hair grow for years at a time, so the hair can grow very long.

Animals that shed have hair follicles that synchronize their rest phase so that all of the follicles enter the rest phase at once.

Some factors that affect the rate of growth and replacement of hair are illness, diet, stress, gender, radiation therapy, and medication.

2. Color

Hair color is due to amount and type of melanin in the keratinized cells.

Melanocytes in the matrix of the bulb synthesizes melanin.

Melanin passes into the cortex and medulla of the hair.

Dark hair contains true melanin

Blond and red hair have variants of melanin in which there are iron/sulfur.

Decline in tyrosinase causes gray hair.

White hair results from the accumulation of air bubbles in the medullary shaft.

3. Functions

Hair on the head protects scalp from injury and sunlight

Eyelashes and eyebrows protect eyes

Nostril and ear hairs protect from foreign particles

Help in sensing light touch due to the touch receptors associated with the hair root plexuses.
B. Skin Glands

1. Sebaceous
(sebace = grease)
oil glands
Sebaceous glands begin to function at puberty, when the male and female reproductive hormones kick in
They are mostly connected to hair follicles.
Sebaceous glands are embedded in the dermis over most of the body.
Absent in the palms and soles.
Vary in size, shape and numbers in other areas of the body.
Secrete an oily substance called sebum.
   Mixture of fats, cholesterol, proteins, inorganic salts, pheromones.
   Coats surface of hair
   Prevents excessive evaporation of water from skin
   Keeps skin soft and pliable
   Inhibits growth of some bacteria.

2. Sudoriferous
(sudori = sweat) (ferous = bearing)
sweat glands
3-4 million glands in your body empties onto the skin thru pores or into hair follicles
Two main types of sweat glands
   Eccrine sweat glands
   Secretes cooling sweat
   Secretes directly onto the skin
   Begans to function soon after birth
   Sweat is composed of 98 percent water and two percent dissolved salts and nitrogenous wastes, such as urea and uric acid
   Helps regulate body temperature/aids in waste removal
   Appocrine sweat glands
   Stimulated during emotional stress/excitement
   Secretes into hair follicle
   Begans to function at puberty
   Slightly more viscous than eccrine secretions
   Composed of the same components as eccrine sweat plus lipids and proteins.
   Referred to as “cold sweat”.

3. Ceruminous
(cer = wax)
modified sweat glands of the exeternal ear open directly onto the surface of the external auditory canal (ear canal) or into ducts of sebaceous glands.
Earwax is the combination of secretion of ceruminous and sebaceous glands.
Earwax and the hair combine to provide a sticky barrier against foreign items.
C. Nails
Made of tightly packed, hard, keratinized epidermal cells
Consist of:
   Nail body: portion of the nail that is visible
   Free edge: part that extends past the distal end of the digit
   Nail root: portion buried in a fold of skin
   Lunula: means little moon
      Crescent shaped area of the nail
   Hyponychium: secures the nail to the fingertip
      Thickened stratum corneum
   Eponychium or cuticle: narrow band of epidermis
Growth of nails is in the nail matrix.
   Nail cells multiply under the skin. Each cell keeps dividing and creating more cells. The new cells push the old cells above the skin surface.
   Once the nail cells are out on the surface, they are pushed from below by new nail cells, towards your finger or toe. However, once they come out they lose the ability to multiply. They become dead cells.
Functions of the nails:
   Grasping objects
   Manipulating objects
   Protects ends of digits from trauma
   Scratching
The record in nail growth is held by an Indian from Pune, called Shridhar Chillal. The nails of his left hand measure a total of 242 inches. Chillal's thumb nails are the longest at 56 inches. He hasn't cut his nails since 1952.

D. Types of Skin
   1. Thick
      Hairless
      Covers palms, and soles
      Thick epidermis and a distinct stratum lucidum
      Epidermal ridges are present due to well-developed, numerous dermal papillae.
      Lacks sebaceous glands, has more sweat glands
      Sense receptors are also more densely packed.
   2. Thin
      Hairy
      Covers all parts of the body except palms, soles
      Thin epidermis and lacks stratum lucidum
      Lacks dermal papillae
      Has more sebaceous glands
      Less sweat glands, sensory receptors than thick skin
IV. Functions of the Integument

A. Temperature regulation
When body temperature rises and is hotter than the external environment the blood vessels in the dermal area dilates and sweat glands are stimulated into activity. Evaporation of the sweat from skin’s surface helps dissipate heat from the body. When it is cold outside, the dermal blood vessels constrict and pull the blood away from the skin and keeps it close to the body core to protect crucial internal organs.

B. Protection
Physical barriers
Due to the skin’s physical characteristics such as the keratinized cells and waterproofing properties of the glycolipids.
Chemical barriers
Skin secretions such as sebum, human defensin, acid mantle of the skin retards bacteria growth and/or killed.
Melanin provides protection from UV damage
Biological
Langerhan’s cells and macrophages present in the skin helps active the body’s immune system.

C. Cutaneous Sensations
Meissner’s corpuscles: light touch
Merkel discs: light touch
Hair root plexus: sensations from movement of hairs
Bare nerve endings: painful stimuli (chemicals, heat, cold)
Pacinian receptors: lies in deeper dermis/hypodermis
Deep pressure

D. Excretion/Absorption
Excretion of water, sodium chloride, ammonia, urea, uric acid

E. Metabolic Functions
Vitamin D is a fat-soluble vitamin that may be absorbed from the intestines or may be produced by the skin when the skin is exposed to ultraviolet light (particularly sunlight). It is converted to its active form by the body in 2 steps, occurring first in the liver and completed in the kidneys. In its active form, vitamin D acts as a hormone to regulate calcium absorption from the intestine and to regulate levels of calcium and phosphate in the bones.

When the body is deficient in vitamin D, it is unable to properly regulate calcium and phosphate levels. If the blood levels of these minerals becomes low, the other body hormones may stimulate release of calcium and phosphate from the bones to the bloodstream.
V. Maintaining Homeostasis: Wound Healing

Epidermal wound:
- Basal epithelial cells divide and migrate across the wound
- Stop migrating due to contact inhibition
- Thickening of the epidermis

Deep wound
- Extends to the dermis and subcutaneous layers
- Scar tissue will form
- Healed tissue loses some of its normal function
- Occurs in 4 stages
  - Inflammatory
    - Blood clot forms
    - Enhanced delivery of WBC
    - Prepares for repair
  - Migratory
    - Clot becomes a scab
    - Epithelial cells begin to migrate
    - Fibroblasts synthesizes scar tissue (collagen, glycoproteins)
      - Scar tissue formation is called fibrosis
    - Damaged blood vessels repair
    - Granulation tissue begins to fill the wound
  - Proliferative
    - Extensive growth of the epithelial cells
    - Fibroblasts randomly deposit collagen fibers
    - Continued blood vessel repair
  - Maturation
    - Scab comes off
    - Collagen becomes more organized
    - Fibroblasts decrease in number
    - Blood vessels restored to normal
VI. Imbalances of Homeostasis

A. Cancer

Cell have a built-in mechanism that causes contact inhibition. Healthy cells stop growing when they come in contact with one another. In damaged cells, contact inhibition is loss and therefore the cells continue to grow until they start lumping up on one another. Cancer cells do not exhibit contact inhibition.

UV radiation, chemicals or physical trauma are predisposing factors to cancer.

3 forms of cancer

- Basal cell carcinoma
  - 78% of all skin cancers
  - Arise from stratum basale
  - Rarely metastasize (spreads)
  - Has a pearly elevation with blood vessels in the middle
  - Best chance of full recovery if detected and treated early

- Squamous cell carcinoma
  - 20% of all skin cancers
  - Arise from squamous cells of the epidermis
  - Spreads rapidly if not removed
  - Good chance of recovery if detected and treated early
  - Hardened small red growth

- Melanomas
  - Arise from melanocytes
  - Most dangerous
  - Spreads rapidly
  - Early detection and treatment is the key to survival

Warning signs as suggested by American Cancer Society

ABCD rule

- A: asymmetry, sides do not match
- B: border, indentations on border
- C: color, contains various colors
- D: diameter, larger than 6 mm (pencil eraser size)

(E): elevation

Risk factors for cancer

- Sun exposure, skin type, family history, age, immunological status
B. Burns

Destroys skin’s contribution to homeostasis
- Microbial protection
- Prevention of desiccation
- Thermoregulation
- Electrolyte imbalance

Graded according to their severity
- First degree: epidermis
  - Redness, swelling, pain
- Second degree: epidermis and upper parts of dermis
  - Blisters also appear
- Third degree: destroys epidermis, dermis and dermal structures
  - Fluid loss and infection and skin grafting is usually necessary

Quick means of estimating burned surface area is called RULE OF NINES
- Head and neck
  - 4 ½% for front, 4 ½% for back
- Trunk
  - 9% for front, 9% for back
- Upper limbs
  - 4 ½% for front, 4 ½% for back
- Lower limbs
  - 9% for front, 9% for back
- Perineum
  - 1%

Burns are critical under these conditions
- Over 25% of body has 2nd degree burn
- Over 10% of the body has 3rd degree burn
- 3rd degree burns of the face, hand, feet

C. Pressure Sores

Pressure sores are areas of injured skin and tissue. They are usually caused by sitting or lying in one position for too long. This puts pressure on certain areas of the body. The pressure can reduce the blood supply to the skin and the tissues under the skin. When a change in position doesn't occur often enough and the blood supply gets too low, a sore may form. Pressure sores are also called bed sores, pressure ulcers and decubitus ulcers.

Pressure sores usually develop over bony parts of the body that don't have much fat to pad them.
D. Aging

Beginning in our 20s, the effects of aging begin to be visible in the skin. Genetically programmed chronologic aging causes biochemical changes in collagen connective tissues that give skin its firmness and elasticity. The genetic program for each person is different, so the loss of skin firmness and elasticity occurs at different rates and different times in one individual as compared with another. As skin becomes less elastic, it also becomes drier. Underlying fat padding begins to disappear. With loss of underlying support by fat padding and connective tissues, the skin begins to sag. It looks less supple, and wrinkles form. The skin may be itchy with increased dryness. A cut may heal more slowly.

E. Bruises

First, the bump that will probably look red or purplish and tender. The bump might swell from the blood collecting under the tissue.

After a couple of days, the bruise will look blue (or even blackish).

After 5 to 10 days, it may look greenish or even yellow.

After 10 to 14 days, the bruise will most likely be a light brown, then get lighter and lighter as it fades away.

Bruises change colors over time in a predictable pattern, so that it is possible to estimate when an injury occurred by the color of the bruise.