Integumentary System

Definition

The integumentary system has 2 major components

- the cutaneous membrane
  - epidermis
  - dermis

- accessory structures
  - hair, nails
  - multicellular exocrine glands
Some Skin Facts

- A surface area of 1.5 - 2 square meters
- Weighs approximately 4-5 kg (9-11 lbs.)
- Every square centimeter contains:
  - 70 cm of blood vessels
  - 55 cm of nerves
  - 100 sweat glands
  - 15 oil glands
  - 230 sensory receptors
  - Half million cells that are constantly dying and being replaced

Functions

- Protection of underlying tissues and organs
- Excretion of salts, water and organic wastes
- Maintenance of normal body temperature
- Storage of nutrients (fats)
- Detection of external stimuli
- Synthesis of Vitamin D3
The Epidermis

- Upper layer of the skin
- Consists out of an a-vascular stratified squamous epithelium (nutrients need to diffuse from dermis up)
- The most abundant cells are Keratinocytes and they form several strata
  - thin skin has about 4 strata of cells
  - thick skin has about 5 strata of cells
- These cells form keratin fibers that are at the basis of protecting the top layer with a water resistant layer: the stratum corneum
  - stratum corneum is thicker in thick skin
Thick vs Thin Skin

Epidermis layer sits on top of the Dermis; they are separated by the basal lamina - the basement membrane to which the lower epidermal cells attach to.

Layers of Epidermis

In thick skin, 5 layers or strata can be identified. Starting with the deepest stratum and moving superficially, we recognize:

- Stratum germinativum (basale)
- Stratum spinosum
- Stratum granulosum
- Stratum lucidum
- Stratum corneum

In thin skin, the *stratum lucidum* is absent!
Layers of Epidermis

One cell layer thick and attaches to the basal lamina with hemi-desmosomes and CAM's. Large basal cells dominate which exhibit a high rate of mitosis.

- Also contains melanocytes that produce the brown pigment melanin.
- Skin surfaces without hair also contain specialize epithelial cell called Merkel cells; these are special touch receptors.
Stratum spinosum

- Contain the divided cells from the stratum basale, which in turn divide themselves
- Typically 8 - 10 layers of cell thick
- Cells start to produce keratin
- Also contains Langerhans’ cells, which help in stimulating a response to micro-organisms or superficial skin cancers.

Stratum granulosum

- Consists out of 3 -5 layers of cells
- Cells are actively producing keratin and keratohyalin, which is visible by the granules in the cells.
- The cells are now far away from the closest blood supply; they become flattened, organelles disintegrate and they start to die off.
### Stratum corneum

- Located at the exposed area of the skin
- Depending on the thickness of the skin, it contains several layers of dead, keratinized cells
- The cells are still connected via desmosomes, forming a tight, water-resistant (but not waterproof) cover
- This layer is important to prevent excessive water loss from the interstitial fluid via the epidermis (called insensible perspiration ~ 500 ml per day)

### More Skin Facts

What happens to your skin when you soak in the bath tub too long?

What happens to your skin when you soak in the sea too long?
Blisters

- Blisters are the result of damage to the skin.
- Water accumulates in pockets within the epidermis.
- Simple blisters have water pockets between superficial and deeper layers of epidermal cells.
- More severe blisters occur when damage results in water pockets between dermis and epidermis.

Skin Color

- Three pigments contribute to skin color; melanin, carotene, and hemoglobin
- Melanin ranges in color from yellow to reddish brown
- Racial differences in skin coloring reflect the relative kind and amount of melanin
- Dark skinned people produce much more and darker melanin than those of fair skinned individuals
• Sunlight stimulates melanocyte to produce more melanin
• Melanin concentrates around the nucleus and protects DNA from UV radiation damage
• Freckles are an area of skin with larger than normal production of Melanin

• Sunlight also stimulates keratinocytes to convert a cholesterol derivative into Vitamin D3 or Cholecalciferol
• Cholecalciferol is converted in the liver and finally in the kidneys to the hormone calcitriol.
• Calcitriol is an essential hormone for absorption of calcium and phosphate from the intestine
The Dermis

- Located immediately deep to the epidermis
- This layer makes up the bulk of the skin
- A tough leathery layer composed of fibrous connective tissue (areolar and dense irregular).
- Dermis is richly supplied with nerve endings, blood vessels, and lymphatic vessels

The Dermis

The Dermis has two regions
- Papillary region
- Reticular region
Papillae and Epidermal Ridges

- Papillary region derived its name from the dermal papillae that extend into the epidermis.
- The projections of the epidermis into the dermis are called the epidermal ridges.
- Papillae and epidermal ridges increase surface area of contact and provide stronger attachment of the layers.

In thick skin, the surface of the skin follows epidermal ridges, producing friction ridges which are genetically determined (e.g. fingerprints).

Reticular Region

- Papillary region contains small capillaries and sensory neuron endings embedded in areolar C.T.
- The Reticular region contains hair follicles, sweat glands, larger blood vessels, nerve fibers and sensory organs.
- C.T is mostly dense irregular C.T. with the collagen fibers extending deeper into the hypodermis layer.
Dermal Issues

- Skin is very flexible and allows for stretching
- Collagen fibers stop distortion when stretching gets too bad
- Stretch-marks and wrinkles develop because of damage to elastic and collagen fibers
- Collagen and elastic fibers run in bundles
- Orientation depends on stress the skin experiences
- The pattern creates lines of cleavage
- Cuts parallel to lines of cleavage close easier, heal faster and leave less scarring

SubCutaneous Layer

- Also called the HYPODERMIS
- Located immediately deep to the Dermis layer
- NOT part of the skin but provides important stabilization for skin and underlying organs
- Superficial area contains many blood vessels = subcutaneous plexus
- Rest contains mostly connective tissue (areolar) and fat tissue
  - Subcutaneous injections
  - Liposuction
Accessory Structures

- Hair
- Exocrine glands
- Nails

Humans: the naked ape

- Humans have on average 2.5 million hairs
- 25% are on the scalp
- Hair is produced in hair follicles

Function

- Protect and insulate the head
- Prevent unwanted particles to enter nose, eyes
- Provide extra sensation to the skin
Hair Structure

- The hair shaft projects from the skin
- The root is embedded in the skin
- The deep end of the follicle is expanded and forms a hair bulb

- Central medulla
  - Flexible soft keratin
- Cortex surrounds medulla
  - Layers of hard keratin
- Cuticle on outside of cortex
  - Most heavily keratinized

Hair Structure

- Hair growth starts in basal cells near the center of the matrix
- They form medulla, cortex and cuticle
- Hair is surrounded by dermal and epidermal layers
  - Internal root sheath: only extends for a short distance
  - External root sheath: reaches all the way to the top of the skin
  - Glassy membrane wrapped in a thick outer connective tissue sheath
Hair Structure

- **Arrector pili**:
  - Smooth muscle that causes hair to stand erect
  - Contraction is result of fear, rage or response to cold
  - In hairy mammals this reflex helps as an insulation barrier
- **Root hair plexus**
  - Sensory nerves that allow us to feel a single hair

Hair Accessories
Skin Glands

- Sebaceous glands (oil glands).
- Eccrine sweat glands (merocrine).
- Apocrine sweat glands.

**SEBACEOUS GLANDS**

- Holocrine glands that produce oily substance called sebum.
- Sebum lubricates the skin and has anti-bacterial properties.
- Most glands have ducts that empty into hair follicles.
- Glands are very active right before birth. They stop after birth but become activated again at puberty (acne).
SWEAT OR SUDORIFEROUS GLANDS

- **Eccrine sweat glands (merocrine).**
  - numerous and widely distributed
  - palms and soles have highest numbers
  - sweat contains 99% water; electrolyte (NaCl), organic components, antibiotics, waste products
  - Functions to
    - reduce body temperature; FAILURE results in heat stroke
    - excrete some ingested drugs
    - discourages bacterial growth
  - Water loss via sweating is called sensible perspiration (can be up to a gallon per hr)

- **Apocrine sweat glands.**
  - They are actually merocrine sweat glands
  - produce odorous secretions since bacteria secretions are nutrient source for bacteria
  - secrete product into hair follicles
  - located mostly in armpits, groin area
SWEAT GLANDS

Most Mammals

- Few eccrine sweat glands
- Lots of apocrine glands

Humans

- MANY eccrine sweat glands
- FEW of apocrine glands
BRIEF OVERVIEW OF BURNS

- 1\textsuperscript{st} degree – damages only epidermis, a sunburn with reddening of the skin

- 2\textsuperscript{nd} degree – burn destroys much of the epidermis but leaves some epidermal remnants
  - Re-growth from remnants is possible
  - Blisters are common and pain is often severe since the skin nerves are irritated by the products of cellular destruction

BURNS

- 3\textsuperscript{rd} Degree – reaches to and through dermis – often exposing muscle and bone
- No epidermal remnants are present
- No feeling because of destruction of nerves
- Treatment requires skin grafts to provide epidermal cells
- Healing is slow at best
**BURN PROBLEMS**

- Infection barrier is destroyed
- Maintaining fluid
- Maintaining electrolyte balance which requires food and fluid intake
- Contractures of skin and underlying CT and muscle due to intense scarring
- Thermoregulation problems

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**Skin Cancers**

- The three major types of skin cancer are:
  - Basal cell carcinoma
  - Squamous cell carcinoma
  - Melanoma
Basal Cell Carcinoma

- Least malignant and most common skin cancer
- Stratum basale cells proliferate and invade the dermis and hypodermis
- Slow growing and do not often metastasize
- Can be cured by surgical excision in 99% of the cases

Squamous Cell Carcinoma

- Arises from keratinocytes of stratum spinosum
- Arise most often on scalp, ears, and lower lip
- Grows rapidly and metastasizes if not removed
- Prognosis is good if treated by radiation therapy or removed surgically
Melanoma

- Cancer of melanocytes is the most dangerous type of skin cancer because it is:
  - Highly metastatic
  - Resistant to chemotherapy

<table>
<thead>
<tr>
<th>Normal Mole</th>
<th>Melanoma</th>
<th>Sign</th>
<th>Characteristic</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Asymmetry</td>
<td>when half of the mole does not match the other half</td>
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<tr>
<td></td>
<td></td>
<td>Border</td>
<td>when the border (edges) of the mole are ragged or irregular</td>
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<td></td>
<td></td>
<td>Color</td>
<td>when the color of the mole varies throughout</td>
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<tr>
<td></td>
<td></td>
<td>Diameter</td>
<td>if the mole’s diameter is larger than a pencil’s eraser</td>
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