Basic Science of the Skin: Structure and Function

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Objectives

By completing the module, you should be able to:

1. Gain familiarity with skin functions and how relevant dysfunction contributes to disease
2. Approach dermatologic disease with an understanding of basic skin structure and microanatomy
Lecture Outlines

- Functions of the skin
  - Skin conditions related to disorder of skin function
- Basic anatomy of the skin
  - Related cutaneous diseases
- Take-home points
The skin provides a physical barrier that regulates water loss and protects against mechanical, chemical and microbial insults from the external environment. Dysfunction of the skin barrier leads to injury, dehydration, infection and inflammation.

- This child has atopic dermatitis, a chronic skin condition associated with barrier dysfunction.
2- Immunologic function

- As an immunologic barrier, the skin both senses and responds to pathogens.
- Dysfunction of the immunologic barrier leads to infection, skin cancer, inflammatory skin conditions and allergy.
  - This HIV-positive man has molluscum contagiosum, a skin infection caused by a virus.
3- Temperature regulation

- The skin maintains a constant body temperature with the insulating properties of fat and sweating and a dense superficial microvasculature.
- Dysfunction of temperature regulation leads to hyper- or hypothermia.
4- Protection from radiation

- The dark pigment melanin in the epidermis protects cells against ultraviolet radiation.
- Dysfunction of melanin production causes the patient to be more susceptible to skin cancer.

- This patient with albinism has a skin cancer on the back.
5- Nerve sensation

- Sensory receptors allow the skin to constantly monitor the environment and mechanoreceptors in the skin are important for the body’s interactions with physical objects.

- Dysfunction leads to pruritus (itch), dysesthesia (abnormal sensation), and insensitivity to injury (e.g. diabetes, leprosy).

  - This photo is of a chronic ulcer on the foot of a patient with peripheral neuropathy related to diabetes.
6- Injury repair

- The cutaneous wound repair
- Loss of ability to repair injury (e.g. post-radiation treatment) leads to delayed wound healing.

- This patient has a chronic ulcer following trauma on the scalp in a site previously irradiated as part of treatment for squamous cell carcinoma.
Skin defects and even physiologic aging can result in considerable psychological distress, an important clinical feature of many cutaneous diseases.

- This patient has HIV-associated lipoatrophy, characterized by loss of fat throughout the face.
- Atrophy of buccal fat pads have an impact on self-esteem.
Module Outline

- Functions of the skin
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Layers of the skin

- Skin is composed of three layers:
  1. Epidermis
  2. Dermis
  3. Subcutis
Can you name the layers of the skin indicated below?

\(a\)

\(b\)
- The epidermis is the topmost layer, and consists primarily of keratinocytes (95%).
- The dermis lies below the epidermis, and consists primarily of fibroblasts, collagen, and elastic fibers.
Layers of the skin

Below the dermis lies fat, also called subcutis, panniculus, or hypodermis.
Outline: basic anatomy of skin

- Layers of the skin
  - Epidermis: layers, cell types, and function
  - Dermis: layers, cell types, and function
  - Subcutis
- Adnexal structures
Can you name the four major layers of the epidermis?
Can you name the four major layers of the epidermis?

- Stratum corneum
- Stratum granulosum (granular cell layer)
- Stratum spinosum (spiny layer)
- Stratum basale (basal cell layer)
Functions of the layers of the epidermis

Epidermal cells mature and differentiate over their two-week life cycle from the basal cell layer to the stratum corneum. They are then shed two weeks after reaching the stratum corneum (for a 28-day cycle).

**1. Basal layer**
- The basal layer is the source of epidermal stem cells.
- Cell division occurs here.
- Keratinocytes start in the basal layer and move upwards.
Functions of the layers of the epidermis

2. Spinous layer
   • Center of epidermis.
   • Has a “spiny” appearance due to desmosomal junctions which hold the keratinocytes together.

1. Basal layer
Functions of the layers of the epidermis

3. Granular cell layer
   - Lipids produced by the keratinocytes in the granular cell layer and secreted into the extracellular space between the keratinocyte forms a water barrier that keeps water in the skin

2. Spinous layer
1. Basal layer
Functions of the layers of the epidermis

4. **Stratum corneum**
   - Made up of desquamating keratinocytes.
   - Thick outer layers of flattened keratinized non-nucleated cells provide a barrier against trauma and infection.

3. Granular cell layer
2. Spinous layer
1. Basal layer
The Stratum Corneum

- You can think of the stratum corneum as a wall of bricks and mortar

1. Bricks: flattened keratinocytes filled with keratin and Mortar: lipid mixture, which surrounds the keratinocytes and provides the water barrier

Keratin and filaggrin-filled corneocyte

Lipid intercellular matrix
Diseases related to dysfunction of the epidermal layers

- Certain diseases cause loss of adhesion:
  - Bullous pemphigoid: an autoimmune blistering disease, typically affects older patients.
  - Autoantibodies form to antigens directly beneath the basal layer of the epidermis.
  - Clinically, presents as tense bullae on an erythematous base on the skin (mucous membranes may also be affected)
- The epidermis forms the roof of the blister
- The dermis forms the base of the blister
Diseases related to dysfunction of the epidermal layers

- In psoriasis, the rate of epidermal turnover is increased (thickening).
- The accelerated rate of movement through the epidermis doesn’t allow adequate time for differentiation, which is recognized as scale.
In the next pathology slide, see if you can identify this common skin cancer based on what you have learned about the layers of the skin.
Can you name the type of skin cancer? (Hint: The cells composing this growth resemble what layer of the epidermis?)
Basal Cell Carcinoma

- Most common form of skin cancer.
- Composed of cells that resemble basal keratinocytes.
Epidermis: Types of Cells

- Three main types of cells make up the epidermis:
  1. Keratinocytes
  2. Melanocytes
  3. Langerhans cells
Keratinocytes

- Keratinocytes make up the majority of cells.
- Keratinocytes are held together by macromolecular structures that look like stripes (or spines) between cells, called desmosomes (primarily visible in the spinous layer).
Melanocytes

- The second type of cell which makes up the epidermis is the melanocyte.
- Melanocytes are staggered along the basal layer at around one in every 10 keratinocytes.
- They are the pigment-producing cells, and transfer their pigment, called melanin, to the keratinocytes in the basal cell layer.
Nevi and Melanoma

- Melanocytic nevi, or moles, are benign collections of melanocytes.
- Melanoma, shown below, is a malignancy of melanocytes.

![Image of melanoma with note about asymmetry]
Langerhans Cells

- Langerhans cells are the third type of epidermal cells
- They are dendritic cells found in the mid-epidermis
- Their main function is in the afferent limb of the immune response by providing for the recognition, uptake, processing, and presentation of antigens to sensitized T-lymphocytes, and are important in the induction of delayed-type hypersensitivity.
  - A common skin disease in which Langerhans cells play a prominent role is allergic contact dermatitis, such as poison oak
Langerhans Cells
Outline: basic anatomy of skin

- Layers of the skin
  - Epidermis: layers, cell types, and function
  - Dermis: layers, cell types, and function
  - Subcutis

- Adnexal structures
Let’s move onto the dermis, which is shown below. Name the two layers of the dermis.
The two layers of the dermis

- Papillary dermis
- Reticular dermis
The Dermis

- The dermis provides a flexible but tough support structure.
- It is between 1-4 mm thick (depending on age and body location), making it much thicker than the epidermis.
- It contains the blood and lymphatic vessels and nerves which supply the skin, as well as sweat glands and hair follicles.
This is a biopsy from the scalp to show the follicles and sebaceous (oil) glands, found in the dermis.

Note the many hair follicles (yellow arrow) running through the dermis.

Each follicle has associated sebaceous or oil glands (blue arrow).

Red arrow – epidermis

Green arrow – reticular dermis

What else is in the dermis?
Cells of the dermis

- Fibroblasts and mast cells reside in the dermis
- Fibroblasts are responsible for the synthesis and degradation of connective tissue proteins
- They are instrumental in wound healing and scaring
  - Keloids (abnormal scars) result from uncontrolled synthesis and excessive deposition of collagen at sites of prior dermal injury and wound repair
Cells of the dermis

- Mast cells are specialized cells that are responsible for immediate-type hypersensitivity reactions in the skin.
  - The mast cell is the major effector cell in urticaria, which is a vascular reaction of the skin characterized by wheals surrounded by a red halo or flare.
Mast Cells
Outline: basic anatomy of skin

- Layers of the skin
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  - Subcutis

- Adnexal structures
The Subcutis

- The subcutis is the fat layer which separates the dermis from deeper underlying structures such as fascia and muscles.
- The subcutis insulates the body, serves as an energy supply, cushions and protects the skin, and allows for its mobility over underlying structures.
Outline: basic anatomy of skin

- Layers of the skin
  - Epidermis: layers, cell types, and function
  - Dermis: layers, cell types, and function
  - Subcutis (fat)

- Adnexal structures
Adnexal structures include the pilosebaceous unit and eccrine gland

Pilosebaceous unit consists of:
1. A hair follicle
2. Sebaceous (oil) glands
3. Apocrine* sweat glands
4. An arrector pili muscle (when these contract you get goosebumps)
• Apocrine glands are found in the axillary and anogenital areas.

• These glands open directly into the hair follicle.
Disorder of pilosebaceous unit

- Acne vulgaris is a disorder of the pilosebaceous unit.
Eccrine Glands

- In contrast to apocrine glands, eccrine sweat glands do not involve the hair follicle.
- They open directly onto the skin surface and are present throughout the body.
- Eccrine glands help regulate body temperature by excreting sweat onto the skin surface, where cooling evaporation takes place.
- Eccrine glands are sometimes genetically absent, which will predispose a patient to hyperthermia.
The epidermis is the purple stripe at the top of the biopsy, and is noted with the red arrow. The reticular dermis is noted with the green arrow. The papillary dermis is the thin bright pink band visible just below the epidermis. The subcutis (fat) is the mostly clear area in the bottom half of the image.
Module Outline

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### Review Chart: Functions of the Skin

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<th>Tissue Layer</th>
<th>Function</th>
<th>Associated Diseases</th>
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<tr>
<td>Epidermis</td>
<td>Permeability barrier</td>
<td>Atopic dermatitis</td>
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<tr>
<td>Epidermis, dermis</td>
<td>Protection from pathogens</td>
<td>Molluscum contagiosum</td>
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<tr>
<td>Epidermis, dermis, subcutis</td>
<td>Thermoregulation</td>
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<td>Epidermis</td>
<td>Ultraviolet protection</td>
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<td>Epidermis, dermis, subcutis</td>
<td>Sensation</td>
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<tr>
<td>Epidermis, dermis</td>
<td>Wound repair/regeneration</td>
<td>Venous stasis ulcer, Keloid</td>
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<tr>
<td>Epidermis, dermis, subcutis</td>
<td>Physical appearance</td>
<td>Lipodystrophy</td>
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