



American Academy of Dermatology

Basic Science of the Skin: Structure and Function

Basic Dermatology Curriculum

Last updated November 2014

Goals and Objectives

- The goal of this module is to introduce medical students to some of the important basic science principles necessary in understanding dermatologic disease.
- By completing the module, the learner will be able to:
 - Gain familiarity with skin functions and how relevant dysfunction contributes to disease
 - Approach dermatologic disease with an understanding of basic skin structure and microanatomy



Module Instructions

- The following module contains a number of blue, underlined terms which are hyperlinked to the [dermatology glossary](#), an illustrated interactive guide to clinical dermatology and dermatopathology.
- We encourage the learner to read all the hyperlinked information.



Module Outline

- Functions of the skin
 - Skin conditions related to disorder of skin function
- Basic anatomy of the skin
 - Related cutaneous diseases
- Take-home points



Functions of the Skin:

Barrier function

- 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.



Functions of the skin: 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.



Functions of the skin: Temperature regulation

- The skin helps maintain a constant body temperature with the insulating properties of fat and hair and through accelerating heat loss with sweat production and a dense superficial microvasculature.
- Dysfunction of temperature regulation leads to hyper- or hypothermia. Another example of thermoregulation dysfunction is Raynaud phenomenon (chronic episodic attacks of digital ischemia provoked by exposure to cold).

Functions of the skin: 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.



Functions of the skin: 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.



Functions of the skin: Injury repair

- The cutaneous wound repair process has four phases: coagulation, inflammatory phase, proliferative-migratory phase (tissue formation), and remodeling phase
- 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](#).



Functions of the skin: Appearance, Quality of Life

- 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 can be of particular concern to patients since it gives the appearance of facial wasting and can have an impact on self-esteem.



Module Outline

- Functions of the skin
 - Skin conditions related to disorder of skin function
- Basic anatomy of the skin
 - Related cutaneous diseases
- Take-home points

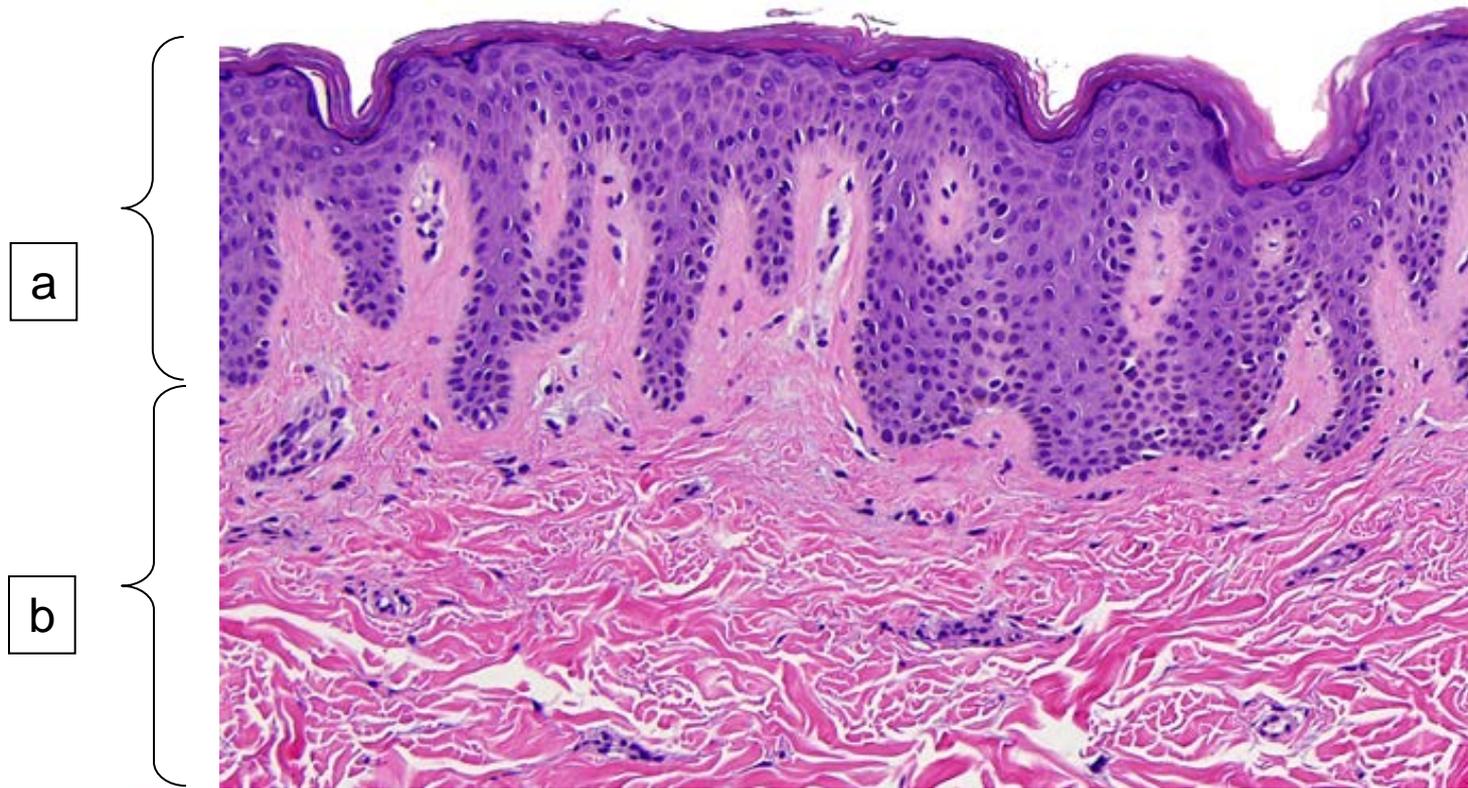


Layers of the skin

Skin is composed of three layers:

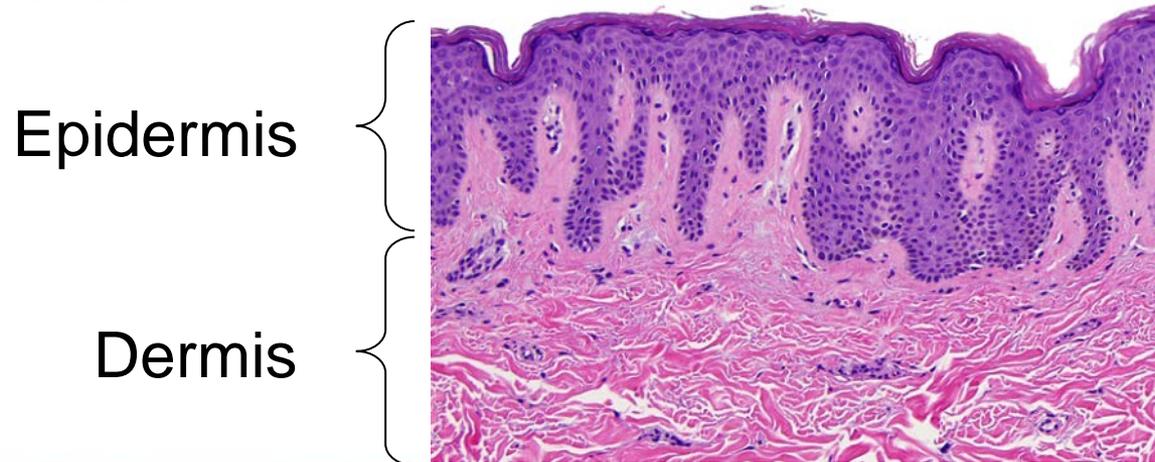
- Epidermis
- Dermis
- Subcutis

Can you name the layers of the skin indicated below?



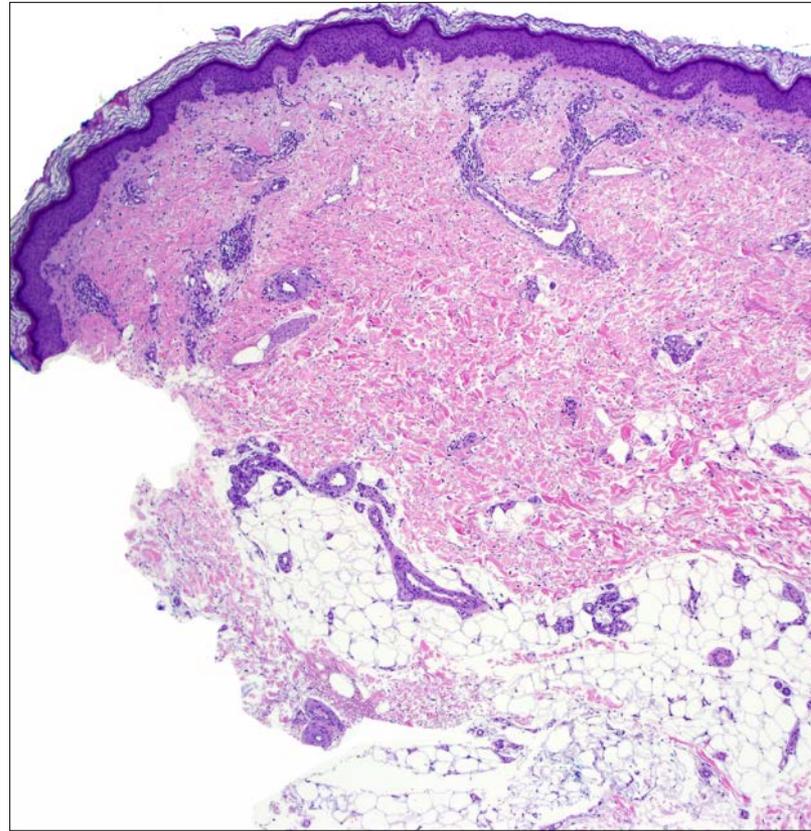
Layers of the skin

- The epidermis is the topmost layer, and consists primarily of keratinocytes.
- 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.



Epidermis

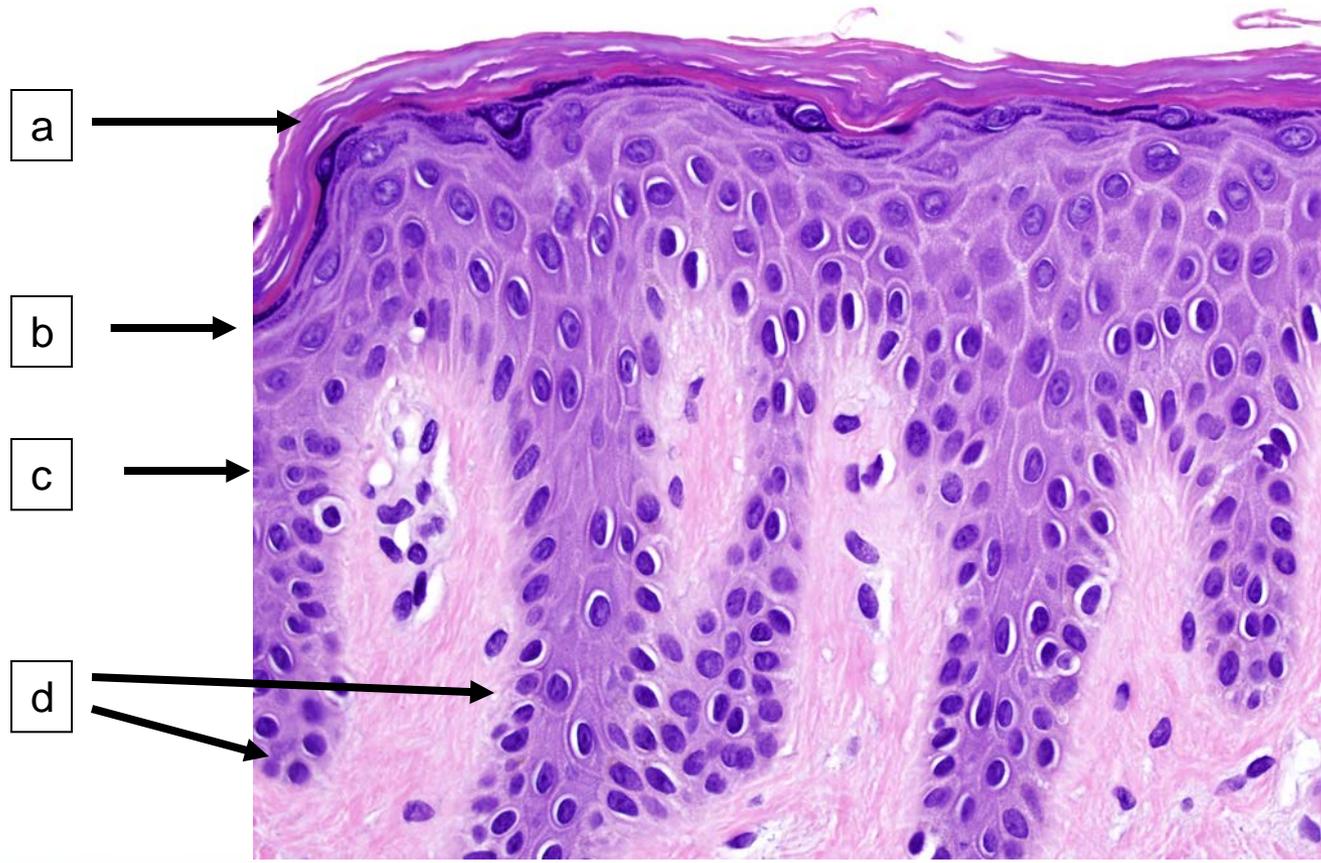
Dermis

Subcutis

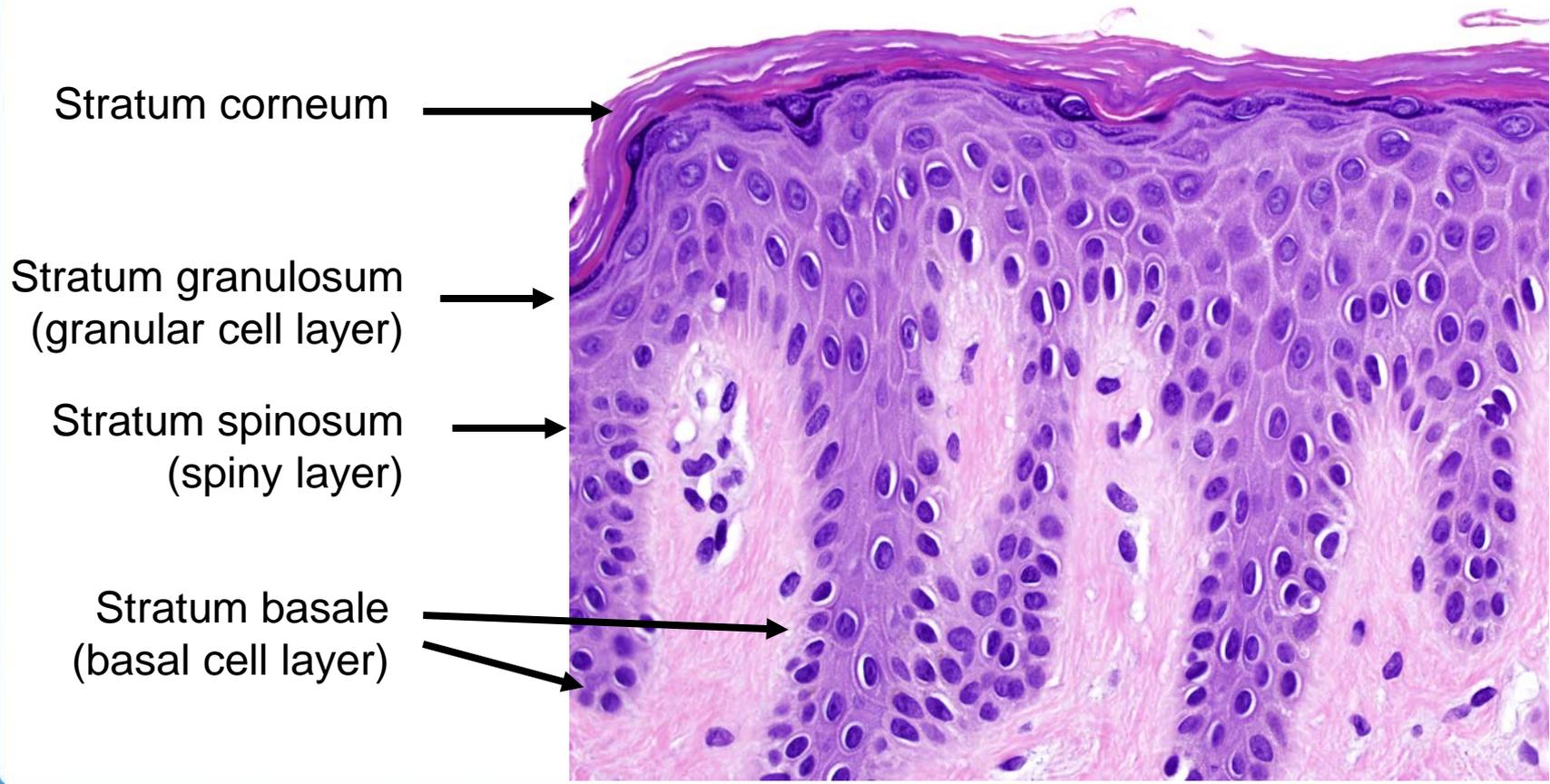
Outline: basic anatomy of skin

- 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?



Functions of the layers of the epidermis

We will review the layers from bottom up, since that is the order in which epidermal cells mature 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). The cells differentiate as they move upwards through the layers.

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 (see slide 32), which hold the keratinocytes together.

1. Basal layer



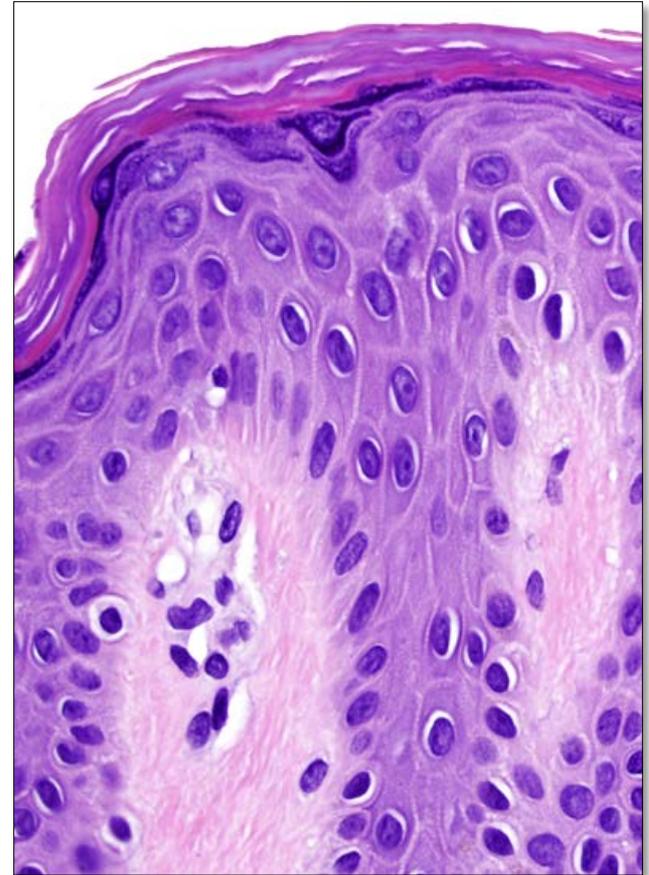
Functions of the layers of the epidermis

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

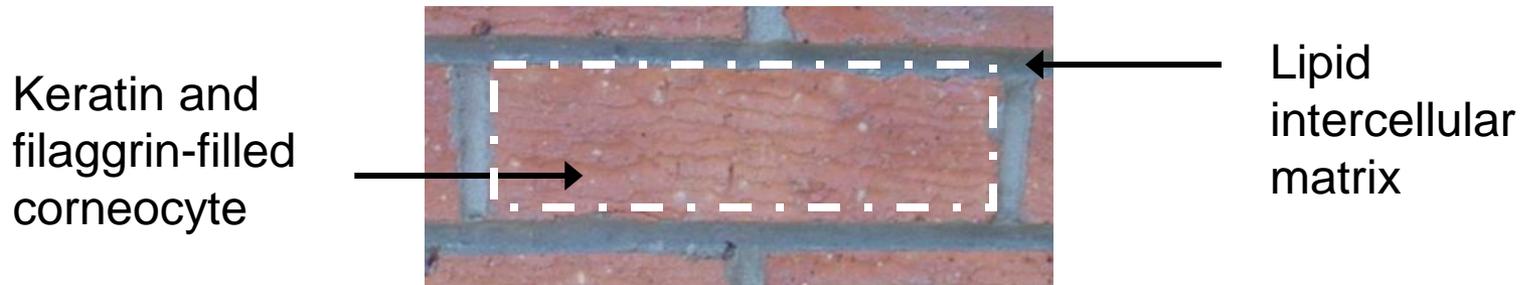
2. Spinous layer

1. Basal layer



The Stratum Corneum

- You can think of the stratum corneum as a wall of bricks and mortar
 - Bricks: flattened keratinocytes filled with keratin and filaggrin
 - Mortar: lipid mixture, which surrounds the keratinocytes and provides the water barrier



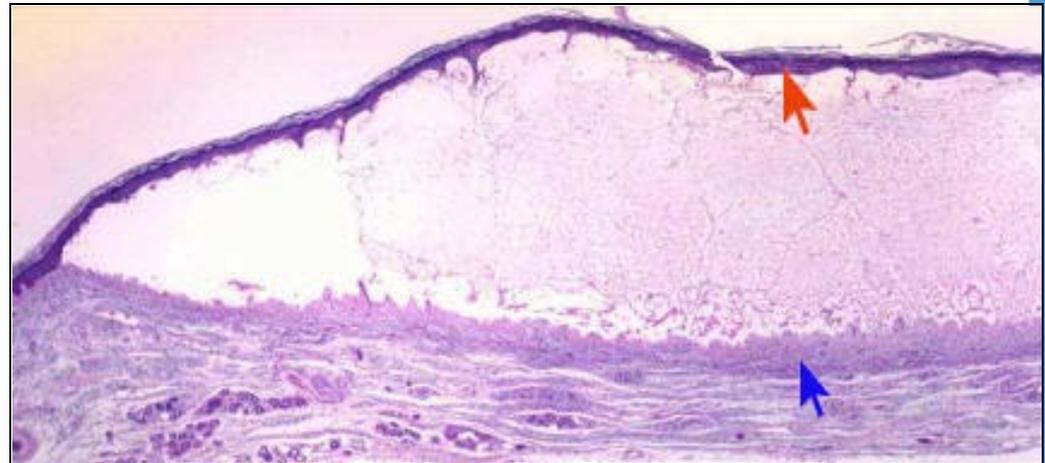
Filaggrin - an important protein in barrier function

- Filaggrin is a protein found in the granular cell layer of the epidermis.
- Filaggrin retains water within keratinocytes
- Mutations in filaggrin cause [atopic dermatitis](#) and other atopic diseases, such as asthma
 - This child has atopic dermatitis. Notice the dry, erythematous, plaques on the lower leg



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

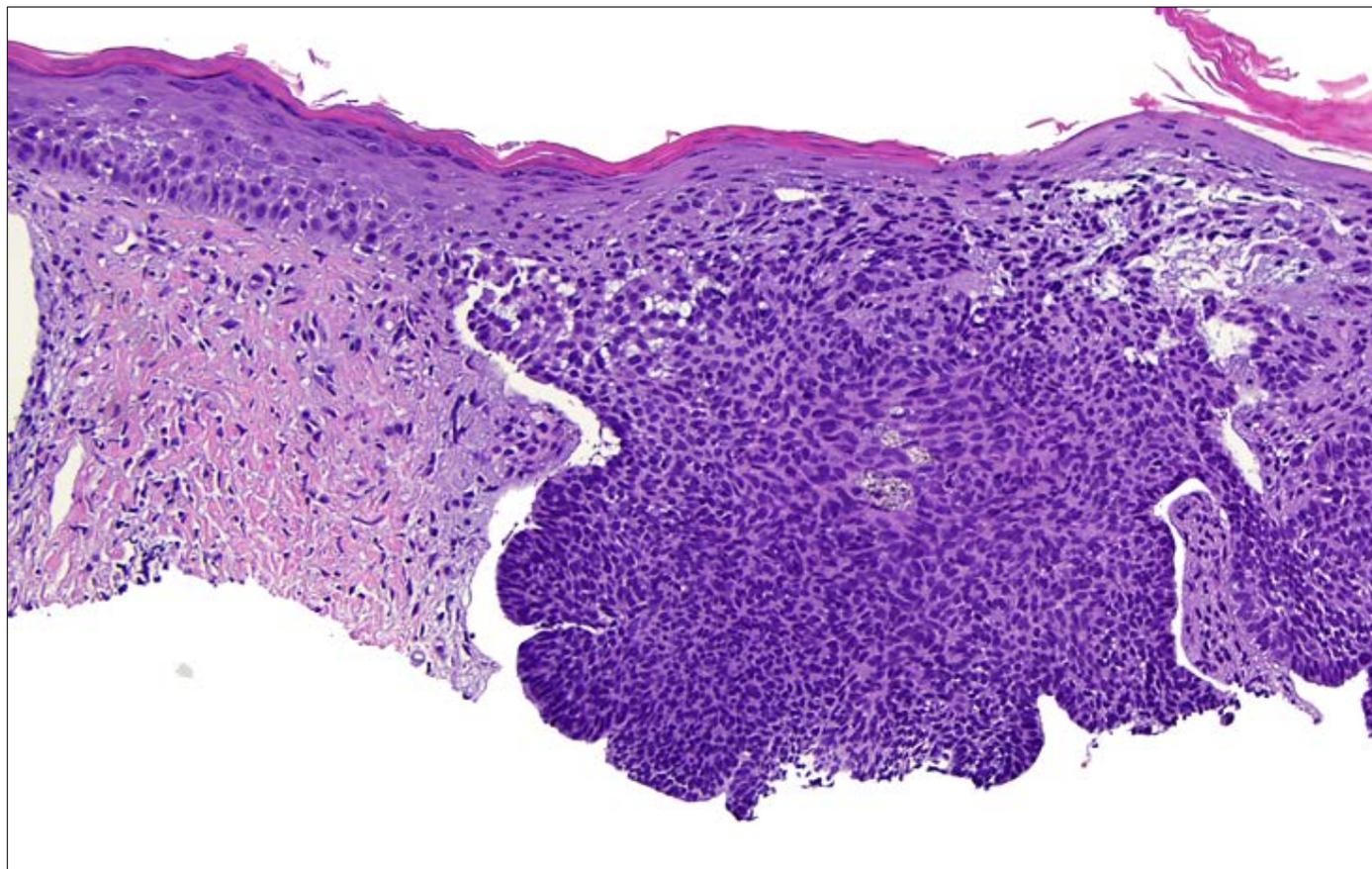
- In [psoriasis](#), the rate of epidermal turnover is increased (thickening).
- The accelerated rate of movement through the epidermis doesn't allow adequate time for differentiation, which is recognized as scale.



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

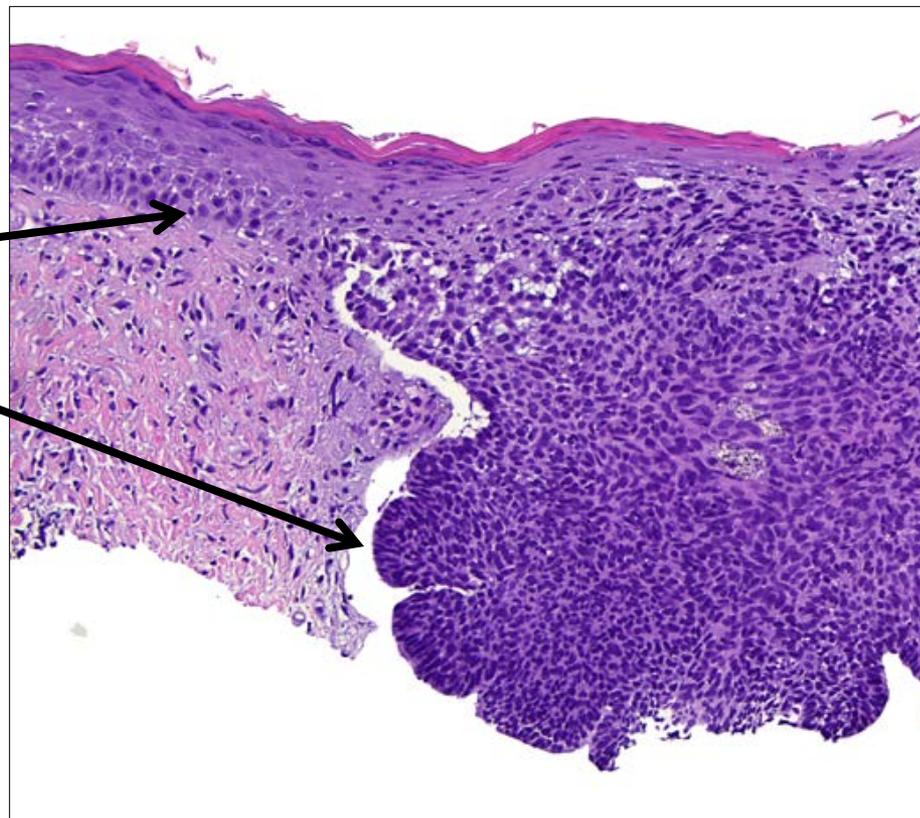


Can you name the type of skin cancer?
(Hint: The cells composing this growth resemble what layer of the epidermis?)



Basal Cell Carcinoma

- Most common form of skin cancer.
- Composed of cells that resemble basal keratinocytes.
- Most commonly presents as pearly, erythematous papules or plaques with rolled borders and telangiectasias in sun-exposed areas.

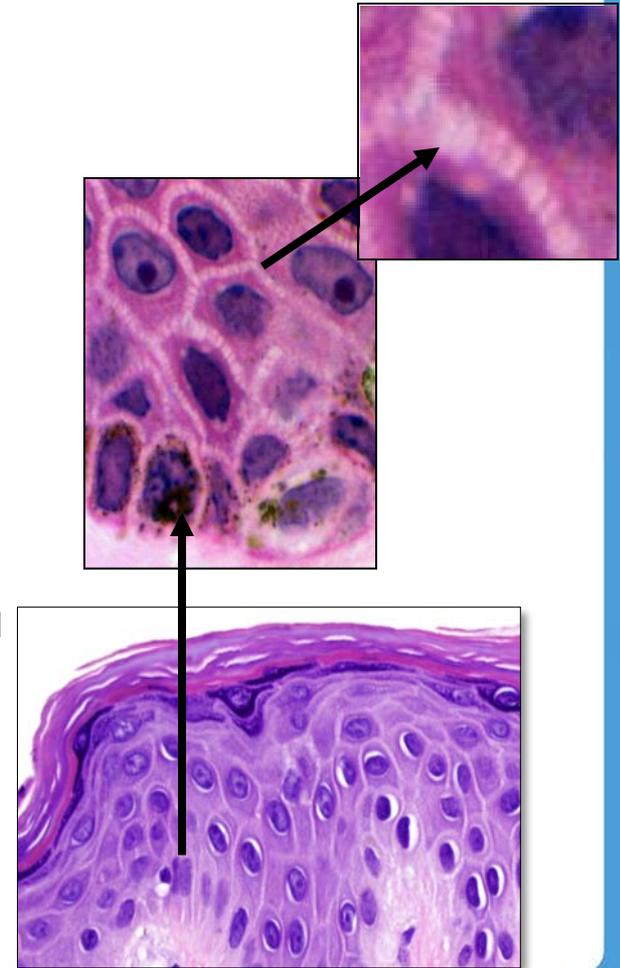


Epidermis: Types of Cells

- Three main types of cells make up the epidermis:
 - Keratinocytes
 - Melanocytes
 - Langerhans cells

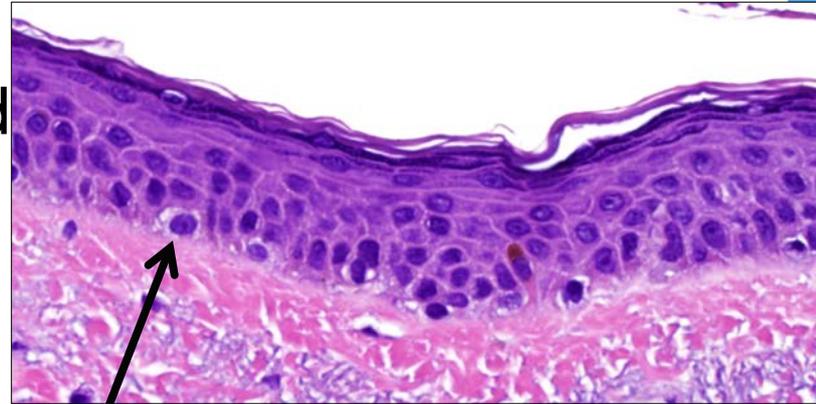
Keratinocytes

- 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).



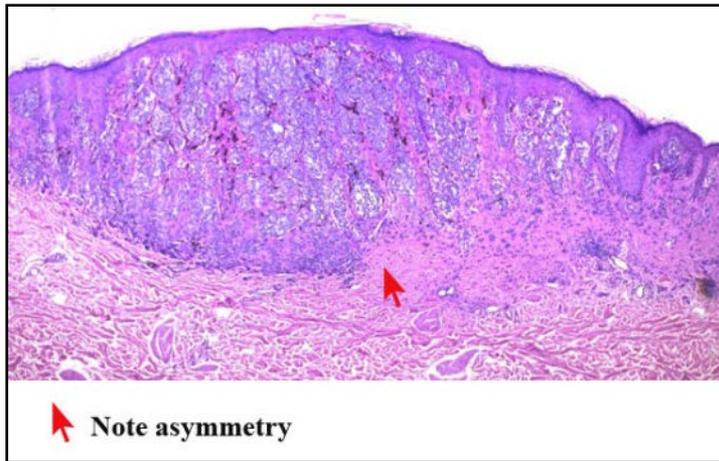
Melanocytes

- 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.

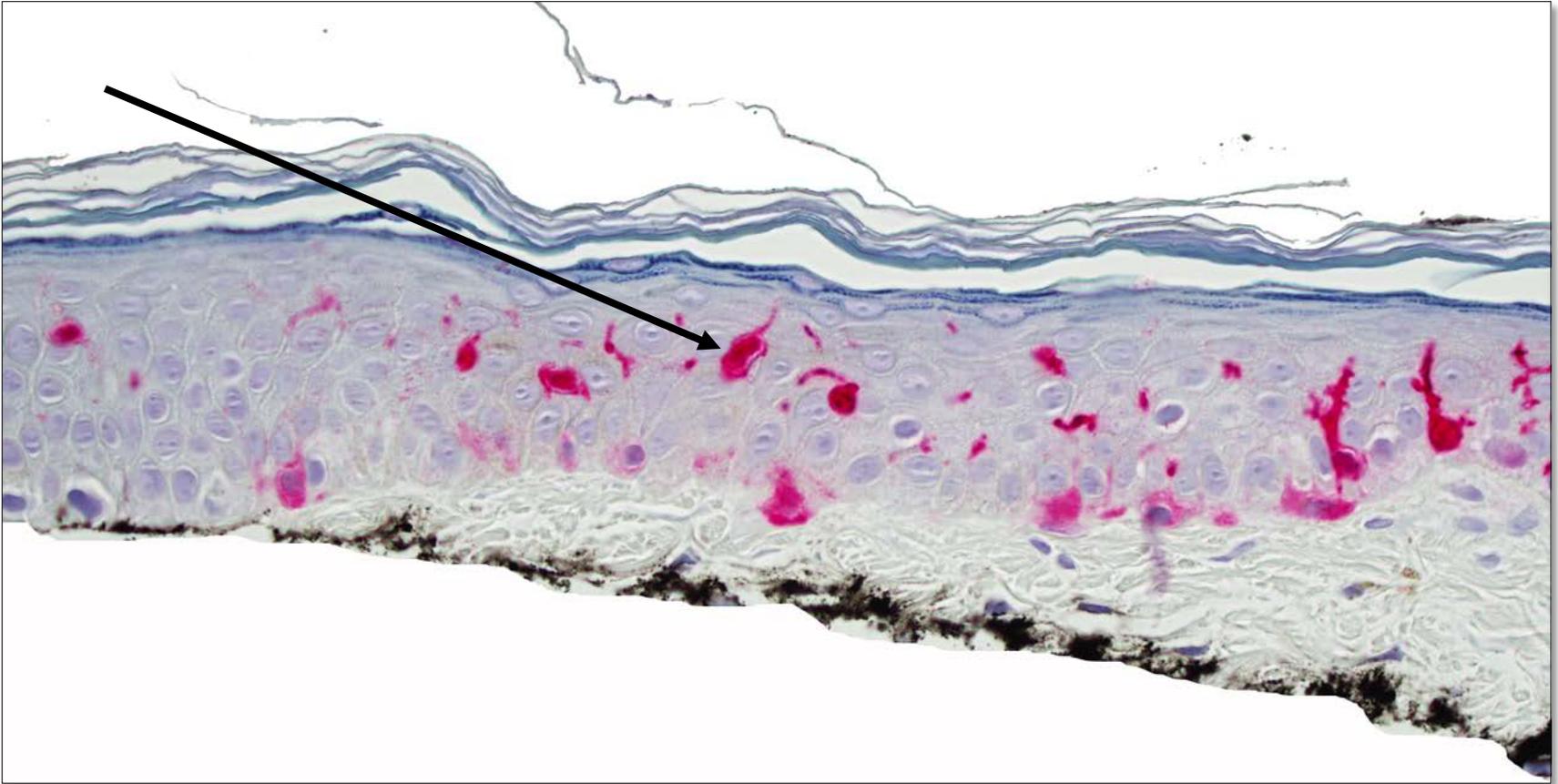


Langerhans Cells

- 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



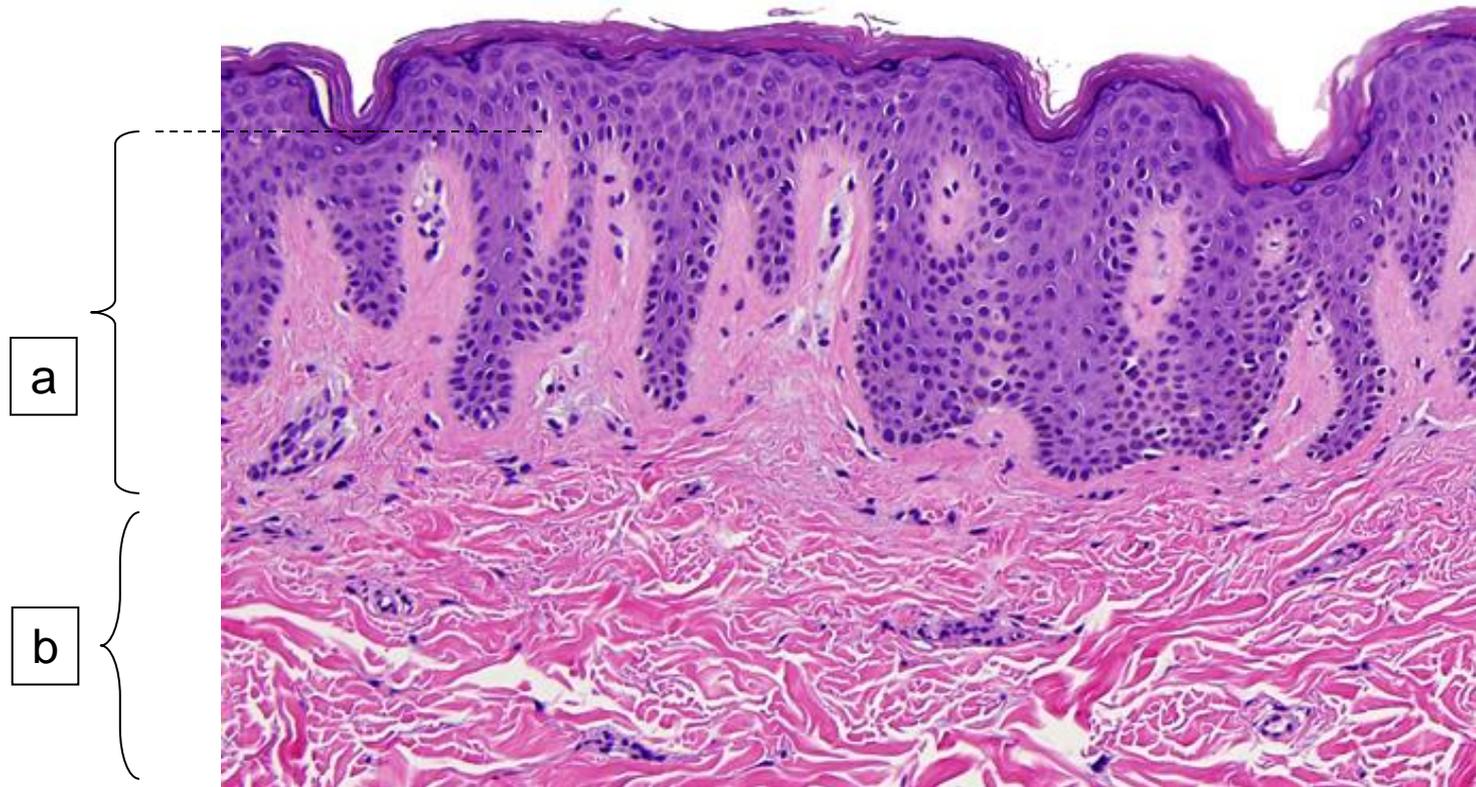
Langerhans Cells



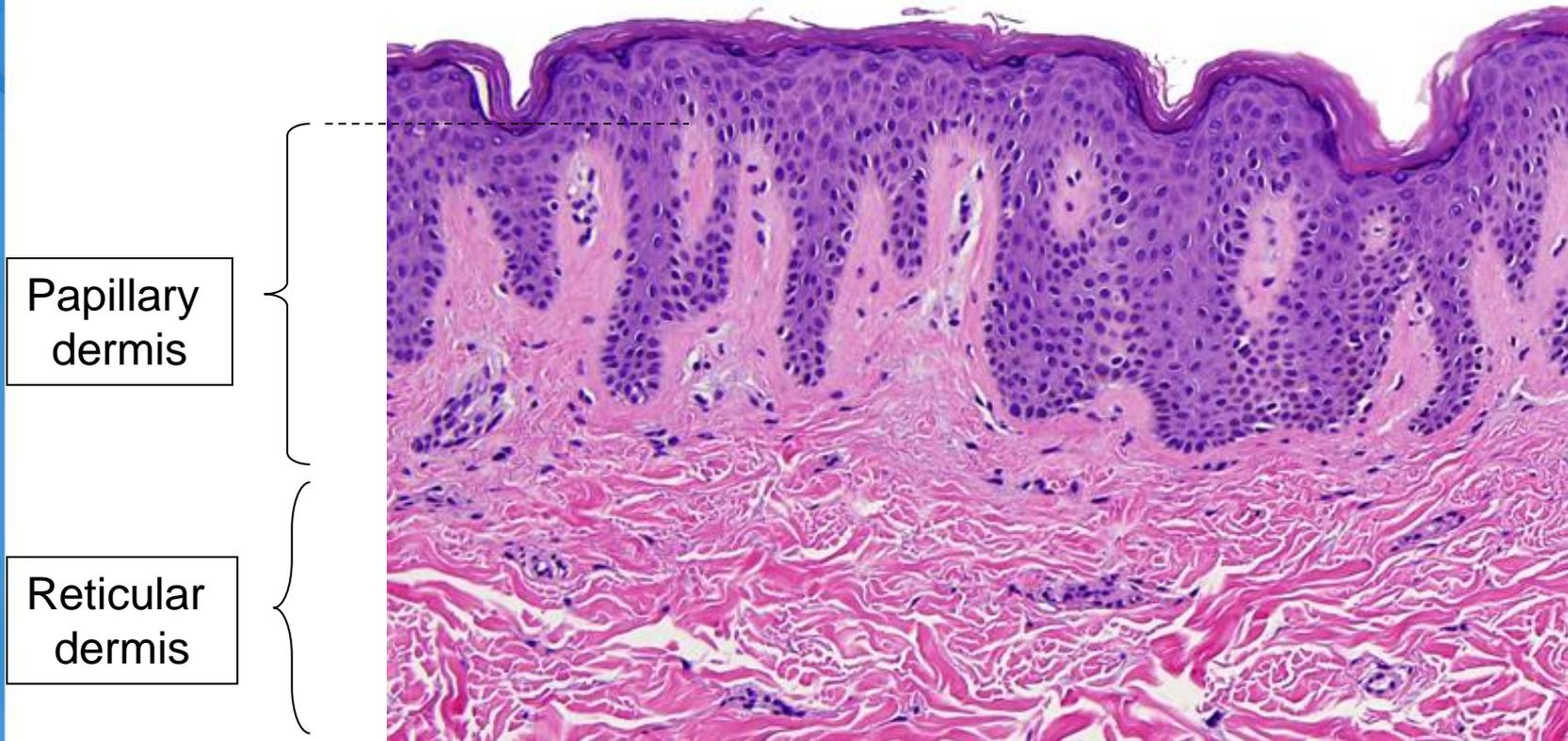
Outline: basic anatomy of skin

- 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

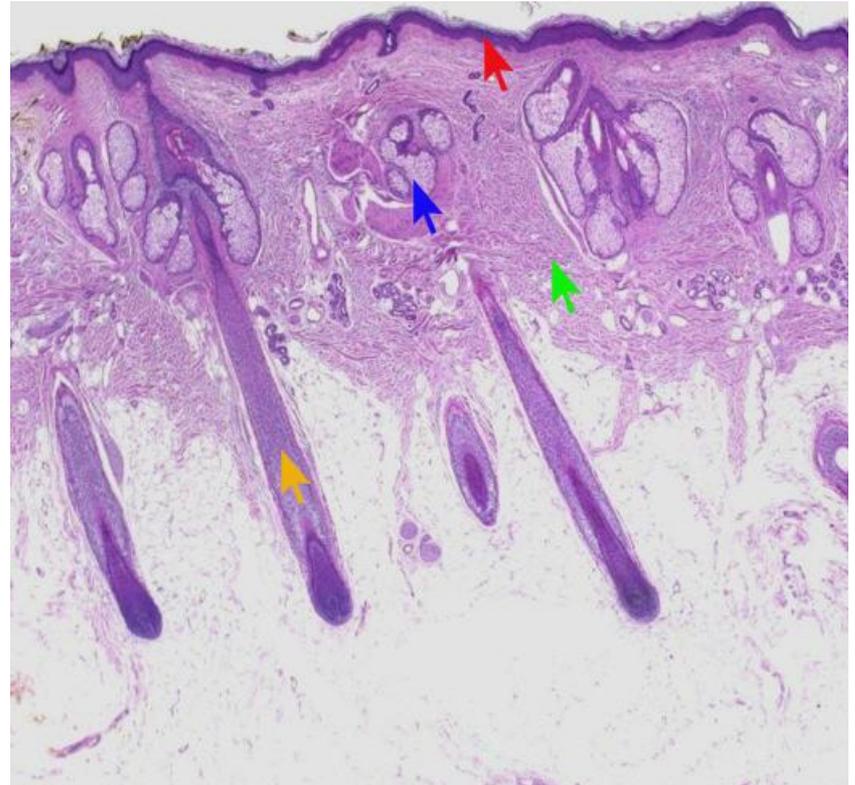


The Dermis

- 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.

What else is in the dermis?

- 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



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 scarring
 - [Keloids](#) (abnormal scars) result from uncontrolled synthesis and excessive deposition of collagen at sites of prior dermal injury and wound repair

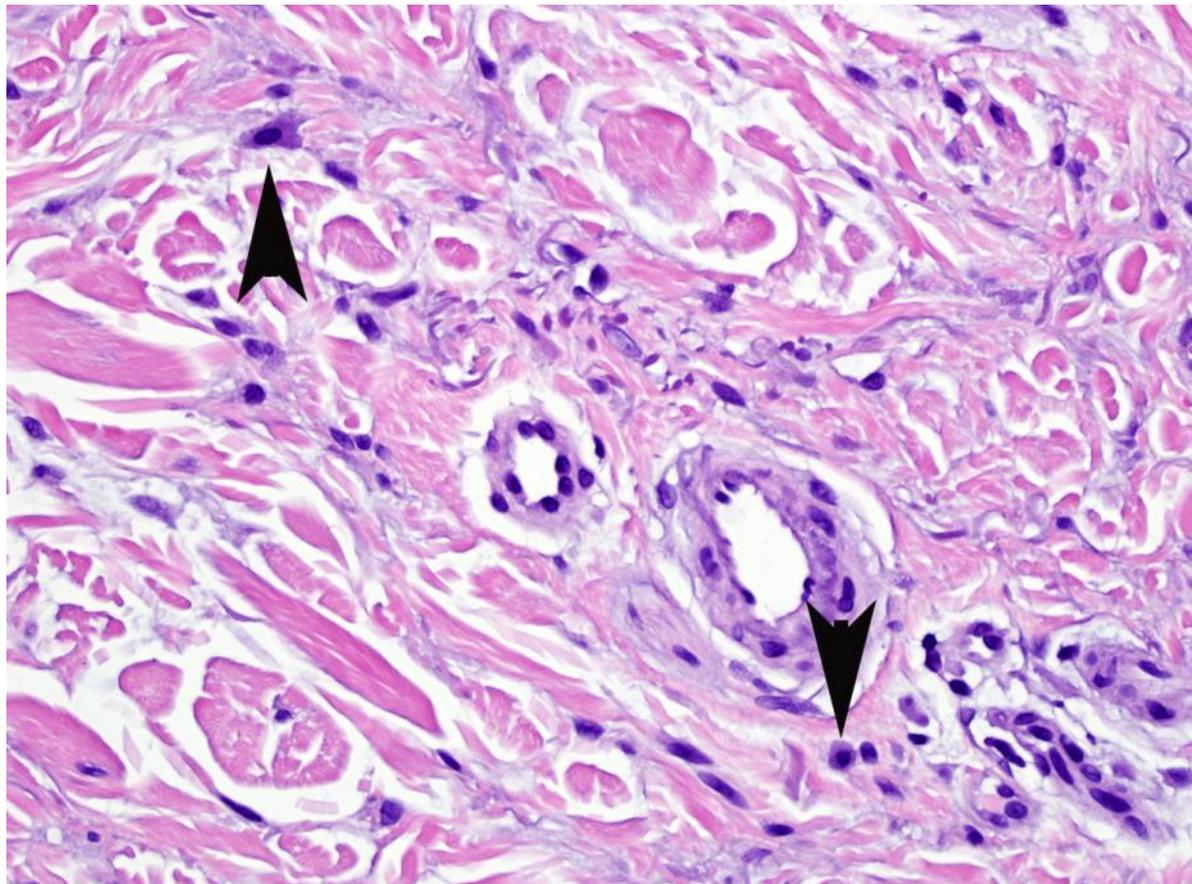


Cells of the dermis

- 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
 - Epidermis: layers, cell types, and function
 - Dermis: layers, cell types, and function
 - **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

Disorder of the subcutis

- [Erythema nodosum](#) is an example of panniculitis (inflammation of the subcutis)
 - Clinically appears as deep-seated erythematous nodules, typically on the shins
 - Erythema nodosum may be idiopathic or a reaction to infections, medication, or an underlying autoimmune disease (e.g. Crohn's disease)



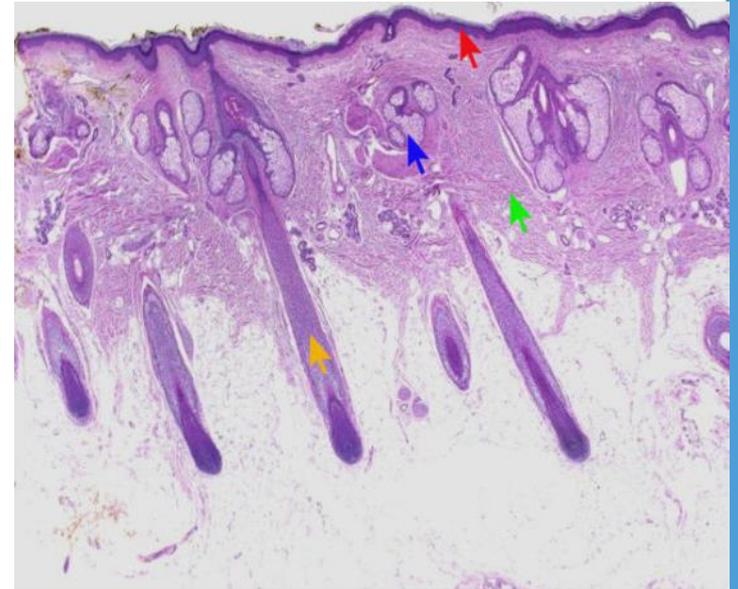
Outline: basic anatomy of skin

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

The pilosebaceous (hair/oil gland) unit

- 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, which is why we do not see them on this biopsy of the scalp. These glands open directly in to the hair follicle.



- ▶ Epidermis
- ▶ Sebaceous gland
- ▶ Reticular dermis
- ▶ Hair follicle

Disorder of pilosebaceous unit

- [Acne vulgaris](#) is a disorder of the pilosebaceous unit.
- It is caused by 4 factors:
 - Plugging of the hair follicle as a result of abnormal keratinization of the upper portion (gives rise to comedones)
 - *P. acnes* (bacteria) in the hair follicle (lives on the oil and breaks it down to free fatty acids which cause inflammation)
 - Presence of hormones (androgens)
 - Sebaceous gland activity (increased in presence of androgens)



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.

Review, Layers of the skin

Epidermis →
Papillary dermis →
Reticular dermis }
Subcutis }



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

- Functions of the skin
 - Skin conditions related to disorder of skin function
- Basic anatomy of the skin
 - Related cutaneous diseases
- Take-home points

Review Chart: Functions of the Skin

Tissue Layer	Function	Associated Diseases
Epidermis	Permeability barrier	Atopic dermatitis
Epidermis, dermis	Protection from pathogens	Molluscum contagiosum
Epidermis, dermis, subcutis	Thermoregulation	Hyperthermia
Epidermis	Ultraviolet protection	Albinism
Epidermis, dermis, subcutis	Sensation	Diabetic neuropathy
Epidermis, dermis	Wound repair/regeneration	Venous stasis ulcer, Keloid
Epidermis, dermis, subcutis	Physical appearance	Lipodystrophy

Acknowledgements

- This module was developed by the American Academy of Dermatology's Medical Student Core Curriculum Workgroup from 2008-2012.
- Primary author: Elizabeth Buzney, MD.
- Contributors: Sarah D. Cipriano, MD, MPH; Ron Birnbaum, MD.
- Peer reviewers: Susan Burgin, MD, FAAD; Peter A. Lio, MD, FAAD.
- Revisions: Sarah D. Cipriano, MD, MPH Joslyn S. Kirby, M.D. Last revised November 2014.



References

- Berger T, Hong J, Saeed S, Colaco S, Tsang M, Kasper R. The Web-Based Illustrated Clinical Dermatology Glossary. MedEdPORTAL; 2007. Available from: www.mededportal.org/publication/462.
- Bologna JL, Jorizzo JL, Rapini RP. Dermatology, 2003, Elsevier Limited.
- Chu David H, "Chapter 7. Development and Structure of Skin" (Chapter). Wolff K, Goldsmith LA, Katz SI, Gilchrest B, Paller AS, Leffell DJ: Fitzpatrick's Dermatology in General Medicine, 7e: <http://www.accessmedicine.com/content.aspx?aID=2950881>.
- Proksch Ehrhardt, Jensen Jens-Michael, "Chapter 45. Skin as an Organ of Protection" (Chapter). Wolff K, Goldsmith LA, Katz SI, Gilchrest B, Paller AS, Leffell DJ: Fitzpatrick's Dermatology in General Medicine, 7e: <http://www.accessmedicine.com/content.aspx?aID=2977622>.

To take the quiz, click on the following link:

<https://www.aad.org/quiz/basic-science-learners>



American Academy of Dermatology