LAYERS OF THE SKIN*

OpenStax College

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Abstract

By the end of this section, you will be able to:

• Identify the components of the integumentary system
• Describe the layers of the skin and the functions of each layer
• Identify and describe the hypodermis and deep fascia
• Describe the role of keratinocytes and their life cycle
• Describe the role of melanocytes in skin pigmentation

Although you may not typically think of the skin as an organ, it is in fact made of tissues that work

together as a single structure to perform unique and critical functions. The skin and its accessory structures

make up the integumentary system, which provides the body with overall protection. The skin is made

of multiple layers of cells and tissues, which are held to underlying structures by connective tissue (Figure 1

(Layers of Skin)). The deeper layer of skin is well vascularized (has numerous blood vessels). It also has

numerous sensory, and autonomic and sympathetic nerve fibers ensuring communication to and from the brain.

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Figure 1: The skin is composed of two main layers: the epidermis, made of closely packed epithelial cells, and the dermis, made of dense, irregular connective tissue that houses blood vessels, hair follicles, sweat glands, and other structures. Beneath the dermis lies the hypodermis, which is composed mainly of loose connective and fatty tissues.
View this animation\(^1\) to learn more about layers of the skin. What are the basic functions of each of these layers?

\section*{1 The Epidermis}

The \textbf{epidermis} is composed of keratinized, stratified squamous epithelium. It is made of four or five layers of epithelial cells, depending on its location in the body. It does not have any blood vessels within it (i.e., it is avascular). Skin that has four layers of cells is referred to as “thin skin.” From deep to superficial, these layers are the stratum basale, stratum spinosum, stratum granulosum, and stratum corneum. Most of the skin can be classified as thin skin. “Thick skin” is found only on the palms of the hands and the soles of the feet. It has a fifth layer, called the stratum lucidum, located between the stratum corneum and the stratum granulosum (Figure 2 (Thin Skin versus Thick Skin)).

\(^1\)\url{http://openstaxcollege.org/1/layers}
Thin Skin versus Thick Skin

Figure 2: These slides show cross-sections of the epidermis and dermis of (a) thin and (b) thick skin. Note the significant difference in the thickness of the epithelial layer of the thick skin. From top, LM × 40, LM × 40. (Micrographs provided by the Regents of University of Michigan Medical School ©2012)

The cells in all of the layers except the stratum basale are called keratinocytes. A keratinocyte is a cell that manufactures and stores the protein keratin. Keratin is an intracellular fibrous protein that gives hair, nails, and skin their hardness and water-resistant properties. The keratinocytes in the stratum corneum are dead and regularly slough away, being replaced by cells from the deeper layers (Figure 3 (Epidermis)).
The epidermis is epithelium composed of multiple layers of cells. The basal layer consists of cuboidal cells, whereas the outer layers are squamous, keratinized cells, so the whole epithelium is often described as being keratinized stratified squamous epithelium. LM × 40. (Micrograph provided by the Regents of University of Michigan Medical School ©2012)

Figure 3: The epidermis is epithelium composed of multiple layers of cells. The basal layer consists of cuboidal cells, whereas the outer layers are squamous, keratinized cells, so the whole epithelium is often described as being keratinized stratified squamous epithelium. LM × 40. (Micrograph provided by the Regents of University of Michigan Medical School ©2012)

1.1 Stratum Basale
The stratum basale (also called the stratum germinativum) is the deepest epidermal layer and attaches the epidermis to the basal lamina, below which lie the layers of the dermis. The cells in the stratum basale bond to the dermis via intertwining collagen fibers, referred to as the basement membrane. A finger-like projection, or fold, known as the dermal papilla (plural = dermal papillae) is found in the superficial portion of the dermis. Dermal papillae increase the strength of the connection between the epidermis and dermis; the greater the folding, the stronger the connections made (Figure 4 (Layers of the Epidermis)).

2http://openstaxcollege.org/l/Epidermis

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The stratum basale is a single layer of cells primarily made of basal cells. A basal cell is a cuboidal-shaped stem cell that is a precursor of the keratinocytes of the epidermis. All of the keratinocytes are produced from this single layer of cells, which are constantly going through mitosis to produce new cells. As new cells are formed, the existing cells are pushed superficially away from the stratum basale. Two other cell types are found dispersed among the basal cells in the stratum basale. The first is a Merkel cell, which functions as a receptor and is responsible for stimulating sensory nerves that the brain perceives as touch. These cells are especially abundant on the surfaces of the hands and feet. The second is a melanocyte, a cell that produces the pigment melanin. Melanin gives hair and skin its color, and also helps protect the living cells of the epidermis from ultraviolet (UV) radiation damage.

In a growing fetus, fingerprints form where the cells of the stratum basale meet the papillae of the underlying dermal layer (papillary layer), resulting in the formation of the ridges on your fingers that you recognize as fingerprints. Fingerprints are unique to each individual and are used for forensic analyses.
because the patterns do not change with the growth and aging processes.

1.2 Stratum Spinosum
As the name suggests, the stratum spinosum is spiny in appearance due to the protruding cell processes that join the cells via a structure called a desmosome. The desmosomes interlock with each other and strengthen the bond between the cells. It is interesting to note that the “spiny” nature of this layer is an artifact of the staining process. Unstained epidermis samples do not exhibit this characteristic appearance. The stratum spinosum is composed of eight to 10 layers of keratinocytes, formed as a result of cell division in the stratum basale (Figure 5 (Cells of the Epidermis)). Interspersed among the keratinocytes of this layer is a type of dendritic cell called the Langerhans cell, which functions as a macrophage by engulfing bacteria, foreign particles, and damaged cells that occur in this layer.
Figure 5: The cells in the different layers of the epidermis originate from basal cells located in the stratum basale, yet the cells of each layer are distinctively different. EM × 2700. (Micrograph provided by the Regents of University of Michigan Medical School ©2012)

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to explore the tissue sample in greater detail. If you zoom on
the cells at the outermost layer of this section of skin, what do you notice about the cells?

The keratinocytes in the stratum spinosum begin the synthesis of keratin and release a water-repelling
glycolipid that helps prevent water loss from the body, making the skin relatively waterproof. As new
keratinocytes are produced atop the stratum basale, the keratinocytes of the stratum spinosum are pushed
into the stratum granulosum.

1.3 Stratum Granulosum

The stratum granulosum has a grainy appearance due to further changes to the keratinocytes as they are
pushed from the stratum spinosum. The cells (three to five layers deep) become flatter, their cell membranes
thicken, and they generate large amounts of the proteins keratin, which is fibrous, and keratohyalin,
which accumulates as lamellar granules within the cells (see Figure 4 (Layers of the Epidermis)). These
two proteins make up the bulk of the keratinocyte mass in the stratum granulosum and give the layer its
grainy appearance. The nuclei and other cell organelles disintegrate as the cells die, leaving behind the
keratin, keratohyalin, and cell membranes that will form the stratum lucidum, the stratum corneum, and
the accessory structures of hair and nails.

1.4 Stratum Lucidum

The stratum lucidum is a smooth, seemingly translucent layer of the epidermis located just above the
stratum granulosum and below the stratum corneum. This thin layer of cells is found only in the thick skin
of the palms, soles, and digits. The keratinocytes that compose the stratum lucidum are dead and flattened
(see Figure 4 (Layers of the Epidermis)). These cells are densely packed with eleiden, a clear protein rich
in lipids, derived from keratohyalin, which gives these cells their transparent (i.e., lucid) appearance and
provides a barrier to water.

1.5 Stratum Corneum

The stratum corneum is the most superficial layer of the epidermis and is the layer exposed to the outside
environment (see Figure 4 (Layers of the Epidermis)). The increased keratinization (also called cornification)
of the cells in this layer gives it its name. There are usually 15 to 30 layers of cells in the stratum corneum.
This dry, dead layer helps prevent the penetration of microbes and the dehydration of underlying tissues,
and provides a mechanical protection against abrasion for the more delicate, underlying layers. Cells in this
layer are shed periodically and are replaced by cells pushed up from the stratum granulosum (or stratum
lucidum in the case of the palms and soles of feet). The entire layer is replaced during a period of about 4
weeks. Cosmetic procedures, such as microdermabrasion, help remove some of the dry, upper layer and aim
to keep the skin looking “fresh” and healthy.

2 Dermis

The dermis might be considered the “core” of the integumentary system (derma- = “skin”), as distinct from
the epidermis (epi- = “upon” or “over”) and hypodermis (hypo- = “below”). It contains blood and lymph
vessels, nerves, and other structures, such as hair follicles and sweat glands. The dermis is made of two
layers of connective tissue that compose an interconnected mesh of elastin and collagenous fibers, produced
by fibroblasts (Figure 6 (Layers of the Dermis)).
Figure 6: This stained slide shows the two components of the dermis—the papillary layer and the reticular layer. Both are made of connective tissue with fibers of collagen extending from one to the other, making the border between the two somewhat indistinct. The dermal papillae extending into the epidermis belong to the papillary layer, whereas the dense collagen fiber bundles below belong to the reticular layer. LM × 10. (credit: modification of work by "kilbad"/Wikimedia Commons)
2.1 Papillary Layer

The papillary layer is made of loose, areolar connective tissue, which means the collagen and elastin fibers of this layer form a loose mesh. This superficial layer of the dermis projects into the stratum basale of the epidermis to form finger-like dermal papillae (see Figure 6 (Layers of the Dermis)). Within the papillary layer are fibroblasts, a small number of fat cells (adipocytes), and an abundance of small blood vessels. In addition, the papillary layer contains phagocytes, defensive cells that help fight bacteria or other infections that have breached the skin. This layer also contains lymphatic capillaries, nerve fibers, and touch receptors called the Meissner corpuscles.

2.2 Reticular Layer

Underlying the papillary layer is the much thicker reticular layer, composed of dense, irregular connective tissue. This layer is well vascularized and has a rich sensory and sympathetic nerve supply. The reticular layer appears reticulated (net-like) due to a tight meshwork of fibers. Elastin fibers provide some elasticity to the skin, enabling movement. Collagen fibers provide structure and tensile strength, with strands of collagen extending into both the papillary layer and the hypodermis. In addition, collagen binds water to keep the skin hydrated. Collagen injections and Retin-A creams help restore skin turgor by either introducing collagen externally or stimulating blood flow and repair of the dermis, respectively.

3 Hypodermis

The hypodermis (also called the subcutaneous layer or superficial fascia) is a layer directly below the dermis and serves to connect the skin to the underlying fascia (fibrous tissue) of the bones and muscles. It is not strictly a part of the skin, although the border between the hypodermis and dermis can be difficult to distinguish. The hypodermis consists of well-vascularized, loose, areolar connective tissue and adipose tissue, which functions as a mode of fat storage and provides insulation and cushioning for the integument.

: Lipid Storage

The hypodermis is home to most of the fat that concerns people when they are trying to keep their weight under control. Adipose tissue present in the hypodermis consists of fat-storing cells called adipocytes. This stored fat can serve as an energy reserve, insulate the body to prevent heat loss, and act as a cushion to protect underlying structures from trauma.

Where the fat is deposited and accumulates within the hypodermis depends on hormones (testosterone, estrogen, insulin, glucagon, leptin, and others), as well as genetic factors. Fat distribution changes as our bodies mature and age. Men tend to accumulate fat in different areas (neck, arms, lower back, and abdomen) than do women (breasts, hips, thighs, and buttocks). The body mass index (BMI) is often used as a measure of fat, although this measure is, in fact, derived from a mathematical formula that compares body weight (mass) to height. Therefore, its accuracy as a health indicator can be called into question in individuals who are extremely physically fit.

In many animals, there is a pattern of storing excess calories as fat to be used in times when food is not readily available. In much of the developed world, insufficient exercise coupled with the ready availability and consumption of high-calorie foods have resulted in unwanted accumulations of adipose tissue in many people. Although periodic accumulation of excess fat may have provided an evolutionary advantage to our ancestors, who experienced unpredictable bouts of famine, it is now becoming chronic and considered a major health threat. Recent studies indicate that a distressing percentage of our population is overweight and/or clinically obese. Not only is this a problem for the individuals affected, but it also has a severe impact on our healthcare system. Changes in lifestyle, specifically in diet and exercise, are the best ways to control body fat accumulation, especially when it reaches levels that increase the risk of heart disease and diabetes.
4 Pigmentation

The color of skin is influenced by a number of pigments, including melanin, carotene, and hemoglobin. Recall that melanin is produced by cells called melanocytes, which are found scattered throughout the stratum basale of the epidermis. The melanin is transferred into the keratinocytes via a cellular vesicle called a melanosome (Figure 7 (Skin Pigmentation)).

![Skin Pigmentation Diagram](image)

**Figure 7:** The relative coloration of the skin depends on the amount of melanin produced by melanocytes in the stratum basale and taken up by keratinocytes.

Melanin occurs in two primary forms. Eumelanin exists as black and brown, whereas pheomelanin provides a red color. Dark-skinned individuals produce more melanin than those with pale skin. Exposure to the UV rays of the sun or a tanning salon causes melanin to be manufactured and built up in keratinocytes, as sun exposure stimulates keratinocytes to secrete chemicals that stimulate melanocytes. The accumulation of melanin in keratinocytes results in the darkening of the skin, or a tan. This increased melanin accumulation protects the DNA of epidermal cells from UV ray damage and the breakdown of folic acid, a nutrient necessary...

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for our health and well-being. In contrast, too much melanin can interfere with the production of vitamin D, an important nutrient involved in calcium absorption. Thus, the amount of melanin present in our skin is dependent on a balance between available sunlight and folic acid destruction, and protection from UV radiation and vitamin D production.

It requires about 10 days after initial sun exposure for melanin synthesis to peak, which is why pale-skinned individuals tend to suffer sunburns of the epidermis initially. Dark-skinned individuals can also get sunburns, but are more protected than are pale-skinned individuals. Melanosomes are temporary structures that are eventually destroyed by fusion with lysosomes; this fact, along with melanin-filled keratinocytes in the stratum corneum sloughing off, makes tanning impermanent.

Too much sun exposure can eventually lead to wrinkling due to the destruction of the cellular structure of the skin, and in severe cases, can cause sufficient DNA damage to result in skin cancer. When there is an irregular accumulation of melanocytes in the skin, freckles appear. Moles are larger masses of melanocytes, and although most are benign, they should be monitored for changes that might indicate the presence of cancer (Figure 8 (Moles)).
Moles

![Moles](credit: the National Cancer Institute)

**Figure 8:** Moles range from benign accumulations of melanocytes to melanomas. These structures populate the landscape of our skin. (credit: the National Cancer Institute)

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**Integumentary System**

The first thing a clinician sees is the skin, and so the examination of the skin should be part of any thorough physical examination. Most skin disorders are relatively benign, but a few, including melanomas, can be fatal if untreated. A couple of the more noticeable disorders, albinism and vitiligo, affect the appearance of the skin and its accessory organs. Although neither is fatal, it would be hard to claim that they are benign, at least to the individuals so afflicted.

**Albinism** is a genetic disorder that affects (completely or partially) the coloring of skin, hair, and eyes. The defect is primarily due to the inability of melanocytes to produce melanin. Individuals with albinism tend to appear white or very pale due to the lack of melanin in their skin and hair. Recall that melanin helps protect the skin from the harmful effects of UV radiation. Individuals
with albinism tend to need more protection from UV radiation, as they are more prone to sunburns and skin cancer. They also tend to be more sensitive to light and have vision problems due to the lack of pigmentation on the retinal wall. Treatment of this disorder usually involves addressing the symptoms, such as limiting UV light exposure to the skin and eyes. In vitiligo, the melanocytes in certain areas lose their ability to produce melanin, possibly due to an autoimmune reaction. This leads to a loss of color in patches (Figure 9 (Vitiligo)). Neither albinism nor vitiligo directly affects the lifespan of an individual.

Vitiligo

Figure 9: Individuals with vitiligo experience depigmentation that results in lighter colored patches of skin. The condition is especially noticeable on darker skin. (credit: Klaus D. Peter)

Other changes in the appearance of skin coloration can be indicative of diseases associated with other body systems. Liver disease or liver cancer can cause the accumulation of bile and the yellow pigment bilirubin, leading to the skin appearing yellow or jaundiced (jaune is the French word for “yellow”). Tumors of the pituitary gland can result in the secretion of large amounts of melanocyte-stimulating hormone (MSH), which results in a darkening of the skin. Similarly, Addison’s disease can stimulate the release of excess amounts of adrenocorticotropic hormone (ACTH), which can give the skin a deep bronze color. A sudden drop in oxygenation can affect skin color, causing the skin to initially turn ashen (white). With a prolonged reduction in oxygen levels, dark red deoxyhemoglobin becomes dominant in the blood, making the skin appear blue, a condition referred to as cyanosis (kyanos is the Greek word for “blue”). This happens when the oxygen supply is restricted, as when
someone is experiencing difficulty in breathing because of asthma or a heart attack. However, in these cases the effect on skin color has nothing do with the skin's pigmentation.

This ABC video follows the story of a pair of fraternal African-American twins, one of whom is albino. Watch this video to learn about the challenges these children and their family face. Which ethnicities do you think are exempt from the possibility of albinism?

5 Chapter Review

The skin is composed of two major layers: a superficial epidermis and a deeper dermis. The epidermis consists of several layers beginning with the innermost (deepest) stratum basale (germinatum), followed by the stratum spinosum, stratum granulosum, stratum lucidum (when present), and ending with the outermost layer, the stratum corneum. The topmost layer, the stratum corneum, consists of dead cells that shed periodically and is progressively replaced by cells formed from the basal layer. The stratum basale also contains melanocytes, cells that produce melanin, the pigment primarily responsible for giving skin its color. Melanin is transferred to keratinocytes in the stratum spinosum to protect cells from UV rays.

The dermis connects the epidermis to the hypodermis, and provides strength and elasticity due to the presence of collagen and elastin fibers. It has only two layers: the papillary layer with papillae that extend into the epidermis and the lower, reticular layer composed of loose connective tissue. The hypodermis, deep to the dermis of skin, is the connective tissue that connects the dermis to underlying structures; it also harbors adipose tissue for fat storage and protection.

6 Interactive Link Questions

Exercise 1 (Solution on p. 18.)
The skin consists of two layers and a closely associated layer. View this animation to learn more about layers of the skin. What are the basic functions of each of these layers?

Exercise 2 (Solution on p. 18.)
Figure 3 (Epidermis) If you zoom on the cells at the outermost layer of this section of skin, what do you notice about the cells?

Exercise 3 (Solution on p. 18.)
Figure 5 (Cells of the Epidermis) If you zoom on the cells of the stratum spinosum, what is distinctive about them?

Exercise 4 (Solution on p. 18.)
This ABC video follows the story of a pair of fraternal African-American twins, one of whom is albino. Watch this video to learn about the challenges these children and their family face. Which ethnicities do you think are exempt from the possibility of albinism?

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7 Review Questions

Exercise 5  
(Solution on p. 18.)  
The papillary layer of the dermis is most closely associated with which layer of the epidermis?  
   a. stratum spinosum  
   b. stratum corneum  
   c. stratum granulosum  
   d. stratum basale

Exercise 6  
(Solution on p. 18.)  
Langerhans cells are commonly found in the _______.  
   a. stratum spinosum  
   b. stratum corneum  
   c. stratum granulosum  
   d. stratum basale

Exercise 7  
(Solution on p. 18.)  
The papillary and reticular layers of the dermis are composed mainly of _______.  
   a. melanocytes  
   b. keratinocytes  
   c. connective tissue  
   d. adipose tissue

Exercise 8  
(Solution on p. 18.)  
Collagen lends _______ to the skin.  
   a. elasticity  
   b. structure  
   c. color  
   d. UV protection

Exercise 9  
(Solution on p. 18.)  
Which of the following is not a function of the hypodermis?  
   a. protects underlying organs  
   b. helps maintain body temperature  
   c. source of blood vessels in the epidermis  
   d. a site to long-term energy storage

8 Critical Thinking Questions

Exercise 10  
(Solution on p. 18.)  
What determines the color of skin, and what is the process that darkens skin when it is exposed to UV light?

Exercise 11  
(Solution on p. 18.)  
Cells of the epidermis derive from stem cells of the stratum basale. Describe how the cells change as they become integrated into the different layers of the epidermis.
Solutions to Exercises in this Module

to Exercise (p. 16)
The epidermis provides protection, the dermis provides support and flexibility, and the hypodermis (fat layer) provides insulation and padding.

to Exercise (p. 16)
Figure 3 (Epidermis) These cells do not have nuclei, so you can deduce that they are dead. They appear to be sloughing off.

to Exercise (p. 16)
Figure 5 (Cells of the Epidermis) These cells have desmosomes, which give the cells their spiny appearance.

to Exercise (p. 16)
There are none.

to Exercise (p. 17)
D

to Exercise (p. 17)
A

to Exercise (p. 17)
C

to Exercise (p. 17)
B

to Exercise (p. 17)
C

to Exercise (p. 17)
The pigment melanin, produced by melanocytes, is primarily responsible for skin color. Melanin comes in different shades of brown and black. Individuals with darker skin have darker, more abundant melanin, whereas fair-skinned individuals have a lighter shade of skin and less melanin. Exposure to UV irradiation stimulates the melanocytes to produce and secrete more melanin.

to Exercise (p. 17)
As the cells move into the stratum spinosum, they begin the synthesis of keratin and extend cell processes, desmosomes, which link the cells. As the stratum basale continues to produce new cells, the keratinocytes of the stratum spinosum are pushed into the stratum granulosum. The cells become flatter, their cell membranes thicken, and they generate large amounts of the proteins keratin and keratohyalin. The nuclei and other cell organelles disintegrate as the cells die, leaving behind the keratin, keratohyalin, and cell membranes that form the stratum lucidum and the stratum corneum. The keratinocytes in these layers are mostly dead and flattened. Cells in the stratum corneum are periodically shed.

Glossary

Definition 1: albinism
genetic disorder that affects the skin, in which there is no melanin production

Definition 2: basal cell
type of stem cell found in the stratum basale and in the hair matrix that continually undergoes cell division, producing the keratinocytes of the epidermis

Definition 3: dermal papilla
(plural = dermal papillae) extension of the papillary layer of the dermis that increases surface contact between the epidermis and dermis

Definition 4: dermis
layer of skin between the epidermis and hypodermis, composed mainly of connective tissue and containing blood vessels, hair follicles, sweat glands, and other structures
Definition 5: desmosome
structure that forms an impermeable junction between cells

Definition 6: elastin fibers
fibers made of the protein elastin that increase the elasticity of the dermis

Definition 7: eleiden
clear protein-bound lipid found in the stratum lucidum that is derived from keratohyalin and helps to prevent water loss

Definition 8: epidermis
outermost tissue layer of the skin

Definition 9: hypodermis
connective tissue connecting the integument to the underlying bone and muscle

Definition 10: integumentary system
skin and its accessory structures

Definition 11: keratin
type of structural protein that gives skin, hair, and nails its hard, water-resistant properties

Definition 12: keratinocyte
cell that produces keratin and is the most predominant type of cell found in the epidermis

Definition 13: keratohyalin
granulated protein found in the stratum granulosum

Definition 14: Langerhans cell
specialized dendritic cell found in the stratum spinosum that functions as a macrophage

Definition 15: melanin
pigment that determines the color of hair and skin

Definition 16: melanocyte
cell found in the stratum basale of the epidermis that produces the pigment melanin

Definition 17: melanosome
intercellular vesicle that transfers melanin from melanocytes into keratinocytes of the epidermis

Definition 18: Merkel cell
receptor cell in the stratum basale of the epidermis that responds to the sense of touch

Definition 19: papillary layer
superficial layer of the dermis, made of loose, areolar connective tissue

Definition 20: reticular layer
deep layer of the dermis; it has a reticulated appearance due to the presence of abundant collagen and elastin fibers

Definition 21: stratum basale
deepest layer of the epidermis, made of epidermal stem cells

Definition 22: stratum corneum
most superficial layer of the epidermis

Definition 23: stratum granulosum
layer of the epidermis superficial to the stratum spinosum

Definition 24: stratum lucidum
layer of the epidermis between the stratum granulosum and stratum corneum, found only in thick skin covering the palms, soles of the feet, and digits

Definition 25: stratum spinosum
layer of the epidermis superficial to the stratum basale, characterized by the presence of desmosomes
Definition 26: vitiligo
skin condition in which melanocytes in certain areas lose the ability to produce melanin, possibly
due an autoimmune reaction that leads to loss of color in patches