Integumentary System

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Introduction

Your integumentary system is the external covering of your body. It is made up of your skin, hair, and nails. The integumentary system of other animals such as birds and reptiles includes their feathers and scales. The name comes from the Latin term integumentum, which means “a covering.”

The integumentary system has multiple roles in homeostasis, including protection, temperature regulation, sensory reception, biochemical synthesis, and absorption. Keeping water out of the body is an important role for your integumentary system, as is shown by Figure 1.1. Your body systems all work together to maintain relatively stable internal conditions. Each of the parts that make up your integumentary system has a special role in maintaining homeostasis which we will explore a little later. An introduction to the Integumentary System can be viewed at http://www.youtube.com/watch?v=no_XRnoNGfE.

Structure and Function of Your Skin

The skin is a vital organ that covers the entire outside of the body, forming a protective barrier against pathogens and injuries from the environment. The skin is the body’s largest organ, covering the entire outside of the body, and it is only about 2 mm thick. It shields the body against heat, light, injury, and infection. The skin also helps regulate body temperature, gathers sensory information from the environment, stores water, fat, and vitamin D, and acts as a physical barrier in protecting us from disease.

Your skin is constantly in contact with your external environment so it gets cut, scratched, and exposed to radiation, such as ultraviolet (UV) light. You also naturally shed many skin cells every day. Your body replaces damaged or missing skin cells by growing more of them, through the process of mitosis. Two distinct layers make up the skin: the epidermis and the dermis. A fatty layer, called subcutaneous tissue, or hypodermis (below skin), lies under the dermis, but it is not considered to be part of your skin. The layers that make up your skin are shown in Figure 1.2.

The color, thickness and texture of skin vary over the body. There are two general types of skin; thin and hairy, which is the most common type on the body, and thick and hairless, which is found on parts of the body that are
used heavily and experience a lot of friction, such as the palms of the hands or the soles of the feet.

**Epidermis**

Epidermis is the outermost layer of the skin. It forms the waterproof, protective wrap over the body’s surface and
is made up of many layers of epithelial cells, shown in **Figure 1.3**.

The epidermis is divided into several layers where epithelial cells are formed through mitosis in the lowest layer. The epithelial cells move up through the layers of the epidermis, changing shape and composition as they differentiate and become filled with a tough, fibrous protein called keratin. At this point the cells are called keratinocytes. Keratinocytes at the surface of the epidermis form a thin layer of flattened, dead cells, (the stratum corneum in **Figure 1.3**). Although the top layer of epidermis is only about as thick as a sheet of paper, it is made up of 25 to 30 layers of keratinocytes. Keratinocytes get scraped off through everyday activities, and are usually shed about a month after they reach the surface of the epidermis.

The epidermis also contains cells that take up and process certain marker proteins (called antigens) from microbes that enter through the skin. This helps the immune system recognize the microbe as an intruder, and to mount an attack on it. The epidermis contains no blood vessels, so the lower portion of the epidermis is nourished by diffusion from the blood vessels of the dermis.
Structure and Function of Dermis

The dermis is the layer of skin directly under the epidermis and is made of a tough elastic connective tissue. The dermis is tightly connected to the epidermis by a membrane made of collagen fibers. The dermis contains the hair follicles, sweat glands, sebaceous glands, and blood vessels. It also holds many nerve endings that provide the sense of touch, pressure, heat, and pain. Tiny muscles, called arrector pili, contract and pull on hair follicles which cause hair to stand up. This can happen when you are cold or afraid, and the resulting little “bumps” in the skin are commonly called goose bumps.

The dermis has two layers, each of which contains different structures:

**Papillary region (upper layer):** The papillary region is made up of loose connective tissue and contains touch receptors which communicate with the central nervous system. It is named for its finger-like projections called papillae, which extend toward the epidermis, and help secure the dermis to the epidermis. The papillae can be seen in Figure 1.2. The papillae provide the dermis with a "bumpy" surface that causes distinctive friction ridges. They are called friction ridges, because they help the hand or foot to grasp things by increasing friction. Friction ridges, as shown in Figure 1.4, occur in patterns that are unique to the individual, making it possible to use fingerprints or footprints as a means of identification.

![Figure 1.4](image-url)

**Reticular region (lower layer):** The reticular region is made of dense elastic fibers (collagen), which contains the hair follicles and roots, nerves, and glands. It gets its name from the dense concentration of protein fibers that weave throughout it. These protein fibers give the dermis its properties of strength, extensibility, and elasticity. Heat, cold and pressure receptors, nails, and blood vessels are also located in this region. Tattoo ink is injected into the dermis. Stretch marks are also located in the dermis.

**Glands and Follicles**

Glands and follicles open out into the epidermis, but they originate within the dermis. A sebaceous gland, also known as an oil gland, secretes an oily substance, called sebum, into the hair follicle. Sebum is made of lipids and the debris of dead lipid-producing cells. The word sebum comes from the Latin word for fat, or tallow. It “waterproofs” hair and the skin surface to prevent them from drying out. It can also inhibit the growth of microorganisms on the
skin. Sebum is the cause of the oily appearance of skin and hair. It is odorless, but the breakdown of sebum by bacteria can cause odors. A sebaceous gland is shown in Figure 1.5. If a sebaceous gland becomes plugged and infected, it develops into a pimple, also called acne.

Sweat glands open to the epidermal surface through the skin pores. They occur all over the body and are controlled by the sympathetic nervous system. Evaporation of sweat from the skin surface helps to lower the skin temperature, which in turn helps to control body temperature. The skin also functions as an excretory organ because it releases excess water, salts, and other wastes in sweat. A sweat gland is shown in Figure 1.6. There are two types of sweat glands, eccrine glands and apocrine glands. Eccrine glands are the "regular" sweat glands that release sweat to cool the body. Apocrine glands are larger than eccrine glands and are located in the armpits and groin areas. They effectively act as scent glands because they produce a solution that bacteria break down which produces "body odor."

Mammary glands are the organs that, in the female mammal, produce milk to feed their young. Mammary glands are enlarged and modified sweat glands and are a major characteristic of mammals.

Subcutaneous Tissue

The subcutaneous tissue (also called the hypodermis), lies below the dermis and contains fat and loose connective tissue that holds larger blood vessels and nerves. Its purpose is to attach the skin to underlying bone and muscle as well as to supply the skin with blood vessels and nerves. This layer is important is the regulation of body temperature. It is mostly made up of adipose tissue (which is made up of fat cells or adipocytes); the subcutaneous tissue contains about 50 percent of the body’s fat. The functions of subcutaneous tissue include insulation and the storage of nutrients. The size of this layer varies throughout the body and from person to person.

Functions of Skin: Skin and Homeostasis

The skin has multiple roles in homeostasis, including protection, control of body temperature, sensory reception, water balance, synthesis of vitamins and hormones, and absorption of materials. The skin’s main functions are to
serve as a barrier to the entry of microbes and viruses, and to prevent water and extracellular fluid loss. Acidic secretions from skin glands also stop the growth of fungi on the skin. Melanocytes form a second barrier: protection from the damaging effects of UV radiation. When a microbe gets into the skin (or when the skin is cut) an immune system reaction occurs.

Heat and cold receptors are located in the skin. When the body temperature rises, the hypothalamus sends a nerve signal to the sweat-producing skin glands, causing them to release sweat onto the skin surface. The evaporation of sweat helps reduce the temperature of the skin surface which cools the body. The hypothalamus also causes dilation of the blood vessels of the skin, allowing more blood to flow into those areas, causing heat to be released from the skin surface. When body temperature falls, the sweat glands constrict and sweat production decreases. If the body temperature continues to fall, the body will start to generate heat by raising the body’s metabolic rate and by causing the muscles to shiver.

The homeostatic functions of the skin include:

- Protection of the body’s internal tissues and organs.
- Protection against invasion by infectious organisms.
- Protection of the body from dehydration.
- Protection of the body against large changes in temperature.
- Excretion of wastes through sweat.
- Acts as a receptor for the senses of touch, pressure, pain, heat, and cold.
- Makes vitamin D through exposure to UV radiation.
- Stores water, fat, and vitamin D.
Homeostatic Imbalances of the Skin

Many wavelengths of electromagnetic radiation are emitted by the sun, some we can see, and others we cannot. The range of wavelengths of radiation we can see is called visible light. However, visible light makes up only a small portion of the total radiation that comes from the sun. Two other types of radiation that you have probably heard about before include infrared and ultraviolet radiation. Infrared light is the thermal energy, or the “heat rays” that you feel when the sun shines on you. The other, ultraviolet (UV), which we have discussed a little already, helps the body produce vitamin D, but it can also damage DNA in skin cells. Our main source of UV radiation, the sun, is shown in Figure 1.7.

![Ultraviolet radiation emitted by the sun.](image1)

Prolonged exposure to UV radiation can lead to skin cancer and premature wrinkling of the skin.

Beneficial Effects of UV Radiation

A positive effect of ultraviolet radiation (UV) exposure is that it causes the production of vitamin D in the skin. It has been estimated that tens of thousands of premature deaths occur in the United States annually from a range of cancers due to vitamin D deficiency.

Ultraviolet radiation has other medical applications, in the treatment of skin conditions such as psoriasis, a disorder in which red, scaly patches form due to an overproduction of epithelial cells, and vitiligo, a condition that causes loss of pigment, which results in irregular pale patches of skin, as shown in Figure 1.8.

Harmful Effects of UV Radiation

In humans, prolonged exposure to solar UV radiation may result in acute and chronic health effects on the skin, eye, and immune system. While some sunlight is good for health, skin cancer caused by excessive exposure to sunlight is not among the sun’s benefits. Because some types of skin cancer are easy to cure, the danger posed by too much
Vitiligo is a chronic skin condition that causes loss of pigment, resulting in irregular pale patches of skin. The cause of vitiligo is not fully understood. There is some evidence suggesting it is caused by a combination of auto-immune, genetic, and environmental factors. Phototherapy, in which the patient is exposed to long-wave ultraviolet (UVA) light from the sun or from UVA lamps, together with certain medicines, can help in many cases.

Sunlight is perhaps not taken seriously enough. It is important to remember that a more serious form of skin cancer, called melanoma, is also associated with excessive sun exposure. Melanomas are potentially lethal tumors.

The UV radiation excites DNA molecules in skin cells, causing bonds to form between neighboring thymine bases, producing a thymine dimer that changes the shape of the DNA helix. These dimers can lead to mutations. **Mutations** are changes to the base pair sequence of DNA or RNA. Mutations can result in cancerous growths.

Skin cancer is an increasingly common condition. This is due in part to peoples’ increased exposure to UV radiation, because of the increased popularity of sun bathing. Because melanin protects the skin from the effects of UV radiation, lighter-skinned people are at more risk of developing skin cancer than darker skinned people are. However, the risk of developing skin cancer is related to the amount of sunburn and overall length of time a person has been exposed to UV light. The three most common types of skin cancers are shown in **Figure 1.9**.

**FIGURE 1.8**
Vitiligo is chronic skin condition that causes loss of pigment, resulting in irregular pale patches of skin. The cause of vitiligo is not fully understood. There is some evidence suggesting it is caused by a combination of auto-immune, genetic, and environmental factors. Phototherapy, in which the patient is exposed to long-wave ultraviolet (UVA) light from the sun or from UVA lamps, together with certain medicines, can help in many cases.

**FIGURE 1.9**
The three most common forms of skin cancer. Basal cell carcinoma (left), squamous cell carcinoma (center), and melanoma (right). All three types arise from cells in the epithelium.
As a defense against UV radiation, the body tans when exposed to moderate levels of radiation by releasing the brown pigment melanin. This helps to block UV penetration and prevent damage to the vulnerable skin tissues deeper down. Suntan lotion, often referred to as "sun block" or "sunscreen", partly blocks UV and is widely available. Most of these products contain a sun protection factor (SPF) rating that describes the amount of protection given. This protection, however, applies only to a type of UV radiation called UVB rays, the type of radiation that is responsible for sunburn. UVA rays, another type of UV radiation, penetrates more deeply into the skin and may be responsible for causing cancer and wrinkles. Some sunscreen lotion now includes compounds such as titanium dioxide which helps protect against UVA rays. Other UVA blocking compounds found in sunscreen include zinc oxide and avobenzone. Another means to block UV is sun protective clothing, shown in Figure 1.10. This is clothing that has an ultraviolet protection factor (UPF) rating that describes the protection given against both UVA and UVB radiation.

Acne

The most common form of acne is known as acne vulgaris, which means "common acne." Many teenagers get this type of acne. Acne is a highly complicated and variable form of skin infection. It affects more than 85% of teenagers, but frequently also continues into adulthood. For most people, acne tends to decrease or disappear after one reaches his or her early twenties. Excessive secretion of sebum from the sebaceous glands leads to the plugging of the hair follicle with dead skin cells (corneocytes). This blockage is caused by a failure of the normal process in which skin cells that line the pores are usually shed. Within these blocked pores bacteria and yeast begin to multiply. In response to the bacterial and yeast populations, the skin inflames, which produces a red bump.

Nails and Hair

Nails are made up of specialized epidermal cells. Fingernails and toenails contain a tough protein called keratin and are actually a type of modified hair. The nail grows from the nail bed, which is thickened to form a lunula (or little moon), shown in Figure 1.11. Cells forming the nail bed are linked together to form the nail. There are no nerve endings in the nail.

The fingernail generally serves two purposes. It serves as a protective plate and enhances sensation of the fingertip. The protection function of the fingernail is commonly known, but the sensation function is equally important. The
The parts of the nail. The lunula is also called the little moon, the eponychium is also called the cuticle.

fingertip has many nerve endings in it allowing us to receive volumes of information about objects we touch. The nail acts as a counterforce to the fingertip providing even more sensory input when an object is touched.

Nails are made up of many different parts, as shown in Figure 1.11:

- The free edge is the part of the nail that extends past the finger, beyond the nail plate.
- The nail plate is what we think of when we say “nail,” the hard and translucent portion, composed of keratin.
- The lunula is the crescent shaped whitish area of the nail bed (when visible).
- The eponychium or cuticle, is the fold of skin at the end of the nail.

Nails grow at a rate about 1 cm every 100 days. Fingernails require 4 to 6 months to regrow completely and toenails require 12 to 18 months. Actual growth rate is dependent upon age, season, exercise level, and hereditary factors. This growth record can show the history of recent health and physiological imbalances, and has been used as a diagnostic tool since ancient times.

Major illness will cause a deep horizontal groove to form in the nails. Discoloration, thinning, thickening, brittleness, splitting, grooves, spots, lines, receded lunula, or changes in the shape of the nail can indicate illness in other areas of the body, nutrient deficiencies, drug reaction or poisoning, or a physical injury to the nail or nail bed.

Hair

Hair is a filamentous fiber that is found only on mammals. The main component of hair is the tough protein keratin. Hair emerges from the epidermis, although it grows from hair follicles deep in the dermis, shown in Figure 1.12. The hair of non-human mammal species is commonly called fur.

Humans have three different types of hair:

- Lanugo is the fine hair that covers nearly the entire body of fetuses.
- Vellus hair is the short, fine, “peach fuzz” body hair that grows in most places on the human body except for the palms of the hands and the soles of the feet.
- Terminal hair is the fully developed hair which is generally longer, coarser, thicker, and darker than vellus hair.

Different parts of the human body have different types of hair. From childhood onward, vellus hair covers the entire human body except on the lips, the palms of hands, the soles of feet, the navel, and scar tissue. The density of the hairs (in hair follicles per square centimeter) varies from one person to another.
What is the function of hair? In people, hair serves to insulate, to protect, and to sense the immediate surroundings. Insulation serves to conserve heat. The hair on your head insulates your body from heat loss. Eyelashes and eyebrows protect the eyes from water, dirt, and other irritants. Nose hairs act as a physical barrier to any particles or microorganisms that might be in the air we breathe.

Curly hair has a different biological structure than straight hair, shown in Figure 1.13. It tends to be much drier than straight hair because the oils secreted into the hair shaft by the sebaceous glands can more easily travel down the shaft of straight hair. People with very curly hair may find that this hair type can be dry, hard to manage, and often frizzy.

Individual hairs have periods of growth and dormancy. During the growth portion of the cycle, hair follicles are long and bulbous, and the hair grows out at about a third of a millimeter per day. After three to six months, body hair growth stops (the pubic and armpit areas having the longest growth period). The follicle shrinks and the root of the hair grows rigid. Following a period of dormancy, another growth cycle starts, and eventually a new hair pushes the
old one out of the follicle from beneath. Head hair, by comparison, grows for a long duration and to a great length before being shed. Terminal hair is genetically programmed to be straight, curly or wavy, and it tends to change over time.

Hair color is the result of pigmentation due to the presence of different forms of melanin. In general, the more melanin present, the darker the hair color; the less melanin, the lighter the hair color. A person’s hair color may also change over time and may be more than one color at a time.

Summary

- The integumentary system consists of the skin, hair, and nails.
- The skin is the covering of the body. It acts as a physical barrier to the external environment.
- The outermost layer, of the skin, the epidermis, consists of many layers of dead keratinized skill cells. The epidermis is waterproof and prevents fluids from leaking out of the body and into the body.
- The dermis is the layer of skin directly under the epidermis and is made of a tough elastic connective tissue. The dermis is tightly connected to the epidermis by a membrane made of collagen fibers.
- Glands and follicles open out into the epidermis, but they originate within the dermis. A sebaceous gland or oil gland secretes an oily substance, called sebum, into the hair follicle. Sweat glands open to the epidermal surface through the skin pores. They occur all over the body and are controlled by the sympathetic nervous system.
- Melanin is the brownish pigment that gives skin and hair their color. It is found in melanocytes are located in the bottom layer of the epidermis. Melanin acts as a UV filter, it absorbs UV rays from the sun or other sources of UV light, such as a tanning bed.
- The main component of hair and nails is the tough protein keratin.

Review Questions

1. Name all of the parts of the integumentary system.
2. Name the two layers that make up the skin, and identify a function for each layer.
3. Why is subcutaneous tissue also called *subdermal tissue*?
4. Why is the epidermis considered the dead part of the skin?
5. Name the cells that produce melanin and describe where they are found.
6. Explain how sweating helps regulate body temperature. Use Figure 1.14 of *part of the integumentary system* to answer questions 7 and 8.

7. In what layer of the skin would you find this tissue?
8. Name the substance that is found in the uppermost layer of this tissue.
9. Describe one function of hair.
10. Identify the substance that prevents skin and hair from drying out.

**Further Reading / Supplemental Links**

- Anatomy and Physiology © 2002 Elaine Marieb. Published by Pearson Education Inc. as Benjamin Cummings.
- [http://training.seer.cancer.gov/ss_module14_melanoma/unit02_sec01_anatomy](http://training.seer.cancer.gov/ss_module14_melanoma/unit02_sec01_anatomy)
- [http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookINTEGUSYS](http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookINTEGUSYS)
- [http://animaldiversity.ummz.umich.edu/site/topics/mammal_anatomy/hair](http://animaldiversity.ummz.umich.edu/site/topics/mammal_anatomy/hair)
- [http://www.cdc.gov/excite/skincancer/index](http://www.cdc.gov/excite/skincancer/index)
- [http://www.niams.nih.gov/hi/topics/acne/acne](http://www.niams.nih.gov/hi/topics/acne/acne)

**Vocabulary**

- **dermis**: The layer of skin directly under the epidermis, contains the hair follicles, sweat glands, sebaceous glands, and blood vessels.
- **epidermis**: The outermost layer of the skin.
**integumentary system**  
The organ system consisting of your skin, hair and nails.

**melanin**  
The brown pigment that gives skin, hair and eyes their color.

**melanocytes**  
Cells that produce melanin, found in the skin, hair and eyes.

**mutation**  
A change to the nucleotide sequence of DNA or RNA.

**papillary region**  
Part of the dermis that contains touch receptors, which communicate with the central nervous system.

**reticular region**  
Part of the dermis that contains the hair follicles and roots, nerves, and glands.

**sebaceous gland**  
Secretes an oily substance, called sebum, into the hair follicle.

**sebum**  
An oily substance secreted by sebaceous glands that is composed of lipids and debris of dead lipid-producing cells, responsible for protecting the skin and hair against drying out, and infection by microorganisms.

**subcutaneous tissue (hypodermis)**  
Lies below the dermis and contains fat and loose connective tissue that holds larger blood vessels and nerves, attaches the skin to underlying bone and muscle.

**Points to Consider**

- Identify reasons why you should wear sunblock with an SPF value of at least 15 everyday.
- Consider what might happen if hair, fingernails and toenails contained sensory receptors.

**References**

5. Bio36-03-05.