6. Integumentary System

The **integumentary system** consists of the skin and various organs derived from the skin, including hairs, nails, and various glands.

I. Composition and Functions of the Integument

The skin, also called the **integument** or **cutaneous membrane**, is a composite organ that consists of two distinct regions of tissue: The **epidermis** forms the superficial layers of the skin, and the **dermis** forms the deep layers of the skin (Fig. 6.1). The region deep to the dermis, called the **hypodermis** or **subcutaneous layer**, consists mostly of adipose tissue. Technically speaking, the hypodermis is not part of the skin. Deep to the hypodermis is muscle.

Epidermis

The epidermis is a sheet of **keratinized, stratified squamous epithelium**. Depending on the part of the body, there are four or five distinct layers to the epidermis. The layers will be discussed after mention of two types of cells found in the epidermis.

Keratinocytes account for approximately 90% of skin cells. The primary function of a keratinocyte is to produce the protein **keratin**. Keratin provides strength to the skin and its hydrophobic nature provides a barrier to water loss. Keratinocytes are held together by numerous desmosomes. The production of keratin in the epidermis is often referred to as **cornification**.

Melanocytes synthesize the pigment, **melanin**. Melanin produced in the melanocytes is transferred to keratinocytes, where it accumulates and forms a protective barrier against UV radiation (Fig. 6.4). The production of melanin in the epidermis is often referred to as **pigmentation**.

The layers of the epidermis are as follows, going from deep to superficial (Fig. 6.3):

A. The **stratum basale** is the deepest layer. It contains large **basal cells**, which are stem cells that divide to form keratinocytes, glands, and hair follicles. The cell bodies of the melanocytes are also found in this layer.

B. The **stratum spinosum** is made up mostly of newly formed keratinocytes, which may continue to divide in this layer. Cytoplasmic extensions of the melanocytes extend into this region to transfer melanin to the young keratinocytes.

C. The **stratum granulosum** contains mature keratinocytes that now produce large amounts of keratin. The keratinocytes flatten and begin to die off as they move to more superficial layers of the stratum granulosum.

D. The **stratum lucidum** is a region of keratinized tissue that is found only in “thick skin” on the palms, fingers, soles, and toes.

E. The **stratum corneum** is the outermost layer of the epidermis, and it consists of dead keratinocytes packed full of keratin. This thick layer provides protection against abrasion and

penetration. The keratin within the cells and glycolypids between the cells provide a fairly waterproof boundary. It takes about two to four weeks for a cell produced in the stratum basale to reach the surface of the stratum corneum.

Dermis

The most obvious feature of the dermis is that it consists of connective tissue loaded with collagen, elastin, and reticular fibers. These fibers give the skin strength, elasticity, and extensibility.

The dermis consists of two layers (Fig. 6.6):

A. The superficial **papillary layer** consists primarily of areolar tissue. Extensions called dermal papillae extend upward into the epidermal ridges. The papillary layer contains many blood vessels, lymphatic vessels, and sensory receptors.

B. The deep **reticular layer** varies in thickness but is much thicker than the papillary layer. It consists primarily of dense irregular connective tissue with thick bundles of collagen fibers.

Functions of the Integument

The integumentary system performs a variety of functions:

A. *Protection*. It forms a protective barrier between the internal and external environments.

B. *Prevention of water loss*. As noted previously, the epidermis is water resistant. This is most important in restricting loss of water from the body.

C. *Metabolic regulation.* When skin is exposed to UV radiation, **vitamin D** is produced in the skin. The liver and kidneys eventually convert vitamin D into the hormone **calcitriol**, which is required for the absorption of calcium and phosphorus by the small intestine. Vitamin D deficiency thus leads to impaired bone growth and maintenance.

How has vitamin D deficiency been greatly reduced in the United States?

Why is it that skin color can be viewed as striking a balance between cancer and vitamin D deficiency?

D. *Secretion and absorption.* The skin is able to secrete water, oils, and various waste products (*e.g.,* urea and salts) in sweat and sebum. The body is able to absorb various chemicals, including drugs such as nicotine and chemicals for birth control. However, it is questionable whether this was intended by nature!

E. *Immune function*. Cells known as **dendritic cells** wander through the epidermis and dermis looking for pathogens that have entered the integument. Dendritic cells can phagocytize

pathogens and initiate an immune response against them. They can also attack cancer cells.

F. *Temperature regulation.* Subcutaneous fat provides a layer of insulation. Sweat glands cool the body. Blood vessels in the skin can dilate or constrict to help radiate or conserve heat.

G. *Sensory reception.* Cutaneous sensory receptors gather information about the environment.

II. Integumentary Structures Derived from Epidermis

The integumentary system includes a number of structures derived from the epidermis to perform special functions.

Hair

Hairs (Fig. 6.10) consist of densely packed keratinocytes. They develop in deep invaginations of the epidermis, which are called the **follicles**. Be able to distinguish the **hair follicle**, **hair bulb, hair root**, and **hair shaft**. Each hair is associated with a smooth muscle, called the **arrector pili**, that raises the hair.

Sweat glands

Sweat glands are coiled structures located in the dermis (Fig. 6.11). Each has a duct that leads to the surface of the skin. The two main types of sweat glands are as follows:

A. **Merocrine (or eccrine) sweat glands** are found over most of the body. They are most dense on palms and soles. These glands have ducts that empty onto surface of the skin. The secretion is thin and watery, and its function is primarily temperature regulation.

B. **Apocrine sweat glands** are located in armpits and pubic regions. These glands do not become functional until puberty. They generally empty into hair follicles, and they produce a more viscous secretion. The function is unclear.

Sebaceous glands

Sebaceous glands are found next to hair follicles (Fig. 6.11), and they produce an oily substance called **sebum**. Sebum consists of a mixture of triglycerides, cholesterol, proteins, and electrolytes. It inhibits the growth of bacteria, lubricates the hair shaft, and conditions the nearby skin. **Sebaceous follicles** are sebaceous glands that are found in the skin but not associated with hair follicles.

Other integumentary glands

Ceruminous glands are found in the external ear canals where they secrete ear wax. They are modified apocrine sweat glands.

Mammary glands secrete milk and are considered further in Chapter 29. They also are modified apocrine sweat glands.

III. Repair and Regeneration of the Integumentary System

All parts of the body are susceptible to injury, but this is particularly true of the integument, which is exposed to the outside world. When tissue is damaged, the body attempts to repair the damage through a variety of processes that involve the inflammatory and immune responses. The outcome of tissue repair typically has two results: (1) **regeneration** is the replacement of damaged tissue with new, fully-functional tissue of the same kind; (2) **fibrosis** involves the proliferation of fibrous connective tissue that forms a **scar**, and does not completely restore function..

The relative amounts of regeneration and fibrosis that result from repair typically depend on the type of tissue and the severity of the injury. The integument is generally pretty good at regeneration after an injury, but some amount of fibrosis is likely to occur as well. Steps in the process of repair of the integument are as follows (Fig. 6.12):

1. Bleeding at the site of the injury brings various materials to the wound. Clotting proteins, white blood cells, and antibody molecules will be used to repair the wound and/or fight off possible infection.

2. A blood clot forms. This stems the flow of blood and restricts the entry of pathogens. White blood cells begin clearing the wound of debris.

3. Damaged blood vessels regrow and the wound begins to heal. Macrophages remove clotted blood and fibroblasts produce collagen fibers at the site of the injury.

4. Damaged epithelial tissue is typically replaced by regeneration. The underlying connective tissue is typically replaced by fibrosis. If the damage is severe, some of the epithelium may not be restored to its original functionality; hair follicles, glands, and other structures may not be replaced.

As mentioned above, some tissues are very good at regenerating with little fibrosis, these tissues include epithelial tissues and bone. Some tissues have considerably less regenerative capacity, examples are dense regular connective tissue and cartilage. Cardiac muscle and nervous tissue of the brain and spinal cord have essentially no functional regenerative capacity.

What are the implications of the last sentence for victims of heart attack, stroke, or spinal cord injury?