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Fundamentals of Dermatology

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Preface

Why another dermatology text? In 1973, when Drs. Nasemann and Sauerbrey wrote the introduction to the first edition of *Hautkrankheiten und venerische Infektionen,* they addressed this question. They promised their book would be concise and profusely illustrated to best teach the fundamentals of dermatology. The German text, now in its fourth edition, has been widely successful. In undertaking an American revised translation of their work, it was my hope to meet a need in the English-language literature similar to that met by the German text. I believe that both students and nondermatologic physicians will find this volume a useful introduction to the art and science of treating skin disorders.

The practice of dermatology differs from country to country. This text is therefore not simply a translation, but an adaptation that incorporates much new material. In the pages that follow, I have built on the successful framework of the German text, incorporating its excellent photographs and other teaching aids. Discussion of therapy has been extensively revised to reflect current practice in the United States. Original chapters on male infertility and proctology (two dermatologic domains in Germany) are not included in this book. They have been replaced by wholly new chapters on cutaneous surgery and tropical dermatology. We are grateful to Ronald G. Wheeland, M.D., for contributing the surgical chapter.

I met Dr. Nasemann during my military service with the U.S. Army in West Germany, and later I was lucky enough to spend six months as a guest at his clinic in Frankfurt. I consider it an honor to have been given the opportunity to prepare this edition of their work. While I have relied heavily on their ideas, responsibility for any shortcomings of this text are entirely mine.

Walter Burgdorf

Contents

1. The Skin

A knowledge of dermatology is essential for every physician, regardless of his specialty. A wide variety of disorders show important cutaneous manifestations, and disorders of the skin itself account for a substantial portion of medical care. A family physician may see up to 20% of his patients for dermatologic complaints. It is estimated, for example, that 1%–2% of the world's population suffers from **psoriasis**,* and although many cases are admittedly mild, almost all of these patients desire treatment.

The skin serves as the main interface between the body and its environment. It often mirrors activity in the body's internal organs, while at the same time reacting to external influences, which range from benign factors such as humidity to more serious problems such as toxic chemicals and ionizing radiation. Occupational illnesses and reactions to medicines are often seen first in the skin, which at times cannot stand up to the stresses modern life imposes on it.

Changing social patterns further increase the importance of dermatology. Increased leisure time has led to greater sun exposure in many lands, and so to a sharp increase in solar damage to the skin and in skin cancers. We have also seen a resurgence in the sexually transmitted diseases, which traditionally have been considered a dermatologic problem because of their cutaneous symptoms.

The key to dermatology is the morphologic description of the skin, derived from both clinical and histologic examination. Because the skin is so readily available for observation, an endless variety of lesions have been identified. An essential skill, then, is the ability to examine the skin and accurately describe what is seen.

* See Appendix II, Glossary, for the definition of this term and all other terms set in boldface type throughout the text.

General Features of the Skin

The skin is the largest organ of the body, with an average surface area of 1.5–2.0 square meters. It may also be one of the heaviest, weighing up to 20 kg (the epidermis weighs about 0.5 kg, the dermis perhaps 3.5 kg, and the balance is made up of subcutaneous fat, which can vary considerably).

The skin shows numerous changes during the lifespan of an individual (see below for a discussion of embryologic changes). At birth, as the infant adapts from a water environment to an air environment, the skin changes from a wet, soggy surface to a relatively dry, scaly, protective covering. Another major change occurs at puberty, when the sebaceous glands enlarge in response to hormonal stimulation and set the ground for potential acne. Menstruation, pregnancy, and birth control pills all induce a variety of changes in female skin, ranging from an increase in pigment (melasma) to the proliferation of small, visible cutaneous vessels to acne to rare diseases associated primarily with pregnancy.

During the later years of life, skin begins to show unmistakable signs of aging. Aging is relative in the skin: one can observe both the inevitable aging process and changes in-

Table 1-1. Factors leading to cutaneous aging.

Factor	Ability to change
Intrinsic nature of patient's skin	Unchangeable
External factors: Job-related, Sun, Other; Climate; Internal illness; Hormonal change	Possible to change
Skin care and protection	Relatively easy to change

duced by controllable outside factors (Table 1-1). Therefore, one finds considerable individual differences in the rate of cutaneous aging. For example, a 35-year-old, fair-skinned farmer working in the southern United States will most probably have sun-damaged skin that could accurately be called aged, while a darker-skinned office worker in a more northern area would not be expected to have these changes. The specific changes induced by sunlight are discussed in Chapter 17; they include precancerous and cancerous lesions, wrinkles, thickening of the skin, graying or loss of hair, and increased sebaceous gland activity leading to oily skin.

Anatomy

By correlating macroscopic and microscopic approaches to morphology, the physician can greatly increase his understanding of cutaneous disease processes. In dermatopathology, clinicopathologic correlations are made readily because quite often the same physician sees the lesion both clinically and, after biopsy, under the microscope. In order to appreciate the changes in diseased skin, however, one must be familiar with its normal structure and function.

Embryology

The skin is derived from two of the primitive germ layers: the ectoderm and the mesoderm. The ectoderm develops into the adult epidermis and its appendages. The mesoderm becomes the embryonic mesenchyme and later the adult dermis, which lies beneath the epidermis and makes up the bulk of the skin. Initially the embryo's surface consists of a single layer of ectodermal cells (Fig. 1-1A). During the second month, the outermost cells flatten out, forming the periderm, while the cells at the interface with the mesenchyme continue dividing to replenish the periderm. These proliferating cells form the basal layer, or stratum germinativum (Fig. 1-1B). By the fourth month, another layer of cells appears between the basal layer and the periderm; because of its position, it is called the stratum intermedium (Fig. 1-1C). At birth, the epidermis has developed all the layers found in mature skin. The mesenchyme undergoes fewer changes, primarily becoming more fibrous as it develops into the dermis. Epidermal–dermal interaction is essential to skin development; when either layer is isolated experimentally, it will not develop properly.

Another ectodermal structure also forms part of the embryonic skin. Early in the first month, the nervous system begins to develop by the invagination and pinching off of the neural tube from the ectoderm of the dorsal surface of the embryo. In this process, a group of ectodermal cells called neural crest cells are left lying in the mesenchyme lateral to the neural tube. These cells remain in approxi-

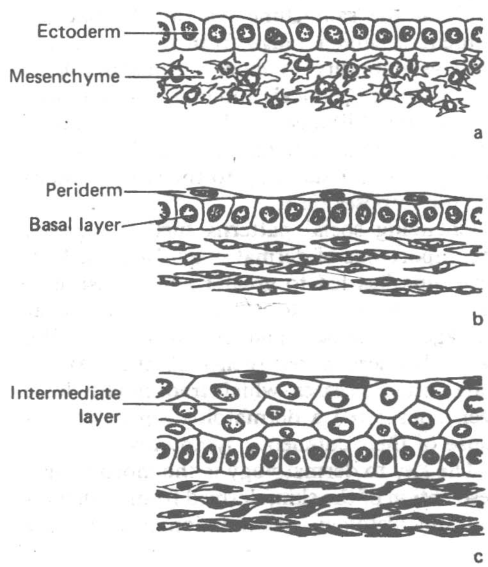
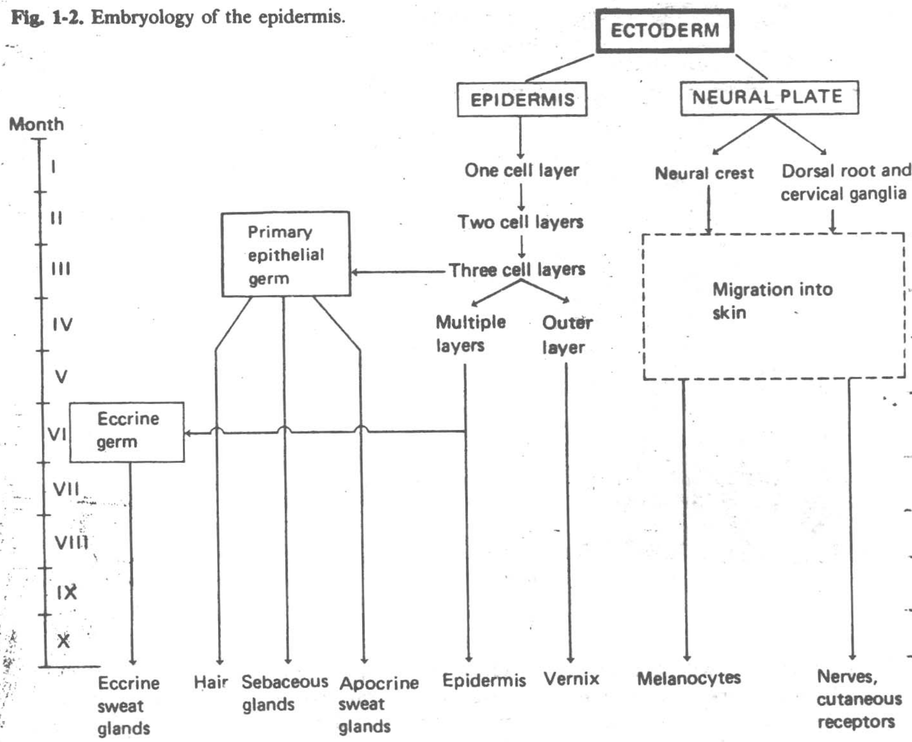


Fig. 1-1. Formation of the skin. **a.** At 5 weeks; **b.** 7 weeks; **c.** 4 months. (Modified from Langman J: Medical Embryology. Williams and Wilkins, Baltimore, 1963, p 313)

Fig. 1-2. Embryology of the epidermis.



mately that location, forming the spinal and cranial sensory ganglia. They also migrate throughout the body, forming the various neuroendocrine cells, such as pancreatic islet and adrenal medulla cells. Other neural crest cells, called melanoblasts, migrate back to the ectoderm, populating the developing epidermis with melanocytes, which are pigment-producing cells. Figure 1-2 reviews cutaneous embryology in a graphic form.

Epidermis

The epidermis is an avascular, multilayered structure that regularly renews itself through cell division in its deepest layer (the basal layer) and undergoes keratinization to produce scales which are shed from the outer layer. Figure 1-3 illustrates the cell layers that make up the adult epidermis.

Stratum Basale (Basal Layer)

The basal layer cells have two main functions: to anchor the epidermis to the underlying dermis and to divide continuously, renewing the outer layers. The cells are arranged in a "fence-post" fashion along the interface between the epidermis and dermis. Although a basement membrane can be identified between the basal cells and the dermis on light microscopy, electron microscopic studies have shown that the epidermal–dermal junction is actually a complex, multilayered arrangement of epidermal and dermal fibers that tie the two layers together.

The normal basal cell is an elongated vertical cell with basophilic bluish cytoplasm and a dark oval nucleus.[1] It is the most metabolically active cell of the epidermis. In addition to being anchored to the dermis, basal cells are attached to neighboring basal cells and overlying prickle cells by desmosomes, or intracellular junctions (Fig. 1-3). These cell-wall connections hold the epidermal cells together while allowing the passage of materials through the epidermis.

Melanocytes are also present in the basal

[1] Unless otherwise indicated, all such descriptions throughout the book refer to the colors produced by the hematoxylin and eosin staining, the most common stain for skin sections.

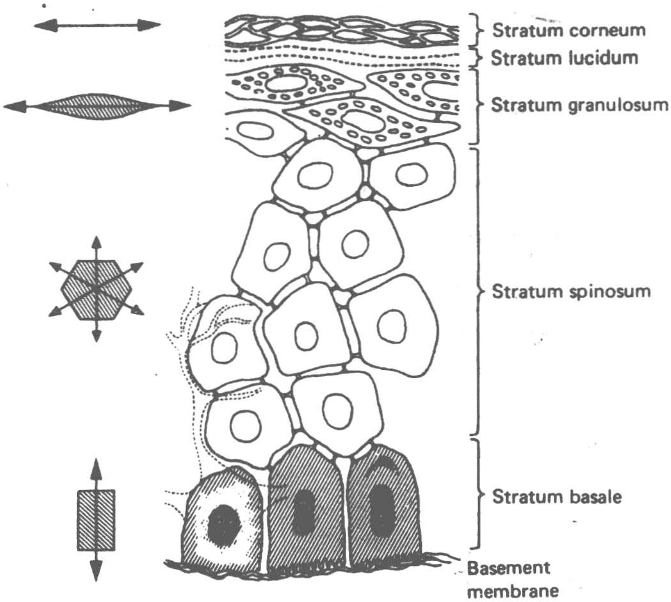


Fig. 1-3. Layers of the epidermis.

layer, in a ratio of about 1 : 10 with basal cells. They are clear cells with dark nuclei, which produce melanin, the main pigment in the skin, and transfer it to the adjacent keratinocytes via long cellular processes, or dendrites. Melanin gives the skin its color and offers protection against ultraviolet radiation. (Defects in melanocytes and melanin production are discussed in Chapter 18.) Melanocytes give rise to the most serious skin tumor, malignant melanoma (Chapter 22).

Stratum Spinosum (Prickle Cell Layer)

The prickle cell is a polygonal cell with basophilic cytoplasm and a round nucleus. It acquires its name from the desmosomes (intracellular bridges) that connect the cells of the stratum spinosum; stretched between cells (Fig. 1-3), they have fancifully been compared to prickles on the surface of a seed. The stratum spinosum forms the mechanical bulk of the epidermis. Occasionally, mitoses occur among the deeper prickle cells, supporting the germinative function of the basal layer.

Stratum Granulosum (Granular Layer)

One or two layers of flattened, horizontally elongated cells form the stratum granulosum. These cells acquire their name from the deeply basophilic keratohyalin granules seen in their cytoplasm. Great metabolic changes occur in the granular layer in the normal keratinization process. The epidermal cell is converted from a nucleated, dividing cell into a flattened cell remnant lacking a nucleus and composed almost entirely of a tough, pliable protein called keratin. Other materials are secreted into the intracellular space in the granular layer to help create the epidermal barrier, a process roughly analogous to caulking between the tiles of a shower wall.

Stratum Corneum (Horny Layer)

The stratum corneum, a layer of overlapping keratin scales constructed much like a shingled roof, is the final destination of the keratinized epidermal cell (now a remnant without a nucleus). This scaly, or horny, layer serves as a mechanical and chemical barrier between the body and the external environment. Occasionally the lower part of the stratum corneum appears as a thick, compact band on which the looser, outermost scales rest. This phenomenon is most often seen on the palms and soles, where the condensed keratin is called the stratum lucidum.

Other Epidermal Cells

Two other cells—the Langerhans cell and the Merkel cell—join the keratinocytes and melanocytes in the normal epidermis. These cells are present in far smaller numbers and have less well-defined functions.

The Langerhans cell is another clear cell, similar to the melanocyte but usually located higher in the epidermis. It is also called a high-level clear cell. It can be distinguished from the melanocyte with special histologic stains and by electron microscopy (it lacks melanin and contains a characteristic ultrastructural organelle resembling a tennis racket). The Langerhans cell seems to be a macrophage that takes up antigens that enter the epidermis and transfers them to the immune system (Chapter 10).

The Merkel cell is even more mysterious. It is found in the lower layers of the epidermis and can be distinguished from keratinocytes only by characteristic electron-dense granules visible on electron microscopy. It is usually associated with nerve endings in the upper dermis, so it is thought to be a type of epidermal nerve cell. In recent years, Merkel cell tumors have been identified, creating renewed interest in this obscure cell.

Epidermal Pathology

Numerous abnormal changes can occur in the epidermis. With tumors, for example, it is first important to know if the tumor is epidermal in origin. Keratohyalin granules and desmosomes are two reliable markers for keratinocytes; they are often sought via electron microscopy to better identify a poorly differentiated tumor. Usually the epidermis consists only of the cells we have mentioned; occasionally inflammatory cells traverse the epidermal–dermal junction and enter the epidermis. This is called **exocytosis.** Sometimes individual keratinocytes in the prickle cell layer will become keratinized while still polygonal. This process, **dyskeratosis,** is seen in congenital disorders of keratinization, sun-damaged skin, and some skin cancers. On occasion, the epidermis becomes thicker than normal. When the thickening occurs in the prickle cell layer, it is called **acanthosis;** the process is referred to as **hyperkeratosis** when it occurs in the stratum corneum. When nuclear fragments persist into the stratum corneum, **parakeratosis** has occurred, suggesting abnormal keratinization.

Epidermal Appendages

A variety of embryonal structures arise from the epidermis, extend into the dermis, and produce the epidermal appendages (Figs. 1-4, 1-5). These early structures include the primary epithelial germ (giving rise to hair, sebaceous glands, and apocrine glands), the eccrine germ (giving rise to eccrine glands), and the

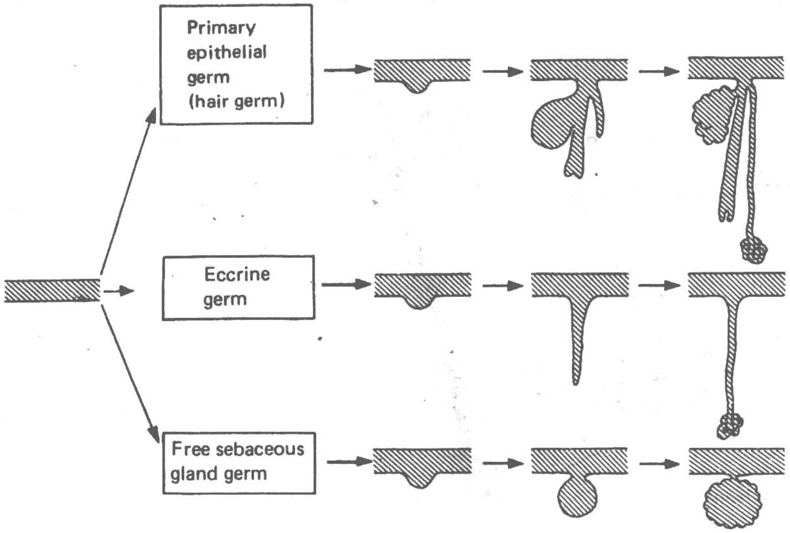


Fig. 1-4. Formation of the skin appendages.

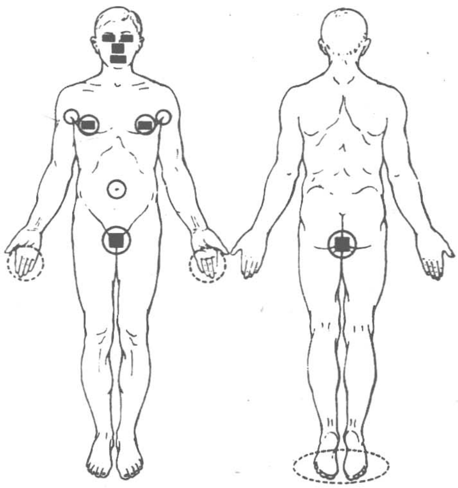


Fig. 1-5. Localization of the appendageal glands. ■ Free sebaceous glands. ○ Apocrine glands. ◌ Areas free of hair and sebaceous glands.

free sebaceous gland germ (giving rise to free sebaceous glands).

Hair

The hair bud in the lower part of the embryonal epidermis thickens and grows diagonally downward into the dermis (Fig. 1-6). The dermis responds by forming the hair papilla, which is eventually encapsulated by the downward-growing hair bud. Papillae contain blood vessels which bring nutrients to the rapidly growing hair matrix.

There are two main types of hair: lanugo and vellus hairs, which are thin and pale, and terminal hairs, which are thicker and may be dark. The fetus initially has long lanugo hairs which are replaced by vellus hairs just before birth. Thus a newborn usually has both lanugo and vellus hairs. The lanugo hairs disappear soon after birth, while the vellus hairs persist. Terminal hairs are usually found only on the scalp, eyebrows, and eyelashes prior to puberty, when they begin to develop elsewhere on the body. Axillary and pubic terminal hairs are major secondary sexual characteristics. The palms, soles, lips, glans penis, and labia minora remain free of hair.

Adult terminal hair is a complex structure (Fig. 1-7). The cylindrical sheaths contribute to the formation of a strong, flexible, tapering cylinder of keratin that exists for many years in its inert form, in contrast to the readily shed keratin scales of the stratum corneum. Each hair is associated with a sebaceous gland and often also with an apocrine gland. The arrector pili muscle attaches to the hair in such a way that when it contracts the hair is pulled vertical, causing "goose bumps."

Human hair is a sparse remnant of the heat-retaining pelt found on most mammals, and is primarily decorative in the modern world. Through its connections with free nerve endings, however, hair also functions as a sensory organ capable of detecting the lightest of touches.

Terminal hairs sometimes grow where they are not usually found, a condition known as **hypertrichosis.** There is obvious sexual and

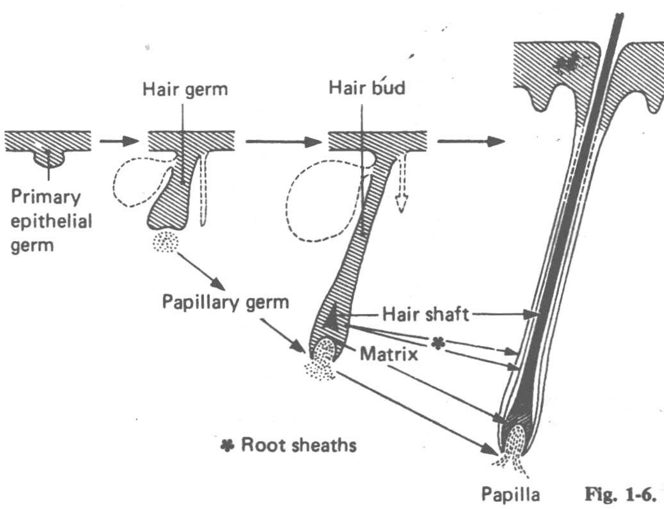


Fig. 1-6. Development and structure of the hair.

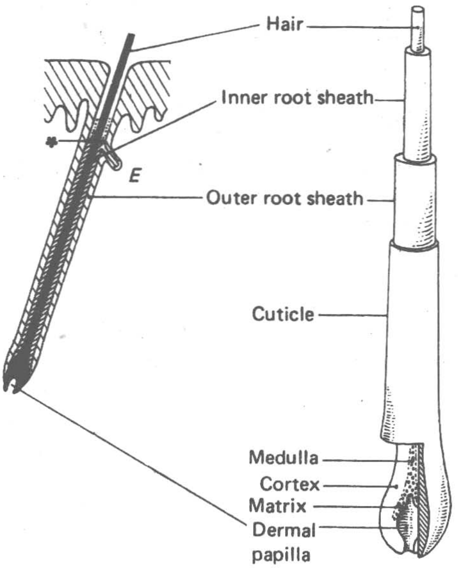


Fig. 1-7. Three dimensional view of hair.

racial variation in the amount of hair normally present. For example, a moustache attracts little attention in a male, but is abnormal in a female. Similarly, what is considered hypertrichosis for an Oriental individual may be normal for a person of Mediterranean extraction. In contrast, **hypotrichosis** is a condition in which the hairs are pale and thin, or even absent.

Sebaceous Glands

Sebaceous glands can either be attached to hairs or lie free. Sebaceous glands arising from the primitive hair germ are found about each hair prior to birth. Free sebaceous glands appear much later in the eyelid (Meibomian gland), oral mucosa (Fordyce spot), nipple, perianal region, and genitalia. Sebum secreted by the sebaceous glands is a mixture of fat, fatty acids, and cell remnants that serves to lubricate the skin and hair.

Sebaceous glands are designated holocrine (Table 1-2), because their secretion comprises cells that have degenerated and fallen off into the glandular lumen. Excessive sebaceous gland activity is responsible for oily skin and appears to play an important role in acne (Chapter 14).

Apocrine Sweat Glands

Apocrine glands develop in connection with each hair germ, as do sebaceous glands. However, most regress during embryonal life. They are found only in limited areas in adults: the axillae, nipples, periumbilical region, perineum, and genitalia. The secretory milk glands in the breast and the ceruminous glands in the external ear are modified apocrine glands.

The apocrine gland is a complex, twisted, tubular mass connected by a large duct to the hair follicle. Apocrine secretion is described as decapitation secretion (Table 1-2) because the outer tip of the cell is discharged into the tubular lumen. Apocrine secretions are usually rich in odor and may be colored. They may serve as markers and sexual attractants in lower species, but have no well-established function in man.

Eccrine Sweat Glands

Eccrine sweat glands arise from the eccrine germ and in man have nothing in common with the primary hair germ. They are present over the entire body and are especially plentiful in the palms, soles, and axillae. Eccrine glands function similar to the kidney, producing a clear secretory product that is excreted into the lumen from a metabolically active cell. They lie deep in the dermis, tightly coiled, with a long narrow duct that winds through

Table 1-2. Characteristics of cutaneous glands.

Parameter	Sebaceous glands	Apocrine glands	Eccrine glands
Secretion	Holocrine	Apocrine (decapitation)	Merocrine (as in kidney)
Opening of lumen	Hair follicle, or free	Hair follicle	Free
Nature of gland	Acinar	Tubular, large lumen	Tubular, small lumen
Function	Lubrication	Unknown	Heat control, excretion

the epidermis in corkscrew fashion. The main function of the eccrine glands is to cool the body through secretion of water and its evaporation. A small amount of water is routinely lost to evaporation without the skin surface feeling wet (insensible water loss). Excessive eccrine secretion makes the skin moist and is known as perspiration or sweat.

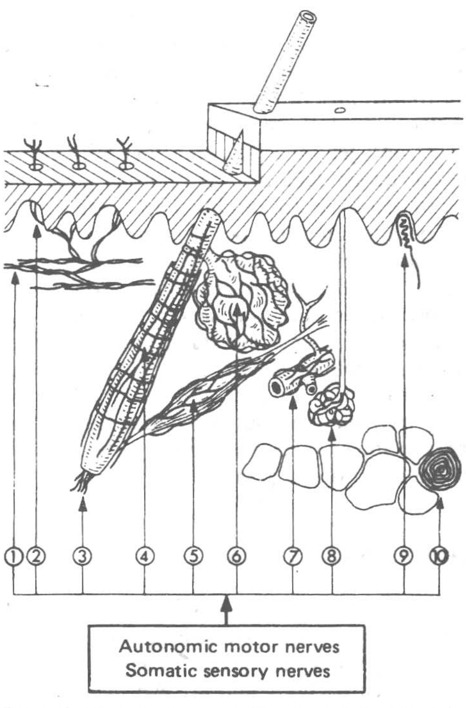


Fig. 1-8. Cutaneous nerves. Numbers 1–10 are defined in Table 1-3.

Cutaneous Nerves

A complex network of somatic sensory and autonomic nerves arise from the neural crest to serve the skin (Fig. 1-8). The nerves have different functions; the sensory nerves are responsible for cutaneous sensation and the autonomic nerves for control of vessels, appendages, and arrector pili muscles (Table 1-3).

Meissner bodies are complex receptors at the epidermal–dermal junction, and Pacini bodies are onion-like pressure receptors in the deeper dermis. Both of these specialized receptors are more common on the palms and soles. Although these two large receptors are easily identified, the free nerve endings and the sensory network about hairs appear to be far more important cutaneous receptors.

Mesenchymal Structures

The mesoderm gives rise to several cutaneous structures: the dermis, skin muscles, vessels, and subcutaneous fat (Fig. 1-9).

Dermis

The dermis is a layer of connective tissue lying beneath the epidermis and supporting it structurally and nutritionally. The two layers interdigitate in a complex fashion (Fig. 1-10); the upper pegs of the dermis are called papillae, the downward-facing pegs of the epidermis are called rete ridges. This interdigitation is responsible for a ridged pattern that is most readily seen on the finger tips (i.e., fingerprints). Because the epidermis is avascular,

Table 1-3. Cutaneous nerves: location and function.

Somatosensory nerves	Autonomic nerves
Location	Location
Flat networks in papillary dermis (1)[a] and possibly entering the epidermis[b] (2)	Flat networks in the papillary dermis (1)
Dense nets about hair follicles (4)	Nerves of the hair papillae (3), arrector pili (5), sebaceous glands (6), vessels (7), and eccrine glands (8)
Meissner bodies (9)	
Pacini bodies (10)	
Function	Function
Cutaneous sensation: touch, heat, cold, pain	Autonomic control

[a] Numbers in parentheses refer to those in Fig. 1-8.
[b] Most workers doubt the presence of nerves in the normal adult epidermis.

Fig. 1-9. Embryology of the dermis.

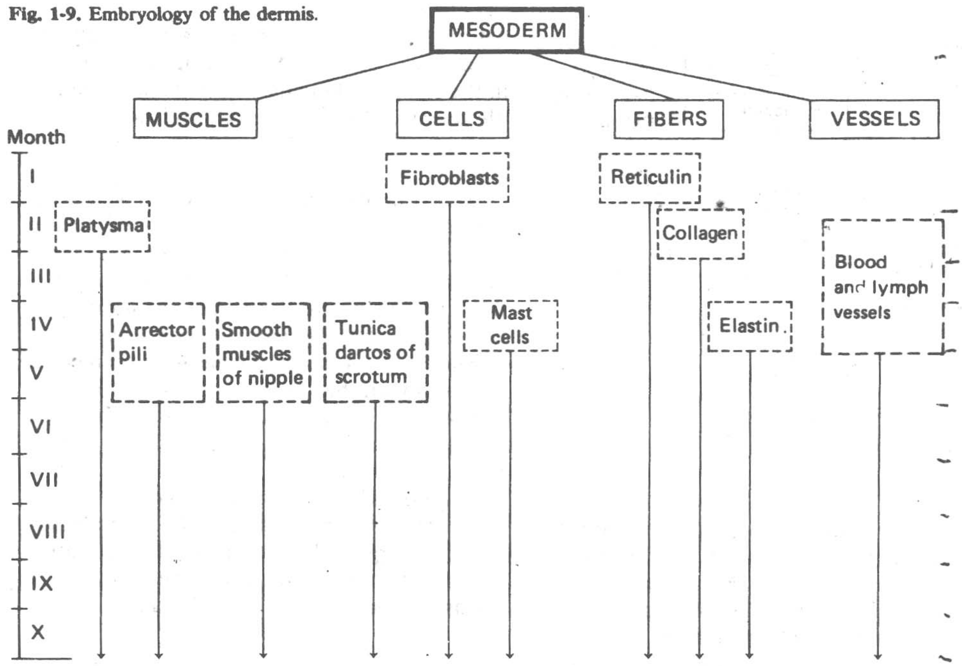
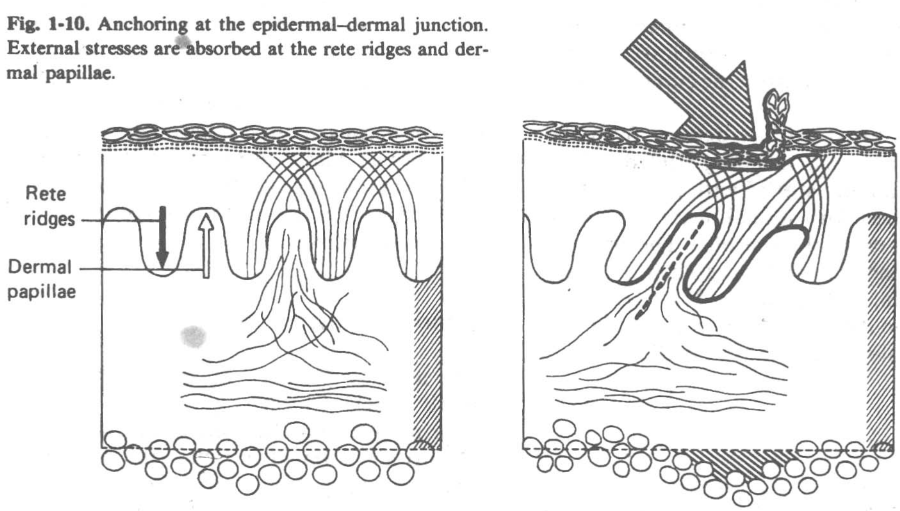


Fig. 1-10. Anchoring at the epidermal–dermal junction. External stresses are absorbed at the rete ridges and dermal papillae.



nutrients must reach it from the highly vascular dermal papillae by diffusion.

The dermis consists of cells, fibers, and amorphous ground substance.

Cells

Fibroblasts are spindle-shaped mesenchymal cells (Fig. 1-11) responsible for producing the fibers and ground substance that form the bulk

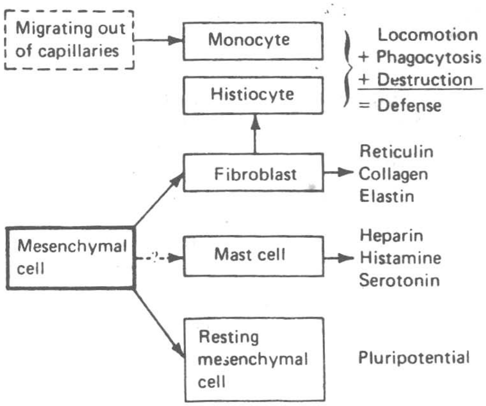


Fig. 1-11. Mesenchymal cells.

of the dermis. Fibroblasts proliferate during wound healing and grow out of control in keloids and fibrous tumors. Many dermal cells are active phagocytes, engulfing objects foreign to the dermis, such as pigment, microorganisms, and abnormal metabolic products (e.g., excessive lipids in xanthomas—see Chapter 23). Phagocytic cells derived from the mesenchyme are called histiocytes; those derived from circulating hematopoetic cells are called monocytes. Other blood cells can also be seen in the dermis in inflammation, including both polymorphonuclear neutrophils and lymphocytes from the cutaneous vessels.

The term "mast cell" is derived from the German word *mast,* meaning stuffed. These cells are round and stuffed with granules that can be seen best with special histologic stains, such as Giemsa or toluidine blue. The granules contain vasoactive substances such as histamine, heparin, and serotonin. Mast cells may be induced to discharge their contents in certain immunologic reactions (Chapter 10).

Fibers

The bulk of the dermis consists of an interlacing network of fibers, which give it strength and elasticity. In the tanning of animal hides, these fibers are what is converted into leather.

The greatest portion of dermal fibers are collagen, an elongated polypeptide with a characteristic repetitive pattern and spiral arrangement. Collagen is synthesized in the fibroblast and is arranged and linked extracellularly. It is elastic in the true sense—it resists deformation. Defects in the various enzymes needed for collagen manufacture are reflected in the stretchy skin characteristic of the multiple forms of Ehlers-Danlos syndrome (Chapter 12). Collagen stains with the van Gieson stain.

Reticulin fibers are very fine collagen fibers that are seen in fetal skin, in wound repair, at the epidermal–dermal junction, and about appendages and vessels in normal skin. Reticulin stains positively with silver stains, perhaps because of its delicate fiber size.

Elastin fibers are somewhat finer than collagen, although thicker than reticulin. Also synthesized by fibroblasts, the elastin fibers are intertwined among the collagen fibers. Elastin is elastic in the usual sense—it stretches. It is responsible for the return of skin to its normal position after stretching. Defects in elastin result in sagging skin, as in cutis laxa (Chapter 12). Elastin stains with a variety of special stains, including the Verhoeff stain.

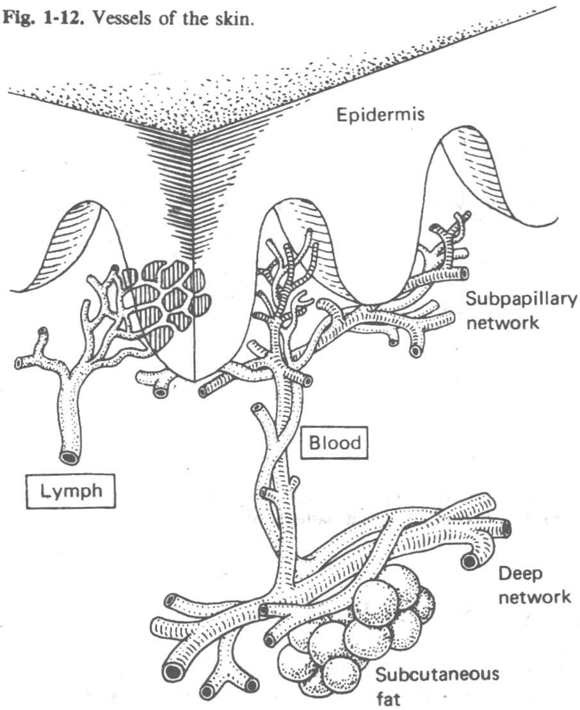
Ground Substance

A variety of mucopolysaccharides, primarily hyaluronic acid and dermatan sulfate, are also synthesized by fibroblasts. These amorphous compounds occupy the space between dermal fibers, adding bulk to the dermis, especially as they bind large amounts of water. The fetal mesenchyme is richest in ground substance, but as the dermis matures it becomes relatively more fibrous. Many metabolic disturbances, such as thyroid disease (Chapter 23), result in the deposition of additional ground substance in the dermis.

Cutaneous Muscles

There are two types of muscle in the skin: smooth muscles (the arrector pili, the muscles of the nipple, and the tunica dartos of the scrotum) and striated muscles (the platysma muscle and some facial expression muscles). The arrector pili are used by animals to raise their fur, providing increased protection against cold. In man, they may aid in expressing sebaceous secretion. The nipple muscles cause nipple erection during sexual stimulation and nursing. The tunica dartos raises and lowers the scrotum, keeping the testicles at a relatively constant temperature. All three of these muscles may contract with cold. The

Fig. 1-12. Vessels of the skin.



platysma and facial muscles are voluntary muscles primarily useful for facial expression.

Vessels

There are two main networks of cutaneous blood vessels: the deep plexus at the dermal–subcutaneous fat junction and the superficial plexus in the papillary dermis (Fig. 1-12). Tiny capillaries branch out from the latter to nourish the epidermal basal cell layer. Although the epidermis is avascular, there is lymphatic drainage of its lower layers, as well as of the entire dermis. Thus metastatic tumors can reach the upper dermis, and occasionally appear to impinge upon the epidermis, as they traverse the lymphatics.

Subcutaneous Fat

A layer of subcutaneous fat usually separates the dermis from underlying muscles, bones, and other structures. This fatty layer is highly variable, virtually disappearing during starvation, and reaching extreme thickness in obesity. It serves as thermal insulation, as physical padding, and as a storage site for metabolically won energy. It is also largely responsible for the contours of the human figure.

Function

All of the skin's functions can be related to its position as interface between the body and the external environment. Cutaneous sensory nerves perceive external influences, such as touch, pain, and temperature differences. Skin structure provides various protective mechanisms, some of which are relatively static, others of which are constantly adjusted by the autonomic nervous system.

Sensation

The body interprets external stimuli as heat, cold, pain, light touch, pressure, itch, and even tickle. Heat and cold perception trigger a variety of temperature control measures. Pain,

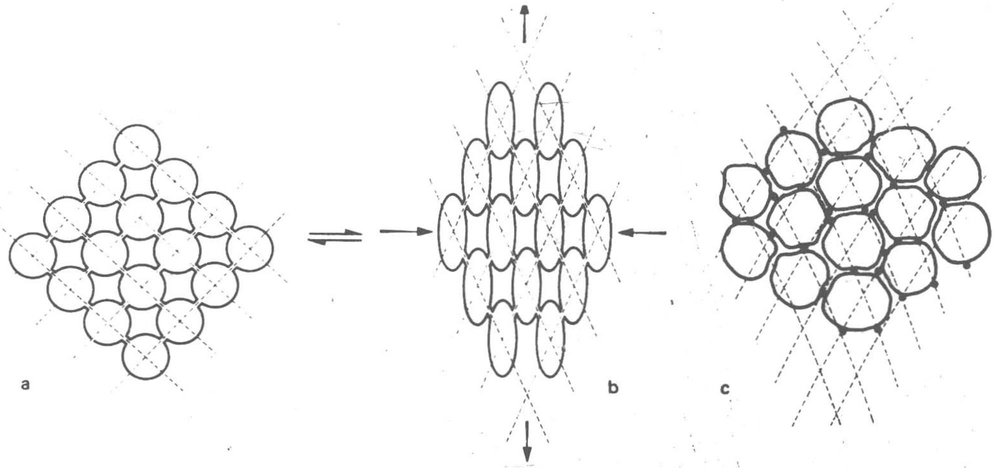


Fig. 1-13. Physical response of the skin to pressure. a. Uniform pattern of cellular alignment. b. Compression results in vertical elongation. c. More realistic representation of alignment patterns of desmosomes.

pressure, and touch usually lead to direct avoidance. Itch, or **pruritus**, is a response to weak but persistent stimulation, perhaps of pain or pressure fibers; it can be overridden by painful stimuli or steady pressure, as well as by the usual responses of rubbing and scratching. Tickle is caused by persistent light movements, as when a fly lands on the skin or when someone purposely tickles a child. The response is usually minor avoidance behavior, such as a flick of the hand or jerking away.

Physical Protection

The skin shields the body against external pressure by several structural means (Fig. 1-13). The stratum corneum is a compact, relatively flexible physical barrier. The intracellular bridges of the prickle cell layer provide both elasticity and support. The complex epidermal–dermal junction holds the two layers together, and the dermis and subcutaneous fat provide bulk and cushioning in addition to mobility. Thus, in response to physical pres-

Fig. 1-14. Action of ultraviolet light on the skin.