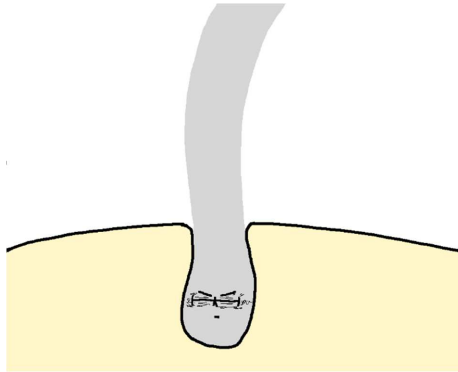


The Biology and Science of Hair, Skin and Nails

Hair

There are approximately 5 million hair follicles on the body with 100-150 thousand located on the scalp. By 22 weeks gestation, the fetus has all of the hair follicles that it will ever have and no more are added during its lifetime. The hair follicles are more dense as a young child and become less so as our body grows. The primary functions of hair are protection against UV rays and heat loss.



Hair cells are called trichocytes and are among the most rapidly dividing cells in the body - doubling every 23-72 hours. The trichocytes are located in the hair follicle, which in turn is located in the dermis of the skin. Each hair follicle has a follicular papilla which is fed by capillaries (small blood vessels). The papilla surrounds the bulb from which the hair grows. This entire complex is located in the dermis of the skin overlying the cranium (also known as the scalp). The follicle has two layers, an outer and an inner. The outer layer continues up to the sebaceous gland and the inner follows the hair shaft and ends below the opening of the sebaceous gland. Each follicle also contains an arrector pili muscle which attaches to the outer sheath just below the sebaceous gland. This causes hair to stand on end when you are frightened or scared or cold.

The sebaceous gland produces sebum which acts as a natural conditioner. The amount of sebum production increases after puberty and decreases in women throughout their lives, particularly after age 40. Sebum also forms a protective film which coats not only hair and skin, but also nails. This protective coating forms the acid mantle layer and keeps the hair at a normal pH of 4.5-5.0. The potential of hydrogen, or pH, is a measure of how acidic or alkaline a substance is. The scale ranges from 1-

14 with the lower numbers being more acidic and higher numbers more alkaline. A pH of 7 is deemed neutral and is the pH of plain water.

The only living part of hair is found below the sebaceous gland of the hair follicle. Once it grows past that point, it is made up of a dead, hard protein called keratin. Keratin is produced by keratinocytes within the follicle. There are three layers of keratin which make up hair: medulla, cortex, and cuticle. The inner layer, or medulla, may be absent. The middle, or cortex, makes up the majority of the hair shaft and gives hair its strength. The cortex contains parallel fibers of keratin. The outer layer, or cuticle, is composed of 6-8 layers of transparent, scale-like keratin cells.

The medulla and cortex contain the pigmented cells which give hair its inherent color. Melanin, produced by melanocytes, is the pigment of hair and different subtypes give rise to different hair colors.

Eumelanin is most dominant in brown and black hair.

Pheomelanin is most dominant in red hair. Blond hair contains relatively little

pigment in the hair strand. At age 40, there is a genetically regulated decline in melanocyte function of each hair follicle which begins the phase of hair "greying."

Hair growth goes through three main stages during the

lifetime of each hair strand. The anagen phase represents the active growth phase. Cells in the hair root are growing quickly as well as melanocytes producing pigment (depending on hair color).

Approximately 85-90% of all hair follicles are in this phase at any given time on the scalp. Scalp hair stays in this phase for 2-6 years. The longer the hair follicle remains in the anagen phase, the longer the hair will grow. Typically,

scalp hair grows 6 inches per year or ½ inch per month. Hair on the arms and legs have anagen phases of 30-45 days which yields short vellous hair. Eyebrows and eyelashes have anagen phases of between 70 and 150 days, leading to longer hair.





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The next phase is the catagen phase which lasts for 2-3 weeks. Approximately 3% of all scalp hair is in this phase at any given time. This is considered a transitional phase and occurs when the outer root sheath shrinks and stops growing. The telogen phase is also known as the resting phase. There is no activity in the hair follicle. Approximately 10-15% of scalp hair is in this phase. Between 25 and 100 telogen hairs are lost every day. Telogen effluvium (Latin for the act of flowing out) is the premature cessation of the anagen phase. This leads to excess shedding of hair and no regrowth in a timely fashion. This may lead to alopecia, particularly in women. Illness, stress, hormonal changes, chemotherapy, medications, and certain medical diseases may be the associated cause.

Cross section of a hair shaft, when viewed under a microscope, yields much information on hair type. Hair that appears circular on cross section tends to be straight. Sebum can more easily travel down the hair and makes it appear shinier and healthier. Hair that appears flattened and elliptical is most consistent with curly or kinky hair. Sebum cannot travel as easily, and the hair looks more dry or dull. Hair strand thickness is most related to a person's background heritage. Those of Asian descent most often have thick and straight hair strands. Those of African-American descent have thick kinky or wiry hair that is more dry and difficult to style. Those of European descent tend to have either curly or straight hair with medium hair shaft thickness. This type is the easiest to color, perm, and style.

An excess of androgens (or male hormones) in women may cause too much hair growth and in unwanted places, such as chin hair or mustache hair. This may be caused by certain medical conditions or medications, or may be idiopathic (unknown reason). In men, excess androgens involving scalp hair has the opposite effect and is the main reason for male-pattern balding or alopecia. The remainder of the skin reacts to excess androgens by increasing hair growth.

Dandruff is another common condition of the scalp which affects the appearance of hair. It merely represents the flaking of the skin of the scalp, typically when the scalp is dry from not shampooing as often as needed or not rinsing the shampoo thoroughly. It is estimated that up to 50% of

people suffer with some degree of dandruff in their lifetime. This is not a contagious condition. If the skin of the scalp is more oily and you see dandruff, you should consider a fungal infection, the most common of which is a fungus called **melassezia globosa**. This is most often treated by a shampoo containing anti-fungal agents such as ketoconazole. Occasionally, a prescriptive shampoo is needed from the dermatologist. This is a contagious condition. Other dermatitis conditions such as eczema or psoriasis may cause the dry form of dandruff. Seborrheic dermatitis causes scaly patches of the scalp, redness and dandruff. None of these conditions are contagious.

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Skin

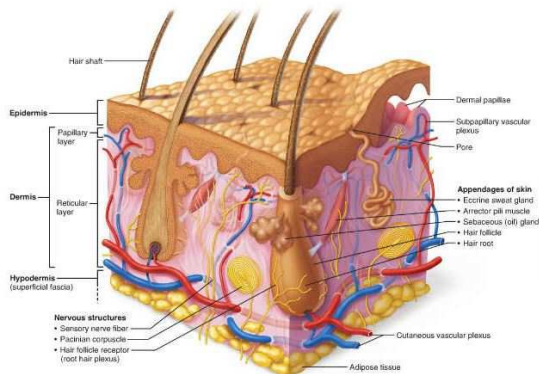
Skin is the largest organ of the body. Its main purpose is to protect underlying muscle, bone and organs from injury. It also is involved in heat regulation and protection against UV rays. Normal skin has an acidic pH between 4.0-7.0, with an average of 4.7. There are approximately 1000



microbes which are present on the skin normally. This acidic pH keeps these bacteria and other microbes in their normal state and impedes the penetration of normal, healthy skin. It also allows for better moisturization. As the pH rises, the acid mantle becomes disrupted and allows for the normal bacteria to penetrate normal skin and increases the risk of infection. Nano particles of up to 40 nm in diameter, particularly spheres, can penetrate into the epidermis and dermis and is a means by which some skin formulations and medications are absorbed.

There are three layers of the skin: epidermis, dermis, and subcutaneous layer. The epidermis is the thin, tough outer layer of skin. The epidermis contains keratinocytes which make the protein keratin. The

keratinocytes move from the basal layer to the surface and are then shed, forming the stratum corneum. The stratum corneum contains approximately 25 layers of dead skin cells, and is relatively waterproof. It assists in preventing foreign substances from entering the skin such as viruses, fungi, and bacteria. Melanocytes are also found in the epidermis. They produce melanin which gives skin its natural color. The primary function of the melanin is to protect against UV rays. Langerhans cells, part of the skin's own immune system, are also found in the epidermal layer.



The dermis is the middle layer of skin and is primarily composed of collagen, elastin, and fibrillin. These give skin its strength and flexibility. Collagen is the most dominant of these three. It is composed of amino acids, particularly glycine, proline, hydroxyproline, and hydroxylysine. Collagen forms into helices which become fibrils. This gives strength to the skin.

Certain enzymes and steroids can break down these fibrils thereby injuring the skin. Disruptions with age leads to wrinkle formation. Collagen injections, derived from young cows, are used medically as a filler in the skin at the site of wrinkles. The dermis contains hair follicles, sebaceous glands, blood vessels, nerve endings, and eccrine glands (These are sweat glands which produce a watery solution and is the primary cooling mechanism of the body). The hair follicles of the face have a very short anagen phase and longer telogen phase. This leads to very fine, vellous hair.

The innermost layer is the subcutaneous layer, or hypodermis. It primarily consists of a fatty layer formed from adipocytes. This layer insulates the body from heat and cold and forms a protective padding. This is also an area of energy storage. This layer is absent in the eyelids. Larger blood vessels are located in the hypodermis and is the area of skin into which injectable drugs enter the body.

A loss of normal skin integrity can result in dermatologic disorders such as eczema, psoriasis and contact dermatitis. Oily skin is found in individuals who overproduce sebum from the sebaceous glands. Larger pore size are often seen in these people. A pore is merely the skin opening of a hair follicle. Larger pores with increased sebum are more prone to dead skin collection and bacterial contamination which is associated with acne, blackhead formation and pimples.

Nails

Fingernails and toenails are made of a protein called keratin. Nail function is to protect the end of the finger and fingertip. It also aids in delicate and precise movements of the ends of the fingers by the activation of nerve endings in the nail matrix through the movement of the nail plate itself. Nail growth rate is related to the length of the finger or the toe. The middle finger grows faster than the little finger. Fingernails grow an average of 3mm per month, while toenails only grow an average of 1mm per month.



Nails are more permeable than skin. They contain 7-12% water, and harmful substances including toxins can enter the body through the nail. Nails often reveal the health, nutritional status, and physiological balances of the body. Deficiencies of vitamin C or folic acid combined with low protein levels result in hangnails. Medical conditions, including dermatologic, may result in abnormal growth, thickening, or horizontal line formation of a nail. Nail color may also indicate the presence of disease such as yellowing or greying with associated malformation resulting from a fungal infection (also called onychomycosis). Clubbing of the nail with associated blue discoloration of the nail bed is often associated with

disorders which cause decreased levels of oxygen in the blood such as certain heart and lung conditions. Smokers will often develop a yellow-brown discoloration of the two nails of the fingers used to hold the cigarette.

The nail plate is the actual nail itself. It protects the matrix layer immediately beneath it which contains nerves, lymph and blood vessels. The matrix produces the cells that become the nail plate. The thickness of the matrix determines the width and thickness of the nail. The shape of the fingertip determines if the nail plate is flat, arched, or hooked. As the matrix makes new nail cells, the older ones are pushed forward. This cycle works normally in the face of adequate nutrition and if the matrix remains healthy. The pink color comes from the pigment in hemoglobin which is found in red blood cells in the blood vessels. The lunula is the visible part of the matrix and appears as a white, crescent shape at the base of the visible nail.

The nail bed is the skin beneath the nail plate. This is an epidermal layer connected to the dermis by tiny longitudinal grooves. Thinner nail plates have more visible grooves. The nail sinus is the base of the nail under the skin and is where the nail root resides. It originates from the matrix.

The cuticle (the part removed during a manicure) is a semi-circular layer of dead skin cells that covers the back of the nail plate. The eponychium is the small band of living skin cells that connects to the cuticle. It extends from the posterior nail wall to the base of the nail. This provides a barrier to the nail and finger from infection. Care must be taken when removing the cuticle not to injure the eponychium. The paronychia is the border tissue around the nail. It is the site of occurrence of hangnails and ingrown nails. The hyponychium is the junction of the free edge of the





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nail and the skin of the digit. The nail groove (or fold) is the cutaneous slit into which the lateral margin of the nail is embedded.