Hair follicle
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A **hair follicle** is a mammalian skin organ that produces hair. Hair production occurs in phases, including growth (anagen), cessation (catagen), and rest (telogen) phases. Stem cells are responsible for hair production.

### Contents

- 1 Structure
  - 1.1 Papilla
  - 1.2 Matrix
  - 1.3 Root sheath
  - 1.4 Hair fiber
  - 1.5 Bulge
  - 1.6 Other structures
- 2 Morphogenesis
- 3 Hair-follicle cycling
  - 3.1 Anagen phase
  - 3.2 Catagen phase
  - 3.3 Telogen phase
  - 3.4 Hair growth cycle times
- 4 Hair follicles in hair restoration
- 5 Additional images
- 6 Skin overview
- 7 References

### Structure

#### Papilla

The papilla is a large structure at the base of the hair follicle.[1] The papilla is made up mainly of connective tissue and a capillary loop. Cell division in the papilla is either rare or non-existent.

#### Matrix

Around the papilla is the hair matrix, a collection of epithelial cells often interspersed with the pigment-producing cells, melanocytes. Cell division in the hair matrix produces the cells that form the major structures of the hair fiber and the inner root sheath. The hair matrix epithelium is one of the fastest growing cell populations in the human body, which is why some forms of chemotherapy or radiotherapy, that kill dividing cells, may lead to temporary hair loss. The papilla is usually ovoid or pear shaped. The matrix wraps completely around it, except for a short stalk-like connection to the surrounding connective tissue. This provides access for the capillary.
Root sheath

The root sheath is composed of an external and internal root sheath. The external root sheath appears empty with cuboid cells when stained with H&E stain. The internal root sheath is composed of three layers, Henle’s layer, Huxley’s layer, and an internal cuticle that is continuous with the outermost layer of the hair fiber.

Hair fiber

The hair fiber is composed of keratin.

Bulge

The bulge is located in the outer root sheath at the insertion point of the arrector pili muscle. It houses several types of stem cells, which supply the entire hair follicle with new cells, and take part in healing the epidermis after a wound. [2][3] Stem cells express the marker LGR5+ in vivo. [4]

Other structures

Other structures associated with the hair follicle include the cup in which the follicle grows known as the infundibulum, [5] the arrector pili muscles, the sebaceous glands, and the apocrine sweat glands. Hair follicle receptors sense the position of the hair.

Attached to the follicle is a tiny bundle of muscle fiber called the arrector pili. This muscle is responsible for causing the follicle lissis to become more perpendicular to the surface of the skin, and causing the follicle to protrude slightly above the surrounding skin (piloerection) and a pore encased with skin oil. This process results in goose bumps (or goose flesh).

Also attached to the follicle is a sebaceous gland, which produces the oily or waxy substance sebum. The higher the density of the hair, the more sebaceous glands that are found.

Morphogenesis

In utero, the epithelium and underlying mesenchyme interact to form hair follicles. [6]

Hair-follicle cycling

Main article: Human hair growth

Hair grows in cycles of various phases! [7] anagen is the growth phase; catagen is the involuting or regressing phase; and telogen, the resting or quiescent phase. Each phase has several morphologically and histologically distinguishable sub-phases. Prior to the start of cycling is a phase of follicular morphogenesis (formation of the follicle). There is also a shedding phase, or exogen, that is independent of anagen and telogen in which one of several hair that might arise from a single follicle exits. Normally up to 90% of the hair follicles are in anagen phase while, 10–14% are in telogen and 1–2% in catagen. The cycle's length varies on different parts of the body. For eyebrows, the cycle is completed in around 4 months, while it takes the scalp 3–4 years to finish; this
is the reason eyebrow hair have a much shorter length limit compared to hair on the head. Growth cycles are controlled by a chemical signal like epidermal growth factor. DLX3 is a crucial regulator of hair follicle differentiation and cycling. Specifically, colocalization of phosphorylated Smad1/5/8 complex and DLX3 regulate role for BMP signaling to Dlx3 during hair morphogenesis in animal models.[8][9]

Anagen phase

Anagen is the active growth phase of hair follicles[10] during which the root of the hair is dividing rapidly, adding to the hair shaft. During this phase the hair grows about 1 cm every 28 days. Scalp hair stays in this active phase of growth for 2–7 years and is genetically determined. At the end of the anagen phase an unknown signal causes the follicle to go into the catagen phase.

Catagen phase

The catagen phase is a short transition stage that occurs at the end of the anagen phase.[11] It signals the end of the active growth of a hair. This phase lasts for about 2–3 weeks while the hair converts to a club hair. A club hair is formed during the catagen phase when the part of the hair follicle in contact with the lower portion of the hair becomes attached to the hair shaft. This process cuts the hair off from its blood supply and from the cells that produce new hair. When a club hair is completely formed, about a 2 week process, the hair follicle enters the telogen phase.

Telogen phase

The telogen phase is the resting phase of the hair follicle.[12] When the body is subjected to extreme stress, as much as 70 percent of hair can prematurely enter a phase of rest, called the telogen phase. This hair begins to fall, causing a noticeable loss of hair. This condition is called telogen effluvium.[13] The club hair is the final product of a hair follicle in the telogen stage, and is a dead, fully keratinized hair.[6] Fifty to one-hundred club hair are shed daily from a normal scalp.[6]

Hair growth cycle times

- Scalp: The time these phases last varies from person to person. Different hair color and follicle shape affects the timings of these phases.
  - anagen phase, 2–6 years (occasionally much longer)
  - catagen phase, 2–3 weeks
  - telogen phase, around 3 months

- Eyebrows etc.:
  - anagen phase, 4–7 months
  - catagen phase, 3–4 weeks
  - telogen phase, about 9 months

Hair follicles in hair restoration

Hair follicles form the basis of the two primary methods of hair transplantation in hair restoration, Follicular Unit Transplantation (FUT) and Follicular Unit Extraction (FUE). In each of these methods, naturally-occurring groupings of one to four hairs, called follicular units, are extracted from the hair restoration patient and then surgically implanted in the balding area of the patient's scalp, known as the recipient area. These follicles are extracted from donor areas of the scalp, or other parts of the body, which are typically resistant to the
miniaturization effects of the hormone DHT. It is this miniaturization of the hair shaft that is the primary predictive indicator of androgenetic alopecia,[14] commonly referred to as male pattern baldness or male hair loss. When these DHT-resistant follicles are transplanted to the recipient area, they continue to grow hair in the normal hair cycle, thus providing the hair restoration patient with permanent, naturally-growing hair.

While hair transplantation dates back to the 1950s,[15] and plucked human hair follicle cell culture in vitro to the early 1980s,[16] it was not until 1995 when hair transplantation using individual follicular units was introduced into medical literature.[17]

Research is under way to multiply hair follicles that are resistant to miniaturization. In hair multiplication, plucked hair or hair fragments, which contain germinative cells, are implanted into the scalp with the hope that they will develop into new hair-producing follicles. In experimental hair cloning, dermal sheath cells could be isolated, multiplied in a Petri dish, and then injected in great numbers to produce hair-producing follicles and, in theory, a full head of hair. Neither method has yet proven to result in a commercially viable hair restoration treatment, but research continues in these areas.

**Additional images**

Cross-section of all skin layers.  
Pili multigemini is a malformation characterized by the presence of bifurcated or multiple divided hair matrices and papillae, giving rise to the formation of multiple hair shafts within the individual follicles.

**Skin overview**
References


Categories: Pages containing blacklisted links | Hair anatomy

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