Hair

There are two main types of human hair: vellus and terminal. Only terminal hair, which is found mainly on men, has a central core or medulla and responds to the male sex hormone, testosterone.

The surface of the human body is covered with millions of hairs. They are most noticeable on the head, around the external genitalia and under the arm. The only regions of the body without hairs are the lips, nipples, parts of the external genitalia, the palms of the hands and the soles of the feet.

Although hair does not really serve to keep us warm, as it does in other mammals, it has a number of other functions:

- Sensing small objects or insects that approach the skin
- Protecting/insulating the head
- Shielding the eyes
- Sexual signalling.

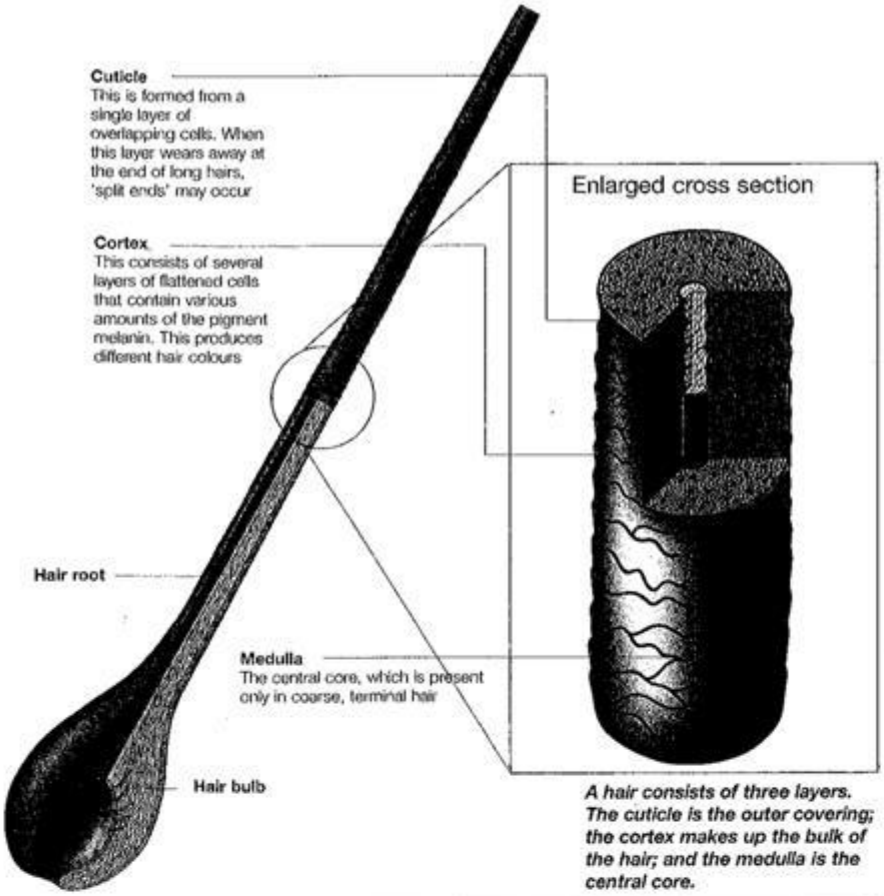
STRUCTURE OF A HAIR

Hair is composed of flexible strands of the hard protein, keratin. It is produced by hair follicles within the dermis (the inner layer of the skin) but arises from an 'inpouching' of the epidermis (the outer layer).

Each hair follicle has an expanded end – the hair bulb – which receives a knot of capillaries to nourish the root of the growing hair shaft. The shape of the hair shaft determines whether the hair is straight or curly: the rounder the shaft in cross section, the straighter the hair.

Each hair is made up of three concentric layers:

- The medulla
- The cortex
- The cuticle.



A hair consists of three layers. The cuticle is the outer covering; the cortex makes up the bulk of the hair; and the medulla is the central core.

Types of hair and their distribution

Eyelashes are one of the few examples of terminal hair to be found on men, women and children. They prevent foreign bodies from entering the eye.

Although it seems as though there are many different types of human hair, it can be divided into just two main groups:

- Vellus hair
- Terminal hair.

VELLUS HAIR

Vellus hair is the name given to the soft hair that covers most of the body in women and children. It is short, fine and usually light in colour, making it much less noticeable than terminal hair. Vellus hair shafts do not have a central medulla.

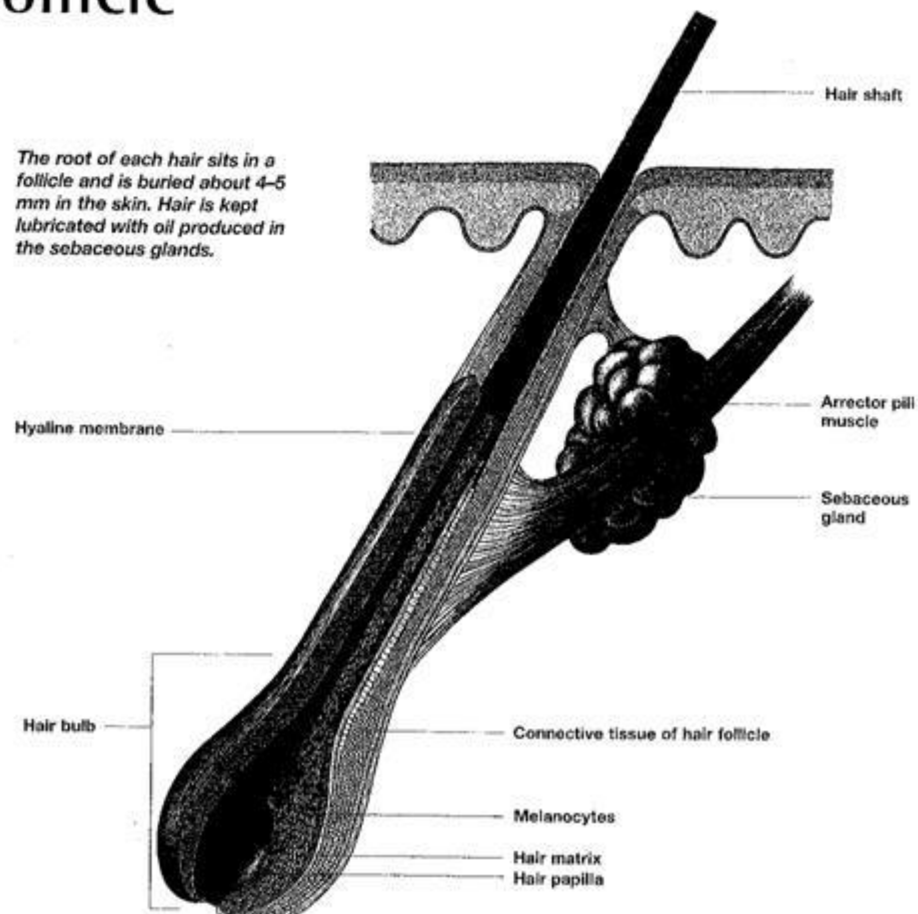
TERMINAL HAIR

Terminal hair is much coarser than vellus hair. It occurs on top of the head, as eyelashes and eyebrows, as pubic and axillary (armpit) hair, and it makes up most of the body hair of adult men. Terminal hair does have a central medulla within its shaft.

Terminal hairs develop and grow in response to the presence of male sex hormones, such as testosterone. In medical conditions where women have too much of these hormones, unwanted male pattern hair growth (hirsutism) occurs.

The hair follicle

Hairs are produced within hair follicles, which are present on most of the skin surface. A number of other structures are associated with these follicles, including sebaceous glands, nerve endings and tiny muscles that pull the hair erect.



The root of each hair sits in a follicle and is buried about 4–5 mm in the skin. Hair is kept lubricated with oil produced in the sebaceous glands.

Sebaceous, or oil, glands lie alongside hair follicles wherever they are on the surface of the body. They produce an oily substance, known as sebum, which drains out of the gland through a sebaceous duct into the hair follicle. The sebum then passes out around the emerging hair shaft to reach the surface of the body.

The amount of sebum produced depends upon the size of the sebaceous gland, which in turn depends upon the levels of circulating hormones, especially androgens (male sex hormones). The largest sebaceous glands are found on the head, neck, and back and front of the chest.

The function of sebum is to soften and lubricate the skin and hair, and to prevent the skin from drying out. It also contains substances that kill bacteria, which might otherwise cause infection of the skin and hair follicle.

NERVE ENDINGS

A network of tiny nerve endings lie around the bulb of the hair follicle. These nerves are stimulated by any movement of the base of the hair. If the hair is bent by pressure somewhere along its shaft, these nerve endings will fire, sending signals to the brain. This is what happens, for instance, when an insect alights on the skin; the slight bending of hairs it causes sets off a chain of events, resulting in a reflex action to remove it before it stings. In this way hair contributes to our sense of touch.

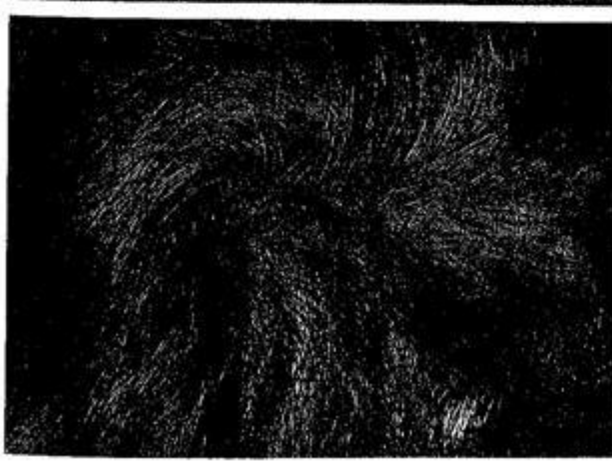
ARRECTOR PILI MUSCLE

Each hair follicle is attached to a tiny muscle called an arrector pili, which literally means 'raiser of hair'. When this muscle contracts, it causes the hair to move from its normal, angled position to a vertically erect one.

When this occurs within many hair follicles, we see (and feel) the condition known as goosepimples, which is commonly stimulated by either cold or fear.

The action of these muscles is more important in furry mammals, as it allows them to trap a large amount of air within their fur for insulation from the cold.

Hair thinning and baldness



Hair growth is fastest between childhood and early adulthood. After about the age of 40 this high rate of growth starts to fall as the hair follicles begin to age.

Hairs are not replaced as rapidly when they fall out, leading to general thinning, and some degree of baldness in both men and women. Thinning of the hair is also caused by the replacing of coarse terminal hairs with less noticeable, softer vellus hair.

After the age of around 40, hair follicles start to age and hair is not replaced as quickly as it falls out. Thicker terminal hair is also replaced by thinner vellus hair

ONSET OF BALDNESS

True baldness, which is usually known as male pattern baldness, is a different condition, linked to a number of factors. These include:

- Family history
- Levels of androgens (male sex hormones)
- Increasing age.

It is believed to be due to a gene that only 'switches on' in adult life and somehow alters the response of the hair follicle to circulating hormones.

Abnormal hair thinning or loss may also be linked to a wide variety of medical conditions and treatments of [illegible]

How hair grows

Hair is a derivative of the skin, and is composed of keratin – a strong structural protein. Hair plays an important role in protecting the body, particularly the scalp, where it is most dense.

Hair is a distinguishing characteristic of mammals and in humans plays a role in the protection of the body from trauma, heat loss and sunlight.

HAIR STRUCTURE

Hair is a complex structure comprised of keratin fibres – keratin is a strong structural protein also found in the nails and outer layer of the skin.

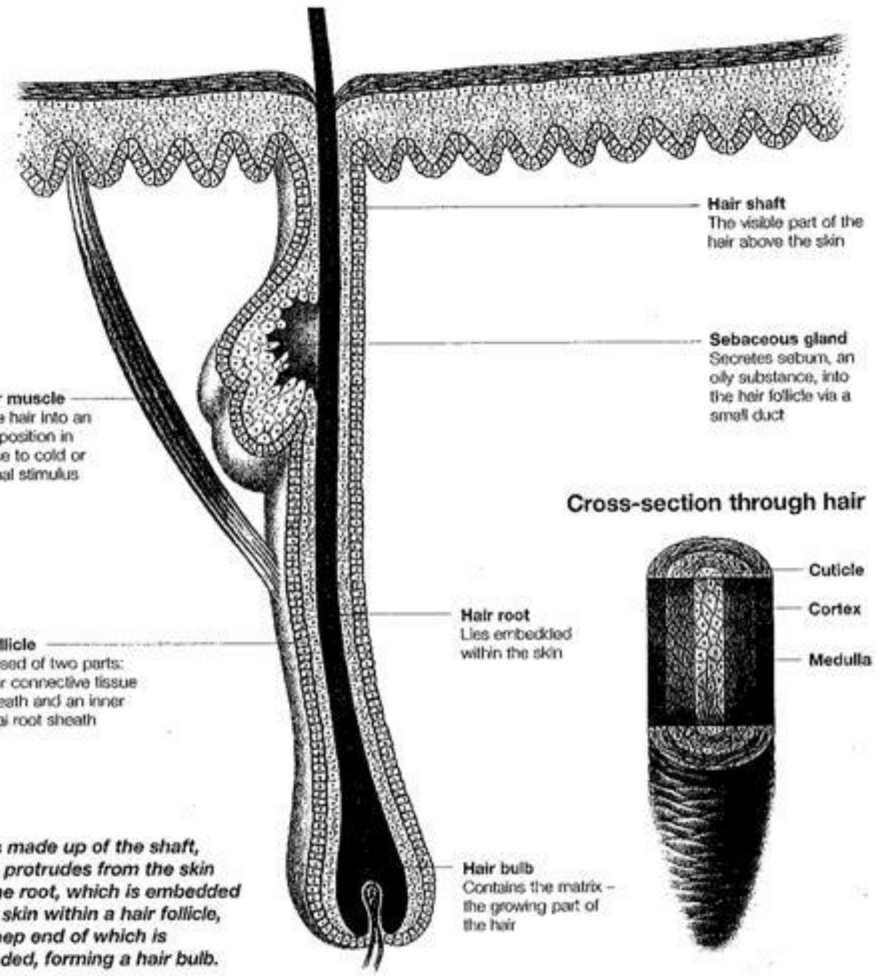
Each hair is made up of three concentric (circular) layers of dead keratinized (keratin-containing) cells: the medulla, cortex and cuticle.

The medulla (the central core) consists of large cells containing soft keratin, partially separated by air spaces. The cortex, the bulky layer surrounding the medulla, consists of several layers of flattened, hard keratin-containing cells.

PROTECTIVE LAYER

The cuticle is the outermost layer, and is composed of a single layer of hard keratin cells that overlap one another like roof tiles.

This outer layer of the hair contains the most keratin, and strengthens and protects the hair, helping to keep the inner layers compacted. The cuticle tends to wear away as the hair becomes older or is damaged, allowing the keratin fibrils, or small fibres, in the cortex and medulla to escape, giving rise to the common phenomenon of 'split ends'.



Hair is made up of the shaft, which protrudes from the skin and the root, which is embedded in the skin within a hair follicle, the deep end of which is expanded, forming a hair bulb.

What causes hair to grow?

This electron micrograph shows hairs on the scalp. There are two shafts of hair emerging from follicles located in the epidermis of in the skin.

Each hair is divided into the shaft (the visible part) and the root. The root of each hair is enclosed within a hair follicle, below the surface of the skin. At its base the hair follicle is expanded to form the hair bulb.

PRODUCTION OF HAIR

The hair bulb encloses a mass of undifferentiated epithelial cells (the hair matrix), which divide to produce hair. The hair bulb is nourished by a dense network of capillaries which are supplied by the dermal papilla (a projection of the dermis).

STIMULATION OF GROWTH

Chemical signals from the papilla stimulate the adjacent matrix cells to divide and produce hair. As new hair cells are produced by the matrix, the older cells are pushed upwards and fuse together. They become increasingly keratinized and die. Thus the hair that extends from the scalp is no longer living, but due to the active cell division at its root, grows at a rate of around 0.3 mm every day.

Stages of growth

Hair is produced in different stages. Any factors, such as stress or certain drugs, that upset this balance can lead to hair thinning and baldness.

Hair is produced in cycles that involve a growth phase, and a resting phase. During the growth phase the hair is formed and extends as cells are added at the base of the root. This phase can last from around two to six years. As hair grows approximately 10 cm a year, any individual hair is unlikely to grow more than one metre long.

RESTING PHASE

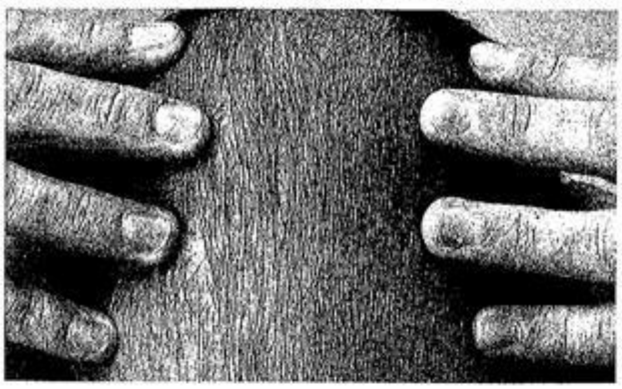
Eventually, cell division pauses (the resting phase) and growth of the hair stops. The hair follicle shrinks to one sixth of its normal length, and the dermal papilla, responsible for the nourishment of new hair cells, breaks away from the root bulb. During this phase the dead hair is held in place. It is these hairs which seem to come out in handfuls when hair is washed or brushed. Eventually a new cycle begins, and the hair is shed from the hair follicle as the production of a new hair begins.

DIFFERENT HAIR TYPES

The length of each phase depends on the type of body hair: scalp hairs tend to grow for a period of three years and rest for one or two years, while eyelash hair, which is much shorter, will grow for around 30 days, and rest for 105 days before being shed. At any one time around 90 per cent of scalp hairs will be in the growing stage, and there is a normal loss of around 100 scalp hairs per day.

Hair does not grow at a constant rate; individual hairs pass through a growth phase and a resting phases, before falling out and being replaced.

Hair loss



As we age the rate at which our hair grows declines. This can mean that hairs are not replaced as quickly as they are shed and there is an overall thinning, with balding in places (alopecia) often occurring, especially in men.

PREMATURE HAIR LOSS

The physiological changes which bring about male pattern baldness are different to those occurring with alopecia. Male pattern baldness is a genetically determined condition and is thought to be caused by changes in the response of the hair follicles to testosterone. The growth cycles of each hair follicle become so short that many hairs never emerge from their follicles before they are shed, and those that do are only very fine.

Hair thinning and loss may also result from factors such as stress that upset the normal hair loss and replacement cycle.

Male pattern baldness is a common hereditary condition. The growth stage of each hair is so short that they are shed before emerging from the scalp.

Hair colour and texture

The colour of hair depends upon the presence of the pigment melanin, produced by melanocytes in the bulb of the hair follicle, and then transferred to the cortex.

Dark hair contains true melanin like that found in the skin, while blond and red hair results from types of melanin that contain sulphur and iron. Grey or white hair results from decreased melanin production (genetically triggered) and from the replacement of melanin by air bubbles in the shaft.

Adults have around 120,000 hairs on their head. Redheads tend to have fewer hairs, while blonds have more.

The exact composition of the keratin produced by the body is determined by our genes and differs among individuals. Since keratin is responsible for the texture of the hair shaft, this can vary greatly.

A smooth, cylindrical hair shaft will produce straight hair, while an oval hair shaft will produce wavy hair. A hair shaft that has a kidney-shaped appearance will produce curly hair.

Hair colour and texture are genetically determined and can vary greatly. Colour is determined by melanin content while texture depends upon the exact composition of keratin.

How nails grow

The nails are extensions of the outer skin layer, and grow continuously throughout life. Apart from their protective function, they can also give a good indication of a person's state of health.

Like the hair, the nails are a derivative of skin, and form part of the outer covering of the body. Each nail is a scale-like extension of the epidermis (outer layer of skin) that covers the end of the finger and toe.

ANATOMY OF THE NAIL

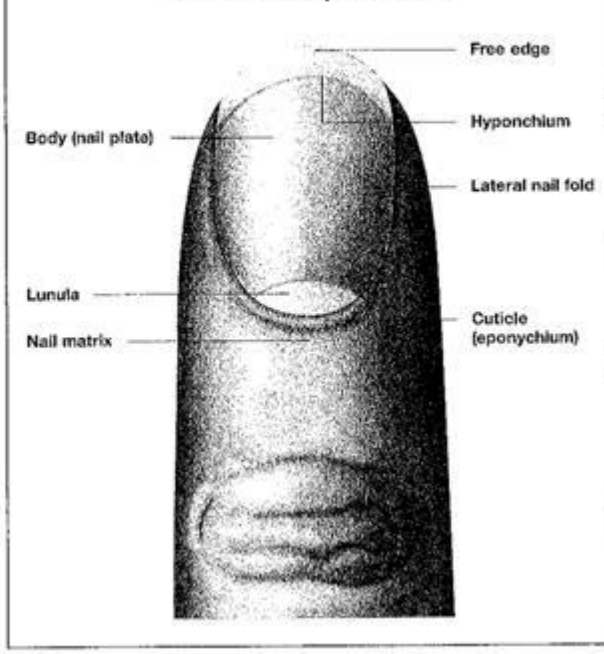
The nails are flattened, elastic structures that begin to grow on the upper surface of the tips of the fingers and toes in the third month of fetal development.

Each nail consists of the following parts:

■ Body – otherwise known as the nail plate. This is the main, exposed part of the nail
■ Free edge – this is the part of the nail that tends to grow beyond the fingertip
■ Lateral nail fold – this is the bulge of skin that grows either side of the nail. Folds arise at the boundary of the epidermis and nail because the epidermal cells divide more quickly than those of the nail and cause the skin to bulge over the nail
■ Eponychium (cuticle) – this is a fold of cornified (dead) skin that partially covers the nail and also protects the growing area of the nail
■ Lunula – this is the slightly opaque area of the nail, which is crescent shaped (lunula means 'little moon' in Latin). This area of the nail may be partially obscured by the cuticle
■ Hyponchium – this is the area of skin attached just below the free border of the nail. The hyponchium has a very rich nerve supply, which is why it can be very painful if foreign bodies such as a splinter of wood penetrate it
■ Root – otherwise known as the matrix, this is the proximal part of the nail (closest to the skin) and is implanted in a groove beneath the cuticle
■ Nail bed – this is the area underlying the entire nail.

The nails consist of curved plates of hard keratin. Beneath the lunula area lies the nail matrix – this is responsible for the growth of the nail.

Visible anatomy of the nail



The role of nails

Despite the fact that the nails are not as strong as those of our ancestors, they still serve a number of important roles.

The nails are well designed for enhancing the movements of the fingers, such as scratching. They also protect the sensitive tips of the fingers and toes.

PROTECTIVE ROLE

Like skin and hair, the nails are composed of keratin, a tough protein. This acts as a shock absorber, protecting the tips of the fingers and toes.

In addition, the fingernails are useful tools for tasks such as undoing a shoelace, picking up small objects or scratching an itch.

Despite the fact that the nails lack nerves, they also serve as excellent 'antennae', since they are embedded in sensitive tissue that detects any impact when the nail touches an object.

Brittle nails

The nails are very porous and they can hold up to 100 times as much water as the equivalent weight of skin. In this way, the nails limit the amount of water entering the tissues of the fingertips.

Water taken up by the nails is eventually lost through evaporation as they dry out and resume their normal size.

Frequent immersion in water and then drying can cause the structure of the nail to become weakened, resulting in nails becoming brittle and splitting.

In addition, the use of nail varnish, and its removal with solvents, can cause the nails to become brittle.

It is a common misconception that the fingernails continue to grow for a short time after death.

It is understandable how this myth came to be believed, however, since after death the skin surrounding the nails dries up and shrivels away from the nail plates. This phenomenon creates the impression that the nails have actually grown in length, in the same way that pushing the cuticles back makes the nails seem longer.

In reality, however, every cell in the body ceases to grow after death, including those of the nails.

It is often suggested that nails and hair continue to grow after death. Once death has occurred, however, every cell in the body ceases to function.

Growth rate of nails

It can take up to six months for a nail to grow from the root to the tip of the finger. At certain times, nail growth is accelerated, for instance in warm weather.

There are two areas of the nail in which growth occurs:

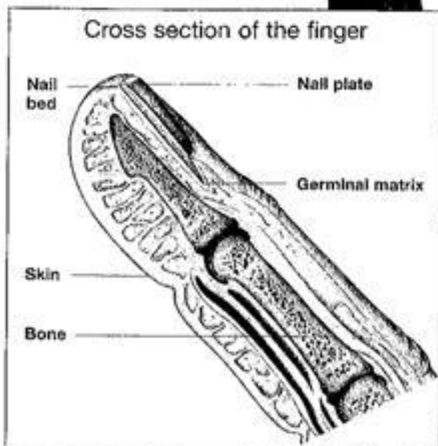
- The germinal matrix – this is the area beneath the root of the nail. Here, epidermal cells divide, and become enriched with keratin, which thickens to become nail
- The nail bed – this is the area underneath the nail plate; it provides a surface over which the growing nail divides.

RATE OF GROWTH

On average, it takes around three to six months for a nail to grow from its base to the tip of the finger. The average fingernail grows at a rate of about 0.5 mm a week, with faster growth taking place in the summer. It is thought that blood circulates faster in the summer so that cell division is more rapid. Fingernails grow around four times faster than toenails; the reason for this is unknown.

Interestingly, if a person is right handed, the nail of the right thumb grows faster than that of the left thumb.

▶ ***In most people, finger and toe nails are kept short due to abrasion or cutting. Without this, the nails are capable of growing to a great length.***



▲ ***Injury to a nail tends to accelerate its growth until it has recovered. However, if the root of the nail is destroyed, the nail will cease to grow.***

The nails can reveal much about the health of a person.

Blood supply

Normal nails are pink in colour due to the rich blood supply in the skin. Beneath it, the nail acts as an indicator of oxygen supply to the tissues during surgery. This is the reason why women are always asked to remove any nail varnish before undergoing an operation. If the nail were to become pale in colour or even to turn blue, this would alert the anaesthetist to the fact that the patient was not receiving enough oxygen.

In yellow nail syndrome, the nails become thickened and yellow. It is associated with swelling of the feet or may be due to thyroid disease.

Nail disorders

The state of the nails can be useful in helping to diagnose a number of disorders.

Grooves running across all the nails may reveal that a person has suffered a serious illness several months before. This is because illness slows down the rate of nail growth, causing ridges to develop in the nail root. These ridges are then pushed outwards as the nail grows.

Similarly, misshapen nails which are bent backwards may indicate anaemia (iron deficiency).

The colour of the fingernails is also very revealing. For example, white opaque nails may indicate cirrhosis of the liver, while white bands on the nails may be a clue that mild arsenic poisoning has taken place.

Nail damage

More severe changes in the nail such as the nail turning blue or falling off altogether are commonly due to the nail bed becoming damaged through injury. As long as the nail root is not destroyed, the nail will eventually replace itself and continue to grow.

Brittle, spoon-shaped nails indicate that a person has koilonychia. This is a sign of anaemia and occurs because of a lack of iron in the cells.

Ingrowing toenails are caused by cutting nails too close at the edges. This causes the nail to grow into the flesh, resulting in inflammation and infection.

How skin protects the body

The skin is a remarkable organ, covering the entire surface area of the body. Skin plays a number of important roles in protecting the body and also helps to control body temperature.

The skin is the largest organ of the body. It can weigh from around 2.5 to 4.5 kg and covers an area of about two square metres.

ANATOMY OF THE SKIN

The skin is composed of two distinct layers: the epidermis and the dermis.

The epidermis, or cuticle, is the outer protective layer of the skin. The outermost layer of the epidermis (the stratum corneum, or horny layer) accounts for up to three quarters of the epidermal thickness.

KERATIN

Cells of the epidermis produce keratin (a fibrous protein also found in the hair and nails) and are progressively pushed outward by dividing cells beneath them.

As the cells move outwards they become enriched with keratin, flatten out and die. These dead cells are constantly shed, the epidermis thus being effectively replaced every few weeks. In fact, the average person sheds around 18 kg of skin (in the form of dandruff or dry skin flakes) in a lifetime.

SKIN THICKNESS

The epidermis is thickest on the parts of the body that receive the greatest wear, for example the soles of the feet and the palms of the hands.

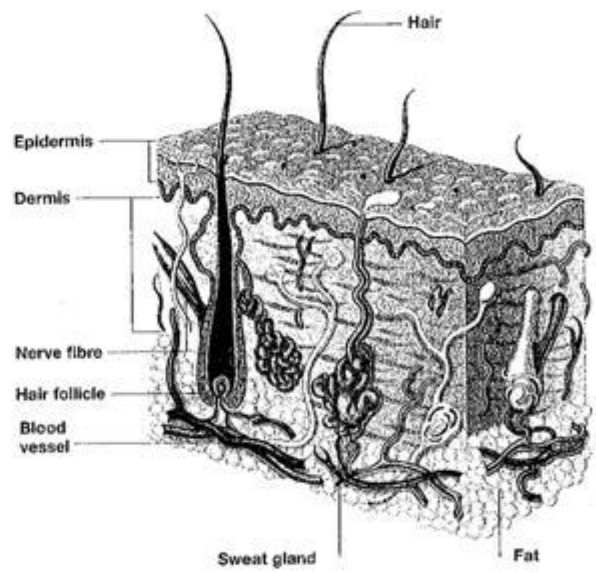
DERMIS

The innermost layer of the skin is the dermis. This fibrous layer comprises a network of collagen and elastic fibres.

The dermis also contains blood vessels, nerves, fat lobules, hair roots, sebaceous glands and sweat glands.

The skin is composed of two main layers: the epidermis and the dermis. The epidermis is nourished indirectly by the blood vessels in the dermis.

Anatomy of the skin



Role of skin

The skin plays an important role in the regulation of temperature. Sweat glands produce a salty solution which cools the body as it evaporates.

The skin plays a number of important roles. These include:

- Protection – the collagen fibres of the dermis give the skin strength and resistance, preventing any object from penetrating the body.
- Regulation of temperature – through vasoconstriction (narrowing) and vasodilation (widening) of blood vessels in the dermis. The production of sweat also helps to cool the body.
- Barrier against bacterial infection – large numbers of micro-organisms are naturally present on the surface of the skin. These compete with harmful bacteria, preventing them from invading the body.
- Sensitivity to touch and pain – the dermis contains a dense network of nerve endings sensitive to pain and pressure. These nerves provide the brain with vital information about the body in relation to its environment, allowing it to act accordingly, for example retracting the hand when something hot is touched.
- Prevention of unregulated water loss – the sebaceous glands of the dermis secrete an oily substance known as sebum. This coats the skin, making it effectively waterproof. Collagen fibres within the dermis also hold water.
- Protection against ultraviolet (UV) radiation – the pigment melanin (produced by melanocytes in the epidermis) acts as a filter to the harmful ultraviolet radiation produced by the sun.
- Manufacture of vitamin D – this is produced in response to sunlight and helps to regulate the metabolism of calcium.

Skin colour

Skin colour largely depends on the presence of melanin. Production of this pigment protects the skin from harmful radiation produced by the sun.

The colour of the skin depends on a combination of factors, such as skin thickness, blood flow, and pigment concentration.

PIGMENTS

In areas where the skin is very thin and blood flow is good, it will appear much darker (such as over the lips) due to the red colour of the pigment haemoglobin in the blood.

In general, the production of melanin will determine how dark the skin is. This pigment is produced by melanocyte cells present in the epidermal layer.

Dark-skinned people have a high proportion of melanocytes, and hence greater concentrations of melanin in their skin.

SUN EXPOSURE

Skin responds to ultraviolet rays in sunlight by producing greater amounts of melanin.

As levels of melanin increase, the skin darkens forming a filter against the harmful radiation produced by the sun.

Freckles are another example of the skin's reaction to the sun, representing concentrated areas of melanin-producing cells.

Skin colour is mainly dependent upon the number of melanin-producing cells. People with albinism have no such cells, making them very pale skinned.

In response to sunlight, melanin-producing cells become more active. As levels of melanin increase the skin darkens, filtering out harmful radiation.

SUN BURN

If sun exposure does not take place gradually however, the skin is unable to produce melanin fast enough to filter out the suns harmful rays.

As a result the skin burns, becoming inflamed and very tender. Prolonged exposure to UV radiation can permanently damage the skin cells leading to premature ageing of the skin and, sometimes, skin cancer.

Skin cancer tends to be less common in dark-skinned people, which is testament to the protective role of melanin.

Skin repair

When skin is cut, for example by surgical incision, the sides of the wound will automatically grow back together if they are held in place with stitches.

Where there is tissue loss however, a remarkable process occurs whereby new skin is regenerated.

Skin cells adjacent to the wound break away from the cells below, migrate to the wounded area and enlarge.

Other cells surrounding the wound multiply rapidly to replace the cells lost.

Eventually from all sides of the wound the migrating cells meet. Once the wound is entirely covered, cell migration stops.

The wound will continue to heal as epithelial cells multiply, and normal thickness is restored.

When skin is wounded, the surrounding cells move to the site of the wound, and multiply until the area is covered.

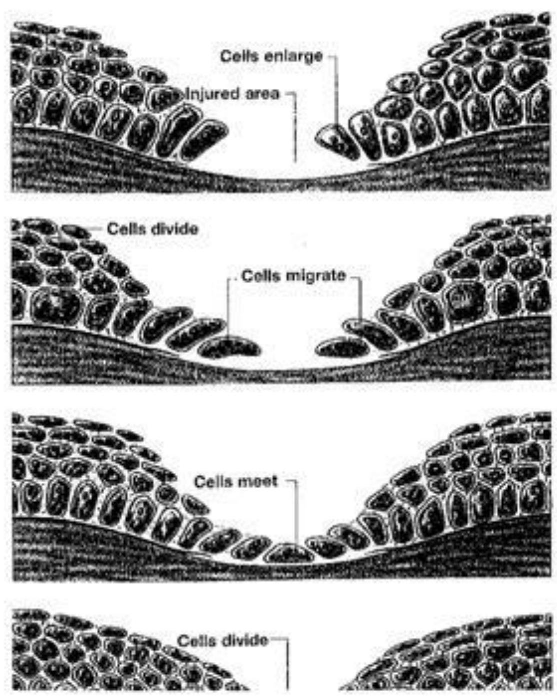
In cases where the skin is severely damaged, such as with third degree burns, medical intervention may be required. This is because the damaged area may be too large for the skin to regenerate itself before infection sets in.

Transplantation of skin
A process known as skin grafting involves the removal of [illegible] sheet of skin from [illegible] the body, usually [illegible] such as the thigh or buttock.

Sometimes damage to the skin is so bad that a skin graft is required. This procedure involves transplanting skin from elsewhere on the body.

This skin is then transplanted on to the wound. With time these new skin cells proliferate, join together and heal the area.

New techniques are being developed, which involve the culturing of skin cells in a laboratory. Using this technique, skin can be grown specifically for transplantation.



How body temperature is controlled

Body temperature is regulated by a part of the brain called the hypothalamus. If the external temperature rises or falls, the body uses various mechanisms to ensure it maintains a comfortable equilibrium.

Endothermic (warm-blooded) animals, such as birds or mammals, maintain their bodies at a more or less constant temperature using internal control mechanisms. In comparison, ectothermic (cold-blooded) animals, such as fish and reptiles, have no such internal mechanisms and are dependent to a great extent on the surrounding temperature.

CONTROLLING BODY HEAT

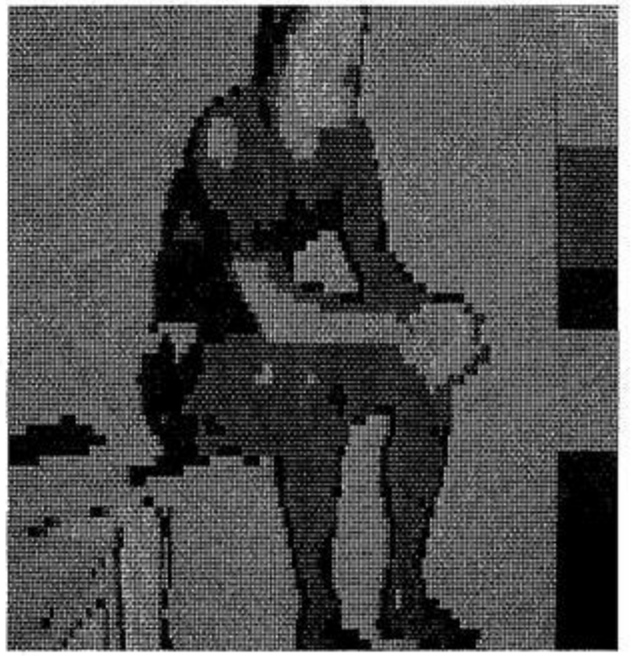
Humans, like all warm-blooded animals, produce heat as a result of metabolism. All of the body's tissues produce heat, but the most heat is produced by the tissues that are most active, such as the liver, heart, brain and endocrine glands.

Muscles also produce heat – about 25 per cent of body heat is produced by inactive muscles. Active muscles may produce up to 40 times more heat than the rest of the body, which is why the body warms during exercise.

HOMEOSTASIS

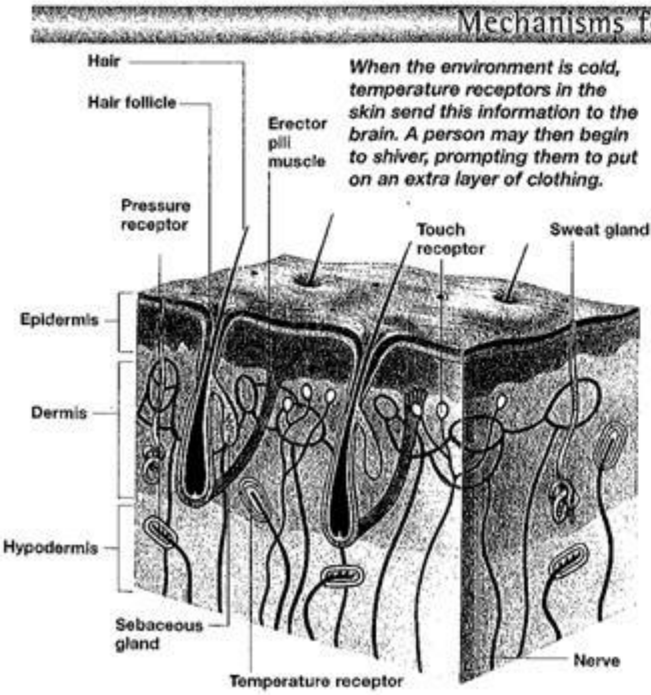
Humans have a fairly constant body temperature that is, under normal conditions, maintained independently of their external surroundings. This maintenance of a constant internal environment, in spite of variations in the outside environment, is known as homeostasis.

One of the advantages of maintaining a constant body temperature is that the danger of overheating is greatly reduced. Extreme cases of overheating can result in convulsions and death, as nerve pathways are suppressed and the activities of vital proteins are affected.



A thermogram (heat image) shows the distribution of heat around the body after exercise. The hottest parts are white, followed by yellow and purple; the coldest parts are shown as red, blue and black.

Mechanisms for warming up



When the environment is cold, temperature receptors in the skin send this information to the brain. A person may then begin to shiver, prompting them to put on an extra layer of clothing.

The normal temperature of the human body varies between 35.6 °C and 37.8 °C. In order to maintain this degree of constancy, the temperature is monitored by a part of the brain called the hypothalamus. This operates using a feedback mechanism, similar to that used by the thermostat of a domestic central heating system.

When the external environment starts to cool the body down, temperature sensors in the skin send this information to the hypothalamus and the person starts to feel cold. This information is then passed to other parts of the brain, which initiate physiological responses designed to increase body heat and reduce heat loss.

Some reactions to feeling cold are conscious, such as jumping up and down, putting on extra clothing or moving to a warmer place. Other reactions occur spontaneously. Shivering occurs when body muscles contract and relax very rapidly, giving out four or five times as much heat as they do in their resting state. At the same time, adrenaline production is increased, which increases the body's metabolic rate – the rate at which energy, stored in the form of glucose, is used. As a result more heat is generated inside the whole body.

REGULATING HEAT LOSS

To reduce heat loss from the body's surface, the capillaries near the surface of the skin become constricted, resulting in a reduced blood flow to the skin and a paler complexion. At the same time, the tiny muscles attached to the hair follicles contract, resulting in the hairs on the skin becoming erect. In most mammals, this has the effect of trapping a layer of warmer air near the skin, but because skin hair is sparse in humans, this pilo-erection has very little effect on heat loss, other than causing 'goose-pimples'.

Temperature control mechanisms

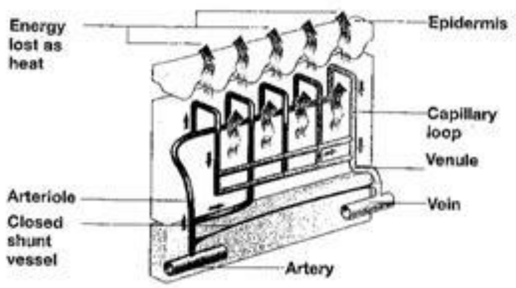
Our skin is equipped with thousands of receptors that monitor the overall temperature of the body. These sensors detect changes in the external environment and alert the brain, which in turn stimulates shivering or sweating to maintain homeostasis.

VASODILATION

Vasodilation is a key mechanism for conserving and losing heat. At high temperatures, the blood vessels dilate (widen), allowing heat to be lost and giving a flushed appearance. The degree of dilation of the blood vessels is controlled by nerves called vasomotor fibres, which are in turn controlled by the brain.

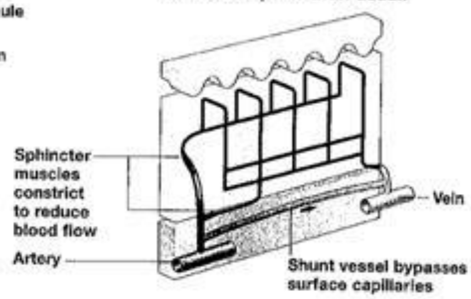
VASOCONSTRICTION

At low temperatures, arterioles (branches of arteries) leading to capillaries in upper skin layers may constrict (vasoconstriction). This reduces blood flow to the skin, and reduces heat loss.



***VASODILATION:** In hot conditions, tiny sphincter muscles in the walls of arterioles relax, allowing blood to flow to the surface. The dilated blood vessels cause the skin to redden.*

***VASOCONSTRICTION:** In cold conditions, the sphincter muscles contract, causing the blood to bypass the capillaries and preventing blood flow to the surface. The skin then looks paler than usual.*



Mechanisms for cooling down

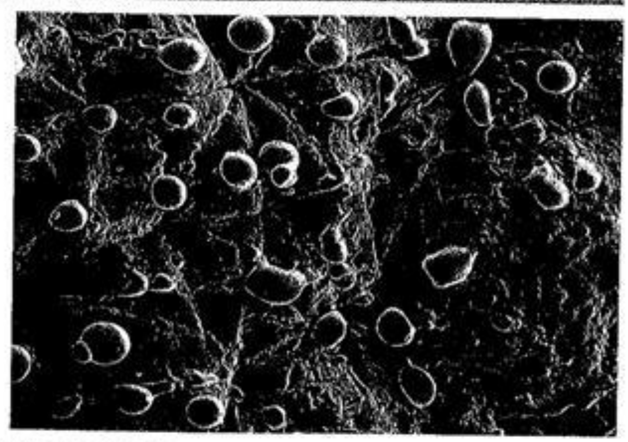
The body's temperature is normally higher than that of the surrounding air. Therefore, heat is lost to the surrounding environment by radiation and convection, as currents of moving air pass over the surface of the skin.

If, however, the body starts to become too warm, due to either a high external temperature or an internal fever, heat sensors send nerve impulses to the hypothalamus, and the brain initiates cooling measures.

The blood capillaries near the surface of the skin become dilated so that blood flow increases and more heat is lost through the skin to the outside. Sweating also increases heat loss: as liquid produced by the sweat glands evaporates, it has a cooling effect on the skin.

In dry air, sweating works very effectively: a person can tolerate temperatures of up to 65 °C for several hours in dry conditions. However, if the air is moist, sweat cannot evaporate easily and the body becomes overheated more rapidly.

A coloured electron micrograph shows droplets of sweat (blue) on human skin. Sweat, mostly in the form of dissolved salts, cools the body down.



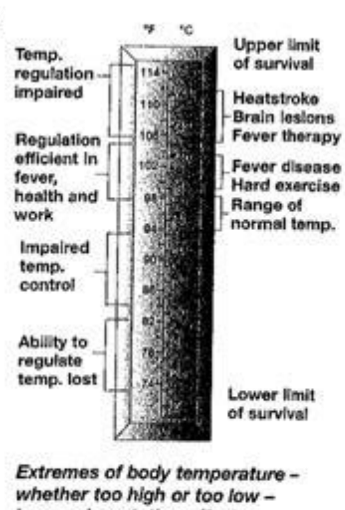
Fever and hypothermia

A fever is a raised body temperature that may occur as a result of infection. Chemical substances called cytokines are released by white blood cells and damaged tissue cells. These chemicals cause the hypothalamus to produce prostaglandins (hormones that dilate blood vessels), which in turn 'reset' the thermostatic control mechanism of the hypothalamus to a higher temperature. The result is that heat-producing mechanisms are triggered; even though the body temperature may rise to 40 °C, the patient still feels a chill.

Body temperature remains high until the infection is cleared. At this point, the normal setting of the hypothalamus is restored and cooling mechanisms are initiated. The patient sweats and becomes flushed as the blood vessels in the skin dilate. Research has shown that fever both boosts the body's immune system and inhibits the growth of micro-organisms.

Hypothermia occurs when the core body temperature falls below 35 °C. It results from the body being exposed to cold conditions, rendering it unable to maintain normal body temperature. Newborn babies, the elderly and those suffering from illness are most susceptible. Hypothermia is usually the result of a combination of inadequate food, clothing and heating in

***Symptoms of hypothermia** include lethargy, muscle stiffness and a confused mental state. If untreated, it results in unconsciousness, brain damage and ultimately death.*



Extremes of body temperature – whether too high or too low – have a devastating effect

How the body produces sweat

Sweat is secreted from the sweat glands during physical exercise, stress and in excessive heat. It is produced in two different types of glands, both of which are located in the dermis of the skin.

The body constantly produces sweat. This process is the body's main way of ridding itself of excess heat.

The amount of sweat the body produces depends upon the state of emotion and physical activity. Sweat can be produced in response to stress, high air temperature and exercise.

SWEAT GLANDS

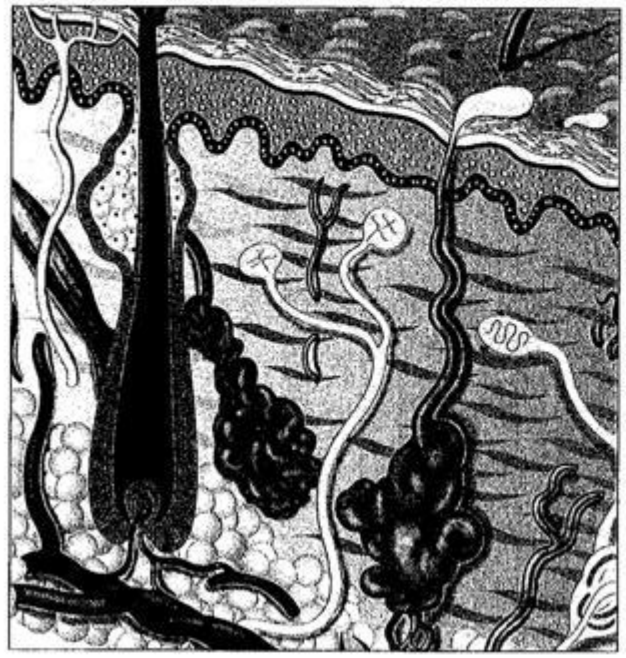
Sweat is manufactured in the sweat glands. These are located in the dermis of the skin, along with nerve endings and hair follicles. On average, each person has around 2.6 million sweat glands, which are distributed over the entire body, with the exception of the lips, nipples and genitals.

Sweat glands consist of long, coiled, hollow tubes of cells. The coiled portion in the dermis is where sweat is produced. The long portion is a duct that connects the gland to tiny openings (pores) located on the outer surface of the skin. Nerve cells from the sympathetic nervous system (a division of the autonomic nervous system) connect to the sweat glands.

TYPES OF SWEAT GLAND

There are two types of gland:

- Eccrine – these are the most numerous type of sweat gland, found all over the body, particularly on the palms of the hands, soles of the feet and forehead. Eccrine glands are active from birth
- Apocrine – these sweat glands are mostly confined to the armpits and around the genital area. Typically, they end in hair follicles rather than pores. These are larger than eccrine glands, and only become active once puberty has begun.

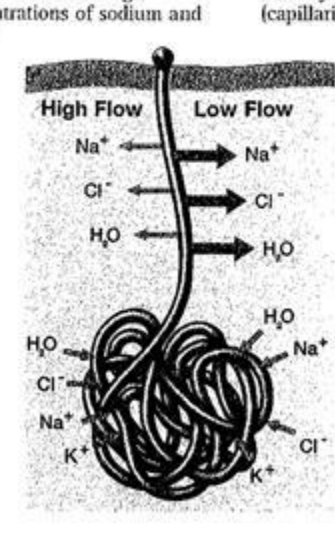


Sweat is produced in sweat glands, located in the dermis. These glands comprise long, coiled tubes of cells that connect to pores on the skin surface.

Sweat production

Stimulation of an eccrine gland causes the cells lining the gland to secrete a fluid that is similar to plasma, but without the fatty acids and proteins. This is mostly water with high concentrations of sodium and chloride (salts) and a low concentration of potassium.

This fluid originates in the spaces between cells (interstitial spaces), which are provided with fluid by the blood vessels (capillaries) in the dermis.



H_2O	Water
K^+	Potassium
Na^+	Sodium
Cl^-	Chloride

The fluid passes from the coiled portion and up through the straight duct. What happens to this fluid when it reaches the straight portion of the sweat duct depends upon the rate of sweat production.

- Low sweat flow – at rest and in a cool environment, the sweat glands are not stimulated to produce much sweat. The cells of the straight duct have time to reabsorb most of the water and salts, so not much fluid actually reaches the surface of the skin as sweat.

  The composition of this sweat is different from that of its primary source: it contains less sodium and chloride, and more potassium.
- High sweat flow – this occurs in higher temperatures or during exercise. Cells in the straight portion of the sweat duct do not have time to reabsorb all the water, sodium and chloride from the primary secretion. As a result, alot of sweat reaches the surface of the skin, and its composition is similar to that of the primary secretion.

The constituents of sweat vary according to temperature and activity. If sweat production is minimal, then the sweat contains less salts.

APOCRINE SWEAT

Sweat is produced in the apocrine glands in a similar way, but apocrine differs from eccrine sweat in that it contains fatty acids and proteins. For this reason, apocrine sweat is thicker and milky-yellow in colour.

ODOUR

Sweat itself has no odour, but when bacteria present on the hair and skin metabolize the proteins and fatty acids present in apocrine sweat, an unpleasant odour is produced. Deodorants are designed to eliminate this distinctive body odour.

The role of sweat

When sweat evaporates, it takes excess body heat with it. In a very hot climate, the sweat glands can produce up to three litres of sweat an hour.

The role of sweat is to cool the body. Sweat on the surface of the skin evaporates into the atmosphere, taking with it excess body heat.

VAPORIZATION HEAT

Heat loss from sweating is governed by a basic rule of physics. Heat is required to convert water from a liquid to a vapour (gas); when sweat evaporates this heat is taken from the body.

However, not all of the sweat evaporates and much runs off the skin and is absorbed by items of clothing. Not all heat energy produced by the body is lost through sweat; some is directly radiated from the skin to the air, and some is lost through breathing.

EVAPORATION RATE

Humidity affects the rate at which sweat evaporates. If the air is humid, for example, then it already has water vapour in it and might not be able to take more (near-saturation). If this is the case, then sweat does not evaporate and cool the body as it does when the air is dry.

When the water in sweat evaporates, it leaves the salts (sodium, chloride and potassium) behind on the skin, which is why the skin can taste salty.

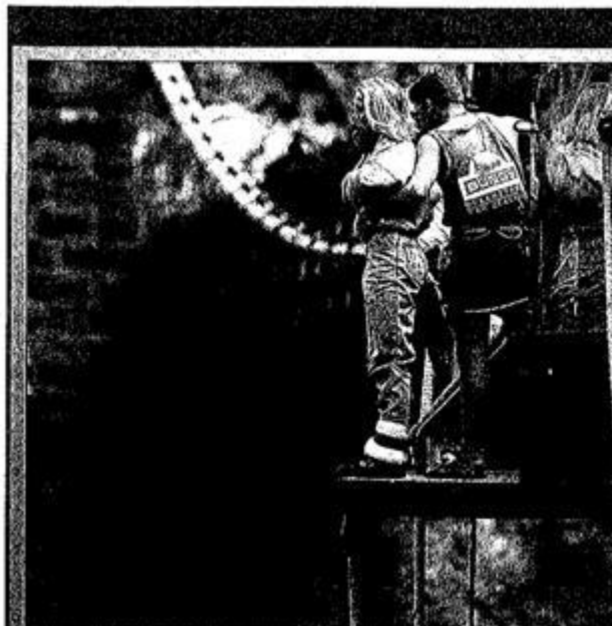
DEHYDRATION

A body that is not acclimatized to very hot temperatures can easily produce one litre of sweat per hour. In fact, the maximum amount that the body can produce appears to be around two to three litres per hour.

The loss of excessive water and salts from the body can lead to dehydration, causing circulatory problems, kidney failure and heat stroke. It is important therefore to drink plenty of fluids when exercising or in high temperatures.

Specialized drinks are also available for people taking part in sports – these contain vital salts to replace those lost through sweating.

In areas of high humidity, such as tropical rain forests, the air is already saturated with water. Thus, reduced evaporation of sweat prevents body cooling.



People in stressful situations can sweat in the absence of a high temperature. This is due to an adrenaline surge that stimulates the sweat glands.

Sweating can also occur as a result of nervous activity, or as the sign of a disorder.

Nervous sweating

Sweating responds to the emotional state. If a person is nervous, afraid or anxious, there is an increase in sympathetic nerve activity, and an increase in adrenaline secretion from the adrenal gland.

Adrenaline acts on the sweat glands, particularly those on the palms of the hands and armpits, causing them to produce sweat. This phenomenon is often referred to as a 'cold sweat' and is a factor exploited in the use of lie detector tests. This is because the increased sympathetic nerve activity in the skin reduces its electrical resistance.

Excessive sweating

Diaphoresis or hyperhidrosis is a condition in which excessive sweating occurs. The exact cause of this embarrassing condition is not known, although it may be due to the following:

- Overactive thyroid gland – the thyroid hormone increases body metabolism and heat production
- Certain foods and medications
- Overactivity of the sympathetic nervous system
- Hormonal imbalances – for example the menopause.

If the problem of sweating becomes severe, surgery to remove the sympathetic nerve trunk may be performed – this procedure is know as a sympathectomy.