

Syllabus : Structure and functions of skin.

Various parts of the skin and their functions. Special derivatives of the skin with reference to sweat glands sebaceous glands, hair, nails and mammary gland. Heat regulation — vasodilation and vasoconstriction.

The skin is not just a **simple covering** to hold the body substance inside. It is one of the most active organs of the body, functioning in numerous ways. Many of our recognising features come from the complexion, hair patterns, *etc.* The most apparent feature of an aged person, a healthy youth or a tender infant is the texture of the skin (whether loose and wrinkled, or tight and smooth). You will learn several interesting things about the skin – the “Jack of all trades” as named by some while some others would even call it “master of many tasks”.

The skin is the largest organ of our body. It accounts for 15% of an adult human's total body weight. Primarily the skin is an almost impermeable barrier.

13.1 WHAT IS SKIN ?

The skin is the outermost covering of the body. It is stretched all over in the form of a layer. There are many structures and glands derived from the skin.

13.2 FUNCTIONS OF THE SKIN

The skin (or the integument) serves a number of important functions as follows:

1. **Protection.** Protection is the primary function of the skin. It affords protection in four different ways :
 - (i) It protects the underlying tissues from **mechanical shocks**.
 - (ii) It holds the body fluids inside and **prevents excessive loss of water** by evaporation.
 - (iii) It **prevents** the entry of harmful substances or **disease - causing germs**.
 - (iv) It **protects** the body **against excess ultraviolet light** which is potentially very harmful.

2. **Sensation.** Our skin serves as a sense organ for touch, pain, pressure, heat, *etc.*
3. **Temperature regulation.** The skin prevents loss of heat in cold weather and facilitates loss of heat in hot weather. (You will read about the actual mechanism of temperature regulation later in this chapter).
4. **Storage of food.** The skin stores reserve food in the form of a layer of fat contained in special cells.
5. **Excretion.** The skin assists in the process of excretion (through sweating) eliminating water, salts and, to a very limited extent, urea. (Since sweating from the skin occurs mainly for temperature regulation, we cannot really consider the skin as an excretory organ).
6. **Synthesis of Vitamin D.** The skin can synthesise vitamin D when exposed to sunshine. This is a minor function and its mechanism is not yet fully understood. In fact, too much sunshine may cause tanning and other ill-effects including even skin cancers.
7. The skin on our fingers and palms forms ridges and grooves which provide a **more efficient grip**.



PROGRESS CHECK

1. List the four ways in which the skin serves as a protective layer for our body.
2. Cross out the items in the following list which are **NOT** the functions of the human skin :
Sensation, respiration, storage of glycogen, excretion, digestion, temperature regulation, synthesis of vitamin D, secretion of hormone

13.3 STRUCTURE OF THE SKIN (Fig. 13.1 & 13.2)

The principal components of the human (mammalian) skin are as follows.

- A. Skin
 Proper → Epidermis – cornified, granular and germinative layers.
 Dermis – elastic fibres, blood vessels, nerves, etc.
- B. Derivatives of the skin → Hair
 Nails
 Mammary glands
 Sweat glands
 Sebaceous glands

13.4 THE SKIN PROPER

Microscopically, the skin proper is composed of two layers — the outer **epidermis** and the inner **dermis**.

13.4.1 EPIDERMIS

The epidermis is the outer thinner part of the skin. It is formed of stratified epithelium piled up layer after layer. At places, the epidermis becomes thick and hard as on the palms, soles and specially on the heels. It is devoid of blood vessels at all places. The epidermis shows three regions (or sublayers) depthwise : (a) outermost cornified layer, (b) middle granular layer and (c) inner malpighian layer.

- (a) The **cornified layer (stratum corneum)** is the outermost layer consisting of several piled up layers of **flattened dead cells**. These cells are made of a horny protein called **keratin** (also found in nails, hairs, horns, hoofs and silk). Its cells are continually worn away or shed and are replaced from beneath by those arising from the deeper malpighian layer. The cornified layer is tough and offers resistance to three things : (i) mechanical damage, (ii) bacterial infection and (iii) loss of water by evaporation.
- (b) The **granular layer** is a very thin middle layer consisting of two or three sub-layers of flattened cells. Gradually, it gives way to the outermost cornified layer.
- (c) The **malpighian layer (stratum malpighi, also called germinative layer)** is the innermost region of the epidermis. Its cells can actively divide to produce new cells which press and shift outward to replace the worn-out cells of the outermost cornified layer.

Colouration of the skin (*e.g.* the complexion of the face) is due to a pigment **melanin** contained in the cells of the malpighian layer. The different quantities of this pigment in different human races lead to form very light-brown to dark colouration of the skin. African negroes have genetically dark coloured skin, the Europeans light coloured (whitish) and most

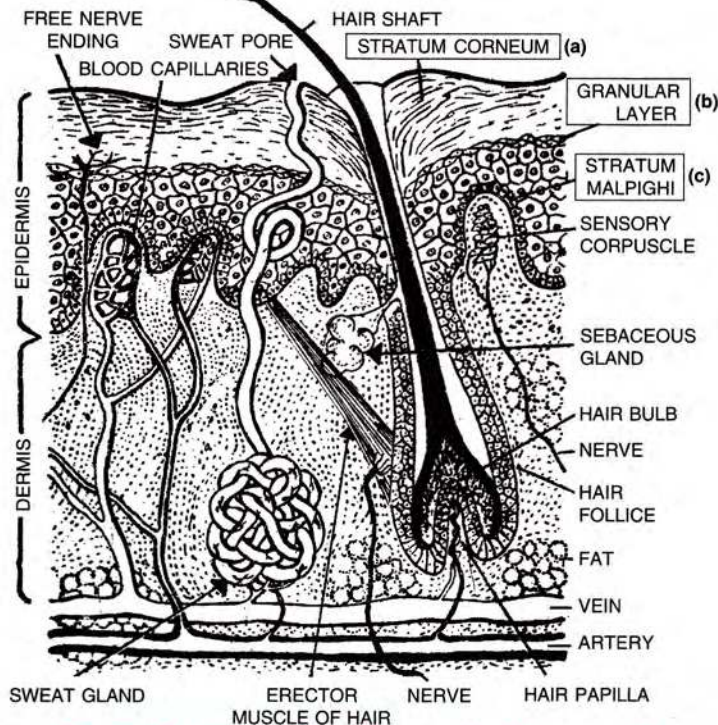


Fig. 13.1 Vertical section of human skin (diagrammatic)

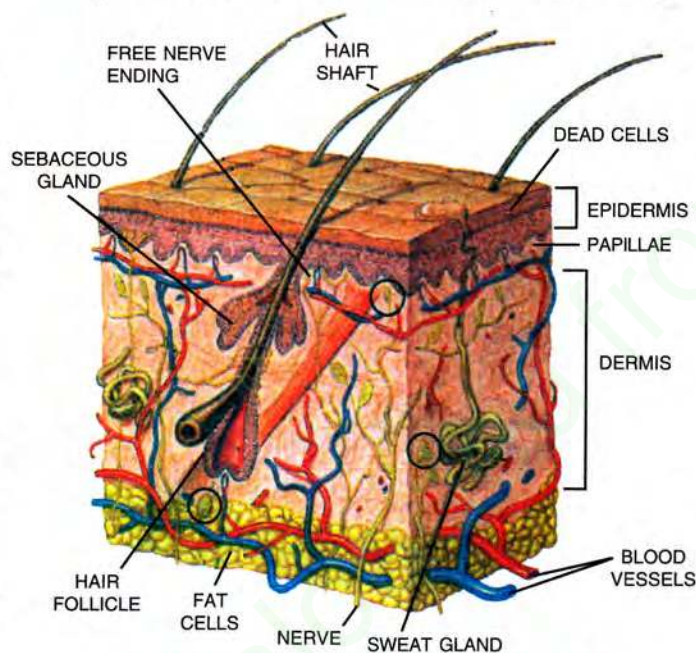


Fig. 13.2 3-dimensional diagrammatic sketch of the microscopic structure of human skin

Indians an intermediate coloured (wheatish) skin. In fair-coloured people also, on continued exposure to sunlight, the face or other parts of the body may get tanned, but revert to original condition when the exposure is cut down.

The skin pigment acts like an “umbrella” to protect inner parts of the body from the harmful effects of the ultraviolet rays of sunlight.

- **Leucoderma** also called "**vitiligo**" : Skin pigmentation (melanin) is lost from smaller or larger patches at different regions of the body; exact cause of this disease is not yet known.
- **Albinism** : Complete loss of pigmentation of the skin all over the body including hair, eyebrows, eyelashes and even the iris. The skin of such persons appears pinkish because of the underlying blood capillaries. Albinism is a recessive trait caused due to inheritance; an albino couple would get all albino children.

13.4.2 DERMIS

The *dermis* is the inner thick layer of connective tissue made of elastic fibres. It is tough and flexible.

At certain places the dermis in our skin is **very thick** as on the palms and soles, and **very thin** at other places as in the eyelids. The dermis contains several other structures — blood vessels, nerve fibres, sensory organs, hair follicles, sweat glands, *etc.* [Leather obtained from the hides of animals is actually the dermis part of the skin].

The outer region of the dermis which lies next to the epidermis is raised into numerous small processes called **papillae** which contain blood capillaries and nerve endings. The nerve endings and sense organs here are concerned with sensations of **touch** and **pain**. The sharp sense of touch in the skin of finger tips enables the blind to read the Braille characters. There are some more sense receptors in the deeper parts, which are concerned with the sensations of **pressure**, **pain**, **heat**, **cold**, *etc.*

FAT

The layers beneath the dermis contain numerous fat cells (adipose tissue). This subcutaneous fat not only serves as a food reserve but also as a heat-insulating layer, as well as a shock-absorber.



PROGRESS CHECK

1. Name the three sub-layers of the epidermis from outer to inner :
2. Write **True** (T) or **False** (F) for the following statements:
 - (i) Stratum corneum is made of dead cells having keratin.
 - (ii) The malpighian layer is hard and resistant to bacterial invasion.
 - (iii) The pigment melanin which imparts colouration to the skin is found in the malpighian layer.
 - (iv) The dermis is very thick on palms and soles.

The special derivatives of the human skin include the following :

1. Hair
2. Nails
3. Sebaceous glands
4. Sweat glands
5. Mammary glands

13.5.1 HAIR

A hair consists of three parts.

(i) **Hair shaft** is the part which projects from the skin and may extend slightly below the surface of the epidermis. In normal situations, they lie obliquely on the skin. (ii) **Hair root** is the part embedded within the dermis. The lowest part of the hair root is expanded to form a (iii) **hair bulb** which contains a projection of the dermis called **hair papilla**, with capillary blood supply.

The **hair follicle** is a structure enclosing the hair root. It is composed of an epithelial and a connective tissue sheath. The hair bulb and the hair follicle together are responsible for the growth and elongation of the hair. The growth of hair occurs by addition of cells at the base, which soon die.

The colour of the hair is due to varying quantities of **melanin**. The gray or silvery colour of the hair is due to minute air spaces formed in the hair when the pigment is lost.

Everyone has sometimes experienced "**goose flesh**" during winter or during some emotion. In this, the hair is lifted called **piloerection**, (**pilo** : hair) and the surface of the skin presents a somewhat contracted and wrinkled appearance. This is caused by the **erector (also called arrector) muscle** of the hair which runs obliquely between the hair follicle and the outer part of the dermis. The contraction of this muscle at one end pulls the hair to a somewhat vertical position, and at the other end, depresses the epidermis.

Hair in human beings are continuously lost and regrown. The duration of scalp hair is 2-5 years and that of the eyebrows and eyelashes is 3-5 months.

Hairs from the different parts of the body (head, chest, arm pit, beard, nose, *etc.*) show subtle differences. These are helpful in forensic (crime detection) investigations.

Hairs also provide a sensation of touch because nerve fibres extend up to their bases.

There are hairs **eyelashes** along the edges of the eyelids helping to prevent entry of particles, raindrops. Similarly, there are **hairs in the nose**, again to prevent dust particles from entering nasal passages. **Facial hairs** in human males, *i.e.* moustaches and beard, help in distinguishing the male sex (sexual dimorphism).

13.5.2 NAILS

Nails are hardened keratinous plate-like structures which grow as dead cells from the nail root, which lies below the skin at the base.

- (i) **Plate** — It is hard and outer part of the nail. It is made up of dead, keratinized cells.
- (ii) **Bed (root)** — It lies below the nail plate.
- (iii) **Matrix** — It lies just below the skin surface at the base of the nail. It is usually visible as whitish half-moon at the base of nail, it produces new cells which on maturation push out the older one towards the tip of the nail and causes growth of the nail.

13.5.3 SEBACEOUS GLANDS

These branched glands usually open into a hair follicle though, sometimes they even open directly to the outside. They give out an **oily secretion** (called sebum) which makes the hair and the outer surface of the skin *oily* and *waterproof* to keep the epidermis supple and to prevent loss of water by evaporation. In cold and dry weather, the skin may become rough and leave a powdery surface when scratched; this is due to reduced secretion of oil from the sebaceous glands. In hot and humid weather, the skin becomes extra oily due to increased secretion of sebum.

Three common problems related to sebaceous glands :

1. Pimples — Sebum accumulation, causes growth of bacteria because it is nutritive, gets infected and results into the formation of boils and pimples.

2. Acne — Sebaceous glands get inflamed due to hormonal influence. It is one of the commonest adolescence problems.

3. Black head — Sebaceous glands of the face get enlarged due to accumulated sebum. On oxidation melanin and sebum give it a black colour named black head.

13.5.4 SWEAT GLANDS

Each sweat gland is a simple coiled tube consisting of a deeper secretory part and an excretory part which runs upwards to open on the surface. The outer openings are called the sweat pores. Their total number in the body is estimated at about two million. Human races belonging to hotter countries usually have more sweat pores than those belonging to colder ones.

SWEAT PORES

The number of sweat pores varies from 60 to 80 per sq cm on the back to 400 per sq cm on the palms of the hands.

Can you guess why the sweat pores are more numerous on the palms ?

Answer : *Surface tension for grip. For the same reason, some people turn the leaves of a book or count the currency notes by applying saliva on their fingertips – a dirty habit indeed and unhealthy, too!*

The secretory part of a **sweat gland** absorbs fluid from the surrounding cells and blood capillaries of the dermis and passes it into the excretory **sweat duct** which pours it out on the surface. Sweating (or perspiration) goes on at all times in minute quantities (incipient or invisible perspiration), or sometimes in large quantities as during strenuous exercise or during hot and humid weather, when a person may lose as much as 1 kg per hour. The major function of sweating is to lose body heat by evaporation.

Sweat consists of about 99 per cent **water**, 0.2 to 0.5 per cent **salts** (mainly sodium chloride) and traces of **urea** (0.08 per cent). The urea lost through the sweat is about 1 per cent of the total urea excreted by the body.

“Cold sweat” may be due to psychic influences such as fright and nervousness. Sweating may also accompany nausea and severe pain (due to loss of body salts).

13.5.5 MAMMARY GLANDS

The **mammary** (or milk) **glands** (Fig. 13.3) are modified sweat glands. These glands are present both in males and females. But in males, they persist only in a rudimentary state, whereas in females at puberty, they enlarge in the form of a pair of breasts. Each breast carries a central conical projection called

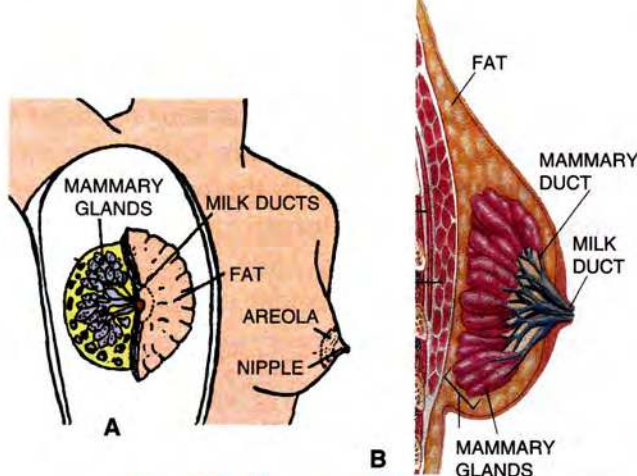


Fig. 13.3 Mammary (milk) glands
A. Front view, B-Sectional side view

nipple. 15-20 milk ducts open on the nipple. Each milk duct is continued inward in a branching manner to join a cluster of 15 to 20 lobes of the mammary glands. The activity of the mammary glands is related to the reproductive hormones (prolactin) and pregnancy. The milk secreted by the mammary glands is highly nutritious for the new-born baby.

Meibomian glands : These are modified sebaceous glands which open on the margins of the eyelids. Their secretion is oily and serves to lubricate the margins of the lids and to prevent the overflow of tears.

Ceruminous glands : These are modified sebaceous glands found in the auditory canal and secrete wax like substance called *cerumen* or *earwax* which lubricates and protects the delicate eardrum from dust particles and germs.



PROGRESS CHECK

1. Match the items in Column I with those in Column II.

Column I

- (i) Air spaces
- (ii) Mammary glands
- (iii) "Goose-flesh"
- (iv) Traces of urea
- (v) More numerous sweat pores
- (vi) Oily secretion

Column II

- a. Hair
- b. Sebaceous glands
- c. Rudimentary in males
- d. Races of hot countries
- e. Gray hair
- f. Sweat

2. How do hairs provide the sensation of touch ?

3. How is the outer surface of the skin made waterproof?

inside; so also are the birds. They all maintain a more or less constant body temperature even if it is very cold or very hot outside.

[Animals other than mammals and birds are cold-blooded or (**ectothermal: body heat gained from outside**). Their body temperature fluctuates with the environmental temperature. This means that they must somehow escape both conditions of too hot or too cold environment and thus they **hibernate** (winter sleep) or **aestivate** (summer sleep) as in the case of frogs.]

Human **body temperature** is usually about 37°C (in the mouth), it is about 1°C higher in the rectum and about 1°C lower in the arm pits.

- Our body temperature may also show variation of 0.3°C to 0.5°C in the course of 24 hours. It is lowest in the early morning and highest in the late afternoon.
- Rise in body temperature above normal means fever and sickness and similarly, a fall in temperature may be dangerous. A suitable (optimum) temperature of 35°C — 40°C is essential for normal body activities, especially for the action of enzymes. The working of enzymes is slowed down with the lowering of temperature, while higher temperatures destroy them.

13.6.1 HEAT PRODUCTION

There are many sources of heat production in our body.

- Chemical reactions occurring in all body cells, especially in the liver by the oxidation of glucose, generally produce heat.
- Most of the heat produced in our body comes from the activity of our muscles. Vigorous activity makes you warm on a cold day and overheats you on a hot day.
- A small amount of heat comes from the ingestion of hot foods and beverages.

ECTOTHERMAL and ENDOTHERMAL

The terms cold-blooded and warm-blooded have been substituted by **poikilothermal** (*poikilo* : varying) and **homeothermal** (*homeo* : same) respectively. The terms **ectothermal** (*ecto* : outside) and **endothermal** (*endo* : inside) are used for animals according to the manner in which they warm their bodies. Mammals and birds have an internal heat-producing mechanism (endothermal). Body temperature of other animals rises or falls with the outside temperature (ectothermal).

13.6 SKIN AND HEAT REGULATION OF BODY

All mammals including humans are warm-blooded (**endothermal : body heat generated from**

13.6.2 HEAT LOSS

Heat is lost from our body through the following four channels.

1. **Skin.** About 85 per cent of the body heat is lost through the skin by convection, conduction, radiation and through evaporation of sweat.
2. **Lungs.** Heat is lost in the warm air which is breathed out. This loss in warm air can easily be experienced by gently blowing on the back of your hand keeping the mouth wide open. Some heat is also lost during vaporisation of water from the lungs.
3. **Urine and Faeces.** These substances are eliminated at body temperature.
4. **Food.** Heat is also lost when cold food, water, or cold beverages are taken into the body.

13.6.3 TEMPERATURE REGULATION

The principal heat-regulating centre is located in the **hypothalamus**, a portion of the fore-brain. This part acts like a thermostat. When the body tends to cool below the normal temperature, it **switches on** or speeds up the heat-producing process, and when the body tends to get overheated, it accelerates the cooling process, and **switches off** the heat-producing processes.

IN COLD WEATHER — When outside temperature is low, the blood vessels get narrowed (**vasoconstriction**) (Fig. 13.4 A). This reduces the blood supply to the skin. As a result, there is less loss of heat by convection, conduction and radiation, and also less loss of it through vaporisation of sweat because, with reduced blood supply, the sweat glands secrete less sweat. This is a natural method to conserve body heat. When vasoconstriction occurs, it makes a person look pale or bluish, because of reduced blood supply to the skin. Simultaneously, the heat production is increased by the increased metabolic rate and through increased muscular activity which is sometimes in the form of shivering.

IN HOT WEATHER — When the outside temperature is high or when a person is engaged in strenuous physical work, which means overproduction of heat within the body, the blood supply to the skin is increased by the dilation of blood vessels in the skin (**vasodilation**)

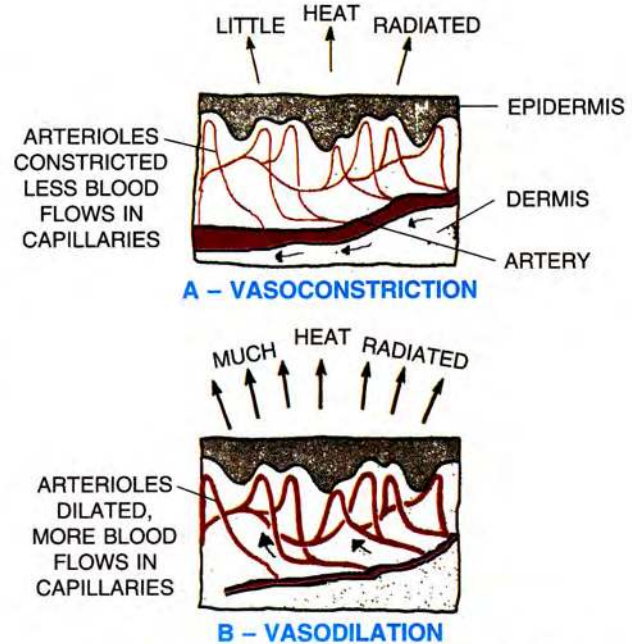


Fig. 13.4 A-Vasoconstriction to cut down heat loss
B-Vasodilation to increase heat loss.

(Fig. 13.4 B). This results in greater loss of heat by radiation, etc., and also by vaporisation of sweat (latent heat) which is now produced in larger quantities due to the rich supply of blood to the skin. Air movements over the body help speed up evaporation of sweat; that is why the fans which do not cool the air of the room, have a cooling effect on our body.

Heatstroke or “sunstroke” is a condition in which sweat production is unable to keep pace with its evaporation in very hot winds. This results in the rise in body temperature (fever) which may sometimes be fatal. Drinking a lot of water and taking a little more of salt in summer is a good precaution against heatstroke.



PROGRESS CHECK

The statements given below have some parts printed in bold face. In case these parts are incorrect, rewrite only these in correct form.

1. All mammals are **ectothermal**.
2. Hibernation is also known as **summer sleep**.
3. Human body temperature normally is **98.4°C**.
4. Vigorous activity on a cold day **overheats** you.
5. The principal heat-regulating centre is located in the **thyroid**.
6. Increased body heat causes **vasoconstriction**.
7. **Facial hair** in humans contributes to sex differences.

POINTS TO REMEMBER

- *The skin serves numerous functions - protection of body in numerous ways, sensation, temperature regulation, storage of food, excretion, synthesis of vitamin D, etc.*
- *The skin is composed of outer thinner epidermis, and the inner thicker dermis.*
- *The epidermis further shows three layers : outermost layer of flattened dead cells performing protective functions, thin middle layer to give way to outermost layer and the innermost malpighian layer to produce new cells.*
- *The dermis is the inner layer of elastic fibres and contains sensory cells for pressure, touch, pain, heat and cold, etc.*
- *Next to dermis is the fat layer which serves as a reserve food as well as a heat insulator and also as a shock absorber.*
- *There are five special derivatives of skin — hair, sebaceous (oil) glands, mammary glands, sweat glands and nails.*
- *Skin regulates body temperature by preventing heat loss in cold weather through hair, fat and vasoconstriction, or by promoting heat loss by sweat evaporation and vasodilation.*

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

1. If for some reason the sebaceous glands fail to function.
(a) the body will not be able to regulate the body temperature
(b) the skin will turn darker with more melanin
(c) the hairs will fail to grow
(d) the skin will turn dry and rough
2. Which one pair of two conditions includes both as abnormal conditions of skin pigmentation ?
(a) Leucoderma, Ringworm
(b) Albinism, Leucoderma
(c) Baldness, Albinism
(d) Rickets, Baldness
3. Which **one out** of the organs listed below, most actively functions in regulating our **body temperature**.
(a) Heart (b) Lungs
(c) Skin (d) Stomach
4. Sweat glands are situated in :
(a) Epidermis (b) Dermis
(c) Both (d) None of the above
5. The epidermis is highly thickened in :
(a) Eyelid (b) Thigh
(c) Lip (d) Palm

B. VERY SHORT ANSWER TYPE

1. Name the principal body **heat regulating centre in our brain**.
2. Name any one **modified sweat gland** and any one modified **sebaceous gland**.

3. Name the skin glands which when inflamed cause **acne**.

C. SHORT ANSWER TYPE

1. State any **two functions** of the mammalian skin other than those concerned with heat regulation.
2. What is “goose-flesh” ? How is it brought about ?
3. **Why** do you shiver and why do your teeth chatter when it is very cold in winter ?
4. What is the **difference** between leucoderma and albinism ?
5. Name **any two glands** found in the human skin. State their functions.
6. An otherwise normal healthy young man started perspiring while it was intensely cold outside. What could have been one reason for it?

D. LONG ANSWER TYPE

1. Enumerate in a tabular form the different structures found in the epidermis and dermis of the human skin respectively.
2. **Explain** the terms “vasodilation” and “vasoconstriction”. How do these processes contribute in temperature regulation of the body?
3. **How** does our skin provide protection to our body against the following ?
(a) Entry of germs
(b) Excessive loss of heat in severe cold
(c) Entry of harmful ultra-violet rays
.....

E. STRUCTURED/APPLICATION/SKILL TYPE

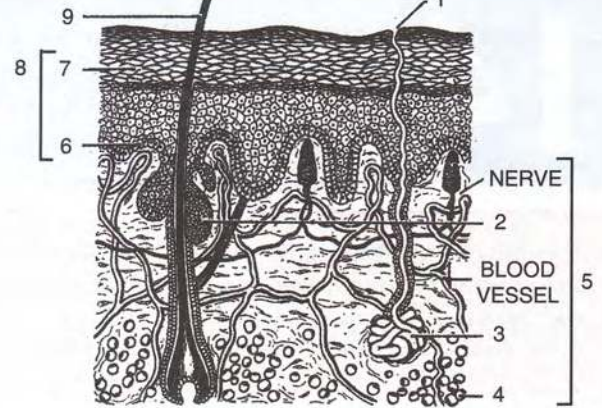
1. Draw a labelled diagram of the generalised vertical section of the mammalian skin.
2. Given below is a diagrammatic sketch of the vertical section of the human skin.

- (a) Label the parts numbered from 1 to 9.
- (b) State **one main function** of each of the following parts :

Part 2. Part 3.

Part 4. Part 9.

Name any one of the above parts which has at least three functions.



- (c) Part 4 may add to one's good appearance or the "figure". State one example of this function which may be common to both men and women.

TWO OUT OF THE NUMEROUS EXAMPLES IN WHICH THE HAIRS CONTRIBUTE IN PROVIDING SECONDARY SEXUAL CHARACTERS IN THE MALE SEX.



MALENESS DISPLAYED



ABOUT PALM AND NOT PALMISTRY, AND SOME MORE SECRETS OF SKIN

- The skin of palm is thick, harder and rough
 - The major lines (so-called fate and life lines, etc.) are simply the creases along which the hand flexes and folds.
 - Extremely fine ridges and furrows all over the surface and specially on finger tips make patterns of curves and twists. These provide efficient grip due to friction. (No two individuals, not even the identical twins, have exactly similar patterns of the fingerprints and hence these are important in forensic science).
 - The ridges also possess special touch sense cell.
- The above adaptations are also found in monkeys and in apes like the chimpanzees, etc. Such a hand provides firm grip and is suited for life on trees. Man has undoubtedly descended from ape like ancestors.



Biology can say much about palm but does not believe in palmistry.

CAN YOU GUESS :

The body hair, what for ?



This structure in birds is a counterpart of mammalian hair.

1. What is this ? _____
2. What is the one **common primary function** served by these structures both in birds and mammals ?

LOOK AT THE FOLLOWING DIAGRAM

