The Anatomy and Physiology of Animals

The skin, sometimes known as the **Integumentary System** is, in fact, the largest organ of the body. It has a complex structure, being composed of many different tissues. It performs many functions that are important in maintaining homeostasis in the body. Probably the most important of these functions is the control of body temperature. The skin also protects the body from physical damage and bacterial invasion. The skin has an array of sense organs which sense the external environment, and also cells which can make **vitamin D** in sunlight.

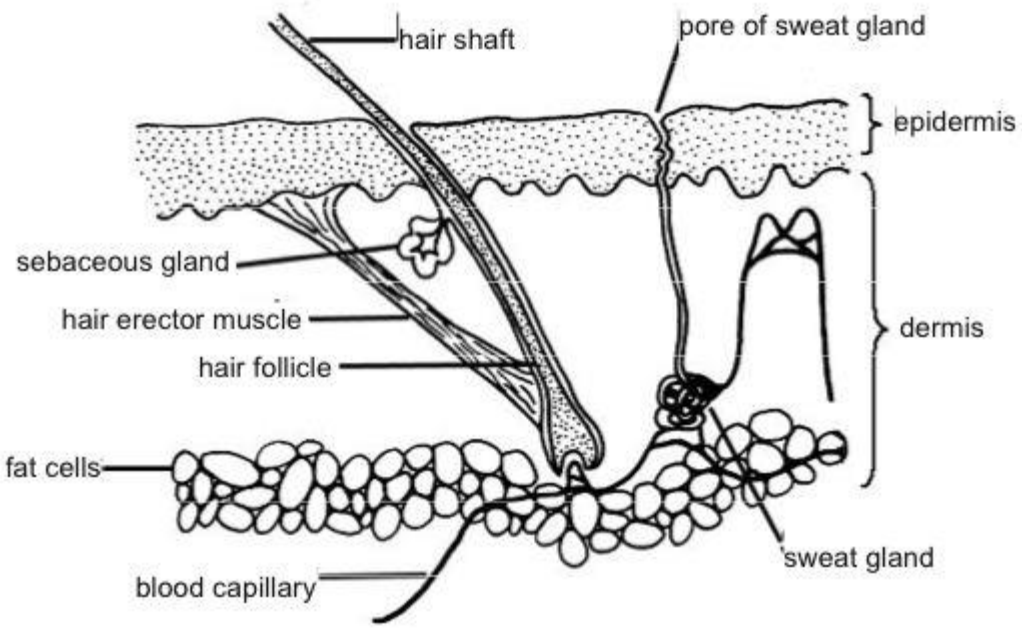
The skin is one of the first systems affected when an animal becomes sick so it is important for anyone working with animals to have a sound knowledge of the structure and functioning of the skin so they can quickly recognise signs of disease.

Skin

Skin comes in all kinds of textures and forms. There is the dry warty skin of toads and crocodiles, the wet slimy skin of fish and frogs, the hard shell of tortoises and the soft supple skin of snakes and humans. Mammalian skin is covered with hair, that of birds with feathers, and fish and reptiles have scales. Pigment in the skin, hairs or feathers can make the outer surface almost any colour of the rainbow.

As humans, it is often the skin of an animal that gives it its appeal to us or repels us. We love the soft feel of a cat's coat but perhaps can't bear to touch a snake. As the main part of an animal visible to us, the skin can often give us clues to the health of an animal. A healthy animal will have a clean,

glowing, flexible skin, while ill health may show itself as an abnormal colour or texture.



Cross section through the skin

Skin is one of the largest organs of the body, making up 6-8% of the total body weight. It consists of two distinct layers. The top layer is called the **epidermis** and under that is the **dermis** .

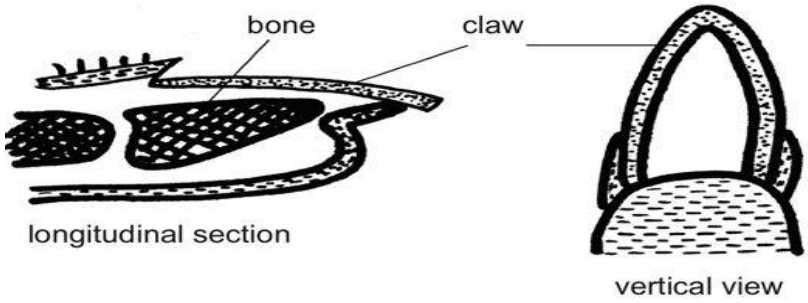
The epidermis is the layer that bubbles up when we have a blister and as we know from this experience, **it has no blood or nerves in it**. The cells at the base of the epidermis continually divide and push the cells above them upwards. As these cells move up they die and become the dry flaky scales that fall off the skin surface.

The cells in the epidermis die because a special protein called keratin is deposited in them. Keratin is an extremely important substance for it makes the skin waterproof. Without it land vertebrates like reptiles, birds and mammals would, like frogs, be able to survive only in damp places.

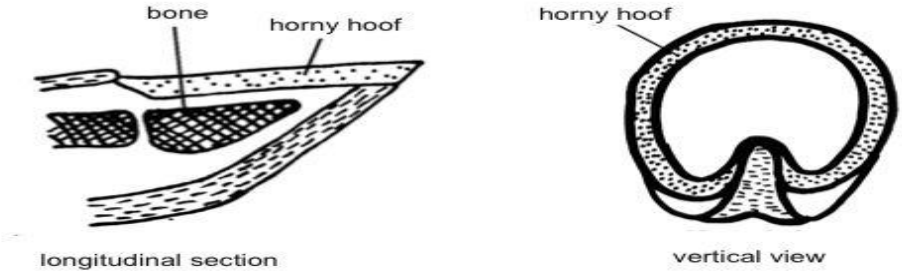
Skin Structures Made Of Keratin

Claws, Nails and Hoofs

Reptiles, birds and mammals all have nails or claws on the ends of their toes. They protect the end of the toe and may be used for grasping, grooming, digging or in defense. They are continually worn away and grow continuously from a growth layer at their base .

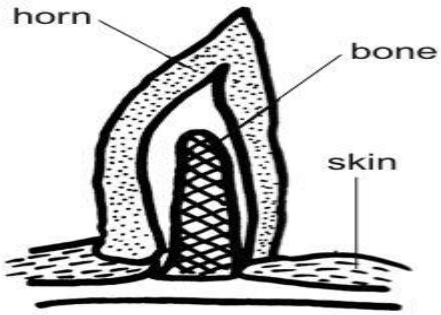


Hoofs are found in sheep, cows, horses etc. otherwise known as **ungulate mammals**. These are animals that have lost toes in the process of evolution and walk on the "nails" of the remaining toes. The hoof is a cylinder of horny material that surrounds and protects the tip of the toe.

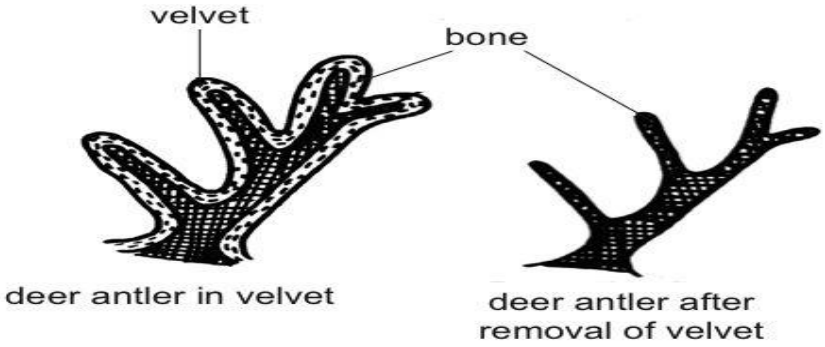


Horns And Antlers

True horns are made of keratin and are found in sheep, goats and cattle. They are never branched and, once grown, are never shed. They consist of a core of bone arising in the dermis of the skin and are fused with the skull. The horn itself forms as a hollow cone-shaped sheath around the bone



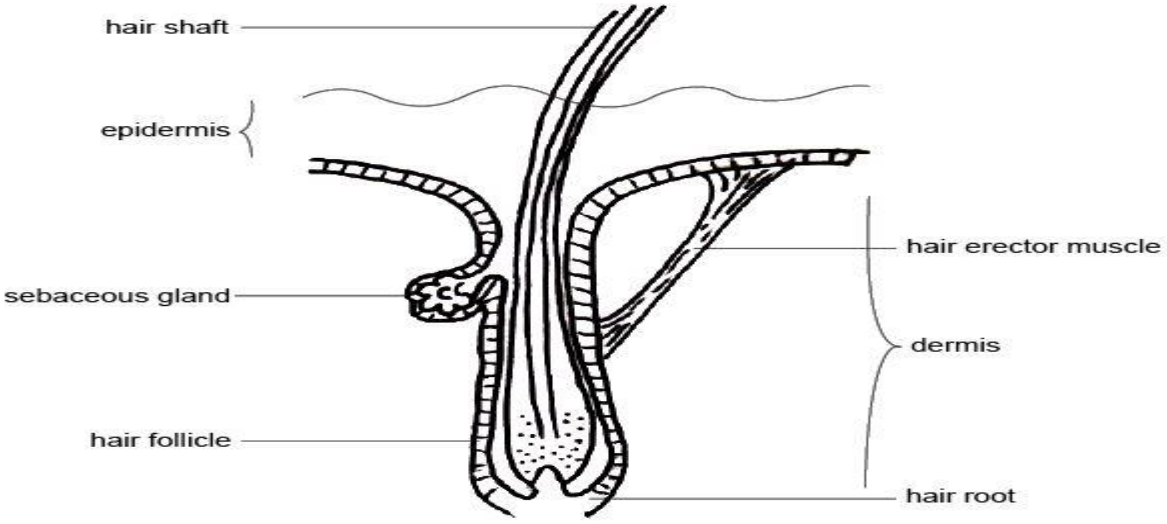
The **antlers** of male deer have quite a different structure. They are not formed in the epidermis and do not consist of keratin but are entirely of bone. They are shed each year and are often branched, especially in older animals. When growing they are covered in skin called **velvet** that forms the bone. Later the velvet is shed to leave the bony antler. The velvet is often removed artificially to be sold in Asia as a traditional medicine .



Other animals have projections on their heads that are not true horns either. The horns on the head of giraffes are made of bone covered with skin and hair, and the 'horn' of a rhinoceros is made of modified and fused hair-like structures.

Hair

Hair is also made of keratin and develops in the epidermis. It covers the body of most mammals where it acts as an insulator and helps to regulate the temperature of the body (see below). The colour in hairs is formed from the same pigment, **melanin** that colours the skin. Coat colour may help camouflage animals and sometimes acts to attract the opposite sex



Hairs lie in a **follicle** and grow from a **root** that is well supplied with blood vessels. The hair itself consists of layers of dead keratin - containing cells and usually lies at a slant in the skin. A small bundle of smooth muscle fibres (the **hair erector muscle**) is attatched to the side of each hair and when this contracts the hair stands on end. This increases the insulating power of the coat and is also used by some animals to make them seem larger when confronted by a foe or a competitor.

The whiskers of a cats etc. and the spines of hedgehogs are special types of hairs.

Skin Glands

Glands are organs that produce and secrete fluids. They are usually divided into two groups depending upon whether or not they have channels or ducts to carry their products away.

-Glands with ducts are called **exocrine glands** and include the glands found in the skin as well as the glands that produce digestive enzymes in the gut.

- **Endocrine glands** have no ducts and release their products (hormones) directly into the blood stream. The pituitary and adrenal glands are examples of endocrine glands.

Most vertebrates have exocrine glands in the skin that produce a variety of secretions. The slime on the skin of fish and frogs is **mucus** produced by skin glands and some fish and frogs also produce poison from modified glands. In fact the skin glands of some frogs produce the most poisonous chemicals known. Reptiles and birds have a dry skin with few glands.

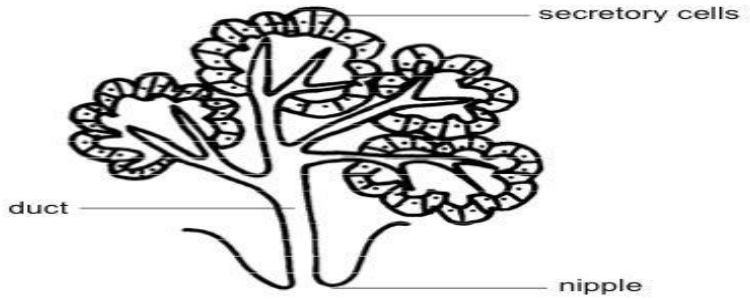
Mammals have an array of different skin glands. These include the wax producing, sweat, sebaceous and mammary glands.

Wax producing glands are found in the ears

Sebaceous glands secrete an oily secretion into the hair follicle. This secretion, known as **sebum**, keeps the hair supple and helps prevent the growth of bacteria

Sweat glands consist of a coiled tube and a duct leading onto the skin surface. Their appearance when examined under the microscope inspired one of the first scientists to observe them to call them “fairies’ intestines” . Sweat contains salt and waste products like urea and the evaporation of sweat on the skin surface is one of the major mechanisms for cooling the body of many mammals. Horses can sweat up to 30 litres of fluid a day during active exercise, but cats and dogs have few sweat glands and must cool themselves by panting. Scent in the sweat of many animals is used to mark territory or attract the opposite sex.

Mammary glands are only present in mammals. They are thought to be modified sebaceous glands and are present in both sexes but are rarely active in males (see diagram 5.10). The number of glands varies from species to species. They open to the surface in well-developed nipples. Milk contains proteins, sugars, fats and salts, although the exact composition varies from one species to another.



The Skin And Sun

A moderate amount of UV in sunlight is necessary for the skin to form **vitamin D**. This vitamin prevents bone disorders like rickets to which animals reared indoors are susceptible. Excessive exposure to the UV in sunlight can be damaging and the pigment **melanin**, deposited in cells at the base of the epidermis, helps to protect the underlying layers of the skin from this damage. Melanin also colours the skin and variations in the amount of melanin produces colours from pale yellow to black.

Sunburn And Skin Cancer

Excess exposure to the sun can cause sunburn. This is common in humans, but light skinned animals like cats and pigs can also be sunburned, especially on the ears.

Skin cancer can also result from excessive exposure to the sun. As holes in the ozone layer increase exposure to the sun's UV rays, so too does the rate of skin cancer in humans and animals.

The Dermis

The underlying layer of the skin, known as the dermis, is much thicker but much more uniform in structure than the epidermis . It is composed of loose connective tissue with a felted mass of **collagen** and **elastic fibres**. It is this part of the skin of cattle and pigs etc. that becomes commercial leather when treated,.

The dermis is well supplied with blood vessels, so cuts and burns that penetrate down into the dermis will bleed or cause serious fluid loss. There are also numerous nerve endings and touch receptors in the dermis because, of course, the skin is sensitive to touch, pain and temperature.

When looking at a section of the skin under the microscope you can see hair follicles, sweat and sebaceous glands dipping down into the dermis. However, these structures do not originate in the dermis but are derived from the epidermis.

In the lower levels of the dermis is a layer of fat or **adipose tissue** . This acts as an energy store and is an excellent insulator especially in mammals like whales with little hair.

The Skin And Temperature Regulation

Vertebrates can be divided into two groups depending on whether or not they control their internal temperature. Amphibia (frogs) and reptiles are said to be"**cold blooded**" (**poikilothermic**) because their body temperature approximately follows that of the environment.

Birds and mammals are said to be **warm blooded (homoiothermic**) because they can maintain a roughly constant body temperature despite changes in the temperature of the environment.

Heat is produced by the biochemical reactions of the body (especially in the liver) and by muscle contraction. Most of the heat lost from the body occurs via the skin. It therefore not surprising that many of the mechanisms for controlling the temperature of the body operate here.

Reduction Of Heat Loss

When an animal is in a cold environment and needs to reduce heat loss the erector muscles contract causing the hair or feathers to rise up and increase the layer of insulating air trapped by them .

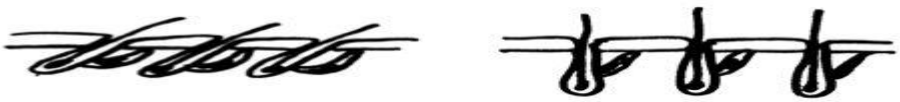


Diagram a) Hair muscle relaxed.....Diagram b) Hair muscle contracted

Heat loss from the skin surface can also be reduced by the contraction of the abundant blood vessels that lie in the dermis. This takes blood flow to deeper levels, so reducing heat loss and causing pale skin (see diagrama).

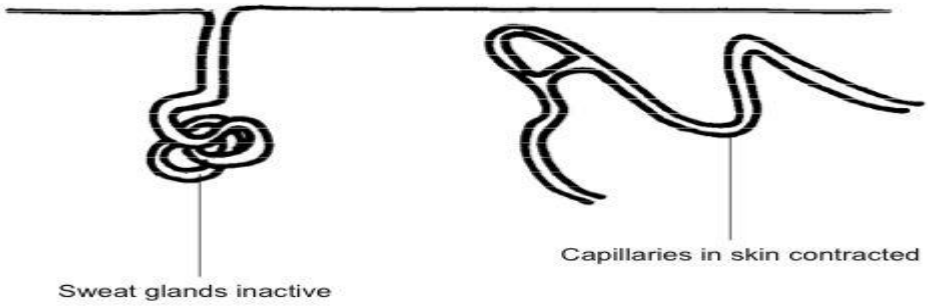


Diagram a) Reduction of heat loss by skin Shivering caused by twitching muscles, produces heat that also helps raise the body temperature.

Increase Of Heat Loss

There are two main mechanisms used by animals to increase the amount of heat lost from the skin when they are in a hot environment or high levels of activity are increasing internal heat production.

-The first is the expansion of the blood vessels in the dermis so blood flows near the skin surface and heat loss to the environment can take place.

-The second is by the production of sweat from the sweat glands (see diagram b). The evaporation of this liquid on the skin surface produces a cooling effect.

The mechanisms for regulating body temperature are under the control of a small region of the brain called the **hypothalamus**. This acts like a thermostat.

Heat Loss And Body Size

The amount of heat that can be lost from the surface of the body is related to the area of skin an animal has in relation to the total volume of its body.

Small animals like mice have a very large skin area compared to their total volume. This means they tend to loose large amounts of heat and have difficulty keeping warm in cold weather. They may need to keep active just to maintain their body temperature or may hibernate to avoid the problem.

Large animals like elephants have the opposite problem. They have only a relatively small skin area in relation to their total volume and may have trouble keeping cool. This is one reason that these large animals tend to have sparse coverings of hair.

Summary

- **Skin consists of two layers: the thin epidermis and under it the thicker dermis.**
- **The Epidermis is formed by the division of base cells that push those above them towards the surface where they die and are shed.**
- **Keratin, a protein, is deposited in the epidermal cells. It makes skin waterproof.**
- **Various skin structures formed in the epidermis are made of keratin. These include: claws, nails, hoofs, horn, hair and feathers.**
- **Various Exocrine Glands (with ducts) formed in the epidermis include sweat, sebaceous, and mammary glands.**
- **Melanin deposited in cells at the base of the epidermis protects deeper cells from the harmful effects of the sun.**
- **The Dermis is composed of loose connective tissue and is well supplied with blood.**
- **Beneath the dermis is insulating adipose tissue.**
- **Body Temperature is controlled by: sweat, hair erection, dilation and contraction of dermal capillaries and shivering.**

The cutaneous ecosystem

the roles of the skin microbiome in health and its association with inflammatory skin conditions in humans and animals

– Inhabiting a sterile world is no longer an acceptable or desirable concept. Recent studies developed in the microbiome field have unveiled complex microbial populations inhabiting the skin, digestive, respiratory and reproductive tracts.

Microbiome studies have opened new venues to explore the human and animal second genome, its functions and its importance in maintaining health. Skin microbiome in health

– The composition of the skin microbiome varies across different body sites and across individuals, being influenced by different host habits, including for instance age, sex, diet, hygiene and lifestyle.

- Exposure to a diverse skin microbiome is now considered to be a key component in immune regulation, and imbalances in these microbial populations are being associated with human and animal skin inflammatory disorders. Skin microbiome in inflammatory skin conditions

– We have learned that in several skin conditions, there is a significant alteration in the diversity and composition of the microbiota colonizing the skin. For instance, in human and animal patients with atopic dermatitis, dysbiosis of the skin microbiota results in lower diversity of microbial populations.

Whether these altered microbial populations are the cause or the effect of inflammatory skin conditions seen in humans and animals are still under investigation, but there is no doubt that the microbiome has an important role in maintaining skin health.

Summary

– This review focuses on the most current studies describing the skin microbiome in humans and animals, its role in modulating the immune system, and its association with human and animal skin diseases. Introduction Several studies

published in the last 20 years have shown that complex communities of microbes, known as the microbiome, inhabit the different surfaces of the human and animal body. These communities often have a commensal relationship with the host and recent studies have also shown the host to be dependent on these communities.

Microbes are no longer seen only as the “bad guys”; they are no longer our main enemies. Certainly, we know this is not true for all microbes, but we have now learned that the vast majority of micro-organisms inhabiting our bodies are actually beneficial.

These commensal microbial communities act as our assistants, competing with pathogenic microbes for nutrients, producing numerous metabolites and modulating our immune system, allowing human and animal bodies to thrive.