The structure and function of the skin

Introduction

The skin is the body's largest organ. It measures about 1.5–2m² in adults and weighs about 15 per cent of total body weight. It is home to up to three million micro-organisms per cm^2, which feed on its scales and secretions. Understanding this fascinating organ's functions will help us to assess patients' skin and evaluate its potential for healing following injury or disease.

Structure of the skin

The skin holds the contents of the body together. It consists of two layers, the epidermis and the dermis, which work closely together.

The epidermis, or outer layer, has four or five distinct layers of cells but no blood vessels or nerve endings. Most regions of the body have four layers but skin exposed to friction, such as skin on the feet or hands, has a fifth layer (the stratum lucidum).

The dermis, or inner layer, forms an elastic bed of connective tissue that nourishes, provides strength and supports the epidermis and the hair, sweat glands, nerve endings, blood vessels and lymph glands within it. The dermis consists of two distinct layers: the papillary layer, next to the epidermis, and the deeper reticular layer. A basal membrane separates the papillary dermis and the epidermis . The undulating nature of the surfaces of the papillary layer and the epidermis means that the two layers are less likely to separate when shearing forces are applied. Blisters are an example of separation of the layers by excessive shearing forces. It can perform these functions because of the types of fibres it contains:

■ Collagen to provide strength;

■ Elastin to allow the skin to stretch (though this can break when overstretched, for example, in pregnancy. This results in silvery lines known as stretch marks);

■ Reticular fibres to help disperse mechanical forces, which may be applied to the skin.

A number of cells within the dermis help to repair and protect the skin. Fibroblasts and tissue macrophages are essential for wound healing; tissue mast cells produce histamine and heparin in response to foreign substances, and cells such as neutrophils and lymphocytes can be moved out of the blood vessels into the surrounding tissues in response to trauma.

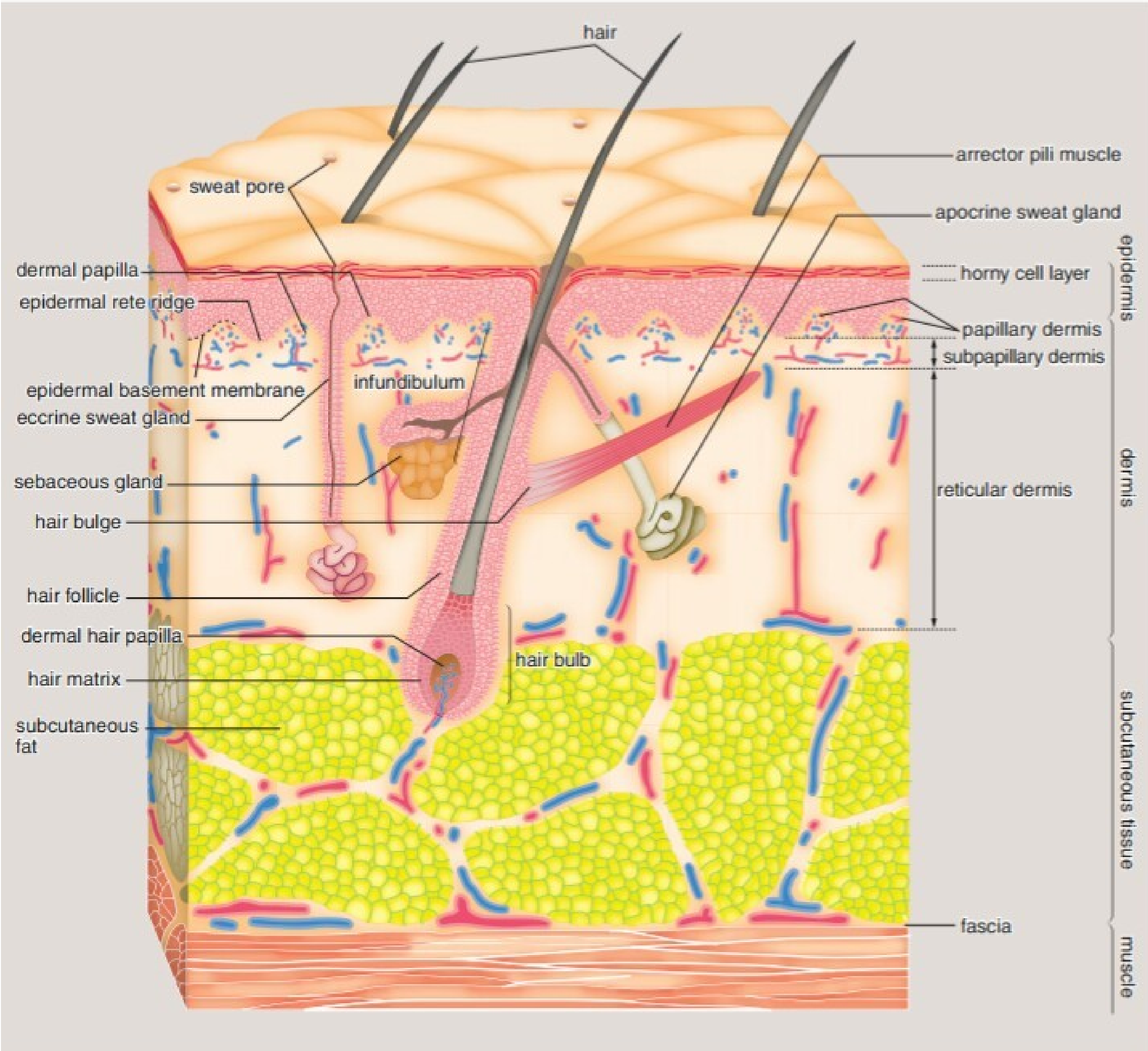

Fig. 1.3 Structure of the skin.
(Nakagawa H, editor. Dermatological disorders. In: Symphonia Medica Nursing (Vol.19). Nakayama-Shoten; 2001. p.3).

with the direction in which the differentiated cell clones extend during fetal skin development.

Skin generally consists of a three-layer structure: the epidermis, dermis and subcutaneous tissues (**Fig. 1.3**). At the boundary between the epidermis and dermis are finger-like projecting structures (the dermal papillae) that project into the overlying tissue (the epidermis) (**Fig. 1.30**). The portion of the epidermis that projects into the dermis is called the epidermal rete ridge, and the portion of the dermis that projects into the epidermis is called the dermal papilla.

Function of the skin

Protection from wear and tear

The skin varies in thickness according to the amount of friction and pressure to which it is subjected – on the eyelids it is about 1mm thick, while on the palms of the hands and soles of the feet it can be up to $1cm^2$. The toughness of skin is due to the amount of the insoluble protein keratin within it. There is little or none where the skin is not subject to friction (for example, inside the lips) and more where the skin is subjected to constant external pressure. Subcutaneous fat beneath the skin acts as a shock absorber and helps to protect the body from trauma.

Protection against infection and chemicals

Although large numbers of micro-organisms live on the skin, these cannot breach the barrier created by intact healthy skin. Trauma to the skin creates an opportunity for invasion by micro-organisms and results in an inflammatory response characterised by redness, swelling, localised heat, pain and pyrexia. Blood flow increases and transports white blood cells and macrophages to the site of injury to fight infection and repair the tissue. The skin also provides protection against weak chemicals and most gases (although those designed for chemical warfare may penetrate its defences).

Protection against ultraviolet rays

The skin protects the body from harmful ultraviolet (UV) rays. The pigment melanin is produced in special cells called melanocytes, which are found at the base of the epidermis. Melanin production is influenced by sunlight. When skin is over-exposed to the sun's rays, it becomes red with erythema (flushing of the skin in response to dilatation of blood vessels in the dermis) due to inflammation. The skin then turns brown as melanin is produced. Melanin absorbs UV light and prevents it damaging cellular DNA (Martini, 2003). Overexposure to UV light can cause malignant melanoma (see p44). Melanin also determines the colour of hair and eye irises. People who do not produce melanin are called albinos. They have pale skin and hair, and colourless irises.

Response to increased temperature

Arteries and veins in the subcutaneous layer immediately beneath the dermis are linked to small arterioles and capillaries, which supply blood to the dermis. Blood flow can be varied by dilatation and constriction of these dermal blood vessels. Blood flow to the skin can vary from about 250ml/min to 3l/min in response to the need to lose or conserve heat. When the body's core temperature rises, blood vessels in the dermis dilatate and the skin becomes warm to the touch, and pink or red in colour. core body temperature (37°C) is an important function of the skin and this regulation is essential for the normal functioning of cellular enzymes throughout the body. The hypothalamus, which contains the temperature regulating centre, can orchestrate a number of changes within the skin in response to temperature changes.

The blood carries heat with it to the skin surface. Heat is lost from the body in four ways:

■ Convection – heat is lost to air currents, for example, when a fan is used to cool a patient;
■ Conduction – heat is lost to cooler solid objects which are in direct contact with the skin;
■ Radiation – heat from a warm body is lost to the cooler surrounding air;
■ Evaporation – heat is lost as a liquid becomes a gas, for example, through evaporation of sweat.

Eccrine sweat glands assist in reducing body heat. There are about 2–5 million of these glands and their distribution varies in different body areas. There are 400/cm2 on the palms and soles of the feet and only 70/cm2 on the back . These glands have their own nerve and blood supply and produce sweat when the skin's temperature rises above 35°C.
Sweat is composed of 99 per cent water, with sodium, urea, lactic acid and potassium making up the remaining one per cent. We sweat an average of 500ml a day in the UK climate , whether we are hot or not. But this can rise to 10 or more litres a day in very hot climates. Spicy foods and exercise also increase water loss through sweat. The watery sweat drips off the skin, is absorbed into clothing or evaporates from exposed skin surfaces. Problems arise if the air is very humid, because sweat cannot evaporate from the skin's surface, reducing heat loss.

Response to a fall in temperature

In cold weather, blood supply to the skin is reduced , as is sweat production. This conserves heat in the deeper organs, which are also insulated by the layers of subcutaneous tissue and fat.
Another method used in the skin to conserve heat is the mechanism that erects the body's hair. Tiny arrector pili muscles, around the shaft of the hair, contract and pull the hair vertically.

In animals with lots of hair, this results in the trapping of a layer of warm air around the body, and is an important means of insulation. However, in humans it only results in goose pimples.

Shivering occurs when the body becomes cold – this involuntary muscle action throughout the body is a metabolic process, which produces heat.

Receiving stimuli from the outside world

The skin is the body's largest sensory organ and its sensory (or afferent) nerve receptors detect a number of different stimuli: mechanical, such as pressure or stretching; and thermal, in terms of heat and cold (Marieb, 2003). This ability to sense and provide information about contact of the skin with the outside world allows the brain to interpret and act upon the stimuli and helps to protect the body and avoid damage to it.

There are nerve endings throughout the dermis but none in the epidermis. Their distribution varies – for example, the fingertips and lips have many sensory receptors, giving them very fine sensory discrimination . The skin hairs also have a sensory nerve supply that senses when the hair is being touched.

Absorption and excretion

Sebacious glands are outgrowths of hair follicles in the dermis. They secrete a lipid, sebum, to make the skin water-resistant. Sebum is bactericidal but if the glands become blocked, this results in a boil .

Very small amounts of carbon dioxide are excreted through the skin. In addition to water, sweat excretes a number of waste products including sodium chloride and urea .

Although the skin is normally water-resistant, it is a useful absorbent medium for some medicines, including hormones and glyceryl trinitrate (used to treat angina). It is also useful for the application of topical medications for a range of skin diseases. Because of the problem of penetrating the barrier of intact skin, medications may need to be massaged into the skin and/or covered with an occlusive dressing to prolong contact time.

Nutrient and water storage

Water stored in the skin cells can be accessed in emergency situations when blood volume falls , for example when a patient haemorrhages. The skin also contains a potential energy source in the form of triglycerides (fatty acids and glycerol) stored in the adipose tissue .

Exposure to UV radiation not only encourages the production of melanin but also initiates vitamin D production from a cholesterol compound (7dehydrocholecalciferol) in the dermis. Most of our vitamin D comes from food, especially dairy produce and fish oils.

However, where these foods are lacking in the diet, exposure to sunlight is important because vitamin D is needed for optimum calcium absorption from the gut. This is essential for bone formation and bone health.

Communication Nurses can gain a lot of information about patients' health and well-being simply by examining patients' skin . Physiological changes in the skin are common – when we are hot, the skin reddens and sweat breaks out; when we are in pain, it tends to be pale; patients experiencing a heart attack often look grey; a yellow tinge to the skin may be a sign of jaundice; blue (cyanosis), a sign of oxygen deficiency.

Physiological health is indicated not only by the colour of the skin but by its appearance, elasticity and sensitivity.
Changes include:
■ Effects of the ageing process, such as loss of elasticity leading to wrinkling of the skin;
■ Dehydrated skin loses its turgor (becoming lax);
■ When the blood supply to an area of skin is compressed, a pressure ulcer may occur.
Another physiological mechanism, which impinges on those around us, is the production of sweat from the apocrine glands. These are different from the eccrine glands and are not activated until puberty. They secrete small amounts of waxy fluid, which is odour-free but is quickly invaded by bacteria, producing an unpleasant body odour. The secretion probably contains pheromones. These secretions increase when we are fearful or sexually excited.
Psychological aspects of daily life also affect the skin. Most people try to optimise or improve their appearance. Hair is a common tool of sexual display and make-up can enhance beauty. But skin can give us away – we blush when embarrassed, blanch and sweat more when terrified – and there is nothing we can do about it. 'Lie-detector' tests rely on this involuntary sweating reaction to determine the truth.