The Anatomy of Touch, with a Special Consideration to Anatomy of Skin

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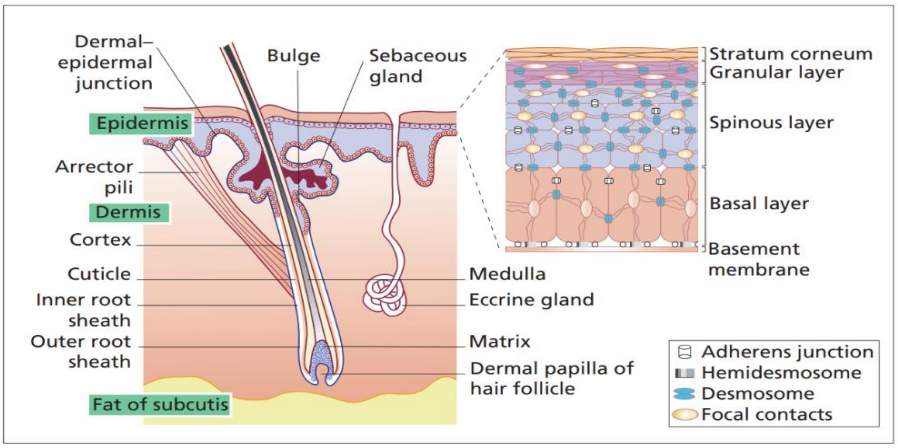
Abstract: Skin has been the largest organ in the body and covers the body's entire external surface made up of three layers, including epidermis, dermis, and the hypodermis significantly maintaining the anatomy and physiology of human. In this scenario, understanding the anatomy and organisation of skin requires appropriate alignment for the evaluation of any internal feature associated with it. As a famous proverb says, "The best foundation you can wear is glowing healthy skin", it is essentially to evaluate and understand this largest organ across the body covering and safeguarding our internals appropriately under any adaptation suffered. Hence, this paper has based on expert analysis and visualisation of underlying skin anatomy as well as featuring essential theories of love, hug, and physiological role of touch in social beings.

Keywords: Anatomy of Touch, Anatomy of Skin, Touch sensation, Anatomy, Touch reflex

Introduction:

Skin is the outermost layer of body, characterized by its soft & flexible architecture & is a part of integumentary system made up of multiple layers of ectodermal tissue and guards the underlying muscles, bones, ligaments, and internal organs. From birth to older age, the skin's distinctive features change. It is smooth, moist, soft and generally free of wrinkles and imperfections in infants and children. The integumentary system refers to the skin and its accessory structures, and it is responsible for much more than simply lending to your outward appearance. In the adult human body, the skin makes up about 16 percent of body weight and covers an area of 1.5 to 2 m2. Children under two years of age sweat poorly and irregularly; their sebaceous glands do not function at all. In adolescence, hair grows longer, thicker, and more pigmented, especially on the scalp, axillae, pubic area, and male face. General skin pigmentation increases, localized pigmented foci appear mysteriously, and acne lesions often develop. The growth of hair, sweat and sebaceous glands starts to grow. The skin is left, in particular not protected by clothing, dryness, wrinkled or flaccid, as a result of ageing and changes to the body's anatomy and physiology due to exposure to sunlight and wind. It carries out a multitude of essential tasks, including as preventing the body from losing too much water and aiding in thermoregulation, in addition to providing defence against external physical, chemical, and biological threats. The mucous membranes that line the surface of the body form a continuous layer of skin. The architecture of skin is made up of an intricate network which serves as the body's initial barrier against pathogens, UV light, and chemicals, and mechanical injury. It also regulates temperature and the amount of water released into the environment.

Human skin consists of a stratified, cellular epidermis and an underlying dermis of connective tissue. The dermal–epidermal junction is undulating in section; ridges of the epidermis, known as rete ridges, project into the dermis. The junction provides mechanical support for the epidermis and acts as a partial barrier against exchange of cells and large molecules. Below the dermis is a fatty layer, the panniculus adiposus, usually designated as 'subcutaneous'. This is separated from the rest of the body by a vestigial layer of striated muscle, the panniculus carnosus. There are two main kinds of human skin. Glabrous skin (non-hairy skin), found on the palms and soles, is grooved on its surface by continuously alternating ridges and sulci, in individually unique configurations known as dermatoglyphics. It is characterized by a thick epidermis divided into several well-marked layers, including a compact stratum corneum, by the presence of encapsulated sense organs within the dermis, and by a lack of hair follicles and sebaceous glands. Hair-bearing skin (Fig. 3.1), on the other hand, has both hair follicles and sebaceous glands but lacks encapsulated sense organs. There is also wide variation between different body sites. For example, the scalp with its large hair follicles may be contrasted with the forehead, which has only small vellus-producing follicles, albeit associated with large sebaceous glands. The axilla is notable because it has apocrine glands in addition to the eccrine sweat glands, which are found throughout the body. Regional variation is further considered below.



The superficial epidermis is a stratified epithelium largely composed of keratinocytes that are formed by division of cells in the basal layer, and give rise to several distinguishable layers as they move outwards and progressively differentiate. Within the epidermis, there are several other cell populations, namely melanocytes, which donate pigment to the keratinocytes, Langerhans' cells, which have immunological functions and Merkel cells.

The hair follicles comprise pockets of epithelium that are continuous with the superficial epidermis. They undergo intermittent activity throughout life. During the active phase, the follicle envelops at its base a small papilla of dermis. A bundle of smooth muscle, the arrector pili, extends at an angle between the surface of the dermis and a point in the follicle wall. Above the insertion, the holocrine sebaceous gland opens by a short neck into the pilary canal, and some follicles in certain areas of the body, notably the axilla, have, in addition, an apocrine gland. Also derived from the epidermis, and opening directly to the skin surface, are the eccrine sweat glands, present in every region of the body in densities of 100– 600/cm2 .

The basis of the dermis is a supporting matrix or ground substance in which polysaccharides and protein are linked to produce macromolecules with a remarkable capacity for retaining water. Within and associated with this matrix are two kinds of protein fibre: collagen, which has great tensile strength and forms the major constituent of the dermis, and elastin, which makes up only a small proportion of the bulk. The cellular constituents of the dermis include fibroblasts, mast cells and histiocytes (monocyte/macrophages). The dermis has a very rich blood supply, although no vessels pass through the dermal–epidermal junction. The motor innervation of the skin is autonomic, and includes a cholinergic component to the eccrine sweat glands and adrenergic components to both the eccrine and apocrine glands, to the smooth muscle and the arterioles and to the arrector pili muscle. The sensory nerve endings are of several kinds: some are free, some terminate in hair follicles and others have expanded tips. Only in glabrous skin are some nerve endings encapsulated. Sense organs are described later in this chapter.

The skin of humans, more than any other mammal, shows remarkable topographic differences. For example, the palm and the back of the hand and fingers are very different.

- The eyebrows are thick, coarse and hairy;
- The eyelids are thin, smooth and covered with barely visible hairs.
- The face rarely shows hair on its forehead and cheekbones;
- The face is completely hairless on its vermilion border at the lips, but coarsely hairy over its chin and jaws as a male.
- The surfaces of forehead, cheeks and nose are generally oily, as opposed to the relatively greasy lower surface of its chin and jaws.
- Skin of the chest, the pubic region, the scalp, the axillae, the abdomen, the soles of feet and the ends of your fingers differ as much in structure and function as if they belonged to different animals.

Embryology of Skin:

The skin emerges by the juxtaposition of two major embryological components: the imminent epidermis, which begins from a surface region of the early gastrula and the planned mesoderm, which is brought into contact with the internal surface of the epidermis amid gastrulation. The mesoderm not as it were gives the dermis but is fundamental for actuating separation of the epidermal structures, such as the hair follicle in well evolved creatures. Undoubtedly, an impact from the dermis is basic for the upkeep of grown-up epidermis, in spite of the fact that organized dermis is not in this occurrence obligatory, the property moreover dwelling in powdered dermis or ligament. The neural peak

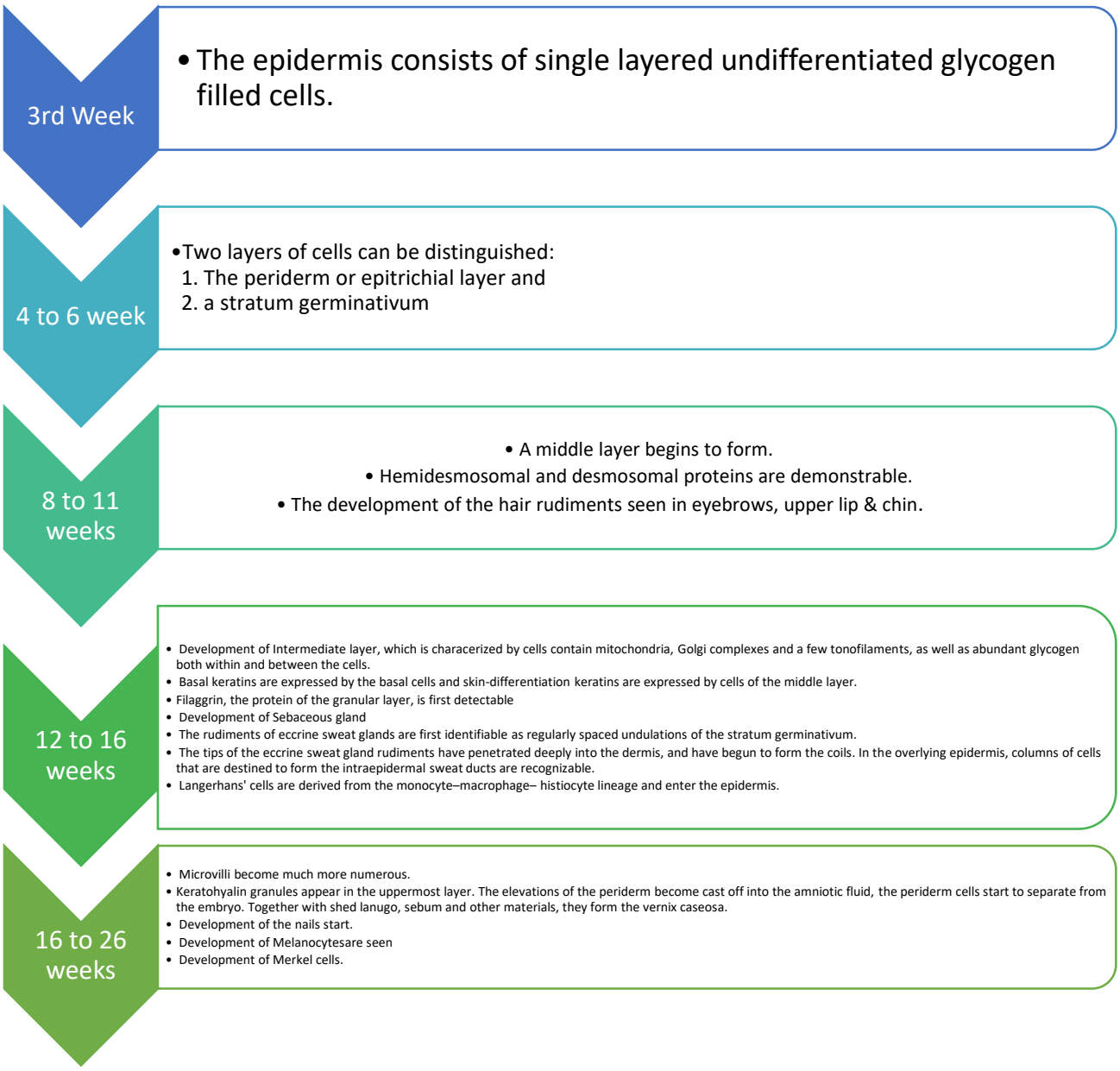
moreover makes a critical commitment to the skin, specifically the colour of cells, in spite of the fact that their bulk is little.

Structures	Gestational Month (GM)
Hair peg	4th GM
Exposed hair	5th GM
Nails	4th GM
Sebaceous gland	5th GM
Apocrine gland	6th GM
Eccrine gland	6th GM
Follicular keratinization	5th GM
Interfollicular keratinization	6th GM
Melanocytes in Non-functional state	3rd GM
Melanocytes in active state	4th GM
Langerhans' Cells	4th GM
Merkel cells	4th GM

Morphological events during fetal skin development. (Data from Holbrook and Hoff)

➢ **Epidermis:**

The development of the epidermis and its appendages relies on specific signals for initiating the process. Although complex, critical events appear to be governed by opposing interplay between the Notch and Wingless-related signalling pathways, with β-catenin, Lef1 and Notch peptide all having key roles. Signals from the Sonic hedgehog pathway and bone morphogenetic proteins (BMPs) also are important in early embryogenesis, notably in determining whether cells have an ectodermal or neural fate. Specifically, BMP signalling promotes ectodermal development, while Sonic hedgehog promotes neural tube and central nervous system (CNS) development. Thus, a complex interaction between these two components, as well as signals from fibroblast growth factors (FGFs) and additional regulatory control mechanisms from the Wingless-related signalling pathways, underlies the preliminary stages of epidermal development.



Dermis:

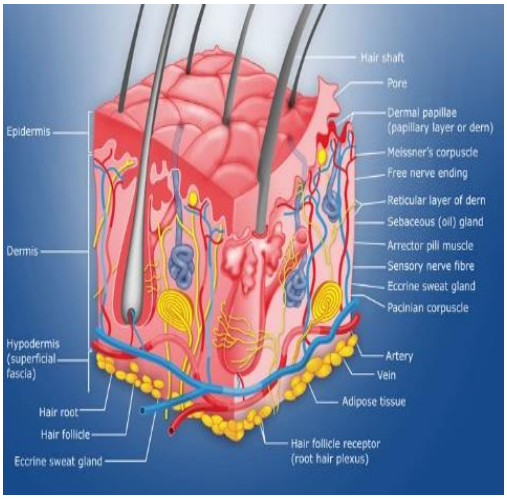
It was at one time believed that the mesenchymal cells forming the dermis came from the ventrolateral part of the somite, which for that reason was named the dermatome. Although some cells may migrate from the dermatome and take part in the formation of the skin, most of the dermis is formed by mesenchymal cells that migrate from other mesodermal areas. These mesenchymal cells give rise to the whole range of blood and connective tissue cells, including the fibroblasts and mast cells of the dermis and the fat cells of the subcutis. Nevertheless, a new type of stem cell from the dermis, called skin-derived precursor (SKP) cells, has been identified. Such cells are capable of being converted into several different cell types in vitro (e.g. neurones, smooth muscle cells or adipocytes) and might constitute a highly accessible source of pluripotential autologous stem cells. The embryonic dermis is at first very cellular, and in the second month the dermis and subcutis are not distinguishable from each other. Fibrillar components shortly make their appearance, and regular bundles of collagen fibres are evident by the end of the third month. Later, the papillary and reticular layers become distinct and, at the fifth month, the connective tissue sheaths are formed around the hair follicles. Elastic fibres are first detectable at 22 weeks. Beneath the dermis is a looser tissue characterized by fat islands that begin to form in definite places. In embryos of 6–14 weeks, three types of cell have been described in the dermis: stellate cells, phagocytic macrophages and a granule-secretory cell, either a melanoblast or a mast cell. From weeks 14–21, fibroblasts are numerous and active, and perineurial cells, pericytes, melanoblasts, Merkel cells and mast cells can be individually identified. Another cell, of bone marrow origin, may be ancestral to the Langerhans' cell and the histiocyte. At first, the under surface of the epidermis is smooth, but during the fourth month, at the same time as the hair follicle starts to develop, it becomes irregular. Touch pads become recognizable on the hands and fingers, and on the feet and

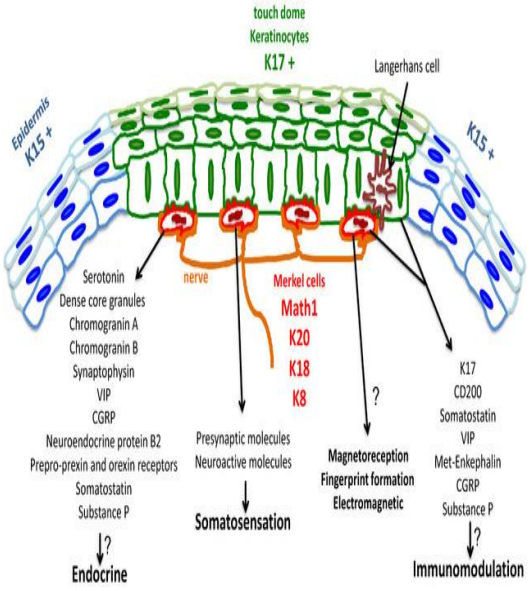
toes, by the sixth week, and reach their greatest development at the 15th week. After this, they flatten and become indistinct. It is these areas, however, that determine the pattern of dermatoglyphs athe systems of papillary ridges- that take their place.

Dermo-Epidermal Junction:

A continuous lamina densa of the basement membrane becomes evident in the second month of gestation and hemidesmosomes appear in the third month.

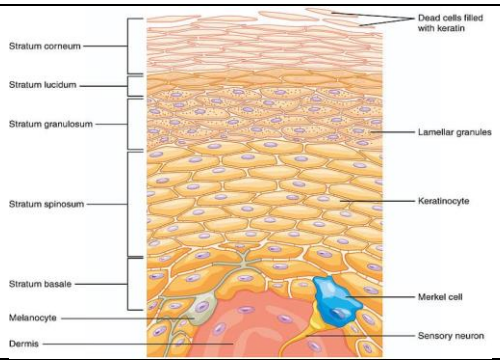
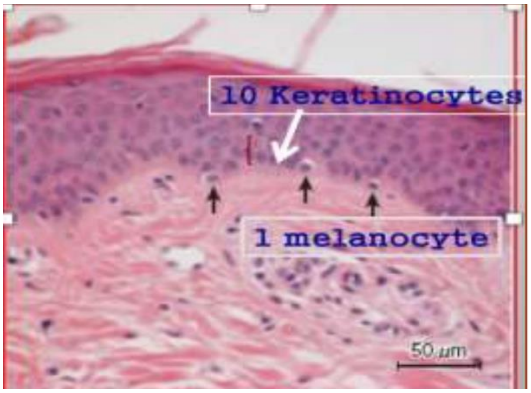
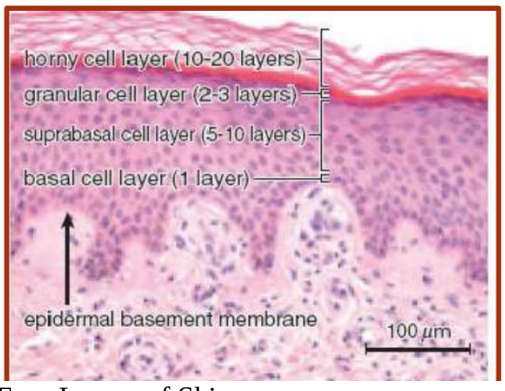
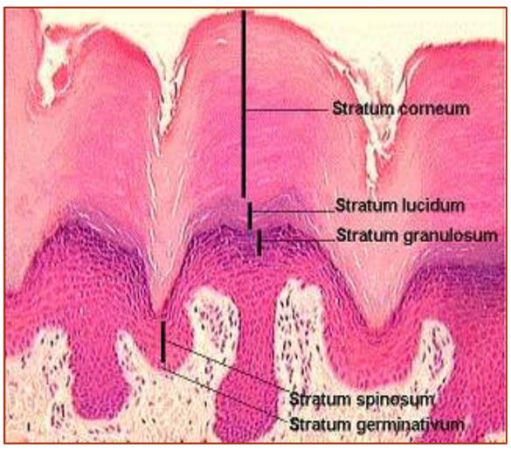
❖ **Layers of Skin:**

<table>
<tr><th>Sr. No.</th><th>Layer of Skin</th><th colspan="3">Characteristics</th><th>Photograph</th></tr>
<tr><td rowspan="4">01</td><td rowspan="4">Epidermis</td><td colspan="3">Cells</td><td rowspan="4"> 

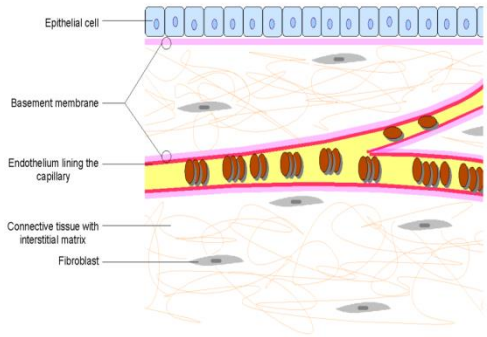
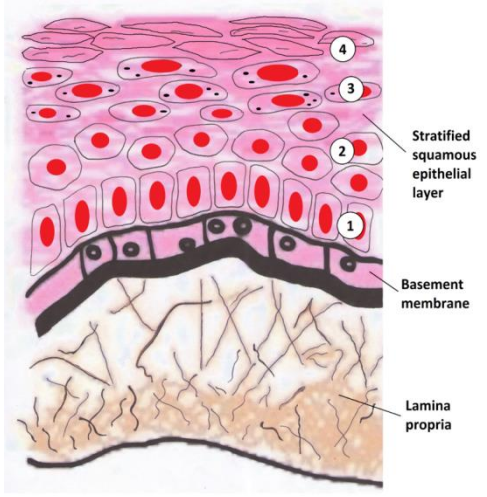

</td></tr>
<tr><td>Keratinocytes</td><td colspan="2">Function: Cornification</td></tr>
<tr><td rowspan="2">Non-Keratinocytes</td><td>Melanocytes</td><td>• Melanocytes are responsible for melanin production and pigment formation.

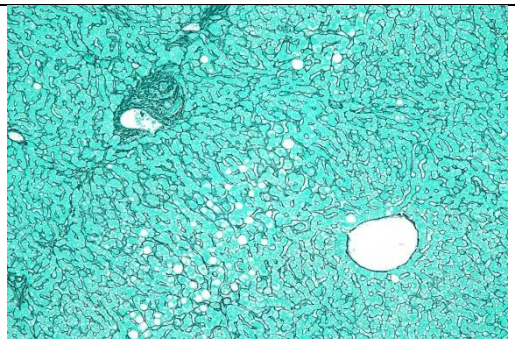
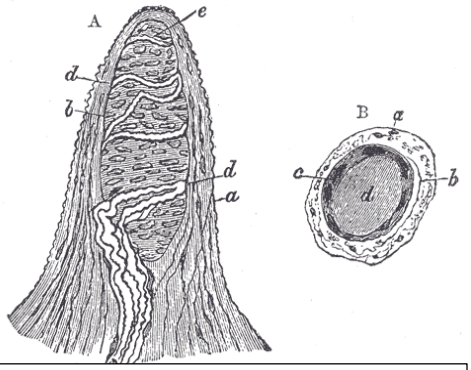
• Melanocytes are derived from neural crest cells and primarily produce melanin, which is responsible for the pigment of the skin. They are found between cells of stratum basale and produce melanin. UVB light stimulates melanin secretion which is protective against UV radiation, acting as a built-in sunscreen.
• Melanin is produced during the conversion of tyrosine to DOPA by the enzyme tyrosinase.
• Melanin then travels from cell to cell by a process that relies on the long processes extending from the melanocytes to the neighboring epidermal cells.
• Melanin granules from melanocytes are transferred via the long processes to the cytoplasm of basal keratinocyte.</td></tr>
</table>

				• Melanin transferred to neighboring keratinocytes by "pigment donation"; involves phagocytosis of tips of melanocyte processes by keratinocytes.	
			Langerhans' Cell	• Antigen-presenting dendritic cells • Langerhans cells, dendritic cells, are the skins first line defenders and play a significant role in antigen presentation. • These cells need special stains to visualize, primarily found in the stratum spinosum. • These cells are the mesenchymal origin, derived from CD34 positive stem cells of bone marrow and are part of the mononuclear phagocytic system. • They contain Birbeck granules, tennis racket shaped cytoplasmic organelles. • These cells express both MHC I and MHC II molecules, uptake antigens in skin and transport to the lymph node.	
			Merkel Cells	• Sensory mechanoreceptors • Merkel cells are oval-shaped modified epidermal cells found in stratum basale, directly above the basement membrane. • These cells serve a sensory function as mechanoreceptors for light touch, and are most populous in fingertips, though also found in the palms, soles, oral, and genital mucosa. • They are bound to adjoining keratinocytes by desmosomes and contain intermediate keratin filaments and their membranes interact with	

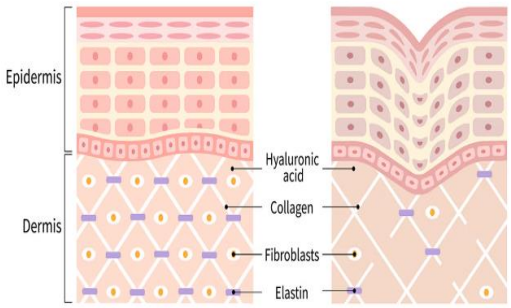
		free nerve endings in the skin.	
Layers			
Stratum basale (Stratum germinavitum)	• Stratum basale is the deepest layer, connected to the basement membrane by hemidesmosomes and divided from the dermis by the basal lamina. The cuboidal to columnar mitotically active stem cells that make up this layer are continuously generating keratinocytes. • Melanocytes are also present in this stratum. • Stratum basale layer is responsible for mitosis of the keratinocytes.		 Stratum basale
Stratum spinosum	• 8-10 cell layers, also known as the prickle cell layer contains irregular, polyhedral cells with cytoplasmic processes, sometimes called "spines", that extend outward and contact neighboring cells by desmosomes. Dendritic cells can be found in this layer. • In the layer of Stratum spinosum, keratinocytes are joined by tight intercellular junctions called desmosomes.		 Four Layers of Skin
Stratum granulosum	• 3-5 layers of cells with lamellar and keratohyalin granules inside diamond-shaped cells. Keratin precursors found in keratohyalin granules eventually agglomerate, crosslink, and form bundles. The glycolipids found in the lamellar granules are secreted onto the cell surface where they act as a glue to hold the cells together. • Cells of this layer secrete lipids and other waterproofing molecules in this layer.		 Layers of Epidermis
Stratum lucidum	• In the Stratum lucidum, cells lose nuclei and drastically increase keratin production.		

❖

			• 2-3 cell layers, present in thicker skin found in the palms and soles, is a thin clear layer consisting of eleidin which is a transformation product of keratohyalin.	
		Stratum corneum	• Cells of this layer will lose all organelles, continue to produce keratin. • 20-30 cell layers, is the uppermost layer, made up of keratin and horny scales made up of dead keratinocytes, known as anucleate squamous cells. • This is the layer which varies most in thickness, especially in callused skin. • Within this layer, the dead keratinocytes secrete defensins which are part of our first immune defense.	
02	Basement Membrane	The basement membrane is a thin, pliable sheet-like type of extracellular matrix that provides cell and tissue support and acts as a platform for complex signalling.		 
		Layers	Basal lamina — Lamina lucida: Lighter colored layer closer to the epithelium. The lamina lucida layer is made up of laminin, integrins, entactins, and dystroglycans.	
			Basal lamina — Lamina densa: Denser colored layer closer to the connective tissue. Thickness: 30 – 70 nm	
			Reticular lamina: Reticular fiber is composed of one or more types of very thin and delicately woven strands of type III collagen. These strands build a highly ordered cellular network and provide a supporting network. Many of these types of collagen have been combined with carbohydrate. Thus, they react with silver stains and with periodic acid-Schiff reagent but are not	

		demonstrated with ordinary histological stains such as those using hematoxylin. Organization • Epithelial/mesothelial/endothelial tissue (outer layer) • Basement membrane • Basal lamina • Lamina lucida • laminin • integrins (hemidesmosomes) • nidogens • dystroglycans • Lamina densa • collagen IV (coated with perlecan, rich in heparan sulfate) • Attaching proteins (between the basal and reticular laminae) • collagen VII (anchoring fibrils) • fibrillin (microfibrils) • Lamina reticularis • collagen III (as reticular fibers) • Connective tissue (Lamina propria)	 Reticulin Stain
03	Epidermo-Dermal Junction	The dermal papillae (DP) (solitary papilla, minute of Latin papula, 'pimple') are little, nipple-like expansions (or interdigitations) of the dermis into the epidermis. At the surface of the skin in hands and feet, they show up as epidermal, papillary or contact edges (colloquially known as fingerprints). Blood vessels in the dermal papillae nourish all hair follicles and bring nutrients and oxygen to the lower layers of epidermal cells. The ridges that develop in the hands and feet are partly genetically determined traits that develop before birth. They remain substantially unaltered (except in size) throughout life, and therefore determine the patterns of fingerprints, making them useful in certain functions of personal identification . The dermal papillae is part of the uppermost layer of the dermis, the papillary dermis, and the ridges that form are very large, increasing the surface area between the dermis and the epidermis. This significantly increases the exchange of oxygen, nutrients and waste products between these two layers as a result of the main function of the dermis is to support the epidermis. Additionally, the increase in the surface area prevents the dermal and epidermal layers from separating by strengthening the junction between them. With age, the papillae tend to flatten and sometimes increase in number.	 Papilla of the hand, treated with acetic acid. Magnified 350 times. A. Side view of a papilla of the hand. a. Cortical layer. b. Tactile corpuscle. c. Small nerve of the papilla, with neurolemma. d. Its two nervous fibers running with spiral coils around the tactile corpuscle. e. Apparent termination of one of these fibers. B. A tactile papilla seen from above so as to show its transverse section. a. Cortical layer. b. Nerve fiber. c. Outer layer of the tactile body, with nuclei. d. Clear interior substance.
04	Dermis	Cells Fibroblast | Macrophages | Mast Cells	

Matrix components		
Collagen Function: It provides Strength	Elastin Function: It provides Elasticity	Extra fibrillar matrix Function: Extra fibrillar matrix is an extracellular gel-like substance primarily composed of glycosaminoglycans (most notably hyaluronan), proteoglycans, and glycoproteins.

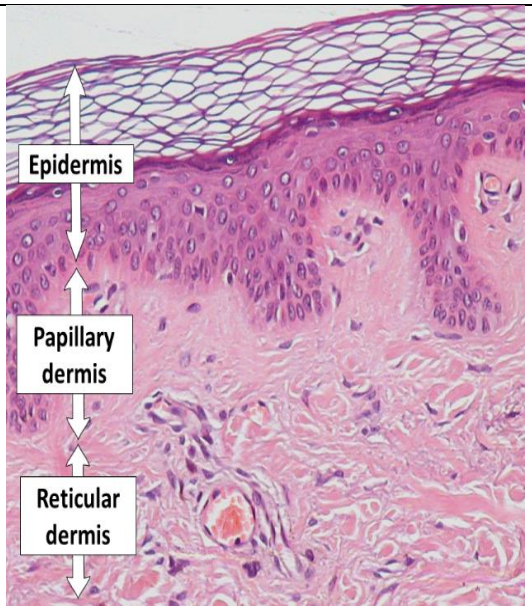


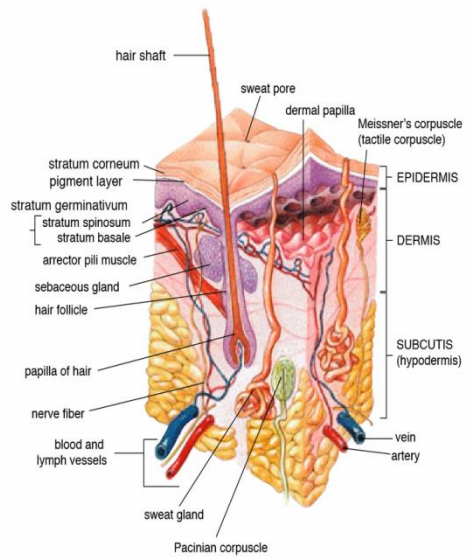
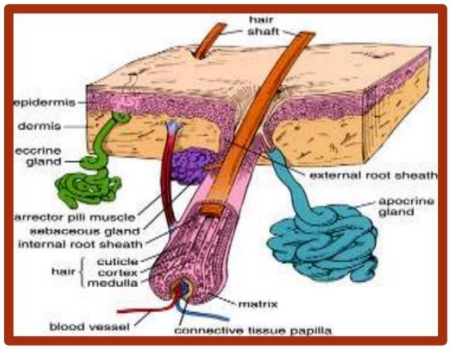
Matrix Components

Layers	
Papillary Dermis	The papillary dermis is the superficial layer, lying deep to the epidermis. The papillary dermis is composed of loose connective tissue that is highly vascular.
Reticular Dermis	The reticular layer is the deep layer, forming a thick layer of dense connective tissue that constitutes the bulk of the dermis.

Contents	
Blood Vessels	The blood vessels supply nutrients and oxygen to the skin and take away cell waste and cell products. The blood vessels also transport the vitamin D produced in the skin back to the rest of the body.
Lymph Vessels	The lymph vessels bathe the tissues of the skin with lymph, a milky substance that contains the infection-fighting cells of the immune system. As the lymph moves to its lymph nodes, these cells seek to destroy any infection or invader organisms.
Hair Follicles	The hair follicle is a tube shaped sheath that surrounds part of the hair beneath the skin, nourishing it.
Sweat Glands	The average person has about 3 million sweat glands. Sweat glands are classified according to two types: • Apocrine glands are specialized sweat glands that can be found only in the axilla and pubic region. These glands secrete a milky sweat that encourages the growth of the bacteria responsible for body odour. • The real sweat glands are the eccrine gland. These glands, which are found all over the body, allow water to

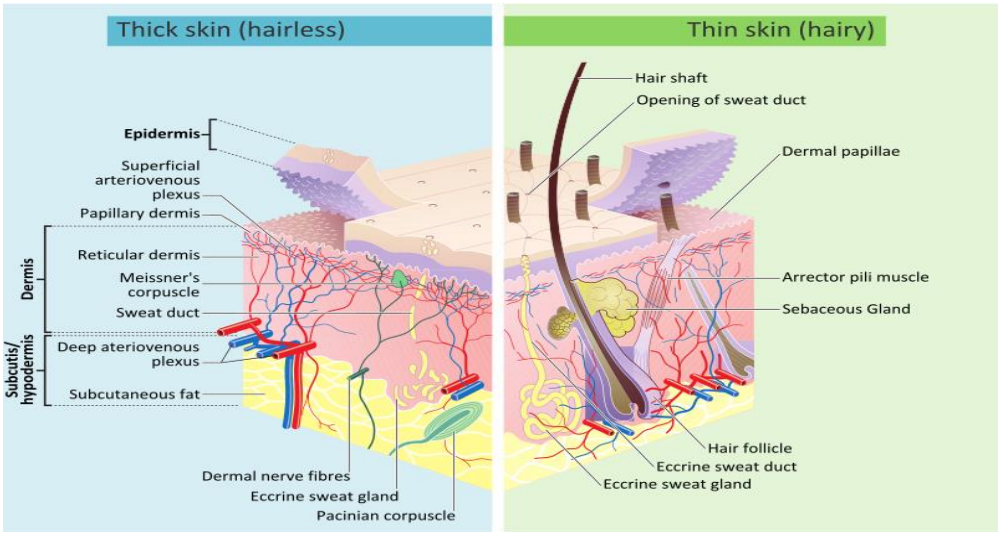
Sebaceous gland

			pass through its pores into the surface of the skin where it is dissolved and reduced in temperature. These glands are capable of producing up to two liters of sweat an hour, but they produce mostly water, which is not conducive to the growth of odor producing bacteria.	 Layers of Dermis
		Sebaceous glands	Sebaceous glands, also known as oil glands, attach to hair follicles. They can be found anywhere on the body except on the palms of your hands and on the soles of your feet. The sebaceous glands release oil that keeps your skin soft and supple. This oil also helps keep your skin hydrated and prevents the growth of harmful bacteria and fungi on your skin.	
		Nerve Endings	There are also pain and touch receptors on the dermis layer that send sensations of pain, itching, pressure and temperature information to the brain for processing. When needed, shivering (voluntary contractions and relaxation of the muscles) occurs, producing body heat.	
		Collagen & Elastin	Fibroblasts make collagen, the protein that holds the dermis together. The skin is made up of many different types of cells, but it's the skin cells that make up the dermis. Collagen helps keep the skin strong and resilient. It's an insoluble protein that's found in connective tissues throughout the body, where muscles and organs attach to each other. In your skin, collagen holds your epidermis together and gives your skin the durability it needs. Elastin is another type of protein that holds your skin together. When you stretch your skin, it stretches back into place and keeps your skin flexible.	
05	Hypoderm is	Function	Insulator Shock Absorber	
		Structure	• • Fibrous bands anchoring the skin to the deep fascia. • Collagen and elastin fibers attaching it to the dermis.	

			• Fat is absent from the eyelids, clitoris, penis, much of pinna, and scrotum. • Blood vessels on route to the dermis. • Lymphatic vessels on route from the dermis. • The glandular part of some sweat glands; mammary glands lie entirely within the subcutaneous tissue (which are modified apocrine sweat glands). • Cutaneous nerves and free endings • Hair follicle roots • Ruffini and Pacinian corpuscles • Mast cells • Bursae, in the space overlying joints in order to facilitate smooth passage of overlying skin • Fine, flat sheets of muscle, in certain locations, including the scalp, face, hand, nipple, and scrotum, called the panniculus carnosus	
06	Skin Appendages	Eccrine / Apocrine sweat glands Sebaceous glands. Hair Follicles. –Nails		

❖ **Comparison between the Thick & Thin Skin:**

Sr. No.	Points	Thick Skin	Thin Skin
01	Area covered	The skin from the palms & soles having thicker epidermis	Other portions of the body having thinner epidermis
02	Epidermis	• Thick: Thick Malpighian layer & granular layer • Very thick horny layer • Posses a Lucidium layer	• Thin: Thin Malpighian layer & granular layer • Very thin horny layer • Lacks a Lucidium layer
03	Hair Follicles	Lacks hair follicles	Contains hair follicle
04	Arrector pili	Absent	Present
05	Dermis	Thin	Thick
06	Sebaceous gland	Lacks	Contains
07	Sweat Glands	Has numerous, spirally coiled	Fewer sweat glands
08	Sensory Receptors	Denser	Sparser
09	Characteristics of Surface	Contains both ridges & furrows	Lacks in both ridges & furrows
10	Dermal papillae	Regular	Irregular



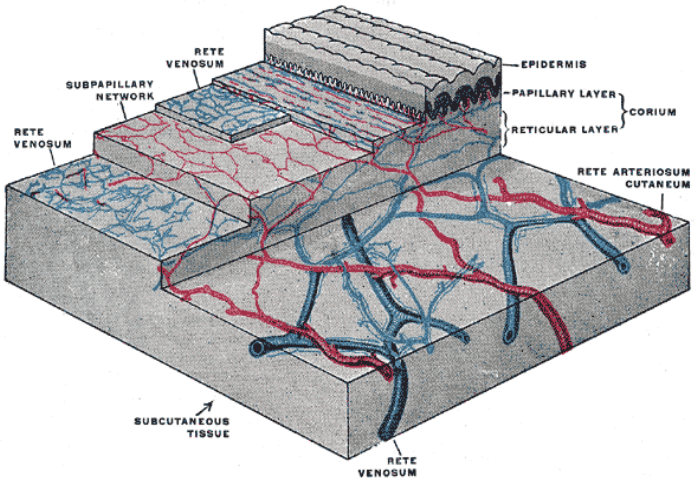
Comparison Between Thick & Thin Skin

❖ **Vascular Supply & Lymphatic Drainage:**

▪ The two plexuses that make up the blood supply to the skin are located between the dermis's papillary and reticular layers and between the dermis and subcutaneous tissues.

▪ The superficial arteriovenous plexus, also known as the subepidermal/papillary plexus, provides supply to the epidermis. These containers are crucial for controlling temperature. The body's highly efficient system for controlling temperature through the skin transfers heat from the body to the surroundings by increasing blood flow to the skin.

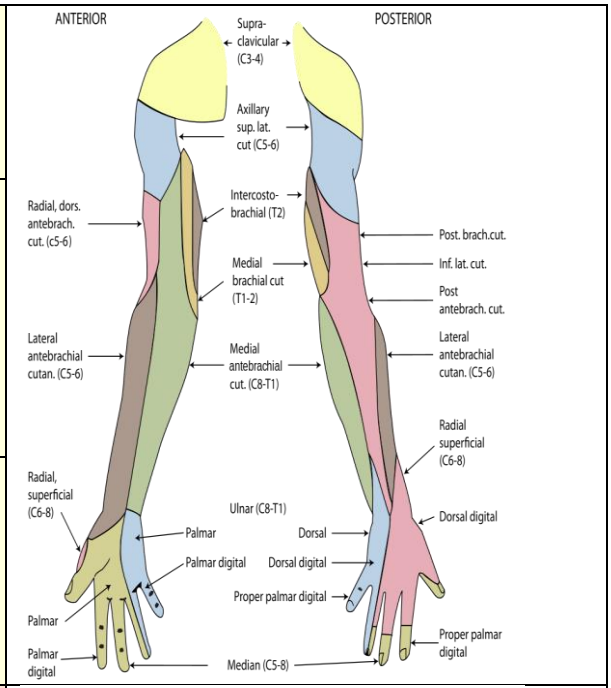
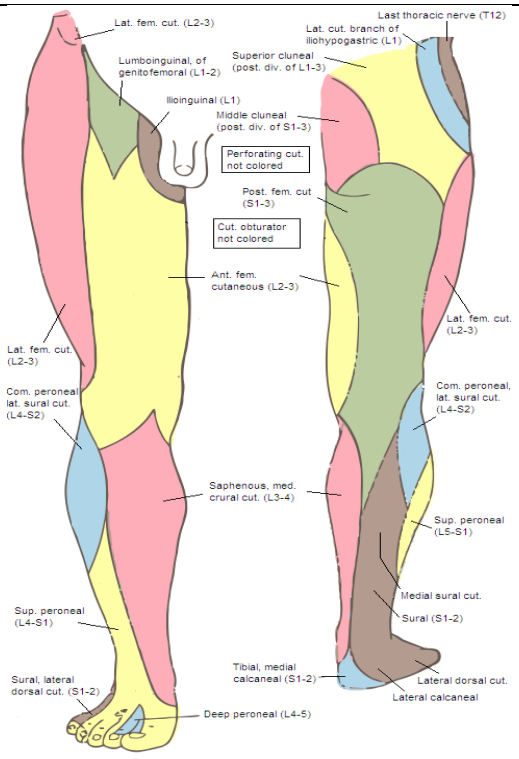
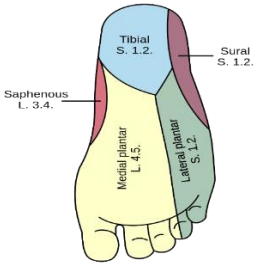
▪ The autonomic nervous system regulates blood flow, with sympathetic stimulation leading to vasoconstriction (heat retention) and vasodilation (heat loss).

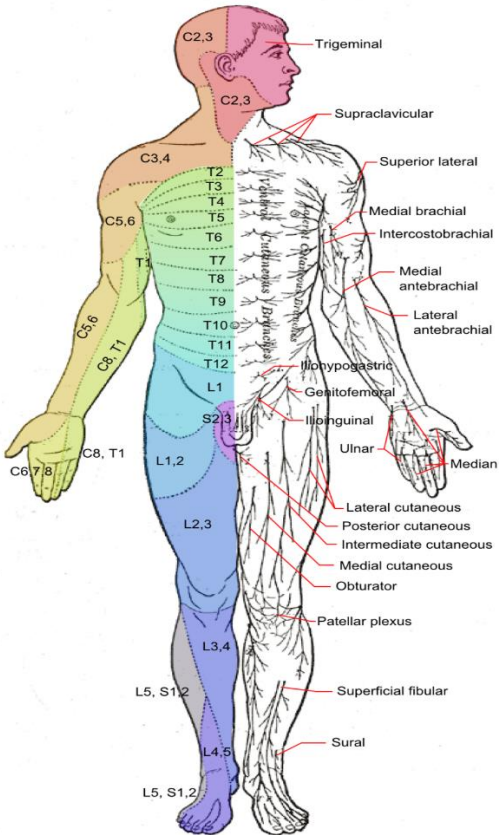
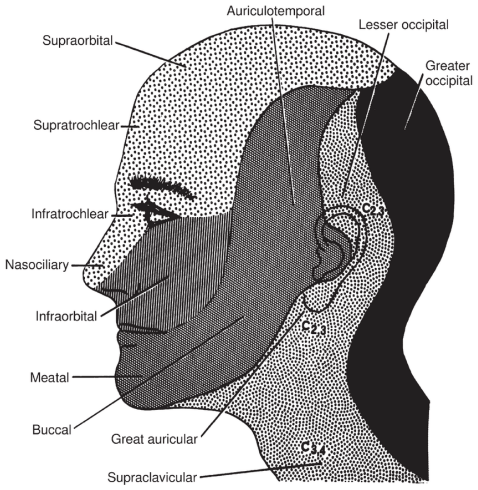


Vascular Supply of Skin

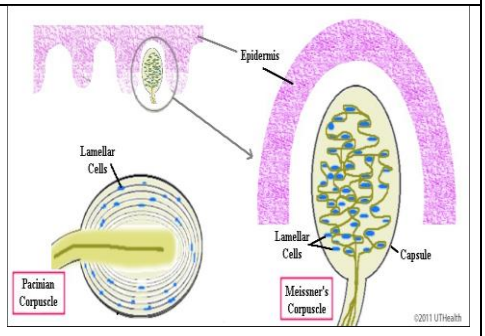
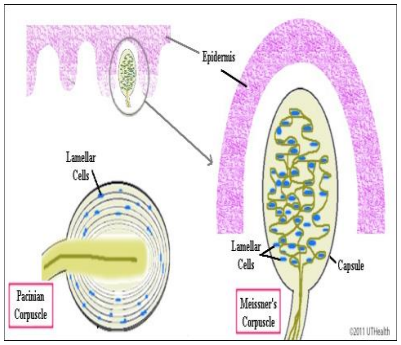
❖ **Nerve Supply:**

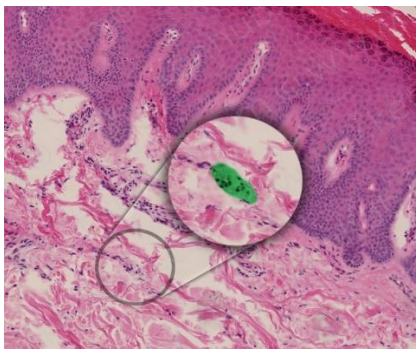
Sr. No.	Area of Supply	Structures supplied	Name of the Nerve	Diagrammatic view
01	Superior Extremity	Arms & Shoulders	• Supraclavicular nerve • Axillary Nerve • Inferior lateral cutaneous nerve of arm • Intercostobrachial nerve	

			• Medial cutaneous nerve of arm • Posterior cutaneous nerve of arm	
		Forearms	• Lateral cutaneous nerve of forearm • Medial cutaneous nerve of forearm • Posterior cutaneous nerve of forearm	
		Hands	• Superficial branch of the radial nerve • Median nerve • Superficial branch of ulnar nerve	
02	Inferior Extremity	Pelvis & Buttock	• Lumboinguinal nerve • Medial cluneal nerves • Inferior cluneal nerves • Perforating cutaneous nerve • Superior cluneal nerves • Iliohypogastric nerve • Subcostal nerve	
		Thighs	• Lateral cutaneous nerve of thigh • Anterior cutaneous branches of the femoral nerve • Cutaneous branch of the obturator nerve • Posterior cutaneous nerve of thigh	
		Legs	• Common fibular nerve • Saphenous nerve • Superficial fibular nerve • Sural nerve	
		Feet	• Deep fibular nerve • Medial calcaneal branches of the tibial nerve	

			• Medial plantar nerve • Lateral plantar nerve	
03	Trunk		• Ventral cutaneous branches • Lateral cutaneous branches • Dorsal cutaneous branches	
04	Neck & Head		• Supraorbital nerve • Infraorbital nerve • Mental nerve • Buccal nerve • Auriculotemporal nerve • Supraclavicular nerves (C3, C4) • Great auricular nerve (C2, C3) • Greater occipital nerve (C2)	

Sr. No.	Structures	Characteristics	Image
01	Free Nerve Endings	Neuronal receptors in the epidermis. • Terminate in the stratum granulosum.Most numerous.	

		• Lack a connective tissue or Schwann cell investment, "free." • Heat, cold, itch, and pain. • Surround most hair follicles - mechanoreceptors ("whiskers" Neuronal receptors in the epidermis. • Terminate in the stratum granulosum.Most numerous. • Lack a connective tissue or Schwann cell investment, "free." • Heat, cold, itch, and pain. • Surround most hair follicles - mechanoreceptors ("whiskers" • Neuronal receptors in the epidermis. • Terminate in the stratum granulosum. Most numerous. • Lack a connective tissue or Schwann cell investment, "free." • Heat, cold, itch, and pain. • Surround most hair follicles - mechanoreceptors ("whiskers").	
02	Pacinian Corpuscle	• Deep pressure receptors for mechanical and vibratory pressure; enclosed in connective tissue capsule. • Found in deeper dermis, hypodermis, and associated with joints, periosteum, organs. • Myelinated nerve ending surrounded by a capsule. • "Onion" appearance on microscope. • Responds to pressure and vibration by displacement of the capsule lamellae which causes depolarization of the axon.	
03	Meisner's Corpuscle	• Touch receptors within dermal papillae. • Especially responsive to low-frequency stimuli in papillary layer of • Appear like a twisted string on microscopy. • Touch receptors within dermal papillae. • Especially responsive to low-frequency stimuli in papillary layer of hairless skin (lips, palmar surfaces, etc.). • Appear like a twisted string on microscopy	

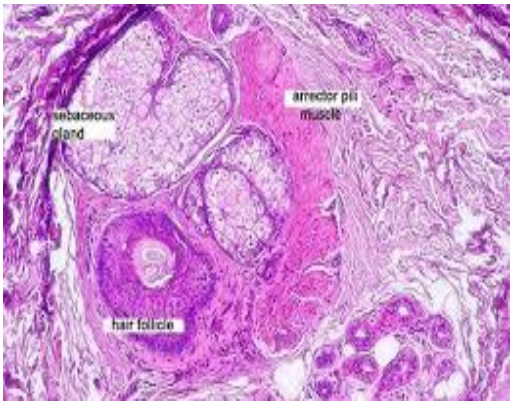
04	Ruffini's Corpuscle	• In the dermis. • Mechanical displacement of collagen fibers • Location: Dermis and hypodermis of both hairy and glabrous skin & in the dermis. • Mechanical displacement of collagen fibers • Respond to stretch and movement stimuli	

Neuronal receptors in the epidermis.

- Terminate in the stratum granulosum.Most numerous.
- Lack a connective tissue or Schwann cell investment, "free."
- Heat, cold, itch, and pain.
- Surround most hair follicles - mechanoreceptors ("whiskers"

❖ **Muscles:**

➢ **Arrector Pili Muscle:**



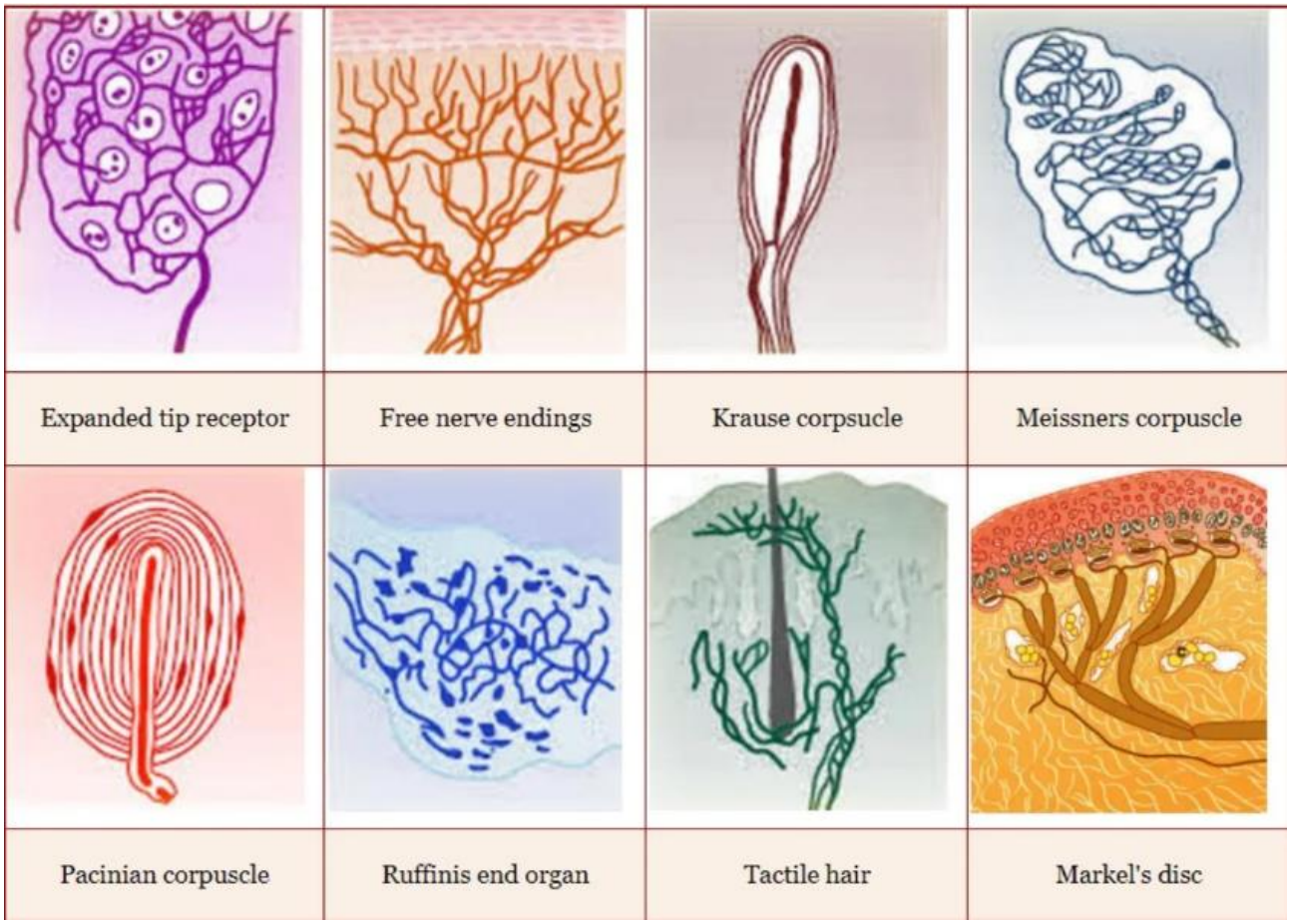
• A bundle of smooth muscle fibers that attach to the connective tissue sheath of the hair follicle.

• When muscle contracts, pull hair follicle outward and makes the hair stand up. Hairs do not exit perpendicular but at an angle.

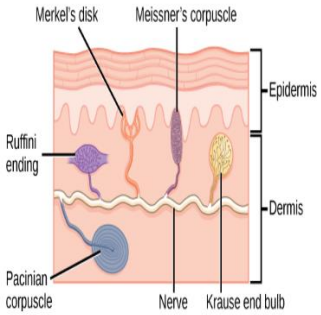
• Produce Goosebumps or dimpling of the skin.

• Also, produces a squeezing of sebaceous glands causing their secretions to be emptied.

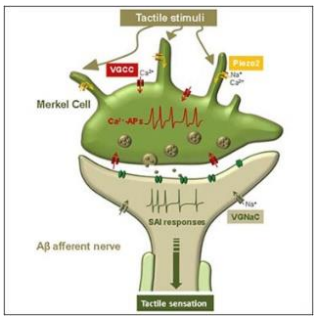
❖ **Cutaneous Receptors:**



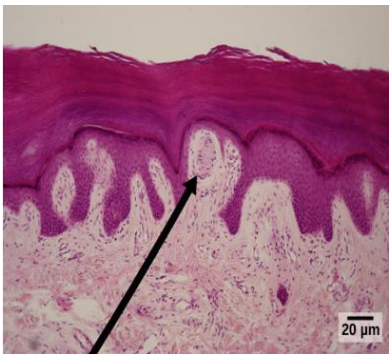
Cutaneous Receptors

Receptors	Type of Receptors	Descriptions			
Somatosensory Receptors	Mechanoreceptors 	**Classes**	Tactile Proprioceptors Baroreceptors	Types	**Merkel's Discs:** Located near the surface of the skin. Merkel's discs are found in the upper layers of skin near the base of the epidermis, both in skin that has hair and on glabrous skin; that is, the hairless skin found on the palms and fingers, the soles of the feet, and the lips of humans and other primates. Merkel's disks are densely distributed in the fingertips and lips. They are slow-adapting, unencapsulated nerve endings, which respond to light touch. Light touch, also known as discriminative touch, is a light pressure that allows the location of a stimulus to be pinpointed. The receptive fields of Merkel's disks are small, with well-defined borders. That makes them very sensitive to edges; they come into

use in tasks such as typing on a keyboard. Merkel's discs are responsible for the transduction & encoding of tactile stimuli.

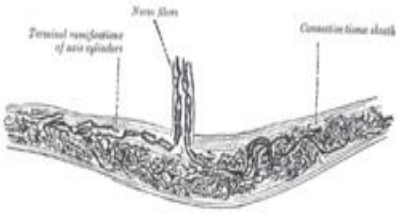


Meissner's corpuscles: Located near the surface of the skin. Meissner's corpuscles are found in the upper dermis, but they project into the epidermis. They are found primarily in the glabrous skin on the fingertips and eyelids. They respond to fine touch and pressure, but they also respond to low-frequency vibration or flutter. They are rapidly- adapting, fluid-filled, encapsulated neurons with small, well-defined borders which are responsive to fine details. Merkel's disks and Meissner's corpuscles are not as plentiful in the palms as they are in the fingertips.

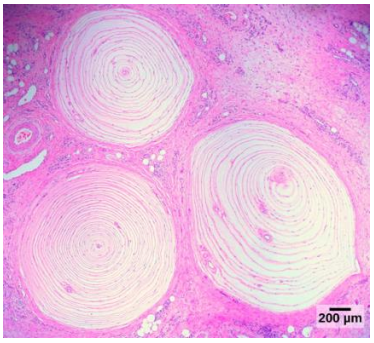


Ruffini Endings: Located deeper to the surface of the skin. They are found in both glabrous and hairy skin. These are slow-adapting, encapsulated mechanoreceptors that detect skin stretch and deformations within joints; they provide valuable feedback for gripping objects and controlling finger position and movement. Thus, they also contribute to

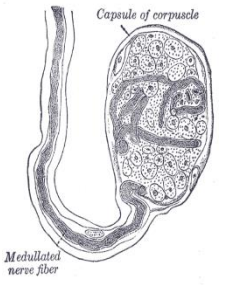
proprioception and kinaesthesia. Ruffini endings also detect warmth. Note that these warmth detectors are situated deeper in the skin than are the cold detectors. It is not surprising, then, that humans detect cold stimuli before they detect warm stimuli.



Pacinian corpuscle: Located deeper to the surface of the skin. Pacinian corpuscles, located deep in the dermis of both glabrous and hairy skin, are structurally similar to Meissner's corpuscles. They are found in the bone periosteum, joint capsules, pancreas and other viscera, breast, and genitals. They are rapidly-adapting mechanoreceptors that sense deep, transient (not prolonged) pressure, and high-frequency vibration. Pacinian receptors detect pressure and vibration by being compressed which stimulates their internal dendrites. There are fewer Pacinian corpuscles and Ruffini endings in skin than there are Merkel's disks and Meissner's corpuscles.



Krause & Bulbs: found in specialized regions.

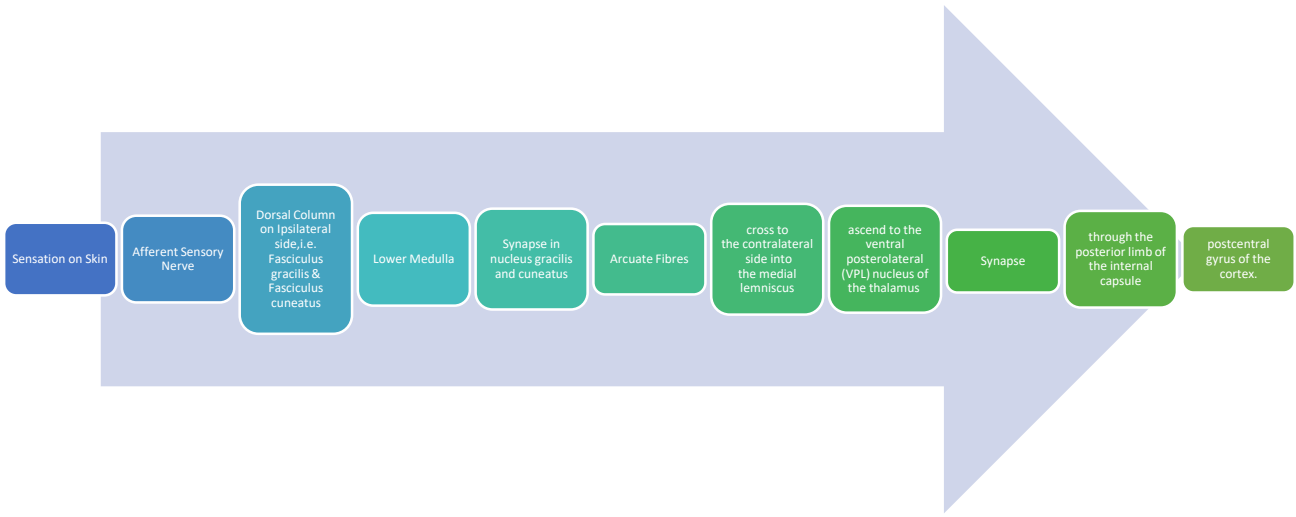
					
	Thermoreceptors	Types	Receptors sensing Heat: Sensing temperatures sensing between 30 and 45°C Receptors sensing Cold: Sensing temperatures sensing between 17 and 27°C	Pathway	The thermoreceptor pathway in the brain runs from the spinal cord through the thalamus to the primary somatosensory cortex. Warmth and cold information from the face travels through one of the cranial nerves to the brain.

❖ **Anatomy of Touch:**

Sensations begin as signals generated by touch receptors in your skin. They travel along sensory nerves made up of bundled fibers that connect to neurons in the spinal cord. Then signals move to the thalamus, which relays information to the rest of the brain. Next stop is the somatosensory cortex, where signals are translated into a touch perception.

Somatosensory information from all over the body spreads onto the cortex forming a topographic map that curls around the brain like headphones. Sensitive areas, like lips and fingertips, stimulate much larger regions of the cortex than less sensitive parts. A region's sensitivity depends on the number of receptors per unit area and the distance between them. Unlike the very sensitive lips and hands, receptors on your back are few and far apart so it's much less sensitive.

Sensitivity will be measured by examining the minimum distance between two points on the skin a person can identify as distinct stimuli rather than a single stimulus. Perception is greatest where the two-point threshold is lowest, in the most densely nerve-packed areas, like fingers and lips. But you can distinguish two stimuli on your back only if the are several centimeters apart.



Both a sensory and emotional experience, pain signals tissue damage or the potential for damage and makes the experience feel unpleasant and upsetting. During any exposure, irrespective of the nature of stimuli special sensory neurons, nociceptors, respond to the impact. Nociceptors are attuned to stimuli that cause tissue damage. They respond to strong stimuli, telling you when something is truly dangerous. Different nociceptors are sensitive to different painful stimuli, like thermal (heat or cold), mechanical (wounds), and chemical (toxins or venoms).

Some nociceptors respond only to chemical stimuli causing itch. Histamine receptors activate when skin irritation, bug bites, or allergies trigger the release of histamine in the body. Itch receptors have molecular channels in their cell membrane that open when they detect histamine. There are identified other itch-specific receptors that activate when they detect other molecules including, prostaglandins, neuropeptides, and proteases the body releases in response to pain and irritants.

Injury triggers the release of various chemicals at the site of damage, causing inflammation. This inflammatory "soup" prompts nerve impulses that keep you feeling pain, so you'll protect the injury. Prostaglandins make receptors more sensitive to pain, so pain feels more intense. A long-lasting injury may lead to nervous system changes that enhance perceived pain, even without pain stimuli. This neuropathic pain is caused by an over-sensitive nervous system rather than an injury. In diabetic neuropathy, prolonged exposure to high blood sugar damages nerves in the hands and feet, sending signals of numbness, tingling, burning, or aching pain.

➢ **The Science of Hugs:**

Our bodies are equipped with two distinct touch systems: the rapid touch system and the slow touch system. The rapid touch system is responsible for our ability to quickly detect and discriminate between different types of touch. It's what allows us to feel the texture of a surface or the pressure of a handshake.

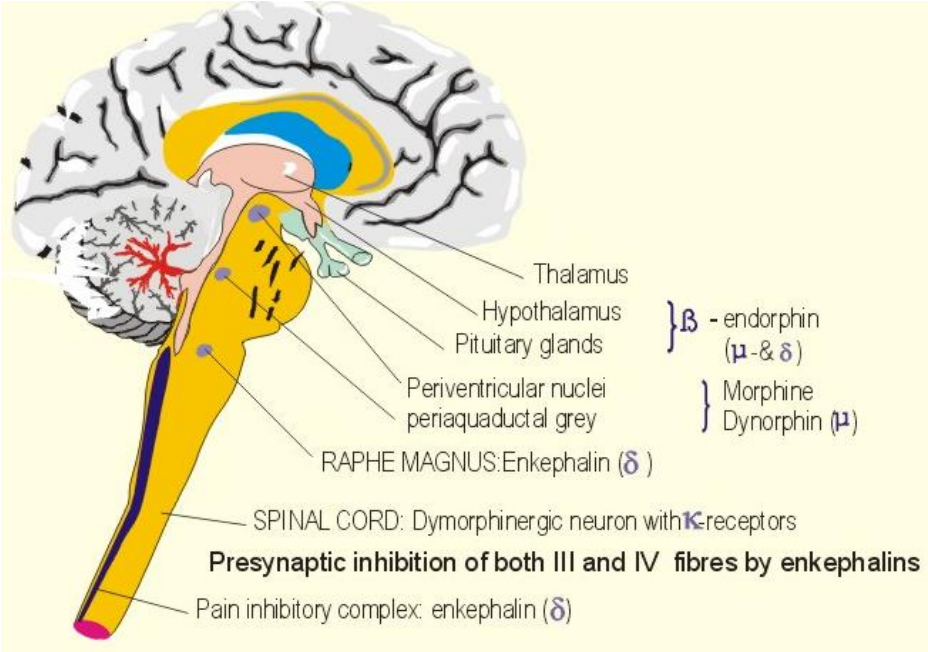
In contrast, the slow touch system is responsible for the emotional aspects of touch. It's what allows feeling the warmth and comfort of a hug or the gentle caress of a loved one. This system is mediated by a recently discovered type of nerve fiber called C-tactile afferents, which are unmyelinated and slower-conducting than the myelinated A-beta afferents of the rapid touch system. The slow stroking involved in grooming stimulates a particular set of nerves – the afferent c-tactile neurons that are found only in hairy skin and are quite different to the usual nerves that convey information about touch, pain and pressure. These neurons respond only to light and slow stroking. They have a direct route into the brain, where they trigger the release of endorphins.

Endorphins are neuropeptides, small molecules that are used by neurons in the brain to signal to each other. Endorphins are part of the pain control system, and produce an opiate-like analgesic effect. In fact, they are chemically closely related to opiate drugs like morphine, but differ in two key respects: on a weight for weight basis, they are 30 times more effective as painkillers than morphine, and there is no adverse effects one can encounter in case of morphine & the chance of its addiction.

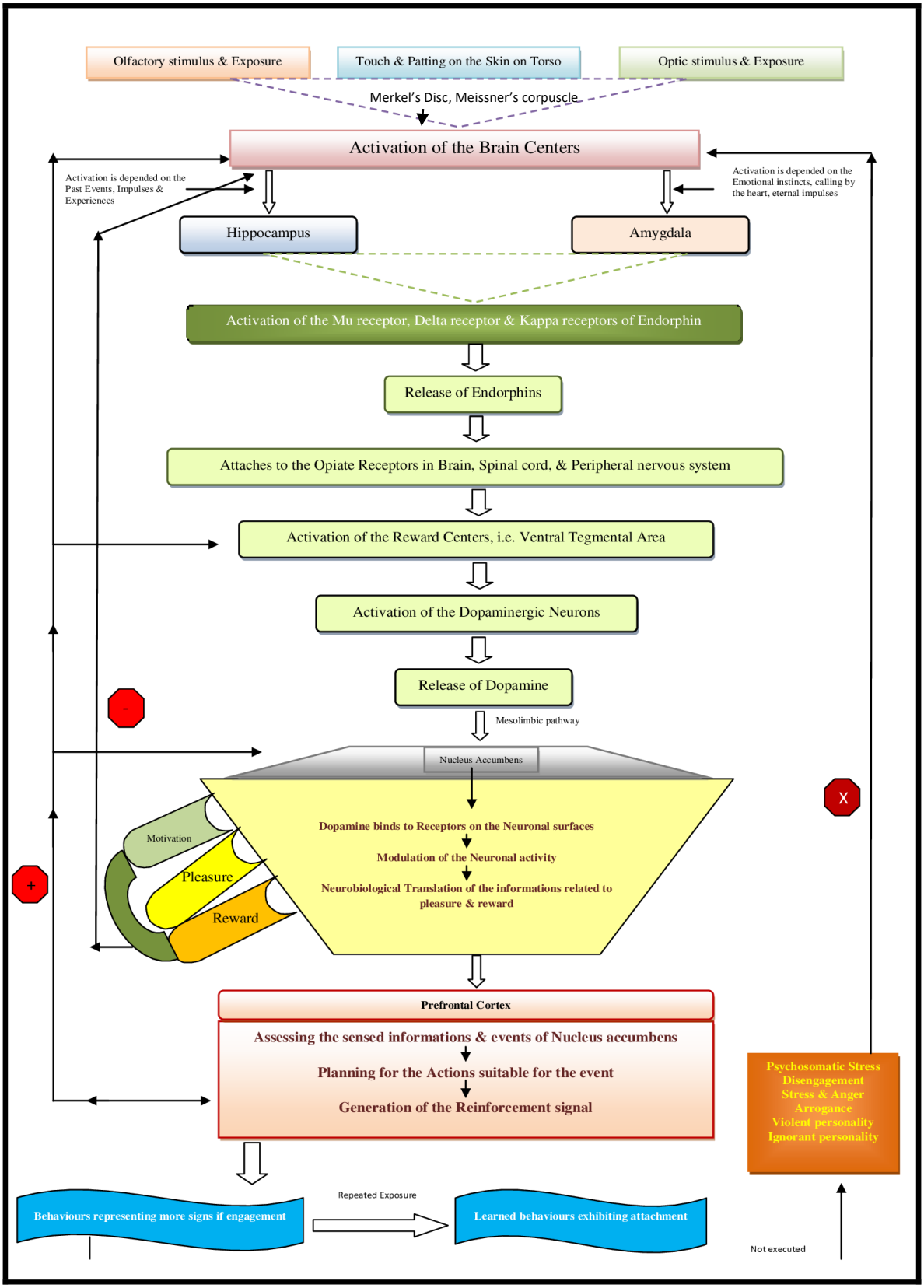
Positron emission tomography (PET for short) is useful to show that light stroking of the torso triggers a massive endorphin response in the human brain. Cuddling, with its concomitant behaviours of stroking, patting and even the occasional leafing through the hair, is the human form of primate grooming, and is designed to create and maintain the foundations of relationships. Pain from both psychological & from physical origin are processed by same regions of

brain, notably part of anterior cingulate cortex & periaqueductal gray, mainly responsible for release of endorphin, used to resolve the pain with its adverse reaction.

Endorphins, often famous as androgens or endorphins, are morphine-like biochemically generated hormones that are endogenous (secreted by the pituitary gland). It is an amino molecule (peptide) released by vertebrates' pituitary glands and hypothalamus. These are very useful for the secretion of dopamine & also responsible for the commitment, relationship building, sense of pleasure & reward.



Receptors for Endorphin Action



Mechanism of Touch, Love & Engagement

➢ **Benefits:**

Categories	Benefits	Description
Psychological benefit	**Oxytocin & Bonding**	At the heart of the psychological benefits of hugs lies the hormone oxytocin. Hugging stimulates the release of oxytocin, often referred to as the "love hormone." This neurochemical cascade fosters feelings of bonding, trust, and emotional connection, solidifying the foundations of relationships.
	Stress Reduction	Hugs are powerful stress busters. The activation of the slow touch system and oxytocin release act as a natural antidote for stress. Cortisol, the stress hormone, will take its place and allow a calmer state of mind to develop.
	Mood Elevation	The emotions of hugging are contributing to an increase in mood. A positive feedback loop, which increases feelings of happiness and wellbeing, is created by sensory input from a slow touch system combined with the release of endorphins.
	Boosts Self-Esteem	Hugs have been demonstrated to increase serotonin and dopamine levels, neurotransmitters related to mood and wellbeing. The release of endorphins, natural painkillers which produce feelings of happiness and wellbeing are also released by hugging. These positive effects can increase self-esteem and promote a positive image of oneself.
	Strengthens Relationships	By increasing the level of oxytocin, hugs foster social connection and bonding. Oxytocin helps to promote empathy, trust and attachment, strengthening relationships with loved ones as well as reducing feeling of loneliness.
Physiological benefit	**Cardiac Health**	In addition to its psychological impact, hugging has a tangible effect on the health of the heart. The calming effect of hugging can lead to a reduction in blood pressure, and over time it may also promote the well being of your heart.
	Modulation of the Immune system	The emotional connection facilitated by hugs is not limited to the realm of emotions. Oxytocin has an immune modulating effect, as well as its role in bond formation. A more effective immune system can be supported by regular embraces.
	Pain Relief	Natural relief from pain is the release of endorphins, caused by a gentle touch system in hugs. In particular, individuals who are uncomfortable with their own bodies may benefit from this.

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