The Skin

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The integument or skin

Forms the external covering of the body. In fishes it protects against mechanical injury and noxious agents on the one hand and helps in respiratory, excretory and osmoregulatory functions on the other. The skin in teleosts shows some inter-species differences; some species have no scales while others have special large epidermal alarm substance cells (club cells). The skin is composed of two layers, an outer epidermis and an underlying dermis.

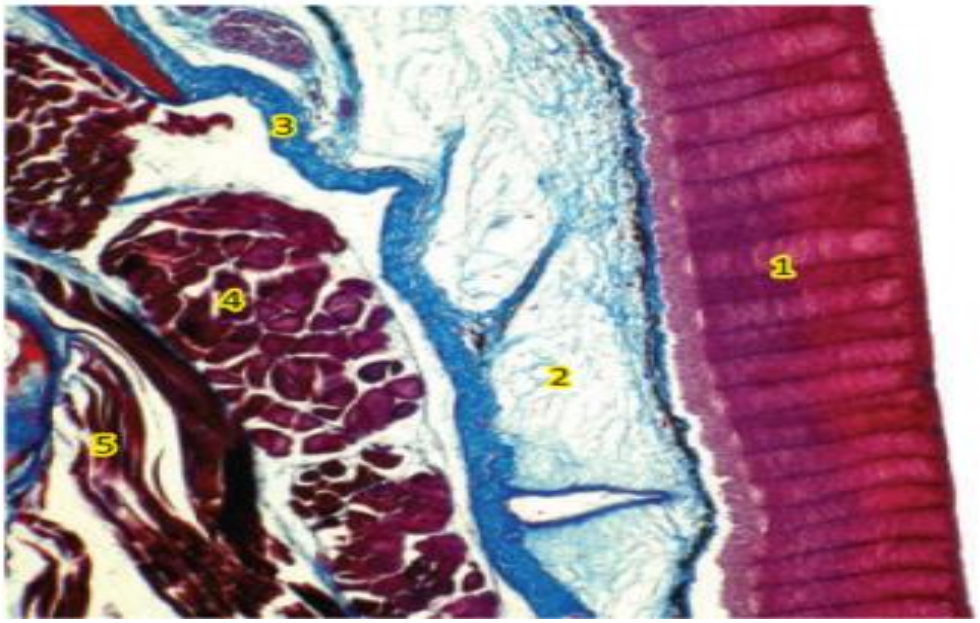


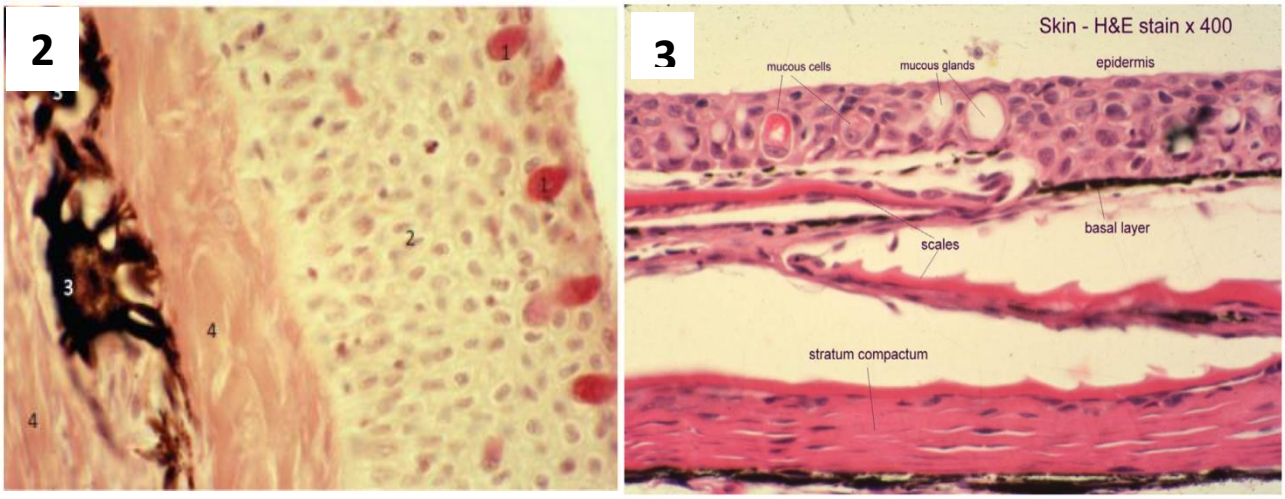
Fig. 1: The typical two layers of teleost skin comprise epidermis (1) and dermis. This latter usually is made up of two strata: an upper spongiosum (2) right beneath the epidermis and a deeper compactum (3). Collagen is stained blue.

EPIDERMIS

The epidermis (Fig.1) is a non-keratinizing stratified squamous epithelium that varies in thickness from 3-5 cells (caudoventral region) up to 20-25 (cephalodorsal region). The thickness of the epidermis varies greatly depending on the part of the body, age, sex, stage of reproductive cycle, and environmental stresses. The epidermis of a yearling rainbow trout is 5 to 10 cells thick; it consists of outer squamous and cuboidal cells and a basal germinal layer, that gives rise to the differentiated cells outside it.

A major difference from mammals is that in teleosts, the outermost epidermal fusiform cells remain viable, and retain the capacity to divide; this has obvious implications for healing processes. Cells found within the epidermis include : the filament-containing or malpighian cells that represent the major component; mucous cells responsible for secreting primarily glycoproteins (mucus), forming a slimy protective coat (Figs. 2,3). Functions attributed to this coat include drag reduction, predator evasion, and isolation of superficial epithelial cells from bacteria. Immunoglobulins, also present in mucus, provide additional protection against infection. In addition, the skin contains wandering leucocytes and macrophages.

Some fish have large eosinophilic (acidophilic) epidermal cells releasing fright substances when ruptured (the club cells). Other cellular types may also be present : sensory cells, glandular cells and also granular complex cells, with various roles, not always fully understood. In mormyrids the electroreceptive epidermis consists of three layers : the superficial polyhedral cells, the flat cells of the intermediate layer and the basal polyhedral layer.



Figs. 2,3: The epidermis is non-keratinized the protective role of this epithelium seems to be limited primarily to the deposition of the outer mucous coat by the mucus-secreting cells (magenta - 1). The other epidermis cells are filament-containing or Malpighian cells (2) always in majority. One can see chromatophores (3) in the dermis (4).

DERMIS AND HYPODERMIS

The dermis (Figs. 1,4) contains two layers : spongiosum (laxum) and compactum. The thickness of stratum spongiosum situated at the base of the epidermis is variable in different parts of the body and contains collagen and reticulin fibers, nerves, capillaries, fibroblasts and pigment cells.

The stratum compactum is more developed than the stratum laxum and is formed by densely compressed bundles of collagen fibers that run parallel to the skin surface. Sometimes only the stratum compactum is present (Fig. 4).

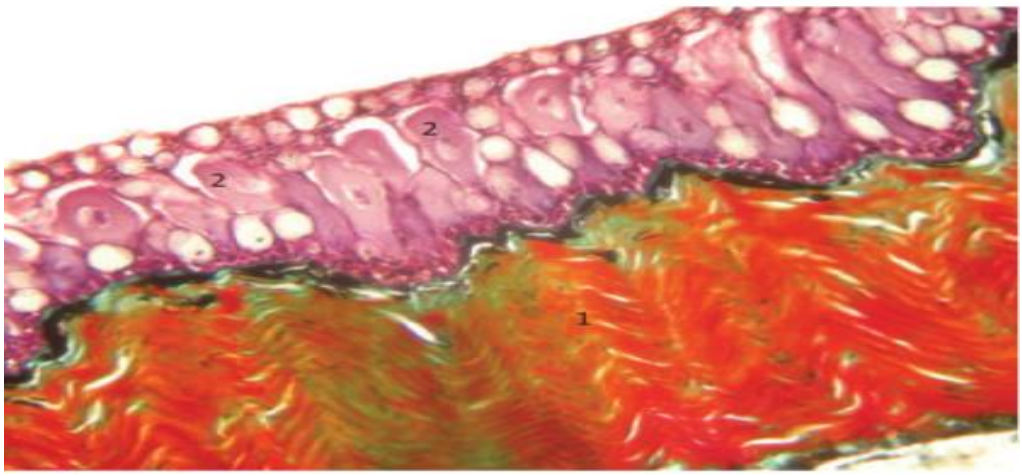


Fig. 4: A stratum compactum (1) The dermis acts as a tendon in parallel with the muscles. The epidermis contains large pink club (alarm) cells (2) and unstained mucous cells scattered throughout the epithelium.

Beneath the dermal layer is a looser, adipose tissue, which is generally more vascular than the overlying dermis. This is the hypodermis. It is a frequent site of development of inflammatory processes. However, the hypodermis is not distinguishable in many regions, and some authors say that this layer does not exist in fish and is part of the deep dermis.

SKIN COLORATION

In fish, the skin coloration is well marked. A large number of teleosts are brightly and brilliantly colored, while others are of a more uniform. The pattern of coloration relates to the life style of the animal and has functional significance.

Coloration has been attributed to the presence of large numbers of a variety of pigment-cells types (chromatophores- Figs. 5) that are present at different levels within the dermis : these include melanophores, xanthophores, erythrophores and iridophores.

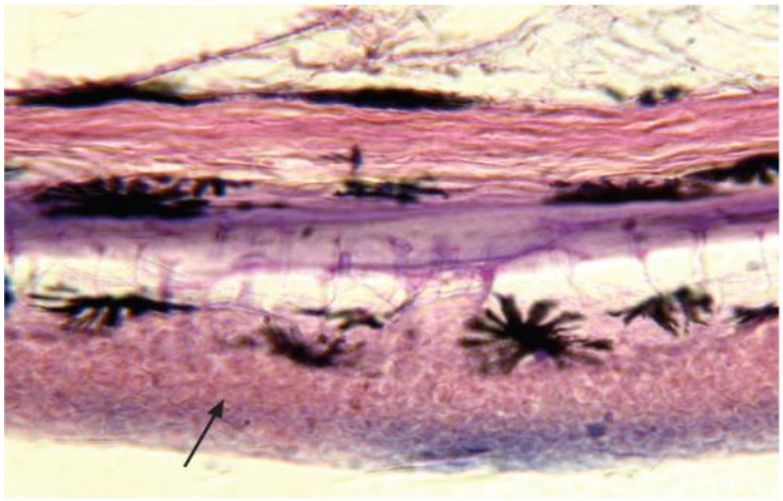


Fig. 5: Fishes may contain both dermal and epidermal melanophores (black). Dermal melanophores are located just underneath the epidermis (arrow) in close apposition to the

Melanophores are the most common class of fish pigment cells. The pigmented material of melanophores, called melanin, is deep brown in color. Melanin synthesis involves conversion of the amino acid tyrosine, by means of copper containing enzymes. Within melanophores, melanin accumulates in vesicles known as melanosomes. The melanophores are often star-shaped, of neuroectodermal origin. Light microscopy is often unable to identify xantophores by histologic observation, perhaps because of xanthophore pigments, which consist mainly of carotenoids and pterines. These are, respectively, fat- and water-soluble and may be lost during sample preparation. Iridophores are also difficult to detect in routine histology. Color patterns of a majority of fishes are due to the combined effects of chromatophores containing different kinds of pigments. The coloration in fishes performs adaptive functions and is useful to the animal in a variety of ways such as camouflage, aggressive purpose, courting patterns, etc.

Scales are a major feature of most species of teleosts but they can be very reduced in some groups of fish another lack scales completely, have one highly complex physiological feature in common which is absent in all other groups of teleostean fishes: the fright reaction elicited by alarm substance produced by special epidermal cells : the club cells. These large cells have a centrally located nucleus and an eosinophilic cytoplasm. As they do not reach the surface of the integument, only injury of the skin can release the content of these cells into the water leading to the fright reaction of congeners (Fig. 6)

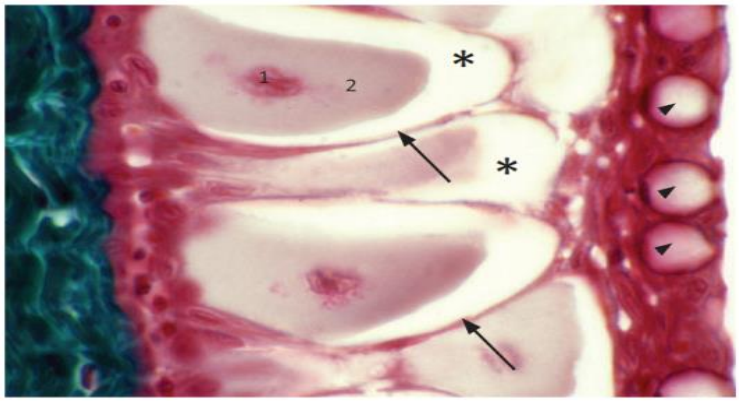


Fig. 6: These large cells have a centrally located nucleus (1) and an eosinophilic cytoplasm (2). The arrowheads point to superficial mucous cells. In green, the dermis.

They are several types of scales. The placoid scale is found in the skin of some fish and consists of a spine and a basal plate; it contains a pulp cavity and is composed of a layer of dentine covered by enamel (Fig.7).

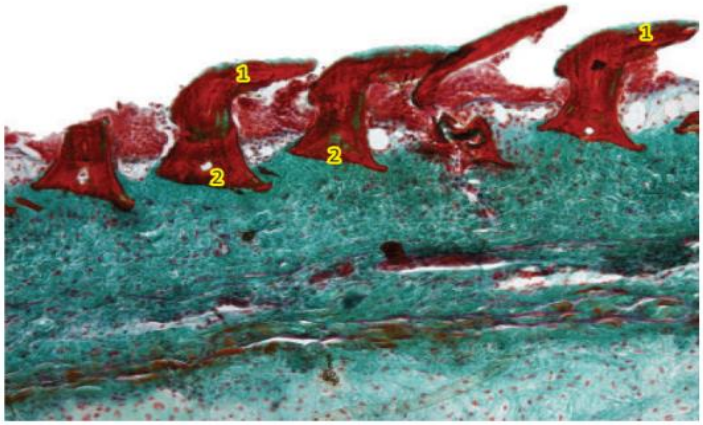


Fig. 7: Dogfish are protected by a rough skin covered by dermal bony denticles or placoid scales consisting of a backward-pointing spine (1) and a basal plate (2). These denticles bear a resemblance to teeth, and are larger on the dorsal surface of the body. They do not increase in size but are continuously replaced from underneath. Collagen in green.

Ganoid scales found in Polypteridae and Lepisosteidae are the only fish which possess, often rhomboidal in shape, with thick outer ganoine layer (enamel-like substance). Cosmoid scales are scales with four layers, and are characteristic of Sarcopterygii. The teleost scale comprises an outer osseous part, and an inner layer that consists of parallel collagen fibers embedded in an organic matrix. They

originate in scale-pockets (Figs. 8) in the dermis and extend toward the exterior of the animal in an overlapping way and are covered by the epidermis.

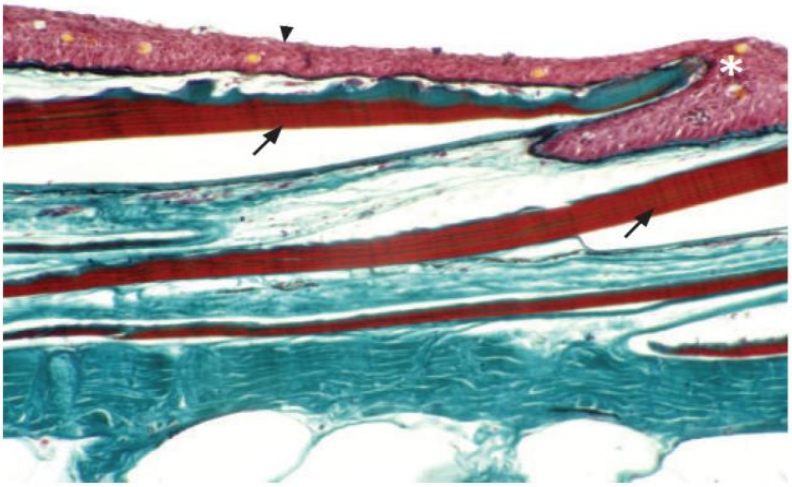


Fig. 8: Section showing the general structure of a scaled bony fish skin. Scales (arrows) embedded in the dermis, overlap one-another in an imbricated manner with free ends caudally pointed. The (*) pinpoints a scale-pocket actually formed by a skin fold in which a scale is seated. The arrowhead points to the epidermis.

Teleosts have ctenoid scales (with small spines on the posterior edge – Figs. 9-10) or cycloid scale (round or oval scale composed of acellular dermal bone without spines).

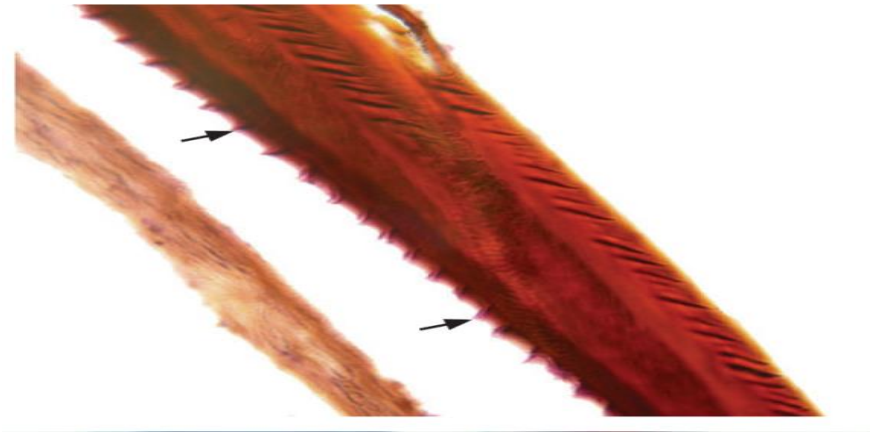


Fig. 9: (cycloid and ctenoid) scales are restricted to teleosts. They consist of an outer osseous part and an inner layer of parallel collagen fibers embedded in a proteinic extracellular matrix. The resulting bone is flexible and soft. This micrograph illustrates a fragment of ctenoid scale. The small stiff spines (ctenii- arrows) on its free posterior surface different ctenoid from cycloid scales which lack such spines.

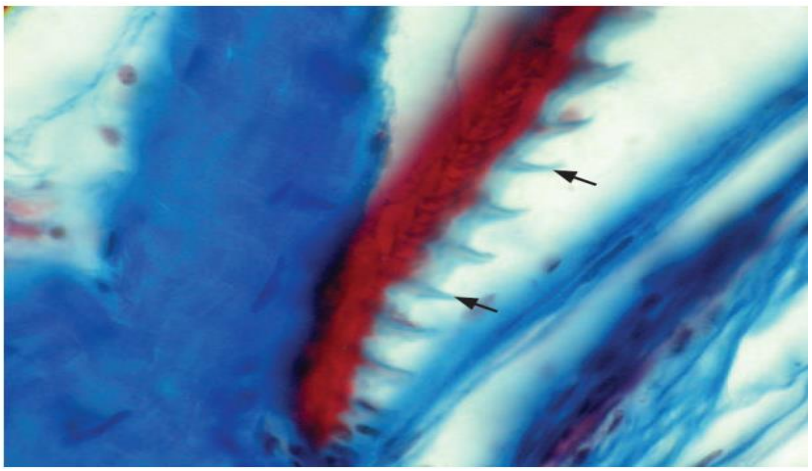


Fig. 10: Fragment of ctenoid scale (red) showing clearly comb-like projections (ctenii - arrows) on the free exposed edges. Connective tissue stained blue.