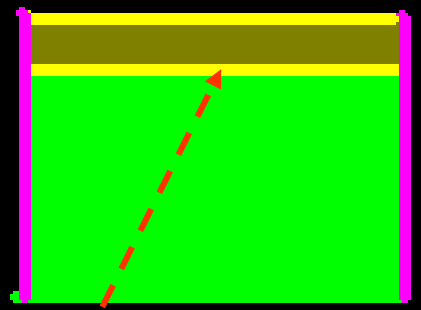
Vertebrate Integument

Adaptive radiation in an homologous tissue (skin)

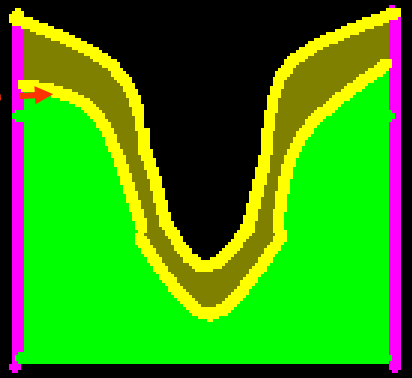
Cuban tree frog at night



Epidermis (stratified, squamous epithelium)

Dermis (connective tissue & smooth muscle,nerves and blood supply)

Basement membrane

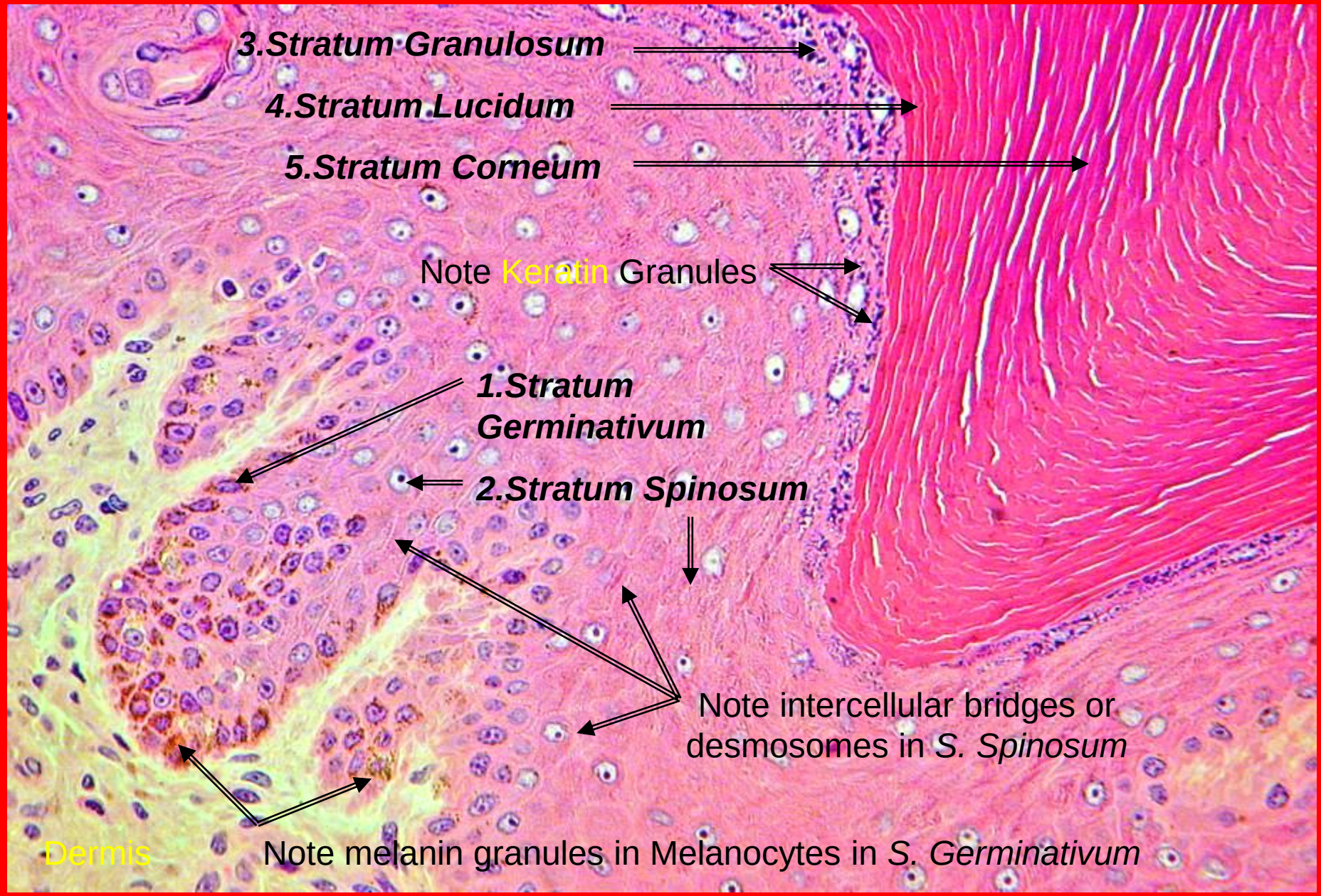


Epidermis forms an invagination

Follicle of Epidermis' Stratum Germinativum (Basale)

*Dermal Papilla: **induces** epidermis*

***Epidermal epithelium of** Follicle **can become hair, scales, teeth, feathers, nails, hoofs made of** KERATIN*



The 5 Layers of the Epidermis (1.5 *u*m ultra thin section, @100X, H&E)

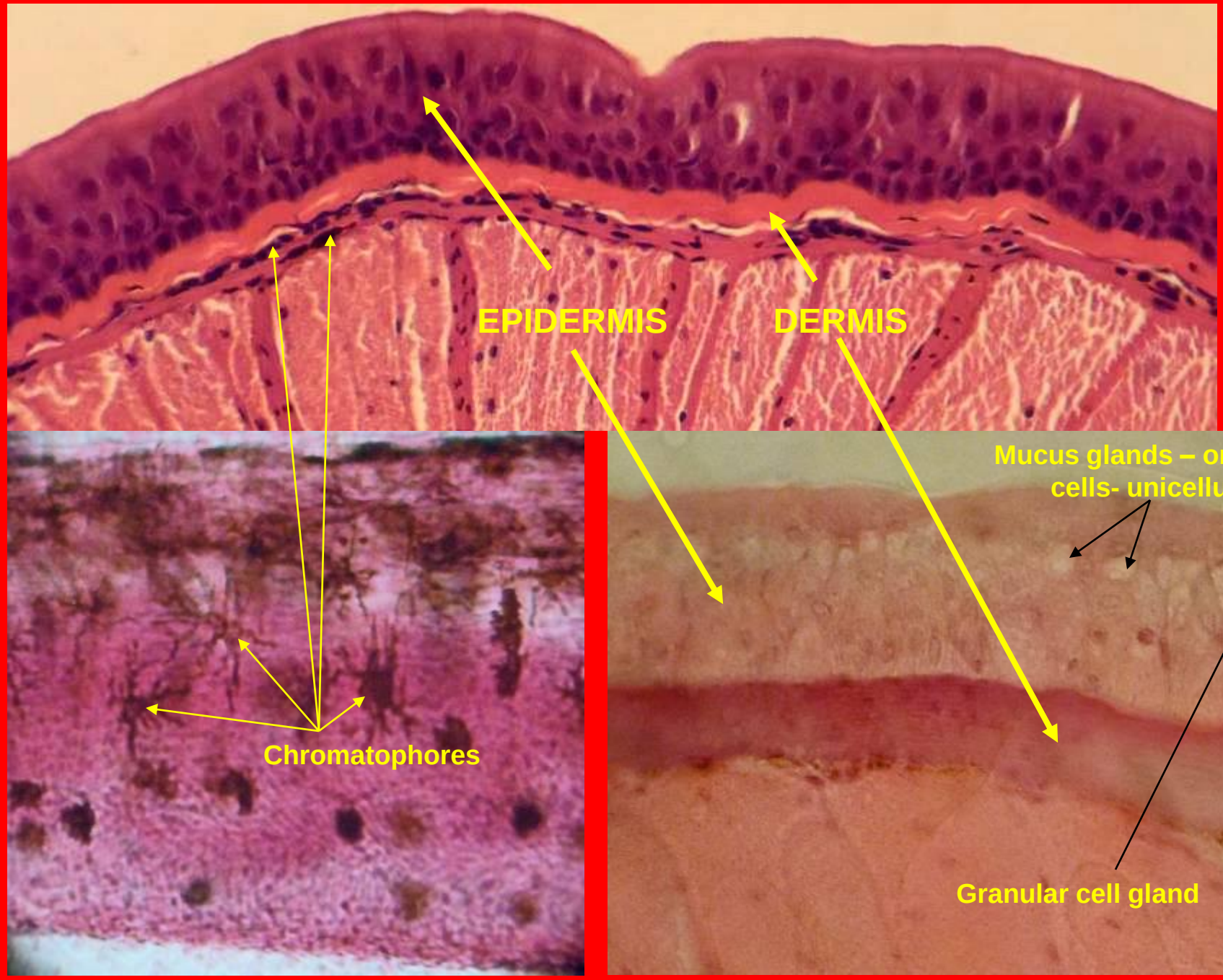
FISH:

1. Agnatha

1 No scales

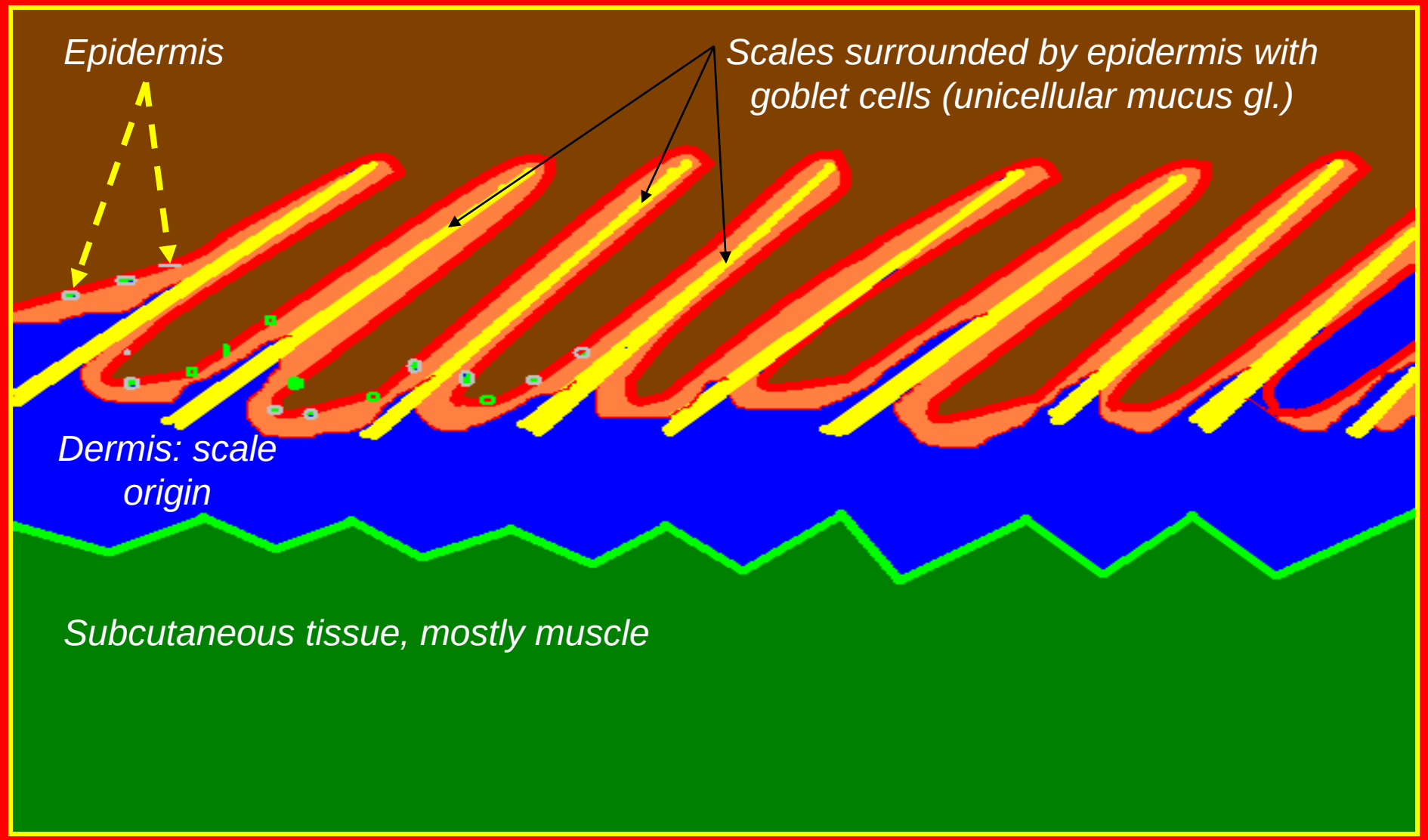
2 Goblet cells in epidermis

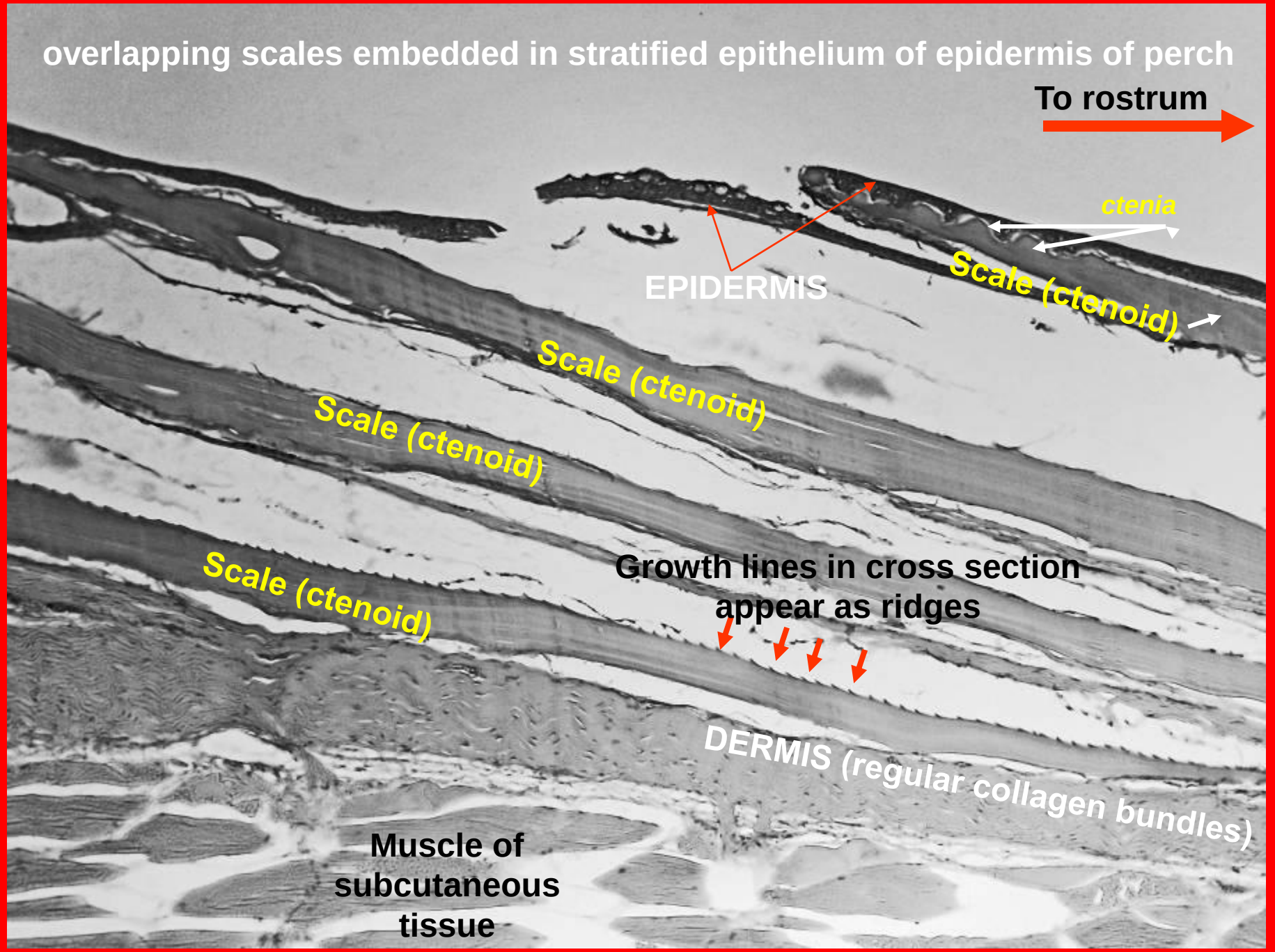
3 Thin dermis


EPIDERMIS
DERMIS
Chromatophores
Mucus glands – or goblet cells- unicellular
Granular cell gland

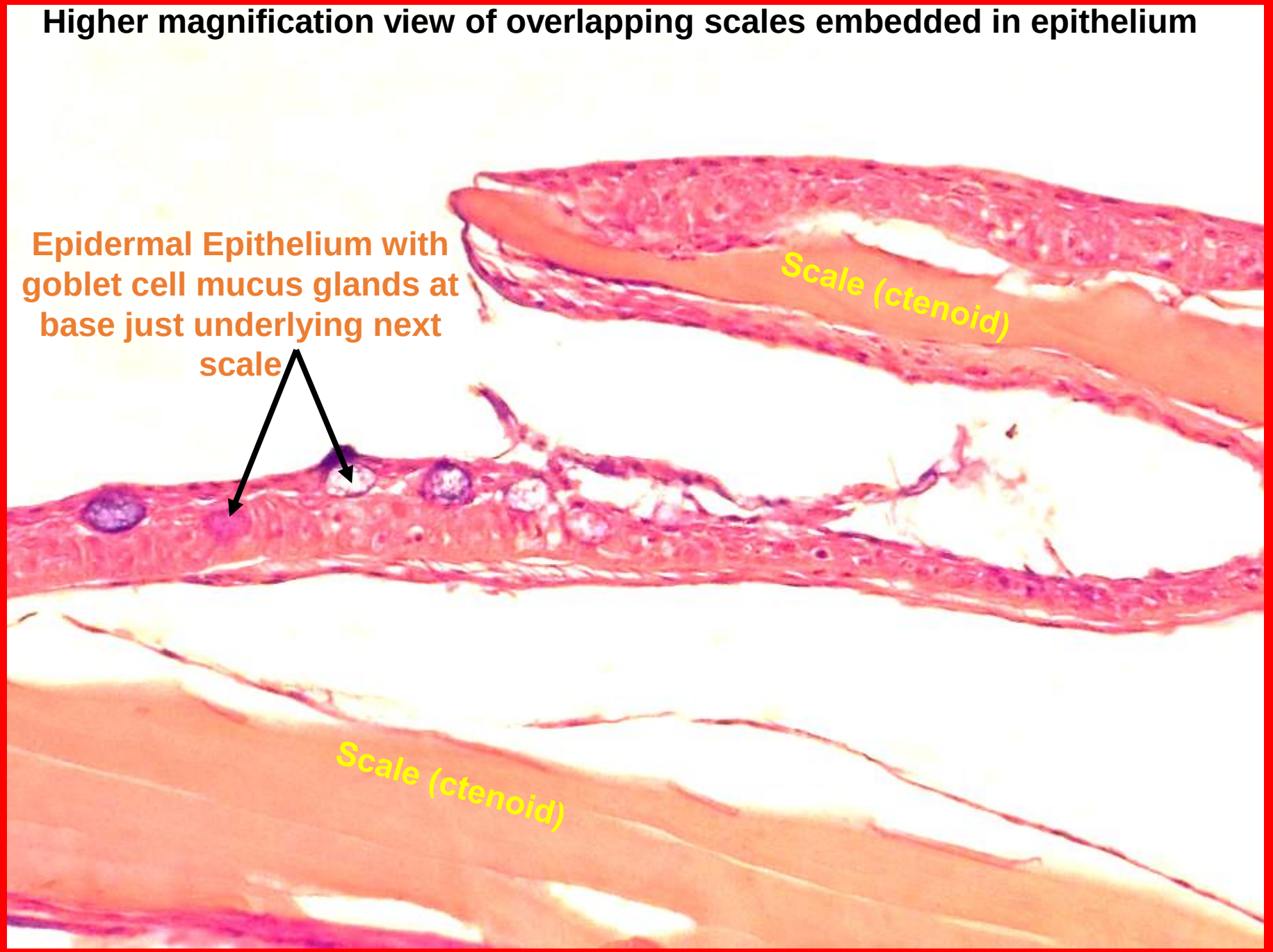

FISH: 2 Teleosts
20 lb. King Salmon, Ketchikan, Alaska 2007

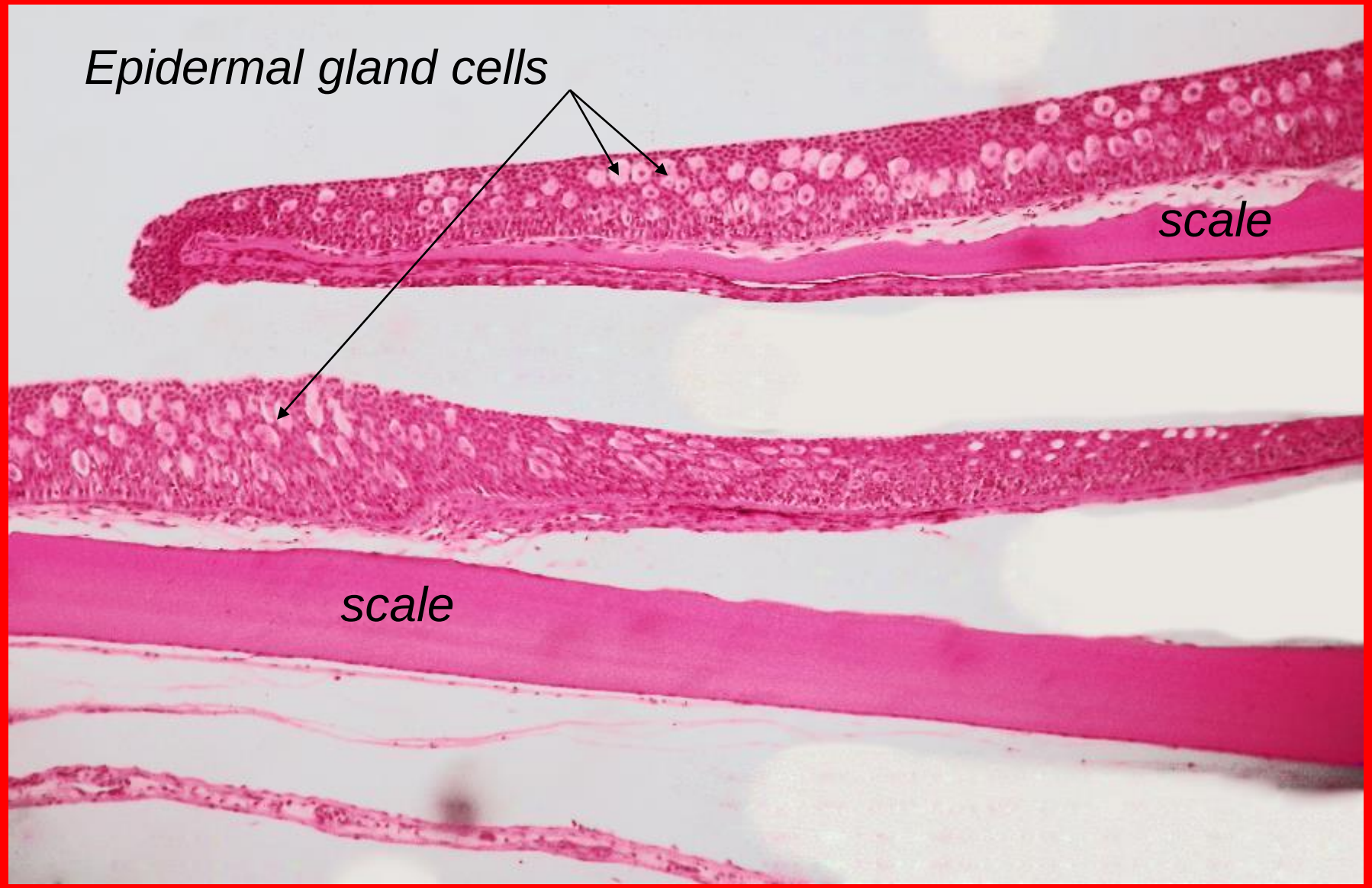
TELEOST (BONY FISH) SKIN - OVELAPPING SCALES : CYCLOID OR CTENOID



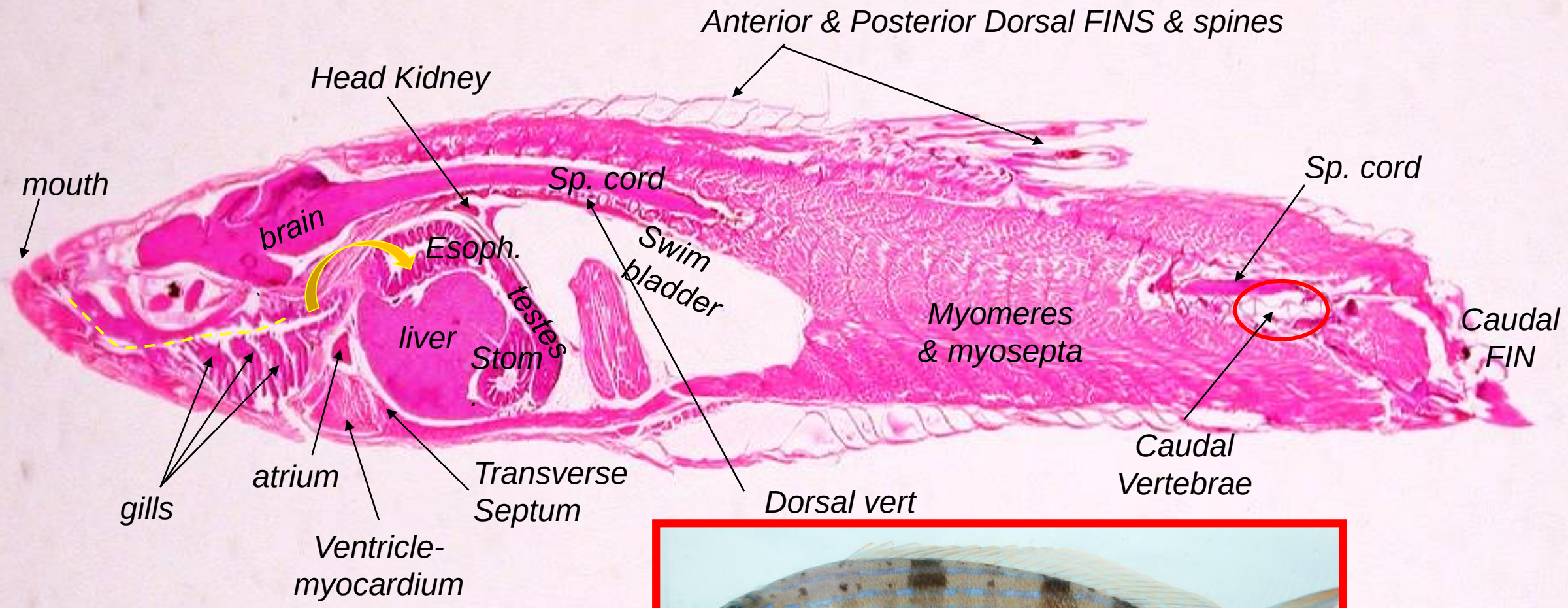

overlapping scales embedded in stratified epithelium of epidermis of perch
To rostrum
ctenia
EPIDERMIS
Scale (ctenoid)
Scale (ctenoid)
Scale (ctenoid)
Scale (ctenoid)
Growth lines in cross section appear as ridges
DERMIS (regular collagen bundles)
Muscle of subcutaneous tissue

Higher magnification view of overlapping scales embedded in epithelium



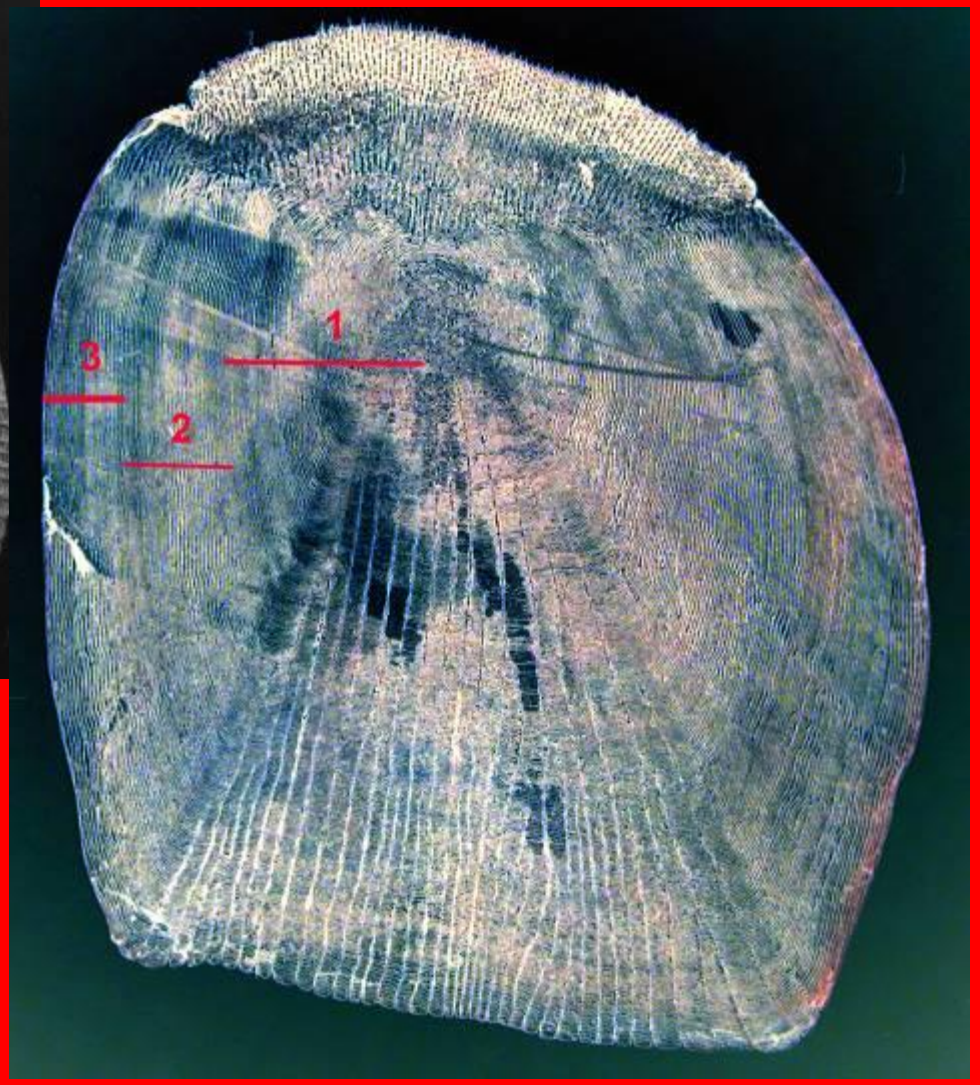

Epidermal gland cells
scale
scale

‘Modern’ BONY FISH: Teleosts

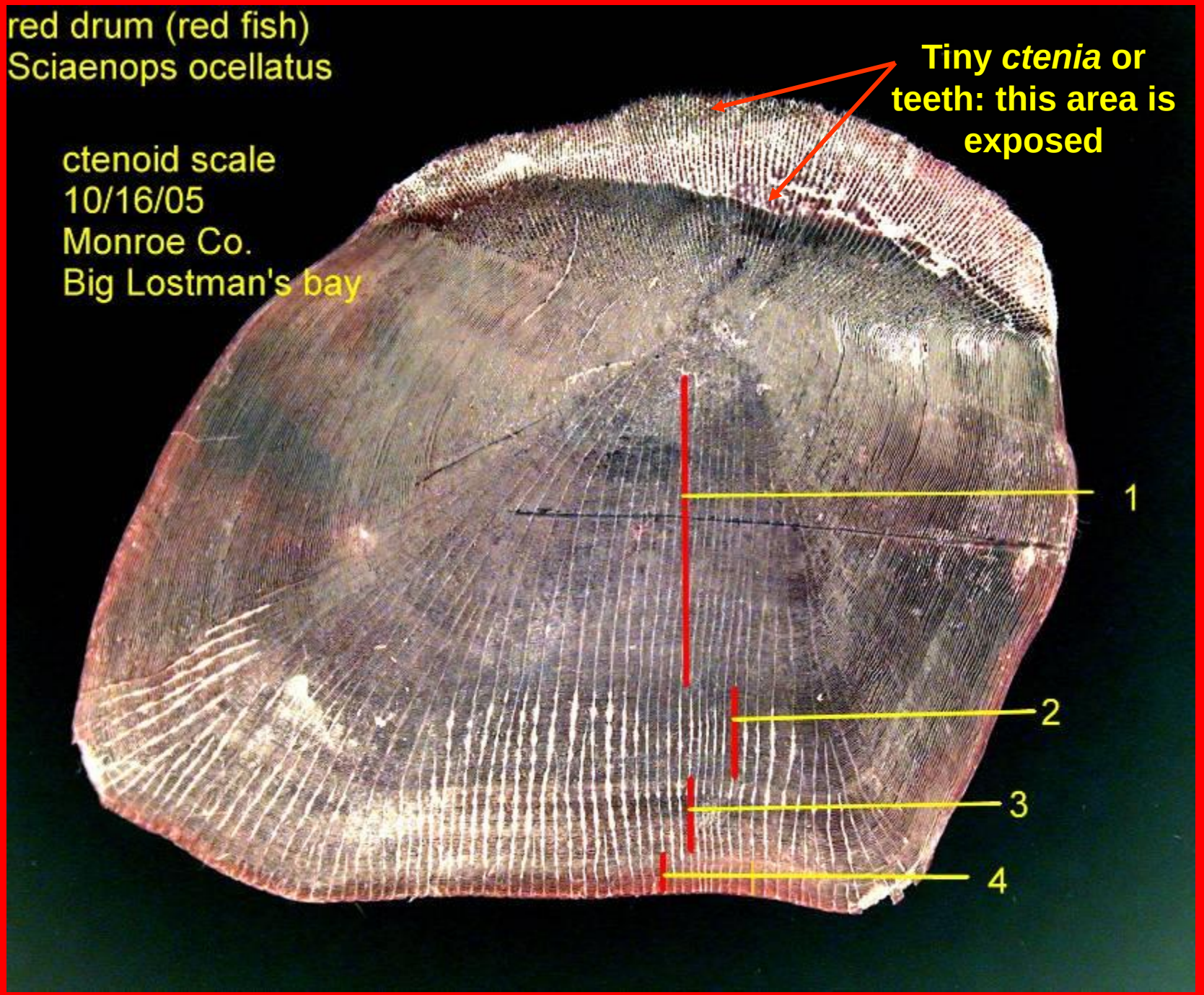


Sagittal section of small teleost

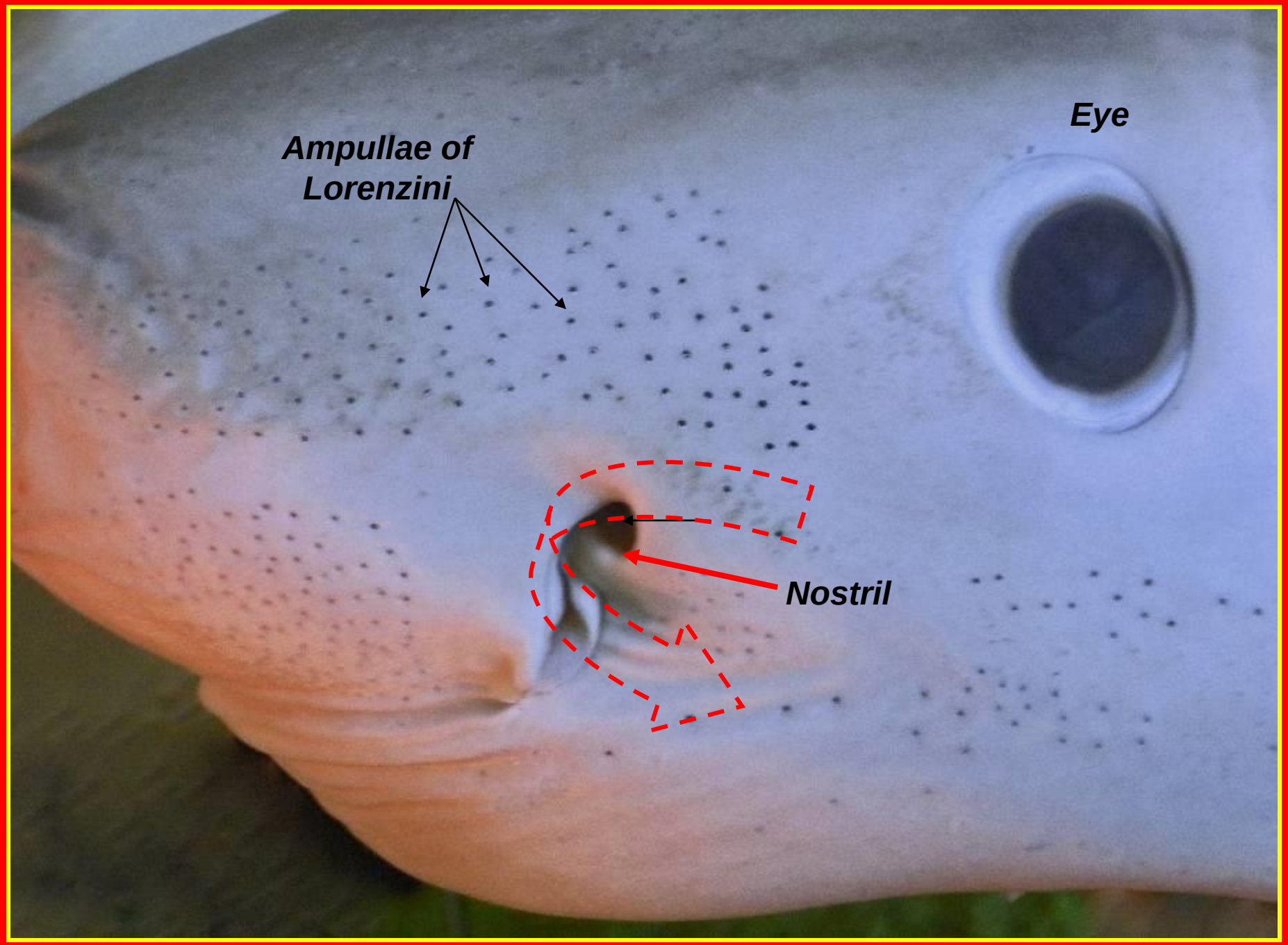
Scales can tell a fish's age with their growth lines

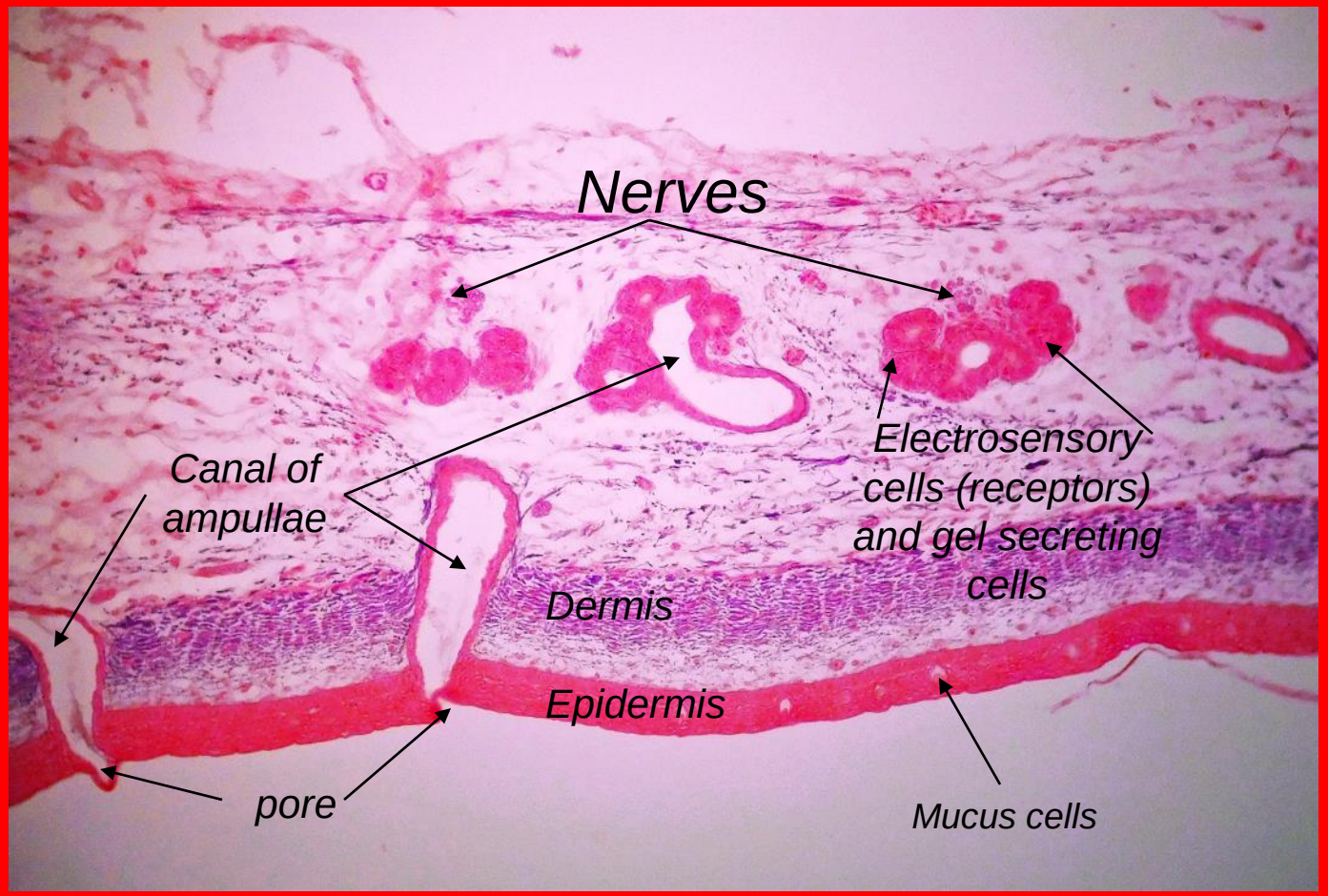


'Cycloid' scales are similar, but without the ctenia. Some fish (catfish) have lost scales altogether

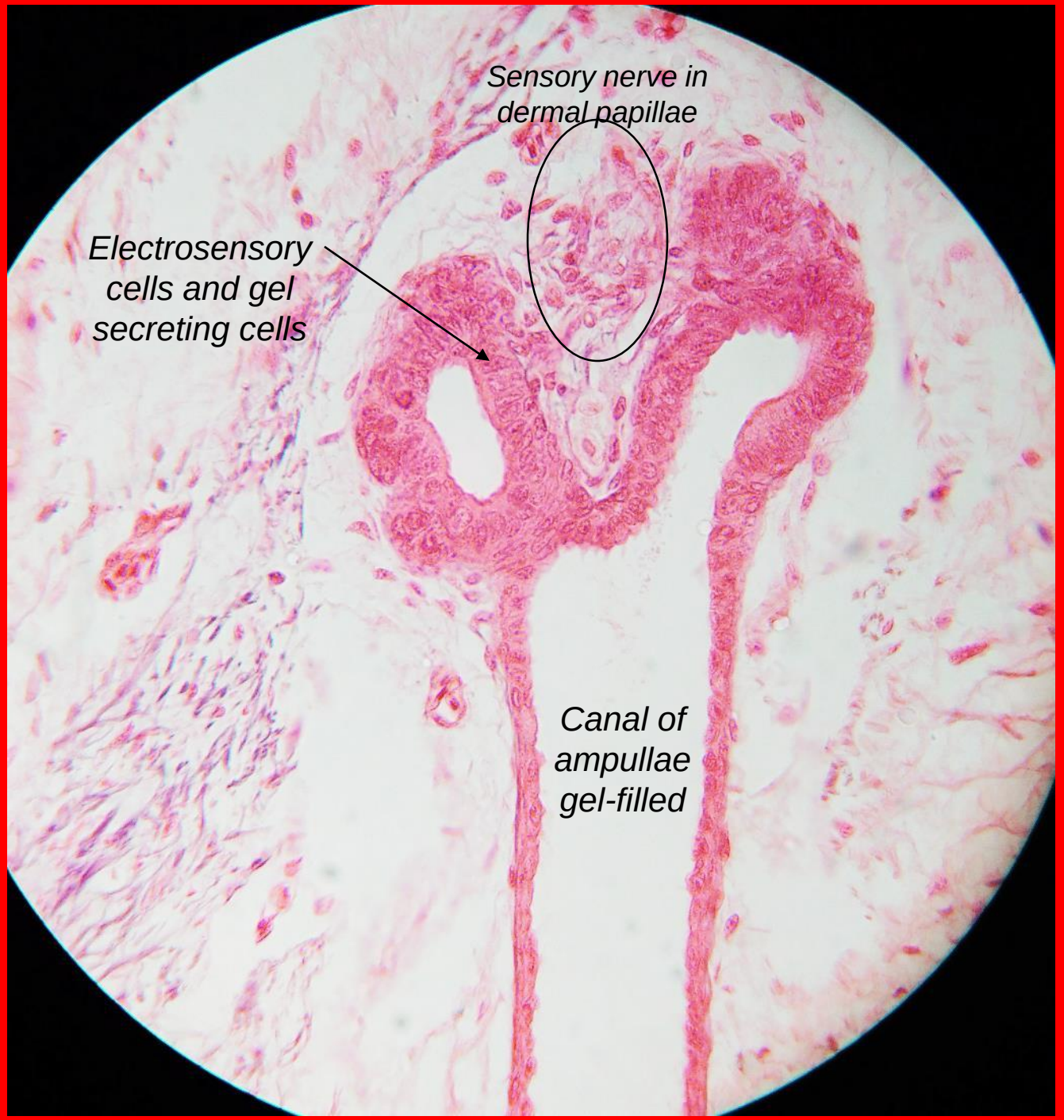

red drum (red fish)
Sciaenops ocellatus
ctenoid scale
10/16/05
Monroe Co.
Big Lostman's bay
Tiny *ctenia* or teeth: this area is exposed
1
2
3
4

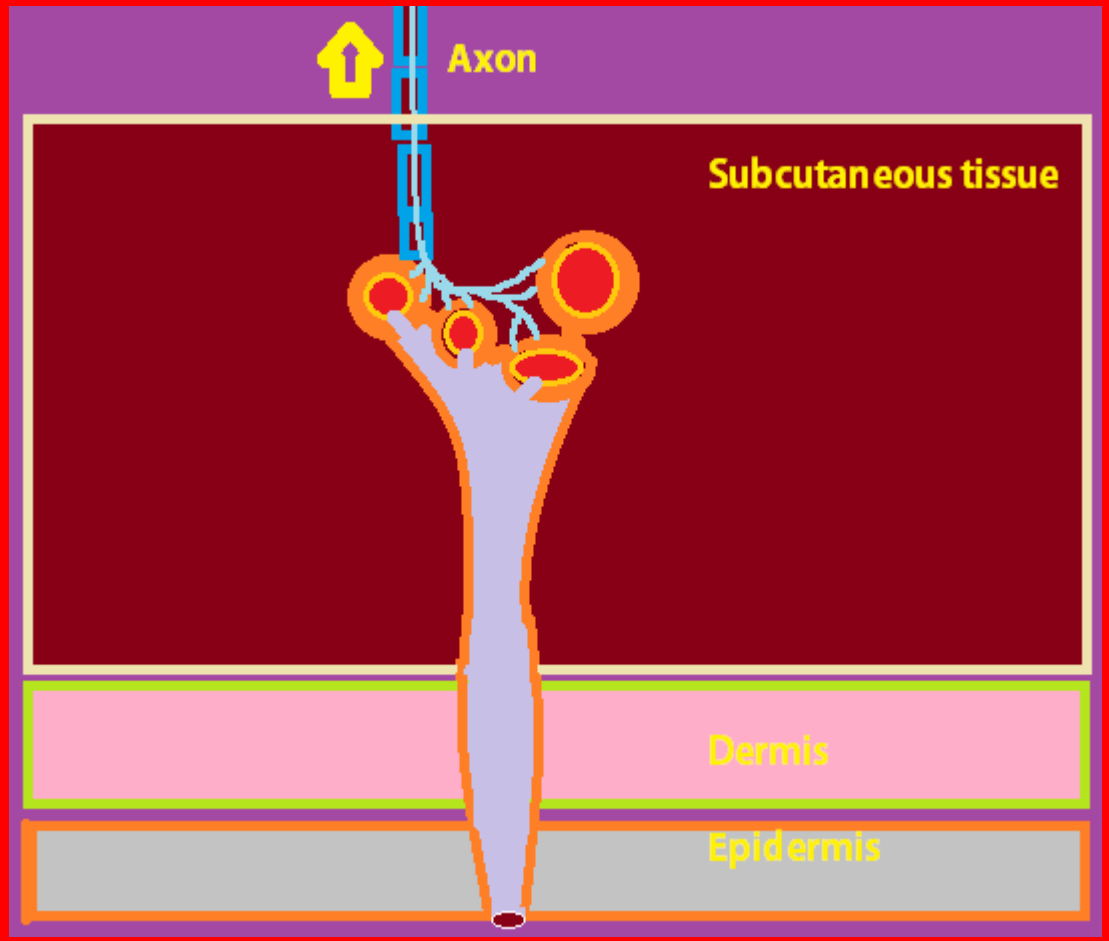
FISH: 3 Chondricthyes (elasmobranchs)


Ampullae of
Lorenzini
Eye
Nostril



***Ampullae of Lorenzini* – sense electrical stimuli in environment from cardiac or skeletal muscle of other fish (Prey) and any other source. 'Electrosensory' cells in expanded inner part of ampullae duct have support cells which secrete a gel (which you can squeeze out of the pore). This gel conducts electric stimulae through the canal/duct to the sensory receptors.**





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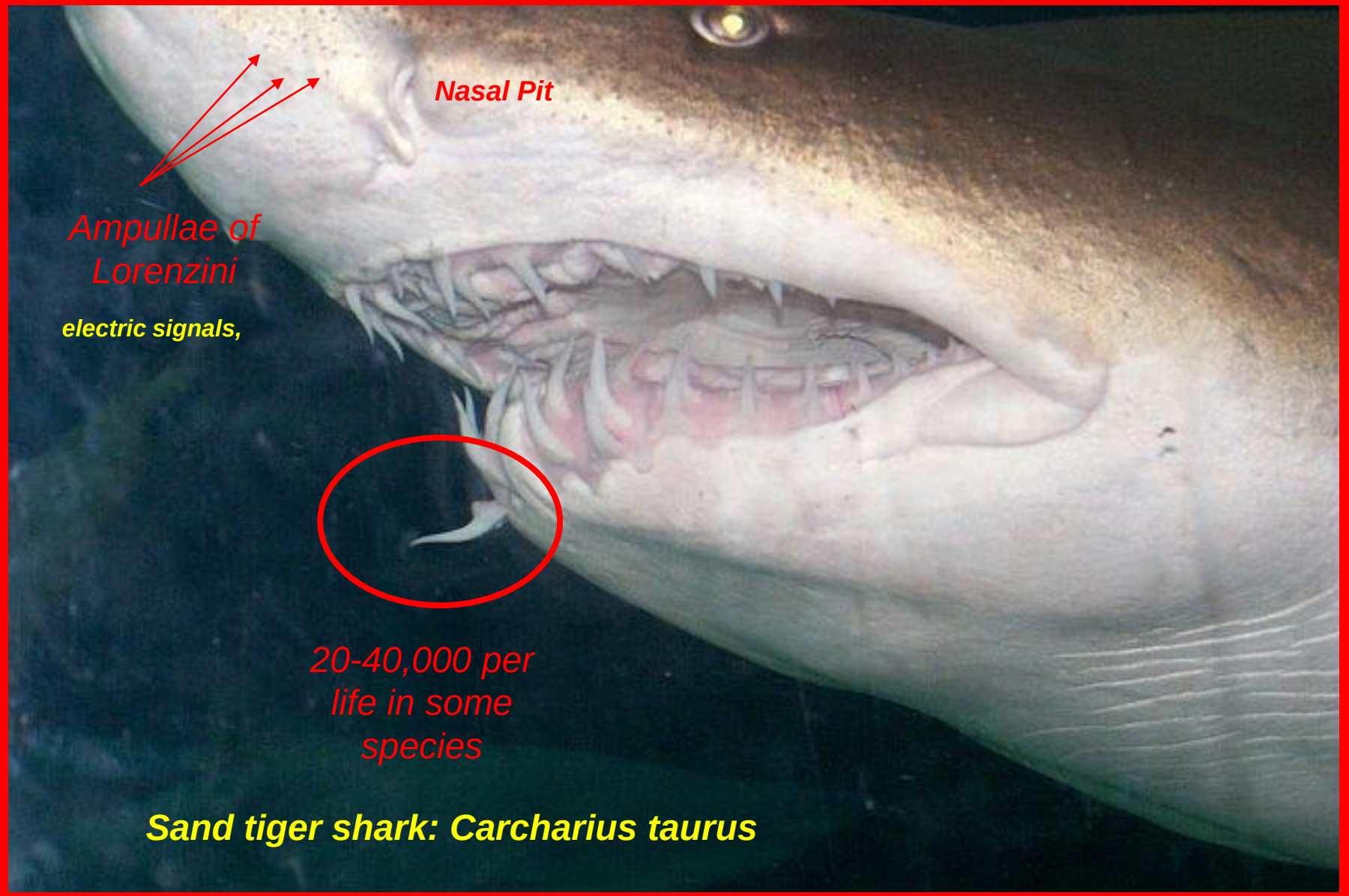
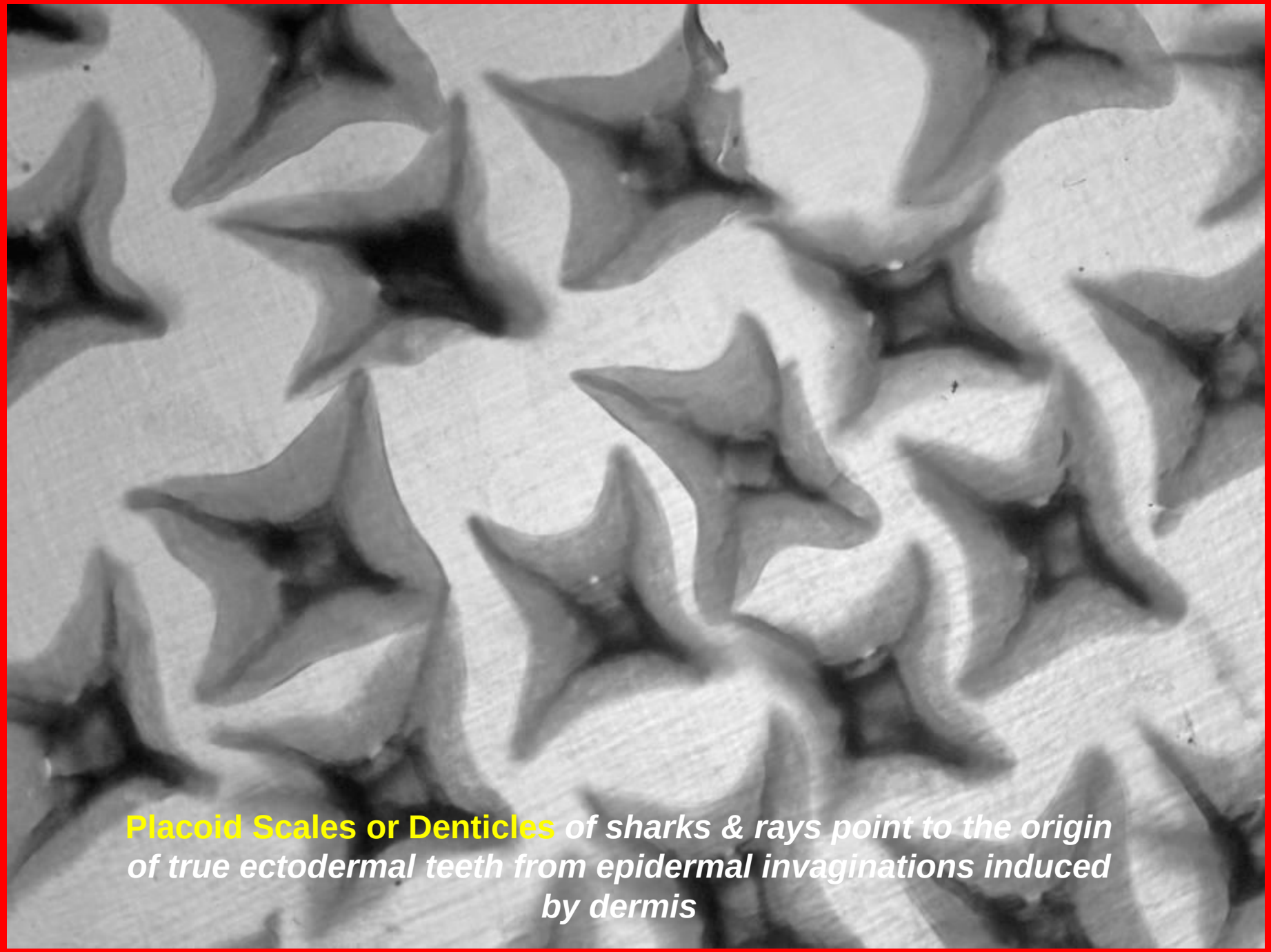
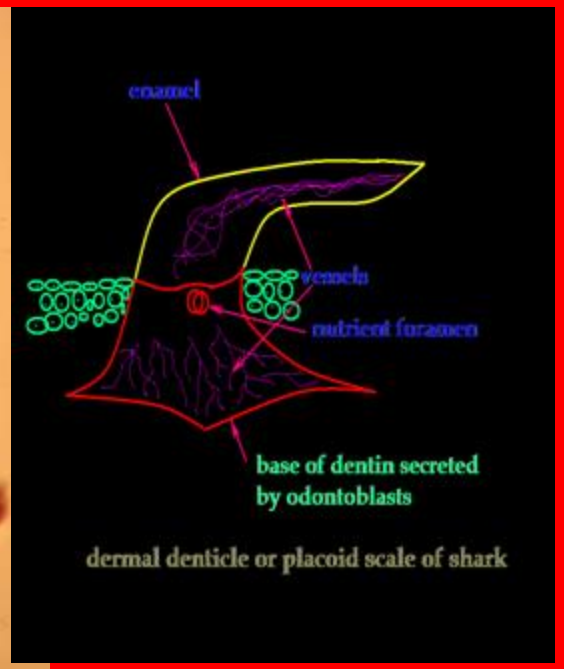

Nasal Pit
Ampullae of Lorenzini
electric signals,
20-40,000 per life in some species
Sand tiger shark: Carcharius taurus

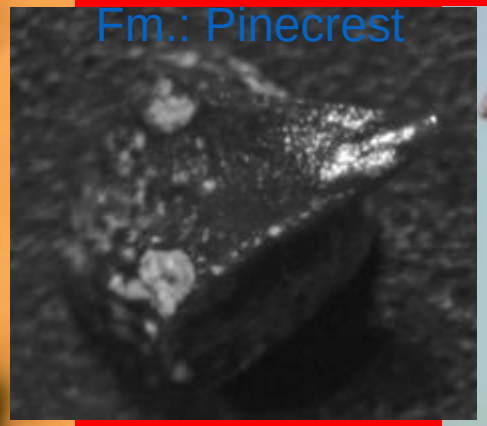


Placoid Scales or Denticles *of sharks & rays point to the origin of true ectodermal teeth from epidermal invaginations induced by dermis*

Shark dermal denticles

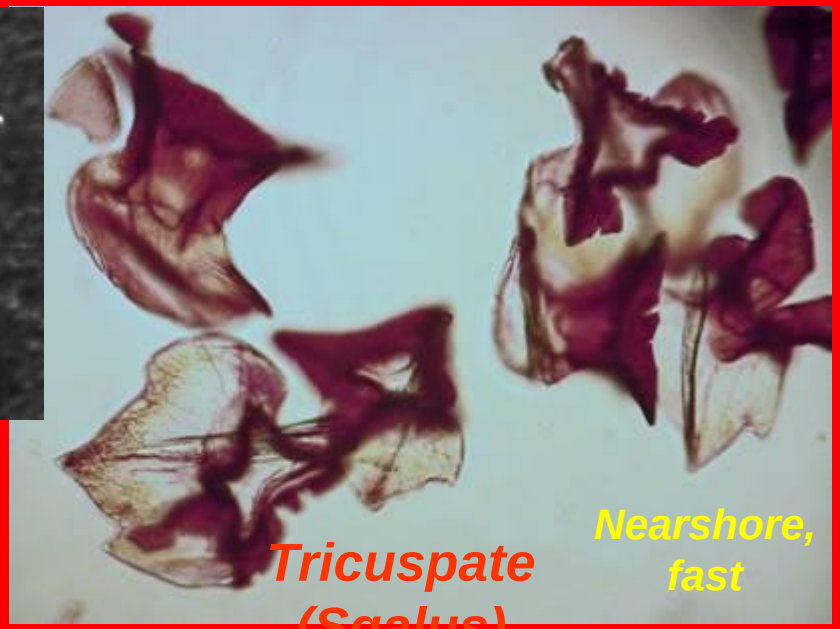


Pliocene,Tamiami Fm.: Pinecrest



Unicuspate

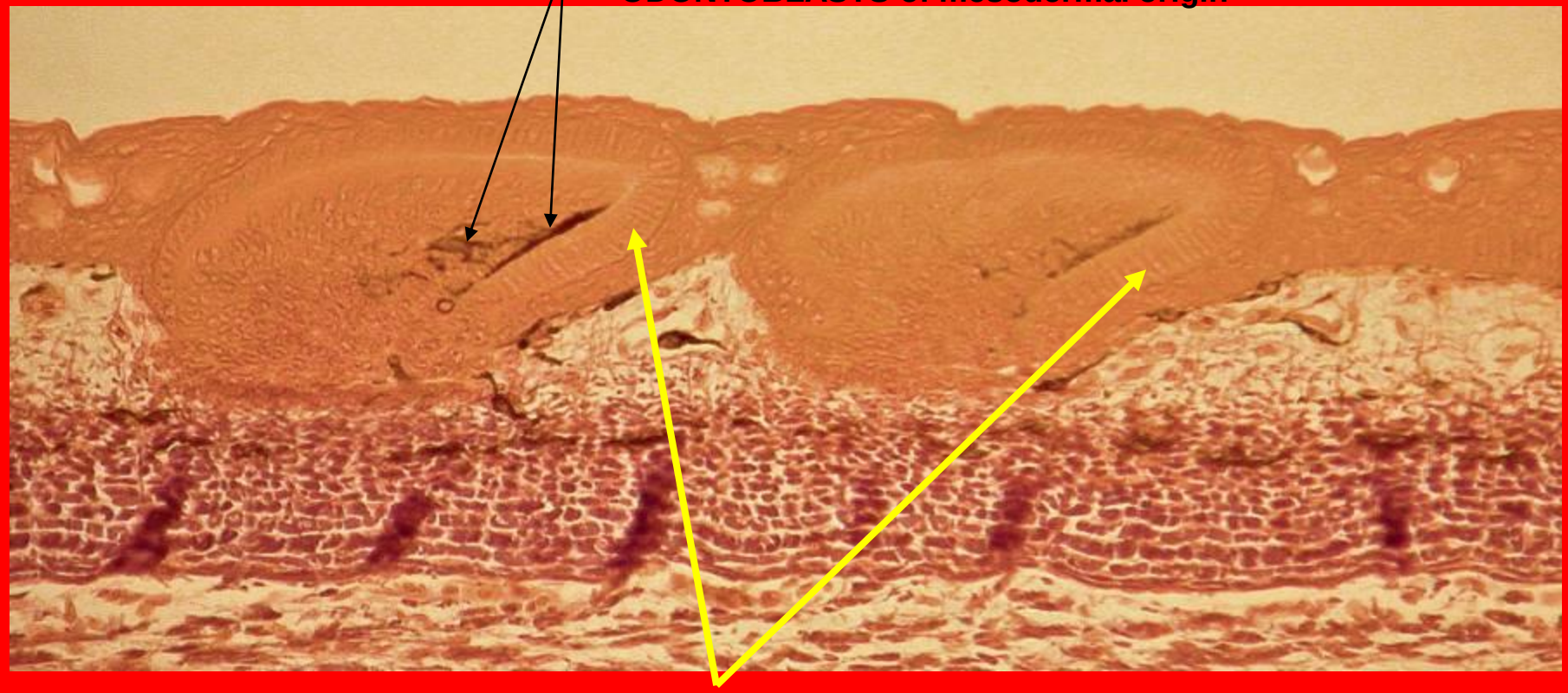
Nearshore, slow



Tricuspate (Sqalus)

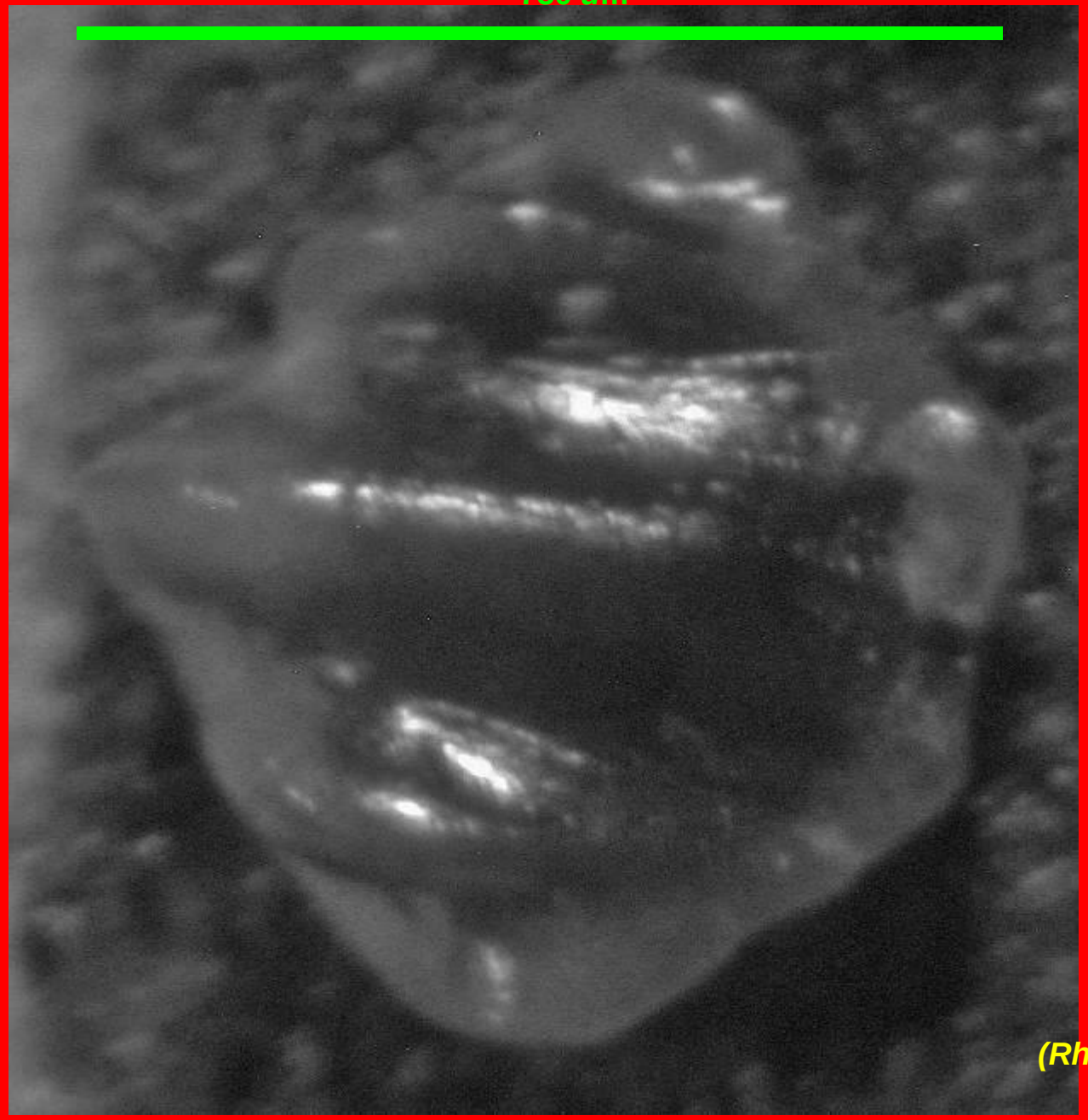
Nearshore, fast

Note dentine being deposited by
ODONTOBLASTS of mesodermal origin



2 dorsal developing placoid scales or dermal denticles: note ameloblasts of stratum basale of ectodermal epidermis – Dorsum of head

750 *um*

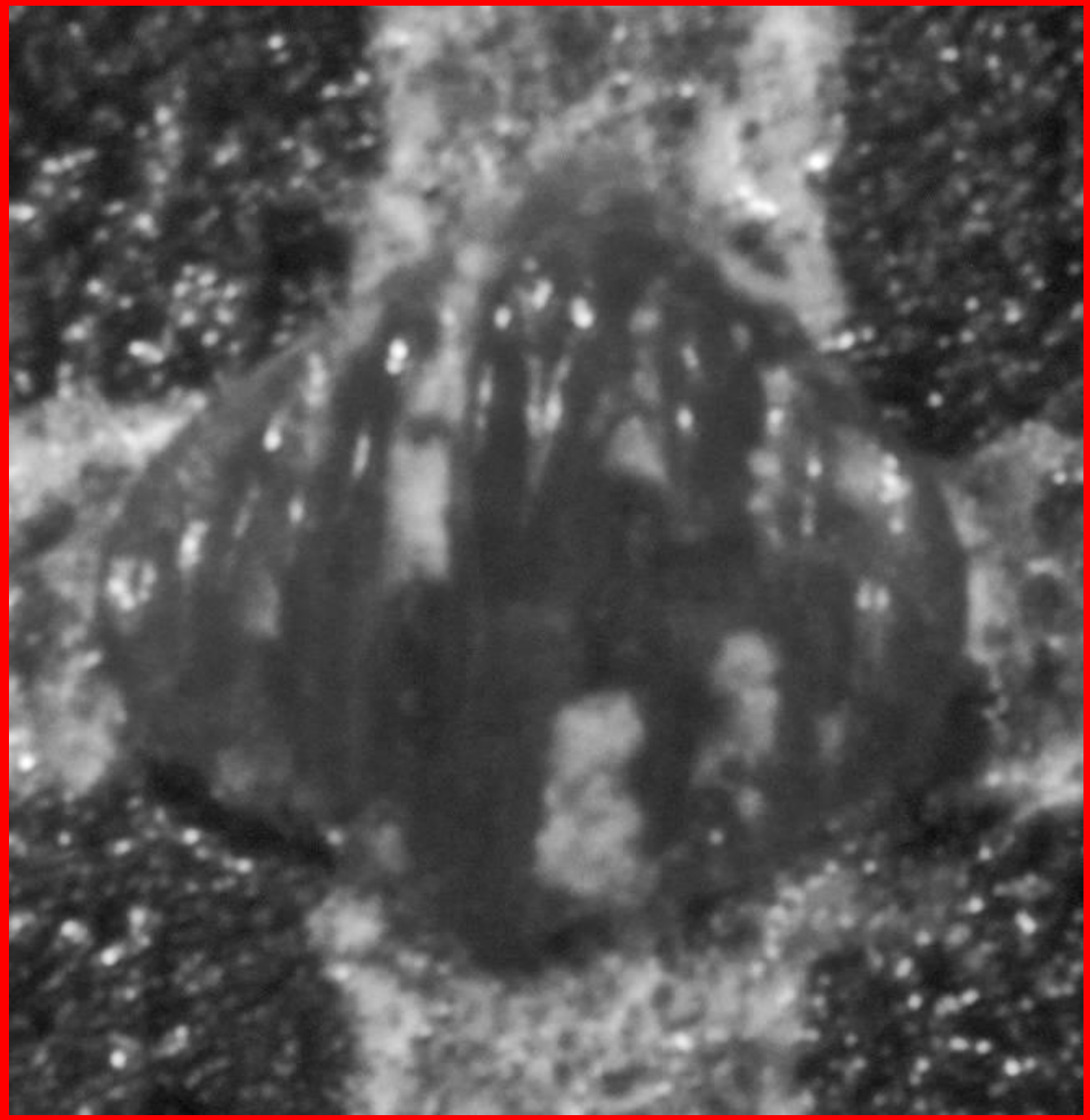


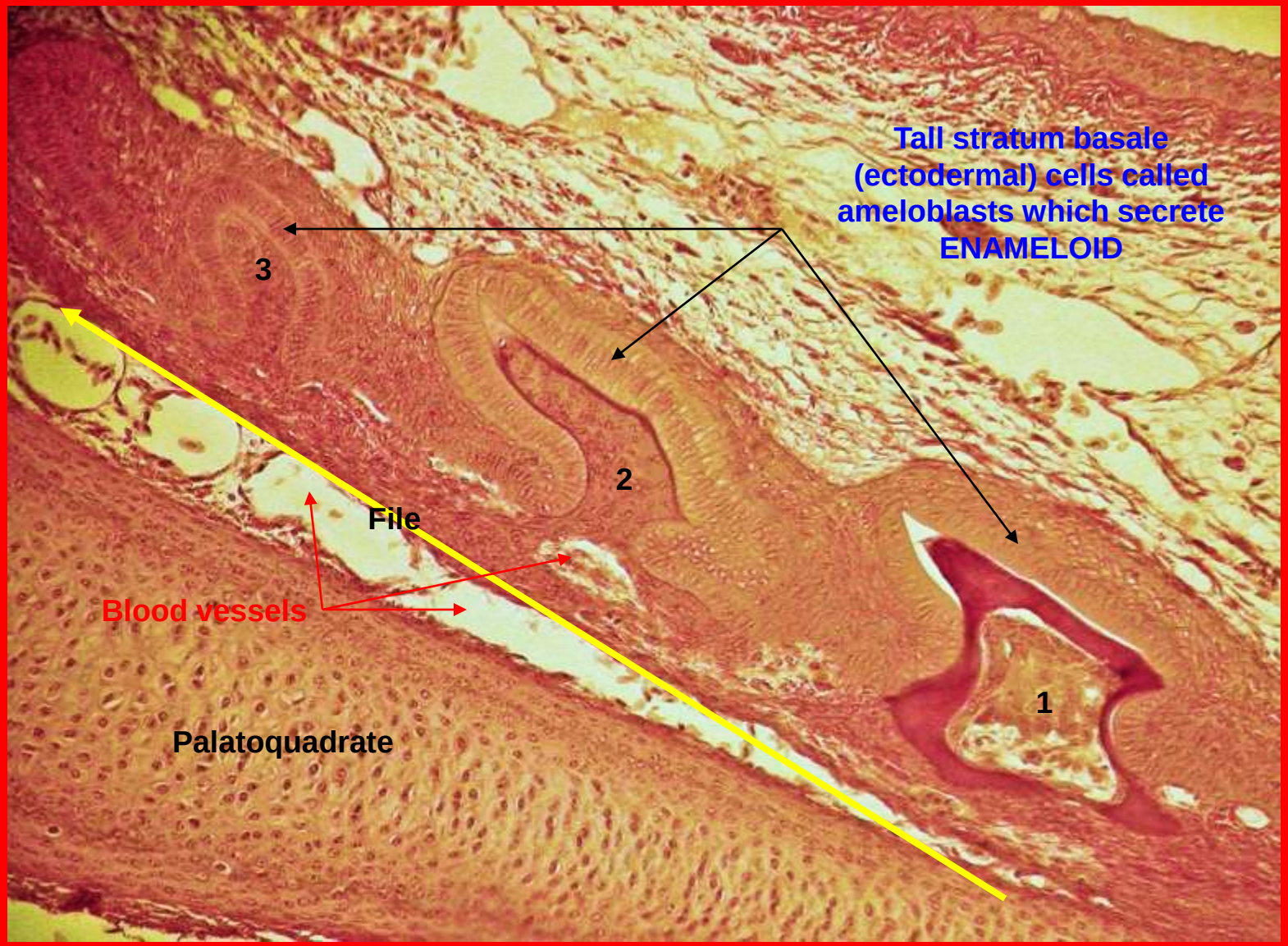
Recent 2mi W of Lido Key, Lynn Silvertooth Wreck 10m,30’

Nearshore, fast

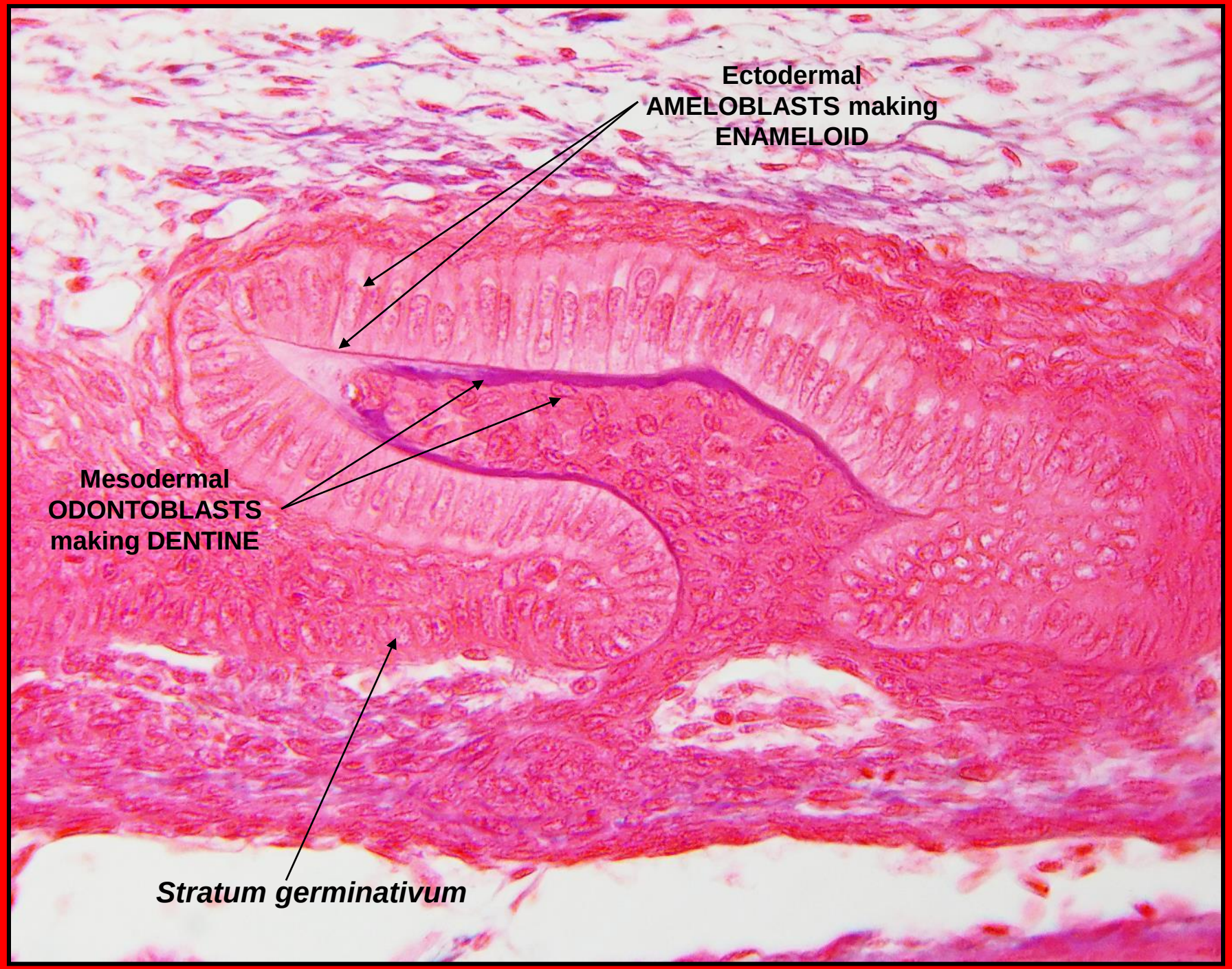
Tricuspate (Rhizoprionodon?)

250 *u*m multicuspate specimen from Tamiami Fm. Pinecrest beds(6-7)- ~2.5 Ma

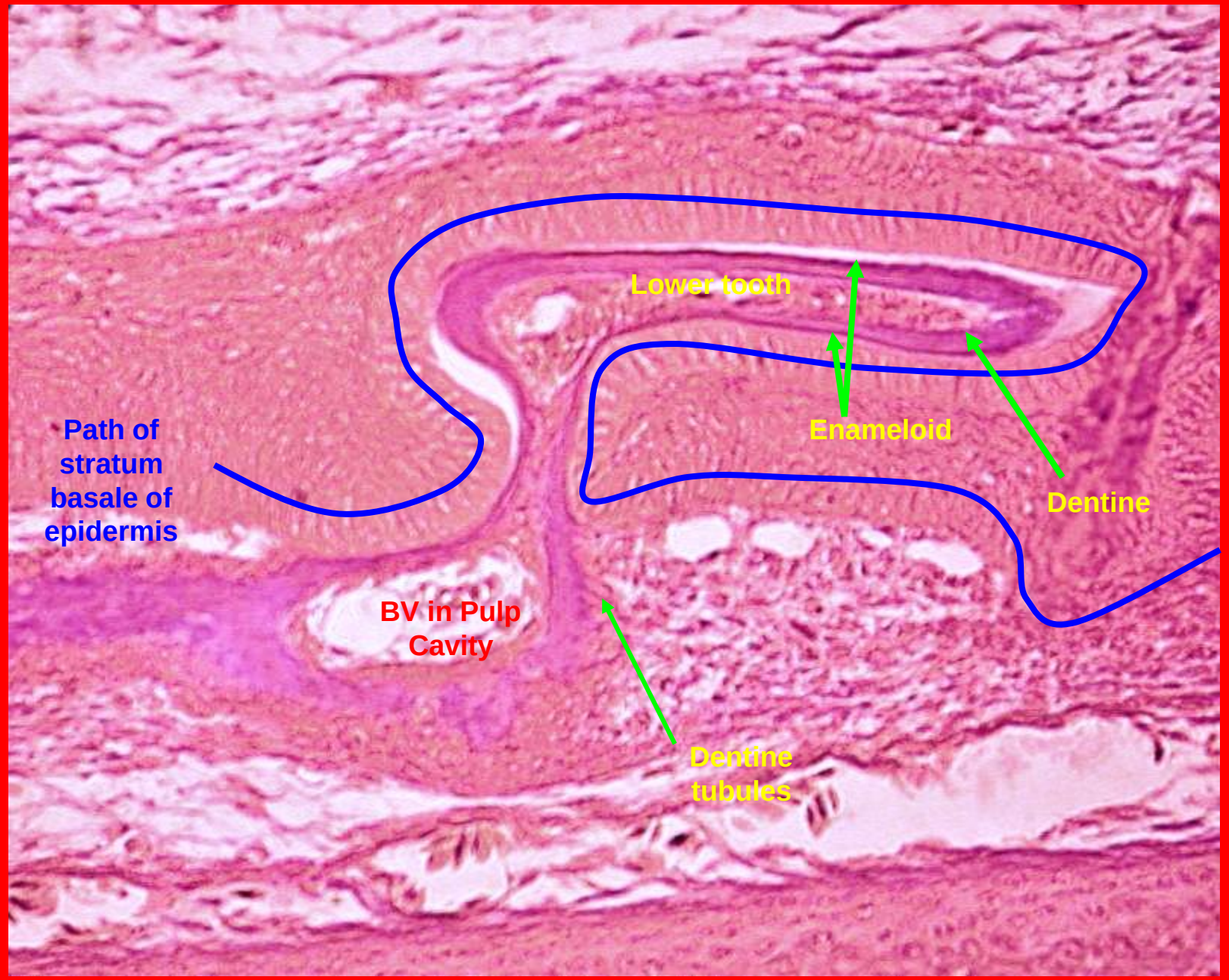


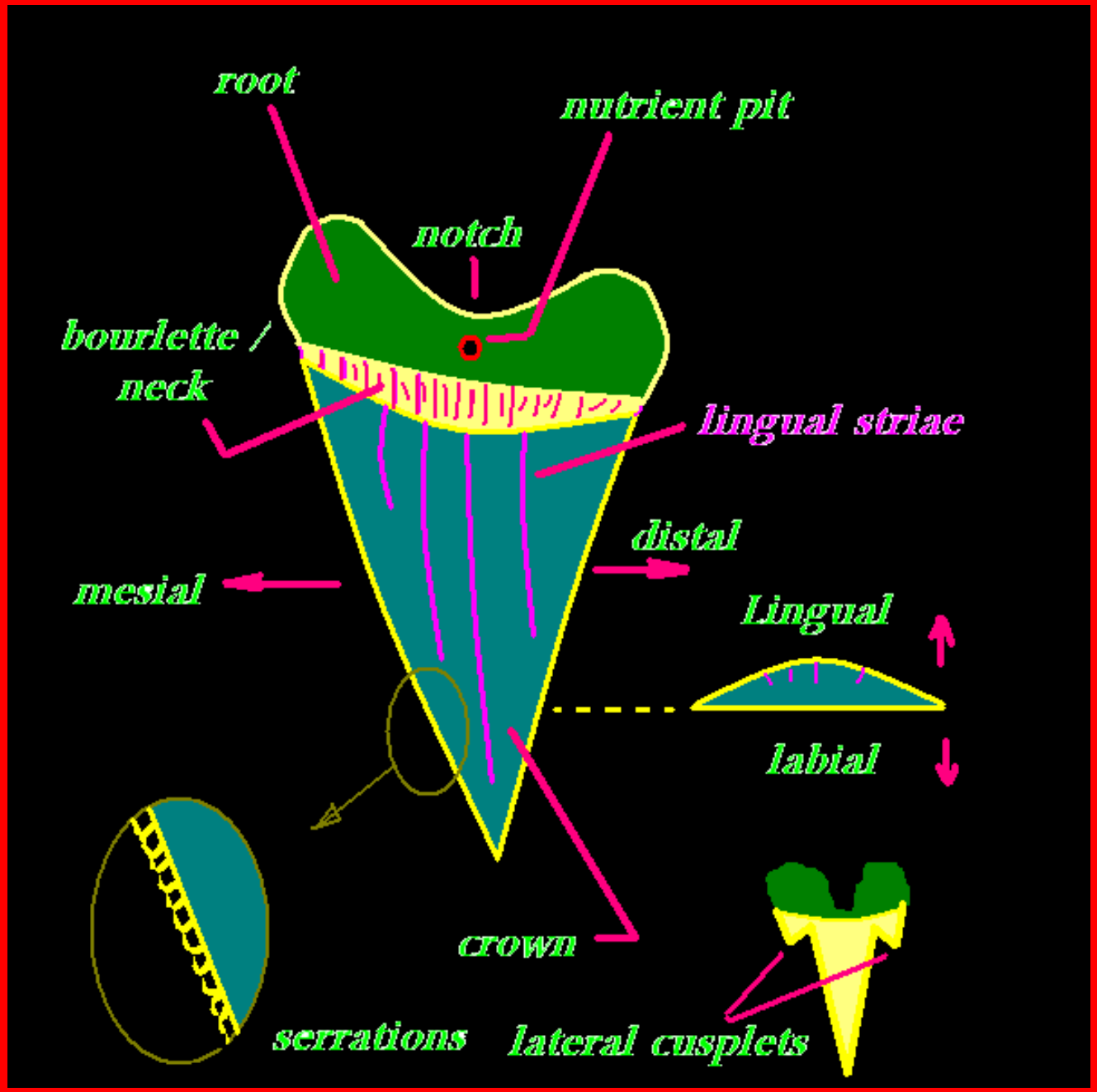


Section through shark fetus or pup upper Jaw (*Squalus*?)


Ectodermal
AMELOBLASTS making
ENAMELOID
Mesodermal
ODONTOBLASTS
making DENTINE
Stratum germinativum

Lower tooth primordium

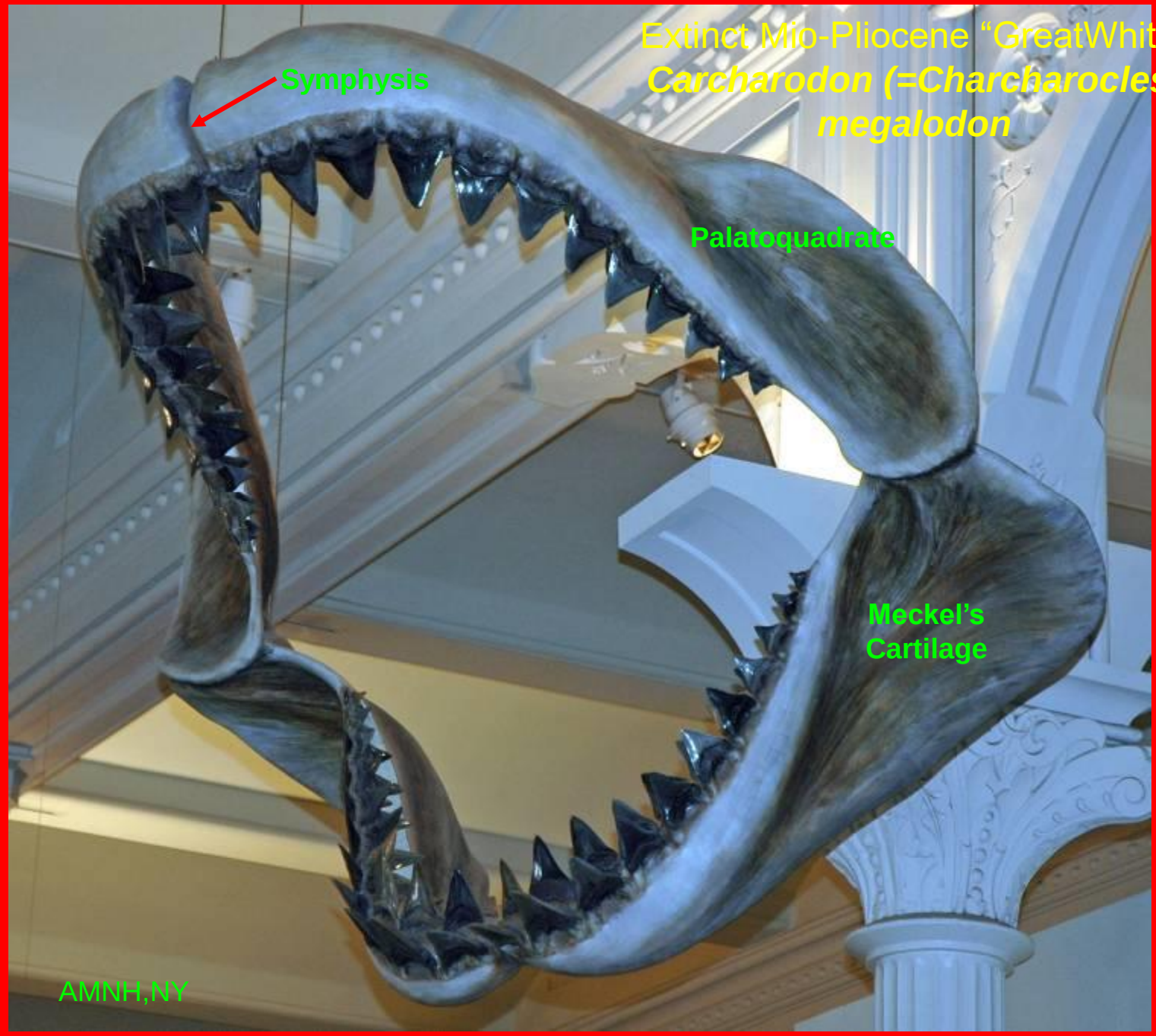


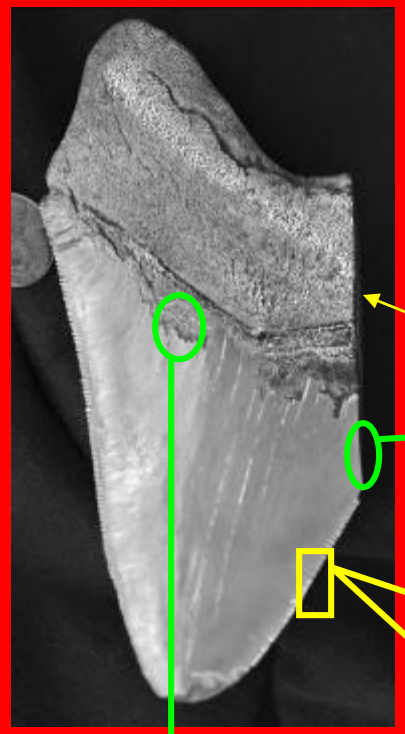


Shark Tooth Anatomy

Eocene *Otodus obliquus, SE Atlantic Coast & Morocco*

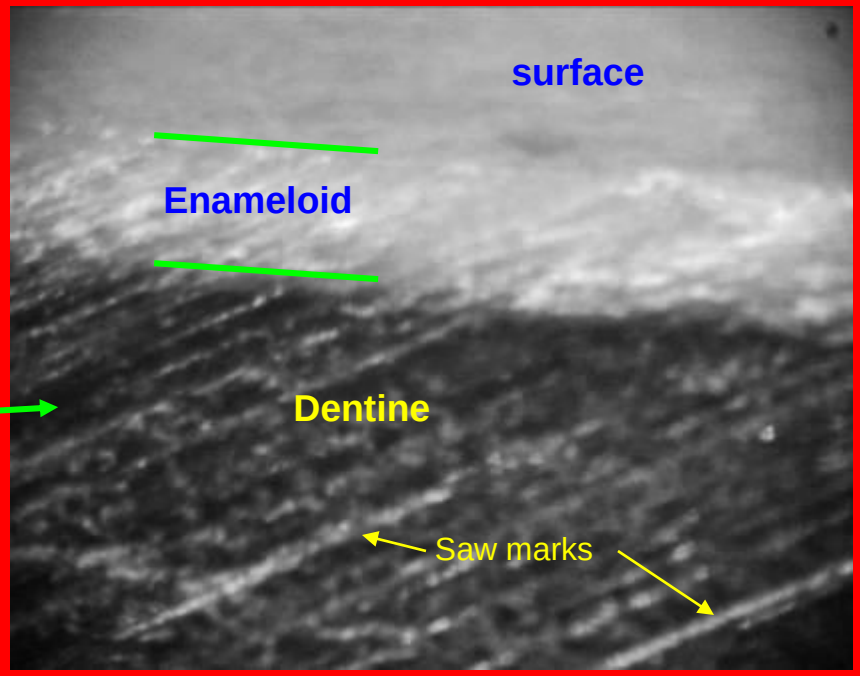
4 cm

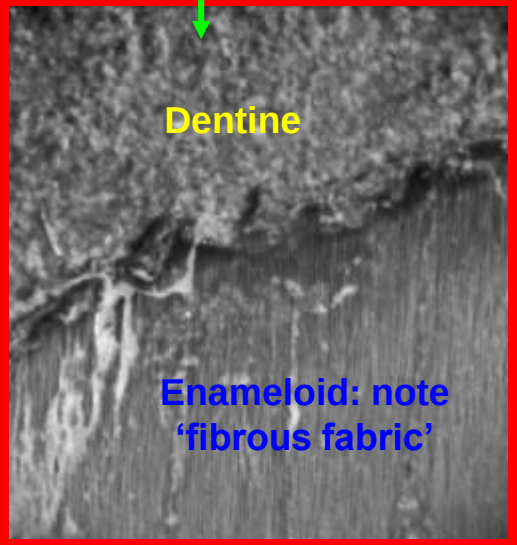

Extinct Mio-Pliocene "GreatWhite"
Carcharodon (=Charcharocles) megalodon
Symphysis
Palatoquadrate
Meckel's Cartilage
AMNH,NY

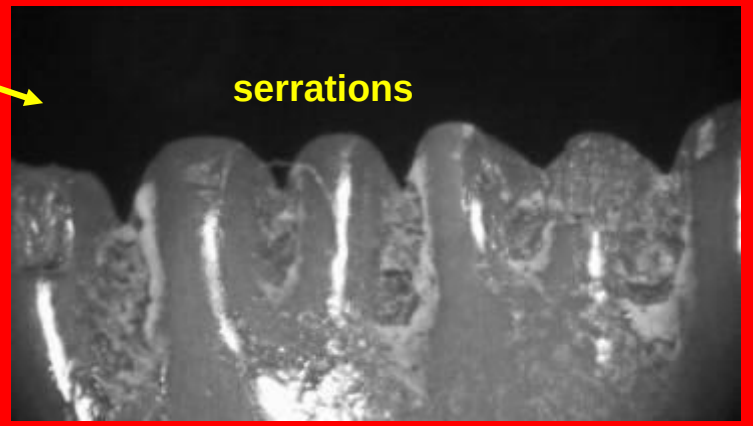


Cut surface of 5.5 “

C. megalodon

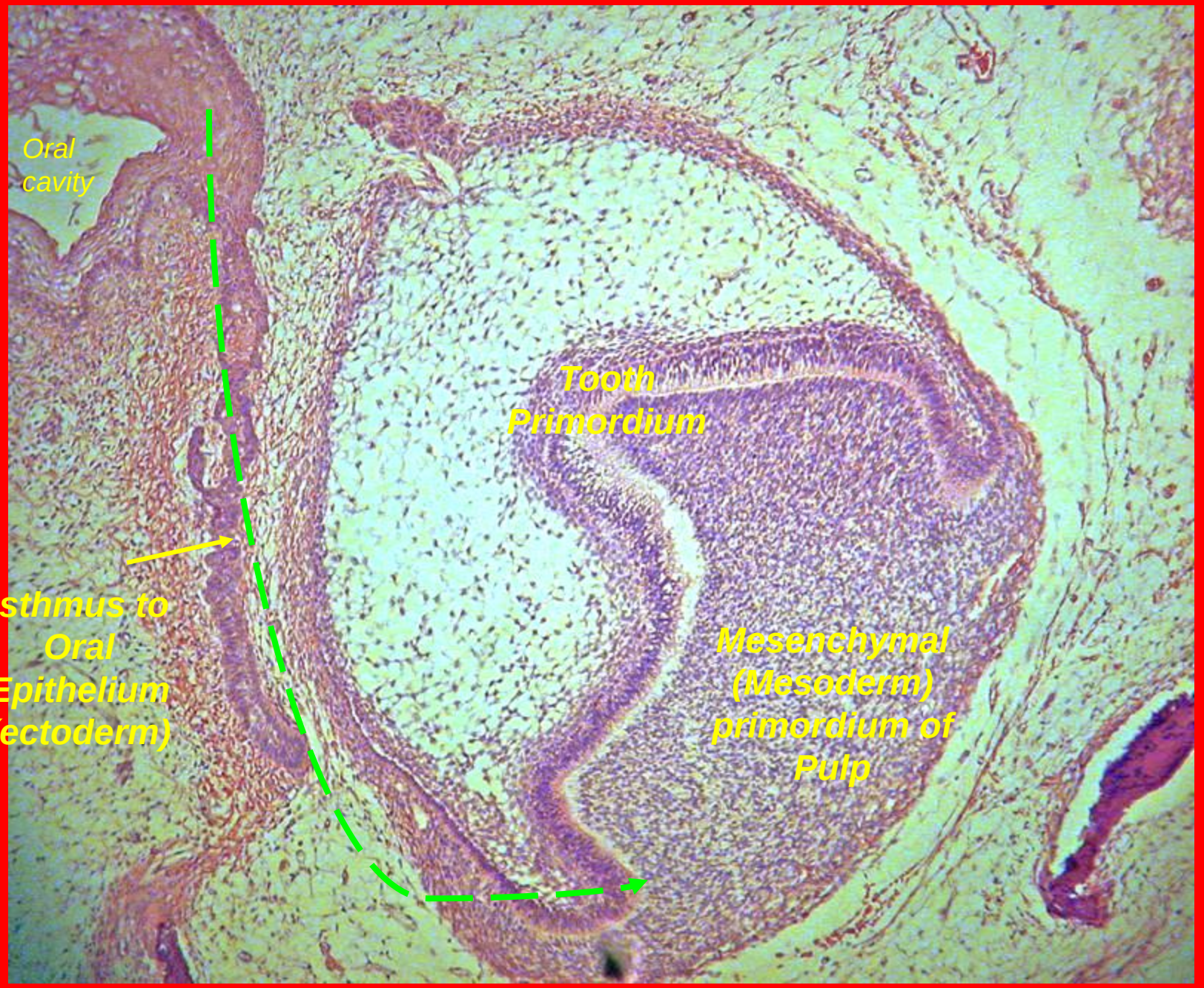




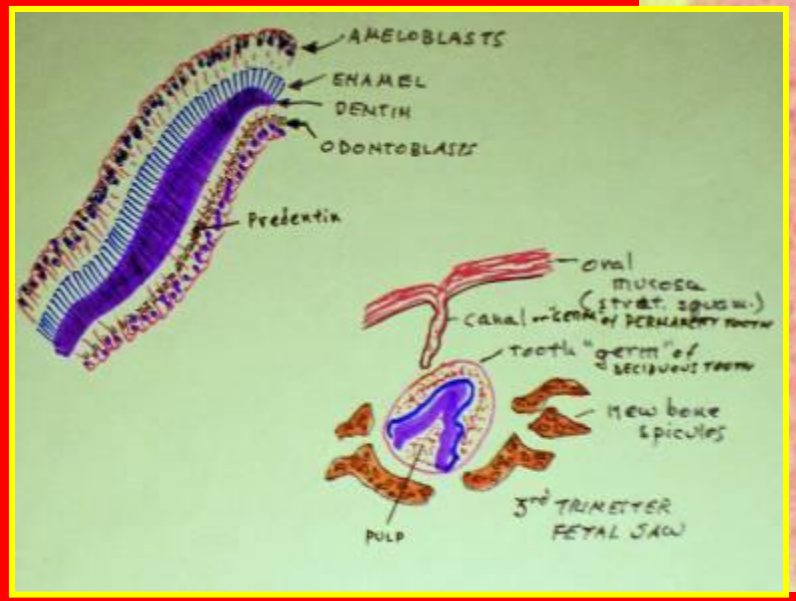


Extinct Mio-Pliocene “GreatWhite”

Carcharodon (=Charcharocles) megalodon



Early Mammal tooth



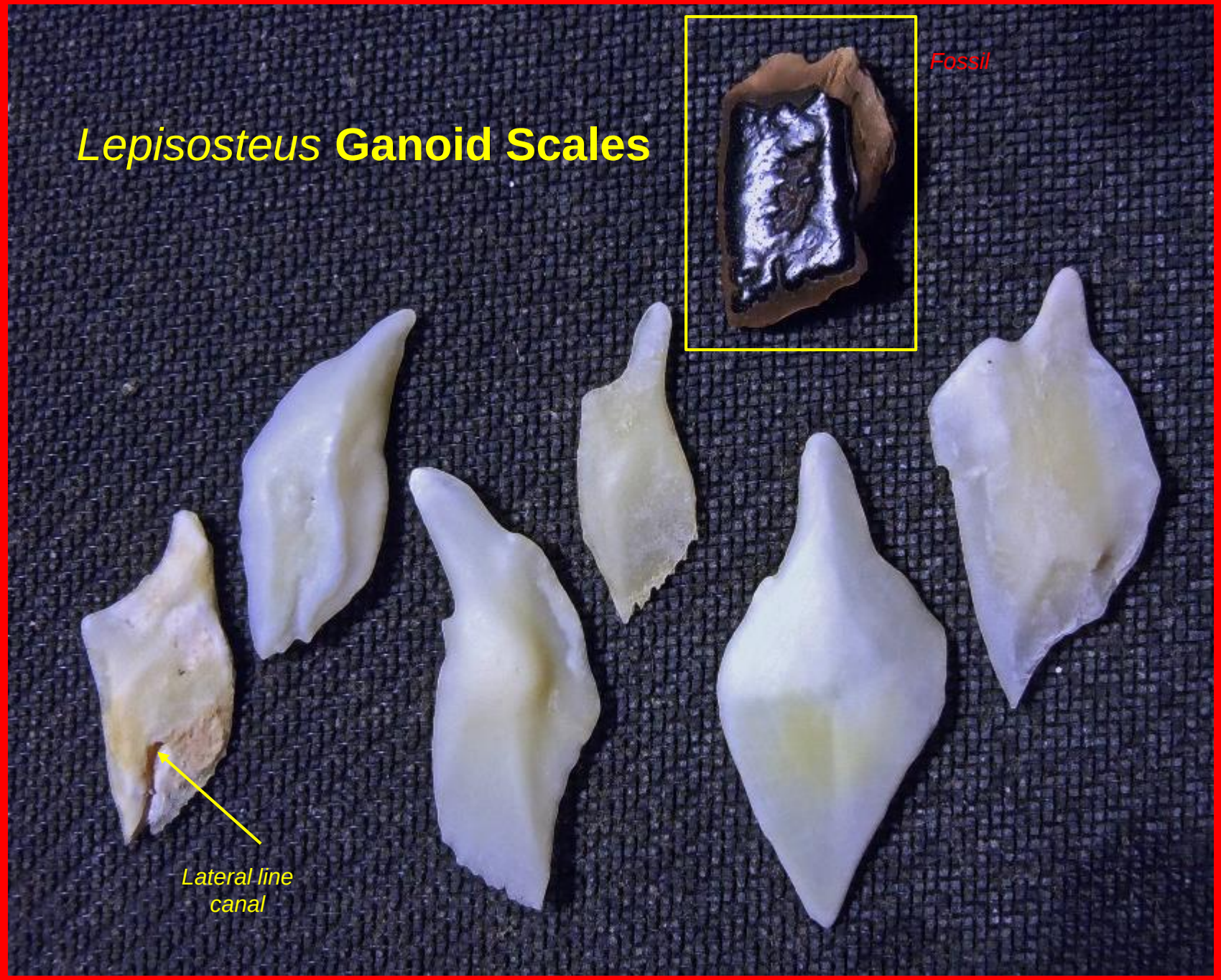
Later mammal tooth

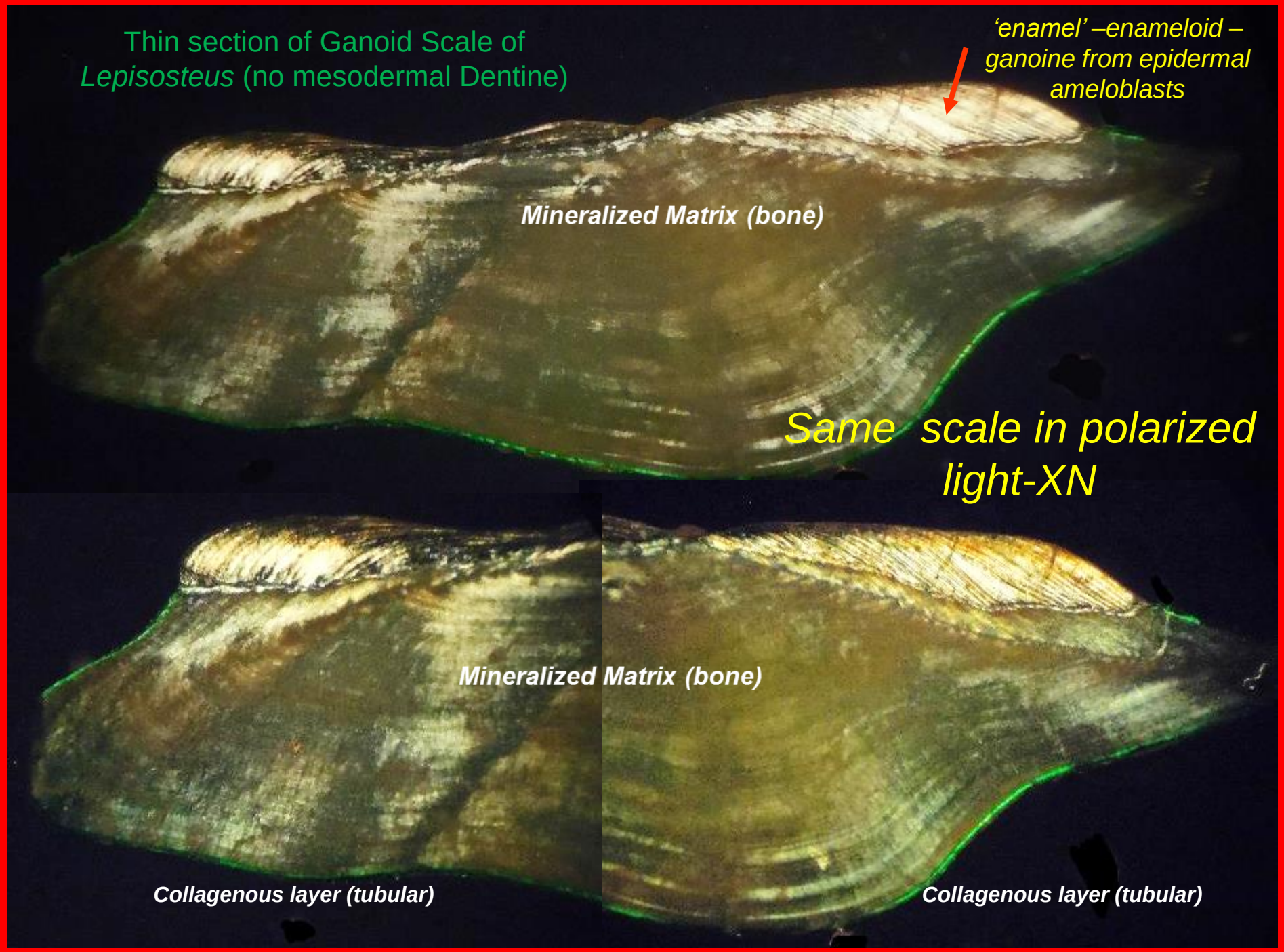
Diamond shaped *bony* scales of the <u>alligator gar</u>

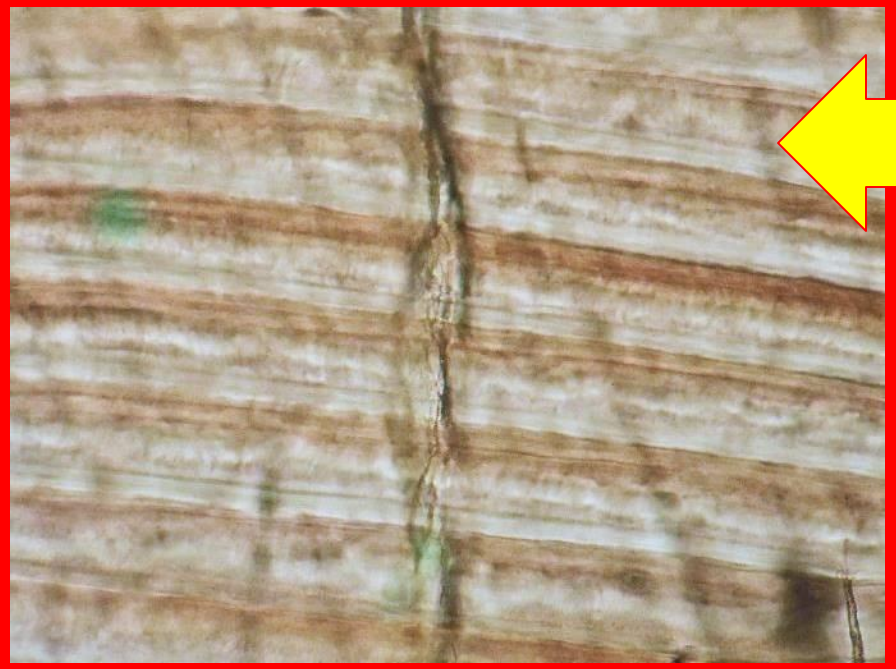
Lepisosteus

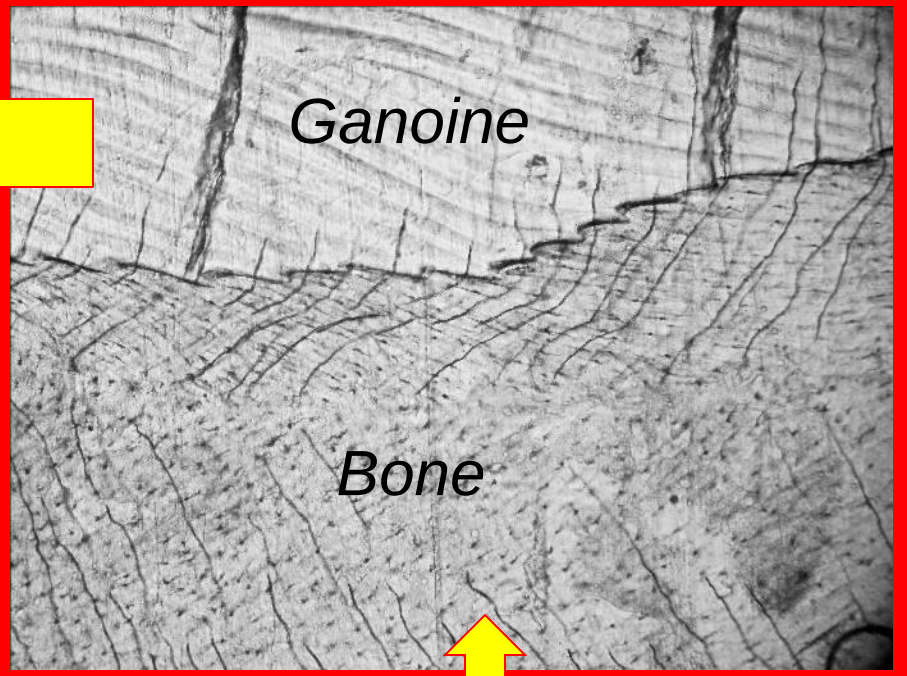
Gars have bony enamel&dentine scales called 'GANOID' scales

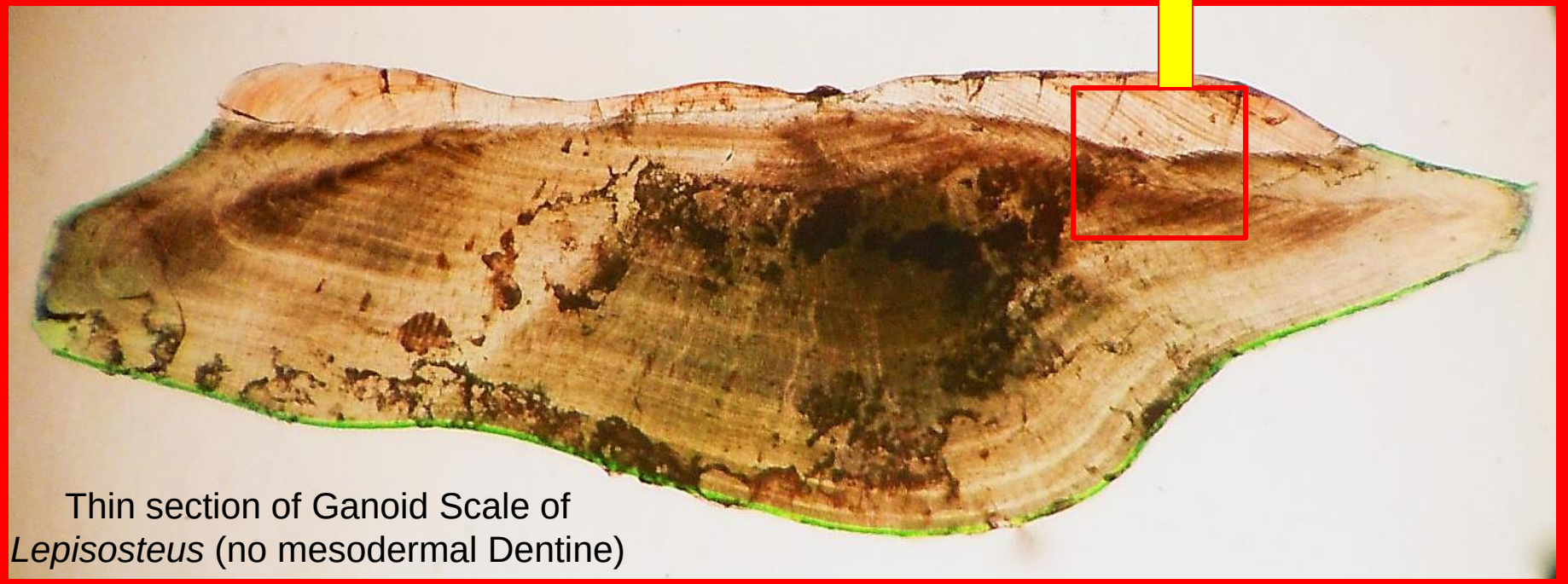
Lepisosteus


Lepisosteus **Ganoid Scales**
Fossil
Lateral line canal

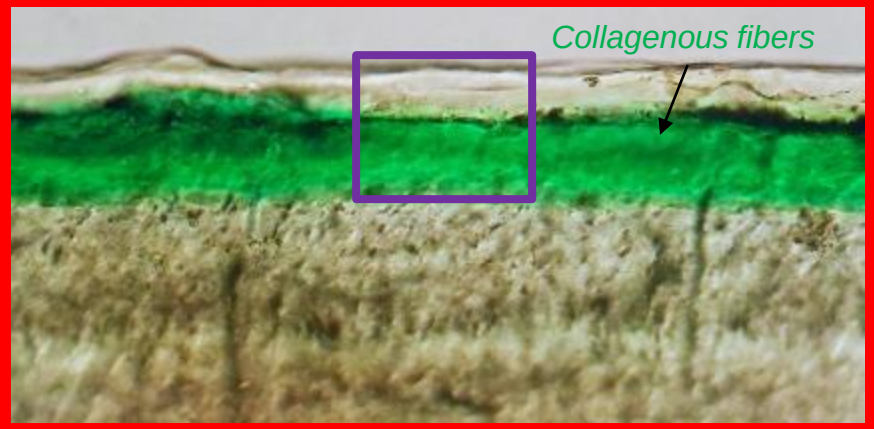

Thin section of Ganoid Scale of
Lepisosteus (no mesodermal Dentine)
'enamel' –enameloid – ganoine from epidermal ameloblasts
Mineralized Matrix (bone)
Same scale in polarized light-XN
Mineralized Matrix (bone)
Collagenous layer (tubular)
Collagenous layer (tubular)

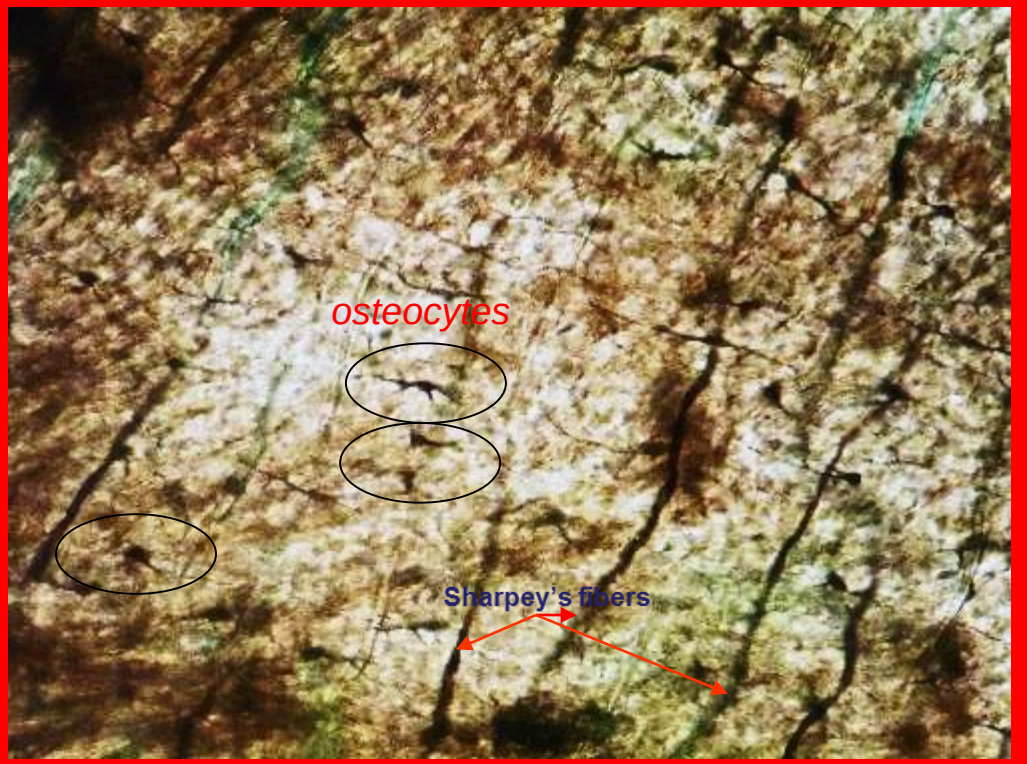


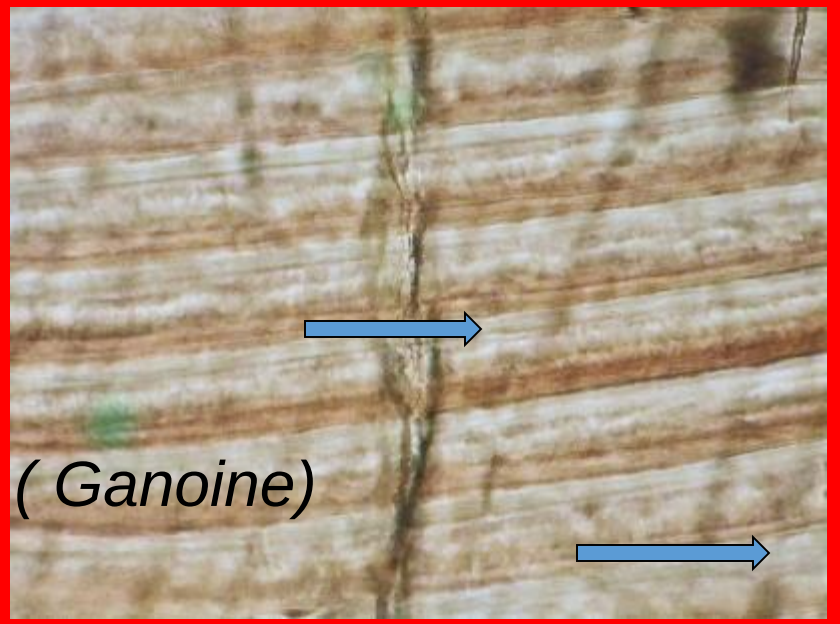




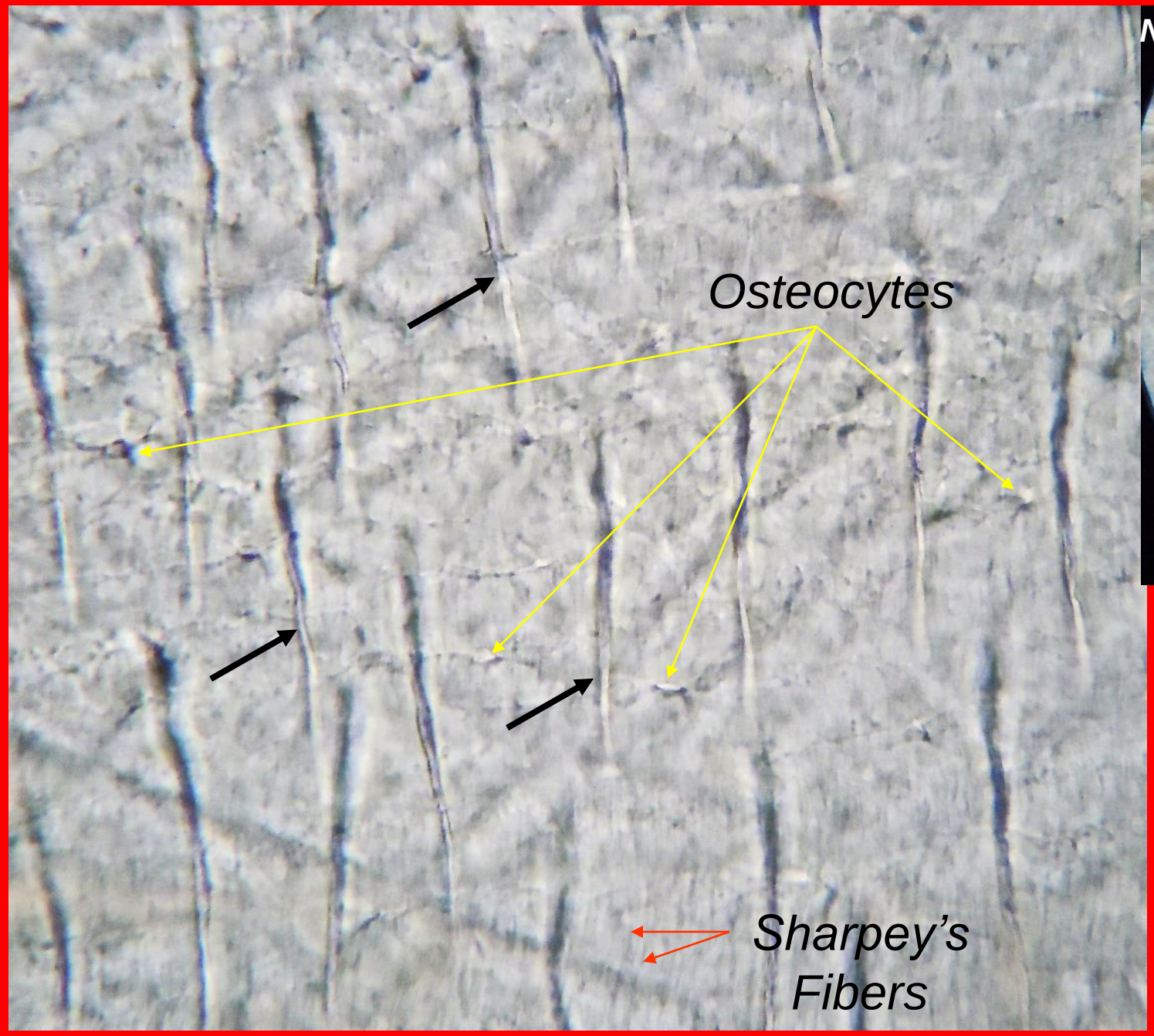
Thin section of Ganoid Scale of
Lepisosteus (no mesodermal Dentine)

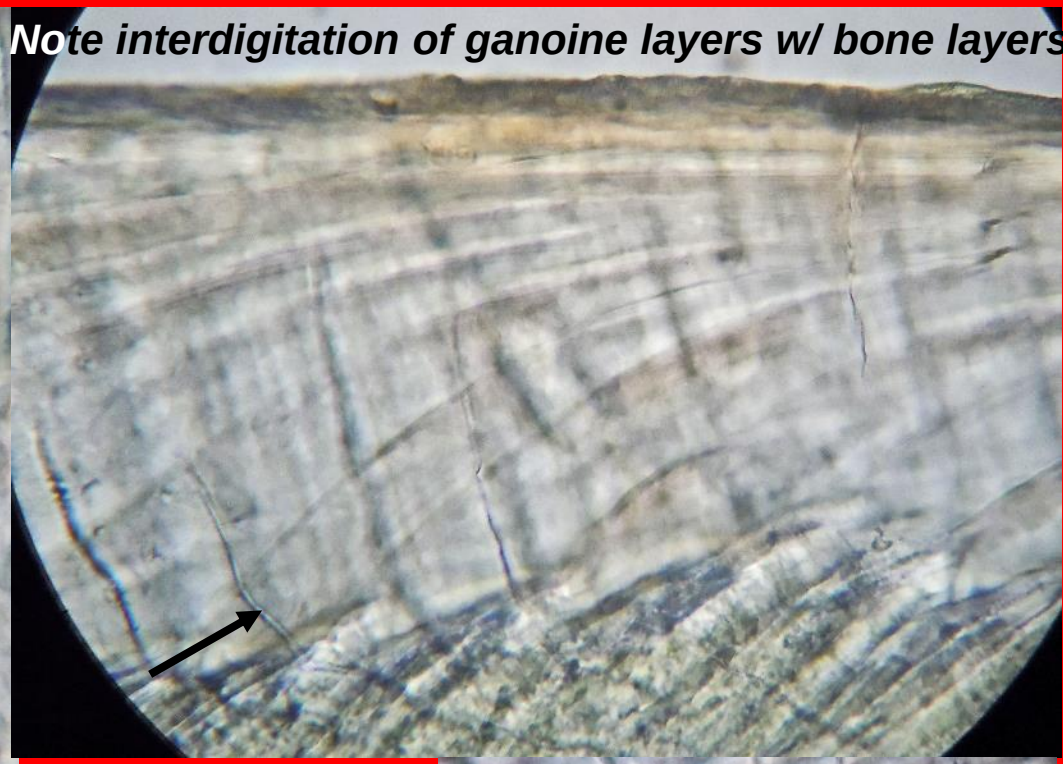




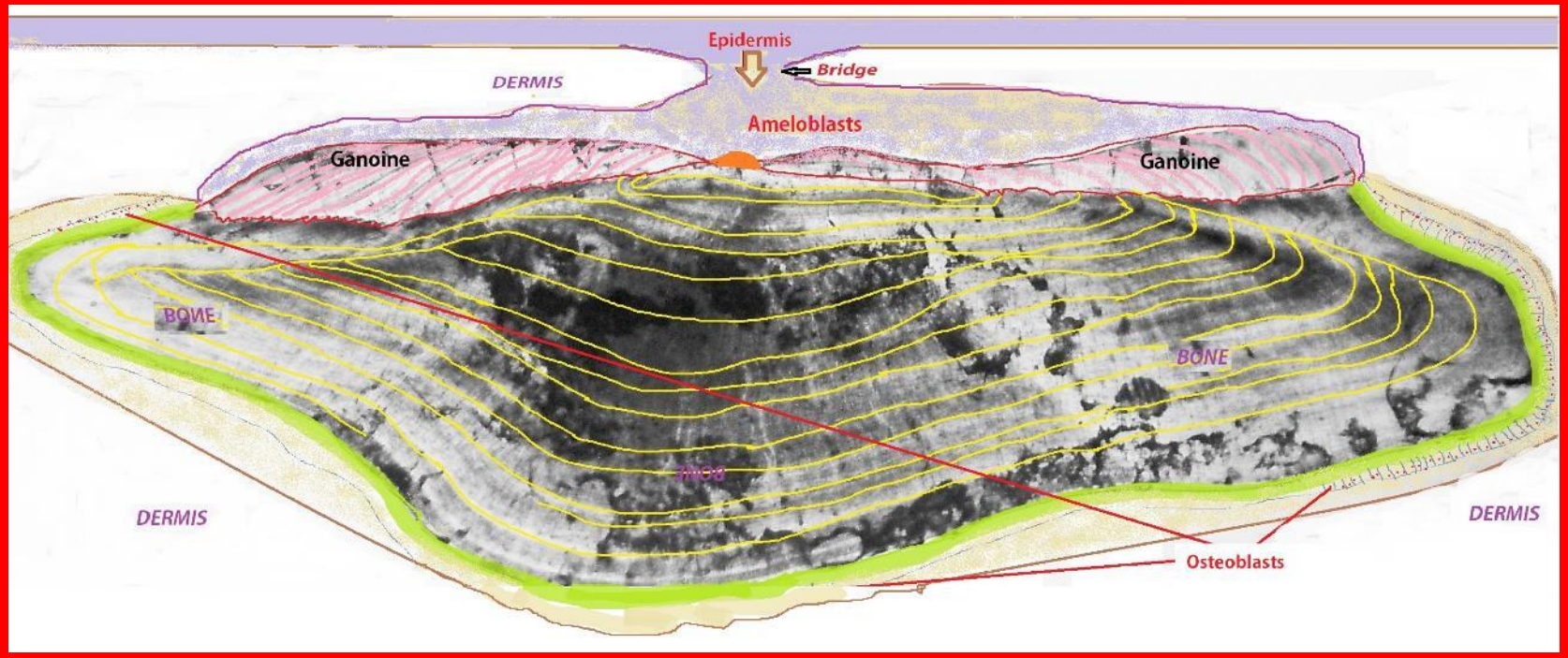


Enameloid (Ganoine)

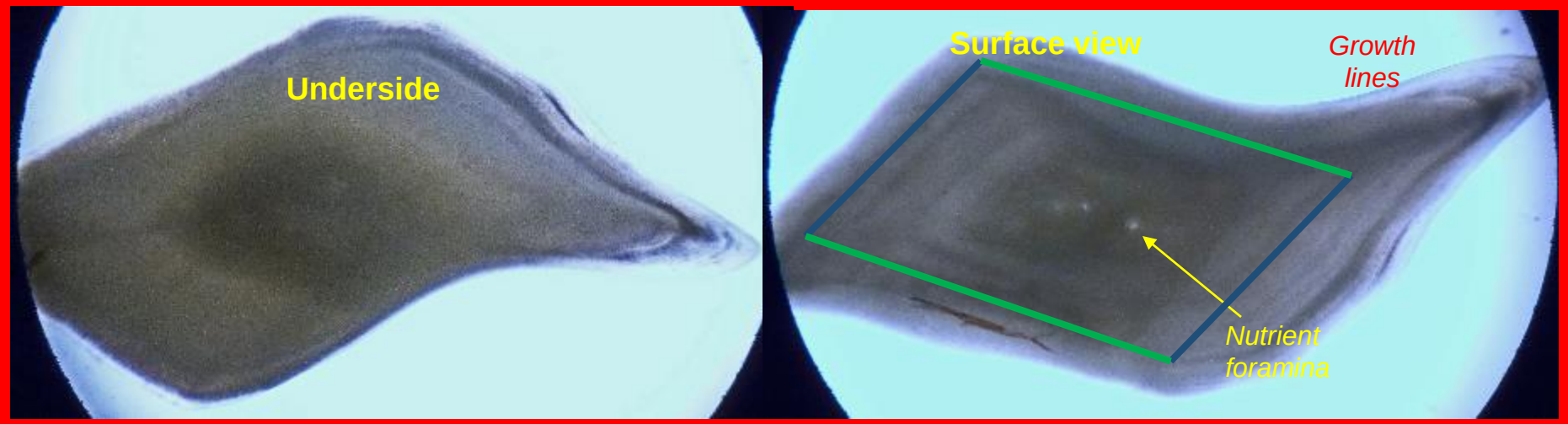


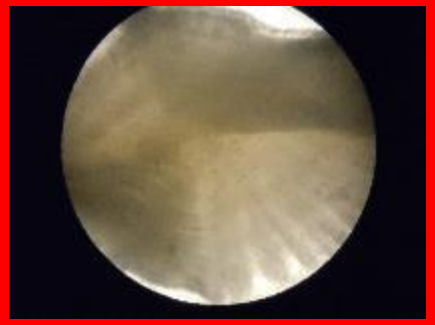


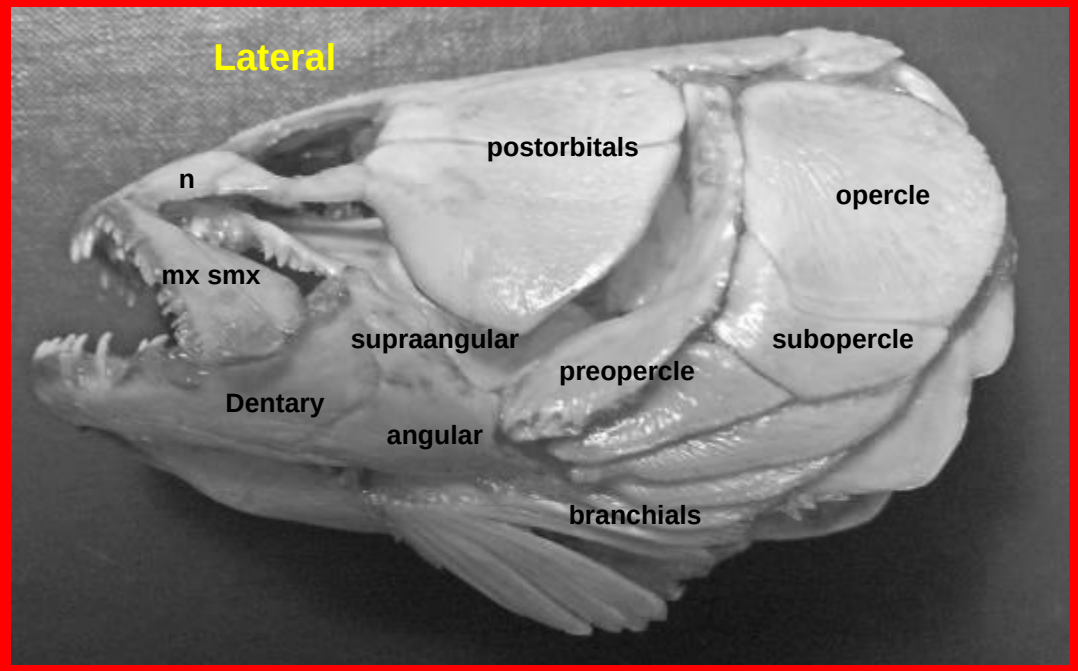
Williamson's canals in bone, some extend into ganoine (enamel)


Epidermis
Bridge
DERMIS
Ameloblasts
Ganoine
Ganoine
BONE
BONE
DERMIS
DERMIS
Osteoblasts

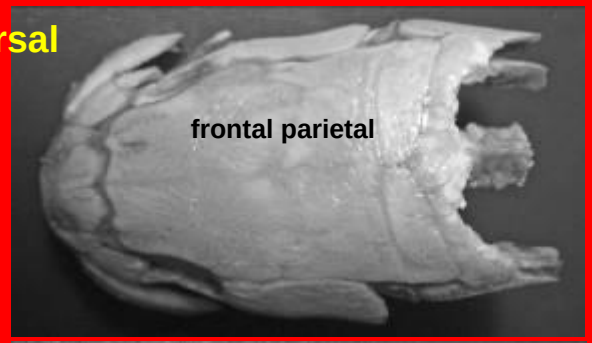

Fossil forms
Pliocene


Underside
Surface view
Growth lines
Nutrient foramina

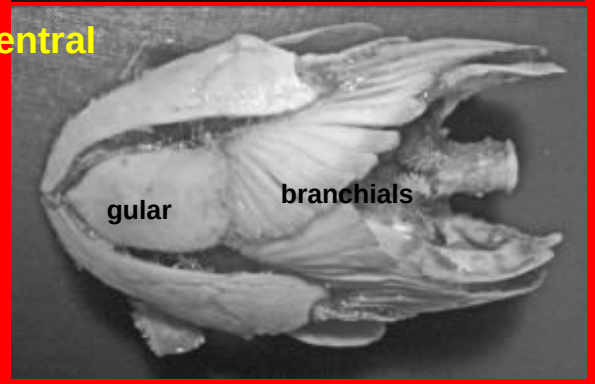




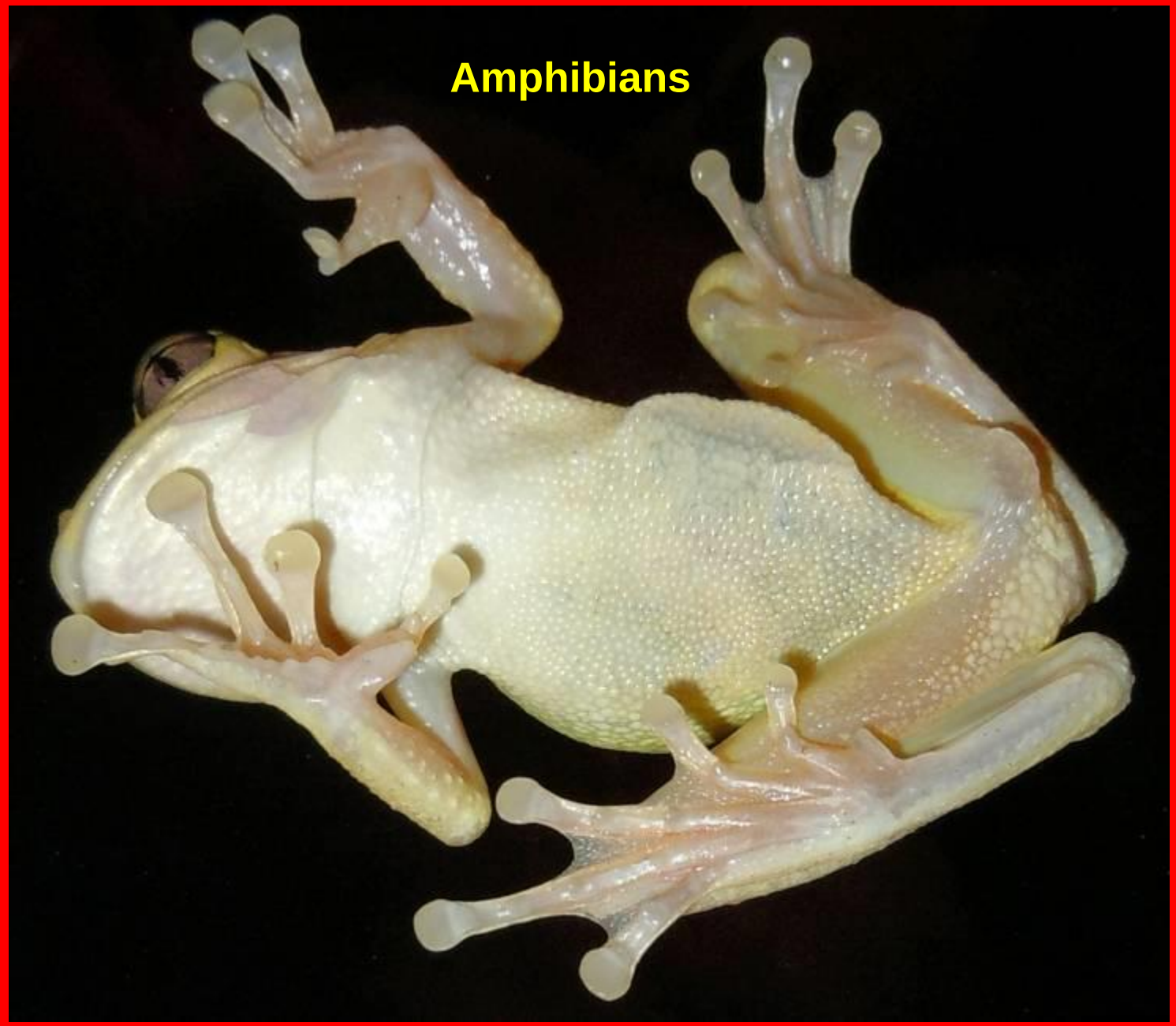
dorsal



ventral



Amphibians

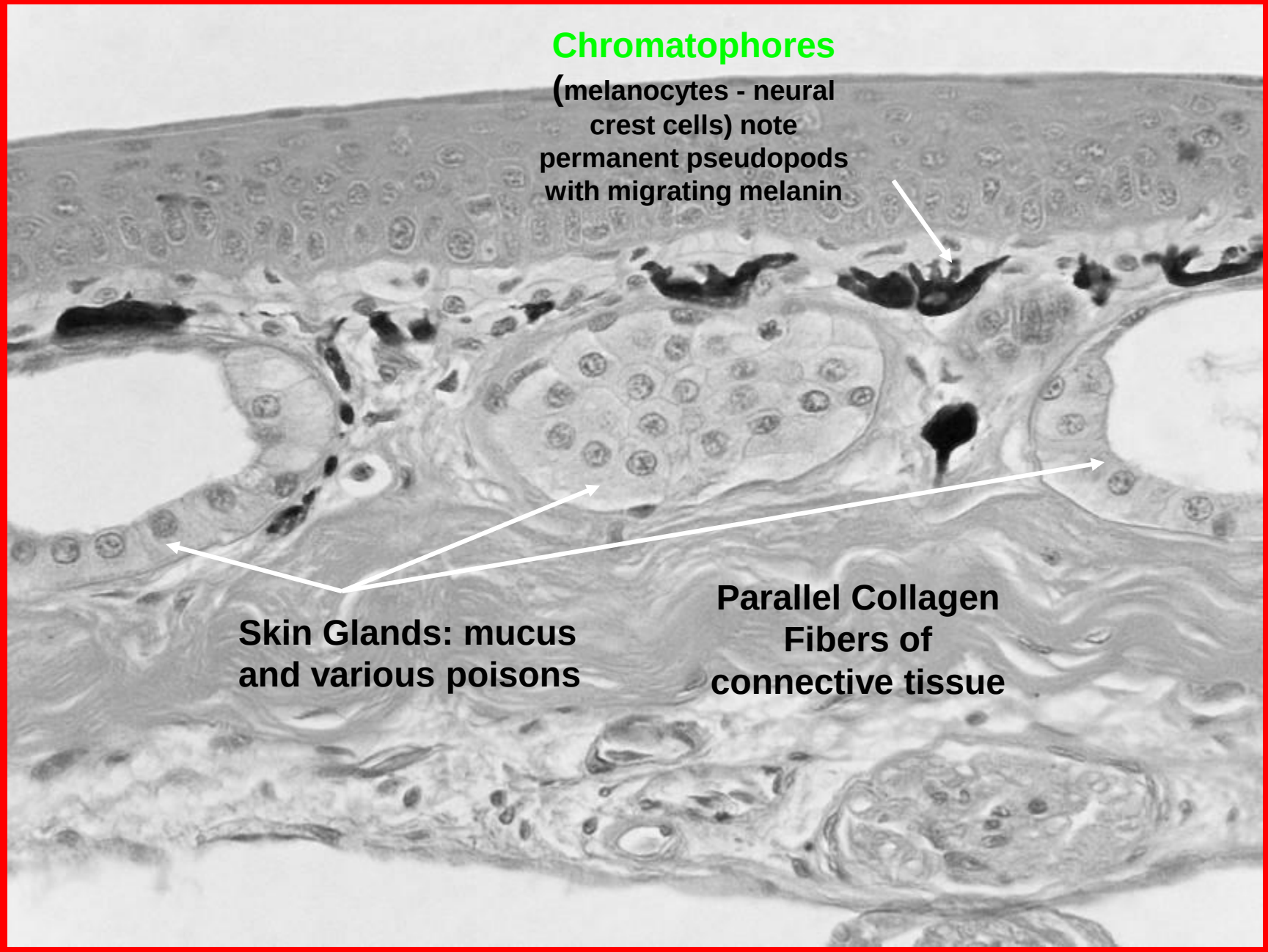


Cuban tree frog at night

Cuban tree frog in
the daylight


Hyla cinerea

Amphibians


Chromatophores
(melanocytes - neural crest cells) note permanent pseudopods with migrating melanin
Epidermis
Dermis
Skin Glands: mucus and various poisons
Parallel Collagen Fibers of connective tissue

Strawberry poison frog (*Renita venenosa rojiazul*) Costa Rica, April 2013

Size ~3/4“ or 2cm maximum use of chromatophores & skin glands

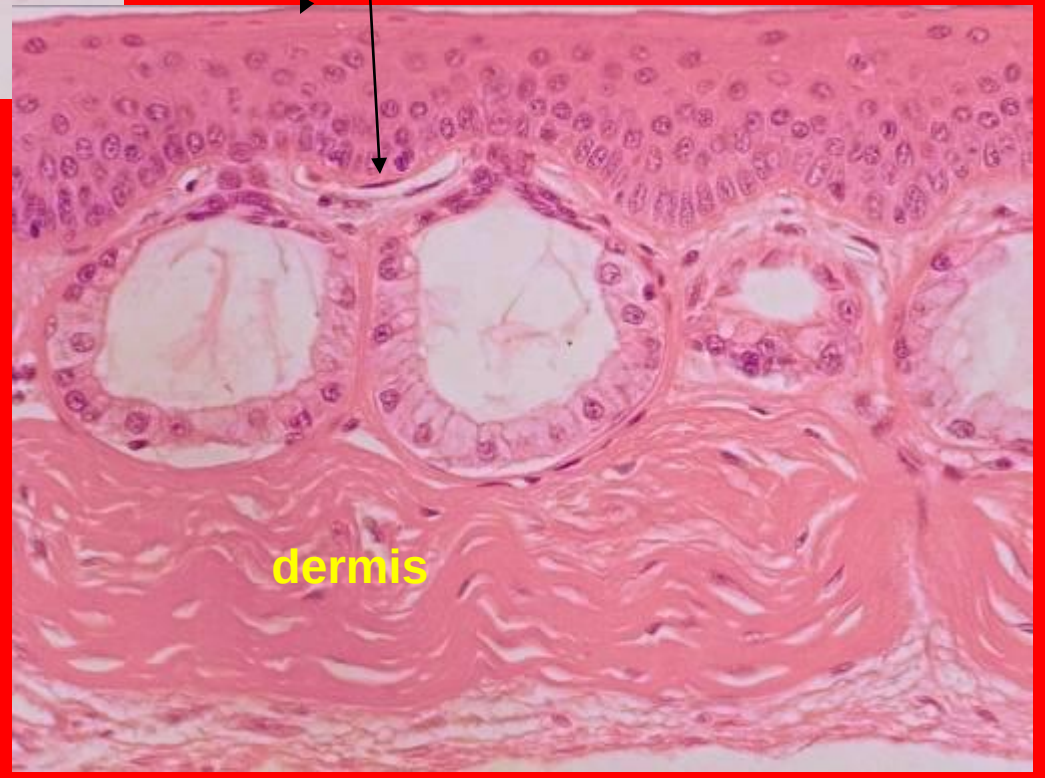
Green poison frog (*Renita venenosa verdinegro*) Costa Rica, April 2013

Native cultures tipped darts with glandular secretions from these frog’s skin to bring down monkeys and sloths from tree tops

pigmented skin

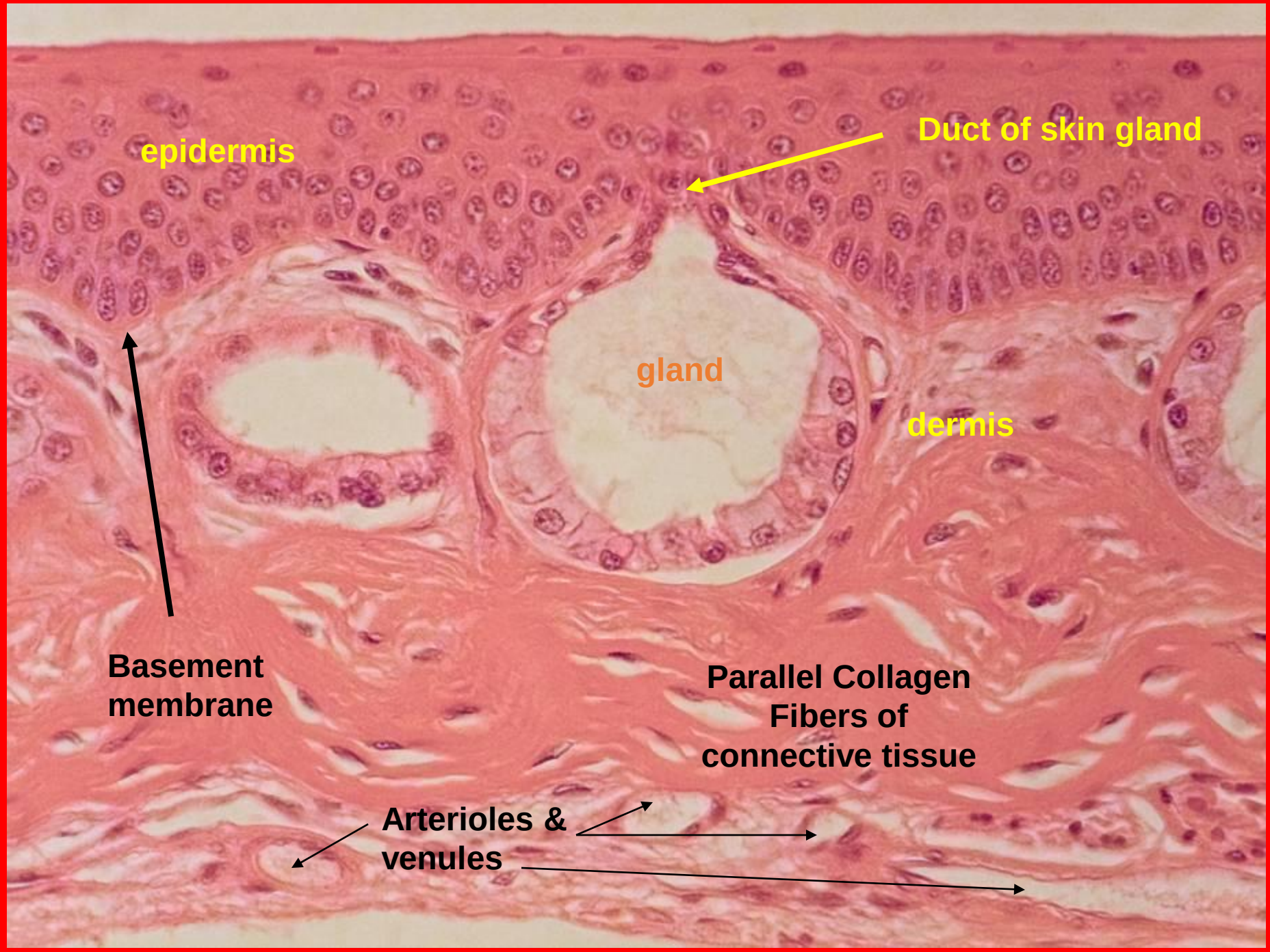
epidermis

unpigmented skin



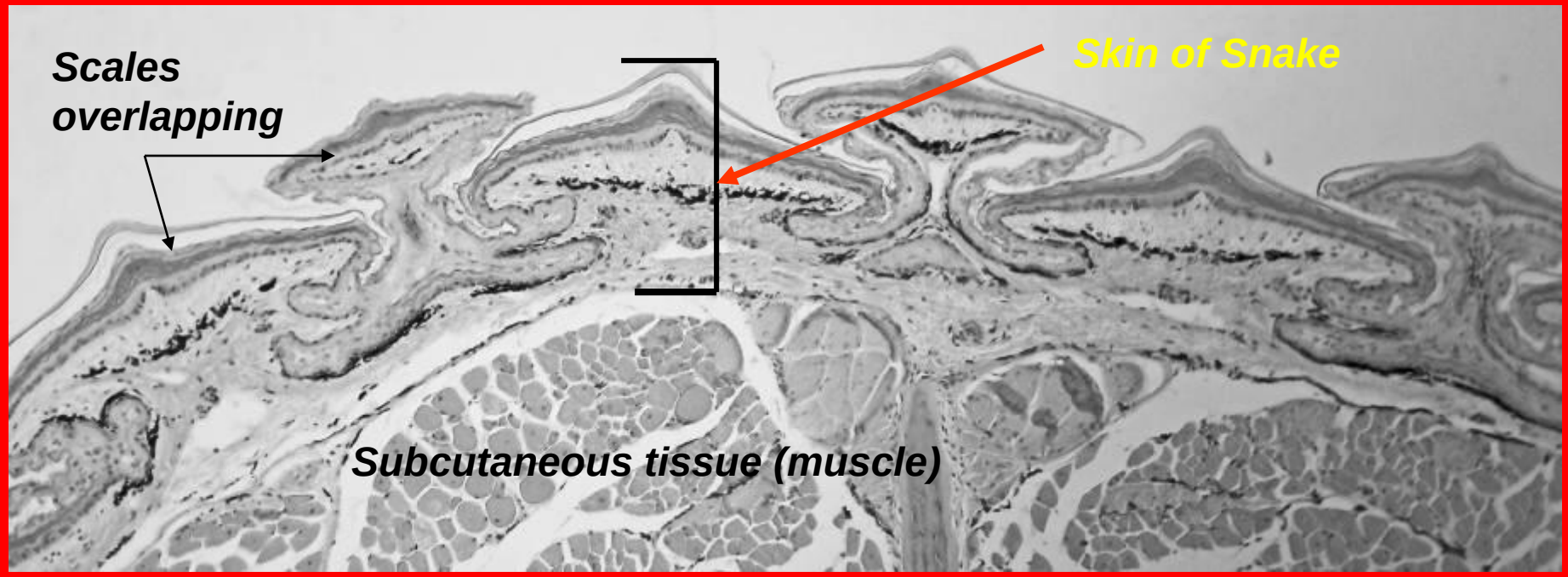
Frog skin

Arrows - chromatophores


epidermis
Duct of skin gland
gland
dermis
Basement membrane
Parallel Collagen Fibers of connective tissue
Arterioles & venules

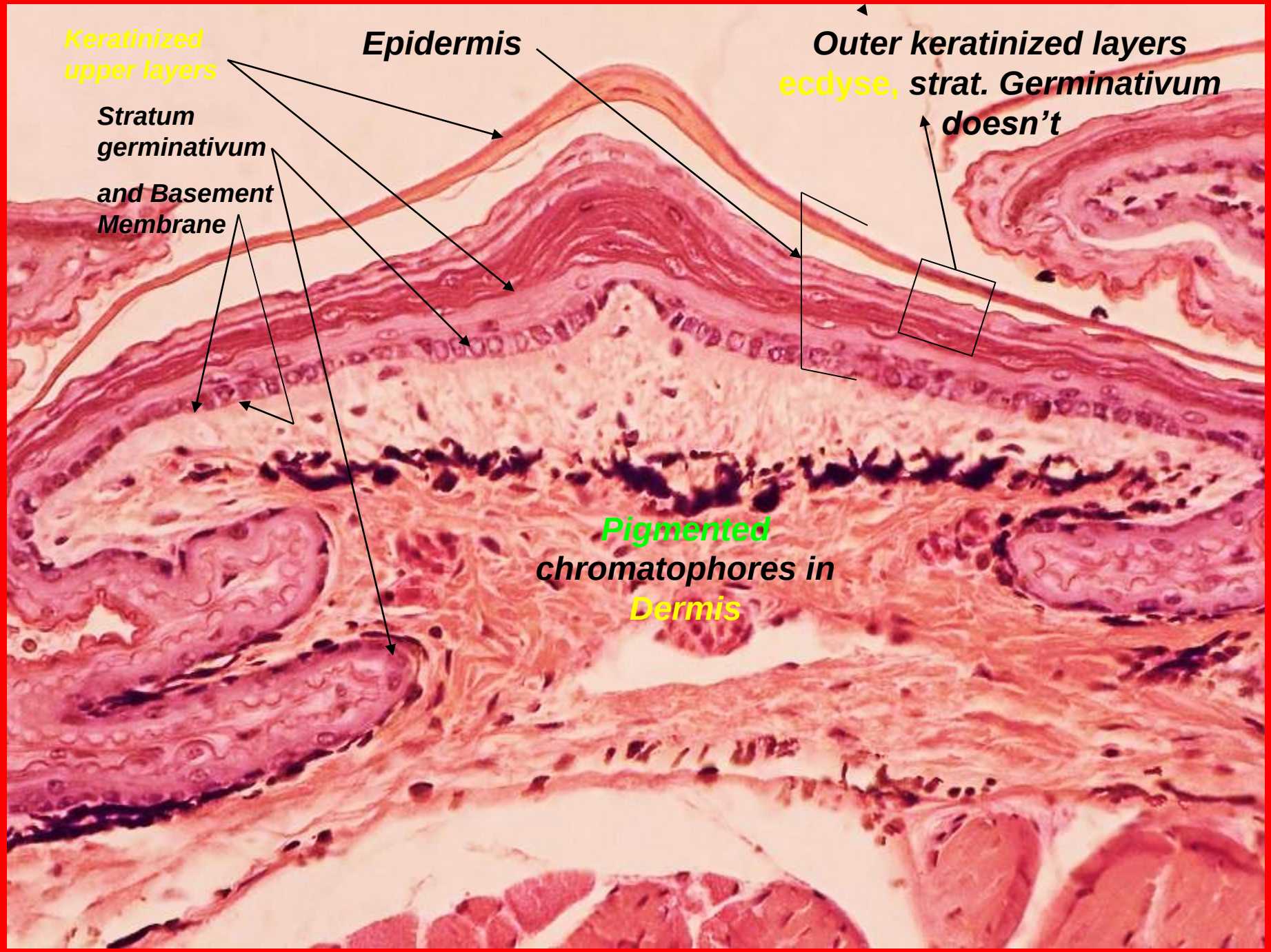
Amphibian Skin

Lizards *and* ***Skinks***

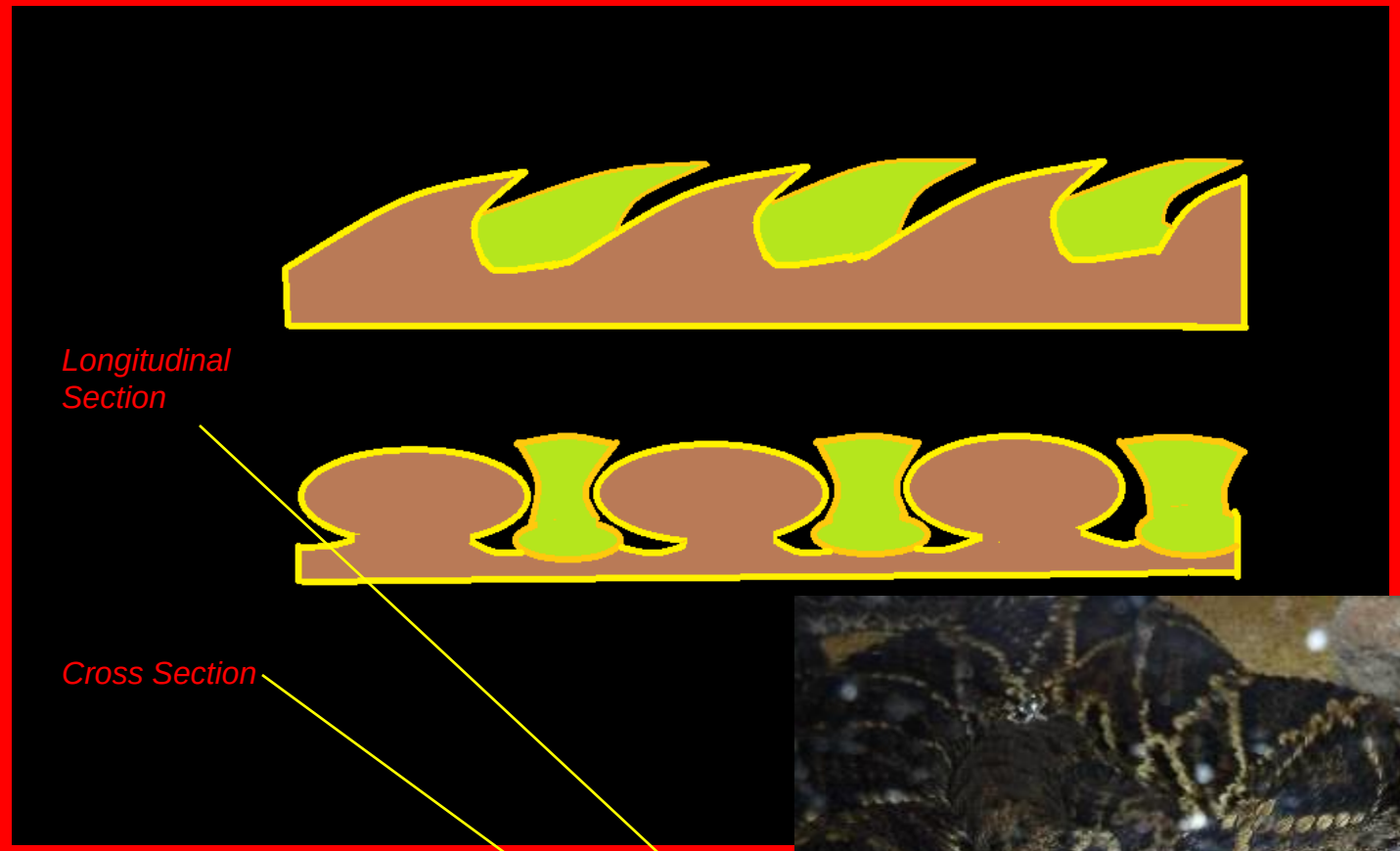

Scales overlapping
Skin of Snake
Subcutaneous tissue (muscle)


Water Snake


Corn snake


Keratinized upper layers
Epidermis
Outer keratinized layers
ecdyse, strat. Germinativum doesn't
Stratum germinativum
and Basement Membrane
Pigmented
chromatophores in
Dermis

REPTILES



Eastern
Diamondback

Aligator scutes are bony replacements of scales in the skin.

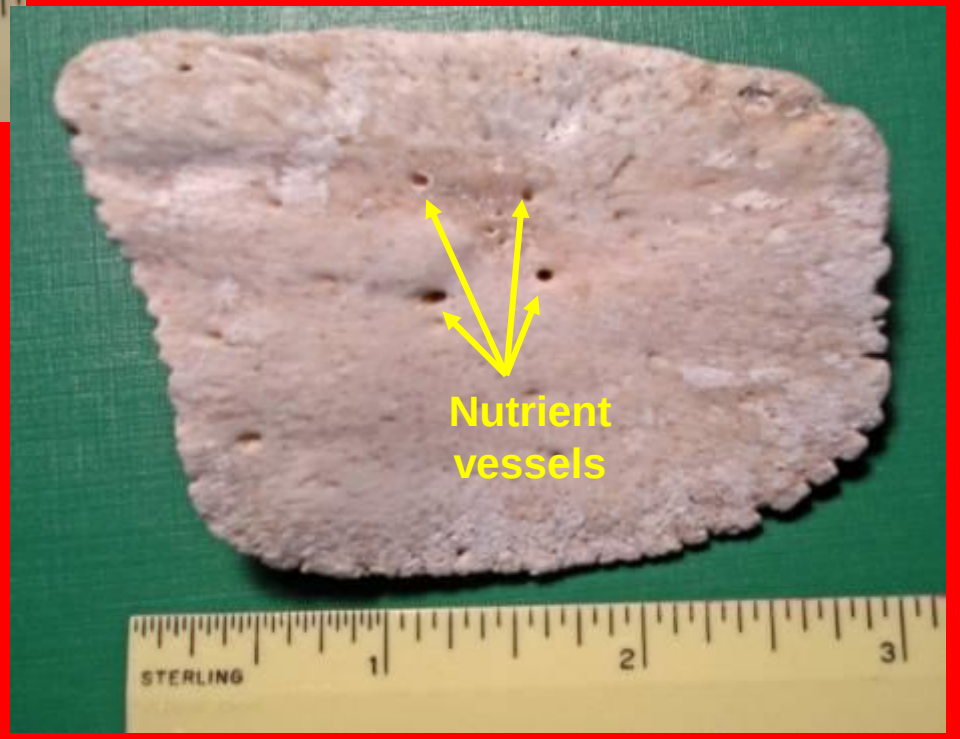
Dorsal bony scute or osteoderm
with ‘keel’or ‘spine’

Alligator mississippiensis

Dermal scutes or osteoderms: protection and thermal regulation

Dorsal view of osteoderm

Ventral view of osteoderm



Tortoises and Turtles have epidermaly derived coverings on their bony carapace & plastron; the 'beak' is a horny or keratin derivative as well.


Keratinized and shed plate on top of bony scute of common ‘slider’

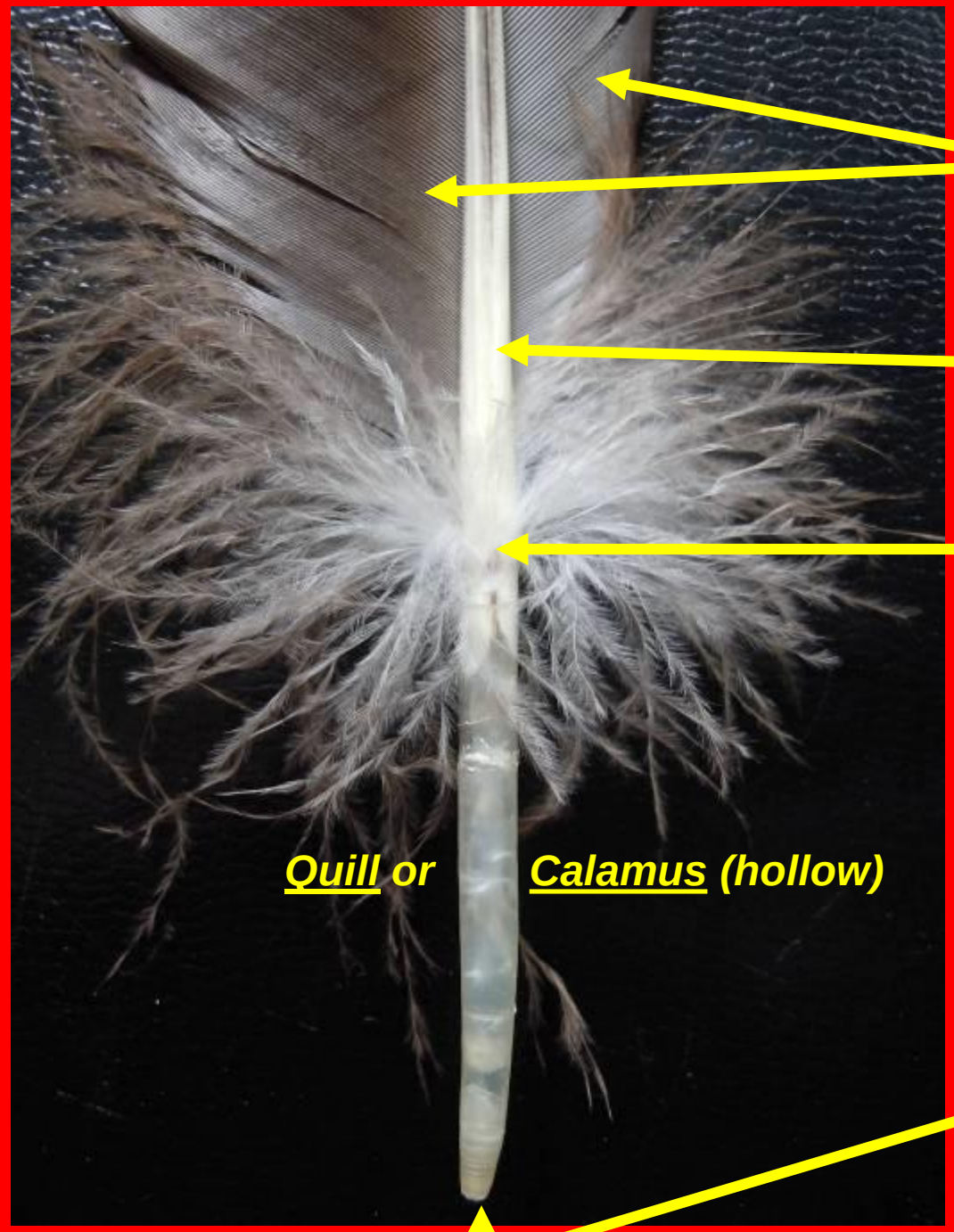
BIRDS and FEATHERS

Feathers- insulation, flight (air foils), sexual display and attraction- competition and of course protection and water proofing

Contour or flight feathers

Vane with its solid Shaft or Rachis

hollow Quill or Calamus

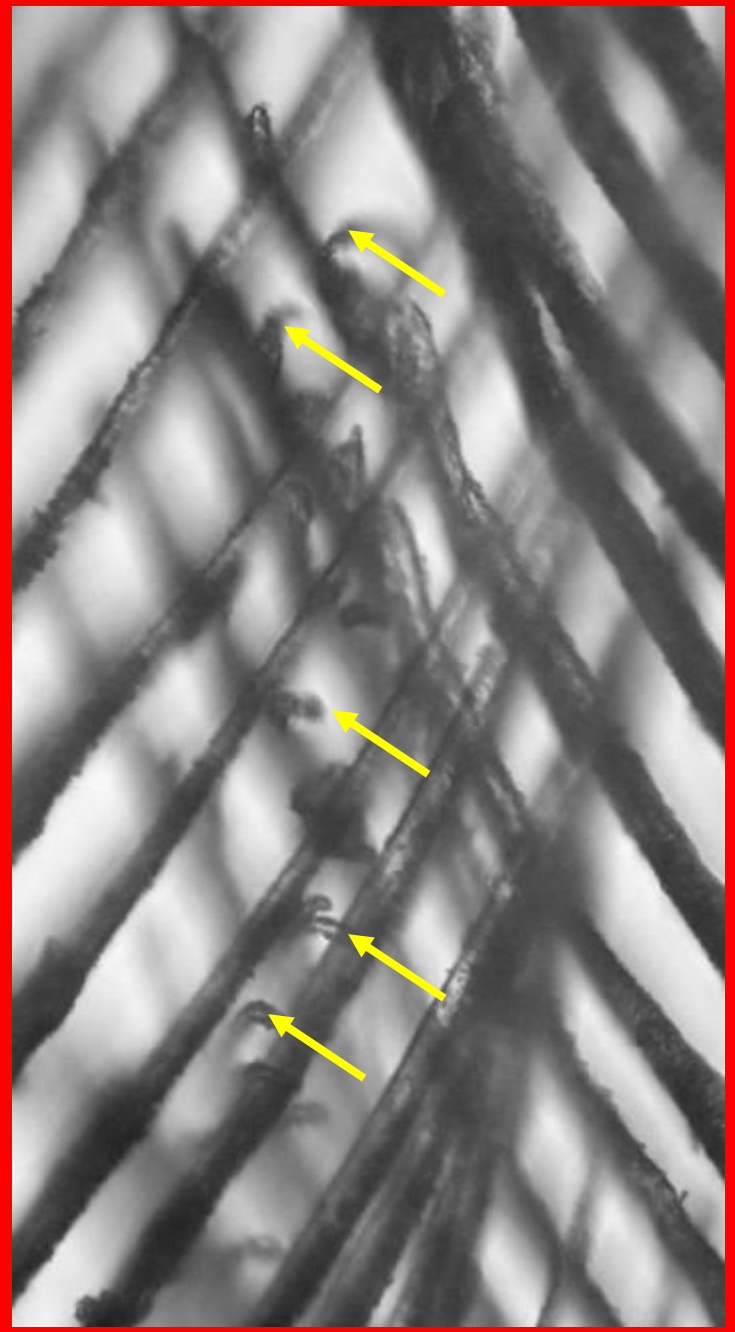


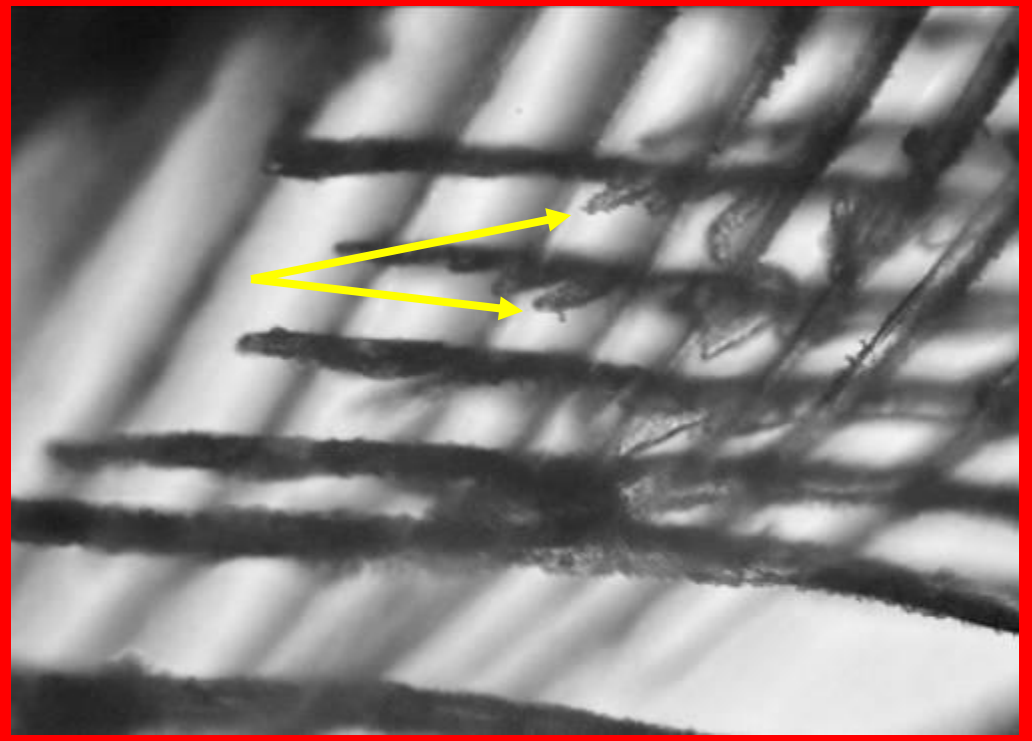
Vane with Barbs & Barbules

solid Shaft or Rachis above Sup. Umb.

Superior (Distal) Umbilicus – note tufts of insulational barbs around this opening

Inferior (Proximal) Umbilicus





2 views of opposing barbules with <u>Hooklets</u> (arrows) that hold them together – if ripped apart 'preening' with the bill can re-hook them again

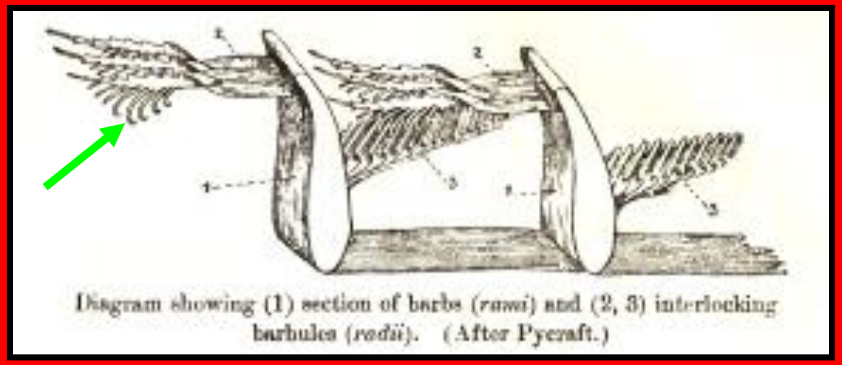
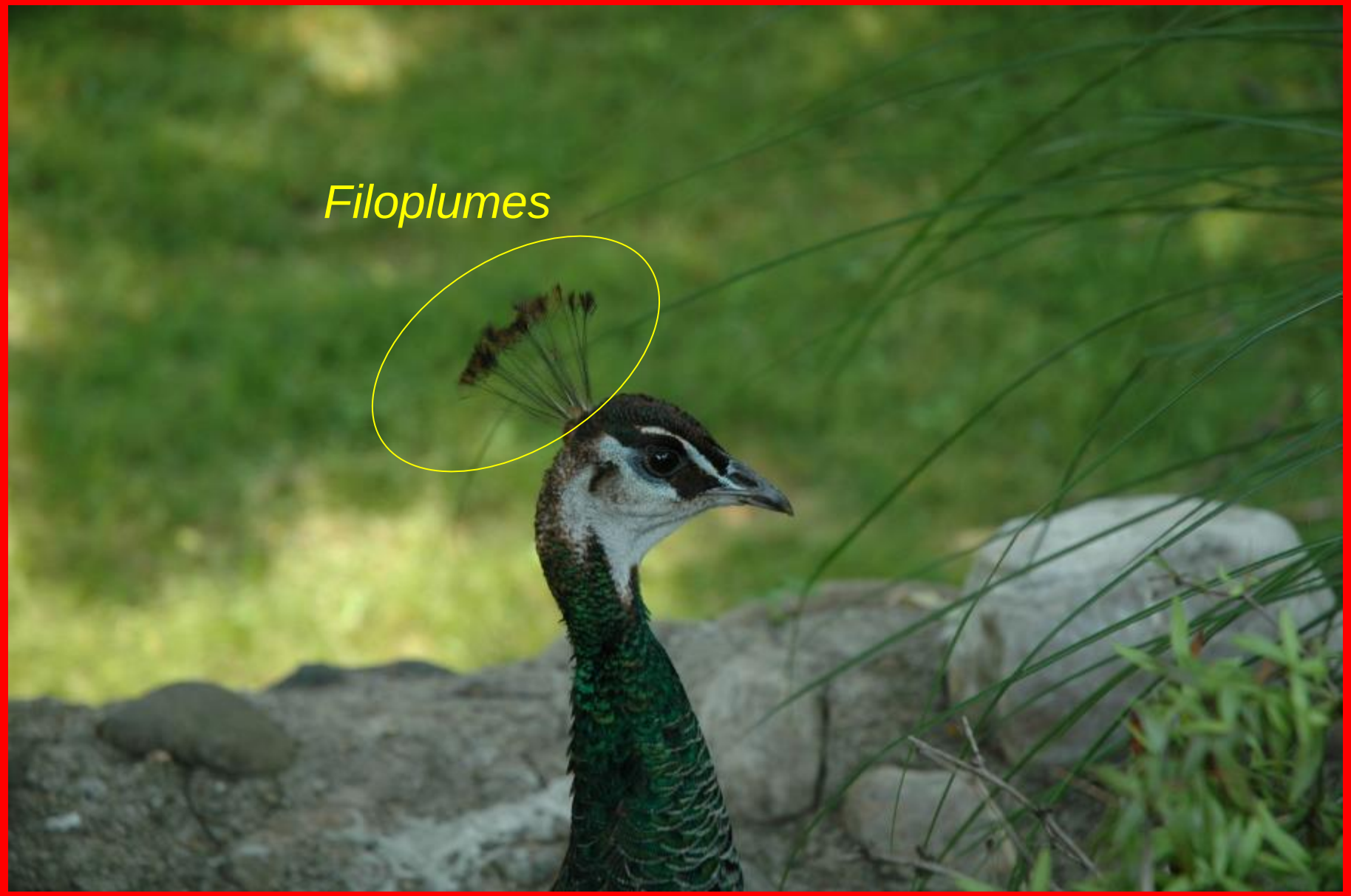
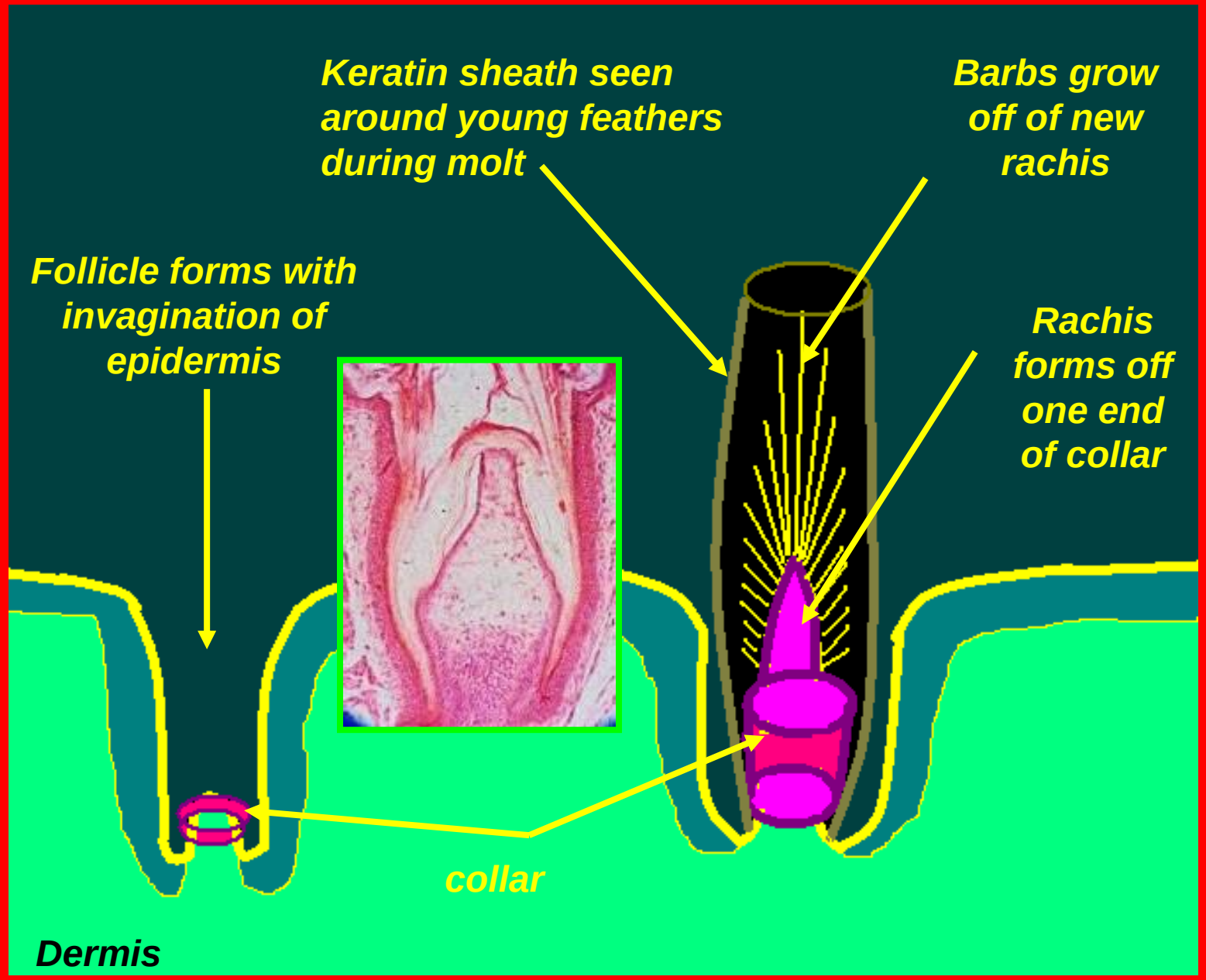
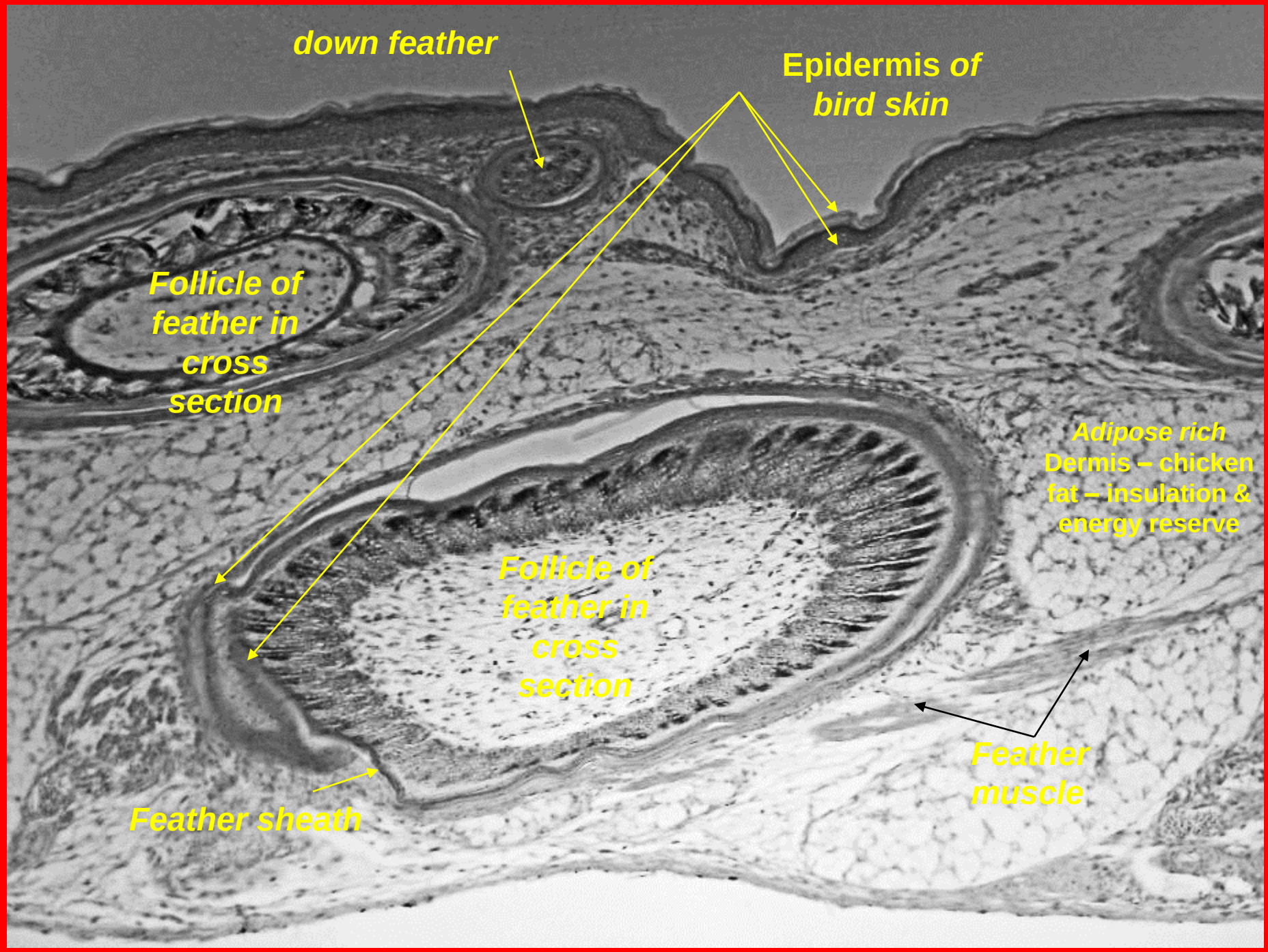


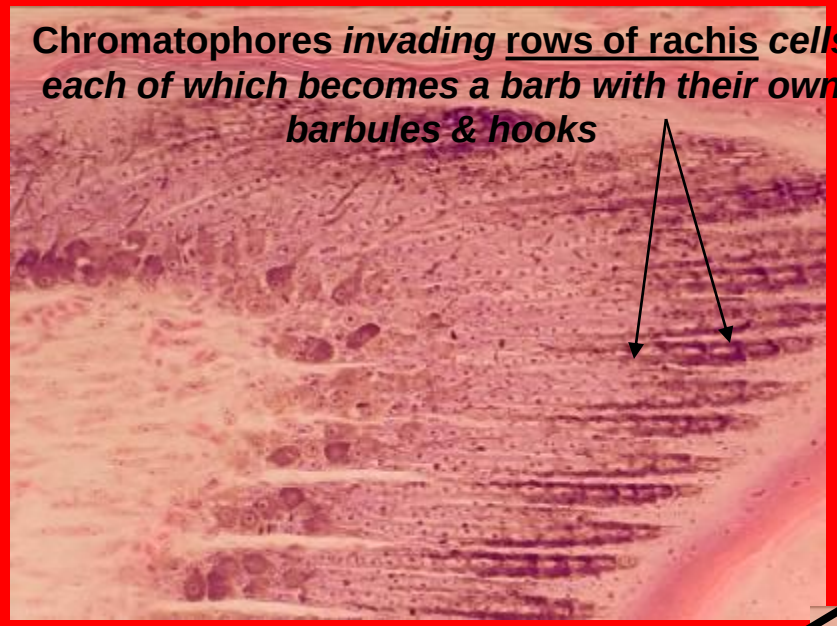
Diagram showing (1) section of barbs (*rami*) and (2, 3) interlocking barbules (*radii*). (After Pycraft.)


Filoplumes

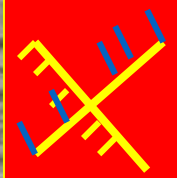
Avian chromatophores in overdrive - display plumes of male: PEACOCK

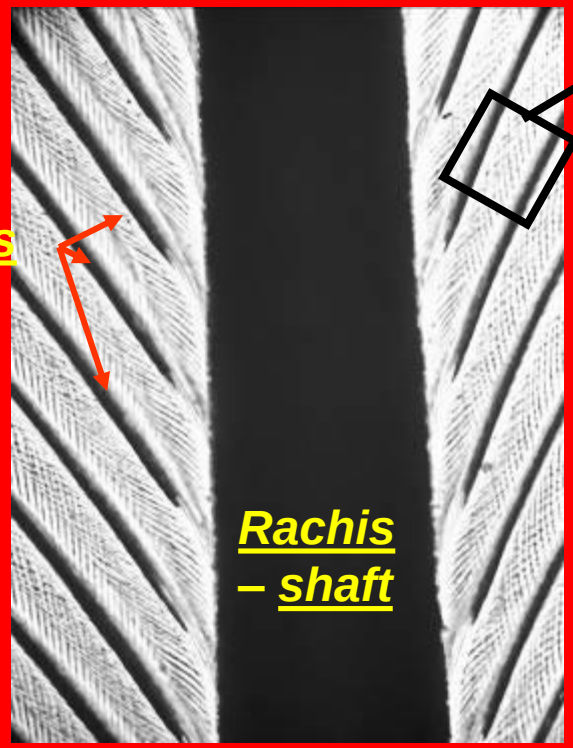

Keratin sheath seen around young feathers during molt
Barbs grow off of new rachis
Follicle forms with invagination of epidermis
Rachis forms off one end of collar
collar
Dermis

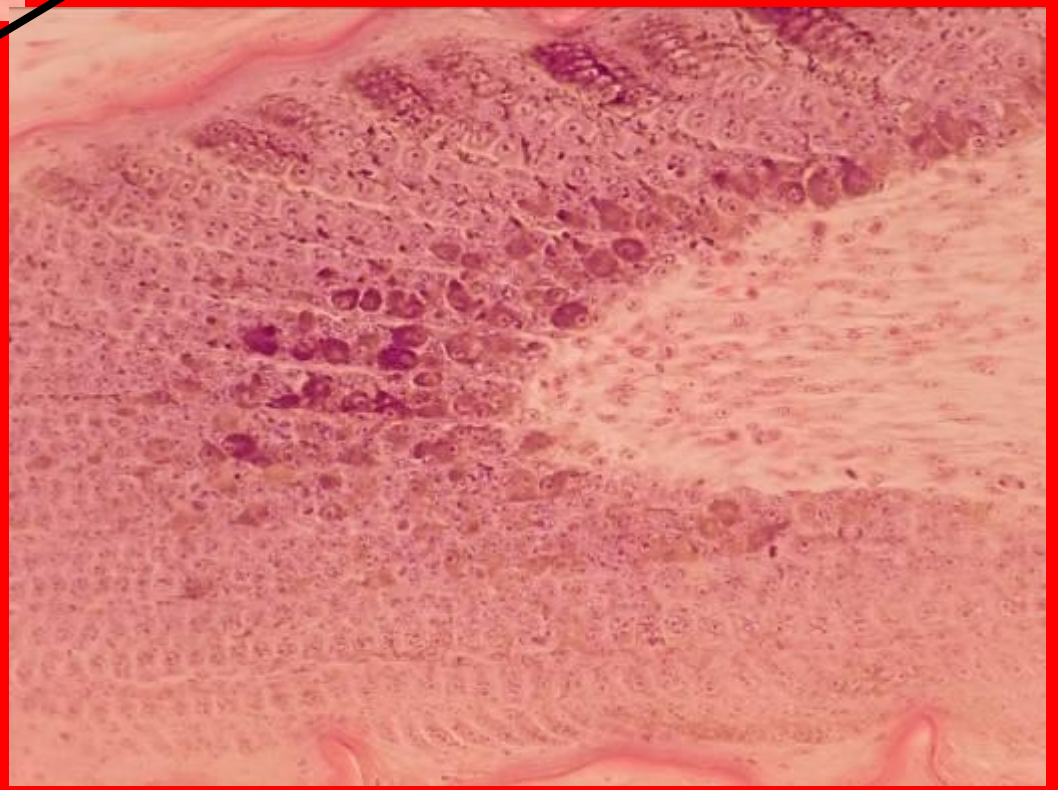

down feather
Epidermis of bird skin
Follicle of feather in cross section
Adipose rich Dermis – chicken fat – insulation & energy reserve
Follicle of feather in cross section
Feather muscle
Feather sheath

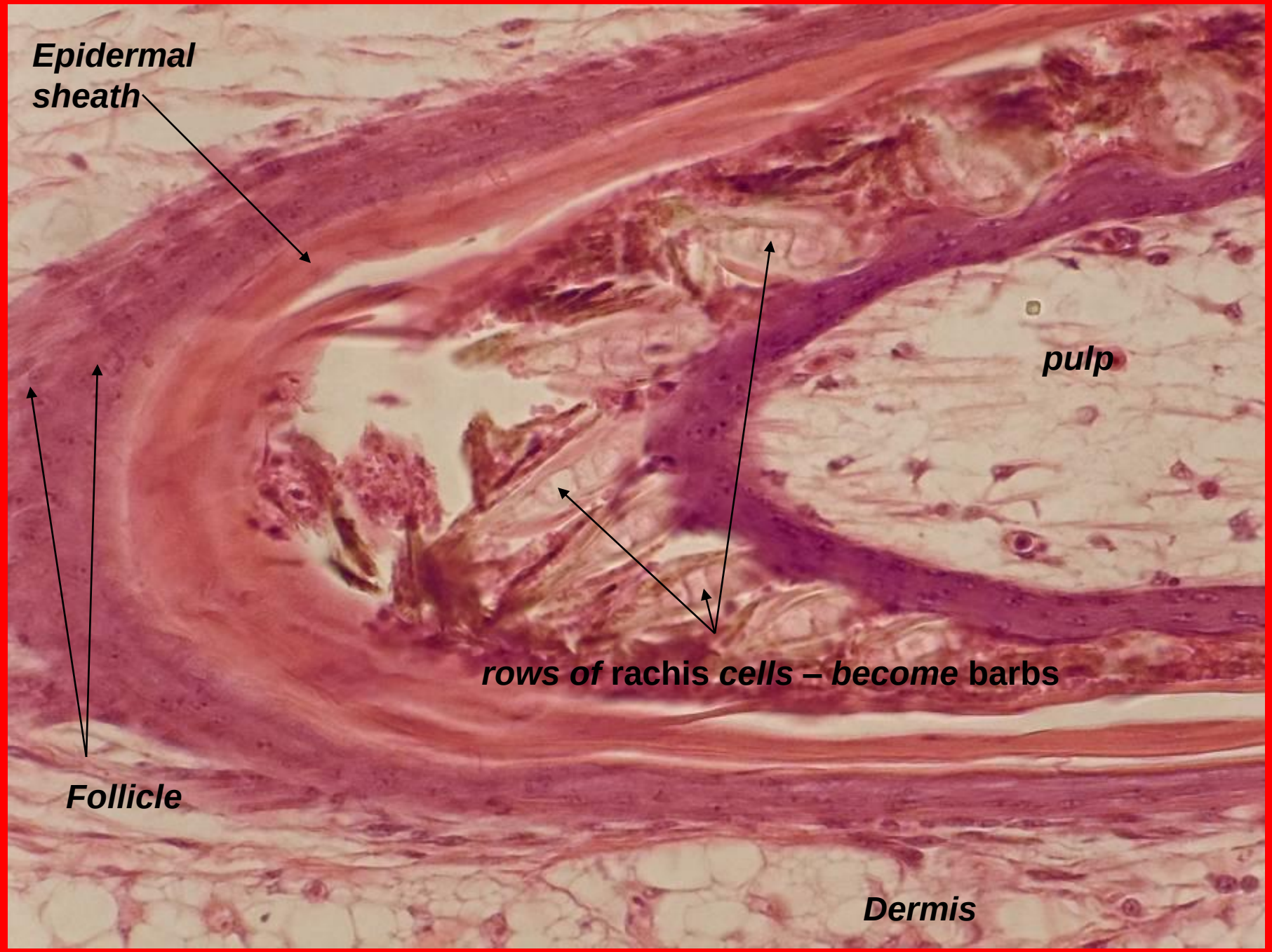

Chromatophores *invading* rows of rachis *cells each of which becomes a barb with their own barbules & hooks*

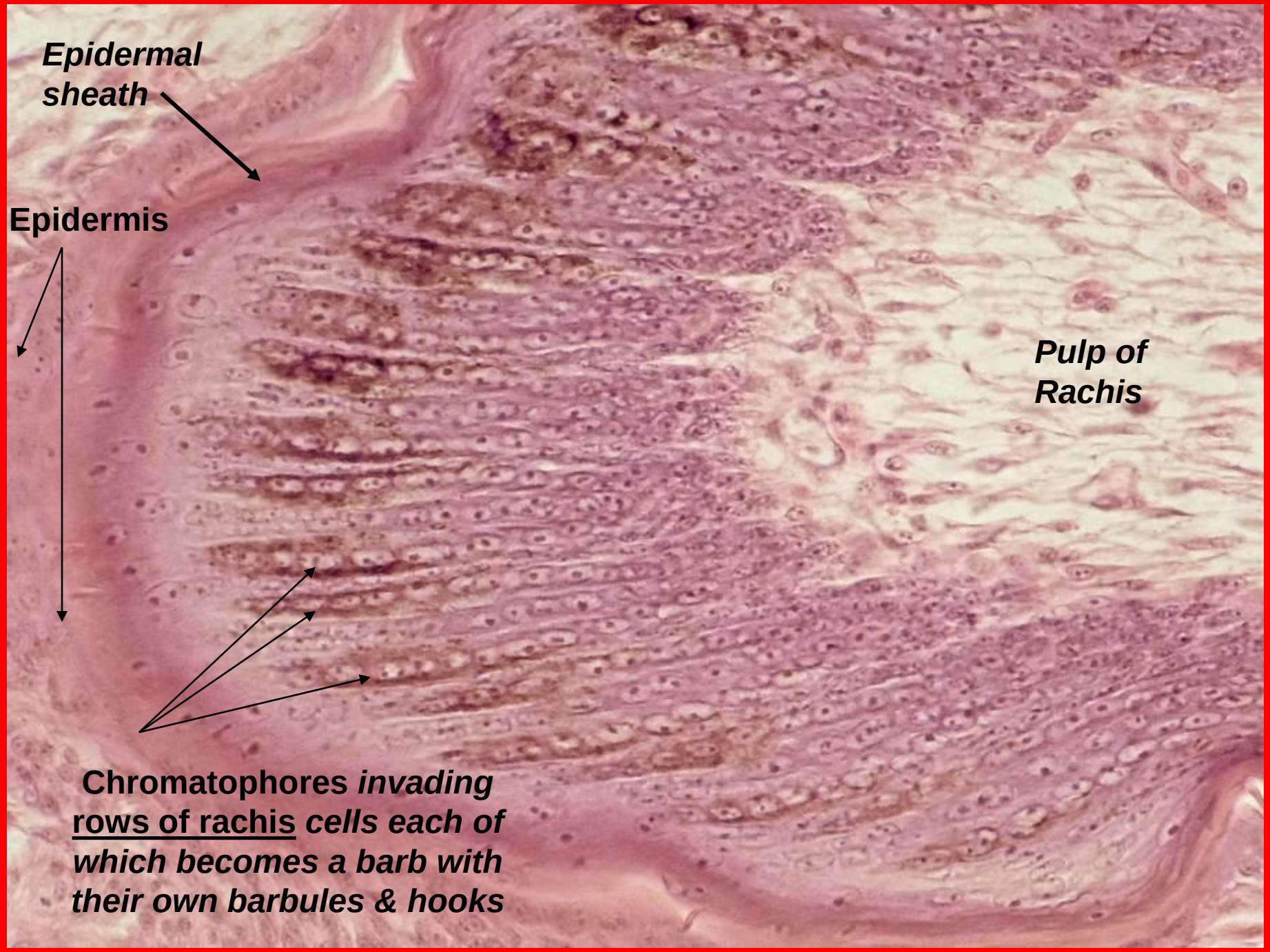

barbs
Barbules *with hooklets, if displaced are preened back*
barbs



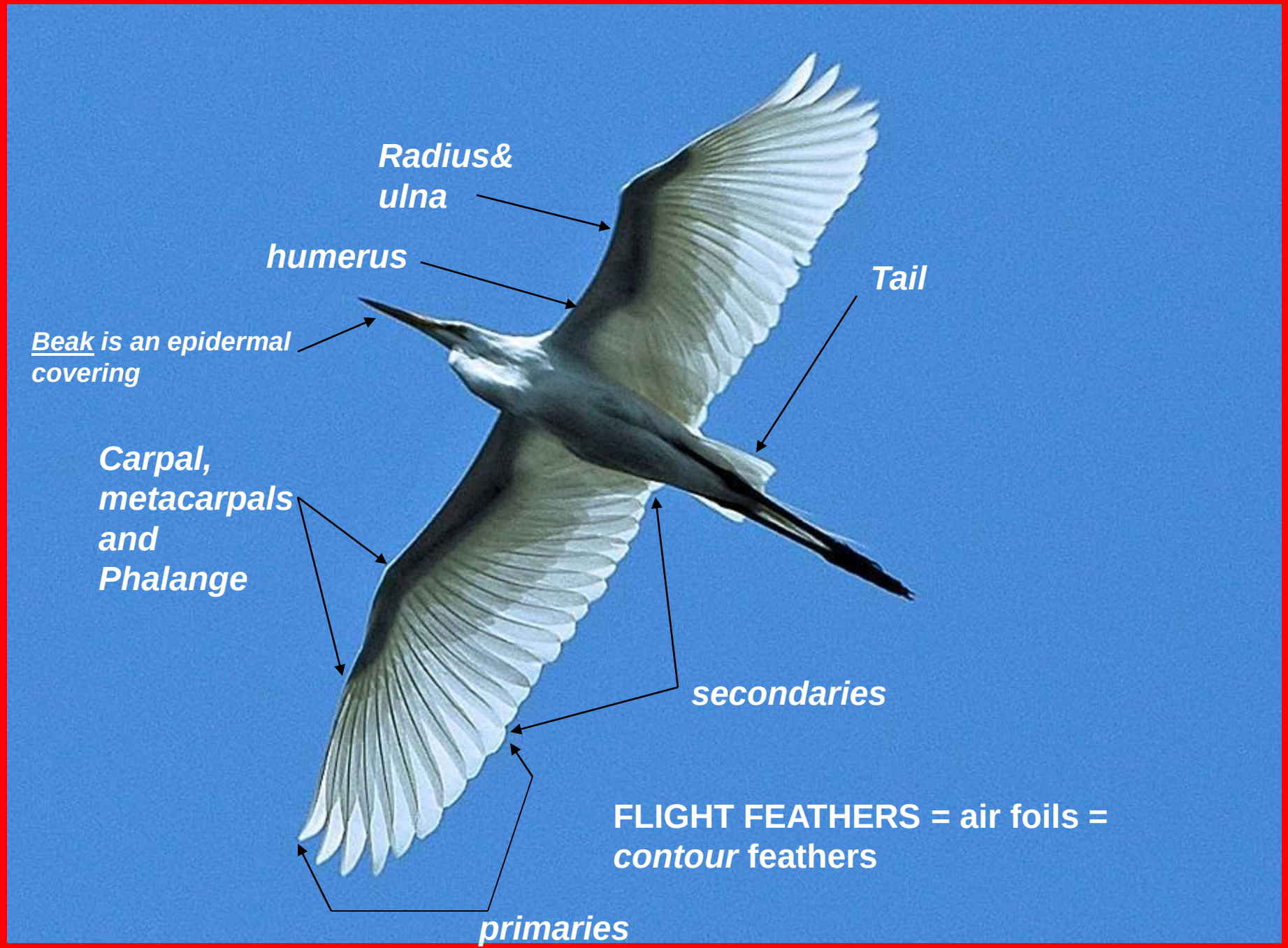

barbs
Rachis – shaft

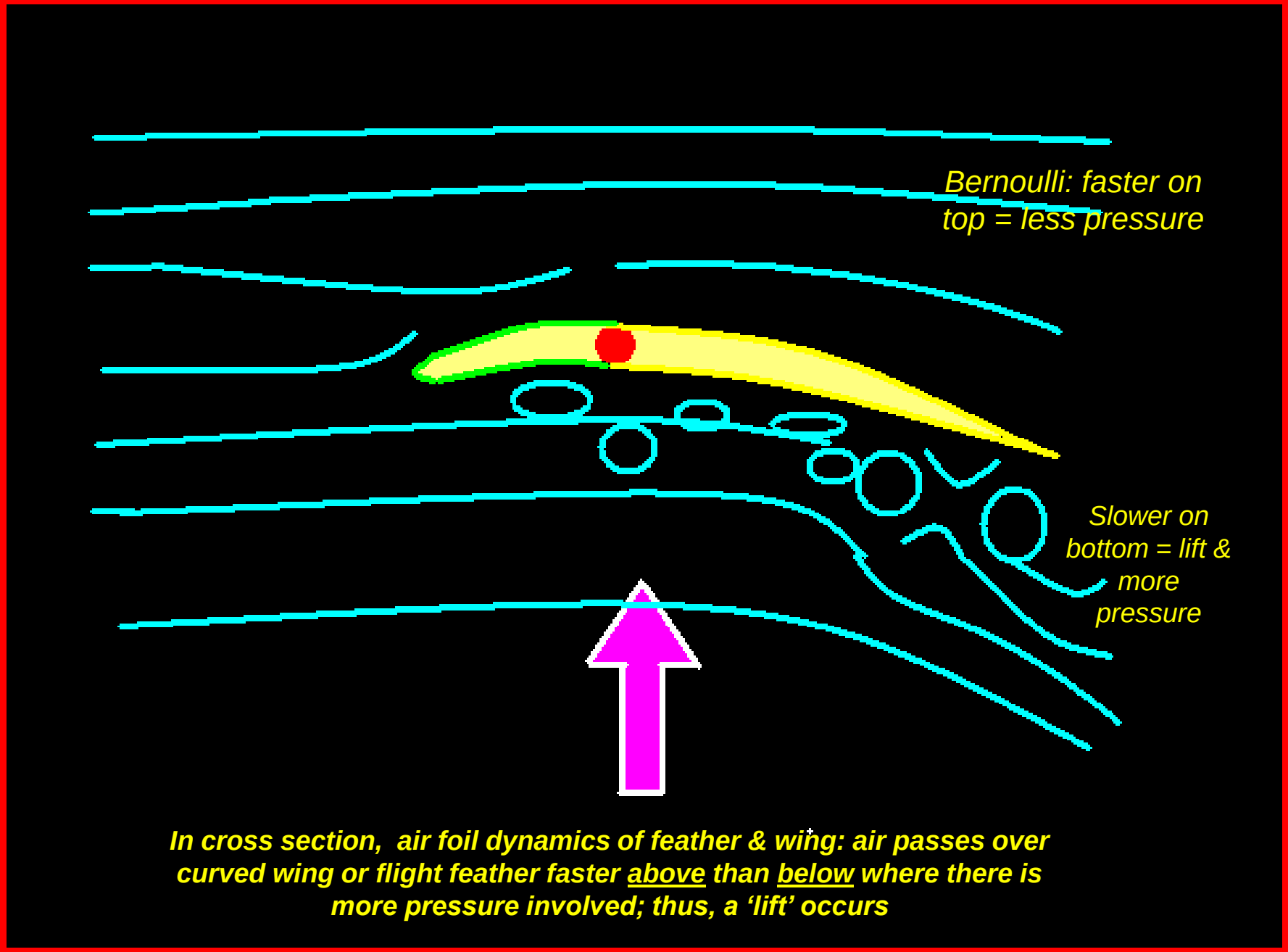



Epidermal sheath
pulp
rows of rachis cells – become barbs
Follicle
Dermis


Epidermal sheath
Epidermis
Pulp of Rachis
Chromatophores ***invading*** **<u>rows of rachis</u>** ***cells each of which becomes a barb with their own barbules & hooks***

Down feathers - insulation


Radius&
ulna
humerus
Tail
Beak is an epidermal
covering
Carpal,
metacarpals
and
Phalange
secondaries
FLIGHT FEATHERS = air foils =
contour feathers
primaries



In cross section, air foil dynamics of feather & wing: air passes over curved wing or flight feather faster <u>above</u> than <u>below</u> where there is more pressure involved; thus, a 'lift' occurs

Anhingas *have no oil secreting gland in the skin above their tail base (uropygeal gland) to waterproof the feathers during preening. This permits them to dive deeper for fish, but they have to dry-off in the sun to prevent waterlogging. This guy is sun bathing for a reason.*

Like Reptiles and 'Dinosaurs', bird's legs and feet are covered with epidermal scales and the distal phalanges (claw cores) are covered by a keratin CLAW: <u>Emu</u>

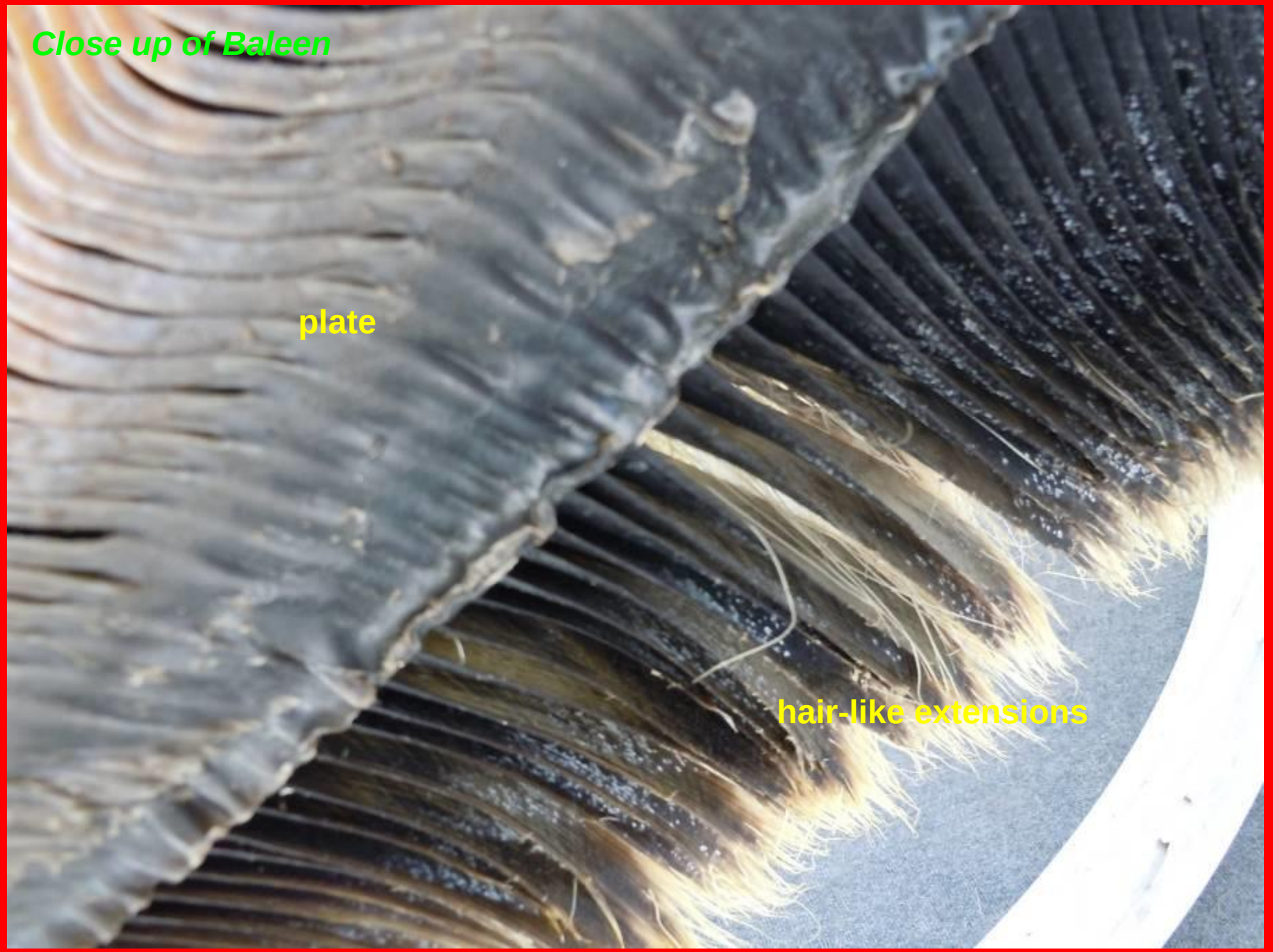
The <u>Beak</u> is also an epidermal, keratin overgrowth on the jaws

An osprey catches and holds its food (fish)… with its <u>Claws</u>

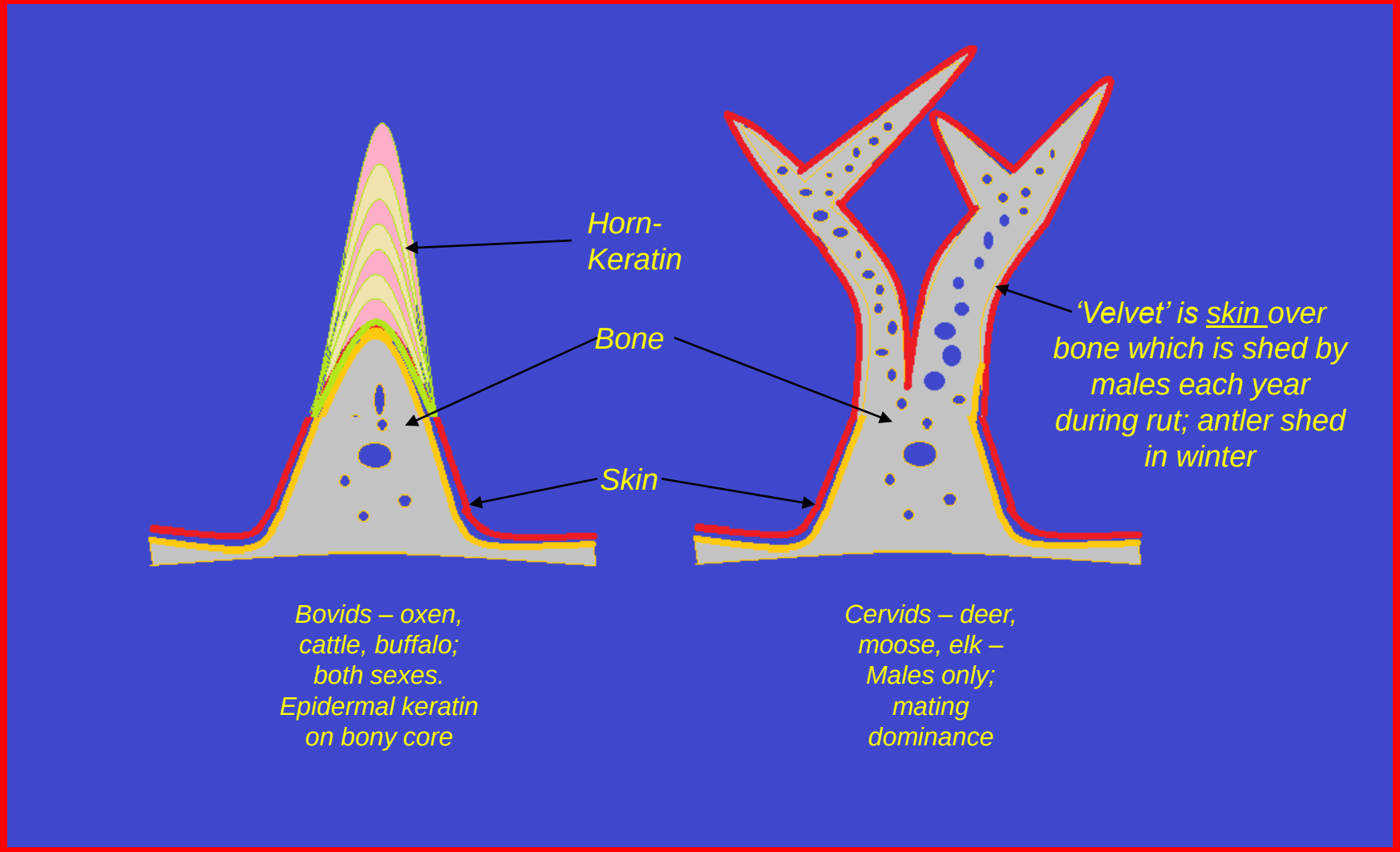
Skin on fingers = wings of bat

Skin color patterns are for camouflage or display

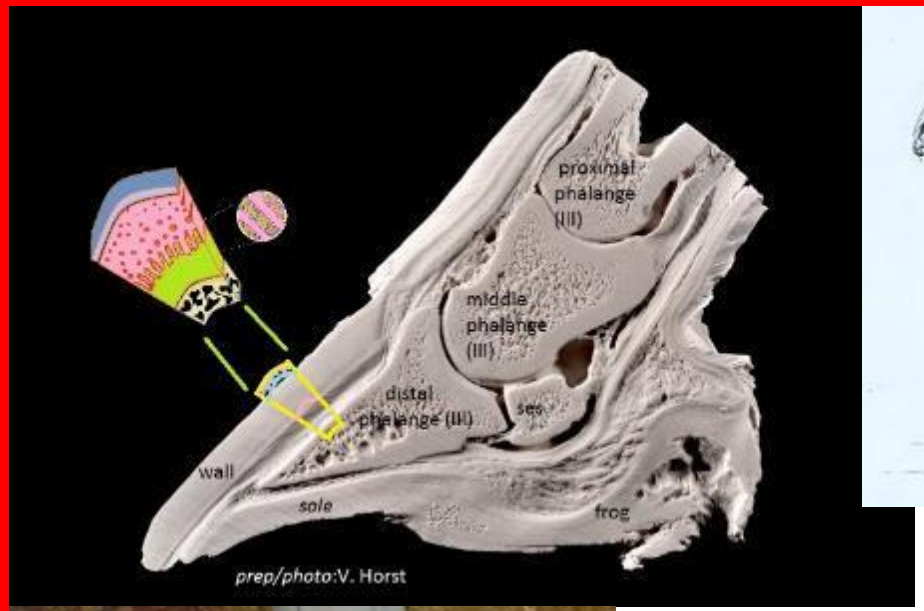
Baleen whales – epidermally derived baleen plates with hair-like extensions filter plankton and krill which tongue scrapes off to swallow

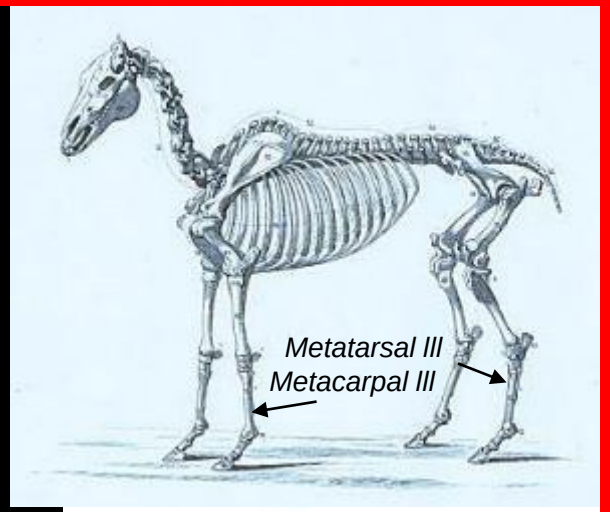

Close up of Baleen
plate
hair-like extensions

Bones and Antlers

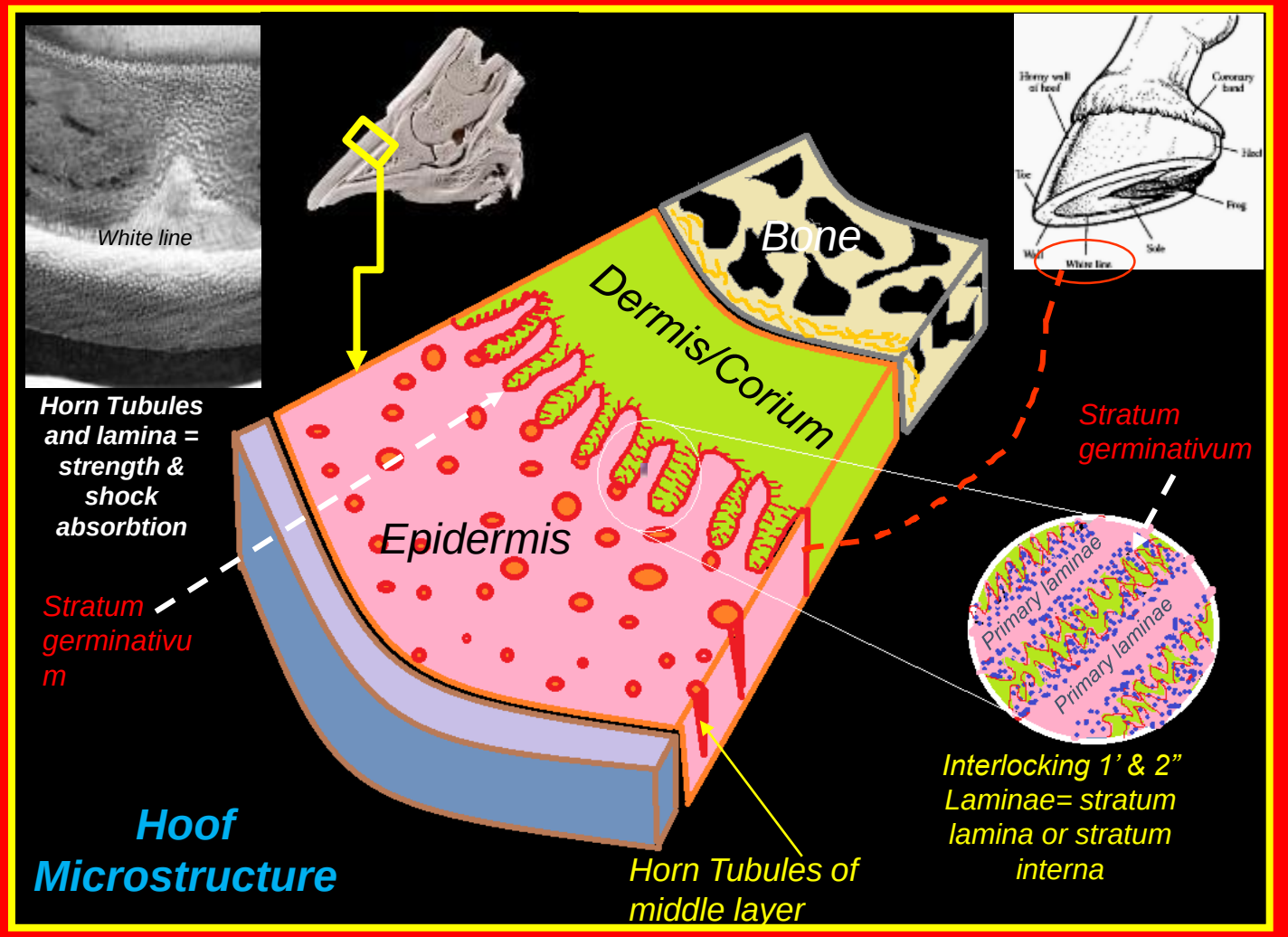


Horns *(hollow, keratin, not shed)* & **Hooves** *(Hoof) are epidermal derivatives; especially in ungulates;*
Antlers *have a bony core, usually shed, and covered with skin ("velvet") early in growth season.*


proximal phalange (II)
middle phalange (III)
distal phalange (III)
ses
wall
sole
frog
prep/photo:V. Horst


Metatarsal III
Metacarpal III


wall


White line
Horn Tubules and lamina = strength & shock absorbtion
Bone
Dermis/Corium
Epidermis
Stratum germinativum
Stratum germinativum
Primary laminae
Primary laminae
Interlocking 1' & 2" Laminae= stratum lamina or stratum interna
Horn Tubules of middle layer
Hoof Microstructure

Bovidae: Goat-domestic

Sheep-domestic

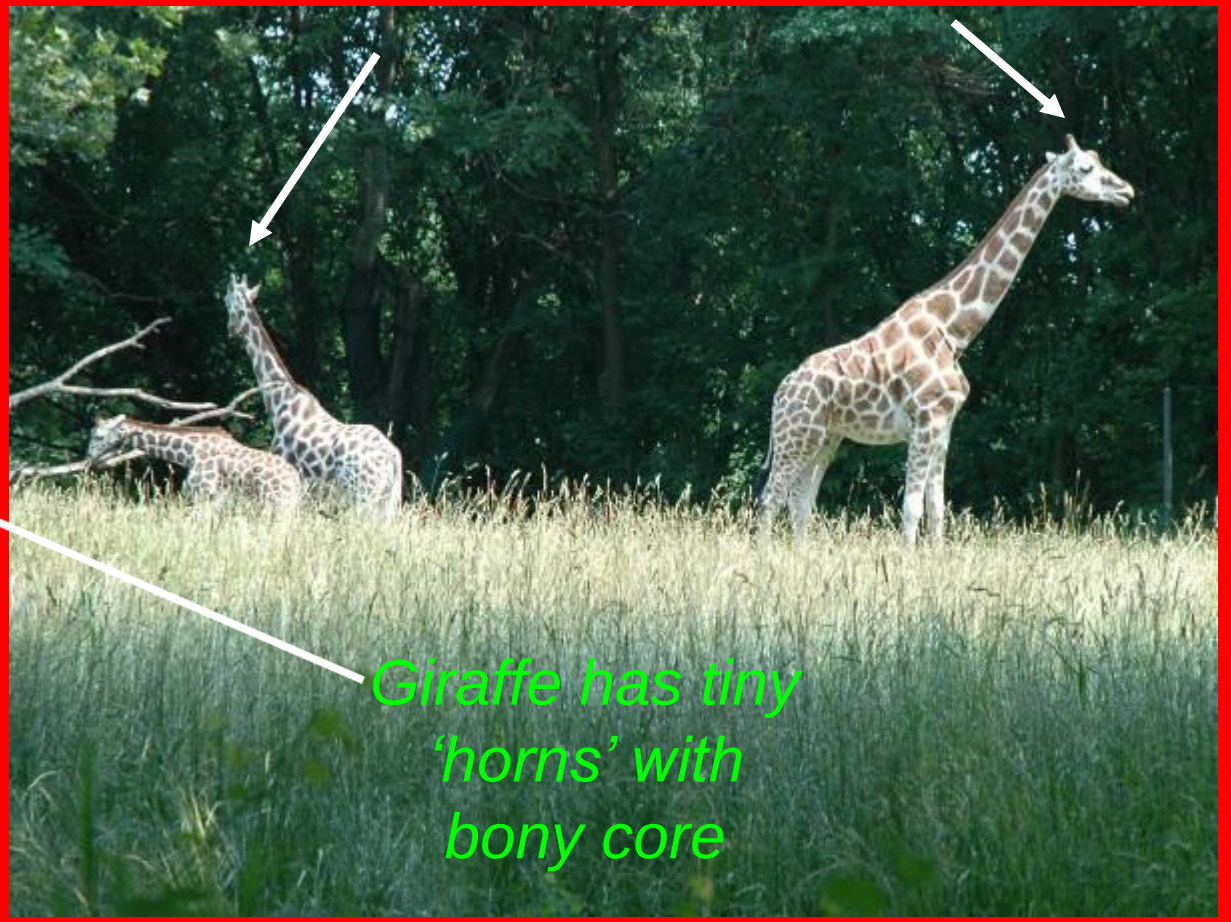
Cape Buffalo

bifid

Rhinoceras horns are made of columns of hair

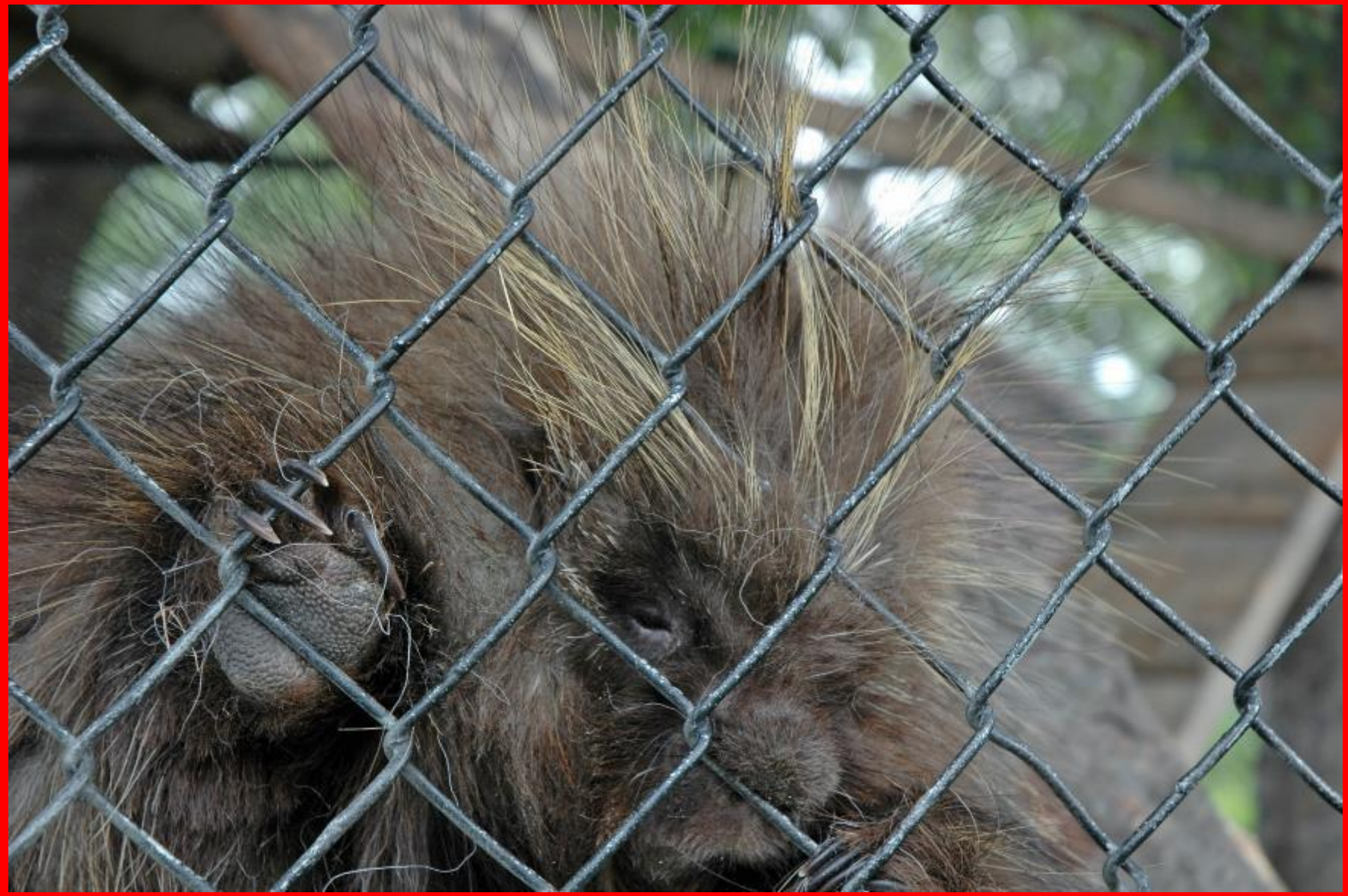
Female deer don’t have antlers

***Antlers** are bony outgrowths, usually shed annually in males, covered during growth by a “velvet” skin which is sloughed during the **rut** season*



Shed & collected male elk antlers forming arches in Jackson Hole, Wyoming

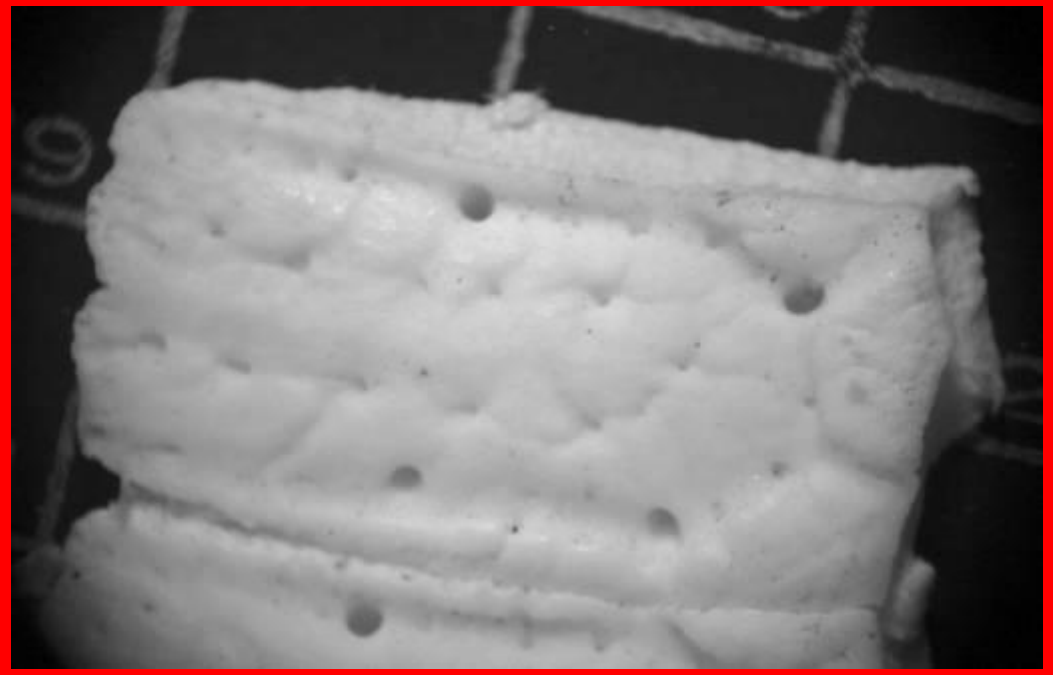
*Moose with **velvet** covered antlers in late Spring*

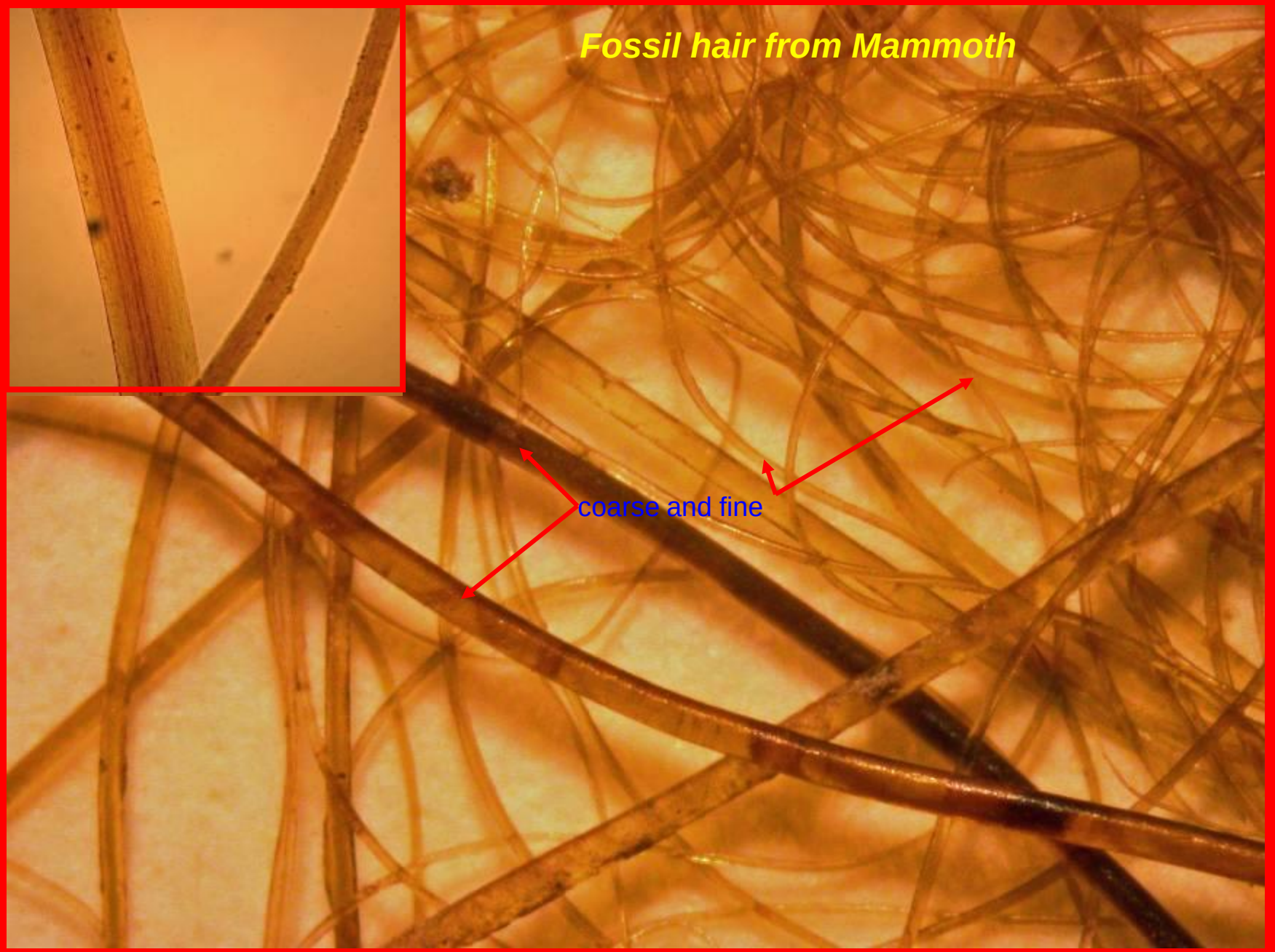


Porcupine ‘Guard’ Hair is painful

Xenarthra: *Dasypus novemcinctus*

Bony scutes of the armadillo are rare mammalian dermal derivatives; note holes for hairs

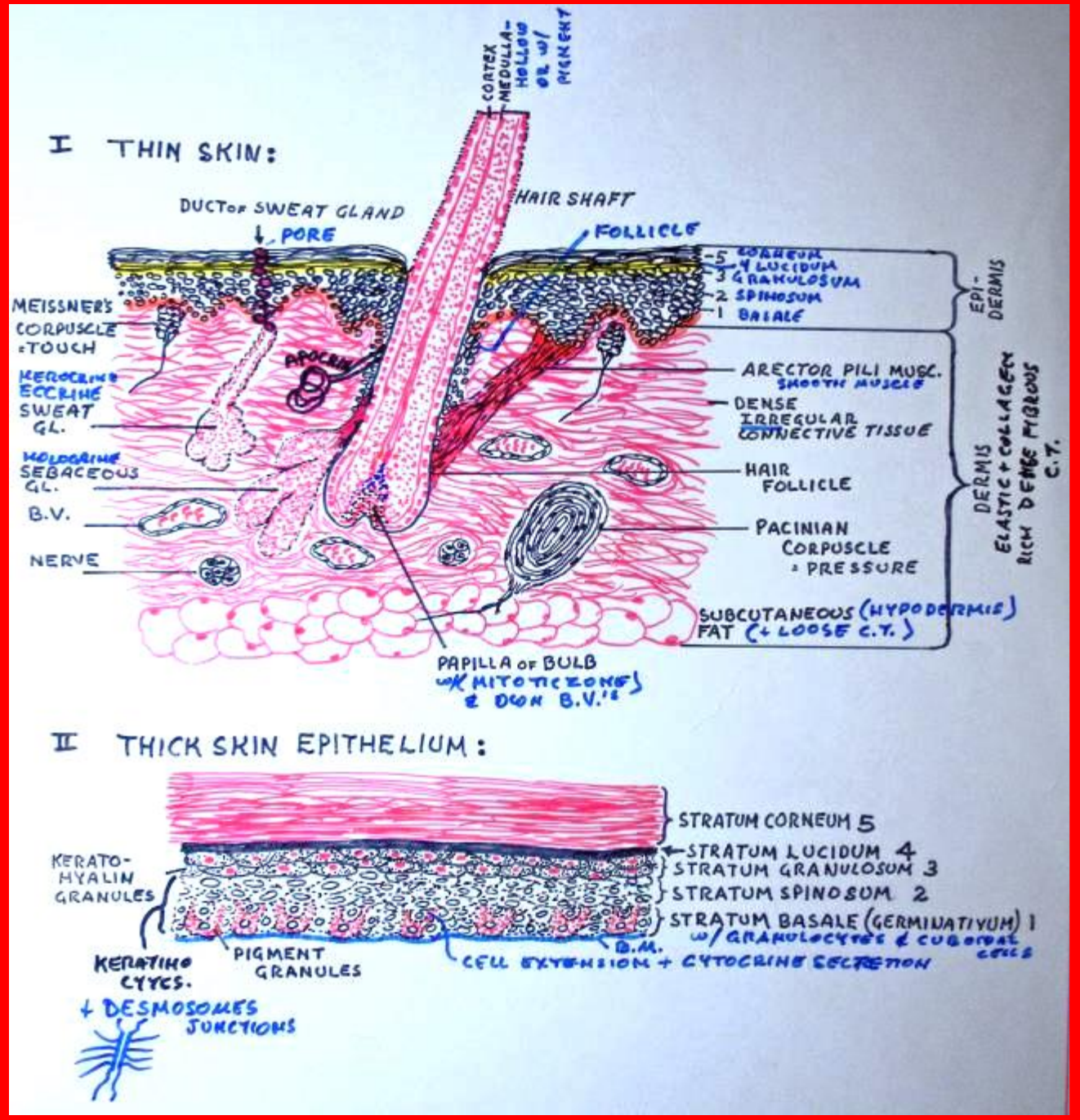




Pleistocene *Mammuthus primigenius*, Taimyr, Siberia (Permafrost preserved)

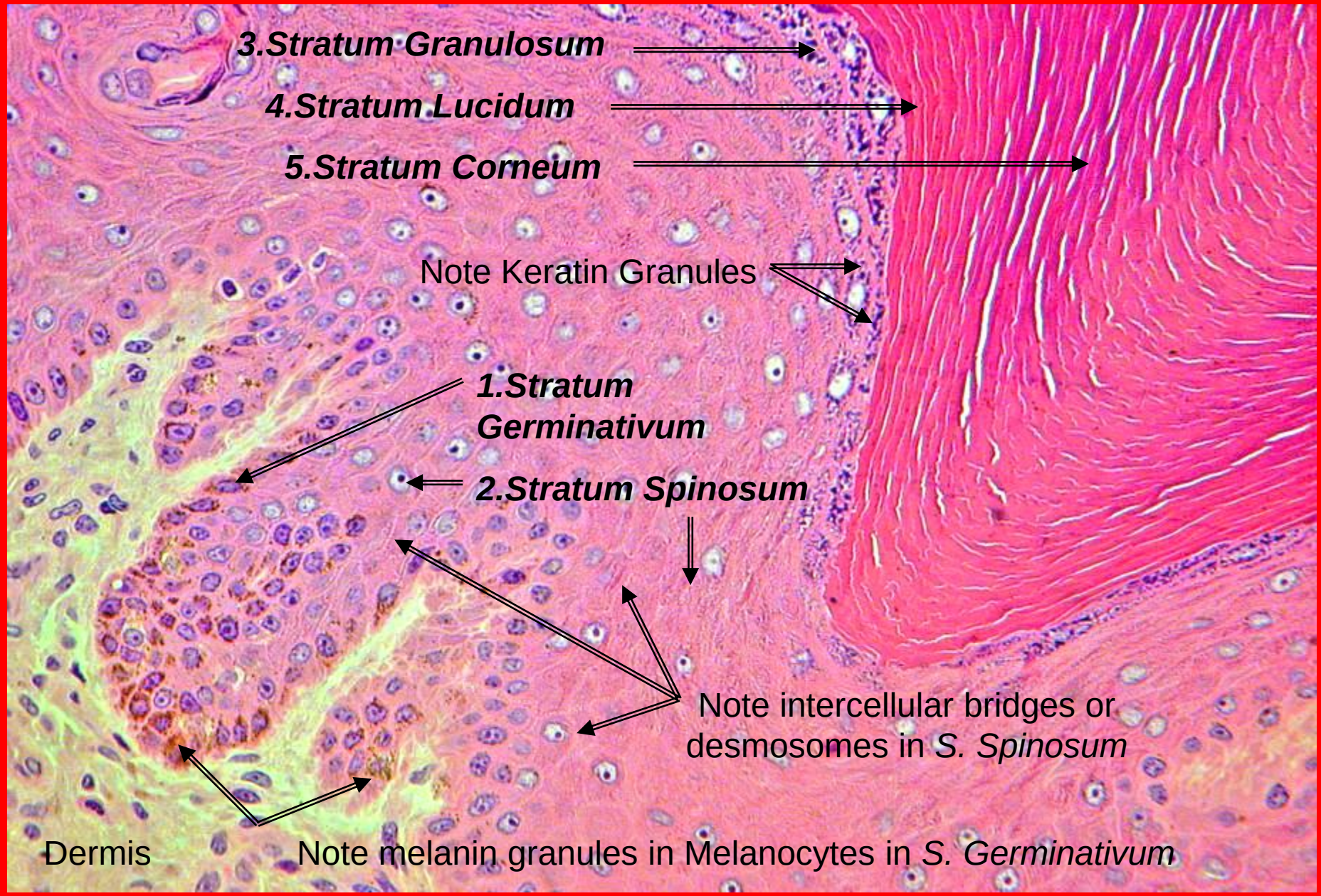

Primate
skin

MAMMAL SKIN

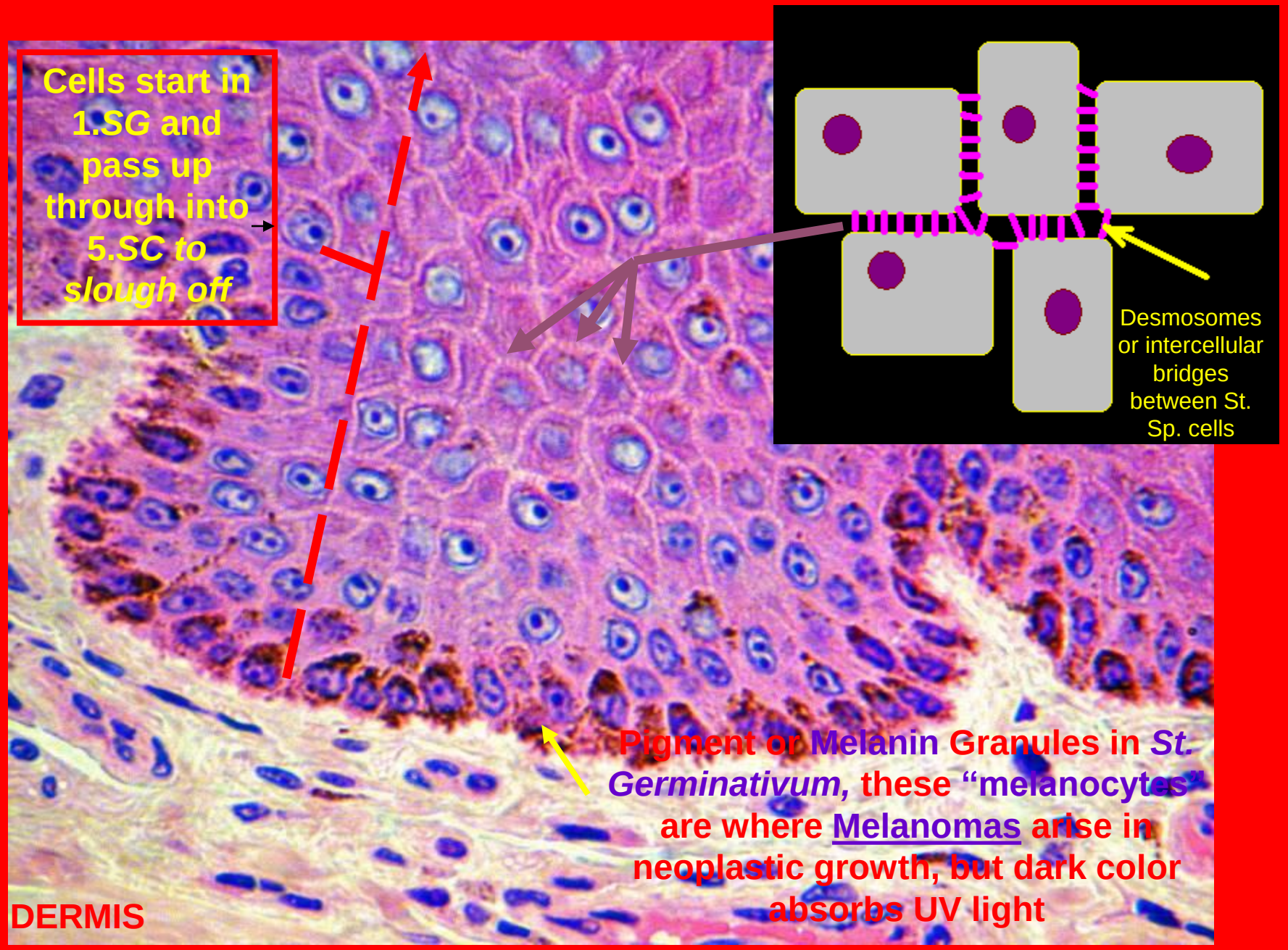


Hair follicles, sweat glands, sebaceous glands (even teeth) are products of the epidermis,embryo-logically speaking *ectododerm*, that extend downward into the dermis.

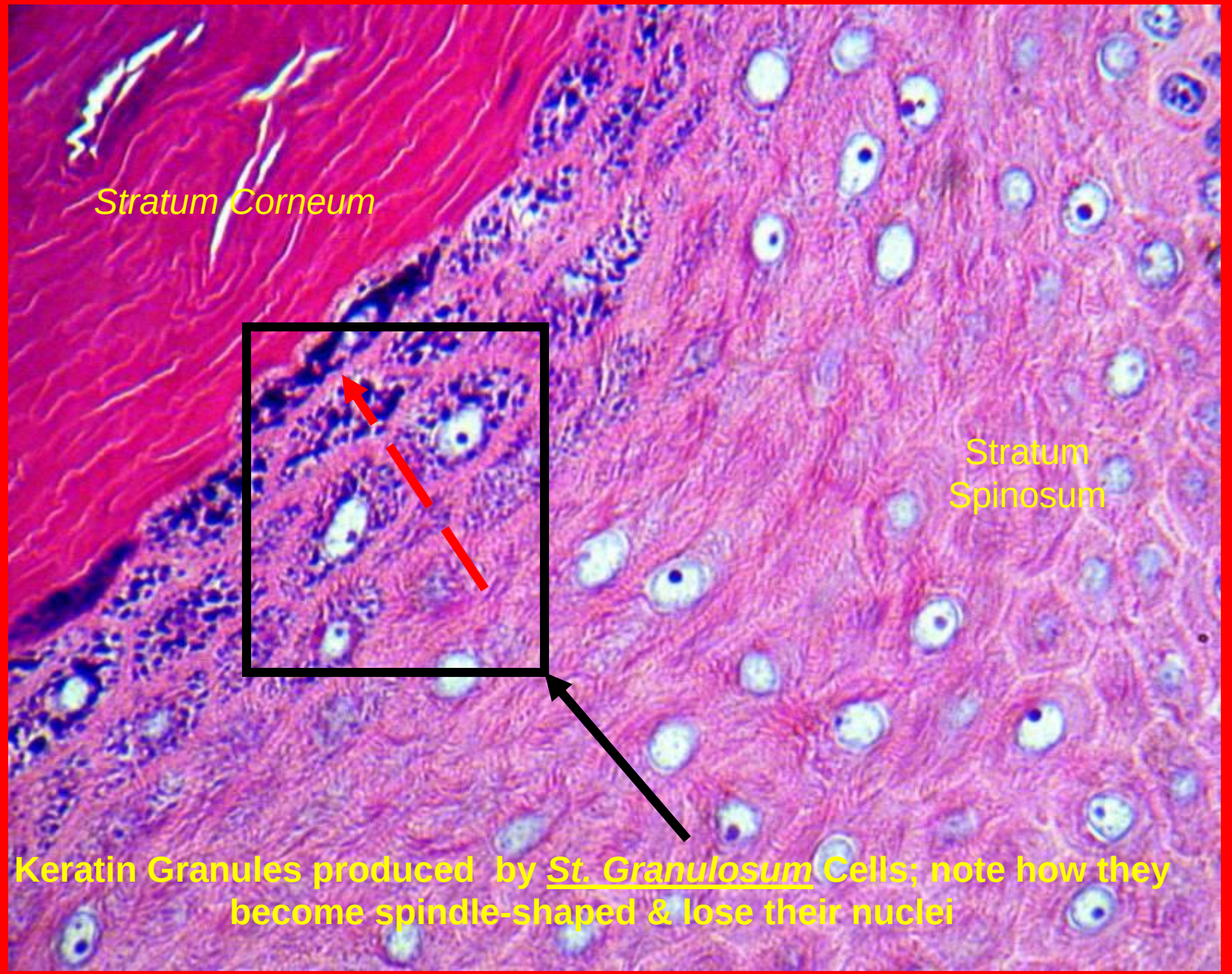
Palms & soles – ‘thick skin’

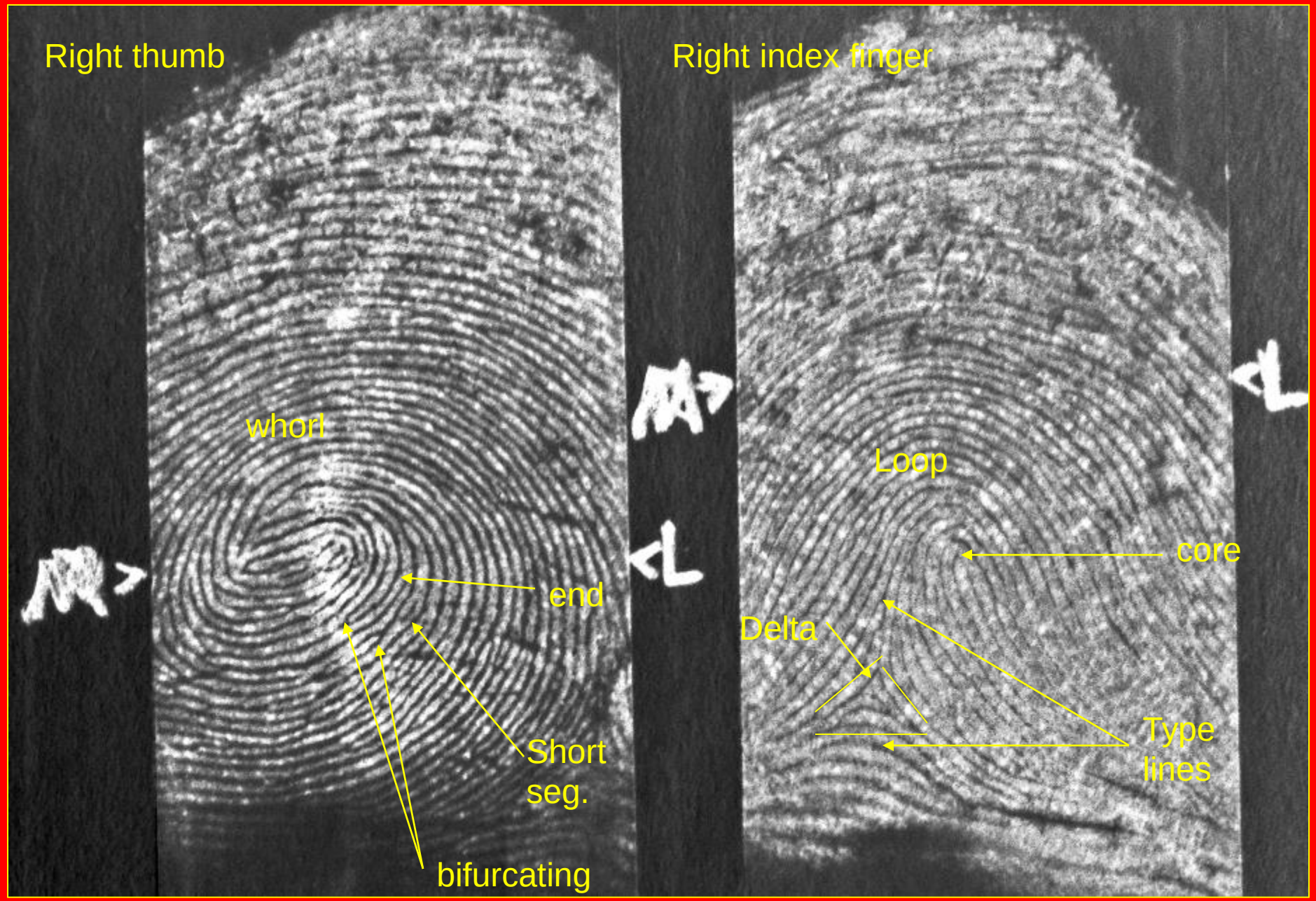


The 5 Layers of the Epidermis (1.5 *u*m ultra thin section, @100X, H&E)

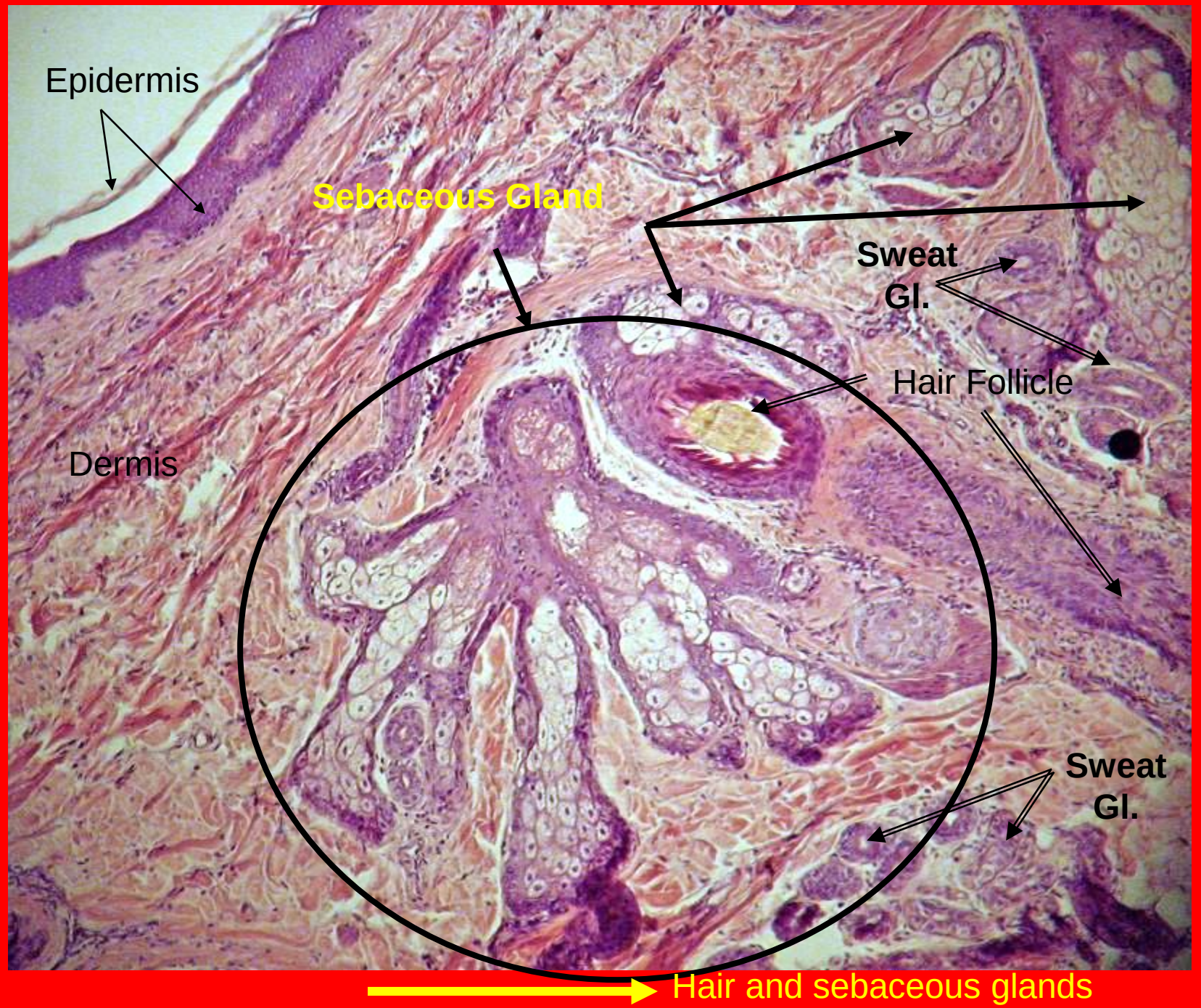


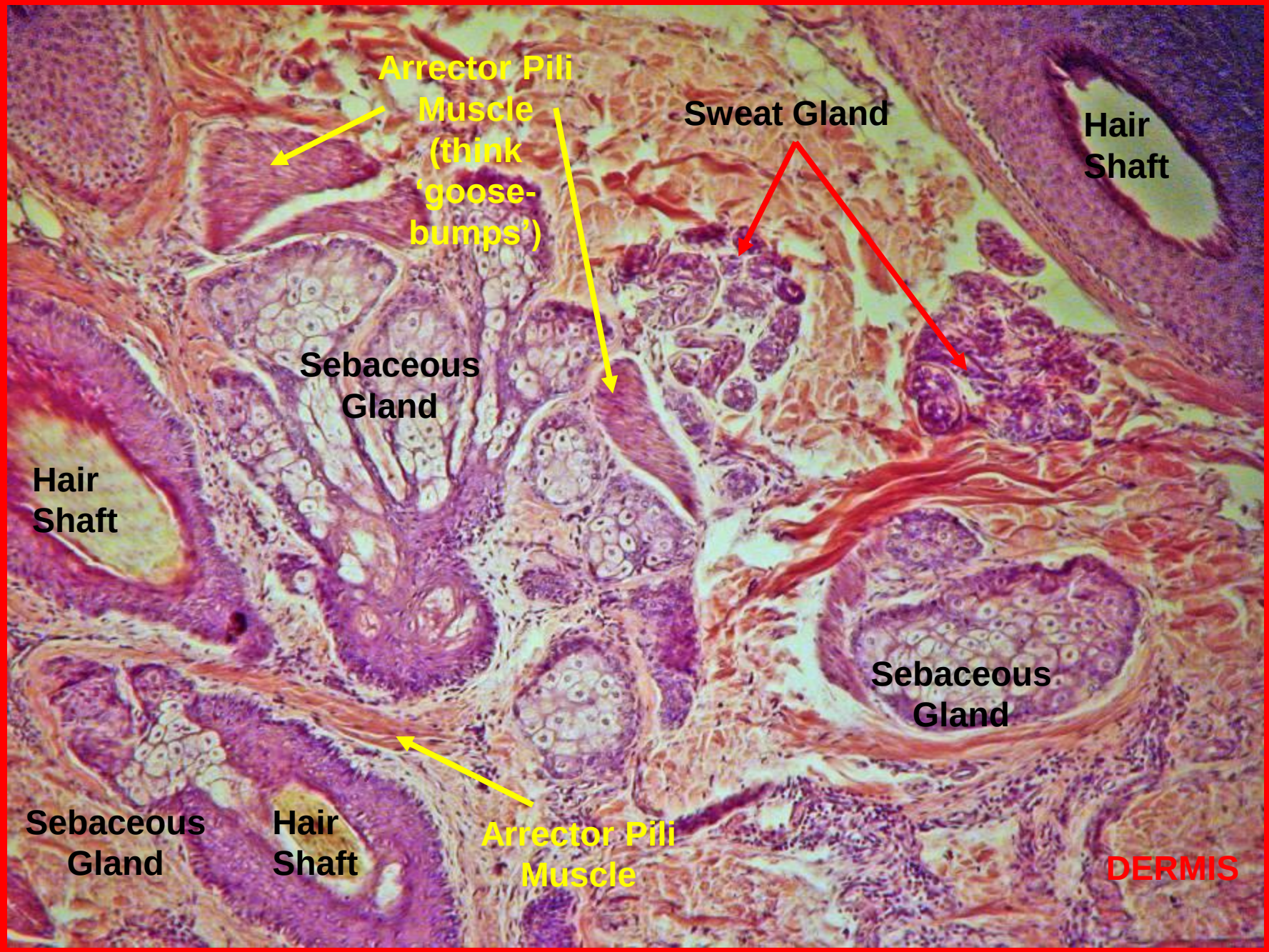
Intercellular Bridges (Desmosomes →) in *Stratum Spinosum*

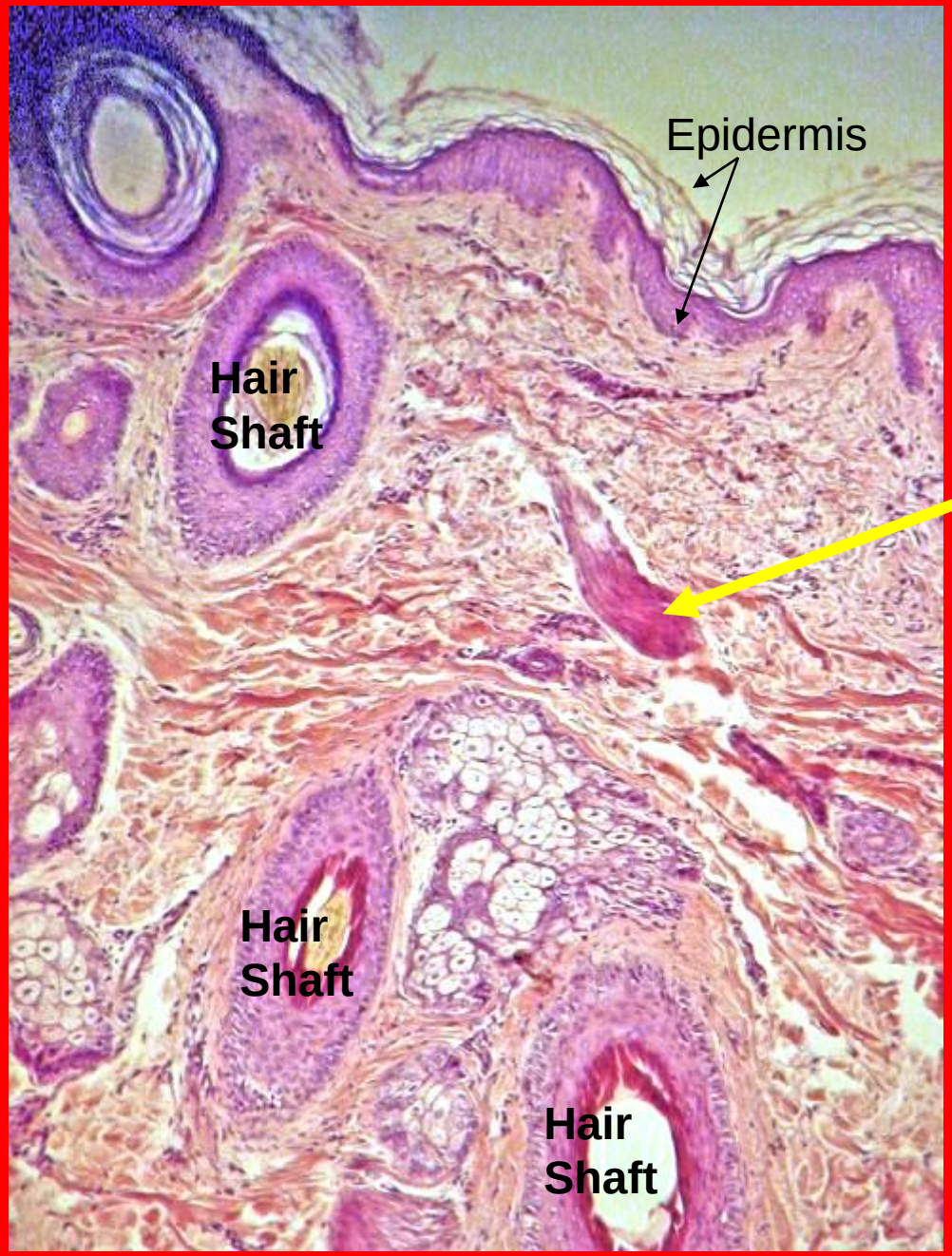

Stratum Corneum
Stratum
Spinosum
Keratin Granules produced by St. Granulosum Cells; note how they
become spindle-shaped & lose their nuclei



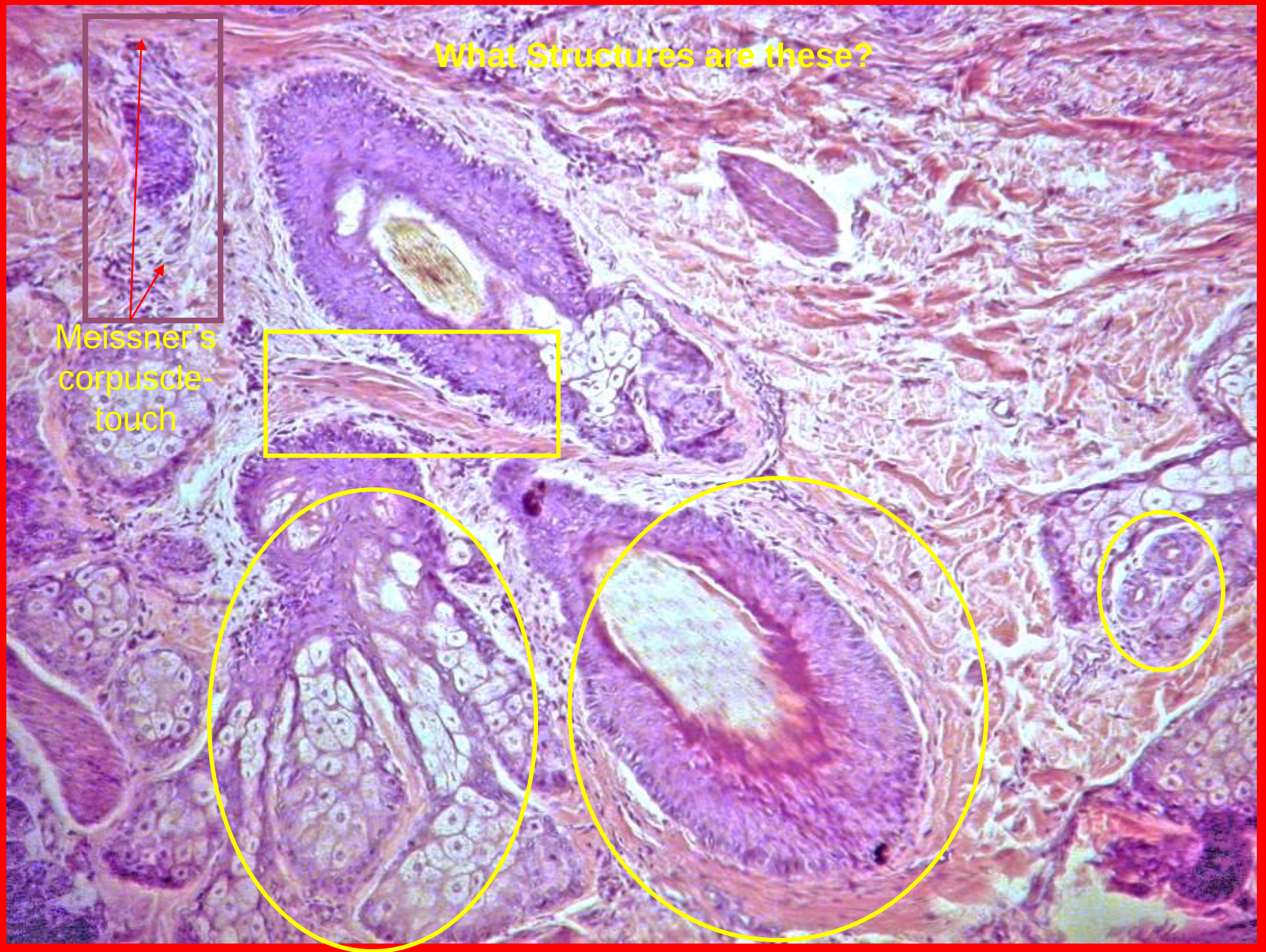
*Matching an individual's **dermal ridge** patterns in **fingerprint** analysis – NO 2 are alike*

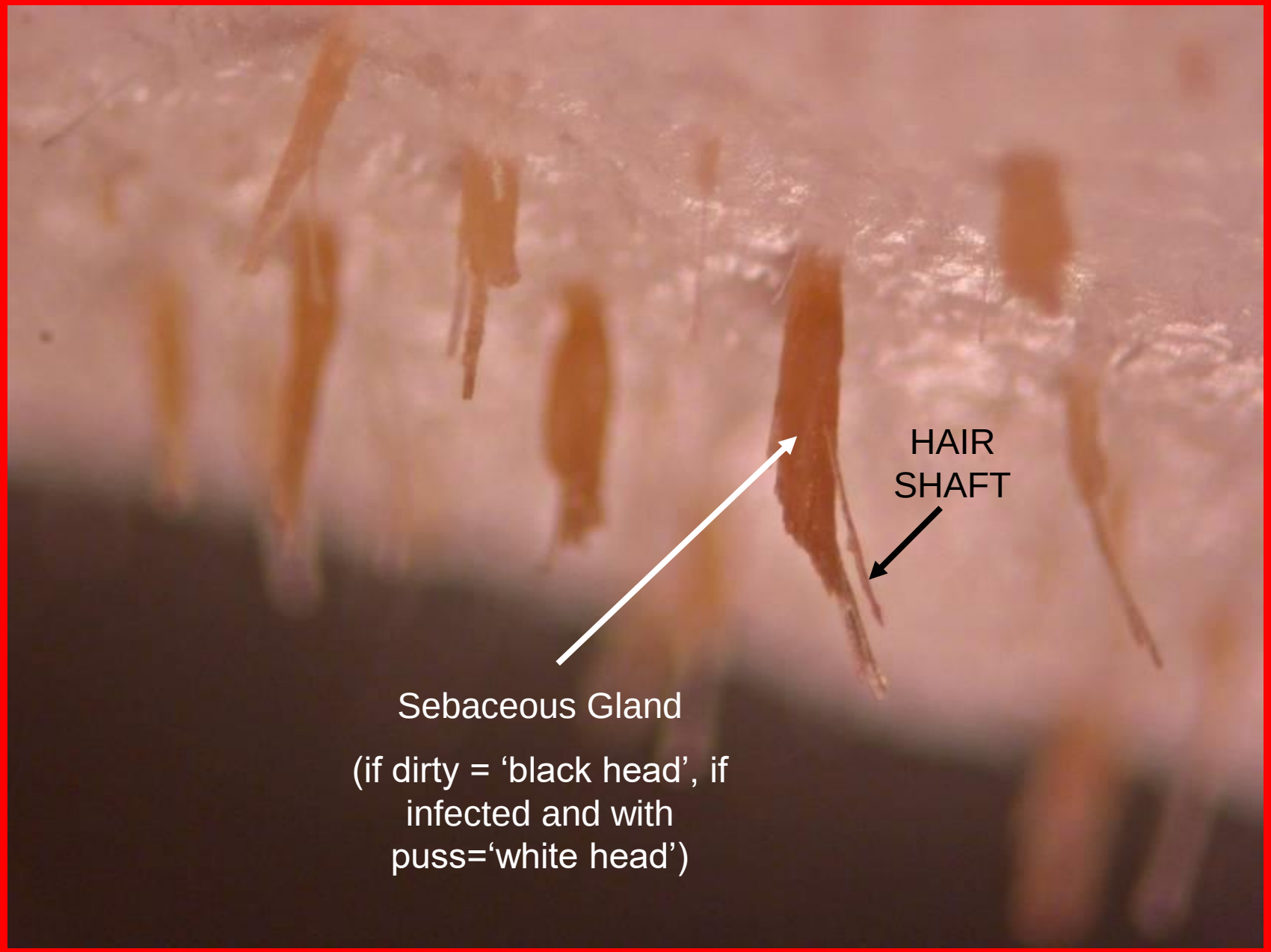

Epidermis
Sebaceous Gland
Sweat Gl.
Hair Follicle
Dermis
Sweat Gl.
Hair and sebaceous glands

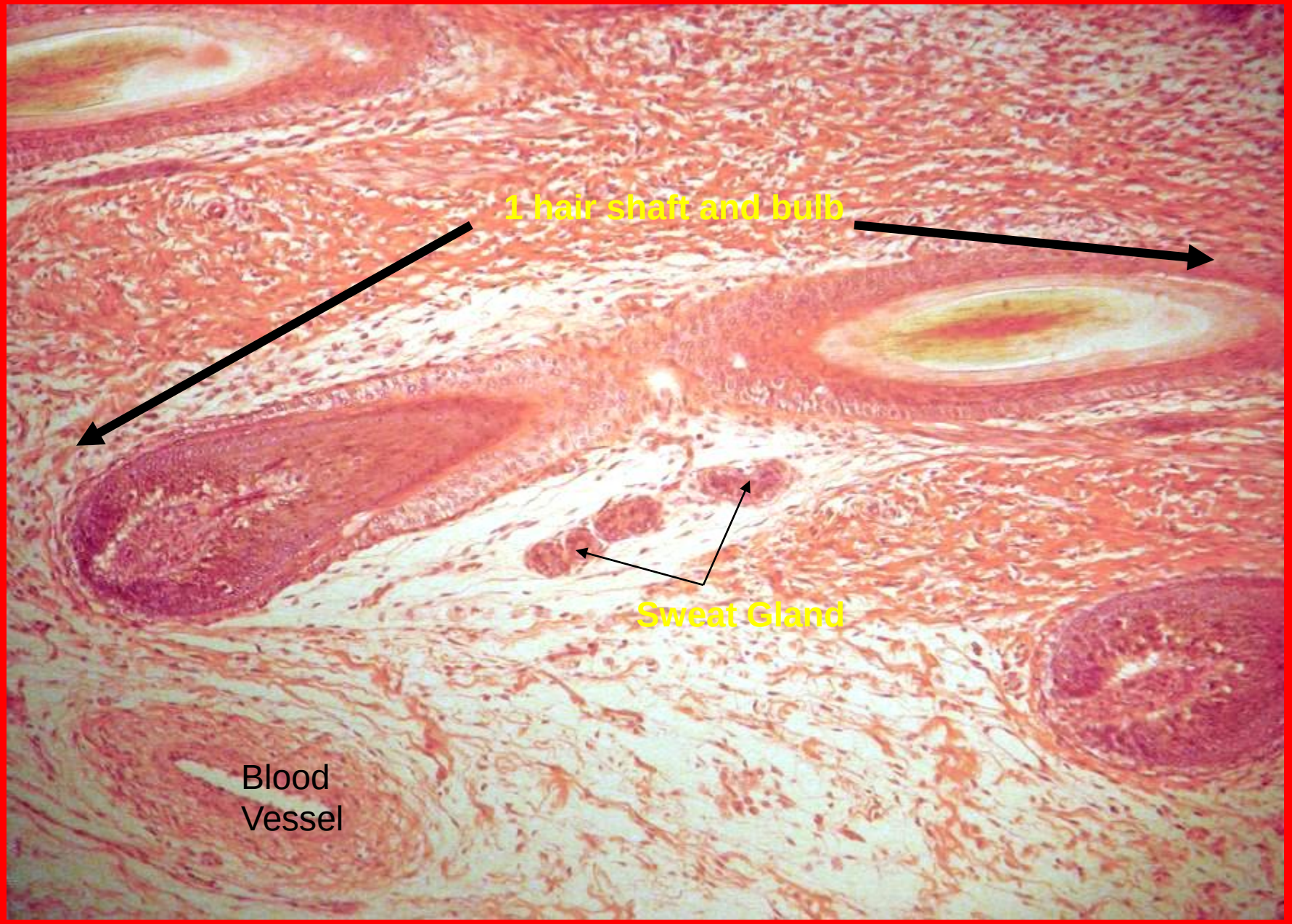

Arrector Pili Muscle (think 'goose-bumps')
Sweat Gland
Hair Shaft
Sebaceous Gland
Hair Shaft
Sebaceous Gland
Sebaceous Gland
Hair Shaft
Arrector Pili Muscle
DERMIS


Epidermis
Hair Shaft
Hair Shaft
Hair Shaft
Arrector Pili Muscle

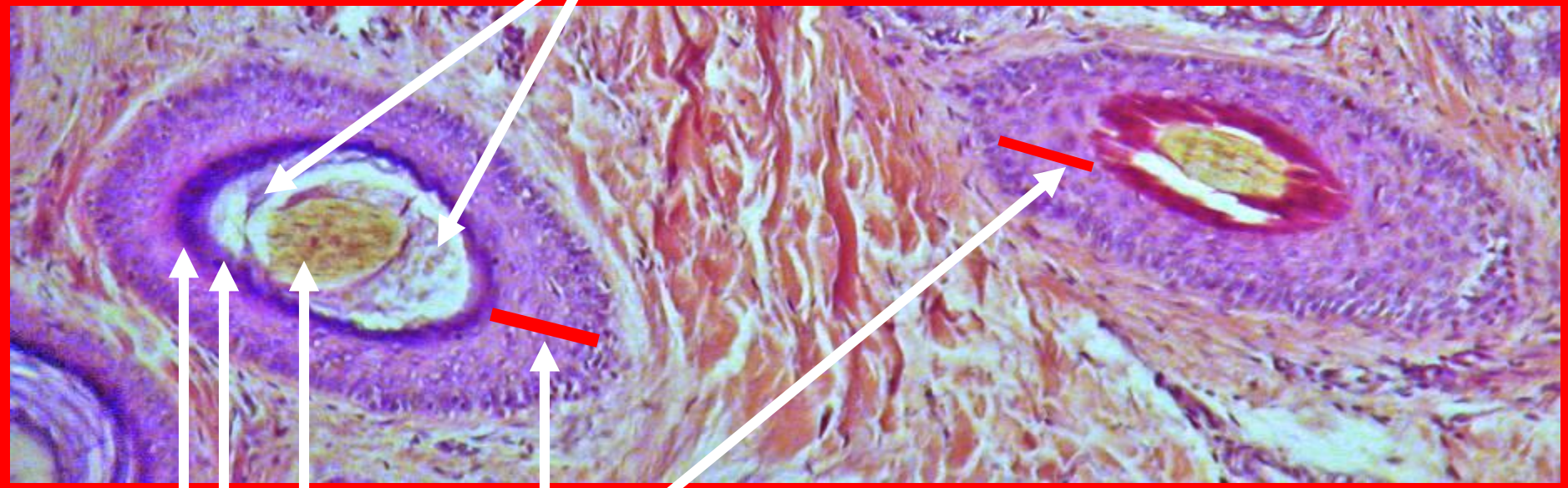

Epidermis
DERMIS
Arrector Pili Muscle
Coiling Sweat Gland Duct


What Structures are these?
Meissner's corpuscle-touch


HAIR
SHAFT
Sebaceous Gland
(if dirty = ‘black head’, if infected and with puss=‘white head’)


1 hair shaft and bulb
Sweat Gland
Blood
Vessel

Cuticle of hair & inner root sheath



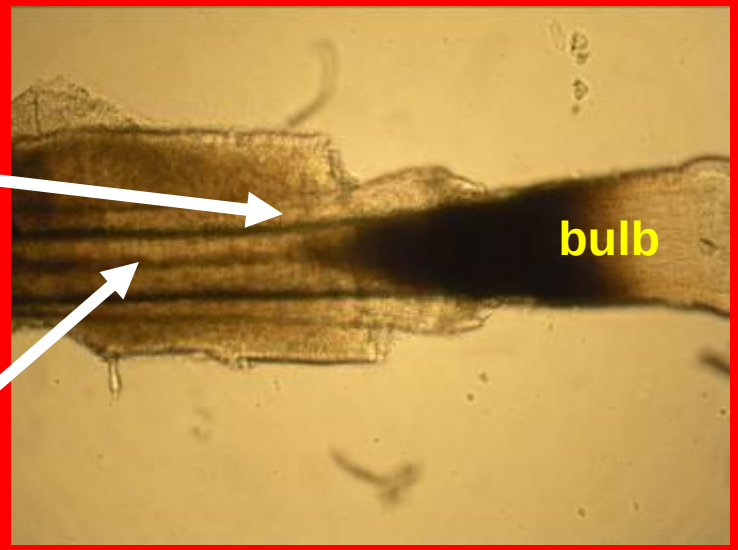
Outer epithelial root sheath

Cortex of hair

"Huxley's layer"

"Henley's layer"

Medulla in center of Cortex; together = hair shaft



Plucked hair and bulb

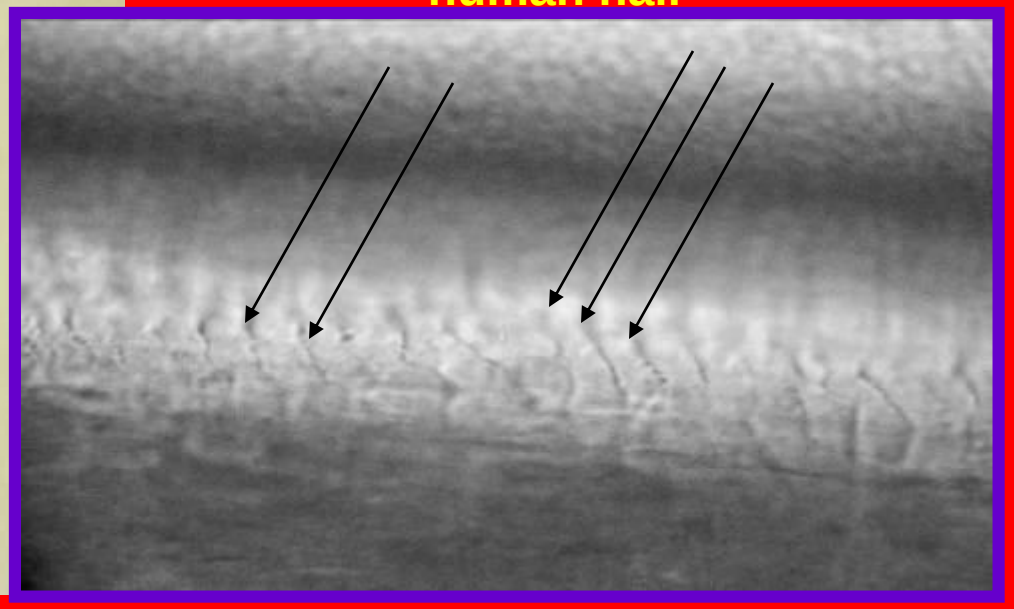
Pulled hair

Hair Shaft

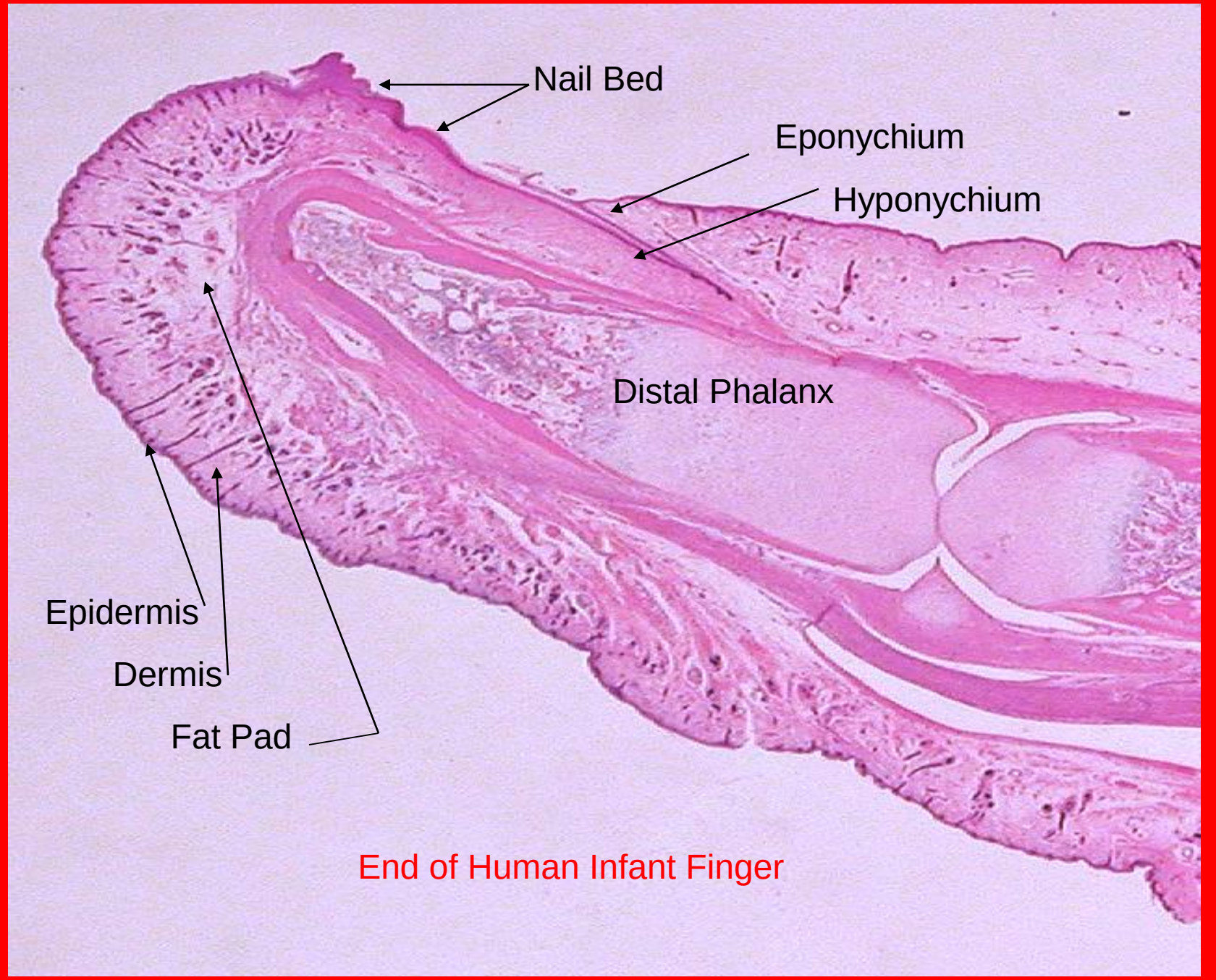
Broken frag. of epidermis

Hair ‘Bulb’: full of DNA

overlapping scales on surface of human hair

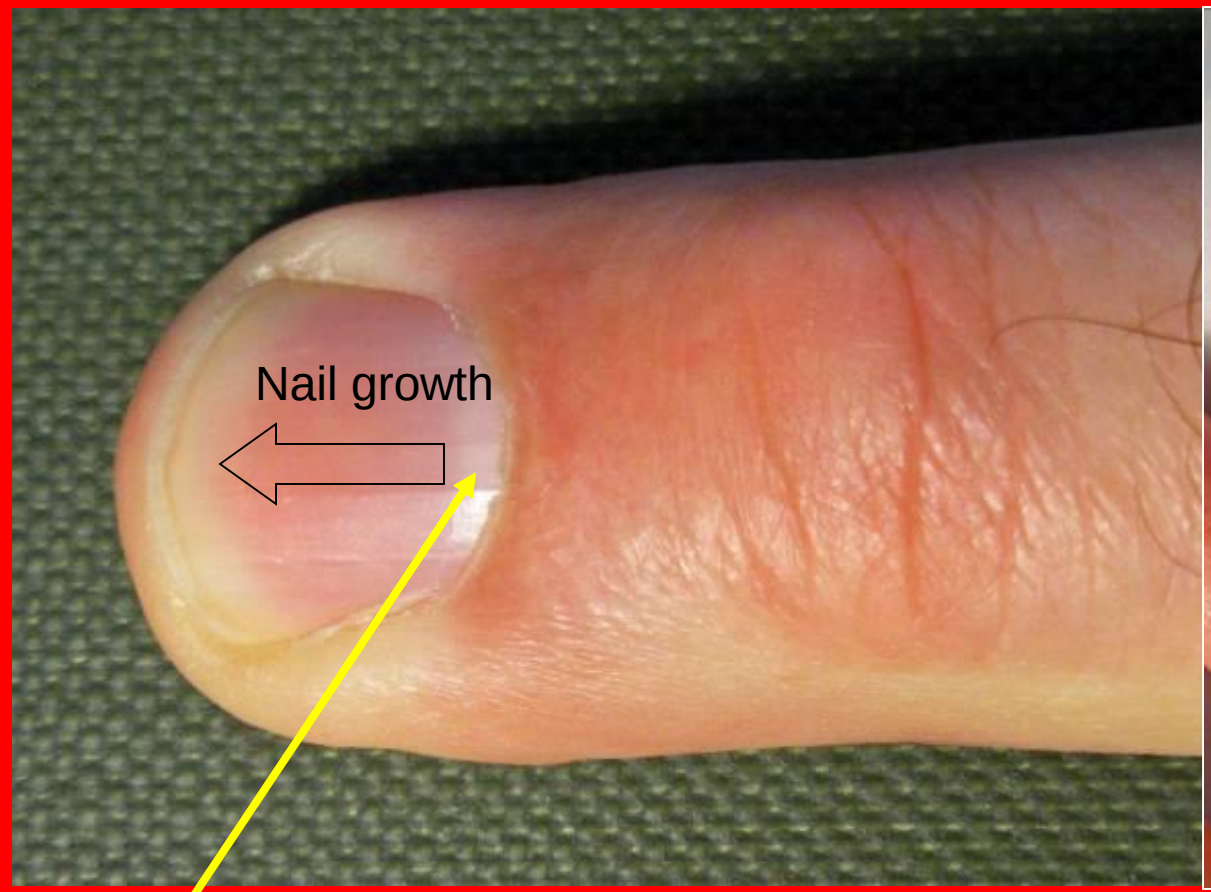



Bulb
Root of Hair with its Dermal Papilla



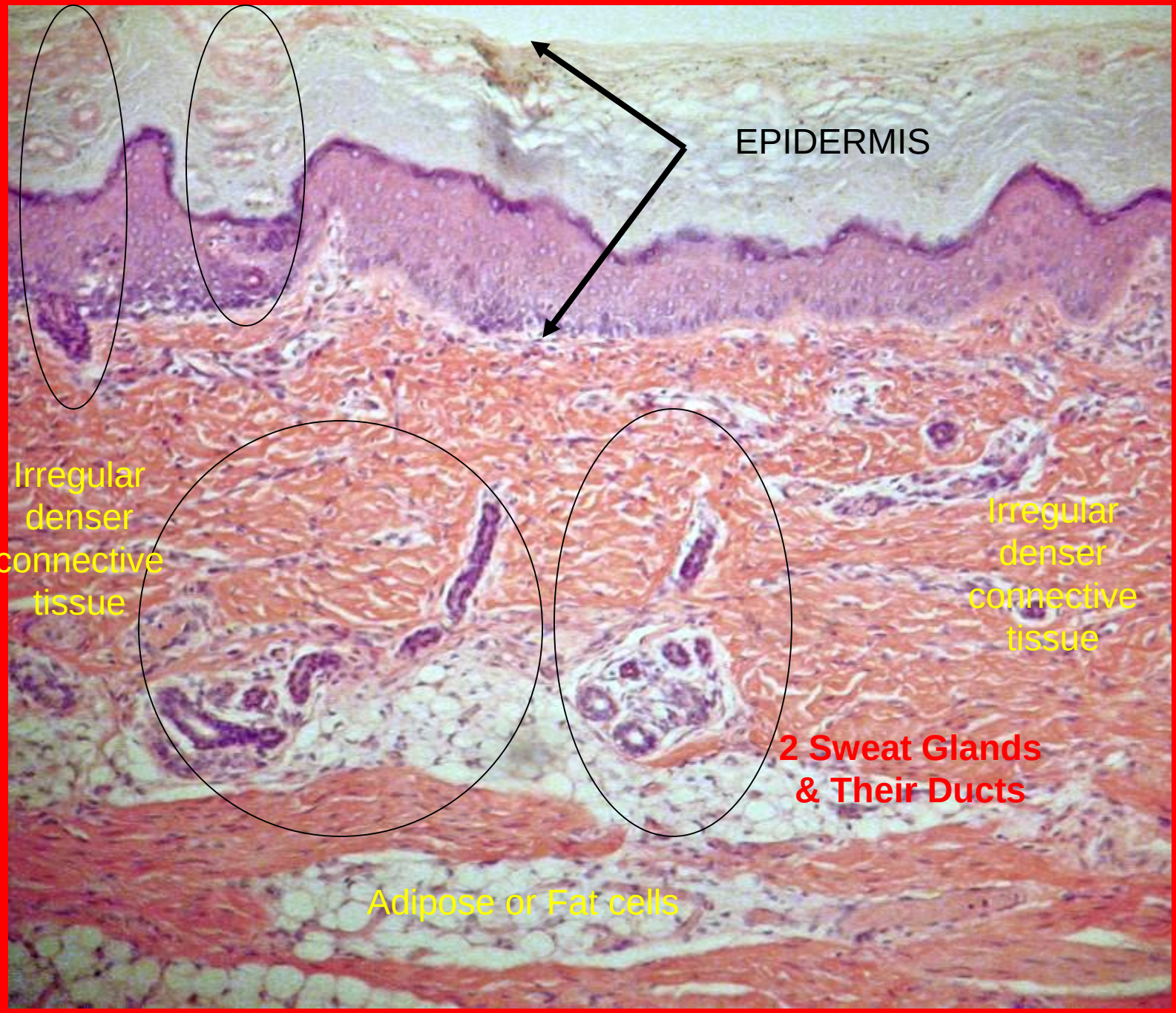
End of Human Infant Finger

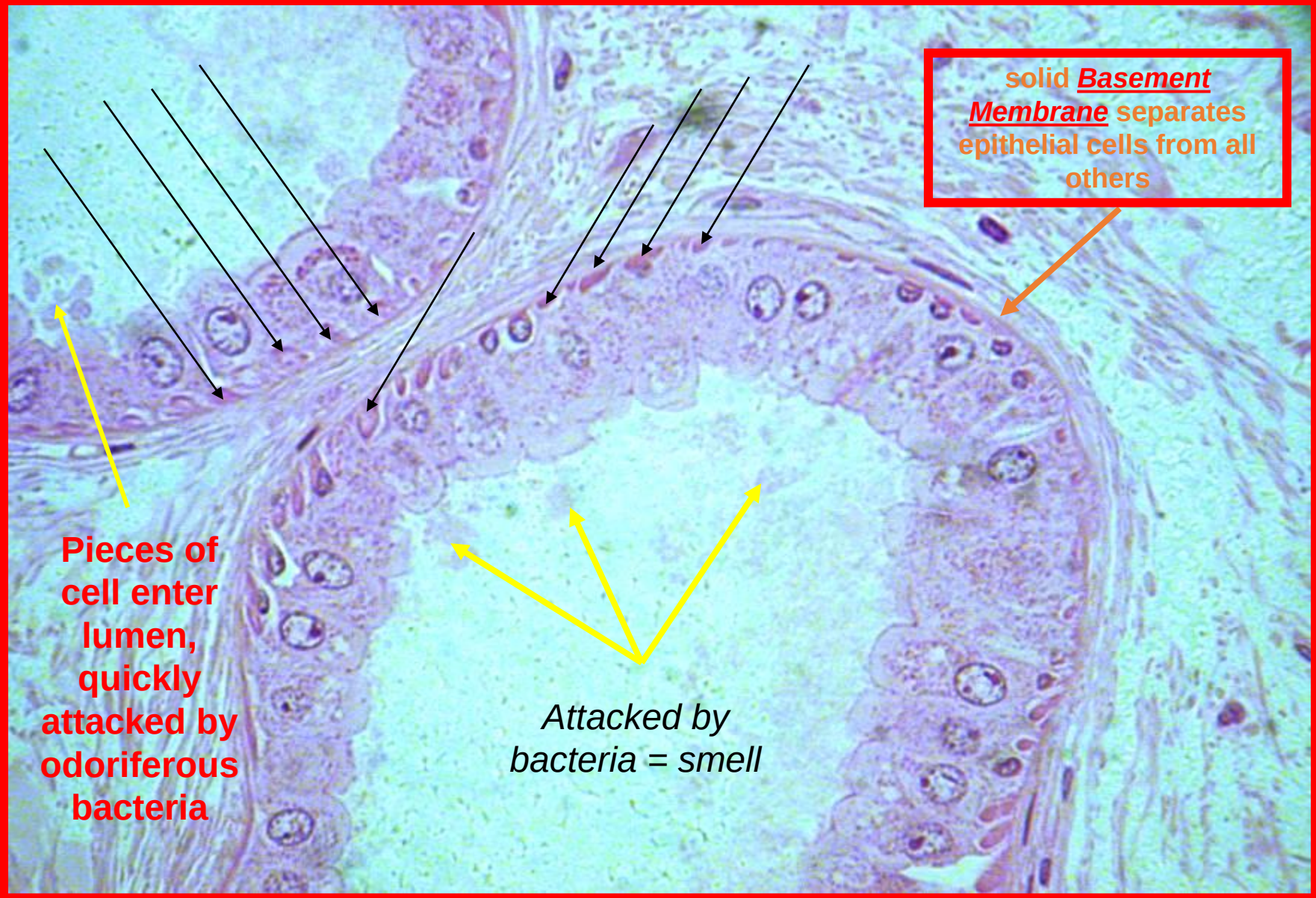
Nails and hair are ‘dead’ keratin (protein)



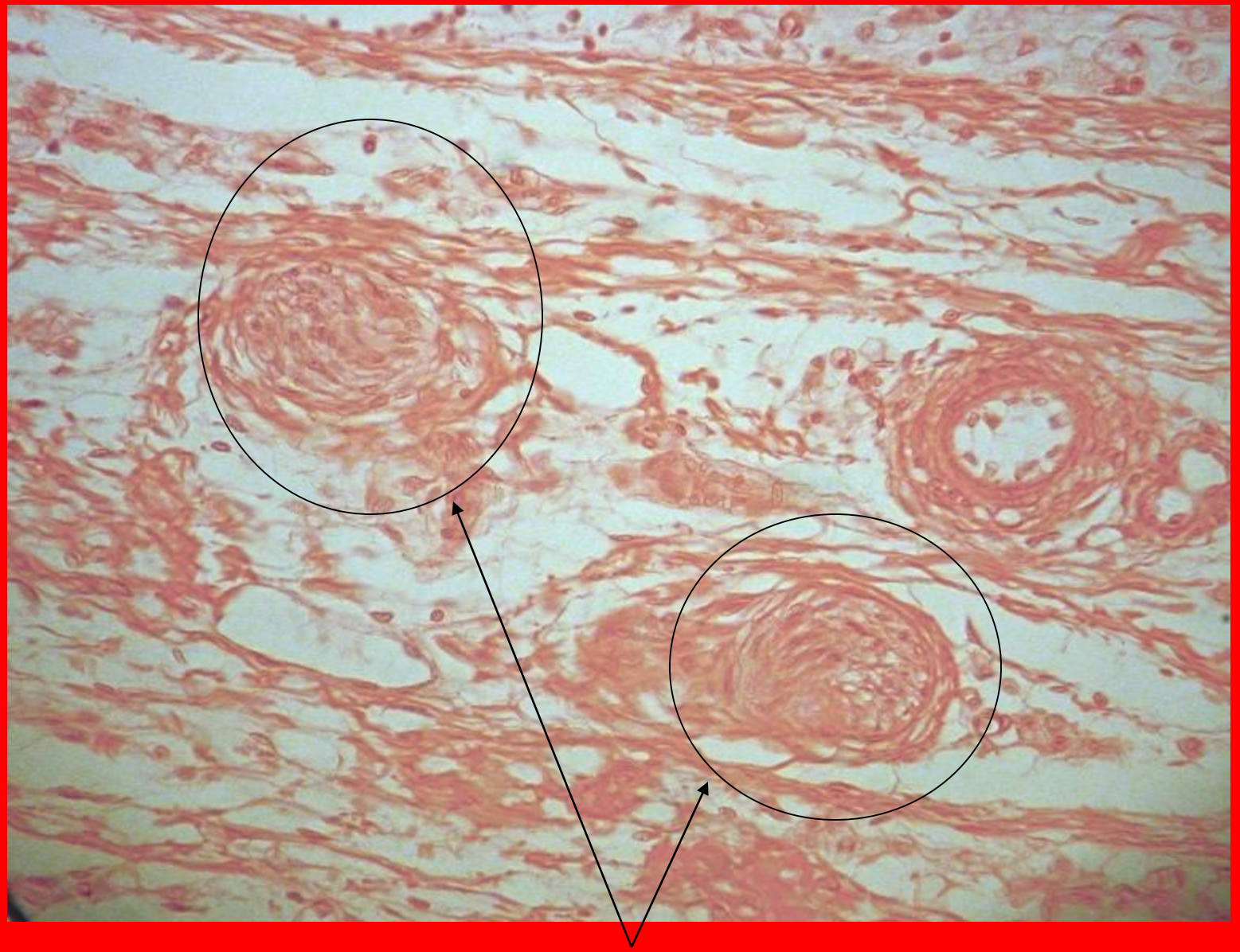
Lunule (site of nail growing stratum germinativum) below eponychium

Skin is rapidly repaired

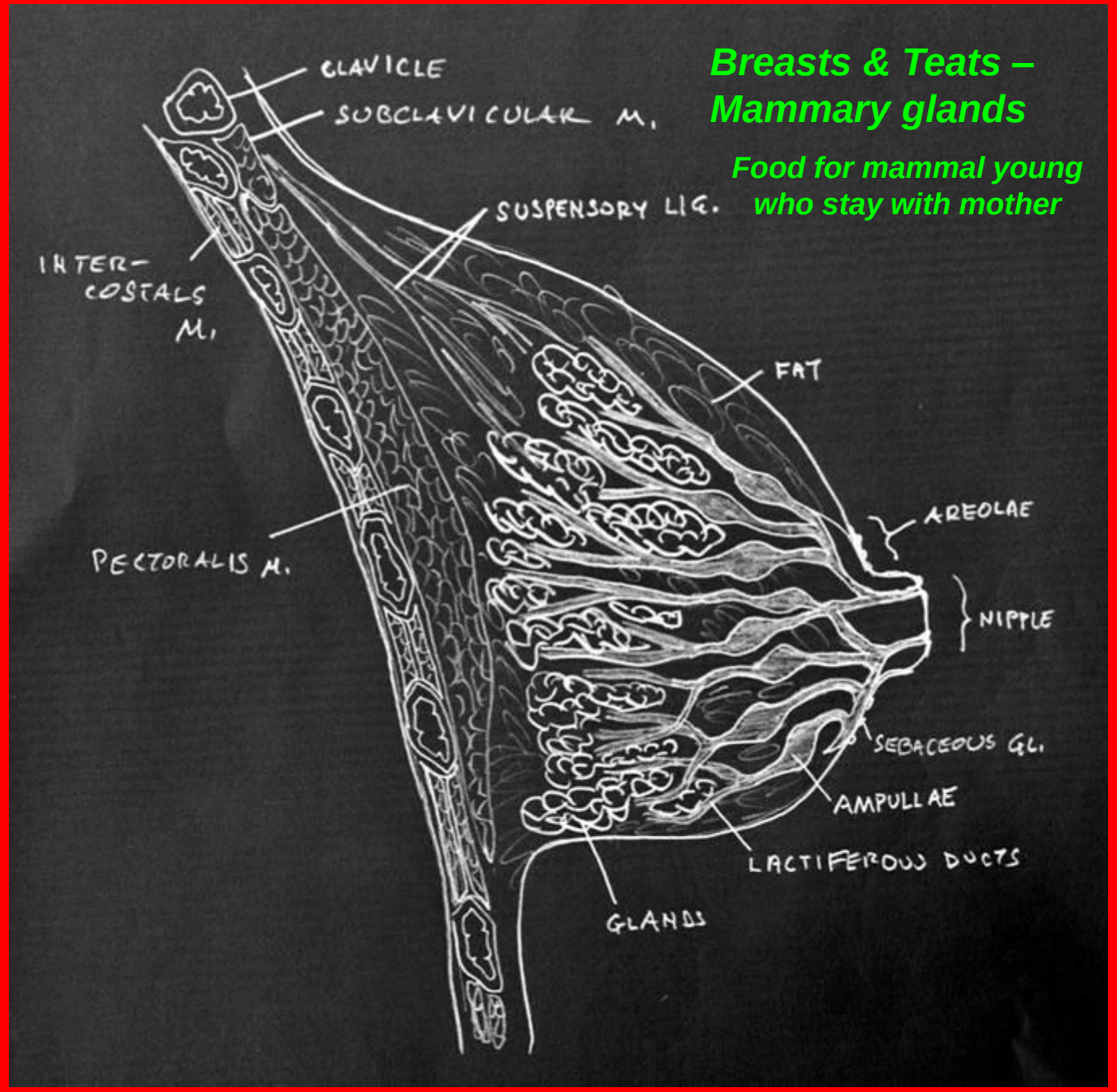

EPIDERMIS
Irregular denser connective tissue
Irregular denser connective tissue
2 Sweat Glands & Their Ducts
Adipose or Fat cells



Human Axilla: *Apocrine Sweat Glands* (arm pit & crotch area) – note copious secretion granule formation and 'Myoepithelium' smooth muscle fibers (*arrows*) at base of each secretory cell

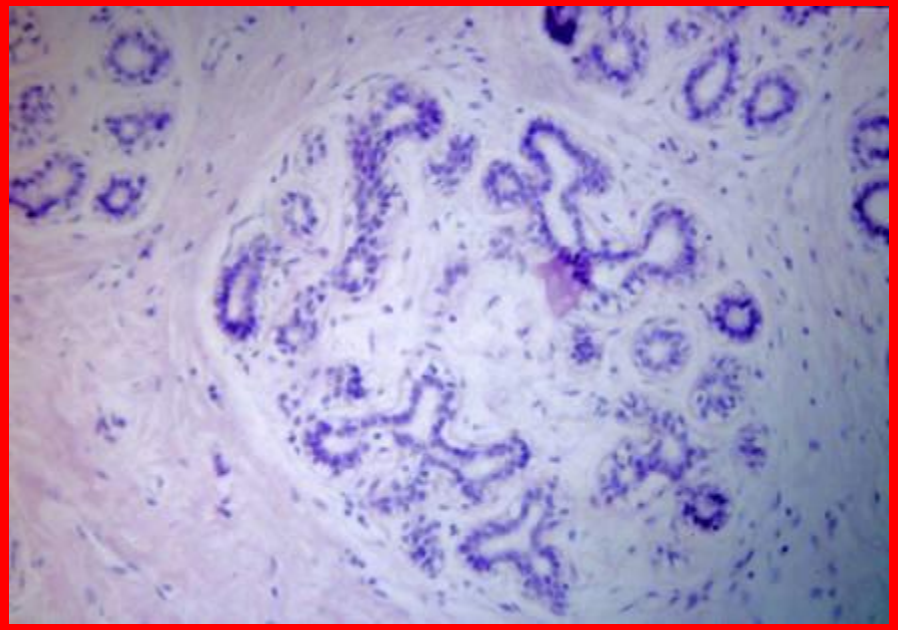


Pressure sense – Paccinian Corpuscles



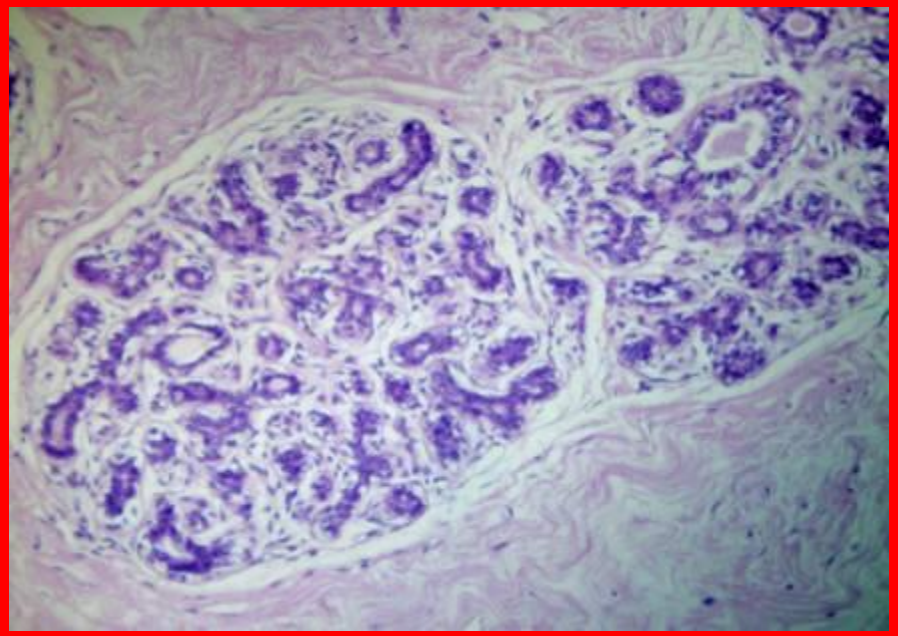
Breasts & Teats – Mammary glands

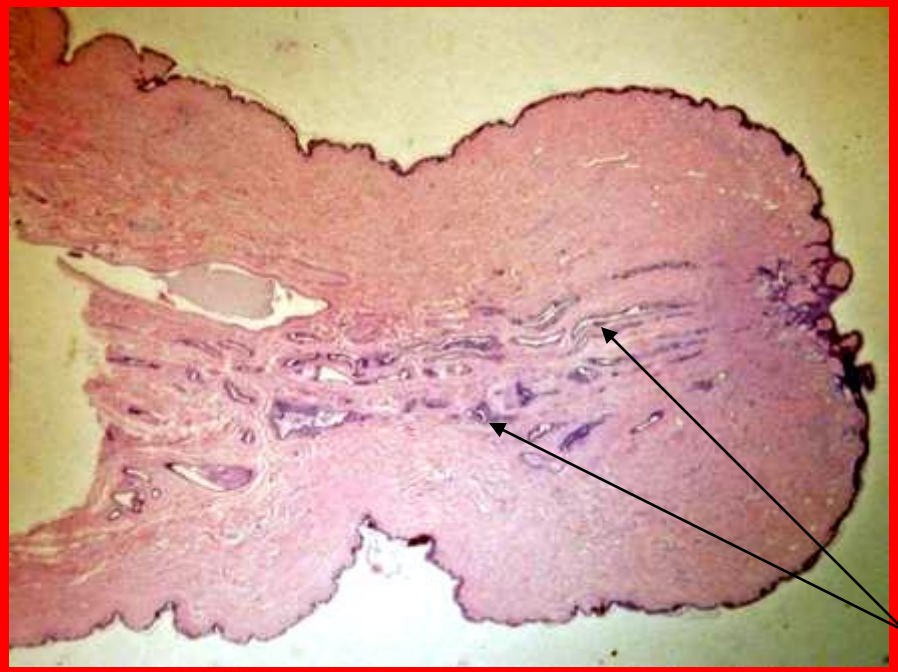
Food for mammal young who stay with mother



Mammary Gland-Inactive

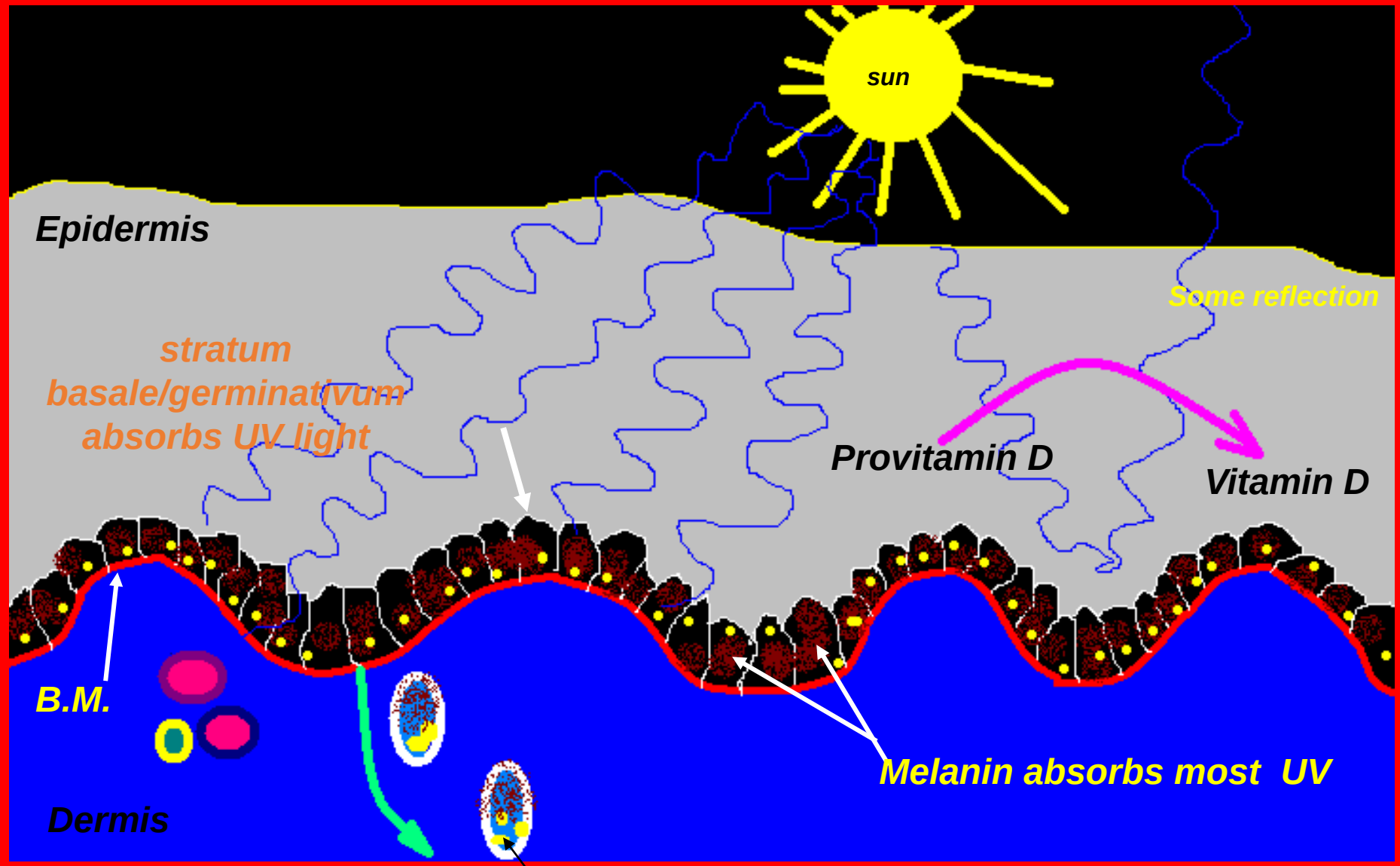
Proliferative





Human-Nipple

ducts



UV Abused melanocytes of stratum basale/germinativum become cancerous & metastasize to body through blood & lymph= MELANOMA