

Scales Chromatophores and Fukarin

Presented by:
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Skin of Koi

- Three layers, plus cuticle
- Cuticle – slime coat
- Epidermis – outermost cellular layer
- Dermis – contains the scales
- Hypodermis – fatty layer

Cuticle

- The slime coat
- Protects koi from
 - Bacteria
 - Toxins in water
 - Handling by humans

Slime Coat (Cuticle) also contains

- Antibodies
- Enzymes
 - Antibacterial lysozymes
 - Some lysozymes can destroy the cell walls of certain bacteria - Ich
- Protein
- Mr. Spike says it is a “koi’s first line of defense against water-borne irritants and parasites”.
- Reduces drag for a “smooth ride”.

Epidermis

- Outermost cellular layer
- 14 to 20 cells thick
- Contains goblet cells that have mucus producing glands – forms slime coat
- Covers most of the scale

Epidermis contains:

- Goblet cells
 - Makes up the cuticle
 - Leukocytes
 - Macrophages
- Outermost epidermal cells can divide

Dermis

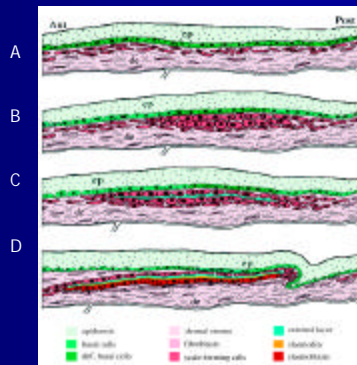
- This layer contains:
 - Scales
 - Scale forming cells
 - Granules containing pigment in chromatophores
 - Blood vessels
 - Nerves

Cycloid Scale

- Small plate-like outgrowth of the skin
- Cycloid comes from Greek "cyclo" meaning circle
- More or less circular with fairly smooth edges
 - Second type of leptoid scale is "Ctenoid" which has toothed outer edge (bass).
- Forms "rings" as it grows from the center out

Development of a scale

- A Fibroblasts along epidermal – dermal boundary
- B Differentiation of cells in areas
- C Cell layers differentiating and deposit of scale formation, matrix, and elastomdin (plywood like tissue)
- D Folding of epidermis around scale. Anterior sinks and posterior erupts forming scale



Type: Leptoid Form: Cycloid

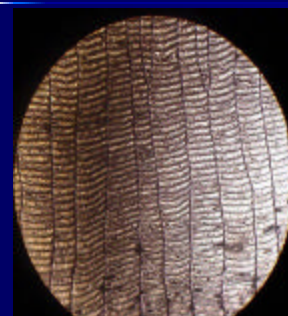
- Koi scales are of the Leptoid scale type in the form of a Cycloid Scale –
 - smooth outer edge
 - Valleys and ridges
 - Most common on fish with soft fin rays
 - As they grow, cycloid scales add concentric layers
 - You cannot "count the rings" to tell a koi's age
 - Scales grow as a koi grows

Cannot count growth rings (called circuli) because:

- They form circular pattern like the rings of growth on a tree
- In cooler months circuli grow more slowly and closer together but numerous rings can be added due to these
 - Weather
 - Health
 - Water quality
 - Nutrition
 - Other factors including variable weather changes in one season
 - May be possible for koi to use scales as a source of calcium if starving or prespawning activity

The outer surface is marked by bony ridges that alternate with valley-like depressions.

The inner part is composed of layers of criss-crossing fibrous connecting tissue.

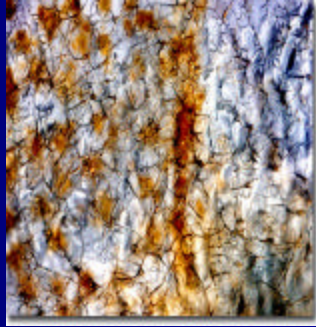


A detailed look at the growth rings as seen through a microscope appears like this (100x) Picture courtesy of Brett Rowley – from AKCA website – KHA – Koi Anatomy by Spike Cover

Differential Interference Contrast Image – From

olympusmicro.com in the DIC Gallery

- Rigid surface layer made mainly of calcium-based salts
- Fibrous inner layer mainly made of collagen



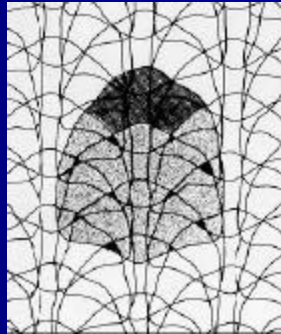
Purpose of scale

- External protection
- Smoother flow of water over koi's body, reducing drag
- Keeps the koi "water-proof"
 - Don't want "pruned" koi!
- Cycloid-type scale gives flexibility as scales "slide" over each other
- Helps keep the body shape

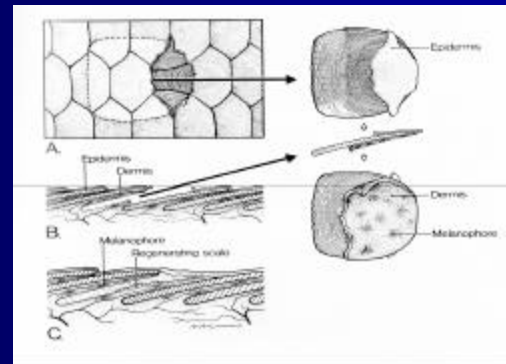
Overlapping of scales

- Up to six or seven layers in some spots (small dark areas)
- About 20% of most scales are exposed to the exterior (portion of scale without overlapping scale – large dark area on scale)

From AKCA Website – KHA – Anatomy by Spike Cover!



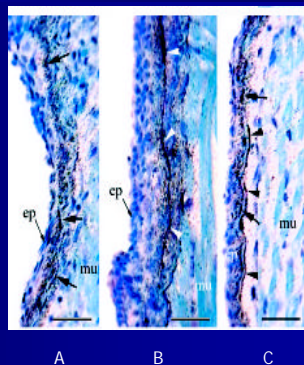
Overview of scales – from AKCA Website – Koi Anatomy by Spike Cover



Deep formation of scales

- A: Fibroblasts (dk. Arrows) in collagen stroma
- B: Scale forming cells (white arrows)
- C: More fibroblasts
 - ep: epidermis
 - mu: muscle

From: Skin Development in Fish



Dermis contains color storing cells - Chromatophores

- Chromatophores are where we get our amazing variety of koi colors
 - Granules in the chromatophore cell store pigment
 - Melanophore: Black pigment – melanine
 - Xanthophore: Yellow pigment (carotenoid) and red pigment are both pteridines
 - If the xanthophore is predominantly red it is called a erythophore
 - Guanine or purine crystals (the iridescent or shimmering part of the scale)
 - Does not produce pigment – What color is reflected depends on type of purine in the chromatophore and how crystal is arranged on the scale.
 - No pigment at all - Leucophore

Color Qualifications

- Color-enhancing foods contain carotenoids
 - Koi can retain these throughout life depending on:
 - Quality of food
 - Quantity of food
 - Type of carotenoid in food
- Genetic predisposition can determine intensity of color or whether the koi can store the carotenoid

Hormones and Pigment

- Hormones stimulate the dispersion of pigment.
- Hormones regulated and located in pituitary and pineal glands
- Calcium is needed to bind hormone to the color producing cell
- High calcium content in chromatophores helps promote the aggregation of color
 - Includes enzymes, messengers, motors, etc. (very scientific stuff)

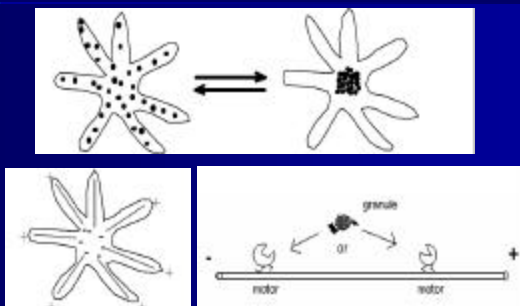
Chromatophores in action:

- Granules migrate out from cell center
 - Increases color
- Speed and manner of movement varies
- Melanophores, xanthophores, and erythrophores store pigments that absorb light
- Leucophores and irridophores reflect light
- Question:
 - Do high quality koi have more chromatophores that the "garden variety"

Transport of color

- Chromatophores with dendritic cell body
 - Migrate out from cell center increasing color
 - Aggregate in center decreasing color
- Transport of melanophores and erythrophores in microtubules
- Transport of xanthophores with microfilaments
- Motor, i.e., nucleoside triphosphate, ATP, hydrolyzing protein
- Complex systems using neural and endocrine mechanisms
- Chromatophores are cells derived from the neural crest
- Neural regulation is via the sympathetic component of the autonomic nervous system.
- Elevated calcium levels may aggregate melanosomes

Neural, microtube, or Motor for dispersion of pigment?



Fukarin

1 – 3 from AKCA Website – KHA – Anatomy by Spike Cover!

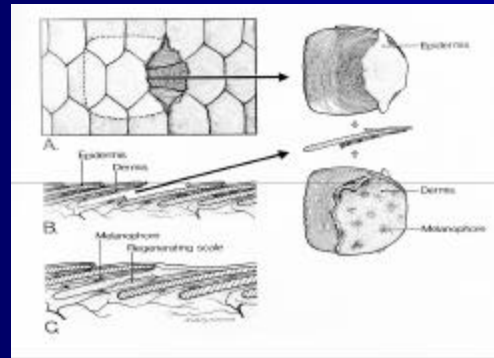
- Dermis grows from beneath the scale and is seen as "fukarin".
- On the fish to the right, the platinum or white areas are the fukarin.
- Darker or yellowish areas are the scales
- Research has found there is more than one type of fukarin.



Fukarin

- Dermis layer grows beneath scale up against underside of scale
- “wraps” around external edges of scale
- Fukarin sign of good genetics

Overview of scales – from AKCA Website – Koi Anatomy by Spike Cover



Hypodermis

- Very thin fatty layer between the layers above (cuticle, dermis, epidermis) and the muscle of the koi's body

Questions:

- Do high quality koi have more pigment granules than the “garden variety”?
- Does calcium help koi in color dispersement?
- Genetics: more granules or predisposition to contain more granules?
- Better mind or better chromatophores?
- Can you increase the amount of chromatophores?
- Discussion?

Thank you

- This information was provided from numerous sources....copies will be provided if you wish.
- Disclaimer: I am not an expert nor a scientist! I just play one in the movies.
- The End