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Observations on the Lens Structures of the Teleost Fishes, *Gambusia affinis affinis* and *Scomber japonicus*

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Abstract

In these two species, as in other teleostean fishes, the crystalline lens shows a global shape and is covered on its outer surface with a homogeneous capsule, that is a transparent thin membrane. Under the latter, hexagonal cells are distributed uniformly except a limited area of the posterior pole, forming a layer of cuboidal epithelium. At the margin of this polar area, lens fibers are thought to be produced by transformation of the flattened epithelial cells, which become elongated and compose nearly all of the peripheral layers of the lens. This differentiation occurrs markedly at the young, then, decreases according to the aging. Each of columnar lens fibers connects its both ends to the linear sutures on respective poles, that is the anterior or the posterior, arranging itself in a meridional row. The latter shows each other an orthogonal slip of phase to an outward appearance. Central part of the lens possesses a colloidal substance at the hatched larva, however the substance becomes to have a hyaloid character and gradually a solid core has been formed accroding to the aging.

In the vertebrates, the eye functions like a camera, possessing a crystalline lens which is concerned with the refraction of a ray and with the image formation on the retina[1]. The lens is covered with a homogeneous capsule, coating on the outer surface of the layer of flattened or cuboidal cells comprising the epithelium of the lens and is composed of a mass of elongated lens fibers which are differentiated from the epithelium[2]. As for the teleosts, the lens is spherical and non-collagenous[2][3]. Focusing of objects that move nearer to the eye is effected by moving the lens away the retina, being aided by a faciliform process, contrary to the method of the curvature-changing of the lens in the higher vertebrates[1][4].

Well, the structures and functions concerning the retina or the faciliform process have been studied from old times, however it seems that the references to the lens are not so well, especially in the fishes. Therefore, the authors have tried to clarify the micro-anatomical constructions of lenses of the teleostean such as the mackerel and the mosquitofish.

Materials and Method

The mackerel, *Scomber japonicus*, and the mosquitofish, *Gambusia affinis affinis*, were

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used for the investigations of lens structures. The former was obtained by a fish dealer at a market. It was suited to an outward observation of the superficial structures of the lens because of its comparatively large size. Before the observation under binocular microscope (×10~20), eyeballs were fixed with 10% formalin, then lenses were extirpated from the eyeballs taking care of their orientation. As for the latter, the sampling was practised at laboratory ponds of the faculty. The histological specimens of the eyeballs were prepared after the fixation with BOUIN's solution. Sectionings were performed transversally, that is from anterior to posterior, and also laterally. The staining methods of MAYER's hematoxylin-eosine or HANSEN's iron-hematoxylin were applied to properly. In addition, the variations of the histological structure of the lens were compared with the aging of the fishes, at such stages as the before-hatch, the hatched larva, the young and the adult.

Results and Discussion

In the case of the mackerel, the lens shows a global shape and is covered with a transparent membrane of the lens capsule. The lens epithelium which is underlying except the polar region of the posterior shows its ground plan as a hexagon (**Fig. 1**).

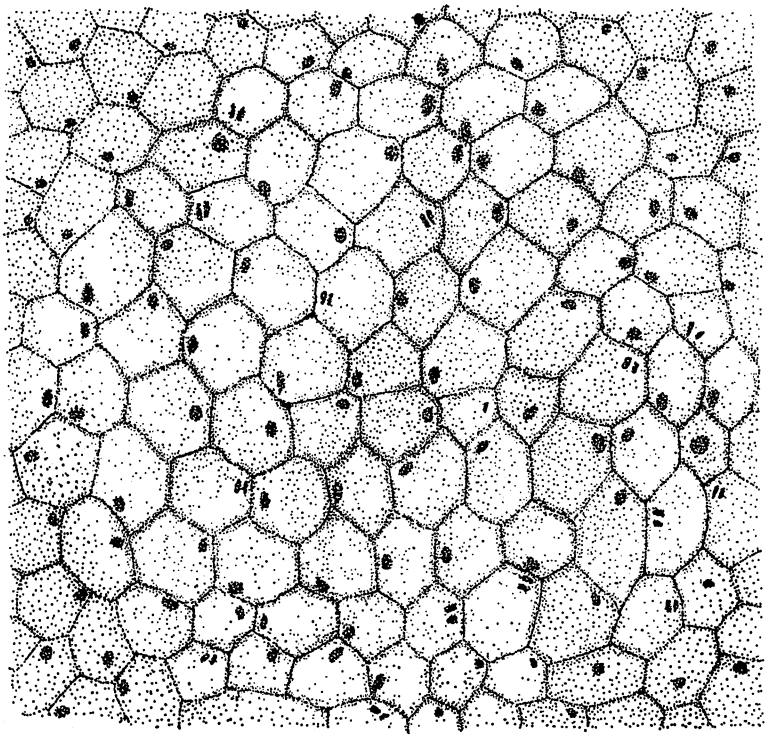


Fig. 1. Ground plan of the lens epithelium of the mackerel. Each of the cells shows a hexagonal figure. Nuclear divisions are recognized in some of the cells.

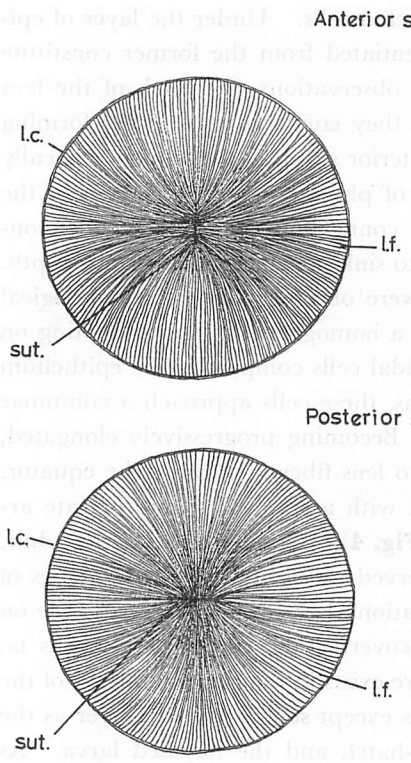


Fig. 2. Locality of the sutures and their connections with the lens fibers on the surface of the lens of the mackerel. Linear sutures are situated at each of the anterior and posterior poles. Anterior one shows a vertical position, contray to the posterior. The latter is horizontal. Lens fibers arrange themselves in meridional rows, converging to these sutures at their ends.

Abbrev., l. c.: lens capsule, l. f.: lens fiber, sut.: suture of the lens.

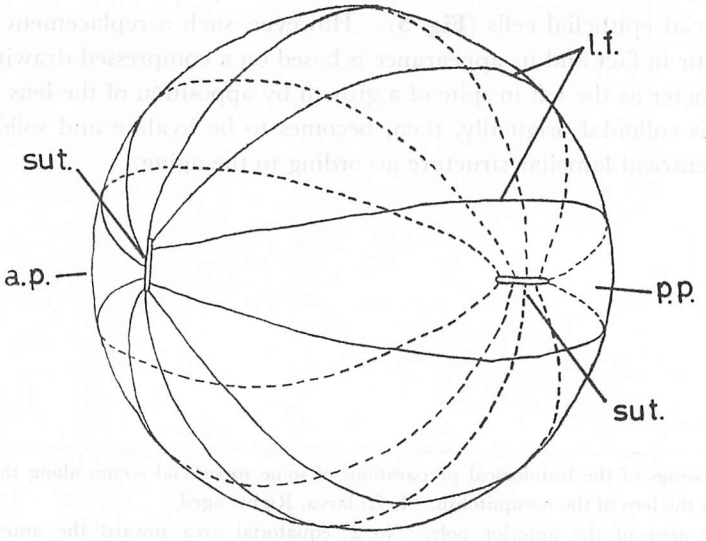


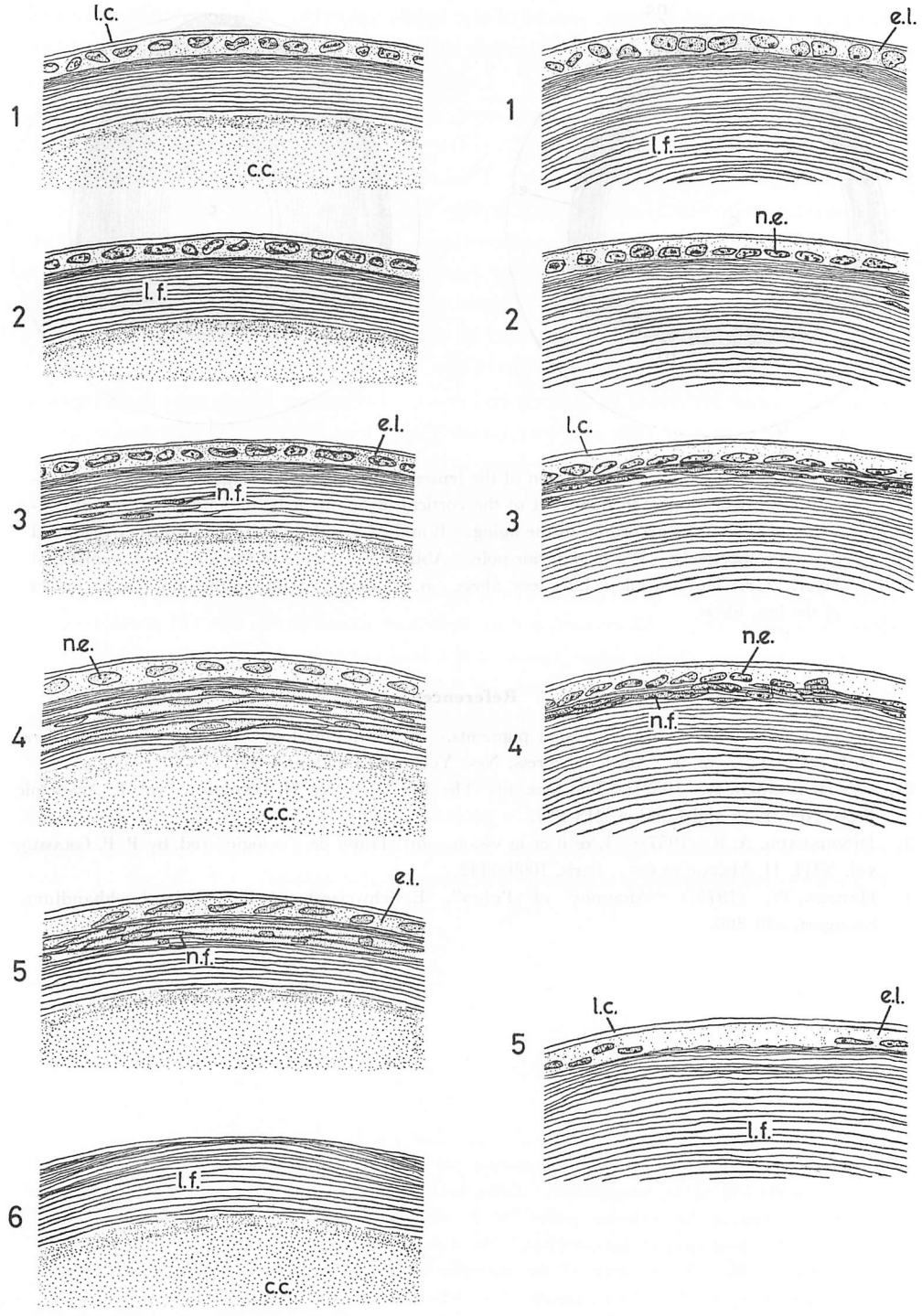
Fig. 3. Diagram of the arrangement pattern of the lens fibers and the locality of the sutures, drawn from an outward appearance.

Abbrev., a. p.: anterior pole, l. f.: lens fiber, p. p.: posterior pole, sut.: suture.

Mitoses are recognized in some nuclei of the epithelial cells. Under the layer of epithelium, lens fibers which may have been differentiated from the former constitute the bulk of the substance of the lens. Outward observations give each of the lens fibers an arrangement in a meridional row, and they converge each other forming linear sutures at the both poles (**Fig. 2**). The anterior suture is positioned vertically at a right angle to the posterior one. This slip of phase is concisely shown in the diagrammatic representation accompanying the connections of some of the convergent lens fibers (**Fig. 3**). These sutures seem to sink interiorly to a certain depth.

As for the mosquitofish, the following results were obtained from the histological preparations. The spherical lens is covered with a homogeneous capsule coating on the outer surface of the layer of flattened or cuboidal cells comprising the epithelium of the lens. Near at the posterior pole of the lens, these cells approach a columnar form and become arranged in meridional rows. Becoming progressively elongated, the cells at the posterior pole are transformed into lens fibers. Passing the equator, toward the posterior pole the epithelium is lined with a simple- or multiseriate arrangement of flattened nuclei of the lens fibers (**Fig. 4**). Compared with the adult, such a multiseriate arrangement of nuclei is observed more broadly in the lenses of the young. It seems therefore that the differentiation at the young may advance on a larger scale than the old ones. The capsule covering the posterior pole has no underlying epithelium. Moreover, a core structure exists in the central portion of the lens. This occupies almost inner space of the lens except such a cortical layer as the lens fibers, especially at the stages of the before-hatch and the hatched larva. As for the adult, this core shows to be replaced relatively by the lens fibers originating from superficial epithelial cells (**Fig. 5**). However, such a replacement as in **Fig. 5** may not occur in fact and its appearance is based on a compressed drawing to a same scale of diameter as the left in spite of a growth by apposition of the lens fibers. The above core is colloidal originally, then, becomes to be hyaline and solid developing itself a concentrical lamellar structure according to the aging.

Fig. 4. Drawings of the histological preparations of some superficial scenes along the meridional line in the lens of the mosquitofish. Left: larva, Right: aged.
No. 1: area of the anterior pole, No. 2: equatorial area toward the anterior, No. 3: equatorial area toward the posterior, No. 4–5: middle areas between the equator and the posterior pole, No. 6: area of the posterior pole. Abbrev., c. c.: colloidal core, e. l.: epithelial layer, l. c.: lens capsule, l. f.: lens fibers, n. e.: nuclei of the epithelial cells, n. f.: nuclei of the fiber cells.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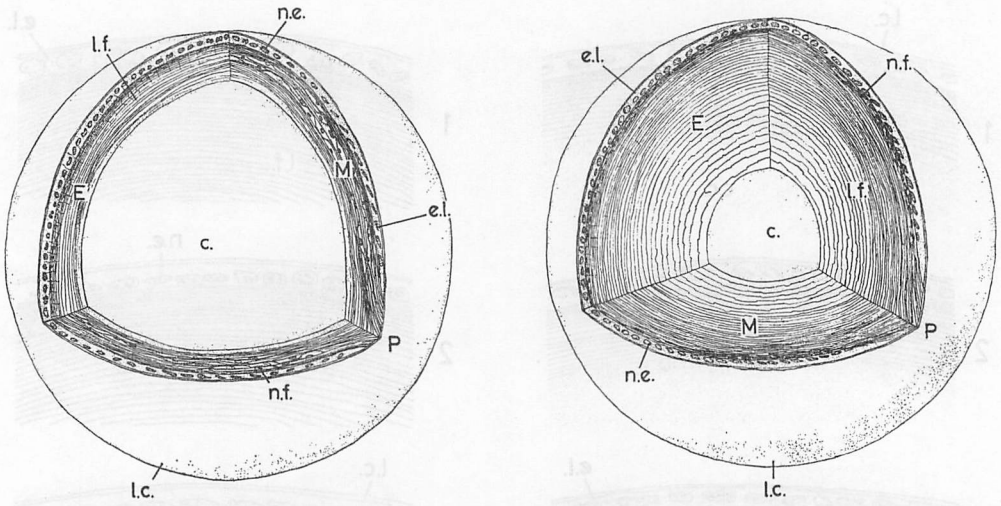

Fig. 5. Three dimensional representation of the lenses of larva (left) and aged (right) of the mosquitofish, dissecting each quadrant of the cortical layers for a better understanding of constructional changes according to the aging. E and M are the equatorial and the meridional planes, respectively. P is a posterior pole. Abbrev., c.: core of the lens, e. l.: epithelial layer, l. c.: lens capsule, l. f.: lens fibers, n. e.: nuclei of the epithelium, n. f.: nuclei of the lens fibers.

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