Chapter 11.

Historical.
HISTORICAL

1. General.

In most of the fishes, the connective tissue of the dermis is replaced by the dermal skeleton in the form of scales. These scales may be used for knowing many secrets in the life of the fish. A historical background for having a knowledge of the previous work done by various ichthyologists is given under separate heads.

2. Structure, Origin and Evolution:

a) Structure.

Thomsen (1957), while describing the scale structure of the yellow eye mullet, Aldrichetta fosteri (Cuv.& Val.) says that the nucleus here is displaced posteriorly. The shoulders of the scale as given by Thomson (1957), divide the field of the scale into four sectors. Both primary and secondary radii have been located by him in the scales. The annuli according to him (Thomson) were noticed in the form of broken circuli.

b) Origin and Evolution of scales:

Van Gosten (1957) states that earliest fish like fossil Vertebrates, the Ostracoderms and Placoderms of Silurian and Devonian eras were armoured in various degrees with plates or shields and scales of different shapes that consisted typically of three layers. Acanthodii possessed scales, which are similar to Ganoid scale of higher bony
fishes. According to Van Oosten, the cosmoid scale has its origin from that of the Placoderm scale, with some modifications. The Ganoid scale has originated from the Cosmoid scale as a result of replacement of the thin covering surface by a hard substance called Ganoine. He proposes that the Placoid scale has arisen as a papilla formed by the multiplication of the fibreblasts.

The eyleoid and Ganoid scales as given by Van Oosten have their origin in a dermal papilla formed by the mitotic multiplication of the fibreblasts.

3. Scale types and Arrangement:

a) Types of scales.

Van Oosten (1956) classified scales on the basis of chemical composition and structure. Lagler (1963) has given two types of scales on the basis of structure vis (i) Placoid and (ii) nonplacoid, the non placoid being of three types: (i) Cosmoid (ii) Ganoid and (iii) Bony ridge scales.

b) Arrangement of scales:

Van Oosten (1957) states that vast majority of the Teleosts are covered with scales, whereas others are partly covered (leather carp). He adds that the sword fish when young has b tuberculoid scales, but with growth, they disappear and larger individuals are scaleless.

Lagler (1962) points out that scales are mostly arranged intricately. He however adds that in Lota (burbet) and Anguilla, the pattern of scale arrangement is mosaic, rather
than overlapping one another.

4. **Importance of fish scales in fish systematics**

Agassiz (1833-1844) classified the fish into the groups: Placoides, Ganoides, Cycloides, and Ctenoides, according to the character of the scales. The Placoides having only Placoid scales; the Ganoides having only flat rhombic Ganoid scales; Cycloides having thin rounded cycloid scales and lastly Ctenoides having similar thin scales, but provided with spiny projections.

Lagler (1956) has given an elaborate account of the classification of fishes on the basis of scale counts along the lateral line; between the lateral line and pelvic fin; and between dorsal fin and lateral line. He has also given an account of the classification on the basis of type and arrangement of scales. Van Oosten (1956) says that the structures of the scale used in Taxonomy are the circuli or striae, radii or sulci and Ctenii.

5. **Assessment of age by scales (Annuli):**

Leeuwenhoek (op. cit) the pioneer microscopist is generally given the credit for making the first generalization that the rings or annuli on fish scales had something to do with the age of the fish.

Hoffbaur (1898 op. cit.) working with carp of known age correctly interpreted the age of the fish. Kendall and Dence (1927) published for the first time, the use of scales in assessment of age in brook-trout, but the results
were indecisive.

Ricker (1932), Hazzard (1932), Greely (1934, 1935, 1936, 1937, 1939, 1940), Cooper (1940), Rawson (1941), Smith (1941), Shetter and Leonard (1943- op.cit) Cooper and Fuller (1945) and Doan (1948) have aged Salvelinus fontinalis by means of scales with the assumption that the methods as used for other Salmonids could be applied to this species as well.

Raj (1951) has stated that the growth rings on the scales of Hilsa are two numerous to be counted as annual growth rings. Jones and Menon (1952), as quoted by Tandon (1962), have mentioned that it has not been possible for them to interpret the exact significance of the growth rings on the scales of Hilsa.

Seshappa and Bhimachar (1951) have noticed the occurrence of certain annuli, which appear to be formed every year under the influence of South West monsoon in the scales of Malabar Sole, Cyanoglossus semifasciatus. They have thus established that these growth rings on scales could be used in age determination and in the assessment of year class composition of the sole fishery.

Cooper (1951) states that the annulus is formed once a year in the scales of Salvelinus fontinalis and that all scales from a single fish are consistent in depicting age. Moreover, the annuli are true year marks. Thomson (1951), Kerr (1952) and Hiyama (1952) have established the feasi-
bility of age determination in fresh water fishes, with the help of scales.

Lagler (1956) states that the scale method is good only in those waters, which become cold enough to interrupt growth in the part of each year. Van Oosten and Eschmeyer (1956) state that they studied, the scales of 212 fin-clipped recaptured lake trout *Salvelinus namaycush* from Lake Michigan, which were read and maximum discrepancy of 20% was found between known and estimated (calculated) ages from scales. Jhingran (1957) and Thomson (1957) have shown age-annuli in the scales of *Cirrhina* and the yellow-skye mullet.

Das (1962, 64) studied age and annuli in sixteen species of fishes from India, and was the first to show that age can be determined in most freshwater fishes of India. He demonstrated age-annuli in the scales of *Anabas testudineus*, *Mugil corsula*, *Hilsa ilisha*, *Cirrhina mrigala*, *Labeo bata*, *Cirrhina reba*, *Barbus sarana*, *Gadusia chapra*, *Notopterus chitala*, *Ophicephalus marulius*, *Catla catla*, *Osphranemus gourami*, *Labeo rohita*, *Tor tor*, *Psettodes fasciatus* and *Pleuronectes platessa*, with photomicrography of the scales. He thus, contradicted Lagler's statement (1956) that scale method is good enough only in those waters which become cold enough to interrupt growth in the part of each year.

Sunderraj (1960) has determined the age of the *Leiostomus Xanthurus* by scales and confirmed it by otoliths. Van Oosten (1961) determined age by scale in *Hiodon tergisus* and confirmed the results by length-frequency method.

Natarajan and Jhingran (1963) also reported on age-annuli in *Catla catla*.

Tandon (1962) studied scales of *Selaroides leptolepis*, but
ed that those from the pectoral axis had clear ring-like structures on them, but he failed to estimate the age by scale method.

Tokareva (1963) and Vanicek (1964) both have established age in the Baltic sea cod and the Sauger, Stizostedion Canadense by means of scales respectively.

Llewellyn (1966), while working on scale, age and growth of the murray cod Maccullochella macquarreesis, the silver perch Bidyanus bidyanus and the golden perch Plectroplites ambiguus states that by studying fish of a known age, and first learning to interpret the scales of different fishes, it was found that the silver perch was the easiest of the three species to "age" using the scale-method.

6. Use of Otoliths, Opercula and Vertebrae for age determination:

For otoliths, Cunningham (1905), Nichling (1931, 33), Arora (1951), Molander (1957) state that the opaque bands in the otoliths of Gadidae & Pleuronectidae, the hake, the plaice and the sand dab respectively, are due to calcification, which occurs during summer due to rapid rate of growth and that the translucent bands are formed during winter, when the growth is small.

Chidambaram (1933), Dakin (1939), Adams (1940), Martin (1941), Walford (1946) Mosher (1950) and Kohler (1958) showed annuli in otoliths of Indian mackerel, the spot,
the American Ostariophysi, the burbot, the pacific Sardine, and the haddeek respectively. Sunderraj (1960) states that there was a general agreement between the scale year marks and otolith year rings, from the spot, *Leiostomus Xanthurus* Lacepede.

Pantulu et al. (1962) state that a critical examination of the periodic markings on otoliths has helped to establish that the markings could be used for the estimation of age and growth of the eel, *Anguilla nebulosa*. Tandon (1962) states that no growth rings could be detected either in supra occipital bones, or in Otoliths, pre-opercular bones and Vertebrae in *Selaroides leptolepis*.

Llewellyn (1966) says that annual growth rings are discernible in the otoliths of the silver perch and the golden perch, but are not clearly defined in the murray cod. For *Operculum*, Chugunov (1926) treated all the bony parts such as Operculum and cleithrum with picrascarmine, the results showed that clear annuli or annual growth rings could be clearly seen in the Operculum.

For *Vertebrae*, Appelget and Smith (1951) state that, while studying the age and growth of the channel cat fish, *Lepomis Punctatus* selected fifth Vertebra and that they were able to observe growth rings from the face of the centrum.

7. False annuli, spawning rings and variations in circuli and radii:
For false annuli

Cooper (1951) has found false annuli on the scales of *Salvelinus fontinalis* (brook trout) and has established that false annuli could be distinguished from true annuli by tracing the time of true annulus formation by monthly collections.

Van Oosten (1957) states that an extra accessory check may be sometimes found on the scales of fishes, as a result of disease, parasitization, injury, starvation, sexual maturation, pollution, drop in temperature or any other prolonged change in the environment. Sunderraj (1960) states that false annuli were often encountered and with some practice easily identified in the scales of *Leiostomus* Kantharurus Lacepede, as they are often close to the true annuli and more distinct in the anterior part of the scales than in the lateral areas.

Tandon (1962) has found some annuli on the scales of *Selaroides leptolepis* (Cuv. & Val.), which however he does not consider as annual growth rings. Pantulu (1962) considers those annuli as false, which are patchy broken and appear only for short lengths in *Mystus julio* (Ham.). Pantulu and Singh (1962) state that no categorical statement can be established regarding the validity of an opaque zone in the Leptocephali of *Anguilla nebula* McCelland.

Natarajan and Shingran (1963) have given an account of differentiation between false and true annuli in the scales
of *Catla Catla* (Ham.). They however state that the density variation in the basic material often provides the optical illusion of a band or groove, which can easily be differentiated from true annulus as it does not conform the properties of a true annulus.

For *Spawning rings*: Zamakhaev (1940) states that at the time of spawnings the scales begin to break down, which leads to the formation of definite type of mark on it in the Caspian shad.

Cooper (1951) reports that confusing accessory checks are found on the scales of the brook trout by which he could distinguish between naturally spawned and non-spawned fishes on the pattern of circuli. Lagler (1956) reports the presence of spawning rings on the scales of *Salmo salar* (Atlantic salmon). Russel and Yonge (1960) also state that spawning rings are easily discernible in the scales of the Herring and the cod.

Natarajan and Jhingran (1963) state that the spawning rings are marked in the form of a sharp break in circuli and subsequent resumption of growth on the scales of *Catla Catla* (Ham.). Moreover, they add that spawning rings are not found on the scales of virgin fish i.e. spawning rings are not obvious during the first year of fish life.

For *Circuli and radii*

Raj (1946) states that the variation in the number of radii is related to the age of the fish and that the radii
in the scales of *Hilsa illisha* (Ham.) represent the body
length of the fish in inches. Chaenko (1948) tried to
establish a relationship between the number of radii and
the body length. Sunderraj (1960) states the number
of circuli may be used to determine the approximate age
of the spot in fractions of a year, which appears of doubt­
tful value.

8. Scale-annuli and fish-length correlations:

Johnston (1905) was the first to devise a method to
calculate the length of a fish for each year of its life
by comparing the widths of the annual growth areas of the
scale. Welsch and Breeder (1923) reported a spot 300 m.m.
in total length, which they determined to be 4 ½ years old.
Creaser (1932), Rounsefell and Everhart (1953) and Lagler
(1956) list several formulae for back-calculating the age
of the fish after taking into consideration the scale ra­
dius and the distance between the nucleus and the annulus.

Townsend (1956) working on the age and growth of the
spot examined scales from 13 individuals of different
lengths. He found that the number of annuli varied in these
fishes, but he did not test the validity or otherwise of
annuli.

9. Experimental scale studies:

Bhatia (1932) states that at both low and high temp­
eratures (17°C and 4°C) fish fed abundantly show on their
scales peripheral bands of comparatively broad rings; while
fish starved show narrow bands of peripheral rings. Moreover he showed that variations in temperature have no direct effect on the production of the periodic rings on the fish scales.

Adelman (1955) has given an elaborate account of the affect of starvation on the scales of the brook trout of three sizes.

10. Fish scale and fish Ecology:

Audige (1921) found that for species of carps no growth takes place below certain temperature and thus is recorded in the scales. In _Sardinella longiceps_, Hornell and Nyefiu (1923) observed only two rings and mention that the period of arrested growth coincides, with the period of plankton scarcity from January- April any year.

Brown (1957) has given unrefutable evidence for the growth of Salmonids depending upon the ionic composition of water, which is reflected in the scales.

Nikolsky (1963) states that the fact, that the annual rings are not formed directly under the influence of the temperature is supported by the presence of annual marks on the scales and bones of fishes in the Equitorial and Tropical zones, e.g. in _Curimatus elegans_ Steind studied by Vieira (1938).