VIII. Nervous System
Fig. 1 A - Dorsal view of the brain of *Xenentodon*.

1 B - Ventral view of the brain of *Xenentodon*.

Fig. 2 - Camera lucida sketch of a longitudinal section of the brain of *Xenentodon* showing the ventricles.

Abbreviations:

- ACOU.TUB. - Acoustic tubercle
- CB. - Cerebellum
- CER. - Cerebrum
- FR.L. - Frontal lobe
- HYP. - Hypophysis
- INF. - Infundibulum
- INF.L. - Lobii inferiores
- INF.V. - Cavity in the infundibulum
- LAT.V. - Lateral ventricle
- META. - Metacoele
- M. OBL. - Medulla oblongata
- OC.L. - Occipital lobe
- OLF.L. - Olfactory lobe
- OP.L. - Optic lobe
- OP.N. - Optic nerve
- PAR.L. - Parietal lobe
- PIN. - Pineal
- PIN.STK. - Pineal stalk
- REC.HYP. - Recessus hypophysis
- REC.P.OPT. - Recessus preopticus
- SP.C. - Spinal cord
- VOL. - Volvulus cerebelli
- III.V. - Third ventricle
- IV.V. - Fourth ventricle
Fig. 3 A - Diagram showing the eye muscles and their innervation.

Fig. 3 B - Lateral view of the brain of *Xenantodon*.

Abbreviations:

- B. - Brain
- CBL. - Cerebellum
- CER. - Cerebrum
- HYP. - Hypophysis
- INF. - Infundibulum
- INF.L. - Lobi inferiores
- M.ANT.REC. - M. anterior rectus
- M-INF.OBL. - M. inferior oblique
- M.OBL. - Medulla oblongata
- M.REC.INF. - M. rectus inferior
- M.REC.POST. - M. rectus posterior
- M.SUP.OBL. - M. superior oblique
- M.SUP.REC. - M. superior rectus
- OLF.L. - Olfactory lobe
- OLF.T. - Olfactory tract
- OP.L. - Optic lobe
- OP.N. - Optic nerve
- SP.C. - Spinal cord
- II. - Nervus opticus
- III. - Nervus oculomotorius
- IV. - Nervus trochlearis
- VI. - Nervus abducens
Fig. 4 - Dissection of the *Xenentodon* showing the cranial nerves excluding the nerves of the eye muscles.

Abbreviations:

- **MAND.TR.** - Mandibular trunk
- **PH.BR.GLOSS.** - Ramus pharyngealis of IX nerve
- **PSEUD.** - Nerve to pseudobranch
- **PT.BR.1** - Pre-trematic branch of branchial one
- **PT.T.BR.1** - Post-trematic branch of branchial one
- **TFC.** - Trigemino-facial complex
- **I.** - Nervus olfactorius
- **II.** - Nervus opticus
- **V.1** - Ramus supraorbitales
- **V.1.1** - Ramus opthalmicus superficialis trigemini
- **V.1+VII.1** - Ramus opthalmicus superficialis facialis
- **V.2** - Ramus maxillaris
- **V.3** - Ramus mandibularis
- **V.3.1** - Ramus mandibularis externus
- **V.3.2** - Ramus mandibularis internus
- **VII.2** - Ramus buccalis
- **VII.3** - Ramus palatinus
- **VII.3.1** - Ramus palatinus anterius
- **VII.3.2** - Ramus palatinus posterius
- **VII.4** - Ramus hyomandibularis
- **VII.4.1** - Ramus opercularis
- **VII.4.2** - Ramus preopercularis
- **VII.4.3** - Ramus hyoideus
- **VII.4.4** - Ramus mandibularis facialis
- **VII.5** - Ramus lateralis accessorius
- **VIII.** - Nervus acusticus
- **IX.** - Nervus glossopharyngeus
- **X.** - Nervus vagi
- **X.1** - Ramus visceralis vagi
- **X.1.4** - Visceralis branch innervating the region behind the fourth gill arch
- **X.2** - Ramus lateralis vagi
- **X.2.2** - Ramus lateralis pectoralis vagi
Fig. 5 - A dissection of *Xenentodon* from lateral side to show the distribution of the branches of nervus vagi.

Abbreviations:

A.F. - Anal fin  
B. - Brain  
BS.R. - Branchiostegal rays  
CARD.N. - Cardiac nerve  
C.F. - Caudal fin  
D.F. - Dorsal fin  
G.A.R. - Gill arches  
GAS.N. - Gastric nerve  
GAS.INT.N. - Gastro-intestinal nerve  
HEP.N. - Hepatic nerve  
L.J. - Lower jaw  
PEL.F. - Pelvic fin  
PNE.N. - Pneumatic nerve  
SP.C. - Spinal cord  
URO. - Urophysis  
VII.₅ - Ramus lateralis accessorius  
X.₁ - Ramus visceralis vagi  
X.₂ - Ramus lateralis vagi
Fig. 6 - Dissection of spinal nerves and sympathetic system from the ventral side.

Abbreviations:

B. - Brain
BR.PL. - Branchial plexus
CAUD.SYM.C. - Caudal part of sympathetic cord
CEPH.SYM.C. - Cephalic part of sympathetic cord
C.F. - Caudal fin
PEC.F. - Pectoral fin
PEL.F. - Pelvic fin
PT.BR.1 - Pre-trematic branch of branchiales one
PT.T.BR.4 - Post-trematic branch of branchiales four
RAM.COMM. - Ramus communicans
SC.PL. - Sciatic plexus
SP.C. - Spinal cord
SP.N. - Spinal nerves
SP.N.1-3 - Spinal nerves 1-3
SYM.GANG. - Sympathetic ganglia
TR.SYM.C. - Trunk part of sympathetic cord
URO. - Urophysis
X.2 - Ramus lateralis vagi
Fig. 7 - Xenentodon, 35 mm.W.L.: T.S. passing through olfactory region of the brain showing the mitral cells. x 60

Fig. 8 - Xenentodon, adult: L.S. of telencephalon. x 60

Fig. 9 - Xenentodon, 35 mm.W.L.: T.S. of telencephalon showing different lobes of cerebrum. x 60

Fig. 10 - Xenentodon adult: L.S. showing velum transversum, paraphysis, pineal and haemnular ganglia. x 36

Abbreviations:

AX.L. - Axial or frontal lobe
CER. - Cerebrum
FR.FIS. - Frontal fissure
HAB.G. - Haemebular ganglion
LAT.V. - Lateral ventricle
MIT.C. - Mitral cells
OLF.L. - Olfactory lobe
OP.N. - Optic nerve
PAR. - Paraphysis
PAR.L. - Parietal lobe
PIN. - Pineal
RHI.FIS. - Rhinal fissure
V.T. - Velum transversum
Fig. 11 - Xenentodon adult: L.S. of cerebrum. x 60

Fig. 12 - Xenentodon adult: A portion of the T.S. of pineal body. x 270

Fig. 13 - Xenentodon, 35 mm.W.L.: T.S. passing through tectum opticum and the infundibulum. x 60

Fig. 14 - Xenentodon, 35 mm.W.L.: T.S. passing through tectum opticum, pineal and pituitary bodies. x 60

Abbreviations:

GANG.C. = Ganglion cells
GR.L. = Granular layer
HYP. = Hypophysis
INF. = Infundibulum
NSC. = Neurosecretory cells
OP.CL. = Opticoel
OP.L. = Optic lobe
PIN.STK. = Pineal stalk
POST.COMM. = Posterior commissure
RAD.NF. = Radiating nerve fibres
TEC.OPT. = Tectum opticum
III V. = IIIrd ventricle
Fig. 15 - Xenentodon adult: L.S. showing the recessus preopticus and the nucleus preopticus. x 60

Fig. 16 - Xenentodon adult: T.S. of diencephalon passing through the region of the pineal and pituitary bodies. x 36

Fig. 17 - Xenentodon adult: L.S. of mesencephalon showing the nucleus rotundus. x 36

Fig. 18 - Xenentodon, 35 mm.W.L: T.S. passing through the tectum opticum and lobi inferiores. x 60

Abbreviations:

CER. - Cerebrum
GRA.L. - Granular layer
HAB.G. - Haebenular ganglia
HYP. - Hypophysis
INF.C. - Infundibular cavity
INF.L. - Lobi inferiores
MID.L. - Middle layer
N.PR.OPT. - Nucleus preopticus
N.ROT. - Nucleus rotundus
OP.CL. - Opticoel
OP.N. - Optic nerve
PIN. - Pineal body
REC.HYP. - Recessus hypophysis
REC.PR.OPT. - Recessus preopticus
SUP.L. - Superficial layer
TEC.OPT. - Tectum opticum
T.LONG. - Torus longitudinalis
III V. - IIIrd ventricle
Fig. 19 - *Xenentodon*, 35 mm.W.L.: T.S. passing through tectum opticum and infundibular ventricle. x 36

Fig. 20 - *Xenentodon* adult: L.S. of mesencephalon showing volvula cerebelli and layers of tectum opticum. x 36

Fig. 21 - *Xenentodon* adult: H.S. of tectum opticum showing neurons with axonic fibres directed towards inner side (Golgi's stain). x 120

Abbreviations:

GRA.L. - Granular layer  
INF.L. - Lobi inferiores  
INF.V. - Cavity in the lobi inferiores  
MID.L. - Middle layer  
SUP.L. - Superficial layer  
T.SEM. - Torus semicircularis  
VOL. - Volvula cerebelli
Fig. 22 - *Xenentodon* adult: L.S. of cerebellum showing different layers (Pal-Weigert stain). x 60

Fig. 23 - *Xenentodon* adult: H.S. of cerebellum showing molecular layer and the purkinje cells sending out numerous processes into the inner plexiform layer. x 120 (Golgi's stain)

Abbreviations:

- GRAN.L. - Granular layer
- MOL.L. - Molecular layer
- PLEX.L. - Plexiform layer (inner side)
- PUR.C. - Purkinje cells
The nervous system of fishes and the related sense organs have been of much interest to the workers due to the variety of feeding habits and their various aquatic adaptations. Apart from the surface anatomy the internal detailed structure has been worked out mainly by Ariens Kappers (1906, '11, '12). In India works of Karandiker and Thakur (1951), Marathe (1937, '55), Sinha (1964), Mookerji and others (1950), Bhimachar (1935, '37, '45), Maheswari (1955) and Saksena (1965) are noteworthy.

The brain of *Xenentodon* is an elongated structure showing various regions. It is securely placed inside the cranium. It is covered by an epithelial covering membrane which is highly vascular. This covering membrane forms the meninx primitive.
The brain of *Xenentodon* may be divided into following parts:

(i) Telencephalon

(ii) Diencephalon

(iii) Mesencephalon

(iv) Rhombencephalon:

(a) Metencephalon

(b) Myelencephalon

(i) **Telencephalon**

The telencephalon includes the olfactory lobes and the cerebrum. The olfactory lobes (OLF.L. Figs. 1 A and 2) are placed just in front of the cerebrum. The two olfactory lobes are swollen rounded structures. The olfactory nerves (OLF.T. Fig. 3 B) from the olfactory epithelium end into them. The main mass of each olfactory lobe is formed of nerve fibres and large-sized mitral cells (MIT.C. Figs. 7 and 8). There are no olfactory peduncles in *Xenentodon*, but they are reported in Cyprinidae and Siluridae (Mookerjee and others, 1950).

The cerebrum (CER. Figs. 2, 3 B and 9) is of average size. It is divided into three lobes namely the axial or frontal (AX.L. Fig. 9), the parietal (PAR.L. Figs. 1 A and 9) and the occipital (OC.L. Figs. 1 A and 3 B). A median longitudinal groove on the dorsal side separates the above lobes of the two sides. The frontal lobe (AX.L. Fig. 9) lies just laterally to the mid-dorsal groove. The frontal lobe also known as the axial lobe, is demarcated from the parietal lobe by a frontal fissure (FR.FIS. Fig. 9)
laterally. An occipital fissure separates it posteriorly from the occipital lobe. The occipital lobe (OC.L. Figs. 1 A and 3 B) is a small rounded or swollen structure just behind the frontal lobe. A rhinal fissure (RHI.FIS. Fig. 9) lies in between the frontal and the olfactory lobes. The frontal and occipital fissures are situated on the dorsal side of the telencephalon while the rhinal fissure is situated on the ventral side.

The cerebral hemispheres (CER. Figs. 2, 3 B and 9) are characterized by the presence of a single median and narrow ventricle (LAT.V. Fig. 2). It represents the two lateral ventricles found in other fishes. This ventricle is narrow due to the thickening of the pallium (dorsal part), lateral walls and the base of the telencephalon. The ventricle is lined by the ependymal cells.

The walls of the cerebrum are not differentiated into strata. The radiating (RAD.NF. Fig. 11) nerve fibres with scattered neurons are found in it. At places the cells are concentrated peripherally which appear to form a sort of granular layer (GR.L. Fig. 11).

(11) Diencephalon

Its limits are demarcated by the velum transversum (V.T. Fig. 10) in front and by the posterior commissure (POST.COMM. Fig. 13) behind. Very little portion of the diencephalon is visible on the dorsal side. Though small in size, it has a number of important structures. The cavity of the diencephalon is known as the third ventricle (III V. Fig. 14). The ventral limit between
the diencephalon and telencephalon is shown by the recessus preopticus (REC.PR.OPT. Figs. 2 and 15). The position of the recessus is indicated by the large-sized nucleus preopticus (N.PR.OPT. Fig. 15) which lies just above it.

Herrick (1892) divides the vertebrate diencephalon into four regions, which can also be recognised in Xenentodon as follows:

(a) **Epithalamus**: The epithalamus is formed by two large oval bodies on either side of the median line known as the habenular ganglia (HAB.G. Figs. 10 and 16).

(b) **Ventral thalamus**: This part of the diencephalon is represented by the region near about the nucleus rotundus (N.ROT. Figs. 17 and 18).

(c) **Dorsal thalamus**: It is poorly developed in Xenentodon. It forms the main centre of the optic fibres of the higher vertebrates but in teleosts it is insignificant.

(d) **Hypothalamus**: The floor of the third ventricle is designated by the term hypothalamus. In Xenentodon it is well developed. The special structures seen in the hypothalamic region are the infundibulum (INF. Figs. 1 B,
2 and 14), the hypophysis (HYP. Figs 1 B, 2, 3 B, 14 and 16), the lobi inferiores (INF.L. Figs. 2, 3 B, 18 and 19). The lobi inferiores are thick-walled evaginations from the bottom of the third ventricle. They run backwards from the diencephalon. The two lobi inferiores are placed close together. There is no median saccus vasculosus. It is present in Notopterus notopterus (Mookerjee and others, 1950). It is reported absent in many teleosts e.g. Ophiocephalus aschius, O. merulius, Anabastestudineus, etc. (Mookerjee and others, 1950)

Dammerman (1910) considers the saccus vasculosus as related to the aquatic life of the fishes living at great depths. Xenentodon lives only in the lighted region of the waters and thus absence of the saccus vasculosus appears to confirm the views of Dammerman.

Infundibulum appears as a recessus of the third ventricle (INF.V. Figs. 2 and 19). Externally it appears as a large ovoid body. The cavity of the infundibulum is continued into the hypophysis. In front of the hypophysis is the optic chiasms (OP.N. Figs. 1 A, 1 B, 2, 3 B, 8 and 15) where the optic nerves of two sides decussate.

Hypophysis or pituitary body (HYP. Figs. 1 B, 2, 3 B, 14 and 16) is described in detail along with the endocrine organs.
Parietal region of Diencephalon:

The parietal region is limited in front by the velum transversum and behind by the posterior commissure. The velum transversum (V.T. Fig. 10) is a fold hanging from the roof of the third ventricle. The velum transversum is mainly made up of ependymal epithelium and connective tissue. It is absent in Siluridae (Cordier, 1939). The roof of the diencephalon near about the velum transversum is membranous. In Xenentodon it shows only minor folds and some vascularisation. The anterior choroid plexus is thus poorly developed. The velum transversum and the roof of the diencephalon are transformed into a real choroid plexus in Gobiidae, Blenidae and Cestrostomus, etc. (Cordier, 1939).

The special structures found on the roof of the diencephalon are:

(a) Paraphysis: It is an outgrowth of the roof in front of the velum transversum. It is present in Belone (Friedrich-Freksa & Studnicka, 1932). However, it could not be ascertained in the adult of the Xenentodon. A small evagination is seen in front of the velum transversum but it may well be one of the many minor folds seen in this region (PAR. Fig. 10).

Behind the velum transversum is seen the well developed pineal body (PIN. Figs. 2, 9, 10, 14 and 16). The parapineal is absent.
(b) The *pineal body* (PIN. Figs. 2, 9, 10, 14 and 16) is an elongated, folded glandular structure lying on the dorsal side of the diencephalon. It is made up of ependymal cells placed on a basement or limiting membrane. Some of the ependymal cells are modified into the neurosensory cells. The neurosensory cells (NSC. Fig. 12) are elongated and show tail-like processes on both ends. The inner process forms a sort of sensory hair while the outer processes are continued into the pineal nerve. The remaining ependymal cells function as supporting cells. Large-sized cells near the limiting membrane are the ganglion cells (GANG.C. Fig. 12). An important feature in the pineal body of *Xenentodon* is the presence of numerous pigment granules in the pineal cells. The lumen of the pineal body is filled with rounded cells which appear to have been derived from the general ventricular (ependymal) epithelium.

(iii) *Mesencephalon*

In the mesencephalon the main structure is the tectum opticum (optic lobes). The tectum opticum (TEC.OPT. Figs. 16, 18, 19, 20 and 21) is divided into two by a median longitudinal groove into two symmetrical halves known as corpora bigemini or the optic lobes. The optic lobes (OPT.L. Figs. 1 A, 2 and 3 B) in *Xenentodon* are of large size and thick walled. On either side of the median line, on the ventricular surface are two ridge-like structures which form the tori longitudinales (T.LONG. Fig. 18).

Further, the cavity of the tectum opticum, specially in the
posterior half is filled with two outgrowths. Each one is known as the torus semicircularis (T.SEM., Fig. 17). The ventral part of the mesencephalon is known as the tegmentum. The main feature of the tegmentum is the formation of the posterior commissure in its anterior part. The fibres of the posterior commissure actually arise from the cells in the tegmentum and from thence, they run upwards forming a transverse structure known as posterior commissure (POST.COM., Fig. 13). It is the anterior limit of the mesencephalon. The optic tectum is the main structure of the brain in *Xenentodon* where the fibres of the optic nerves end.

The tectum opticum is formed of three main layers. The superficial layer (SUP.L. Figs. 16, 18, 19, 20 and 21) contains a number of neurons. These neurons (NEU. Fig. 21) send out axons towards the inner side, which pass through the fibres of the optic tract (middle layer) and reach up to the granular layer. The middle layer (MID.L. Figs. 16 and 20) which follows the superficial layer is mainly a mass of nerve fibres with some scattered neurons. The fibres come from the retina of the eye. The innermost layer is the granular (GRA.L. Figs. 16, 18 and 20) one containing the rounded cells.

(iv) Rhombencephalon

It is divided into metencephalon (cerebellum) and the myelencephalon (medulla oblongata).

The cerebellum (CBL. Figs. 1 A, 2 and 3 B) is roughly
triangular in shape from the dorsal side. Its antero-lateral corners form the acoustic tubercles (ACOU.TUB. Fig. 1 A).

The wall of the cerebellum is made up of an outer plexiform layer or molecular layer (MOL.L. Figs. 22 and 23). This layer shows a network of intermingled fibres. Just below the plexiform layer are found a number of cell bodies. By the Golgi (1903) method these cell bodies are found to be actually the Purkinje cells (PUR.C. Fig. 23). The purkinje cells send out numerous processes into the plexiform layer (PLEX.L. Fig. 22) and go up to the outer limit. The innermost layer of cerebellum consists of rounded cells forming the granular layer (GRAN.L. Fig. 22).

In Siluridae, the cerebellum is directed rostrally, above the tectum opticum while in other teleosts, it is inclined backwards.

The cerebellum throws out an anterior extension which penetrates into the cavity of the mesencephalon just below the tectum opticum. This structure is known as the valvula cerebelli (VOL. Figs. 2 and 20). The valvula cerebelli are bifurcated anteriorly. The bifurcated portion is folded upon itself. In Mormyridae (Cordier, 1938), its development is described as simply monstrous. The cavity of fourth ventricle extends into the cerebellum (META. Fig. 2).

Behind and below the cerebellum lies the medulla oblongata. It is the enlarged portion of the spinal cord. The cavity inside is known as the fourth ventricle. Its roof is quite thin and is made up of ependymal epithelium and the menengial tissue. This
thin membranous roof gives out a number of papillae which hang into the ventricle. These papillae are highly vascularised and form the posterior choroid plexus.

Cranial Nerves

There are 10 pairs of cranial nerves in Xenentodon as follows:

(1) Nervus olfactorius (I. Fig. 4)

From the olfactory lobes arise the first cranial nerves, which run dorsal to the superior oblique muscle and then enter the nasal sac through the orbitonasal canal in the lateral ethmoid bone before they divide into several branches which spread over the olfactory epithelium.

(11) Nervus opticus (II. Figs. 3 A and 4)

They arise from behind the hypophysis in the diencephalon area of brain. The right optic nerve passes over the left one to form the optic chiasma. Each optic nerve reaches the orbit through the foramen formed by alisphenoid, parasphenoid and the interorbital septum. It moves obliquely forwards between the m. superior rectus and m. anterior rectus and internally to m. posterior rectus and then ends over the retina.
(iii) **Nervus oculomotorius** (III. Fig. 3 A)

It originates from the ventral side of the mesencephalon. It moves forwards into the orbit along with the trigemino-facial complex. It adheres to the trochlear nerve for a short distance and then passes outside the cranium. It then divides into a superior and an inferior branch. The superior branch moves forwards to supply the m. superior rectus.

The inferior division divides into an inner and an outer branch. The inner branch gives out a ramus which passes between the muscle superior rectus and muscle inferior rectus to innervate the muscle anterior rectus. The inner branch then finally ends into the muscle inferior rectus. The outer branch comes downwards, runs below the muscle anterior rectus and then supplies the muscle inferior oblique.

(iv) **Nervus trochlearis** (IV. Fig. 3 A)

It arises on the dorso-lateral aspect of the brain between the optic lobe and cerebellum and unites immediately with the underlying n. oculomotorius for a short distance. It then comes out of the cranium along with the n. opticus. It runs above all the eye muscles and innervates the superior oblique muscle.

(v) **Nervus trigeminus (V.)**

It originates from the side of the medulla oblongata above the posterior extremity of the lobi inferiores. The trigemino-facial complex, which is formed by the fusion of the trigeminal
and facial nerves, comes out through the foramen formed by the parasphenoid and aliisphenoid bones. The branches belonging to the n. trigeminus are as follows:

(a) Remus supraorbitalis (V.1 Fig. 4): It runs forwards above the eye ball, crosses over the olfactory nerve and passes between the frontal and the lateral ethmoid bones. Soon after its exit from the cranium, it innervates the superior two-thirds of the m. adductor mandibulae by a number of very fine branches. It then enters into a canal in the premaxillary bone. After running about half the length of the premaxillary bone, it divides into two branches: Remus ophthalmicus superficialis trigeminus (V.1.1 Fig. 4) and Remus ophthalmicus superficialis facialis (V.1+VII.1 Fig. 4). They innervate the lateral line canal in this region.

The supraorbital trunk before its above division has a short connection with the n. buccalis.

(b) Remus maxillaris (V.2 Fig. 4): It passes through the maxillary and then enters into a canal specially meant for it in the premaxillary bone. It anastomoses with the n. buccalis and soon divides into a superior and an inferior branch. Both the superior and the inferior branches run straight forwards up to the tip of the upper jaw, giving out small rami throughout their course.

(c) Remus mandibularis (V.3 Fig. 4): It runs inside the
articular, before it finally separates from the main thick maxillo-mandibular trigeminal trunk. After giving a branch to the m. quadrate mandibularis, it enters the dentary bone. It divides into two branches: Ramus mandibularis externus (V.3.1 Fig. 4) and Ramus mandibularis internus (V.3.2 Fig. 4). These two branches run a parallel course inside the lower jaw. The m. mandibularis externus supplies the dorsal and lateral sides of the lower jaw while the ramus mandibularis internus innervates the m. intermandibularis and the ventral part of the lower jaw and then anastomoses with the ramus mandibularis facialis of the hyomandibular trunk.

(vi) Nervus abducens (VI. Fig. 3 A):

It originates from the ventral aspect of the medulla oblongata. It enters the orbit along with the trigemino-facial complex and innervates the muscle posterior rectus.

(vii) Nervus facialis (VII.)

It originates from the side of the medulla oblongata above the posterior extremity of the lobii inferiores. The trigemino-facial complex, which is formed by the fusion of the trigeminal and facial nerves, comes out through the foramen formed by the parabasaloid and alisphenoid bones. The branches belonging to the n. facialis are as follows:
(a) *Ramus ophthalmicus superficialis facialis* (V.1+VII.1 Fig. 4): As already described with n. trigeminus.

(b) *Ramus buccalis* (VII.2 Fig. 4): Soon after its origin the ramus buccalis takes a downward course and then runs below the eye ball. At about half the distance between its origin and the eye ball it has a connection with the maxillo-mandibular trunk. After reaching the inner side of the lachrymal bone, where it supplies the infraorbital canal, it runs by the side of the ramus ophthalmicus superficialis facialis. The muscle adductor hyomandibulae and neighbouring muscles are innervated by a small branch arising from the trigemino-facial complex just in front of the ramus buccalis.

(c) *Ramus palatinus* (VII.2): There are two palatine branches of the seventh cranial nerve on each side: *Ramus palatinus anterius* (VII.2.1 Fig. 4) and *Ramus palatinus posterius* (VII.2.2 Fig. 4). The ramus palatinus anterius comes out from the under side of the trigemino-facial complex. It then takes a forward course along the roof of the buccal cavity, finally to terminate below the premaxilla. The ramus palatinus posterius on the other hand, arises from the anterior border of the hyomandibular trunk and comes out of the cranium between the prootic and pleurosphenoid bones. It gives out a small branch to the pseudobranch and then joins with the ramus palatinus anterius.
(d) **Ramus hyomandibularis** (VII.4): The hyomandibularis trunk arises from the trigemino-facial complex on the side of the medulla oblongata and passes through the prootic bone to reach the anterior margin of the hyomandibular bone. It then gives out the following four branches: **Ramus opercularis** (VII.4.1 Fig. 4), **Ramus preopercularis** (VII.4.2 Fig. 4), **Ramus hyoideus** (VII.4.3 Fig. 4) and **Ramus mandibularis facialis** (VII.4.4 Fig. 4).

The ramus opercularis (VII.4.1 Fig. 4) arises on the posterior side of the hyomandibular trunk to innervate the various muscles controlling the movement of operculum, viz. Dilator operculi and Levator operculi muscles.

The ramus preopercularis (VII.4.2 Fig. 4) is a thin branch given out from the hyomandibular trunk a little distance after the origin of the opercular branch. It also supplies the opercular area.

The ramus hyoideus (VII.4.3 Fig. 4) takes a downward course on the lower side of the preopercular and the interopercular bones soon after its origin. It innervates the m. hyohyoideus present on the branchiostegal rays.

The ramus mandibularis facialis (VII.4.4 Fig. 4) is actually a downward extension of the main hyomandibular
trunk. It runs inside the articular and dentary after passing obliquely over the hyomandibular and quadrate bones. It forms a small anastomosis with the ramus mandibularis externus (V.3.1 Fig. 4) and ramus mandibularis internus (V.3.2 Fig. 4). It innervates the mandibular lateral line canal.

(e) *Ramus lateralis accessorius* (VII.5 Figs. 4 and 5): A thick ramus lateralis accessorius arises from the dorsal surface of the trigemino-facial complex. It moves towards the posterior side below the frontal and the parietal bones and escapes out of the skull through an aperture in the supra-occipital bone. It passes between the epiploic and the lateral muscles.

(viii) *Nervus acusticus* (VIII. Fig. 4)

This sensory nerve arises from the side of the medulla oblongata behind the nervus facialis (VII). It soon divides into two branches. The dorsal branch further divides into three to supply the anterior semicircular canal and its ampulla, recessus utriculi and the posterior semicircular canal and its ampulla. The ventral branch supplies the sacculus, horizontal semicircular canal and its ampulla (VIII. See Receptor Organs, Figs. 9 A and 9 B)

(ix) *Nervus glossopharyngeus* (IX. Fig. 4)

It originates from the ventro-lateral side of the medulla
behind the eighth nerve and comes out of the cranium through a foramen in the ex-occipital bone. It is divided into two main branches which arch over the first gill slit forming the pre- and post-trematic branches. The pre-trematic branch, however, runs a little further anteriorly by a short ramus to innervate the neighbour area.

\(x\) **Nervus vagi** (X. Fig. 4)

It also originates from the ventro-lateral aspect of the medulla immediately behind the origin of ninth nerve by two roots. It primarily divides into two main branches:

The anterior branch further subdivides forming the branchial nerves which innervate the 2nd, 3rd and the 4th gills. The branchial nerve for each gill has a ganglionic mass from which the pre-trematic (PT.BR. 1, Figs. 4 and 6) and post-trematic branches (PT.T.BR. 1, Fig. 4) arise and run on either side of the gill slits to innervate the gill muscles and the gill filaments. The last branchial nerve corresponding to the 4th gill slit extends further into the body innervating the region behind the 4th gill arch (X. 4 Fig. 4), heart (CARD.N. Fig. 5) and pericardium, pharynx, oesophagus (GAS.N. Fig. 5) and stomach-intestine (GAS.INT.N. Fig. 5) as also the air bladder (PNE.N. Fig. 5). This is the visceralis branch (X. 1 Fig. 5) of the nervus vagi.

The posterior branch - nervus lateralis vagi (X. 2 Fig. 5)
and 6) runs in the mid-lateral region of the body just below the lateral line.

**Spinal Nerves**

The number of spinal nerves corresponds to the number of vertebrae (sixty). They arise from the spinal cord in pairs. Each comes out through the spinal foramen located in front of the neural arch of the vertebra. From the spinal cord each spinal nerve arises by a dorsal and a ventral root. The dorsal root carries a ganglion (dorsal ganglion) outside the spinal cord. The dorsal and ventral roots unite to form the spinal nerve. Each spinal nerve after emerging out of the vertebra divides only into two branches, the ramus dorsalis and the ramus ventralis. The ramus dorsalis is very fine. It runs forwards and unites with the ramus lateralis accessorius dorsalis (VII.5 Figs. 4 and 5) while the ramus ventralis which is comparatively thicker supplies the lateral trunk muscles and the skin. It is also connected with the sympathetic cord by a thin ramus communicans (RAM.COMM. Fig. 6). The first spinal nerve (SP.N. 1, Fig. 6), however, comes out through a foramen in the ex-occipital bone and divides into two branches. The second and third spinal nerves (SP.N. 2 and 3, Fig. 6) run towards the pectoral fin and unite with the branches of first spinal nerve, thus forming the brachial plexus (BR.PL. Fig. 6). The nerves from the brachial plexus innervate the muscles of the pectoral fin.
The sciatic plexus (SC.PL. Fig. 6) is formed by the union of the 24th and 25th spinal nerves. The nerves from the sciatic plexus innervate the muscles of the pelvic fin.

Sympathetic Nervous System

Sympathetic system in this fish is in the form of a pair of sympathetic cords lying below the vertebral column and on either side of the dorsal aorta. For convenience, this cord is divided into three parts:

(i) **Cephalic part** (CEPH.SYM.C. Fig. 6): It lies below the head and branchial region. It is connected with the hyomandibular trunk (VII.4) near the origin of palatinus nerve.

(ii) **Trunk part** (TR.SYM.C. Fig. 6): The next portion of the cord upto the anterior end of the anal fin may be said to form the middle portion of the sympathetic system.

(iii) **Caudal part** (CALD.SYM.C. Fig. 6): It is the remaining part of the cord upto the caudal end of the fish. The sympathetic cord becomes very thin in this region.

All these three parts of the sympathetic cord consist of a series of ganglia connected by the intervening fibres. Sympathetic cord has connections with the spinal nerves by the rami communicantes. Rami communicantes are regularly present in the
trunk and the caudal region. In many of teleosts, like *Megalops*, *Lophius* and *Orthacoriscus*, occipital or occipito-spinal nerves (Furbringer, 1897) are absent. In *Xenentodon* only one occipito-spinal nerve is present in front of the brachial plexus, which, however, has the typical structure of the spinal nerve with dorsal and ventral roots.