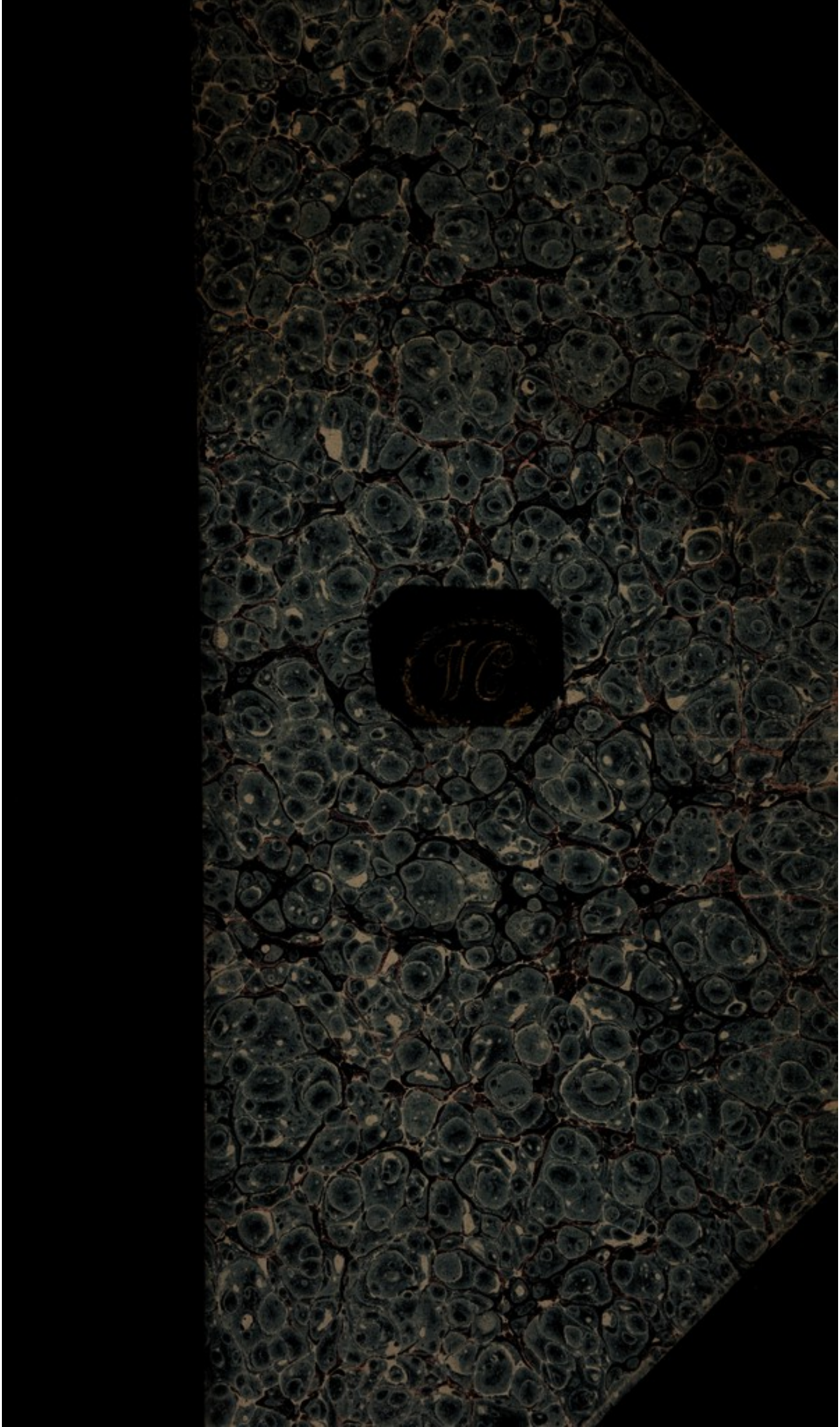
The structure and physiology of fishes explained and compared with those of man and other animals / [Alexander Monro].



THE

STRUCTURE AND PHYSIOLOGY

OF

FISHES

EXPLAINED,

AND

COMPARED

WITH THOSE OF

MAN AND OTHER ANIMALS.

ILLUSTRATED WITH FIGURES.

By ALEXANDER MONRO, M.D.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS,
AND OF THE ROYAL SOCIETY,
AND
PROFESSOR OF PHYSIC, ANATOMY, AND SURGERY, IN THE UNIVERSITY
OF
EDINBURGH.

EDINBURGH:
Printed for CHARLES ELLIOT, EDINBURGH;
And G. G. J. and J. ROBINSON, LONDON.

M,DCC,LXXXV.

TO THE RIGHT HONOURABLE

JAMES HUNTER-BLAIR OF DUNSKEY, ESQ.

LORD PROVOST OF THE CITY OF EDINBURGH;

THIS WORK IS INSCRIBED,

AS A MARK OF THAT RESPECT

THE AUTHOR THINKS DUE TO HIM,

ON ACCOUNT OF THE

LIBERAL AND IMPARTIAL SPIRIT

WITH WHICH HE HAS PLANNED,

AND IS NOW EXECUTING,

VARIOUS SCHEMES,

NOT LESS USEFUL THAN ORNAMENTAL

TO THE

CAPITAL OF HIS COUNTRY.

THE CONTENTS.

EXPLA-

EXPLANATION OF THE TABLES.

TABLE I.

Page.

The Figures of this Table repreſent the extent of the ſurface of the gills, the heart, the branchial arteries and veins, and aorta of a Skate, filled with injection, - - - - - 73

TABLE II.

In this Table the thoracic and abdominal viſcera, with the circulating veins of a female Skate, are repreſented, - - 76

TABLE III.

This Table ſhows fully the arteries and circulating veins of the chylopoietic viſcera of a Skate, with a ſlight ſketch of the lacteals, all filled with injection, - - - - 78

TABLE III*.

This Table repreſents the muſcular coat of the meſenteric vein of an Ox, 79

TABLE IV.

In this Table the lungs, the heart, and large veſſels of a Sea Tortoiſe or Turtle are delineated, - - - ib.

TABLE V.

This Table repreſents a large lymphatic veſſel ſituated on the ſide of the Cod Fiſh; and likewiſe the principal ducts which pour out mucus on the ſurface of the body, - - - 80

TABLE VI.

This Table repreſents chiefly the mucous ducts on the fore part of a Skate, 81

TABLE VII.

The Figures in this Table repreſent the ducts which pour out mucus on the back part of the Skate; and likewiſe the meatus auditorii externi, ib.

TABLE VIII.

This Table ſhows two ſmall canals at the ſides of the anus in the Sturgeon, which lead into the cavity of the abdomen; and two other paſſages, by which the cavity of the abdomen communicates, in that fiſh, with the pelves of the kidneys, - - - 83

TABLE

TABLE

Page.

TABLE XVI.

TABLE XVII.

TABLE XVIII.

TABLE XIX.

TABLE XX.

TABLE XXI.

TABLE XXII.

TABLE XXIII.

TABLE XXIV.

TABLE XXV.

Page.

TABLE XXVI.

TABLE XXVII.

TABLE XXVIII.

TABLE XXIX.

TABLE XXX.

TABLE XXXI. XXXII. and XXXIII.

TABLE XXXIV.

TABLE XXXV.

TABLE XXXVI.

TABLE XXXVII.

TABLE XXXVIII.

TABLE XXXIX.

TABLE

Page.

TABLE XL.

TABLE XL*.

TABLE XLI. and XLII.

TABLE XLIII. and XLIV.

The

The Linnean Names of the Fishes and other Animals described in this Work.

See *Caroli à Linne Systema Naturæ, editio* 13.

The Porpess. Lin. G. 40. *Delphinus:* Sp. 1. *Phocæna.*
The Turtle. G. 119. *Testudo:* Sp. 3. *Mydas.*
The Frog. G. 120. *Rana:* Sp. 14. *Temporaria.*
The Skate. G. 130. *Raja:* Sp. 2. *Batis:* Sp. 5. *Fullonica.*
The Angel or Monk Fish. G. 131. *Squalus:* Sp. 4. *Squatina.*
The Sturgeon. G. 134. *Acipenser:* Sp. 1. *Sturio.*
Conger Eel or Sea Eel. G. 143. *Muræna:* Sp. 6. *Conger.*
Sea Wolf or Sea Cat. G. 146. *Anarhichas:* Sp. 1. *Lupus.*
The Cod. G. 154. *Gadus:* Sp. 3. *Morhua.*
The Haddock. G. 154. *Gadus:* Sp. 1. *Æglefinus.*
The Mackrel. G. 170. *Scomber:* Sp. 3. *Thynnus.*
The Salmon. G. 178. *Salmo:* Sp. 1. *Salar.*
The Herring. G. 188. *Clupea:* Sp. 1. *Harengus.*
The Carp. G. 189. *Cyprinus:* Sp. 1. *Carpio:* Sp. 4. *Tinca.*
The Cuttle Fish or Sepia. G. 296. *Sepia:* Sp. 4. *Loligo.*
The Sea Egg or Echinus Marinus. G. 299. *Echinus:* Sp. 1. *Esculentus.*

THE STRUCTURE AND PHYSIOLOGY OF FISHES EXPLAINED, AND COMPARED WITH THOSE OF MAN.

INTRODUCTION.

A VARIETY of curious circumſtances has occurred to me in examining the ſtructure of fiſhes, ſome of which have been entirely overlooked, and others imperfectly deſcribed by authors. As they relate to points of chief importance in the animal œconomy, I flatter myſelf that an account of them will be not leſs acceptable to the Phyſician than to the Naturaliſt.

By the generic term of Fiſhes, I underſtand that claſs of animals which lives in water, ſwims by the aſſiſtance of fins, and has the water directly applied to the gills, through which organ the whole maſs of blood in the body paſſes in the courſe of circulation.

This definition comprehends the *Nantes Pinnati*, as well as the *Piſces* of *Linnæus*; ſince it will afterwards appear that theſe ought not to be farther ſeparated than as different *orders* of *one* claſs of animals.

The *Raja* ſhall be my chief example of the *Nantes Pinnati*, and the *Gadus* of the *Piſces* of *Linnæus*: but I ſhall occaſionally endeavour to throw farther light on the ſubject, by deſcribing parts of other fiſhes; and, to be better underſtood, I ſhall illuſtrate my deſcriptions with Figures repreſenting the parts of their natural ſize.

I ſhall begin with tracing the blood from their heart, and its return to that organ.

I ſhall next make ſome curſory obſervations on their organs of ſecretion.

I ſhall afterward give an account of their abſorbent ſyſtem; and

Shall conclude with ſome obſervations on their Brain, Nerves, and the Organs of their Senſes (*a*).

CHAPTER I.

A Deſcription of the HEART, VESSELS, and CIRCULATION of the BLOOD, in FISHES.

IN all the fiſhes I have diſſected there is but one heart, conſiſting of one auricle and one ventricle; and, from the latter, one artery is ſent out, which is entirely ſpent on the gills. From the gills, therefore, the returning blood paſſes to all the other parts of the body, without the intervention of a ſecond heart, as in man (*b*).

So far is generally known: but the whole courſe of the blood has not been traced with ſufficient accuracy; ſo that ſeveral curious and intereſting circumſtances have eſcaped notice.

I ſhall therefore give a particular deſcription of the circulating veſſels of the ſkate, with which I have found the *Piſces* of *Linnæus* agree in every material circumſtance; and I ſhall begin with the branchial artery.

SECT. I.

AT the beginning of the branchial artery there are three ſemilunar valves (*c*), the middle parts of which, analogous to the Corpuſcula Morgagni, are much thicker than in man, and illuſtrate the uſe of theſe organs in him, as they very evidently aſſiſt in preventing the return of the blood when the artery is in action. Between theſe valves and the principal cavity of the ventricle in the ſkate, there is a cylindrical canal interpoſed (*d*), the coats of which have the ſame muſcular texture as the ventricle itſelf; and their contraction co-operating with that of the ventricle, we are thence led, more evidently than in man, to perceive the analogy between the ſtructure of the arteries and that of the heart.

The coronary arteries of the heart do not take their riſe from the branchial artery, which, like the pulmonary in man, is ſpent entirely on their lungs or gills, by five pairs of great branches in the ſkate, and by four in the Piſces of Linnæus (*e*).

When

(*a*) To be more readily underſtood, I ſhall generally apply the terms *fore*, *back*, *upper*, *under*, *inner*, *outer*, in the ſame manner as is done in ſpeaking of the human body; or, I ſhall ſuppoſe the fiſh to be placed erect with its head uppermoſt. But in deſcribing the ear and other parts of the head itſelf, I ſhall ſuppoſe the fiſh in its natural ſituation, as the brain and organs of the ſenſes have not the ſame direction as in man, with reſpect to the trunk of the body.

(*b*) If lungs, as well as gills, are found in the Petromyzon and Diodon of Linnæus, it is probable there may be two ventricles in their heart.

In the Sepia, which has been generally conſidered as a fiſh, but which is with more propriety reckoned a worm by Linnæus, I have, many years ago, diſcovered three hearts; of which, and of other curious particulars in the ſtructure of this animal, the reader will find an account ſubjoined to this Work.

(*c*) See Tab. II. 40. (*d*) Tab. I. Fig. 4. (*e*) Tab. I. Fig. 4. and Tab. XXVI. Fig. 1.

When we take a ſuperficial view of the ſmall bulk of the gills; when we reflect, that an organ for reſtoring momentum to the blood, ſimilar to the left ventricle of our heart, is wanting in fiſhes; and when, further, we conſider the extraordinary ſize of the red particles of their blood; we might be tempted, at firſt ſight, to ſuppoſe that their branchial artery did not divide into very minute branches, or that it reſembled the *rete mirabile* of the carotid artery of the herbivorous quadruped. But a nearer view will undeceive us. For I have found, that, by the elegant ſubdiviſions and folds of the membrane of the gills, their ſurface, in a large ſkate, is nearly equal to the whole external ſurface of the human body.

Thus in each ſide of the body of a ſkate there are four double gills, or gills with two ſides each, and one ſingle gill; or there are in all eighteen ſides or ſurfaces on which the branchial artery is ſpread out. On each of theſe ſides there are about 50 diviſions, or doublings of the membrane of the gills (*f*). Each diviſion has on each ſide of it 160 ſubdiviſions, doublings, or folds of its membrane; the length of each of which in a very large ſkate is about one-eighth of an inch, and its breadth about one-ſixteenth of an inch (*g*). So that in the whole gills there are 144,000 ſubdiviſions or folds, the two ſides of each of which are equal to the 64th part of a ſquare inch, or the ſurface of the whole gills in a large ſkate is equal to 2,250 ſquare inches, that is, to more than 15 ſquare feet, which have been ſuppoſed equal to the whole external ſurface of the human body. When, after a good injection of the artery, a microſcope is applied, the whole extent of the membrane of the gills is ſeen covered with a beautiful net-work of exceedingly minute veſſels.

As fiſhes taint the water they reſpire, in nearly the ſame manner as we taint the air we breathe: it appears that ſome matter, either uſeleſs or hurtful, or both, is carried off from their blood as it paſſes through their gills.

When diſtilled oil of turpentine, coloured with vermilion, is injected with moderate force into the branchial artery of a living or recently dead ſkate, ſome of the colourleſs part of the oil exſudes upon the ſurface of the gills. But that theſe are the only paſſages by which the hurtful matter eſcapes, ſeems very doubtful; as, from Dr Prieſtley's experiments, it appears that the colour of the craſſamentum of the blood can be changed by the atmoſphere, though the craſſamentum be incloſed in an ox's bladder and covered with ſerum.

SECT. II.

We ſhall next trace the blood from the gills till it returns to the heart.

In the uppermoſt gill (*b*), which is ſingle, there is but one conſiderable vein.

In each of the four double gills there are two principal veins, an upper and under, joined together by a large tranſverſe canal.

The

(*f*) See Tab. I. Fig. 1. 2. (*g*) Tab. I. Fig. 3. (*b*) See Tab. I. Fig. 5. A B C, &c. to W.

The blood iſſues from both ends of all theſe veins, but chiefly at the poſterior part, between the throat and upper part of the ſpine.

From the trunks of the branchial veins the blood paſſes directly to all the other parts of the fiſh, by veſſels analogous to the branches of our aorta, and which we therefore call Arteries; and the gills and liver are the only organs which are not ſupplied by them ſolely.

SECT. III.

In the ſkate the branchial veins join together, and then diſperſe branches in the following order (*i*).

The vein A of the uppermoſt gill, which is ſingle, is joined, by the canal C, to the uppermoſt vein of the ſecond gill; and then, running inwards and upwards, forms an artery B, which ſupplies the parts of the upper jaw, the eye, the noſe, the ear, and gives ſmall branches to the fore-part of the brain.

From the uppermoſt vein D E of the ſecond gill, other ſmall arteries F F are ſent off to the jaws. After that, a vein K is added, compoſed of the under vein H of the ſecond gill and upper one I of the third. A little below the joining of all theſe veins, a retrograde artery L, analogous to our vertebral, is ſent off to the brain, cerebellum, and top of the ſpinal marrow, the branches of which have large and numerous communications with each other, and with the correſponding artery of the other ſide; and from them, chiefly, the encephalon is ſupplied. Then the trunk M, from which this artery came off, meets at N, with its fellow M, from the other ſide; and, about a finger-breadth lower, there is added, on each ſide, a vein R, formed by the under vein P of the third gill and upper vein Q of the fourth.

About a quarter of an inch below the meeting of all the above at T, is ſent off from each ſide, at nearly right angles, a very large artery U, analogous in ſome meaſure to our ſubclavian. A large branch, *a*, from the root of that artery, ſupplies ſome parts of the lower jaw; then running towards the fore-part of the gills, it anaſtomoſes freely with the exterior ends of all the branchial veins (*k*), after which it ſends branches Q Q Q to the gills themſelves, which ſeem to me analogous to our bronchial arteries; eſpecially as from the ſame part the heart receives its coronary arteries (*l*). The reſt of the great artery, which I have called like to our ſubclavian, ſupplies the numerous and large muſcles and fins on the ſide of the fiſh, as far down as the fins near to the anus.

At laſt, to the trunk T before-mentioned, is added a large vein X, on each ſide, which conveys the blood from the under vein S of the fourth gill, and both veins V W of the fifth gill (*m*); and we are led by it to a great veſſel Y, which now aſſumes plainly the office of an artery, reſembling our aorta deſcendens.

From the fore-part of this trunk two large branches *c d*, analogous to our cæliac and meſenteric arteries, are ſent off to the chylopoietic viſcera; a ſmall branch from which enters the liver, reſembling our hepatic artery (*n*).

From

(*i*) Tab. I. Fig. 5.
(*k*) Vide Tab. I. Fig. 5. *a*, et Fig. 4. P R R R R.
(*l*) Tab. I. Fig. 4. S S.
(*m*) Tab. I. Fig. 5.
(*n*) See alſo Tab. III. R S T U V W.

From the ſides of the aorta the organs of generation and urine are ſupplied by ſmall arteries *eeee*, &c. and from the lower part of the trunk are ſent off two lateral branches *ff*, that may be compared to our iliac arteries, and which ſupply the muſcles and fins at the lower part of the body.

A middle artery *g* runs ſtraight down into the tail, covered and protected by cartilage, and terminates the aortic ſyſtem.

From the remarkable courſe of the arteries of the heart, and of the bronchial and hepatic arteries, ſimilar to that in man, we ſee clear proof, that the blood, which, after paſſing through the gills, has undergone one circulation, or rather here has paſſed through one artery and one vein, is unfit for ſome office or offices which are performed by the blood in the heart, gills, and liver.

Nutrition only has been mentioned by authors: but no fully ſatisfying reaſon has as yet been given, why by one circulation the blood ſhould become unfit for this purpoſe; and particularly, why the gills or the lungs cannot be nouriſhed, though the whole maſs paſſes through them.

SECT. IV.

From the extremities of theſe ſeveral arteries, the blood is returned to the heart, by veins which in general reſemble our vena portarum (*o*) and venæ cavæ (*p*).

When we examine theſe veins more accurately, we find two venæ cavæ, a right and left one, equal in ſize and ſimilar in ſituation, communicating freely by their trunks in the abdomen, and in other places, as in the head, by their branches. In both, the branches are much larger in their courſe than at their terminations; and they, beſides, form conſiderable receptacles of blood. For inſtance, each of the abdominal cavæ has double the diameter of the cavæ conjoined at the heart; and, under the place at which the two cavæ communicate, there is a large receptacle of blood covered by the ovarium in the female, and by the teſtes in the male (*q*). In like manner, the hepatic veins between the liver and diaphragm form ſinuſes, the diameter of which is ten times greater than that of their openings into the cavæ (*r*).

Upon the whole, they join in the following manner. The veins from the tail, joining with the iliac veins, form the bottom of the two venæ cavæ, Tab. II. 24. Then the veins from the organs of urine and generation are added, 24, 25. At 26 the two abdominal cavæ, which are contiguous, communicate freely with each other. At 27, above the diaphragm, and behind cartilages which reſemble our clavicles, the abdominal cavæ join with the veins which reſemble the branches of our ſuperior cava. At 28, 29, 30, veins from the muſcles of the back and lateral parts form a trunk reſembling our right ſubclavian vein; to which the internal jugular 33, and external jugular 34, are ſoon added. A little farther in, the right vena cava hepatica 31, terminates; and this, at 32, is joined to the left vena cava hepatica. The communicating canal alſo receives the blood from a middle

 lobe

(*o*) See Tab. III. XX, Y, ZZ, *aa*, *bb*, *c*, *d*, *e*, *f*. (*p*) Tab. II. (*q*) Tab. IX. V. (*r*) See Tab. II. 31.

lobe of the liver; that organ being divided into three lobes. The two cavæ, 35, at laſt meet; and, after receiving the coronary veins, 37, of the heart, diſcharge themſelves through a round hole with riſing edges, into the back-part of the auricle of the heart.

Within the external jugular veins, and at the termination of the internal jugulars, I obſerve a pair of valves like to thoſe in the veins of the human ſubject: At the termination of the renal veins and large branches of the hepatic veins, we find ſingle membranes fixed by threads from their edges, reſembling the valve of the coronary vein of our heart; and at the termination of the other large veins, eſpecially near the heart, we not only find the orifices contracted, but doublings at their edges, which have ſo far the effect of valves, even in the dead body, that we cannot fill completely all the veins by throwing an injection in at one of their branches; and, between the auricle and ventricle, valves are interpoſed, which perform their office with great accuracy.

SECT. V.

AFTER tracing the blood in its courſe, I compared with each other the coats of the different veſſels through which it paſſes.

When the large branches of the branchial arteries and veins, or the branches of the aorta formed by the latter, were placed contiguous, they were found to agree very nearly in thickneſs, elaſticity, and texture; nor could I perceive that the ſmall branches of the branchial veins differed from the ſmall branches of the arteries, or that any particular place could be pointed out, at which they might be ſuppoſed to ceaſe from performing the office of veins and to begin to do that of arteries. But the coats of their branchial veins, or of the branches of their aorta, ſeem to differ as much from the coats of the veins which compoſe their vena portarum or venæ cavæ, as the coats of our aorta differ from thoſe of our venæ cavæ.

CHAPTER II.

Obſervations on the CIRCULATION of the BLOOD in FISHES.

FROM reviewing the circulating ſyſtem, and reflecting on the colour of the parts of fiſhes, the following concluſions ariſe.

1. As we obſerve that the red particles of the blood are excluded from many parts, as, in white fiſhes, from moſt of their muſcular fibres, which we know have in us numerous circulating arteries diſperſed upon them, it is evident that in them there

there are numberleſs colourleſs arteries; or we find here ſtill clearer proof of the exiſtence of ſuch arteries, than ariſes from the inſpection of the human body.

2. When we next conſider, that from the circulating arteries of their muſcles, liquors muſt be ſecreted into the interſtices of the fibres, in order to prevent their concretion, and to allow of their ready play upon each other, we ſee proof that ſecerning branches may be ſent off from colourleſs arteries; and that it is not neceſſary, on account of the want of impulſe *à tergo* in colourleſs arteries, that ſecreting veſſels ſhould come directly from thoſe that convey red blood, as Dr Haller ſuppoſed (*s*).

3. When to this we add an obſervation I have repeatedly made on the blood of animals, to which I had given madder mixed with their food, to wit, that in their ſerum, which was deeply coloured, I could not, with the beſt microſcopes, perceive the colouring particles, and yet that the colour was excluded from their cornea and from their cartilages, we are led to perceive that the exiſtence of deſcending ſeries of arteries has without juſt reaſon been called in queſtion by Dr Haller and others (*t*).

4. As there are few red parts in white fiſhes, and yet their venæ cavæ, at their heart, bear nearly the ſame proportion to their aorta or branchial artery as in man, we muſt conclude, that their colourleſs, as well as their red arteries, terminate in their cavæ.

Hence, by analogy, it may be allowable to infer, that our colourleſs arteries do not end in our valvular lymphatic veins, but in our cavæ; or that our cavæ correſpond with all the arteries which ſerve for circulating the blood.

5. From the diviſion of the branchial arteries into exceedingly minute branches, we ſhould ſuppoſe, that the force of the ſtroke of the heart upon the blood muſt be very much broken and loſt before the blood gets into the branchial veins; and, in fact, I ſaw no pulſation in the branches of the aorta of a living ſkate. Hence, in the firſt place, we may infer, that the branchial veins are not made thick and tough, merely to enable them to reſiſt the *vis à tergo*.

6. As ſo much ſtrength and elaſticity in the branchial veins are not neceſſary for merely reſiſting the force of the blood, or that more ſtrength and elaſticity than we obſerve in our pulmonary veins were not neceſſary for receiving or for merely conducting the blood to the other parts of the body, we muſt ſuppoſe that theſe thick, tough, and elaſtic coats, are of a living and muſcular nature, and that the progreſſion of the blood through the reſt of the body of the fiſh depends much on their activity.

7. We ſhall ſtill more readily admit that the muſcular power of the veſſels, and particularly of the arteries, is neceſſary for the progreſſion of the blood, when, proceeding a ſtep farther, we obſerve a third circle completed in their liver; though, from the ſituation of their gills, and the membranous nature of their diaphragm, the motion of the blood in their liver is not aſſiſted by their reſpiration, nor does there ſeem to be any other vicarious external impulſe fitted to forward it.

8. Apply-

(*s*) See Haller Prim. Lin. Phyſiolog. § xlv. (*t*) Ibid. & Elem. Phyſ. tom. i. p. 117, &c.

8. Applying to man what we have obſerved of the veſſels and circulation in fiſhes, we in the firſt place receive ſtrong confirmation of an opinion I have always taught, That our arteries are of a muſcular nature; and that their activity is eſſential in circulation, ſecretion, and other important offices.

In the next place we will conclude, that the alternate preſſure of our diaphragm and abdominal muſcles in reſpiration is not, as ſome have ſuppoſed, the principal cauſe of the motion of the blood through the liver; but that the motion of the blood and ſecretion of the bile depend chiefly on the muſcular ſtructure and action of the branches of the vena portarum. Nay, in the large branches of the meſenteric veins and vena portarum of an ox, I can by diſſection demonſtrate a truly muſcular coat, conſiſting of two diſtinct layers. In the external layer the fibres are longitudinal, in the internal they are tranſverſe or circular (*u*).

That reſpiration and other external impulſes aſſiſt, is highly probable, as the diſeaſes of the chylopoetic viſcera are moſt frequent in ſedentary perſons.

9. In their abdominal venæ cavæ, and alſo between their venæ cavæ hepaticæ and venæ cavæ, there are large receptacles of blood, and the abdominal trunks of the cavæ and ſeveral of their branches are larger than their terminations.

In the Seal I have diſcovered a ſimilar dilatation where the venæ cavæ hepaticæ terminate. As in fiſhes the preſſure of the water upon the gills muſt be very much more than the preſſure of the air upon the lungs of land animals, ſuch receptacles were perhaps neceſſary when they deſcend to a great depth; juſt as in the Seal they are wanted when the reſpiration of the air is interrupted by his diving.

There ſeems, however, to be reaſon for ſuſpecting, that ſome other more latent purpoſes are accompliſhed by this ſtructure. This appears from the analogy of the lacteal and lymphatic ſyſtems; in which we ſhall find afterwards there are ſtill larger receptacles.

10. The laſt remark I ſhall make is, That, the circulation of the blood being carried on in the cartilaginous fiſhes in the ſame manner as in the oſſeous or Piſces of Linnæus, and the whole maſs of blood paſſing through their gills, they *muſt* breathe regularly and uninterruptedly to furniſh blood to the brain and other organs, or they *cannot* poſſeſs the pulmo arbitrarius as is ſuppoſed by Linnæus: So that there appears no juſt reaſon for claſſing them with the Amphibia.

In the animals which are commonly reckoned amphibious, to wit the tortoiſe, the frog, the lizard, and the ſerpent, a part only of the maſs of blood paſſes through the lungs. In the frog and common ſmall lizard (*x*), branches are ſent off from the aorta; which, if we may judge from their ſize, convey about one third part of the whole maſs. In the tortoiſe, the ſerpent, and ſuch of the lizard tribe as have two auricles and ventricles, a greater proportion paſſes through the lungs. In the ſea tortoiſe, the heart and large veſſels of which are delineated in Table IV. the blood from the lungs paſſes into the left auricle, and from it into the left ventricle. From the left ventricle it is tranſmitted, by tranſverſe

(*u*) See Tab. III.

(*x*) Linnæus, Syſt. Nat. G. 122. Sp. 42. and 47.

tranſverſe canals or holes in the ſeptum between the ventricles, into the right ventricle, where it is mixed with the blood which is ſent from the venæ cavæ through the right auricle. All the arteries therefore take their riſe from the right ventricle; and the pulmonary arteries are conſiderably ſmaller than thoſe which ſupply the place of our aorta (*y*).

In all theſe animals, therefore, every part of the body may receive a conſiderable portion of blood, although the reſpiration and free paſſage of the blood through their lungs be interrupted. Hence they are not under the ſame neceſſity with the mammalia, birds, and fiſhes, of breathing frequently, regularly, or alternately; or they enjoy the *pulmo arbitrarius*.

CHAPTER III.

Of the GLANDULAR ORGANS and SECRETED LIQUORS in FISHES.

WE ſhall next conſider ſome remarkable circumſtances relating to the glandular organs and ſecreted liquors in fiſhes.

SECT. I.

Of Liquors ſecreted on the external Surface of Fiſhes.

THE ſurface of fiſhes, eſpecially of ſuch as live in the ſea, is defended by a quantity of viſcid ſlime; a great part of which, as has been long known, is poured out in the oſſeous fiſhes by the branches of two ducts which are placed upon their ſides. Theſe ducts, I have obſerved, are continued upon the head and upper jaw; and others of a ſimilar ſtructure are added upon the under jaw (*z*).

In the ſkate, numerous orifices, placed pretty regularly over the ſurface, have been obſerved by Steno to diſcharge this ſlimy matter. With reſpect to theſe laſt, I have remarked ſome memorable circumſtances. Firſt, I have diſcovered one very elegant ſerpentine canal between the ſkin and muſcles, at the ſides of the five apertures into the gills (*a*). Farther forwards it ſurrounds the noſtrils; then it paſſes from the under to the upper part of the upper jaw, where it runs backwards as far as the eyes. From the principal part of this duct, in the under ſide or belly of the fiſh, there are not above ſix or eight outlets; but from the

(*y*) See Tab. IV. and the Explanation of it.

(*z*) See Tab. V. 9. 10. &c. to 20.

(*a*) See Tab. VI. and VII. ABCDEFGHIKLMN.

upper part near the eyes there are upwards of thirty ſmall ducts ſent off, which open upon the ſurface of the ſkin. The liquor diſcharged from theſe has nearly the ſame degree of viſcidity as the ſynovia in man.

But beſides the very pictureſque duct I have been deſcribing, I have remarked, on each ſide of the fiſh, a little farther forwards than the foremoſt of the five breathing holes, a central part (*b*), from which a prodigious number of ducts iſſues, to terminate on almoſt the whole ſurface of the ſkin, excepting only the ſnout or upper jaw. At theſe centres all the ducts are ſhut; and in their courſe they have no communication with each other (*c*). In theſe two central parts, or on the beginning of the mucous ducts, a pair of nerves (*d*), nearly as large as the optic, terminate; and, which is a curious circumſtance with reſpect to them, they are white and opake in their courſe between the brain and theſe ducts; but when they divide, they become ſuddenly ſo pellucid, that it is impoſſible to trace them farther, or to diſtinguiſh them from the coats of the ducts.

The mucus of theſe ducts is ſo extremely viſcid, that it is difficult to ſqueeze it out.

When we review the preceding deſcription, we obſerve,

1*ſt*, Not only a very elegant ſtructure for the preparation of the mucus; but,

2*dly*, Such a ſudden change of the colour of a nerve, that we are tempted to infer, that its continuation is not merely an expanſion of the matter of the brain, but that the texture of the nerve is altered in its courſe.

3*dly*, We ſee clear proof, that ſome, at leaſt, of the organs of ſecretion, are ſo far from being remarkable for the ſmallneſs of their nerves, that an uncommon ſhare of nervous energy ſeems neceſſary for them, to enable their veſſels to ſeparate and change the liquors they ſecrete.

SECT. II.

Of the Liquors ſecreted into the Cavities of the Cranium, Pericardium, and Abdomen.

IT has been long known, that in the greater number of fiſhes a watery liquor is found in conſiderable quantity within the head, between the dura and pia mater: but the nature of that liquor has not been ſufficiently attended to, nor are its uſes in the oſſeous fiſhes fully underſtood.

The cavities of the pericardium and peritoneum in all fiſhes have been ſuppoſed by authors to be ſhut ſacs.

But in the ſkate and ſturgeon I have obſerved ſome circumſtances, both with reſpect to theſe cavities and the liquors they contain, that well merit attention.

1. In

(*b*) See Tab. VI. and VII. 9. 9. (*c*) Tab. VI. and VII. 10. 11. 12. 13. 14. 15. (*d*) Tab. VII. 16. 17.

1. In the firſt place, the liquor within the head (*e*) is of a ſaltiſh taſte; and not leſs than one ſixty-fifth part of its weight is owing to ſea-ſalt diſſolved in it; or it contains nearly one half of the proportional quantity of ſalt diſſolved in our ſea-water.

2. Within the cavity of the abdomen or peritoneum of a ſkate, a great quantity of a ſimilar liquor is to be found, but containing ſomewhat leſs of the ſalt, or about one ſeventy-eighth part (*f*).

3. The great quantity and evidently ſalt taſte of the liquor of the abdomen, which I remarked before I examined the liquor within the head, led me to look for paſſages by which I ſuſpected the ſea-water might get into the abdomen; and I ſoon found two holes or paſſages, one at each ſide of the anus, through which a gooſe-quill may be paſſed (*g*). One thing, however, ſtruck me, that within each of theſe paſſages, there is a ſemilunar membrane or valve, ſo placed as to allow liquors to get out from the abdomen readily, but to reſiſt ſomewhat their entrance into it (*h*).

4. Further, I diſcovered, that in the ſkate the bottom of the pericardium is lengthened into the ſhape of a funnel, which divides into two branches, which are tied cloſely to the lower part of the œſophagus, and open into the cavity of the abdomen (*i*). From the obliquity of theſe branches, and their intimate adheſion to the œſophagus, neither air nor water can be forced into them from the abdomen: Hence, unleſs we ſuppoſe that in the living animal they take up the fluid from the abdomen, in the way our puncta lachrymalia take up the tears, which is highly improbable, we muſt conclude that they ſerve to convey the liquor of the pericardium into the cavity of the abdomen.

5. In the Sturgeon, I have likewiſe found two holes or paſſages at the ſides of the anus ſimilar to thoſe of the ſkate (*k*): but, further, I have in this fiſh obſerved a large funnel on each ſide of the abdomen, which at its bottom opens into the middle of the pelvis of the correſponding kidney (*l*).

When we review the foregoing obſervations, we are led to ſuppoſe,

1. That the liquor of the pericardium of the ſkate paſſes, through the funnel and ducts deſcribed, into the cavity of the abdomen.

2. We can have little or no doubt that the liquor in the abdomen of the ſturgeon paſſes into the pelvis of the kidney; for we cannot ſuppoſe that the urine paſſes through the holes deſcribed into the cavity of the abdomen, as the pelves have large openings into the common cloaca, as in other fiſhes.

3. In like manner, conſidering the funnel ſhape of the lower parts of the abdomen, and of the paſſages at the ſides of the anus of the ſkate, and diſpoſition of

(*e*) See in Tab. XXXIV. the ſize of the cavity of the cranium.

(*f*) The quantity of ſea-ſalt contained in theſe liquors was, at my requeſt, examined by my learned and accurate friend Dr Rutherford. One fiſh only was examined.

(*g*) Tab. XVIII. 29. 30. and Tab. XIX. 26.
(*h*) Tab. XVIII. 30.
(*i*) Tab. II. 21. 22. 22. 23. 23. 23. and Tab. XVIII. 10. 11. 12.
(*k*) Tab. VIII. fig. 1. Q. R. S. and Fig. 2. Q. R.
(*l*) Tab. VIII. fig. 1. N. O. P.

of the valvular membranes, we can ſcarcely doubt that the liquor of the abdomen is diſcharged through theſe paſſages.

4. From the quantity of liquor found within the abdomen both of the ſkate and of the ſturgeon, and its ſalt taſte, we ſeem naturally led to ſuppoſe, that a great part of that liquor is taken in from the ſea by the holes at the ſides of the anus; and that the valvular membranes of theſe holes are intended to prevent ſolid bodies from getting in. Nay, we would conclude, with ſtill greater probability, that in the ſturgeon the holes at the ſides of the anus were formed to admit the water, and thoſe that open into the pelves of the kidneys ſerved to diſcharge it again.

5. But to the above concluſions, I apprehend we ought to add, that a conſiderable portion of the liquor we find in the abdomen is ſecreted from the arteries, as it contains much leſs ſalt than the ſea-water. Nay, perhaps we are not to ſuppoſe that all its ſalt enters by theſe holes at the ſides of the anus, ſince we have found a ſimilar degree of ſaltneſs in the liquor between the cranium and brain; which, as no paſſages are known to lead directly from the ſea into the cavity of the cranium, we muſt conclude is ſecreted from the arteries.

Afterwards when I come to treat of the lymphatic ſyſtem of fiſhes, I ſhall endeavour to point out the paſſages by which the ſalt-water may readily enter the hydraulic ſyſtem of thoſe fiſhes.

SECT. III.

Of Liquors ſecreted into the Organs of Digeſtion.

AS theſe animals are cold, it is more evident than in man, that the gaſtric liquor acts as a menſtruum upon their food.

In all of them the liver is large, and of courſe the ſecretion of bile copious (*m*); and in all, organs are found which pour out liquors ſimilar, probably, in their effects to thoſe of our pancreatic liquor. In the ſkate, the pancreas is ſimilar to the human (*n*). In all the oſſeous fiſhes, ſo far as I recollect, inſtead of a pancreas, a number of inteſtinula cæca pour out their contents into the duodenum. In the ſturgeon, an organ is found in its internal ſtructure ſimilar to theſe inteſtinula; but in its outward form reſembling the pancreas of the ſkate; and, which is curious, the whole of it is incloſed in a muſcle, evidently intended to expreſs its contents (*o*).

Some facts alſo relating to the liver ſeem to merit attention.

In notes I wrote many years ago, I find the obſervation, That in the cat fiſh about a dozen hepatic ducts diſcharge bile into the gall-bladder (*p*). In the eel and ſalmon, ſome of the hepatic ducts open into the gall-bladder (*q*), and others join with the cyſtic duct. In the cod, where the gall-bladder is at a diſtance from

(*m*) See Tab. IX. K. L. M. N. and Tab. X.
(*n*) Tab. IX. O. P. Tab. XIX. 20.
(*o*) Tab. IX. *.
(*p*) See Tab. X. *.
(*q*) Tab. XXVIII. G. H. I.

from the liver, a number of hepatic ducts open into the cyſtic duct (*r*). To theſe I would add an obſervation I have many years ago made in the common domeſtic cock, that the trunk of the hepatic and cyſtic ducts have no communication with each other in their courſe, and open ſeparately into the duodenum; but that there are large hepato-cyſtic ducts.

I obſerve, that in all thoſe animals the gall-bladder receives directly or indirectly ducts from the liver. Hence we are led to the inference, that the cyſtic bile is not ſecreted from the coats of the gall-bladder, as the late Albinus and ſome other eminent authors have ſuppoſed, but that it is derived from the liver.

An attention to the effects of cyſtic calculi in their deſcent through the cyſtic duct, ſerves to confirm this concluſion. For although it is perhaps merely poſſible, that when the gall-bladder contains a great quantity of bile, a calculus deſcending from it, and ſticking in the cyſtic duct, may occaſion a fit of jaundice; yet I have ſeveral times found them impacted in the cyſtic duct of a dead body without any jaundice having appeared before death: And in many other caſes, I have obſerved jaundice appear after the patient had been for ſeveral days or weeks racked with pain; owing, I apprehend, unqueſtionably to the ſtones having irritated the cyſtic duct before they got down to the common duct.

Whereas if the gall-bladder ſecreted the bile it contains, every obſtruction of the cyſtic duct ſhould create jaundice.

Nay, in a few caſes where ſtones very completely obſtructed the cyſtic duct, very little bile was found in the gall-bladder.

Laſtly, after tying the cyſtic duct of a living pig, I did not find jaundice produced; nor did the gall-bladder, after ſeveral days had elapſed, appear to be more diſtended than at the time of the experiment: yet jaundice appeared ſoon after taking up the hepatic duct with a ligature, and the duct itſelf was obſerved to be greatly dilated.

SECT. IV.

Of the Secretions of the Male Organs of Generation.

THE ſtructure of the milt in the oſſeous fiſhes appears to be very ſimple: but in ſome of the cartilaginous fiſhes, as the ſkate, the apparatus ſeems ſtill more complex than in man; for we obſerve, in place of the teſticle, a ſubſtance compoſed partly of white matter like the milt, and partly of ſmall ſpherical bodies. From theſe an epidydimis is produced, chiefly compoſed of convoluted tubes, which terminate in a ſerpentine vas deferens; the under part of which is greatly dilated, and forms, as in birds, a conſiderable receptacle or veſicula ſeminalis. (*s*).

(*r*) See Tab. X. E. E. G. G. H.

(*s*) Tab. XI. I. K. L. M. N. O. P. Q. R. S.

Contiguous to the outer ſide of the dilated end of the vas deferens, I have found a bag of conſiderable ſize filled with a green liquor, which is diſcharged into the ſame funnel with the ſemen, and probably at the ſame time with it (*t*). As there is no proſtate gland, it is probable that this ſac ſupplies the place of it.

Certain anatomiſts, I have been told, contend, that the organs we commonly call *veſiculæ ſeminales* are not receptacles of the liquor ſecreted by the teſtes, but organs capable of ſecreting from their inner ſurface a prolific liquor, which is mixed with that from the teſtes. To ſuch, the deſcription I have given of a veſicula containing a green liquor very different from the liquor of the teſtes, which is white, will probably appear a full confirmation of their new doctrine.

Yet I apprehend, that the moſt common theory, which ſuppoſes that the veſiculæ are to be conſidered as being ſolely or chiefly receptacles of the ſemen, is well founded.

This new doctrine is, I am told, founded on two obſervations.

Firſt, on examining the liquor of the veſiculæ ſeminales of a man immediately after death, it was found very different in its appearance from the ſemen when it is diſcharged by a living perſon.

Secondly, that, a conſiderable time after caſtration, geldings and oxen had been found capable of generating.

But I would obſerve here, that although the liquor of the veſiculæ ſeminales is indeed very different in colour from the ſemen as it appears when diſcharged in the uſual manner, becauſe it is then mixed with the viſcid and white liquor of the proſtate gland; yet I find it agrees with the liquor in the vaſa deferentia as nearly as the cyſtic bile does with the hepatic.

In the next place, we certainly know, that, in ſome perſons, diſcharges of the ſemen happen very ſeldom. That the ſemen may remain in the veſiculæ ſeminales of a caſtrated animal a much longer ſpace of time, is extremely probable. How long that ſpace may be, it will be very difficult to determine.

But ſuppoſing it were poſſible to prove, that, at the time of caſtration, there was not a drop of ſemen in the veſiculæ ſeminales, and yet that afterwards the animal was capable of generating, it would not follow from this, that the veſiculæ were not the receptacles of the liquor ſecreted in the teſticle. The utmoſt amount of our concluſion would be, that the veſiculæ ſeminales, or terminations of the ſeminal ducts, were capable of ſecreting the ſame liquor as the beginnings of thoſe ducts in the teſticles. Inſtances of caſtrated animals generating are, however, ſo very rare, as to render it improbable that the veſiculæ poſſeſs ſuch a power.

When we throw into the ſcale the few following facts, the common opinion will be found to receive great additional ſtrength.

I have already obſerved the reſemblance between the liquor in the end of the vas deferens and in the veſicula ſeminalis; we may remark a ſimilar correſpondence in the coats of theſe two parts, and in the cells which theſe form. When we

(*t*) See Tab. XII. E. FF. GG. H. I.

we pour a liquor into the vas deferens, it enters the veſicula ſtill more readily than a liquor poured into the hepatic duct does the gall-bladder.

In birds and in the ſkate, the dilated end of the vas deferens ſerves evidently the purpoſe of a veſicula ſeminalis.

In the dog, the veſiculæ ſeminales are altogether wanting: yet the ſtructure of their teſtis agrees with that of other animals of the ſame claſs, or with that of birds; and no other difference is obſervable, except that the ſtructure of the penis is ſuch as renders the copulation tedious.

Upon the whole, it appears that the veſiculæ are receptacles of the liquor ſecreted by the teſticles, calculated to inſpiſſate the ſemen, and thereby render it fitter for its purpoſe, and at the ſame time to prevent copulation from being tedious.

SECT. V.

Of Secretion in the Female Organs of Generation, and of the Nutrition of the Fœtus.

IN the oſſeous fiſhes, the ſtructure of the roe appears to be ſimple, and the ova are ſmall.

In the ſkate, we find an ovarium, containing large yolks; two uterine tubes; an organ in each, from which chiefly the glaire of the egg ſeems to be ſecreted; two uteri, and, within theſe, eggs with horny ſhells (*u*).

The beginning of the uterine tubes is tied to the diaphragm, as in the frog: and hence it is probable that the yolks, before they reach the tubes, float looſe in the cavity of the abdomen, as happens in the frog (*x*); yet I have never found an egg of a ſkate in that ſituation.

The yolk is at laſt conveyed by a duct into the ſmall inteſtine of the fœtus, in the ſame manner as in birds and lizards (*y*).

SECT VI.

Of the ſwimming Bladder of Fiſhes.

WHETHER, in treating of the ſecretions of fiſhes, an account ought to be given of the ſwimming bladder, and the air it contains, is perhaps a fitter queſtion than at firſt ſight it may ſeem to moſt readers.

On this ſubject, I ſhall content myſelf with ſtating a few facts and queries, leaving the chief circumſtances to be determined by more extenſive examination and experiments than I have leiſure for at preſent.

It

(*u*) See Tab. II. 15. 16. 16. 17. 18. Tab. IX. Q. RR. S. Tab. XIII. EE. FF.

(*x*) Tab. XVII. O. P. Q. R. S. T.

(*y*) See Tab. XIV. O. P. and Tab. XIV *.

It has been long known, that in the flat fiſhes there is no ſwimming-bladder. In a few long-ſhaped fiſhes, as in the mackrel, I have alſo found it wanting.

It is likewiſe known, that in many fiſhes the air-bag communicates by a duct with the œſophagus.

On examining this matter, I have found in a ſturgeon a round hole, nearly one inch in diameter, in the upper and back part of the ſtomach, by which it communicates with a very large air-bag. The hole is ſurrounded by thin muſcular fibres, placed between the membranes of the ſtomach and air-bag, which decuſſate at oppoſite ſides of the hole; and, no doubt, have the effect of a ſphincter muſcle (*z*).

In the ſalmon, I have found a hole ſo large as to admit readily the largeſt-ſized gooſe-quill, leading directly through the coats of the œſophagus into the air-bag. The œſophagus in this fiſh has a very thick muſcular coat; but the fibres of that coat do not ſeem to form a diſtinct ſphincter around the hole (*a*).

In the pike, in different kinds of carp, in the perca arenarea, in the conger, ducts of conſiderable length lead from the œſophagus into the air-bag; and if, as in the carp, there are two air-bags, the duct leads to the poſterior bag, from which there is a paſſage into the anterior (*b*).

In the common herring, the under part of the ſtomach has the ſhape of a funnel; and from the bottom of this funnel a ſmall duct is produced, which runs between the two milts or the two roes to its termination in the middle of an oblong-ſhaped air-bag (*c*.) No valves are found in theſe air-bags.

When we carry our reſearches no farther, we very readily conclude, that the air found in the ſwimming-bladder has paſſed into it through the ducts I have been deſcribing. And theſe ſeem well ſuited for the purpoſe; for, as in the common horizontal ſituation of the fiſh their beginning is at the upper part of the ſtomach or œſophagus, we can conceive that the air which we ſee them take in at their mouth when they aſcend, or that the air which may, by ſome more latent proceſs, be diſengaged from the water, is applied to theſe ducts; and that the fiſh, by an inſtinct of nature, diſtinguiſhes the irritation of air from that of water, and propels the air into the air-bag, but excludes the water. We certainly diſtinguiſh air from water contained in our inteſtinum rectum.

But I muſt next obſerve, that in the cod and haddock, although the air-bag is very large, and its ſides remarkably ſtrong, I have not been able to diſcover any communication of it with the mouth, œſophagus, ſtomach, or inteſtines. No intermediate duct is diſcoverable by diſſection. The air-bag is not enlarged by blowing into the alimentary canal; nor can we empty the air-bag without burſting it. Further, a red-coloured organ, the ſurface of which is very extenſive, as it is compoſed of a vaſt number of leaves or membranes doubled, is found on the inner ſide of the air-bag of the cod (*d*), haddock, &c.: but in thoſe fiſhes where the air-bag communicates with the alimentary canal, this red body

(*z*) See Tab. XV. fig. 1. 2. 3.

(*a*) Tab. XV. fig. 1. and Tab. XXIX. F.

(*b*) See Tab. XV. fig. 2. Tab. XV*.

(*c*) Tab. XV. fig. 3.

(*d*) Tab. XV. fig. 4. 5.

body is either very ſmall and ſimple in its ſtructure, as in the conger eel; or entirely wanting, as in the ſturgeon, ſalmon, herring, carp.

Hence there is ſome reaſon to ſuppoſe, that the air may be ſecreted from this red body, ſomewhat in the way it ſeems to be ſecreted into the ſwimming-bladders of aquatic plants, or perhaps into the air-bag of the egg of a bird as the chick grows (*e*).

This, however, I ſhall leave as a mere hypotheſis, perſuaded that moſt readers will rather ſuppoſe that the cod, haddock, &c. have an air-duct, which has as yet eſcaped obſervation.

To ſuch, another queſtion will occur, to wit, What is the uſe of this red body? Does it, like the gills, receive ſomewhat uſeful, or diſcharge ſomewhat hurtful, to the animal? And are we to ſuppoſe that the air-bag not only ſerves to render the body of the fiſh ſpecifically lighter, but alſo that the air received into it is of benefit to the conſtitution, by adding ſomewhat uſeful, or by taking up ſomewhat hurtful?

CHAPTER IV.

A DESCRIPTION of the SYSTEM of LYMPHATIC ABSORBENT VESSELS in FISHES.

IN this chapter, I ſhall deſcribe the courſe and terminations of the lacteal and lymphatic veſſels; firſt, in the nantes pinnati, of which no account has been yet given; and then in the piſces of Linnæus. In a ſubſequent chapter, I ſhall propoſe ſuch obſervations and experiments as ſerve to throw farther light on the lymphatic ſyſtem and ſubject of abſorption in general.

SECT. I.

IN the ſkate, my chief example of the nantes pinnati, the tract of the alimentary canal is remarkably ſhort (*f*). When we open the ſmall inteſtine, we obſerve ſuch large and numerous valvulæ conniventes, that, on a calculation, the length and ſurface of the villous coat is found to be much greater than at firſt ſight we would ſuppoſe (*g*).

The principal lacteal veſſels are ſituated near the large branches of the cæliac and meſenteric arteries and veins; and the principal lymphatic veſſels of the

(*e*) The air-bag of an egg is over the top of the vagina of the hen; and the air it contains before incubation is taken in from the atmoſphere after the glaire is covered by a pellicle.

(*f*) See Tab. XVIII. and XIX. (*g*) Tab. IX. E E.

assistant chylopoietic viscera, to wit, the spleen, liver, and pancreas, attend the chief blood-vessels of these parts (*h*).

The lacteal vessels and lymphatics of the assistant chylopoietic viscera are much larger in proportion to the blood-vessels than in quadrupeds, birds, or even in the amphibia: their branches communicate with each other freely and repeatedly; and, instead of uniting into one or two trunks, they form a right and left plexus (*i*), which are continued undiminished in size till they are about to join with the lymphatic vessels of the rest of the body. Neither the lacteal nor the lymphatic vessels are quite cylindrical, but, by being contracted a little in many places, seem to be jointed (*k*): So that we should expect to find numerous valves in their course, yet these are entirely wanting except at the termination of the whole system.

A cellular reticular substance, with which the lacteals freely communicate, is found at the larger curvature of the stomach (*l*), but nowhere else in the system.

Pursuing the right and left plexuses formed by the lacteals and lymphatics of the chylopoietic organs, we are led upwards, along the sides and back part of the œsophagus, to the sides of the spine and outer sides of the inferior venæ cavæ, and near to large veins covered by strong cartilages which resemble our clavicles, and which therefore may be called Subclavian Veins (*m*). Towards these places all the lymphatic vessels of the body are directed; the lymphatics of the kidneys and organs of generation, with those of the tail and inferior parts, ascending; those of the flesh and side-fins or wings of the trunk of the body running inwards, and those of the superior parts and of the brain, organs of the senses, heart and gills, descending (*n*).

The branches of the lymphatic vessels form larger angles where they terminate in their trunks than are found in the circulating veins; and the smaller branches are connected by transverse canals (*o*).

The large lymphatics of the muscular organs, near their joining with the lacteals, are collected together in the most simple manner, or without forming such intricate plexuses as we have seen in the course and near to the termination of the lacteal vessels (*p*); particularly the lymph from the head and thorax is conveyed chiefly by a single trunk (*q*).

At last a single vessel on each side of the animal, and in which there is no dilatation or large receptacle of the chyle or lymph, receives all the chyle and lymph, and terminates in the subclavian vein, very near its joining with the internal jugular vein, or in the angle nearly which these two vessels form by their joining (*r*). The blood is prevented from getting into these two vessels by a pair of valves placed at the termination of each (*s*).

No

(*h*) See Tab. III. *g* &c. to *q*. Tab. XVIII. and XIX. A B C. &c. to Z.

(*i*) Compare Tab. XVIII. with Tab. XIX. I K L, &c.

(*k*) See Tab. XVIII. and XIX. D E F G H I K L.

(*l*) See Tab. XIX. C D. and Tab. XX. fig. 1. 2.

(*m*) Compare Tab. XVIII. X. and Tab. XIX. R. with Tab. II. 28. to 34.

(*n*) See Tab. XVIII. K L, &c. to X. and Tab. XIX. K L to S.

(*o*) Tab. XVIII. fig. 2.

(*p*) See Tab. XVIII, L. &c. to W.

(*q*) Tab. XVIII. R S T U V W.

(*r*) See Tab. XVIII. X. Tab. XIX. R. and Tab. II. 36.

(*s*) Tab. II. 36. and Tab. XVIII. X. and XIX. R.

No glands, like to our conglobate glands, are found in any part of the lymphatic ſyſtem of fiſhes.

SECT. II.

I ſhall next give a deſcription of the lymphatic ſyſtem of the piſces of Linnæus, taken chiefly from the gadus and ſalmo, but compared in ſome particular points with other kinds of fiſhes.

The chief branches of the lacteal veſſels of the great and ſmall inteſtines, and which are ſmaller in proportion to the blood-veſſels than in the nantes pinnati, run upwards in the meſentery, almoſt parrallel to each other, and near the meſenteric arteries (*t*). In their whole courſe they communicate by a vaſt number of ſmall tranſverſe canals (*u*). At the top of the abdomen near the gall-bladder, the lacteals of the ſtomach and lymphatics of the ſpleen, liver and inteſtinula cæca are added (*x*). The chyle, mixed with the lymph of the aſſiſtant chylopoietic viſcera, paſſes, upwards and towards the right ſide, into a large receptacle contiguous to the gall-bladder, and between it and the right ſide and back part of the lower end of the œſophagus (*y*). From the receptacle of the chyle large canals paſs upwards to right and left, receiving in this courſe the lymph from the organs of urine and generation. Thoſe on the left ſide are chiefly behind the œſophagus (*z*).

The chyle, mixed with the abdominal lymph, having aſcended above the bones which reſemble our clavicles, is poured into large cellular receptacles, ſituated chiefly between the clavicles and the undermoſt of the gills; and which alſo receive the lymph from all the other parts of the body (*a*).

Four lymphatic veſſels, which terminate in theſe receptacles, and which have their extremities contracted by a doubling of their internal membranes, chiefly merit attention. The firſt conveys the lymph from the middle of the belly, from the ventral and pectoral fins, and from the heart (*b*). The ſecond runs up the ſide of the fiſh parallel to the great mucous duct, and brings the lymph from the principal muſcles of the tail and body (*c*). The third is deep ſeated, and conveys the lymph from the ſpine, ſpinal marrow, and upper part of the head (*d*). The fourth lymphatic veſſel, or rather plexus of veſſels, brings the lymph from the brain and organs of the ſenſes, and from the mouth, jaws, and gills (*e*).

Theſe receptacles may therefore be called the common receptacles of the chyle and lymph. The right receptacle communicates freely with the left by large canals, which paſs chiefly behind the heart and œſophagus (*f*).

From

(*t*) See Tab. XXII. fig. 1. 16. 17. 18. 19. 20.

(*u*) Tab. XXII. fig. 2.

(*x*) See Tab. XXII. fig. 1. 21. 22. 23. 24. 25.

(*y*) Tab. XXII. fig. 1. 26. Tab. XXIV. W W. and Tab. XXIX. L.

(*z*) See Tab. XXII. and XXIX.

(*a*) Tab. XXII. fig. 27. &c. Tab. XXIV. X X. Y Y. Z. Tab. XXV. Fig. 1. and 2.

(*b*) See Tab. XXV. fig. 2. X. and Tab. XXIV. Y Y. Z. and Tab. XXVII. N.

(*c*) See Tab. XXIV. *a a b*, and Tab. 25. fig. 2. S. and Tab. XXVII. M.

(*d*) Tab. XXIV. *c*

(*e*) See Tab. XXIV. *d e f*, and Tab. XXVII. O.

(*f*) Tab. XXIV. *g h*

From each of theſe receptacles in the ſalmon, a canal runs downwards and inwards, and opens into the upper end of its correſponding vena cava inferior, contiguous to and on the fore and outer ſide of the internal jugular vein. The terminations of theſe canals are contracted, and their internal membranes are doubled, ſo as to ſerve the purpoſe of valves, in preventing the paſſage of the blood from the venæ cavæ into the receptacles (*g*). In the cod kind, the receptacles are proportionally larger than in the ſalmon; and, beſides tranſmitting the muſcles of the gills and their ſeveral nerves, contain the upper cornua of the air-bladder (*h*).

CHAPTER V.

EXPERIMENTS and OBSERVATIONS on the SYSTEM of LYMPHATIC ABSORBENT VESSELS of FISHES.

1. FROM the want of valves in the lymphatic ſyſtem of fiſhes, except at its termination in the red veins, we can inject coloured fluids from the large lymphatics into the ſmall; and hence trace the ſeveral parts of the ſyſtem much more eaſily and diſtinctly than in the mammalia or in birds. In the nantes pinnati, where, except in the reticular ſubſtances of the ſtomach, the lymph is contained in veſſels nearly of a cylindrical ſhape, and remarkably tough, we can trace the lymphatics with ſtill greater certainty than in the piſces of Linnæus: For in the latter, from the weakneſs of the ſides of the receptacles of the chyle and lymph, their great ſize, irregular ſhape, and numerous communications with each other, a rupture of them, with extravaſation and laceration of neighbouring red veins, happens frequently; and as the injected liquors get thereby into the red veins, we are apt to miſtake theſe for lymphatic veins.

I have therefore made my experiments chiefly on the nantes pinnati; and have found, beyond all doubt, that the diſtribution of the lymphatic ſyſtem is univerſal in them: particularly, by injecting the principal lymphatic from their head (*i*), I have diſcovered numberleſs lymphatics in their brain, eye, ear, noſe (*k*); in all which places the exiſtence of lymphatic veſſels has of late been called in queſtion by men of eminence.

2. I would next remind the reader of an obſervation I formerly made, That the red veins are, in proportion to their arteries, as large in fiſhes as in man or quadrupeds, and yet their blood contains few red particles; and from the veſſels of

(*g*) See Tab. XXVI. fig. 1. 2. 11. 11. Tab. XXVII. S. Tab. XXVIII. M. N. Tab. XXIX. P. Q.

(*h*) See Tab. XXII. fig. 1. 32. Tab. XXIV. O. P. (*i*) Tab. XVIII. R S T U V W. (*k*) Tab. XXI.

of their muſcles, and of many other parts, theſe particles are in a great meaſure excluded: from which I concluded, that their colourleſs, as well as their red arteries, terminate in their red veins.

3. In a great number of experiments, by injecting penetrating liquors into the arteries and lymphatic veins of fiſhes, I have found it impoſſible to make theſe liquors paſs from the arteries into the lymphatics, or from the lymphatics into the arteries, except where there was a laceration or rupture of theſe veſſels; yet I have repeatedly injected their red veins from their arteries.

Hence the lymphatic veins do not ſeem to be the continuation of the lymphatic arteries of fiſhes: or we are led to ſuppoſe that, as they do not aſſiſt directly in circulating the blood, they muſt be of uſe by abſorbing fluids from the ſurface, and from the different cavities of their bodies.

4. From a variety of obſervations and experiments, we can convince our reaſon, that the human valvular lymphatic veins are a ſyſtem of abſorbents; but in this claſs of animals, I have diſcovered that it is poſſible to give a deciſive ocular proof of the truth of that doctrine, by obſerving the effects of injecting fluids from the trunks into the ſmall branches of the lymphatic veins.

My firſt experiments were made upon the lacteal veſſels of the ſkate and of the cod. I found that water, and even air which is leſs penetrating, paſſed into the cavities of the ſtomach and inteſtines, but with difficulty; and as I could not, when puſhing my injection, ſee the villous coat of thoſe parts, I was by no means certain whether the injection was diſcharged from the natural mouths or beginnings of thoſe veſſels, or from the ſides of them burſt by the force with which the injection was puſhed. I therefore thought of making my experiments upon a lymphatic from the external ſurface of the body; and I judged that the great lymphatic from the head and fore part of the ſkate (*l*) would be the fitteſt for my purpoſe, as it is large and its coats are remarkably ſtrong.

I ſoon obſerved that my ſucceſs exceeded my moſt ſanguine expectation: For although I had no doubt that the lymphatic veins began by open mouths, yet I conceived that theſe muſt be ſo exceedingly minute, that no clear view could be got of them, and that the colourleſs part alone of the liquors injected would exſude. But inſtead of this, I found that not only water, but air, milk, quickſilver, and even oil of turpentine coloured with the powder of vermilion, were diſcharged upon the ſurface of the ſkin, by a vaſt number of diſtinct orifices, placed at regular diſtances from each other: yet the force with which theſe liquors were injected was very ſmall, and there was no extravaſation into the cellular ſubſtance any where under the ſkin, or in the interſtices of the muſcles. On the contrary, the preparations of the parts on which theſe experiments were made, give the moſt perfect and beautiful view imaginable of the vaſt number and extreme ſmallneſs of the branches of thoſe veſſels diſperſed upon the ſkin, muſcles, brain, eye, ear, &c. no where diſfigured by extravaſation (*m*). Nay,

(*l*) See Tab. XVIII. fig. 1. R S T U W. (*m*) Tab. XXI.

which is very curious, and the cauſe difficult to aſſign, the effuſion of theſe liquors upon the ſurface of the ſkin is made upon the upper or back part only of the fiſh, where the ſkin is remarkably tough and ſcabrous; whereas, on the ſuppoſition of a rupture, the effuſion ſhould have been chiefly or ſolely obſervable on the inferior part, where the ſkin is thin, ſmooth, and much more tender. From the ſmall force neceſſary to be uſed in thoſe injections, from the want of extravaſation in the cellular ſubſtance, and from the regular diſtribution of the orifices from which the liquor is diſcharged on the ſurface of the ſkin, no perſon uſed to ſuch experiments can entertain a doubt that theſe orifices are the natural beginnings of the lymphatic veins.

The only perplexing circumſtances that will occur to him are, how to account for their being ſeen on the upper part only of the fiſh, and for their being larger there than we would expect, when we conſider the moſt approved opinions about the extreme ſmallneſs of the mouths of abſorbent veſſels.

Theſe difficulties, I apprehend, may be much leſſened, if not removed entirely, by attending to the two following facts.

Firſt, within the echinus marinus eſculentus of Linnæus, a large quantity of ſalt-water is lodged between the inner ſide of the ſhell and outer ſide of the alimentary canal. On carefully examining the outer ſurface of the ſhell, I have diſcovered above two thouſand veſſels with orifices or mouths at their beginning, viſible to the naked eye, and ſurrounded with a hard ſubſtance, ſo that they greatly reſemble the human puncta lachrymalia. Theſe veſſels, after penetrating the ſhell, divide upon membranes into a plexus of branches; from the oppoſite ſide of which other ducts are ſent out, which terminate at the roots of the teeth (*n*).

There can be no doubt, therefore, that theſe veſſels with viſible orifices abſorb from the ſea the ſalt-water which is depoſited within the ſhell.

Secondly, I have found that the water which is contained in conſiderable quantity within the ſkull of the ſkate, between it and the ſurface of the brain, contains a large proportion of ſea-ſalt; for the abſorption of which the veſſels I have deſcribed in the ſkin ſeem to be appropriated.

Upon the whole, I apprehend it may be concluded, that to the many arguments which concur in ſhowing that the lymphatic veins are a ſyſtem of abſorbents, we may now add the demonſtration of ſome of the orifices by which they begin in fiſhes.

5. It may be worth while to remark, that from the deſcription given of the abſorbent veſſels of the echinus marinus, which belongs to the claſs of worms, we receive proof, that the abſorbent veſſels form a diſtinct ſyſtem in the worms as well as in the mammalia, birds, amphibia, and fiſhes. Hence, too, it is highly probable a ſimilar ſyſtem will be diſcovered in the claſs of inſects, or will be found to be univerſal in the animal kingdom.

6. As

(*n*) Of theſe abſorbents and of the other parts of this very curious animal, I gave a full account in a paper I read to the Philoſophical Society of Edinburgh in 1762, which I have annexed to this work.

6. As no valves are found at the beginning or in the progreſs of the lymphatic veſſels of fiſhes, or in the abſorbents of the echinus marinus, we find proof of three very eſſential particulars:

Firſt, That the progreſſive motion of the fluids, in their lymphatic veſſels from their ſmall to their large branches, does not depend on the external preſſure of the muſcles, &c.; for, without valves, this would drive the fluids as readily in the direction from their trunks as towards them.

Secondly, We are of courſe led to conclude, that the coats of the lymphatic veſſels, however thin they may ſeem, are truly muſcular.

Thirdly, Although theſe veſſels are in life conſtantly, or at leaſt generally, filled with fluids, and therefore equally ſtimulated in their whole extent; yet we muſt conceive that their action, contrary to what we obſerve of the arteries, muſt begin at their orifices, and proceed from the ſmall towards the large branches.

7. The obſervations I made in a former chapter on the venous receptacles of the red blood, may be applied to thoſe of the chyle and lymph. But, further, as lymphatic glands are wanting in this claſs, it may ſeem in ſome degree probable, that theſe receptacles aſſiſt in ſupplying their place by the preſſure and agitation to which the chyle and lymph are there expoſed; and that perhaps arterious fluids are ſecreted from their coats, and mixed with the lymph.

8. Our reaſon teaches us, that abſorbent veſſels muſt exiſt in every the moſt minute part of the body: But when we view a well-injected preparation of the lacteal or lymphatic veſſels of fiſhes, we are ſtruck not only with the number of their minute branches, but with the number of their anaſtomoſing canals; many of which enter the neighbouring lymphatics at right angles, inſtead of being directed towards the heart; by which means a net-work is produced, ſo very intricate, that, when we view a ſmall part of it only, it is difficult or impoſſible to aſcertain what has been the natural courſe of the lymph (*o*).

By the great number and unfavourable direction of theſe anaſtomoſing canals, the flow of the lymph muſt be greatly retarded, to ſerve purpoſes which it is difficult to aſcertain or even to conjecture.

From obſerving them, and conſidering their effect in retarding the flow of the lymph towards the heart, we ſee further proof, that general preſſure cannot be a chief cauſe of the progreſſive motion of the lymph, but that each veſſel muſt contribute to its progreſs by a well-regulated action.

9. Very numerous and large lymphatics are diſperſed upon the gills of the ſkate. To this, when we add that fiſhes ſoon die when put into water from which the air has been extracted, and yet that ſuch water is capable of waſhing off exhaled matter from the gills, and of taking up phlogiſton readily (*p*), we are led to the ſuppoſition, that the gills or lungs not only diſcharge hurtful matter,

(*o*) See Tab XVIII. fig. 2. Tab XXI. fig. 2. Tab. XXIII. fig. 2. and 4.

(*p*) See Cavallo on Air, p. 485.

ter, but ſerve alſo to take in from the air, which is mixed with the water, *ſomewhat* neceſſary for life; the preciſe nature of which, experiments do not yet enable us to ſpecify.

We may, however, obſerve, that the colour and quantity of the red particles of the blood, and the heat of animals, are connected with the mode of their reſpiration; and that it is as conceivable that the craſſamentum of blood immerſed in ſerum and incloſed in a bladder, or that blood circulating in the lungs of a living animal, may receive or attract ſubtile matter from the atmoſphere, as that it may diſcharge ſuch into it.

CHAPTER VI.

OBSERVATIONS on the LYMPHATICS of the SPLEEN in FISHES, and on the USES in general of that ORGAN.

THE late Mr Hewſon revived a very laudable attempt to aſcertain by experiments the ſtructure and uſes of the ſpleen. He has deſcribed certain minute cells in the ſpleen unknown to former authors, and ſimilar cells in the lymphatic glands.

In a former work, he had repreſented the red particles of the blood as conſiſting each of a central part or nucleus included in a veſicular, together forming a flat body, the ſhape of which he compares to that of a ſhilling. He contends, that the cells of the lymphatic glands form the central parts, and that thoſe of the ſpleen add the veſicular.

His arguments are numerous, and his concluſions are drawn with an air of demonſtration: Yet I ſhall endeavour to prove, that neither his concluſions, nor the facts on which they are founded, ought to be admitted.

1. It is perhaps not a little queſtionable, whether two kinds of red particles are diſtinguiſhable in the blood of living animals, very different from each other in ſize and ſhape, to wit, the central, and what he calls the full formed flat particles.

2. The appearance of cells in the lymphatic glands and ſpleen I am well convinced proceeds from an optical deception, of which Mr Hewſon had no ſuſpicion; for I have found, that any organ of the body exhibits that appearance as readily as thoſe glands or the ſpleen: nay, Mr Hewſon and Mr Falconer have repreſented the particles of the blood about ſixty times the ſize of thoſe cells, within which, however, they pretended theſe particles are contained (*q*).

3. Mr Hewſon tells us, that many central particles are to be ſeen in the blood conveyed by the ſplenic artery, but none in the blood of the ſplenic vein; whereas

(*q*) See my Obſervations on the Nervous Syſtem, p. 73.

whereas I have not been able to diſcover any difference of particles in the ſplenic artery and vein either in a pig or in a ſkate. Indeed in both, all the red particles appeared to me to be uniform in ſize and ſhape.

4. Mr Hewſon tells us, that the blood of the ſplenic artery coagulates readily, but that of the ſplenic vein ſcarcely at all: hence he infers, that the lymphatic part of the blood conveyed by the artery is converted into the veſicular part of the red particles. But although I think I have obſerved that the blood of the vena portarum is leſs frequently coagulated, or ſomewhat leſs diſpoſed to coagulate, than that of the venæ cavæ, yet I cannot perceive that the blood from the meſenteric veins differs ſenſibly from that of the ſplenic vein.

5. But his great argument, and which may be conſidered as his argumentum crucis, is, that the lymphatic veſſels of the ſpleen in living animals have been obſerved to contain the red particles of the blood completely formed. They are therefore conſidered by him as ducts from the cells: and it is ſuppoſed that this circumſtance as fully eſtabliſhes the uſe of the ſpleen, as the finding bile in the hepatic duct ſhows the function of the liver (*r*).

As a full confutation of this noted argument, I muſt point out three plain facts.

Firſt, That the lymphatic veſſels of the ſpleen are nowiſe remarkable for their number or ſize.

Secondly, That when the ſpleen and its lymphatic veſſels in a living animal are firſt laid in view, their contents are pellucid; and they only receive red particles ſome time after they have been expoſed to the air.

The third fact, which I learned from repeated experiments many years before Mr Falconer's book was publiſhed, and which I mentioned in my lectures, is, That the lymphatic veſſels of any deep-ſeated organ, whether in the thorax or abdomen, ſimilarly expoſed to the air and irritation, take up red particles. Hence after opening the cavity of the abdomen of a living animal, and ſome time thereafter the upper end of the thoracic duct, I have found many red particles mixed with the contents of that duct. To inveſtigate all the cauſes of this fact would be foreign to our purpoſe: but one cauſe readily preſents itſelf; I mean, that the application of the cold air irritates and inflames the deep-ſeated organs; and in conſequence of the inflammation, there is an effuſion of the red matter of the blood into the cellular membranes, whence it is taken up by the abſorbent lymphatics; which too, affected by the irritation, muſt be ſuppoſed to abſorb with more than common vigour.

6. In fiſhes, and particularly in the ſkate, Mr Hewſon has repreſented the red particles of the blood much larger than in man; and of courſe the cells of the ſpleen, in which theſe are ſaid to be completed, ought to be very eaſily ſeen with the microſcope: but this I have not found to be the caſe. Neither in two or three ſkates in which the circulation of the blood was going on, though in a languid way, could I perceive any red particles in the lymphatics of the ſpleen;

(*r*) See M. Falconer on the Blood, &c. ſect. 103.

which in this animal are, in common with the reſt of the ſyſtem, large, and readily appear on opening the abdomen.

Further, the ſpleen is in fiſhes as remarkably dark coloured as in man, and, in proportion to the reſt of the body, as large; nay, in the ſqualus ſquatina, or angel fiſh, I have obſerved two large ſpleens, one attached to the ſmall and the other to the large curvature of the ſtomach; yet there are few red particles in their blood: On the other hand, in the ſturgeon, where there is much more redneſs in the fleſh, and many more red particles in the blood, than in the cod or ſkate, although I have found not fewer than ſeven ſpleens, yet the largeſt of theſe, in a ſturgeon near ſix feet in length, does not in bulk exceed a dried horſe-bean; and the other ſix are none of them larger than a dried garden-pea. Facts which ſuit ill with the theory propoſed.

Upon the whole, therefore, Mr Hewſon appears to have left this part of phyſiology involved in nearly the ſame obſcurity in which he found it.

He likewiſe treated with ill-placed ridicule the common opinion, that the ſpleen is ſubſervient to the liver: For even ſuppoſing that one uſe of the ſpleen had been, as he contended, to complete the red particles of the blood; ſtill, as its venous blood paſſed not into the vena cava, but into the vena portarum and liver, which we cannot ſuppoſe to happen in vain, it would have followed, that the ſpleen was alſo ſubſervient to the liver, although we ſhould not have been able to ſpecify the particular nature of the ſervice it performed.

CHAPTER VII.

Of the firſt DISCOVERY of the SYSTEM of LACTEAL and LYMPHATIC VESSELS of FISHES, BIRDS, and AMPHIBIOUS ANIMALS.

I SHALL take this opportunity of eſtabliſhing, in a few words, my claim to the firſt diſcovery of the exiſtence of the lacteal and lymphatic ſyſtem in birds and amphibious animals, as well as in fiſhes, in oppoſition to the pretenſions of the late Mr Hewſon.

In a paper I publiſhed in 1770 (*s*), I proved, "That in 1758, I obſerved a "veſſel in the meſentery of the common cock, which I ſuſpected to be the "trunk receiving the lacteal veſſels.

"In April 1759, when treating in my Courſe of Lectures of Comparative "Anatomy, I obſerved in a cock what looked like lacteal veſſels collapſed, and "of a bluiſh colour, which ſeemed to terminate at the back-bone between the "teſticles."

(*s*) State of facts concerning the paracenteſis of the thorax on account of air effuſed, and lymphatic veſſels in oviparous animals.

I not only mentioned but ſhowed theſe publicly to the ſtudents of anatomy; and I at the ſame time ſaid, that Dr Cullen had lately told me that Mr John Hunter had ſeen lymphatic veſſels on the neck of a ſwan: And from the two obſervations conjoined, I concluded that fowls had lacteal and lymphatic veſſels like our own.

" Next winter, on April 23d 1760, I diſcovered lymphatic glands on the " neck, blew them up, and valvular lymphatics from them, terminating in the " ends of the jugular veins."

After ſhowing theſe publicly to the ſtudents, I repeated what I had mentioned the preceding winter, but now ſpoke with greater firmneſs concerning their lacteal veſſels, as I always conſidered the lacteal and lymphatic veſſels as different branches of the ſame general ſyſtem. Thus in 1757, I had treated of both under the name of Venæ Lymphaticæ Valvuloſæ (*t*).

The following day, to wit, April 24th 1760, " I diſcovered a whole ſyſtem of " lacteal and lymphatic veſſels in a ſkate fiſh, running towards the heart on the " left of and above the vena portarum; and from theſe the auricle of the heart " was blown up. They are proportionally larger, but have fewer valves than " in man."

This obſervation being made in the forenoon when diſſecting for the ſubject of a lecture on fiſhes, was of courſe mentioned publicly to the ſtudents that day.

In the ſummer of the year 1761, I gave to a dozen living cocks by the mouth different kinds of food, and the food of ſome of them I tinged with madder, ſaffron, rhubarb; or I injected tinged liquors into their inteſtines by a hole I cut in them, without obſerving that thoſe coloured ſubſtances entered their lacteal veſſels.

In the ſame ſummer I repeated my obſervation of the lymphatic veſſels and glands in the neck, and noted their appearance as follows.

" In the neck, I obſerve very diſtinctly lymphatics, which paſs through ſeve- " ral glands like to our glandulæ concatenatæ, and open into the bottom of the " internal jugular vein. If a hole is made into the undermoſt gland, and air " blown in, the vein is immediately filled with the air (*u*)."

In ſummer 1765, I diſcovered lacteal veſſels in the meſentery of a turtle; and after injecting the meſenteric arteries with red wax, and their correſponding veins with yellow, I injected the lymphatics with quickſilver.

I demonſtrated this preparation, which I ſtill preſerve, publicly the following winter; and a drawing of it was then made by Dr Palmer, now phyſician at Peterborough in England. An engraving from this drawing was publiſhed in my ſtate of facts, and is republiſhed in this work (*x*).

From 1759 to the preſent year, it has been my practice, in my courſe of lectures, firſt to deſcribe what I had obſerved reſpecting the lacteal and lymphatic veſſels in thoſe animals; and then to point out in the meſentery of the common cock the lacteal veſſels, and in the neck the lymphatic veſſels and the glands

(*t*) De Venis Lymphaticis Valvuloſis, 1757.

(*u*) Next winter Mr Hewſon attended my courſe of lectures.

(*x*) See Tab. XXX.

glands through which they paſs, before they terminate in the internal jugular veins. Nay, as often as I had a little time to ſpare for the diſſection of the parts, I inflated the lymphatic veſſels and glands of the neck; after which, I handed to the ſtudents theſe diſſected parts laid on plates, that ſuch as choſe might take a nearer view of them. I likewiſe have conſtantly, on this occaſion, handed around my preparation of the lacteals of the turtle injected with quick-ſilver.

Much later, to wit, in October 1768, Mr Hewſon preſented to the Royal Society of London an account of the lymphatic ſyſtem in birds; and in a note added, he ſays, he had ſo long ago as in the winter 1763-64 obſerved lacteals in a turtle.

In a paragraph ſubjoined to the above account, dated December 3. 1768, he adds, That ſince the above paper was put into the hands of the ſecretary, he has diſcovered the ſame ſyſtem in fiſh; and has likewiſe been ſo fortunate as to procure a turtle, whoſe lymphatic ſyſtem he has traced out, and has got delineated.

Accordingly, in June 1769, he preſented to the Royal Society an account of the lymphatic ſyſtem in amphibious animals and in fiſhes.

Not contented with the merit of having merely proſecuted the particular branches of the lymphatic ſyſtem in ſome of the oviparous animals, Mr Hewſon thought proper to aſſume the title of their firſt diſcoverer; endeavouring to perſuade his readers, that although the paragraphs above quoted, the authenticity of which he could not venture to call in queſtion, proved that I had *perſuaſions* and *opinions* of their exiſtence; yet they did not prove I had *in reality* diſcovered them. And, to give colour to theſe pretences, he has ventured to publiſh notes which he thought ſuited his purpoſe, taken indeed by ſome very reſpectable ſtudents who had attended my lectures.

But though theſe notes are palpably erroneous as well as imperfect; and that the principal of them, particularly the notes of Dr Morgan, who attended my courſe of lectures at the ſame time with Mr Hewſon, are not taken from my Lectures on Comparative Anatomy when I accompanied my deſcriptions with diſſection and demonſtration, but from a more early part of my courſe, in which, whilſt treating of the lymphatic ſyſtem in the human body, I uſed to mention the lymphatic ſyſtem in the oviparous animals in a curſory way only; yet even theſe, when compared with the preceding extracts, lead to concluſions very oppoſite to thoſe Mr Hewſon has drawn; for they plainly ſhow that he miſrepreſented the following very material points.

Firſt, Becauſe after ſummer 1761 I told the ſtudents that I had not obſerved coloured liquors enter the lacteal veſſels of birds, he repreſents me as acknowledging I had never ſeen the lacteal veſſels; yet he knew that, for three ſucceſſive years preceding that time, I had ſhown collapſed bluiſh veſſels in the meſentery of fowls, different from the branches of the meſenteric artery and vein. He ſaw me demonſtrate theſe in the winter 1761-2; and he muſt afterwards have certainly

certainly known, as I did, that the veſſels I then, and every year ſince, pointed out, were *in reality* the lacteals of fowls. Nay, before he publiſhed, he himſelf had found by experiment, that the chyle in the lacteals of fowls was always colourleſs; and therefore he knew, that my not ſeeing coloured chyle was no proof that the veſſels I had ſeen were not the lacteals.

Secondly, Mr Hewſon, upon the credit of what he knew or might have known to be in Dr Morgan's notes, has aſcribed to Mr John Hunter a diſcovery of mine in 1760; which, ſo far as I know, that gentleman never aſſumed, and from which the exiſtence of the valvular lymphatic ſyſtem in birds was proved, to any perſon who underſtands the ſubject, beyond all poſſibility of doubt or deception: I mean my having, in 1760, firſt diſcovered conglobate glands at the lower part of the neck of fowls ſimilar to our glandulæ vagæ, and having inflated valvular lymphatic veſſels entering theſe at their upper, and coming out at their lower part, to terminate in the internal jugular veins.

Mr Hewſon's arguments, by which he pretended to ſhow that I had not anticipated him in the diſcovery of the lacteals in fiſhes, are equally unfortunate.

That the reader may not think I miſrepreſent them, I ſhall ſtate them in his own words. "Next (ſays he) as to the lacteals in fiſh. To prove that he (Dr Monro) had found thoſe veſſels eight years ago, he (Dr Monro) tells us, that in a note taken from the diſſection of a ſkate on April 24th 1760, he has ſaid, 'He had diſcovered a whole ſyſtem of lacteals and lymphatic veſſels, running 'towards the heart, on the left of and above the vena portarum; and from 'theſe the auricle of the heart was blown up. They are proportionally larger, 'but have fewer valves than in man.'

"Now (continues Mr Hewſon), I will take upon me to ſay, there is nothing in this note which proves whether he had inflated a lacteal or a vein: For what he ſays of the ſituation of the veſſels, and of his blowing up the heart, is equivocal. The only part of the note which appears to characteriſe the lacteals is in reality a miſtake; that is, where he ſays they have valves."

In anſwer to all this, I would obſerve two plain facts. The firſt of which is, that the red veins of the meſentery in fiſhes, as well as in man, do not lead to the heart, but to the vena portarum. When therefore I found that the veſſels I inflated led directly to the heart, I knew them to be for certain the lacteals.

In the next place, the veſſels I inflated were in their appearance totally different from the red veins. They formed a great plexus, or what I have called "a whole ſyſtem of lacteals and lymphatics running towards the heart; were "larger, and appeared to have fewer valves than in man." But Mr Hewſon exclaims they have *no valves;* and therefore would infer that I had not ſeen their lacteals. But ſuppoſing they had no valves, it would by no means follow that I had not inflated their lacteals; becauſe they are in reality not cylindrical veſſels, but are jointed; and of courſe I judged, from the analogy of the human body, that they were valvular.

Further, it has appeared, that within the lacteals of the ſkate there are cellu-

lar receptacles and membranes of a valvular nature; and that, at the termination of the lymphatic ſyſtem of fiſhes in the red veins, the place of which we have found Mr Hewſon had not been able to trace (y), there are valves exactly like to thoſe in the human body, and which perform their office in the moſt accurate manner.

I ſhall ſubjoin two letters from phyſicians of diſtinguiſhed character, who attended my lectures at critical periods, to wit, Dr Charles Richardſon phyſician at Kingſton in Jamaica, and Dr Adam Kuhn phyſician and profeſſor of materia medica at Philadephia.

Dr Richardſon ſtudied phyſic in this univerſity from 1755 to 1763, when he received his degree of Doctor of Phyſic, and was conſidered by all the profeſſors as one of the moſt ſenſible and intelligent candidates who had ever come before them, and at Kingſton in Jamaica is univerſally eſteemed. He had attended my father's courſes in 1756-7 and 1757-8, and my three firſt courſes, to wit, 1759-60, 1760-1, and 1761-2; in the laſt of which Mr Hewſon was preſent. As the time of his attendance was ſo very critical, I wrote to him in 1769, when Mr Hewſon claimed the firſt diſcovery of the lymphatics and lacteals in birds and fiſhes. As I got no anſwer then, I wrote again two years thereafter, deſiring him to declare what he remembered to have heard or ſeen here concerning the lacteal and lymphatic veſſels of birds and fiſhes. The following is a literal copy of his anſwer.

" SIR,

" You deſire me to appeal to my notes and memory, to do you juſtice with " regard to the prior diſcovery of the lacteals and lymphatic veſſels (in birds and " fiſh) to the late Mr Hewſon. My manuſcripts I had the misfortune to loſe " many years ago: however, it is freſh in my memory, that I was not only as " much convinced of their exiſtence in both, before I left the univerſity of Edin- " burgh, as I am at preſent; but that in the year ſixty-three I demonſtrated " them on the meſentery of a live ſhark to Mr Gilbert Turnbull, then my mate " in the Speaker Eaſt Indiaman, and to ſeveral other gentlemen preſent; and " named you as the diſcoverer.

" Upon the receipt of your letter, I wrote to Mr Turnbull and two more " friends upon this ſubject, whoſe anſwers have not as yet come to hand; " which is the reaſon I have ſo long delayed writing to you. They can now " be of little ſervice when they do come, as poor Hewſon's death puts an end " to the diſpute; which I am ſorry to ſee terminated in that way, both upon " your account and his.

" This will introduce to your acquaintance Mr Richard Trower, who pro- " poſes to complete his medical education in Edinburgh," &c.

" I am, &c.

" Kingſton, Jamaica, May 4. 1776.

" CHARLES RICHARDSON.

" For Dr A. MONRO."

After

(y) Mr Hewſon, on the Lymphatic Syſtem, p. 91. deſcribes " a veſſel, the termination of the whole ſyſtem, going into the " jugular vein juſt below the orbit;" whereas the real termination is in the venæ cavæ. See Tab. II. 36. Tab. XVIII. X. Tab. XIX. R. Tab. XXVI. fig. 2. 3. and Tab. XXVIII. M. N.

After Mr Hewſon's Appendix was publiſhed in 1772, I wrote to Dr Kuhn, aſking his teſtimony; for as the Doctor had been with Linnæus before he ſtudied here, and was particularly attentive to natural hiſtory, I thought he would recollect what he had ſeen more particularly than thoſe ſtudents who attend chiefly to practical ſubjects. He ſtudied here in 1765-6 and in 1766-7, and took his degree of Doctor in 1767. His anſwer is literally as follows:

"DEAR SIR,

"I am under infinite obligations to you for the Treatiſe on the Lymphatics "you were pleaſed to ſend me, as I never could get the book in this country; "and when I left Europe, not a copy could be purchaſed on any account.

"The ſtate of facts between you and Mr Hewſon muſt convince even prejudice that the honour of the invention is due to you. There are ſeverals in "this country who are convinced of it from attending your courſe of anatomy. "My own teſtimony is not of the importance with ſome who were in Edinburgh before me; but I *remember well* your demonſtrating thoſe veſſels in "birds and fiſh publicly in your lectures, at a time numbers came annually "from London, who ſaw them at your theatre for the firſt time.

"Mr L." &c.

"I have the honour to be, &c.

Philad. July 23. 1773.

"ADAM KUHN.

"For Dr A. MONRO."

CHAPTER VIII.

Of the BRAIN and ORGANS of the SENSES in FISHES.

SECT. I.

Of the Brain in Fiſhes, and Nervous Syſtem in general.

THE brain of fiſhes is ſenſibly ſmaller in proportion to their body than in the mammalia or in birds; yet the nerves it ſends off are as large in proportion to the ſeveral organs as in thoſe two claſſes.

In it we find the like principal diviſion into brain and cerebellum; and theſe are hollow, or have ventricles within them.

The

The ſubdiviſions of the brain and cerebellum, or their tubercles and lobes, are more numerous than in the mammalia or birds; and in the various genera of fiſhes, the differences of theſe are ſuch, as to ſhow the vanity of attempting to determine the office of each lobe or tubercle of the brain.

Ganglia are wanting in their nerves.

In one genus of fiſhes, the gadus, I have found ſpheroidal bodies between the dura and pia mater, and covering the greater part of their nerves, like a coat of mail, in their courſe towards the organs to which they are deſtined. That this obſervation may be intelligble to the reader, I have ſubjoined Tables repreſenting them (*x*), which I formerly publiſhed in my work on the Nervous Syſtem.

After theſe few general obſervations on the brain, we ſhall proceed to conſider the organs of the ſenſes, and particularly the noſe, the ear, and the eye; for on thoſe of touch and taſte I find little or no room for remark.

SECT. II.

Of the Organ of Smell in Fiſhes.

IN all fiſhes, external openings or noſtrils for ſmell are very evident, generally two on each ſide in the oſſeous fiſhes (*a*), which, on each ſide of the head (*b*), lead to a complex organ, the ſurface of which is of conſiderable extent; and upon them a pair of large or olfactory nerves terminates, with the addition of ſome branches from nerves reſembling our fifth pair (*c*). In ſome fiſhes, as in the haddock, I have obſerved that the olfactory nerve, in its courſe between the head and the noſe, paſſes through a cineritious ball (*d*), reſembling the cineritious matter connected in our body to the olfactory nerve within the cranium.

There can therefore be no doubt that they enjoy the ſenſe of ſmelling: nay, there is great reaſon to believe, that, ſuited to their ſurrounding element, they are much more ſenſible of odorous bodies diſſolved in water, and applied by its medium, than we ſhould be, if the application of the object was to be made to our organ of ſmell by the ſame medium.

(*x*) See Tab. XXXI. XXXII. XXXIII.
(*b*) See Tab. II. 11. Tab. XL. fig. 1. and 2.
(*d*) See Tab. XXXI. fig. 1. K.
(*a*) Tab. XXXI. fig. 1.
(*c*) Tab. XXXI. OO.

SECT.

SECT. III.

Of the EAR *in Fiſhes.*

§ 1. *Of the Ear in the Cetaceous Fiſhes.*

IT is well known that the ear of the whale-kind reſembles that of man; and ſeveral authors, particularly Dr Tyſon and Dr Camper (*e*), have publiſhed an account of the ſeveral parts which compoſe it: but I have not been able to procure either of theſe works. I obſerve, from the Commentarii Lipſienſes (*f*), that Dr Camper denies that they have ſemicircular canals; a circumſtance in which I apprehend this eminent author to be miſtaken. He is alſo uncertain whether they have an Euſtachian tube. I ſhall for theſe reaſons, as well as for the ſake of connection, give a ſhort account of what I have obſerved in the diſſection of the phocæna, one of the cetaceous order.

On each ſide of the head there is a round hole (*g*), ſcarcely large enough to admit the head of a ſmall pin, which is the beginning of a long meatus auditorius externus (*h*); at the bottom of which we find a concave membrana tympani (*i*). The membrana tympani is connected to the bottom of the cavity of the tympanum by a chain of ſmall bones, tied together by a reddiſh-coloured membrane. The innermoſt piece, analogous to our ſtapes, has evidently a muſcle connected to it (*k*); a large nerve or portio mollis divides into two branches, and then enters the bone at the bottom of the cavity of the tympanum or os petroſum (*l*): and following one of the branches of the nerve, we are led to the cochlea, which is divided by a ſeptum into two ſcalæ; each of which contains a reddiſh-coloured tube, that is eaſily ſeparable from the oſſeous canal which contains it (*m*).

Following the other branch of the nerve, I obſerved part of the ſemicircular canals; the membrane of which is very thin (*n*), and adheres to the bone which contains it.

The cavity of the tympanum is remarkably large, and communicates freely with other cavities which are analogous to our frontal, ſphenoidal and maxillary ſinuſes (*o*).

A tube, ſimilar to our Euſtachian tube, or iter a palato ad aurem, begins towards

(*e*) Tyſon on the Phocæna. Camper acta Harlem. tom. ii. et xvii. in 1765 and 1776.
(*f*) Com. Lipſiens. vol. xvii. p. 460.
(*g*) See Tab. XXXV. fig. 1. F.
(*h*) Tab. XXXV. fig. 5. F G.
(*i*) See Tab. XXXV. fig. 5. I. and fig. 6. I.
(*k*) Tab. XXXV. fig. 6. K L M.
(*l*) See Tab. XXXV. fig. 7. T S.
(*m*) Tab. XXXV. fig. 8. U W. and fig. 9. W Y Z.
(*n*) See Tab. XXXV. fig. 8. X.
(*o*) Tab. XXXV. fig. 6. N O P Q R.

wards the lower end of the fiſtula, through which the animal reſpires; and, contrary to what we obſerve in man and quadrupeds, it gradually enlarges as it runs back towards the cavity of the tympanum, in which it terminates (*p*).

While, therefore, theſe animals float on the ſurface of the ocean, impreſſion is made on the ſeveral parts of their ear in the ſame manner as in man.

The remarkable difference of the ſize of the caverns which, in place of the cells of our maſtoid proceſs, communicate with the cavity of the tympanum, leads us to conſider, Whether the effect of the ſound upon the ear be increaſed by that circumſtance? or, Whether the chief uſe of theſe caverns may be to render the head ſpecifically lighter, and, like ſwimming-bladders, to make it riſe more readily to the ſurface of the ſea?

As the entry into the external meatus auditorius is ſo very ſmall, there is reaſon to ſuppoſe that the animal can ſhut it when it dives to a conſiderable depth, and when the weight of the water might have been in danger of injuring the membrana tympani. And from obſerving the ſmallneſs and ſtructure of the mouth of the external meatus auditorius in the whale, divers may perceive the neceſſity of plugging the ears accurately, in order to prevent the overſtretching of the membranes of the drums.

§ 2. *Of the Ear in Amphibious Animals, and particularly in the Sea Tortoiſe or Turtle.*

Before I proceed to give an account of the ſtructure of the ear in the nantes pinnati and piſces of Linnæus, I ſhall, in a few words, deſcribe the ear in the intermediate tribe of the amphibious animals, taking the ſea tortoiſe or turtle as my chief example of the claſs.

In this animal, as well as in the frog and moſt others of the claſs, there is no external ear nor meatus auditorius externus; but we find a large Euſtachian tube on the back part of the roof of the mouth, near to the articulation of the under jaw with the upper. This tube has a winding courſe behind the condyle of the upper jaw, and leads to a large cavity, reſembling (*q*) our cavity of the tympanum (*r*), covered by the ſkin of the temple and a tough ſubſtance with a thin cartilage on its inner ſide; the whole of which taken together are nearly one ſixth part of an inch in thickneſs (*s*).

To theſe teguments a cartilaginous body, nearly of the ſize of a ſmall probe, and upwards of three quarters of an inch in length, is connected; and paſſes, firſt to the bottom of the tympanum, then through a bone, and through another ſmaller cavity, in which a watery humour is lodged; and at the bottom of which the cartilaginous body is connected to a membrane which fills a hole (*t*).

Within that membrane or hole a third cavity is found, which lodges three ſemi-

(*p*) See Tab. XXXV. fig. 4. O. fig. 5. L M N.
(*q*) Tab. XXXVI. fig. 1. H I K. fig. 2. C.
(*r*) See Tab. XXXVI. fig. 2. B. fig. 3. B.
(*s*) Tab. XXXVI. fig. 2. A. fig. 3. A.
(*t*) See Tab. XXXVI. fig. 2. E. fig. 3. E F. fig. 4. B.

ſemicircular canals, to wit, an anterior, a poſterior, and a middle horizontal canal (*u*), and alſo a ſmall ſac, which contains a ſoft cretaceous ſubſtance (*w*).

The ſemicircular canals contain, and are ſurrounded by, a viſcid watery humour.

On the membranes of theſe canals, and on the ſac, nerves are diſperſed (*x*).

When we compare the parts in this animal with the human ear, the cartilaginous body ſeems to ſupply the place of the ſmall bones of our ear; and the membrane to which the inner end of it is connected ſeems analagous to the membrane of our foramen ovale.

The ſac containing the cretaceous matter, with the three ſemicircular canals and nerves diſperſed upon them, reſemble the labyrinth of our ear.

§ 3. *Of the Ear in the Cartilaginous and Oſſeous Fiſhes.*

THE ſtructure of the ear in the cartilaginous and oſſeous fiſhes has been ſo little examined, till of late, that, for upwards of two thouſand years, it has been a queſtion whether they poſſeſſed organs appropriated for hearing.

Swammerdam (*y*) mentions a wonderful labyrinth of the ear in fiſhes: but moſt anatomiſts ſince his time contented themſelves with pointing out, as the organ of hearing, ſacs at the ſides of the brain of the moſt common fiſhes containing ſtony ſubſtances, without pretending to ſhow external paſſages leading to theſe ſacs, or the nerves or medium by which theſe ſacs were connected with the brain of the animal.

About the beginning of the year 1779, the learned and accurate Dr Soemmering, now profeſſor at Caſſel, and who at that time did me the honour of attending my courſe of lectures, told me, that the ingenious Dr Camper, in a letter he had received, mentioned his having diſcovered ſemicircular canals in the ears of fiſhes. I therefore determined to look for theſe when I ſhould come to that part of my courſe in which I treat of Comparative Anatomy: And accordingly I found, and ſhowed to the ſtudents, in the month of April following, ſemicircular canals both in the ſkate and in the cod.

In the following month of May 1779, I traced the communication of the ſeveral canals of the ear with each other, and the diſtribution of the nerves upon them; and was alſo ſo fortunate as to diſcover the entry into the external ear of the ſkate, its concha, meatus auditorius externus, and its communication with the interior canals: All which I have ſince annually demonſtrated to the ſtudents in my courſe of lectures.

In the month of Auguſt following, I ſhowed to the Philoſophical Society of this place the tables of thoſe parts in the ſkate and cod which I now publiſh, along with the tables which repreſent their circulating and abſorbent veſſels.

Since

(*u*) See Tab. XXXVI. fig. 3. G H I. (*w*) Tab. XXXVI. fig. 4. C. (*x*) Tab. XXXVI. fig. 4. D.

(*y*) Swammerdam, Bibl. Natur. p. 111.

Since that time, I have received a work by M. Geoffroi, on the Organ of Hearing of Fiſhes and other Animals, which was read to the French Academy in 1753, but was not publiſhed till 1778; and find that Dr Camper and M. Vicq. d'Azir, previous to the publication of M. Geoffroi, had given an acaccount of many diſcoveries on the ſame ſubject, which they illuſtrate by tables (z).

In the works, however, of theſe authors, the communication of the canals of the ear with each other has not been fully traced. Little attention has been paid to the nerves which ſupply them; and a very principal part, the external meatus auditorius, has entirely eſcaped their obſervation *.

I ſhall therefore proceed to give a deſcription of the ear; firſt in the cartilaginous flat fiſhes, and then in ſome of the oblong-ſhaped cartilaginous and in the oſſeous fiſhes. After which, I ſhall give an account of a few experiments I have made on hearing in water.

§ 4. *Deſcription of the Ear of a Skate.*

In the back part of the occiput, near the joining of the head with the ſpine, two holes (*a*), not larger than to admit the head of a ſmall pin, are found at the diſtance of an inch from each other in a large fiſh. Each of theſe leads into a capacious winding canal or concha, which deſcribes nearly a complete circle (*b*). The two conchæ are ſeparated from each other by a thin partition (*c*). Each concha terminates in a funnel, from which a ſmall cylindrical canal or meatus auditorius externus is continued (*d*). The meatus is lodged in a hollow left between two thick cartilages (*e*); and as there is no membrana tympani, it opens into a large ſac, which contains a white or opake matter, with a quantity of clear watery-looking, but viſcid, matter (*f*). The white ſubſtance is ſoft and cretaceous, effervеſcing violently with vinegar; has a regular ſhape; and yet, in the meatus auditorius externus and concha, generally ſome portion of a ſimilar matter is found, as if part of it paſſed off by the meatus, or was ſomehow neceſſary for communicating the impreſſion of ſound to the bottom of the ear.

On

(z) See Acta Harlem, tom. xvii. 1762. et Mem. de Math. et de Phyſ. pres-a l'Ac. R. des Sciences, tom. vi. et vii. 1774.

* M. Geoffroi ſays, "L'organe de l'ouie de la raye ne paroit point du tout a l'exterieur, et ſon entrée n'eſt point " aiſée a decouvrir. Cachée ſous des muſcles, elle eſt placée proche les condyles, a leur partie laterale externe ..... en " la ſuivant a l'interieur, on voit qu'elle donne naiſſance a deux canaux; l'un fort court, qui penetre dans la cavité du " veſtibule, une fente longue, irreguliere, dont les bords ſont comme dechirés," &c.

And p. 93. Du trou auditif ..... recouvert des muſcles et de graiſſe,

Dr Camper, Mem. de Math. tom. vi. p. 194. denies that there is an external opening: "L'organe de l'ouie de la raye " n'a donc aucune communication avec l'air de l'atmoſphere; mais il eſt enfermé," &c.

And M. Vicq. d'Azir, tom. vii. p. 20. ſpeaking of the cartilaginous fiſhes or nantes pinnati of Linnæus, ſays, "L'or" gane de l'ouie na point, chez eux, d'ouverture exterieure."

(a) See Tab. VII. fig. 1. fig. 2. A A. fig. 3. 4. 5.

(b) Tab. VII. fig. 2. B C. fig. 3. 6. 7.

(c) See Tab. VII.

(d) Tab. VII. fig. 2. *dc.* fig. 3. 8.

(e) Tab. XXXVII. fig. 2. 16. 17.

(f) Tab. XXXVII. fig. 2. 18. and fig. 3. *ab.*

On the fore part of the great ſac, and communicating with it, a much ſmaller one *e* is found, which likewiſe contains both cretaceous and viſcid watery matter (*g*). From this ſmall ſac a duct *e* is ſent off, which opens into a duct *f*, common to an anterior and exterior horizontal ſemicircular canal *g h*, and the other two ends of theſe ſemicircular canals join together at *i*; and where they meet, they alſo communicate with the end of their common duct *f*. Hence the large ſac *b* communicates by the medium of the ſmall ſac *d* with the anterior and with the horizontal ſemicircular canals *g h*. Theſe again communicate with each other, firſt by their common duct *f*; and in the next place a duct, formed by their common duct *f* and by the duct *e* from the ſmall ſac, joins at *i* with the meeting of the other two ends of theſe canals, juſt under the end of the meatus auditorius externus, where it opens into the large ſac.

The two ends *l m* of the poſterior ſemicircular canal join with each other at *n*; and the upper end *l* communicates directly with the large ſac at *k*.

When we review the deſcription and figures, it appears, that the canals we have from analogy called *ſemicircular* are in the ſkate circular; and that the cavities of all of them communicate, through the two ſacs deſcribed, with the meatus auditorius externus.

In each of the ſemicircular canals there is a dilatation or pouch, ſhaped like that part of our red veins at which valves are found; yet there are no valves in them.

The anterior and poſterior circular canals conſiſt of an upper and under portion; between which there is a thin ligament *p p* which ſerves as a ſupport to them.

The large ſac reſembles our veſtible; and the ſmall ſac has ſome likeneſs to the tube which in birds ſeems to ſupply the place of the cochlea.

The membrane of the drum and the cavity of the tympanum are wanting; which, as the ſound is not conveyed by the air, we might *à priori* have ſuppoſed would be the caſe: and the meatus auditorius externus performs the office of the Euſtachian tube; at leaſt ſo far as that tube may be ſuppoſed to ſerve the purpoſe of diſcharging uſeleſs or hurtful matter. The circular canals are filled with a viſcid liquor ſimilar to that in the large ſac. The membrane which compoſes them is tranſparent, but thick and pretty tough; and even when diſtended, they are ſo much ſmaller than the canals of cartilage which contain them, that between them and the cartilage there is a viſcid watery liquor contained in a cellular ſubſtance; on the threads of which, veſſels both circulating and abſorbent, and nerves, are diſperſed (*h*).

Theſe ſacs and circular canals are furniſhed with very large nerves, derived from nerves which reſemble our fifth and ſeventh pairs (*i*).

The anterior and horizontal circular canals are ſupplied from the fifth pair; the ſacs and poſterior circular canal are ſupplied from the fifth and ſeventh

(*g*) In Tab. XXXVII. fig. 3. theſe ſacs and the ſemicircular canals are very accurately delineated; to which therefore this deſcription chiefly refers.

(*h*) See Tab. XXXVII. fig. 4. *b c d e f.*

(*i*) Tab. XXXVII. fig. 1. and 4. 27—34. and 35. 36. 37.

pairs conjoined. After reaching the ſacs and canals, and running a little way upon their membranes, they loſe their white colour, become pellucid, and diſappear.

§ 5. *A Deſcription of the Ear of the Squalus Squatina of Linnæus.*

In the ſqualus ſquatina, or angel fiſh, another of the flat cartilaginous fiſhes, I have found the ſtructure of the organ of hearing to agree ſo nearly with that of the ſkate, that I think it unneceſſary to obſerve farther, than that the external meatus auditorii are found at nearly the ſame place, to wit, over the upper and poſterior part of the head near its joining with the ſpine (*k*). Within the external orifice there is a winding concha K, from which a ſmall cylindrical meatus L leads into a large ſac or veſtible M, filled with a viſcid watery humour and cretaceous ſoft ſubſtance; and with this three circular canals N O P communicate.

§ 6. *A Deſcription of the Ear in ſome of the long-ſhaped Cartilaginous Fiſhes, and in the Oſſeous Fiſhes.*

At the lower end and poſterior part of the ſides of the cranium, ſeparated from the brain by membranes only, we find the organ of hearing ſituated in the oſſeous fiſhes, and in ſome at leaſt of the oblong-ſhaped cartilaginous fiſhes. I have chiefly examined the cod and the ſturgeon. In both, the organ conſiſts of three ſemicircular canals, to wit, an anterior and poſterior perpendicular canal, and a middle horizontal one (*l*).

Each of the perpendicular canals has a dilated portion or bulb at one of its ends, where it joins with the horizontal canal (*m*); and in the anterior of theſe in the cod, a ſmall ſcabrous calcareous ſtone is lodged (*n*). The anterior end of the horizontal canal is likewiſe dilated (*o*).

The ſmall upper ends of the anterior and poſterior ſemicircular canals join together, and form a common canal, which deſcends perpendicularly (*p*).

The horizontal ſemicircular canal has its large end joined to the bottom of the anterior canal, and its ſmall end joins with the under end of the poſterior ſemicircular canal (*q*).

Theſe common canals open into the under part of the perpendicular canal, and

(*k*) See Tab. XXXVIII. F G H H I.

(*l*) Tab. XXXIX. K L M N O P. and Tab. XL. fig. 3. and 4. A B C D E F G.

(*m*) See Tab. XXXIX. fig. 1. and 4. L P. and Tab. XL. fig. 3. and 4. B D.

(*n*) Tab. XXXIX. fig. 3.

(*o*) See Tab. XXXIX. fig. 1. and 4. L L. and Tab. XL. fig. 3. and 4. E E.

(*p*) See Tab. XXXIX. fig. 1. and 4. K. and Tab. XL. fig. 4. G.

(*q*) See Tab. XXXIX. fig. 1. and 4. and Tab. XL. fig. 4.

and of courſe meet there, and communicate freely with that canal and with each other (*r*).

We next find a ſac of conſiderable ſize, in which a large ſcabrous calcareous ſtone is lodged (*s*). This large ſtone, as well as the ſmaller in the ſemicircular canal, ſeems to be ſurrounded by a viſcid humour.

A hole or opening in the fore or under part of the common perpendicular canal leads into this ſac in the ſturgeon (*t*): but I have not obſerved any ſuch opening in the cod or haddock.

Very large nerves are fixed to the bulbous parts of the ſemicircular canals; and ſpreading out on theſe canals, they become ſuddenly pellucid (*u*).

On the ſac which contains the large ſtone, eſpecially of the cod, a conſiderable nerve is ſpread in a moſt elegant manner (*x*).

The ſemicircular canals and large ſac contain, beſides the ſtones, a viſcid humour; and as the ſemicircular canals are much ſmaller than the canals of bone or cartilage which contain them, ſo we find a quantity alſo of viſcid humour between their outer part and the bones or cartilages.

In the cod, haddock, and perhaps the whole genus of gadus, a number of ſmall ſpheroidal bodies, which I have obſerved to form part of their nervous ſyſtem, is to be found in this viſcid humour ſupported by ſmall fibres of veſſels and of nerves (*y*).

I have alſo in the cod obſerved a bag about the ſize of a pea a little farther back than the poſterior ſemicircular canal, filled with viſcid humour, and with a nervous filament from the nerve which ſupplies the large ſac; and which I ſuppoſe to be part of the ear (*z*).

I have not, however, been able as yet to diſcover in theſe fiſhes any meatus auditorius externus.

(*r*) See Tab. XXXIX. fig. 1. and 4. K. and Tab. XL. fig. 4. G.

(*s*) See Tab. XXXIX. fig. 1. and 2. Tab. XL. fig. 4. H I.

(*t*) Tab. XL. fig. 4. I.

(*u*) See Tab. XXXIX. fig. 1. and 4. Q R S.

(*x*) Tab. XXXIX. fig. 1. and 4. R R.

(*y*) See Tab. XXXIX. fig. 1. and 4. T.

(*z*) Tab. XXXIX. fig. 4. V.

CHAP.

CHAPTER IX.

EXPERIMENTS ON HEARING IN WATER.

AFTER describing the ſtructure of the ear in fiſhes, I ſhall give an account of a few experiments I made, in 1780, on hearing in water, that we may be able to judge better of the effect of ſound upon the ears *.

I employed two bells, the ſound of which I was uſed to; one of them a ſmall tea-table bell; the other much larger and thicker, ſo that the ſound of it could be very well heard at the diſtance of a quarter of a mile.

When theſe were plunged under water and rung, I obſerved that the ſound of them was very ſenſibly graver; but ſtill the ringing tremor of both was very diſtinguiſhable. On performing an accurate experiment, the tea-table bell was found to ſound in air the higheſt G of a common harpſichord; but in water it ſounded a fifth falſe lower, or it ſounded the C ſharp under the G.

I next plunged my head under the water while I rung the bell in the air, and heard the ſound of it diſtinctly. As the tone of the bell is louder and more acute in the air than in the water, I need ſcarcely obſerve that its ſound is better heard when the head of the perſon making the experiment is under the water and the bell above it, than when the bell is rung under the water while the head is above it.

I next plunged my whole body with the bells, holding their handles in my hands, under the water; and then rung them, and was ſurpriſed with the loudneſs and diſtinctneſs of their ſounds, and could readily diſtinguiſh their different tones.

In like manner, when, plunged under the water, I ſtruck two ſtones held in my hands againſt each other, I was ſurpriſed with the ſhock communicated to the ears.

* The ingenious Abbé Nollet has, about forty years ago, publiſhed an account of various experiments he made on this ſubject: "Le reſultat en a été, que non ſeulement le bruit, quoique plus ou moins affoibli, ſe tranſmettoit à travers "l'eau, mais encore l'eſpece de bruit, les tons et les articulations de la voix humaine (*a*)." And the celebrated Dr B. Franklin mentions, in 1762, as his opinion (*b*), "That water will convey ſound farther and more readily than air; be- "cauſe two ſtones being ſtruck ſmartly together under water, the ſtroke may be heard at a greater diſtance by an ear pla- "ced alſo under water in the ſame river than it can be heard through the air. He thinks he has heard it near a mile: "how much farther it may be heard he knows not; but ſuppoſes a great deal farther, becauſe the ſound did not ſeem "faint, as if at a diſtance, like diſtant ſounds through air, but ſmart and ſtrong, and as if preſent juſt at the "ear (*b*)."

(*a*) See Hiſt. de l'Acad. R. des Sciences 1743, p. 26. et Mem. p. 199. &c.

(*b*) See Letters, &c. by Dr B. Franklin, L. xliv. dated July 20. 1762.

I afterwards, by means of a ſtring tied to the handle of the largeſt bell, and to an inflated bladder, ſuſpended that bell in a very deep pool, ſix feet under the ſurface of the water, and took hold of a cord twelve yards long, which I had before tied to its handle. I then plunged under the water and pulled the cord, and found that the ſound was inſtantly conveyed to my ears.

In the laſt place, I thought of trying an experiment, to determine whether air or water conveyed ſound quickeſt: but as we have no lake near Edinburgh above eight hundred feet broad, I found it impoſſible, independently of the difficulty of conſtructing a proper apparatus, to perform an experiment in a deciſive way.

It may however be worth while to mention one trial I made. I charged three Engliſh-pint bottles each with about ten ounces of gunpowder. I then inſerted a tin-tube four feet in length into each bottle, and prevented the water from getting into the bottle by wrapping a piece of wet bladder around the neck of it and the end of the tube which entered into it, and tying the tube and neck of the bottle to each other.

After filling the tube with gunpowder, I fixed to the top of it a piece of match-paper; and into the match-paper, juſt over the top of the tube, I put two ounces of gunpowder.

I then ſunk the bottle near the ſide of a lake to the depth of about two feet, and went into the water at the greateſt diſtance poſſible, which was about eight hundred feet, and laid myſelf on my back in the water, with my ears under its ſurface, and noſe and eyes alone above it. The match was then ſet fire to by another perſon; and as it was midnight, I ſaw the flaſh of the gunpowder contained within the match, and ſoon after heard the noiſe of the exploſion of the powder within the bottle. But I found it was impoſſible in this way to determine the velocity of the ſound with accuracy; for the gunpowder within the bottle was not ſet fire to through the tube ſo inſtantaneouſly as I had expected.

When the powder contained within the match-paper of the ſecond and third bottles took fire, I plunged myſelf entirely under water.

Upon the whole, beſides not being provided with a proper apparatus, and not having acceſs to a piece of water of ſufficient extent, this experiment was not repeated often enough: So that all the concluſion I could draw was, that after the bottle burſt, I heard one, but did not hear two exploſions; ſo that the water ſeemed to convey the ſound in nearly the ſame time as the atmoſphere *.

* A good method of making ſuch an experiment would be, to ſuſpend under water, in a broad lake, a very large and loud-ſounding bell, ſuch as is uſed in church-ſteeples, and for one perſon to ſtrike this with an iron-hammer, between the handle of which and the trigger of a muſket, or cannon fitted with a lock, a rope was ſtretched; while another perſon was ſtationed at the diſtance of a mile or more, with one or both ears under the water.

By this means, as two very different ſounds would be produced at the ſame inſtant, the one in air and the other in water, it might be obſerved which of them ſtruck the ear ſooneſt. Beſides this, the flaſh ſhowing the exact time at which the bell was ſtruck, the velocity of the ſound in the water might be accurately determined.

CHAPTER X.

Of the ſeveral Ways in which the TREMOR of SONOROUS BODIES is communicated, in the different CLASSES of ANIMALS, to the Nerves ſpread out on the Bottom of the EAR.

HAVING deſcribed the ſtructure of the ear in the amphibious animals and in fiſhes, and that of the mammalia and birds being ſuppoſed to be underſtood, we ſhall proceed to conſider the way in which the tremor excited by ſonorous bodies is communicated in the different claſſes of animals to the nerves ſpread out on the bottom of the ear.

It is very generally ſuppoſed, that in the mammalia and in birds, beſide the impreſſion which may be communicated to the nerves of the ear by the tremor of the whole bones of the head *, a diſtinct impreſſion may be conveyed to them in three different ways.

In the firſt place, and chiefly, by the chain of bones, cartilages, and ligaments, regulated by their muſcles, which connects the membrane of the drum to the membrane of the oval hole.

In the next place, as one ſcala, or one half of our cochlea, begins at the membrane of the round hole which is not directly connected to the membrane of the drum, and as men and other animals have ſeemed to diſtinguiſh ſounds, with conſiderable acuteneſs, after the chain of ſmall bones was deſtroyed by diſeaſe or experiment, there is reaſon to believe that we receive a ſecond and pretty diſtinct impreſſion by the medium of the air contained in the cavity of the tympanum.

This air is ſuppoſed to be agitated, and to communicate its tremor in two different ways, to wit, by receiving motion from the membrane of the drum; and beſides this, by a tremor of the external air communicated to it through the Euſtachian tube, which, authors pretend, is admirably ſuited to this purpoſe by its ſituation, ſhape, and the elaſtic materials of which it is compoſed. Nay, the generally accurate Valſalva relates a caſe, which has been conſidered as an undoubted proof that ſound is conveyed by this channel.

Yet

* The ſound of an ordinary watch applied to the fore-teeth of the upper jaw is heard diſtinctly; but its ſound is not ſo well perceived on applying it in like manner to the teeth of the under jaw: ſo that the tremor ſeems to be conveyed to the portio mollis, not by the branches of the fifth pair of nerves, or portio dura of the ſeventh pair, as has been ſuppoſed, but by the bones of the head.

Yet the following ſimple experiment which I made twenty years ago, is ſufficient to convince us that no diſtinct impreſſion is tranſmitted through the Euſtachian tube.

I placed an alarm-clock, which rings very loud, upon one cuſhion, and I ſtood upon another. Then having ſtopped my meatus auditorii externi, I ſet the clock a-ringing, without being able to hear its ſound. In like manner, when I held my watch near to the external ear, I heard its ſound diſtinctly; but when I held it within my mouth, between my tongue and the roof of my mouth, without allowing it to touch either, and then ſtopped my external ears, I did not hear its ſtrokes.

The primary uſe, therefore, of the Euſtachian tube is to furniſh air to the cavity of the tympanum, through which the tremor of the membrane of the drum may, in the firſt place, be communicated to the membrane of the round hole: but, in the next place, as air is conveyed to the cavity of the tympanum in amphibious animals where the round hole and cochlea are wanting, we muſt ſuppoſe that the tremor of the air in the tympanum ſerves to influence the foot of the ſtapes and membrane of the oval hole; or that two different impreſſions are made on the membrane of the oval hole.

We ought farther to conſider, that in the amphibia the tremor of the chain of ſmall bones will be much leſs interrupted by air than it would have been by a watery liquor filling the cavity of the tympanum.

From the membranes of the oval and round holes the impreſſion of ſound is undoubtedly conveyed to the portio mollis by the medium of a watery liquor, which fills the cavities of the veſtible, ſemicircular canals, and cochlea, in all animals.

When we now compare the mammalia and birds with the amphibia and fiſhes, we underſtand the reaſon of ſome principal differences of ſtructure.

The whale, though he ſeems at firſt ſight amphibious, has the ſame ſtructure of heart and lungs as man; and is therefore obliged to breathe air frequently and regularly, and to live chiefly upon the ſurface of the ocean. Hence his ear is calculated to receive ſound from the air by an external meatus.

But in the amphibia, where a part only of the maſs of blood paſſes through the lungs, and which therefore poſſeſs the power of breathing arbitrarily, or of plunging under water, and ceaſing from breathing for a length of time †, the ear is conſtructed ſo as to receive the firſt impreſſion either from the air or from the water; but by means of an Euſtachian tube, air is introduced into the cavity of the tympanum when they breathe; and through it the impreſſion is conveyed from the atmoſphere, to which their ears are generally expoſed, to the bottom of the ear with more force than it would have been by the medium of a watery fluid ſecreted into the cavity of the tympanum.

In fiſhes, living in and breathing in water, not only the impreſſion of ſound on the ſurface of the ear is tranſmitted by the water, but is of neceſſity conveyed by

† I have obſerved a turtle keep under water for three quarters of an hour; and I have found that it requires five or ſix hours to drown a frog.

by the ſame medium to the bottom of the ear. Hence it is evident they have no occaſion for a cavity of the tympanum nor for an Euſtachian tube.

At the bottom of the ear we find in all fiſhes ſemicircular canals, ſimilar in ſhape and ſituation to thoſe found in the mammalia, but much larger and more extenſive in their ſurface; in order, perhaps, to compenſate for the leſs forcible impreſſion made by the water in them than in us by the air.

Connected with the ſemicircular canals, we find ſacs containing cretaceous matter, which perhaps we may think have as much reſemblance to the cochlea as to the veſtible in our ear, if we reflect that in birds the place of the cochlea is ſupplied by a ſhort ſtreight tube.

The cretaceous matter, which in the piſces of Linnæus, and ſome of his nantes pinnati, forms hard and rugged ſtones, may ſerve, like the ſmall hard bones of our ear, to convey a more forcible impreſſion to the nerves ſpread out on the membranes which contain them.

Several of the cartilaginous fiſhes, the raja, ſqualus, &c. have a meatus auditorius externus, through which the ſound is conveyed by a watery viſcid liquor to the inner ſides of the membranes of the ſemicircular canals and ſac or ſacs containing the cretaceous matter: but in the piſces of Linnæus, and in ſome of his nantes pinnati, as the ſturgeon, I have not yet found a meatus auditorius externus; and as I farther obſerve, that the common canal or veſtible, where the three ſemicircular canals communicate, is ſeparated from the cavity of the cranium by a thin membrane only; and that this cavity, in by far the greater number of fiſhes, contains a watery liquor in conſiderable quantity; and that, from the thinneſs of the cranium, the tremor excited by a ſonorous body may be as readily tranſmitted through their cranium to the water within it, and ſo to the ear, as through the temple of the turtle to his ear; I am more inclined to ſuppoſe, that in them there is no meatus auditorius externus, than that, from the want of ſufficiently accurate inveſtigation, it has not as yet been diſcovered.

CHAP.

CHAPTER XI.

Of the EYES in FISHES.

IN treating this ſubject, I ſhall firſt make ſome curſory obſervations on the coats, and afterwards conſider the humours of the eye, their texture, ſpecific weight, ſhape, and powers of refraction.

In fiſhes, birds, and in all animals in which objects often impreſs one eye ſolely or chiefly, the optic nerve is, as *à priori* we might have ſuppoſed, much more eccentrick than in man.

I have in a former work obſerved (*a*), that the retina terminates in man near to the roots of the ciliary proceſſes; which circumſtance is equally obſervable in fiſhes.

In all fiſhes, ſo far as I have obſerved, the pigment on the inner ſide of the choroid coat is, as in land-animals which ſeek their food in the night-time, of a bright colour at the bottom of the eye; perhaps becauſe the light ſtrikes the bottom of their eye with leſs force than in the land-animals, many of its rays being intercepted by the water. To account, however, for the diverſity of the colour of this pigment, or tapetum as it has been called, in the different genera of animals, ſeems to be a matter of much difficulty. Nay, it may be a queſtion, whether the chief uſes of the choroid coat in any animal have been clearly aſcertained; or whether we certainly know in what manner the choroid coat is ſubſervient to the retina. Perhaps attention to the powers of the eye in two animals which are mere varieties of the ſame ſpecies, may ſerve to throw farther light on this curious ſubject; I mean the brown and the white rabbit: for in the former, the choroid is every where covered with a dark pigment; whereas in the latter, although the choroid coat is as much compoſed of veſſels as in other animals, I have found that the black paint, tapetum, or inner layer of the choroid, is altogether wanting: And hence the colour of the red blood circulating in the veſſels of the choroid is ſeen when we look into the eye, or makes their eyes appear red †.

(*a*) On the Nervous Syſtem, chap. xxi.

† In juſtice to an ingenious and diligent ſtudent of phyſic, Mr William Roſs, I think it proper to obſerve, that I was led to examine this curious circumſtance by a letter I received from him in ſpring 1781; in which he alledged that the choroid coat was altogether wanting in the white rabbit. In a ſecond letter, above ſix months thereafter, he retracted as an error what he had wrote to me. In the mean time I had found, that although they have the choroid coat, the pigment is wanting. It would be worth while to examine the choroid coat in the mixed breed between the brown and white rabbit.

The iris, though not the continuation of the choroid coat, reſembles it in being covered on its inner or back part by a dark pigment; but it has the addition of a coloured matter laid over its fore part; and theſe concealing its veſſels and their contents in a living animal, ſeveral eminent authors, whom Dr Haller follows, have entertained the erroneous idea, that the arteries of the iris in man and quadrupeds do not in life convey the red part of the blood, but the lymph alone; and that they are colourleſs or lymphatic (*b*). Yet thoſe very authors admit, that the arteries of the iris may be filled with an injection coloured with the powder of vermilion; and Dr Haller in particular has delineated the large branches of thoſe arteries in a very juſt and elegant manner as they appear to the naked eye (*c*). By what power or mechaniſm, then, could he, Mr Ferrein, and others, conceive the red blood to be excluded in life?

The plain facts here are, as I have repeatedly obſerved, 1*ſt*, That by a ſkilful injection the whole iris, to the very edge of the pupil, may be made nearly as red as a piece of ſcarlet cloth. 2*dly*, That the whole courſe of the blood, from the trunk of the ocular artery to the arteries of the iris, may be traced with the naked eye. 3*dly*, That if any part of the iris be cut or punctured in a man, which I have ſeen happen in the attempt of extracting the cryſtalline lens, red blood immediately flows from its veſſels. Nay, in one ſuch caſe, a red-coloured fungus, rooted in the iris, afterwards puſhed out at the wound in the cornea.

In one kind of fiſh, the ſkate, the upper part of the iris in the horizontal poſture is formed into a beautiful palmated proceſs (*d*); which it is probable the animal has the power of elevating and depreſſing according to the quantity of light; and perhaps he lets fall this curtain in time of ſleep. It may likewiſe be worth while to obſerve, whether the mind of the animal, independent of the degree of light, poſſeſſes ſuch a power over it as I have very long ago obſerved to be exerciſed by the parrot; which, in an obſcure light, opens and ſhuts the pupil alternately when agitated by paſſion.

In man, the cornea is, beyond doubt, covered with the continuation of the ſkin; which in the ſound ſtate poſſeſſes a conſiderable degree of ſenſibility, and, when irritated by extraneous ſubſtances ſticking in it, occaſions, as I have ſeveral times ſeen, violent inflammation of the whole eye; in conſequence of which, ſpecks, full of veſſels containing red blood, are often produced upon the cornea: and, what is remarkable, and uſeful to be attended to by the oculiſt, theſe veſſels, from whatever cauſe produced, are, ſo far as I have obſerved, not the original veſſels of the cornea running between its layers, dilated by the inflammation, but are new veſſels growing from the veſſels of the tunica adnata, and extended over the external ſurface of the cornea. Hence we perceive the propriety of attempting to remove theſe by operation and external applications (*e*).

The

(*b*) Ruyſch, Vieuſſens, Ferrein, Mem. de l'Ac. 1739. Haller, Phyſ. t. v. p. 439.

(*c*) Haller, Faſcicul. VII. Tab. VI. fig. 4. 5. 6.

(*d*) See Tab. VII. fig. 3. 22.

(*e*) Dr Haller, El. Phyſ. L. xvi. p. 362. unjuſtly denies the ſenſibility of the cornea: "Neque ſenſus ſigna aut homo edit, aut "animal," &c.

The inner part of the cornea ſeems to be lined with a thin very denſe membrane, fit for confining the aqueous humour. But in man and quadrupeds it is very difficult to ſeparate theſe coats of the cornea from each other; whereas in fiſhes they may be ſeparated with the utmoſt eaſe.

The humours of the eyes of fiſhes are proportionally in greater quantity, or much larger, than thoſe of animals living in air. Thus the eye of the cod is very nearly of the ſame weight and depth, and its axis of the ſame length (*f*), as the eye of the ox. On this account I have, in the following experiments, made chiefly the compariſon of thoſe with each other.

As the rays of light ſuffer great refraction in paſſing from the rare medium of air into water, the cornea of land-animals is very convex. From this they poſſeſs alſo two other advantages; that a ſmall motion of their iris excludes the ſuperfluous quantity of light; and that their cryſtalline lens needs not be very convex, and may therefore be placed at a diſtance from danger.

But as there is little or perhaps no refraction of the light paſſing from ſalt-water into the aqueous humour of the eyes of fiſhes, their cornea has little convexity, and perhaps would have been altogether flat, but that a quantity of aqueous humour is neceſſary for giving room and protection to their very convex cryſtalline lens, and for allowing the motion of the iris. Nay, in one animal, which makes the neareſt approach to this claſs of animals, the ſepia loligo, I have found the cryſtalline lens attached to the cornea, and the aqueous humour and iris altogether wanting (*g*).

The cryſtalline lens is known to be compoſed of concentric layers, and theſe of fibres; and the central part being harder than the ſurface of the lens, has been called its nucleus. But it may be obſerved, that the hardneſs does not increaſe from the ſurface to the centre in a perfectly equable manner; but that, at the depth of one third nearly of the diſtance of the ſurface from the centre, there is a ſudden increaſe of the hardneſs of the lens: So that if the capſule of the lens be ſeparated from a number of lenſes of the ſame kind of animal, and the lenſes rolled between the thumb and fingers in a baſon-full of water, with the view of detaching the ſoft ſuperficial parts, the nuclei of all the lenſes will remain nearly of one ſize; and their diameter will be to the diameter of the entire lens nearly as two to three.

After repeatedly comparing together the ſpecific gravity of the aqueous, the cryſtalline, and vitreous humours of the ox and cod, by weighing them in air and water, I found their proportional weight to be as follows:

	Parts.
Spring-water,	1000
Aqueous humour,	1000
The vitreous humour of the ox,	1016
The vitreous humour of the cod,	1013

The

(*f*) Dr Porterfield, and others, miſtake in ſuppoſing the eyes of fiſhes to be flatter behind, as well as before, than the eyes of land-animals.—Porterfield, v. ii. p. 262.

(*g*) See Tab. XLI. fig. 3. *r. u.*

	Parts.
The whole cryſtalline lens of the ox,	1104
The whole cryſtalline lens of the cod,	1165
The outer part of the cryſtalline lens of the ox,	1070
The outer part of the cryſtalline lens of the cod,	1140
The nucleus of the cryſtalline lens of the ox,	1160
The nucleus of the cryſtalline lens of the cod,	1200

On comparing the cryſtalline lens of the ox with that of the cod, I found that they were very nearly of the ſhape delineated in Table XL *. fig. 1. where the outermoſt dotted lines repreſent an horizontal ſection of the lens of the ox, and the continued lines the ſame of the cod: and they meaſured one-fourth part of the diameter repreſented; or one-tenth of an inch in this figure repreſents one-fortieth of an inch in their cryſtallines: Or I found the radii of the ſpheres which compoſe the lens in theſe two animals to be in fortieths of an inch nearly as in the following table.

The radius of the anterior part of the lens of the ox,	21
The radius of the anterior part of the lens of the cod,	14
The radius of the poſterior part of the lens of the ox,	15
The radius of the poſterior part of the cod, which is nearly an hemiſphere †,	$13\frac{11}{20}$

In the laſt place, I found that the focus of the rays of the ſun, which was nearly $\frac{1}{40}$th part of an inch in diameter, was diſtant from their poſterior part,

In the ox, $\frac{11}{40}$ of an inch;

But in the cod, not more than $\frac{1}{40}$.

And I obſerved that the diſtance of the focus from the ſurface of the whole lens, or from that of the nucleus in the cod, was nearly the ſame.

The focus of the nucleus of the lens of the cod placed in water was about $\frac{16}{40}$ of an inch diſtant from its back part.

Hence it is evident, that the cryſtalline lens of the cod, but eſpecially its nucleus, is much more denſe, and refracts light more readily, than that of the ox: nay, that its refraction, inſtead of bearing proportion merely to its ſpecific weight, with ſome little addition on account of its containing inflammable matter, which is the common ſuppoſition ‡, is more powerful than that of common

† The celebrated Dr Petit has, in the Mem. de l'Acad. 1730, p. 9. deſcribed the breadth and thickneſs of the cryſtalline lens, particularly of the ox, and the radii of the ſpheres which compoſe it, with ſo much appearance of accuracy, that his deſcriptions have been univerſally received by authors: Yet I have not only obſerved by meaſuring, that the lens of the ox is much more convex on both ſides than he repreſents it; but it will be found impoſſible, with ſuch radii, to deſcribe a lens of the breadth and thickneſs he himſelf aſſigns to it. When we aſſume his radii and breadth, a much flatter lens than that of the ox is produced; and which the innermoſt dotted lines I i L m repreſent in Tab. XL *. fig. 1.

Nay, it is demonſtrable, that he has erred greatly in every example in his Table of the human lens, as well as in that of the lens of the ox, his radii not correſponding, in a ſingle inſtance, with the breadth and thickneſs of the lens he found by meaſurement.

‡ Dr Porterfield, v. i. p. 232. § 9. p. 278. &c. Pemberton. Haller, El. Ph. l. 16. p. 402. Neque vitri habebit vim refractilem..... Parvam eſſe qua aquam ſuperat prærogativam nuperi fatentur.

common glaſs: for the nucleus of the lens of the cod, which is nearly ſpherical, forms its focus at the diſtance of a little more than one-ſixth part of its diameter; whereas parallel rays of light, paſſing from air through a ſphere of glaſs, are not collected into a focus till they are one-fourth of its diameter diſtant from its poſterior part.

The lateſt and moſt eminent writers on the eye have taught, that a principal uſe of the ſpherical figure of the cryſtalline humour of fiſhes, is to enable it to collect the rays of light more powerfully, or nearer to the fore part of the eye, than could be done by a lens compoſed of two ſmall portions of a ſphere †.

But on caſting the eye on Table XL*, fig. 2. it appears, that the focus of a ſphere is nearly, but not exactly, for the proportion varies according to the medium, as much more diſtant from its anterior part, than the focus of a lens compoſed of two portions of the ſame ſphere, by as much as the thickneſs or diameter of the ſphere is longer than the thickneſs or axis of the lens.

Nay, from the ſame figure it is evident, that a lens, the axis or thickneſs of which is equal to the radius, and its breadth equal to the diameter of the ſphere, and compoſed therefore of two portions of a larger ſphere, has its focus conſiderably nearer to its fore part than the ſphere has.

Upon the whole, therefore, we are led to the concluſion, That the primary uſe of the almoſt completely ſpherical figure of the cryſtalline lens of fiſhes, or great convexity eſpecially of the anterior part of their lens, which I find projects in the cod about ſeven fortieths of an inch beyond the iris, is to take in a large field of the objects around them; which was particularly neceſſary, as the motion of their neck is inconſiderable.

To enable them, with the ſame length of the axis of the eye as in the quadruped, to collect into a focus on the retina the rays of light coming from the denſe medium of water, four chief circumſtances concur.

In the firſt place, We obſerve that their cryſtalline lens is more convex, or compoſed of portions of ſmaller ſpheres, than in land-animals.

In the next place, We have found that their cryſtalline lens is, in correſponding parts, much more denſe than in animals which live in air.

Thirdly, That the lens in fiſhes poſſeſſes powers of refracting light far beyond what have been calculated by authors, who have proceeded on the ſuppoſition that theſe powers were proportioned nearly to its ſpecific gravity.

In the laſt place, The vitreous humour of fiſhes being lighter than that of land-animals, the rays of light iſſuing from their lens will be refracted in a greater degree, or brought ſooner to a focus ‡.

† Dr Porterfield on the Eyes, v. ii. p. 261, 262. Dr Haller, El. Phyſ. L. xvi. p. 468. Hinc piſcibus, quorum radii minus refringuntur, lens pene ſphærica.

‡ Dr Haller, on this ſubject, Pr. Lin. Phyſ. DXXXVIII. and in Elem. Phyſ. t. v. p. 467. commits the overſight of ſuppoſing, that becauſe the vitreous humour is more rare than the cryſtalline lens, it will have the effect of making the rays longer of coming to a focus; whereas the leſs its denſity is ſuppoſed in proportion to that of the lens, the more the rays will be refracted and the diſtance of the focus leſſened. Hence the vitreous humour is made viſcid and heavy, merely becauſe a cuſhion for ſupporting the lens at a proper diſtance from the retina was neceſſary.

I cannot conclude without obſerving the probability, that attention to the denſity, ſhape, refracting powers, and connection of the humours of the eyes of animals, may lead to the ſtill farther improvement of optical inſtruments.

CHAPTER XII.

ANATOMY of the SEPIA LOLIGO.

TO this account of the ſtructure of fiſhes, I ſhall ſubjoin a deſcription of that of the Sepia Loligo; which I have found not leſs remarkable in its internal ſtructure than in its external ſhape. By moſt authors it has been ranked among the fiſhes; by Linnæus it has been placed among the worms; but perhaps it may moſt juſtly be conſidered as a link connecting theſe two claſſes of animals.

The ſepia loligo, which wants fins, has a triangular-ſhaped tail (ſee Tab. XLI. fig. 1. A A), and a hollow conical-ſhaped muſcular ſheath, which incloſes its thoracic and abdominal viſcera; reaching from its throat, where it is open and admits the ſea-water freely, to its tail, where it is ſhut. This ſheath cut open is repreſented at B B.

Near the mouth of the great ſheath there is another fleſhy conical funnel C, wide behind and narrow before.

The ſepia I laſt diſſected had ten arms D D D, &c. with a great number of cups E E E on each; by means of which it fixes itſelf to a rock; and with a beak F, like that of a parrot, it breaks the ſhells of the ſea-worms on which it feeds.

From the mouth the œſophagus G G fig. 3. runs ſtraight down, covered behind by its principal bone, or os ſepiæ, to end in a very muſcular ſtomach H, fig. 1. ſituated near the tail.

From the fore part of the ſtomach, very near its cardia, the inteſtinal canal, I, begins; and after making a very few turns, ends in the rectum K K, which runs ſtraight upwards on the fore part of the liver, and opens about the root of the fleſhy funnel C.

The liver M M is of great ſize, and is ſituated lengthwiſe on the fore ſide of the œſophagus.

On the fore ſide of the liver, between it and the rectum, the ink-bag N is ſituated, tied to both. This bag is of a conical ſhape, and of conſiderable ſize.

The

The duct from it, O, runs upwards between the liver and rectum, parallel with the rectum; into which, very near the anus, it diſcharges itſelf.

As I did not obſerve any other bladder connected with the liver, I ſuppoſe that the ink is the gall of this animal; yet while I was detaching the ink-bag and its duct from the liver, I did not obſerve that any gall-ducts were cut, nor could I perceive, on ſqueezing the liver or ink-bag, that any gall or ink was effuſed. Still, however, conſidering the ſituation and connection of the ink-bag, this is perhaps not an improbable conjecture. If ſo, we are led a ſtep farther; I mean, that as in this animal the bile does not ſerve any of the purpoſes commonly aſſigned to it, but is thrown out merely to aſſiſt the animal in making its eſcape, there is ſome reaſon to ſuſpect, that one principal uſe of the liver may be to drain off from the conſtitution ſome matter that is hurtful to it, or that the bile is an excrementitious liquor.

Notwithſtanding the great ſize of the liver, I did not obſerve any organ analogous to the ſpleen.

When we review the parts that have been deſcribed, it ſeems propable that the animal may puſh its body forwards by the motion of its tail. But if the tail is at reſt, and the large outer ſheath ſtrongly and ſuddenly contracted, the reaction of the water within the ſheath will throw the whole body of the animal backwards, whilſt, at the ſame inſtant, the ink will be thrown out of the bag, and perhaps directed and thrown with ſtill greater force by the action of the muſcular funnel C.

If the tail be directed upwards, it is plain that the animal may, by ſuch an exertion, jump upwards out of the water, and ſtill more readily make an eſcape from its enemy.

Between the abdominal bowels and the back-bone I obſerved a large thin-coated bag P, which in the firſt ſepia I examined was empty, and ſeemed to reſemble the ſwimming-bladder of fiſhes: but in others I diſſected afterward, I found it filled with a watery liquor, and a paſſage or duct into it from a glandular-looking organ; from which I ſuppoſe it to be the bladder of urine (*b*).

On the under fore part of the liver and ink-bag, I remarked a glandular-looking organ LL, conſiſting of a number of minute lobes; which I ſuſpected to be the ovarium of this animal.

In another larger ſepia, I found a conſiderable ſac, with a large and long duct from it, which terminated near the anus; and from which, on a ſlight preſſure of the ſac, vermiform bodies were diſcharged (*i*). Whether theſe are portions of the organs of generation, which, after ſome degree of putrefaction, were detached in this tender animal by ſlight preſſure; or whether theſe bodies are naturally diſcharged in the production of the young, future obſervation muſt determine.

The gills or lungs of this animal are two conical-ſhaped bodies QQ; one fixed

(*h*) See Tab. XLII. PQRS.

(*i*) See Tab. XLII. MNO, and two figures at the ſide of the Table.

fixed on each ſide to the inner part of the looſe muſcular ſheath, between it and the abdominal bowels.

Each of theſe gills is provided with a heart for driving the blood through it; in conſequence, perhaps, of the diſtance from each other at which the gills are placed. Another ſingularity occurs, that the branchial or pulmonary veins, or veins returning the blood from the gills, inſtead of joining together to form the aorta, as in fiſhes, run into different ſides of a muſcular ſac or ventricle, ſhaped like an egg; from the two ends of which the aortæ are ſent out.

Hence there are in this animal three hearts or organs for reſtoring momentum to the blood: of which, with their veſſels, I ſhall now give a more particular deſcription, beginning with the venæ cavæ.

The anterior vena cava (*k*), R, is placed under the liver, contiguous to the rectum; and receives branches from the arms and the head S, the liver T, the ovarium, the ſtomach, inteſtines, and from ſome ſhare of the upper and back part of the body V V.

Near to the back part of the liver, the anterior vena cava divides into two equal branches W W, which meet with two large veins X X from the under and poſterior part of the animal, and which are analogous to the poſterior venæ cavæ of fiſhes. The cavæ, where they meet, have a degree of reticular work, or corneæ columnæ et foveæ, on their inner ſide; and from their meeting, ſacs Y Y, of the ſame ſize and ſhape on right and left ſides, are produced; or on each ſide an oblong bag is formed, analogous to our right auricle; and both bags are incloſed in one large membranous ſac or pericardium. To each of the auricles a ventricle Z Z is connected, of the ordinary conical ſhape, and incloſed in its proper membranous bag or pericardium.

From each ventricle an artery *a a a a* is ſent out to the correſponding gill.

When the ventricle of the heart and this artery are cut open, the communication between the auricle and ventricle is found to be of a round ſhape, fig. 2. *b*; and a riſing fleſhy edge *e*, on the outer ſide of it between it and the artery, ſeems to ſerve the office of a valve.

At the beginning of the artery *a* three valves *d* are formed, reſembling the valves in fiſhes.

The artery of the gill, or pulmonary artery *a a*, fig. 1. is remarkably large in proportion to its correſponding vein *e e*.

The pulmonary veins terminate near the middle of a thick fleſhy ſac *g*, which produces a conical end both on the fore and back parts, or reſembles two cones joined together by their baſes. From the fore end of this conical ventricle a large artery *b* is produced, which may be called the anterior or aſcending aorta.

The artery from the back end of the ventricle or poſterior aorta *i*, is conſiderably ſmaller than the anterior.

When this ventricle and theſe two arteries are ſlit open (ſee fig. 2.), a pair of mem-

(*k*) See Table XLI.

membranous valves, like thoſe at the termination of our thoracic duct, are found at the termination of each of the veins of the gills *k k*.

At the beginning of both aortæ there are membranous valves *l l*.

The anterior aorta ſupplies the arms, the head, the liver, the muſcles above the back-bone *m*, the alimentary canal (ſee fig. 1. *n*), and the organs of urine and generation.

The poſterior aorta gives ſmall branches to the two pulmonary hearts *o o*, and to the ink-bag *p*, and then runs towards the tail and under part of the outer muſcular ſheath *q*, ſupported by a double membrane *r*, which fixes the abdominal viſcera to that ſheath.

From all the branches of the aorta the blood returns directly by the two venæ cavæ to the pulmonary hearts; for there is no vena portarum as in fiſhes.

The eyes (ſee fig. 3. 1, 1,) are very large, and have broad eye-lids. The vitreous humour has the uſual appearance: but the cryſtalline *t* is incloſed behind in a ſofter ſubſtance or coat *u*; and before is glued by a hard plate to the cornea, without the intervention of the iris or aqueous humour. So that the cryſtalline lens conſiſts of three different parts or pieces.

Between the eyes a ſoft ſubſtance is found, which I ſuppoſe to be the brain *v*, and which is placed immediately above the œſophagus G G. To it two large lobes *x x*, ſomewhat firmer than the middle part, are cloſely connected, whether cerebral or muſcular parts I am uncertain; and from or through them the optic nerves *y y* run to the bottom of the eye.

The middle part of the brain is connected by crura to two lobes *z z*, placed lower and farther back, which ſeem to be analogous to our cerebellum. The left lobe is left bare at *z*.

From the latter a white thread, larger than a briſtle, runs backwards, which has ſome diſtant reſemblance to the ſpinal marrow; but from the ſmallneſs of it, there is a difficulty in determining its nature with certainty or much probability.

Near to the ſubſtance which I ſuppoſe to be the brain, I found a ſmall ſtone which reſembles the ſtone in the ear of fiſhes(*k*); but I have not lately met with one of theſe animals in order to proſecute this obſervation.

(*k*) Tab. XLII.

CHAPTER XIII.

ANATOMY of the ECHINUS MARINUS.

IN treating of the abſorbent veſſels of the ſkate fiſh, I obſerved that the firſt origin, by open mouths, of ſome of its cutaneous abſorbents, could be demonſtrated by injecting liquors from the trunks into the ſmaller branches of certain lymphatic veſſels; and I mentioned abſorbent veſſels proper to one of the claſs of worms, to wit, the Sea-egg or Echinus eſculentus of Linnæus, G. 299. S. 1. which I had diſcovered and read an account of to the Philoſophical Society of this place in Auguſt 1761. I ſhall therefore add, as an Appendix to this work, the deſcription of this very curious animal.

I was led to examine the ſtructure of it, by having been appointed by the Philoſophical Society of Edinburgh to report to them my opinion of a paper on the ſubject, which had been preſented to the Society in November 1760 by the late ingenious Dr Thomas Simſon ſenior of St Andrew's.

The Doctor, in his paper, which was afterwards withdrawn, dwelt chiefly on the want of brain in this animal; from which he thought additional force was given to the doctrines he had publiſhed in his Eſſays on the Vital and Involuntary Motions.

I entitled my Paper, Further OBSERVATIONS on the SEA-EGG or ECHINUS.

Since that time, I have traced with greater accuracy ſome particulars in the ſtructure of its parts; which, though few in number, are ſo ſingular and remarkable, that the knowledge of them ſerves to enlarge our views in intereſting points of phyſiology.

THE ſhell of the Echinus is covered with a ſkin, and has many thouſand thorns articulated with it by means of muſcular ligaments (*l*): Hence the thorns ſerve in place of feet; and are ſo tenacious of their powers, that I have ſeen the pieces of a broken ſhell walk off in different directions. Yet there is no appearance of any organ like to the brain.

It does not, however, follow that they are deſtitute of nerves; ſince theſe may exiſt independent of the brain, and be ſo ſmall as to eſcape obſervation.

In the interſtices of the thorns there are three kinds of bodies, ſoft at the ends, ſupported on calcareous ſtalks incloſed in a membrane, and articulated with

(*l*) See Tab. XLIII. and Tab. XLIV. fig. 3.

with the ſhell by means of muſcular membranes. Not only the roots but the points of theſe bodies, which are ſhorter than the thorns, are in continual motion, poſſeſſing the powers of opening and ſhutting like the fingers of our hand, and having theſe points ſupported by a mixture of cretaceous particles with muſcular ſubſtance (*m*).

Theſe bodies ſomewhat reſemble the antennæ of inſects, and probably ſupply the place of the organs of the ſenſes in the more perfect animals.

The mouth is furniſhed with five teeth, with large ſockets (*n*), which are tied to the ſhell by a very ſtrong membrane; around which there is placed, on the inner ſide of the ſhell, an irregular ſtrong circle of cretaceous matter, from which a pair of muſcles is extended to each tooth, and other muſcles join the ſockets of the teeth to each other (*o*).

The œſophagus (*p*), after running about three inches in length, and being tied by a ligament to the ſide of the anus, makes a turn, and ſoon opens into a wider canal or inteſtine, nearly in the way our ilium opens into the ſide of the colon; and this inteſtine, after deſcribing two waving circles around the ſhell, deſcends to the anus (*q*).

On the under edge, of the whole length of the meſentery, I found two veſſels without valves, nearly equal in ſize and parallel to each other, which I injected with quickſilver (*r*); and from them filled a beautiful net-work of veſſels, not only on the inteſtines (*s*), but diſperſed on fine membranes, which tie the inteſtine to the inner ſide of the ſhell.

I could not, however, obſerve that theſe two veſſels communicated with each other directly, nor by the medium of any organ like to our heart; nor could I obſerve in the living animal any beating organ like to the heart: yet near to the anus, and connected to the rectum, which is the place of the heart in many other worms, I found a ſmall organ W, Tab. XLIII. fig. 2. which ſeems to be hollow.

It appears highly probable, that one of theſe veſſels is the principal artery or aorta, and the other analogous to our vena cava; and that they communicate by inviſible branches, and circulate the blood by the muſcular action of their coats, without the intervention of a heart, nearly in the way the veſſels in fiſhes carry the blood from the gills back to their heart.

In what manner the chylous or lacteal veins communicate with theſe two veſſels, I have not yet been able to diſcover.

In ſome animals, as in the human tænia, or faſciola hepatica in ſheep, the œſophagus, I have obſerved, may be conſidered as the aorta, conveying the chyle or bile directly to all the parts of their bodies: but here it is probable the lacteals

(*m*) Tab. XLIV. fig. 18. 19. 20. 21.

(*n*) See Tab. XLIV. fig. 3. fig. 16. 17.

(*o*) See Tab. XLIII. fig. 1. D. E. Tab. XLIV. fig. 13. 17.

(*p*) Tab. XLIV. fig. 17.

(*q*) See Tab. XLIII. F G H I K L M N O P Q, and Tab. XLIV. G K L Q.

(*r*) See Tab. XLIII. fig. 1. K L M N O P Q.

(*s*) Tab. XLIII. M.

lacteals pour the chyle into that veſſel in the meſentery which is the largeſt, and reſembles our vena cava.

A large roe, which almoſt ſurrounds the rectum, and is divided into five lobes, diſcharges itſelf by as many ducts, which pierce the ſhell near to the anus, after communicating with each other (*t*).

The roe, with the inteſtinal tube, are the chief parts which preſent within the ſhell; and to which that part of the ſtructure, which is by far the moſt intereſting to the phyſiologiſt, and which I am about to deſcribe, may be conſidered as ſubſervient.

BETWEEN the inner ſide of the ſhell and the parts I have been deſcribing, to wit, the inteſtinal tube and the roe, a large quantity of a watery liquor is lodged, which taſtes like ſea-water, and contains a thirty-ſecond part of its weight of ſaline matter; which, chemically examined, was found to conſiſt chiefly of common or ſea ſalt, but with all the other principles which ſea-water contains.

This watery liquor is ſecreted from the ſea-water by means of the following very beautiful ſtructure.

The ſhell of the echinus is pierced with upwards of four thouſand holes, diſpoſed in five pairs of rows or phalanges, which extend from near the outer ſides of the teeth to near the anus.

The holes are diſpoſed on the outer ſide of the ſhell in pairs (*u*); and with each pair an abſorbent veſſel correſponds (*x*).

This abſorbent veſſel, in its collapſed ſtate after the death of the animal, is upwards of half an inch in length. Its end is covered by a flat plate; in the middle of which is a hole, viſible to the naked eye, being about one hundred and twentieth part of an inch in diameter, and very like one of our puncta lachrymalia.

From the outer edge of this plate a number of teeth project, like the teeth on the wheel of a watch.

The flat plate is very tough; contains ſome cretaceous particles; and, when preſſed between the fore teeth, feels almoſt like a plate of talc. It ſeems to conſiſt of a number of pieces joined together; which are broader near its outer edge than at the hole in its centre (*y*).

The duct from this plate to the ſhell is compoſed of pale-coloured circular or tranſverſe fibres in faſciculi or bundles (*y*); and two ſmall bands of ſuch pale-coloured longitudinal fibres are obſervable on oppoſite ſides of the tube (*z*): or its ſtructure reſembles our colon with the muſcular bands called its ligaments.

Theſe fibres, which have the appearance and the action, as we ſhall find, of muſcular fibres, are lined with a membrane.

When we trace the two holes which pierce the ſhell, we find they diverge to

(*t*) See Tab. XLIII. fig. 2. X Y Z.

(*u*) Tab. XLIV. fig. 1. 2.

(*x*) See Tab. XLIV. fig. 3. and 5.

(*y*) See Tab. XLIV. fig. 6. 7. 8.

(*z*) Tab. XLIV. fig. 11. and 12.

to oppoſite ſides of the row or phalanx of holes (*a*), and lead to leaves or doubled membranes, not unlike the proceſſes or ſubdiviſions of the gills of a ſkate (*b*).

When I injected quickſilver into the mouths of the external abſorbent veſſels, I found that it filled and diſtended completely the internal leaves or doubled membranes (*c*).

When, after this injection, I applied a common magnifying glaſs, I could diſtinctly obſerve the ducts by which the quickſilver entered the doubled membrane: nay, I could trace a plexus of communicating branches formed upon it, ſurrounded by a circular veſſel, from which the quickſilver was conveyed by a ſingle tube into a large pipe, nearly one-twentieth part of an inch in diameter; and which ſerves as a trunk, receiving the fluid from one of the pairs of rows or phalanges (*d*).

Each leaf or doubled membrane receives at leaſt two branches from different external abſorbents. Hence we ſee the reaſon why each external abſorbent divides into two diverging branches; that although an accident ſhould deſtroy one of the external tubes, the internal membrane may not be without its ſupply of liquor.

The trunk laſt deſcribed, and there are five ſuch (*e*), divides into two branches, which terminate in large ſacs or receptacles (*f*), over the ſockets of the teeth, communicating with each other: and from theſe the liquor paſſes down the ſockets of the teeth, and is diſcharged into the ſea, on each ſide of the tooth, between the ſocket of the tooth and beginning of the œſophagus (*g*).

The external abſorbent veſſel has not only the appearance of being muſcular, but contracts ſuddenly when touched with ſea-ſalt; and, like an earth-worm, or the proboſcis of an elephant, it poſſeſſes motion in all directions (*h*); and particularly the animal poſſeſſes the power of ſtretching it to the length of an inch and a half, and upwards.

When it is elongated, it becomes much ſmaller; and the plate at its end, which, as I have obſerved, appears flat after death, is puſhed out into a conical form, and the hole in its centre becomes much ſmaller (*i*).

The internal double membrane, with its vaſcular plexus, is likewiſe evidently muſcular, altering its ſhape and ſituation when it is touched rudely with a knife or probe, or when ſea-ſalt is ſprinkled on it.

There are no valves within theſe veſſels: for, from the internal trunks, the plexus upon the doubled membranes, and the external abſorbents, may be filled with injection; or when, after death, the teeth with their ſockets are preſſed inwards, the watery liquor contained in the internal ducts paſſes outwards through the ſhell, and fills the external veſſels.

(*a*) See Tab. XLIV. fig. 1. 2. 5.

(*b*) Tab. XLIV. fig. 13. D E.

(*c*) See Tab. XLIV. fig. 13. D E.

(*d*) Tab. XL IV. fig. 13. D E F, fig. 14. fig. 15.

(*e*) See Tab. XLIII. fig. 1. and 2. R S T U V.

(*f*) Tab. XLIV. G G G G.

(*g*) See Tab. XLIV. fig. 17. E E.

(*h*) Tab. XLIV. fig. 9. 10. 11. 12.

(*i*) See Tab. XLIV. fig. 11. and 12.

No communication of the internal ducts and plexus with the cavity within the ſhell is diſcoverable by the injection of quickſilver.

On reviewing the ſtructure of theſe ducts, there can be no doubt that the ſea-water is abſorbed by the external open-mouthed veſſels, and conveyed from them through the ſhell into the plexus of the internal doubled membranes: from which a ſecretion of part of it is made by inviſible veſſels into the cavity of the ſhell, while the remainder of the ſea-water paſſes from theſe plexus into the five large internal ducts; and from them through the receptacles at the roots of the ſockets of the teeth, to be diſcharged into the ſea by ten apertures at the ſides of the teeth.

We muſt likewiſe ſuppoſe that there is a conſtant change of the water within the ſhell; and that there are therefore abſorbing veſſels which correſpond with the ſecerning. Theſe are inviſible; and whether they terminate in the plexus and five inner ducts, or with the lacteals in the circulating ſyſtem of the animal, may perhaps be a queſtion.

No other individual of the animal kingdom ſeems to afford ſuch an opportunity of inveſtigating the ſtructure of an abſorbent veſſel, and of obſerving how it performs its office.

When the external abſorbent is elongated by the action of its muſcular fibres, it becomes ſmaller in proportion to its elongation; and it likewiſe acquires a tenſion or degree of rigidity. The jointed plate which covers its beginning, is at the ſame time thruſt out into a conical form; and the diameter of the hole or perforation in its middle, inſtead of becoming larger, is ſo very much diminiſhed, as ſcarcely to be diſtinguiſhable with a magnifying glaſs of two inches focus.

While the tube is elongated, and while the plate at its end preſerves its conical figure, I have never been able to obſerve any motion of the ſides of the hole reſembling the motion of the lips or mouth of an animal.

As the tubes are thick coated, and the ſea-water has little colour, I could not perceive it entering the tubes, or moving within them, ſo as to be able, from ocular obſervation, to determine the motions the tubes perform at the time they abſorb.

In a few experiments, I coloured the ſea-water with milk, with indigo, and with madder; but have not yet ſeen theſe colours enter the abſorbents. I am, however, far from deſpairing of ſucceſs in ſuch experiments.

Upon the whole, There ſeems to be little or no reaſon for ſuppoſing, that the ſides of the hole in the plate, at the origin of the abſorbent tubes, open and ſhut the orifice alternately; or that ſuch a motion takes place at our puncta lachrymalia, or at the mouths of the abſorbent lymphatic veſſels I have deſcribed on the ſkin of the ſkate; or that the reception of liquors into theſe veſſels, or in general into the abſorbent veſſels of animals, depends on an action like to that of the lips and mouth of animals in eating.

We

We are, on the contrary, from the facts above ſtated, led to the concluſion, that the abſorbent tube is, by its proper muſcular action, and perhaps alſo by an influx of liquors into the arteries which are diſperſed on its coats, made tenſe, and its cavity at the ſame time much contracted: in conſequence of which it acquires the property of a glaſs capillary tube, of attracting liquors; which, by the well-regulated action of its muſcular fibres, are puſhed onward from their entrance to their termination.

Theſe abſorbent tubes ſerve for the farther purpoſe, which at firſt ſight we ſhould not have expected, of ſeizing and ſecuring the buccina, on which the animal preys.

I was led to ſuſpect this from obſerving, that when I put them into a glaſs-veſſel with water, in order to view the action of their abſorbent veſſels, they fixed themſelves by their abſorbent tubes to the ſides of the glaſs.

It immediately occurred to me, that, by a ſimilar action, they might ſecure the ſhelled worms, on which I knew they preyed, as I had found particles of ſhells in their alimentary canal.

I therefore directed the fiſhermen to bring me, along with the echini, ſome living buccina: to which, as I had ſuppoſed they would do, they attached themſelves ſo effectually, that when I lifted the echinus out of the water, I found it could ſupport with eaſe a buccinum which weighed nearly a quarter of a pound.

Perhaps, for this particular purpoſe, the plate at the mouth of the abſorbent, which they apply as a boy does a piece of wetted leather to a ſtone, is ſo conſtructed as to be made flat; while, for the abſorption of liquors, it is puſhed out into a conical ſhape, and has its orifice contracted.

EXPLANATION

EXPLANATION

OF THE

TABLES.

TABLE I.

THE figures of this Table repreſent the extent of the ſurface of the gills, the heart, the branchial arteries and veins, and the aorta, of a ſkate, filled with injection.

The figures 1, 2, 3 of this Table ſerve to ſhow the extent of the ſurface of the gills of a ſkate.

Fig. 1. Shows a proceſs or diviſion of the gills of its natural ſize.

Fig. 2. Shows the ſame magnified with a glaſs.

Fig 3. Shows the appearance, with a magnifying glaſs, of the leaves into which the proceſſes or diviſions of the gills are ſubdivided.

Figures 4. and 5. of this Table repreſent the heart, the branchial arteries and veins, and aorta, of a ſkate, filled with injection.

FIG. 4. gives a fore view of,

A, The auricle of the heart.

B, The ventricle of the heart.

C, The root of the branchial artery.

D, The place at which the three ſemilunar valves are ſituated (ſee Tab. II. 40.) Between this place and the ventricle the root of the artery has the ſame red colour and texture as the ventricle itſelf; but beyond the valves, the artery becomes much thinner and of a white colour.

E E, The two firſt branches of the branchial artery ſent off at nearly right angles, and each of them dividing into three branches.

K L M, Which are ſpent on the three undermoſt pairs of gills K L M.

F, The continuation of the trunk of the branchial artery, which divides into two equal branches G G; each of which is ſubdivided into two branches H I, which are ſpent on the two uppermoſt pairs of gills H I.

That the courſe of the blood may be more eaſily traced, I ſhall now drop the farther explanation of fig. 4. and proceed to

The EXPLANATION of FIGURE 5.

The ſternum, the heart, and branchial artery, the whole tract of the alimentary canal and chylopoietic viſcera, the baſis of the cranium and bodies of the uppermoſt vertebræ, are cut away, in order to give a full view of the branchial veins and the aorta.

1, Repreſents the mouth.

2, The fore part of the cavity of the cranium, which was filled with a viſcid fluid.

3, The anterior lobes of the brain.

4, A middle cineritious lobe.

5, The cerebellum.

6, The ſpinal marrow.

7, The olfactory nerve.

8, The optic nerve.

9 and 10, Nerves reſembling the third and fourth pairs in man.

11, A very large nerve which reſembles our fifth pair.

12 and 13, Nerves which have ſome reſemblance to our ſeventh and eighth pairs.

14, Nerves reſembling our ninth and ſub-occipital nerves; and below this place the nerves of the ſpinal marrow are ſeen.

15, The inferior or poſterior ſemicircular canal of the ear.

16, 17, 18, 19, and 20, Show the back part of the openings into the throat under and between the gills, through which the water paſſes in reſpiration.

21, The muſcles in the ſide of the fiſh.

22, The fore part of the vertebræ.

23 and 24, The teſticle and epididymis ſlightly ſketched.

25, The termination of the dilated end of the vas deferens or veſicula ſeminalis in the common cloaca.

26, The

26, The kidney.

27, The bladder of urine and urethra of the right ſide.

28, An opening on the outſide of the ſphincter ani, by which there is a paſſage from the cavity of the abdomen.

A A, Repreſents the trunk of the branchial vein in the uppermoſt gill which is ſingle, or has the blood from the branchial artery diſperſed on its under ſide only.

B, The direct continuation of A, which conveys the blood to the noſe and other external parts of the head, ſerving the office of an artery.

C, A communication of A with D, the uppermoſt branchial vein of the ſecond gill, which is double.

E, A trunk formed by C and D joining.

F F, Small arteries ſent off from this trunk to the muſcles and other external parts of the head.

G, A communication of D, the upper branchial vein of the ſecond gill, with H the under branchial vein of the ſame gill.

I, The upper branchial vein of the third gill.

K, A trunk formed by the joining of H and I.

M, A trunk formed by the joining of E and K.

L L, Two large arteries, from which chiefly the top of the ſpinal marrow, the cerebellum, and brain, are ſupplied; and which communicate, freely and repeatedly, with each other. Other ſmall arteries derived from B and F enter the cranium.

N, A large trunk formed by the joining of M M.

O, The joining of I with P, the under branchial vein of the third gill.

Q, The upper branchial vein of the fourth gill.

R, The trunk formed by the joining of P and Q.

S, The communication of the upper and under branchial veins of the fourth gill.

T, A trunk formed by the joining of R R with N; which therefore receives blood from the three uppermoſt gills and one half of the fourth.

U U, Two large arteries from the ſides of T; each of which divides into two principal branches *a* and *b b*; one of which, *b b*, ſupplies the numerous muſcles on the ſide of the fiſh, whilſt the other, *a*, runs upwards on the fore part of the anterior ends of the gills, and there at *c* communicates freely with the outer ends of all the branchial veins *d d d*, which are at the ſame place connected to each other; ſo that they form ovals around the openings between the different gills. From the great branch *a* other arteries are ſent off: for a view of which the reader will now return to the

Further

Further EXPLANATION of FIGURE 4. in which P repreſents the Branch *a* of Figure 5.

From P are ſent off,

QQQ, Branches dividing into ſmaller parts upon the outer ſides of the gills; and which appear to me analogous to our bronchial arteries.

RRRR, The branches which ſink deep, and in Fig. 5. were ſeen joined to the branchial veins at the outer end of the ovals they form.

SS, Arteries ſent to the pericardium and heart, analogous to our coronary arteries.

TU, The termination of this artery in the muſcles and other parts of the upper jaw.

The reader will now turn again to the 5th figure, to finiſh what remains to be explained concerning the joining of the branchial veins and courſe of the blood in the aorta.

V, Repreſents the upper branchial vein of the fifth gill, joined to W the undermoſt branchial vein.

XX, A trunk formed by the joining of S V and W.

Y, The trunk of the deſcending aorta.

cd, The cæliac and meſenteric arteries.

eeeeeeeeee, Arteries ſent off to the organs of generation and urine.

ff, Two large arteries to the lower part of the trunk and fins at the ſides of the anus.

g, The termination of the aorta running into the tail, where it is covered and protected by the vertebræ.

TABLE II.

IN this Table the thoracic and abdominal viſcera, with the circulating veins, of a female ſkate cut open, are repreſented.

1, 1, The organs of ſmell.
2 and 3, The upper and under jaws.
4, The œſophagus.
5, The ſtomach.
6, The pylorus.
7, The ſmall gut.
8, The appendix vermiformis or cæcum.
9, The right lobe of the liver.
10, The gall-bladder.

11, The

11, The middle lobe of the liver.

12, The ſpleen.

13, The pancreas.

14, The lower part of the right kidney.

15, The ovarium or egg-bed of the right ſide.

16, 16, The mouths of the two uterine or Fallopian tubes, with probes introduced into them.

17, A white glandular organ, through which the right uterine tube paſſes.

18, The uterus of the right ſide filled with a complete egg.

19, 19, The cavity of the pericardium.

20, The ventricle of the heart turned upwards, after being cut away from

21, The diaphragm.

22, 22, 22, and 23, 23, 23, Two probes paſſed behind the heart into a funnel-like tube, which, below, divides into two branches connected to the œſophagus; by which the cavity of the pericardium communicates with the cavity of the abdomen.

24, Repreſents the lower part of the right vena cava abdominalis; at which place there is a very large receptacle of the blood covered by the ovarium, the root of which only appears here; and even that is imperfectly ſhown.

25, The opening of the renal veins into the cava.

26, Large paſſages by which the two cavæ communicate.

27, The top of the right abdominal cava.

28, A large vein from the muſcles and other parts behind the abdomen.

29, A large vein from the abdominal muſcles and ſide of the fiſh.

30, A large vein reſembling our poſterior external jugular.

31, A receptacle formed by the venæ cavæ hepaticæ; the diameter of which is ten times greater than that of the opening from the receptacle into the cava, into which a probe is put.

32, Dotted lines, marking the ſituation of a tranſverſe vein which joins the right and left venæ cavæ hepaticæ, and receives into it the middle vena cava hepatica.

33, 33, The right internal jugular vein; at the termination of which there is a pair of valves.

34, A ſmall vein, ſomewhat like to our anterior external jugular.

35, The termination of the left vena cava, which is compoſed of branches exactly correſponding with thoſe of the right ſide.

36, The termination of the lacteal and lymphatic veſſels, or of the lymphatic ſyſtem, into the trunk of the great vein which reſembles our ſubclavian, and which next receives the internal jugular vein. At this termination there is a pair of valves, which perform their office with great accuracy. So that the termination of the lymphatic ſyſtem in the ſkate reſembles the termination of that ſyſtem in man, both as to place and ſtructure.

As there are two venæ cavæ of equal ſize, ſo we ſhall find that the termina-

tions of the lymphatic ſyſtem on the two ſides correſpond nearly in all reſpects.

37, 37, Two principal coronary veins of the heart.

38, The meeting of the two venæ cavæ, and their opening into the auricle of the heart.

39, The upper end of the fleſhy cylindrical root of the branchial artery laid open.

40, Three ſemilunar valves; in the middle of each of which there is a round ſubſtance, reſembling in office, but not in ſhape, the corpuſculum Arantii.

41, 41, The two firſt large branches of the branchial artery.

42, The continuation of its trunk.

43, 43, The other two branches by which the branchial artery terminates in the gills.

TABLE III.

This Table ſhows fully the arteries and circulating veins of the chylopoietic viſcera of a ſkate, with a ſlight ſketch of the lacteals, all filled with injection.

AA, The œſophagus.

B, The ſtomach.

C, The pylorus.

D, The ſmall inteſtine.

E, The appendix vermiformis.

F, The common cloaca.

G, The pancreas.

H, The ſpleen.

I, K, L, The right, middle, and left lobes of the liver.

M, The gall-bladder.

N, A glandular body, through which the uterine tube paſſes into O, the uterus of the right ſide.

P, The ſpine.

Q, The aorta deſcendens.

R, An artery like to our cæliac, ſupplying by its branches STUU, the liver, ſtomach, ſpleen, and pancreas.

VW, An artery reſembling our ſuperior meſenteric artery.

XX. The inteſtinal veins.

VZZ, Veins from the pancreas, pylorus, fundus of the ſtomach, and left ſide of the ſpleen.

a a, A large vein formed by the meeting of all the above-mentioned veins.

b b, Veins from the leſſer curvature of the ſtomach and reſt of the ſpleen.

c, The trunk of the vena portarum.

def, Three

def, Three great branches into which the vena portarum divides, and which are diſperſed like arteries in the liver for the ſecretion of the bile.

ghh, A faint ſketch of the lacteals from the ſmall inteſtine.

iii, Lacteals from the fundus of the ſtomach joined by lymphatics from the ſpleen and pancreas.

k, A plexus where the above-mentioned lacteals and lymphatics communicate.

ll, Lymphatics from the ſpleen and lacteals from the leſſer curvature of the ſtomach.

m, Lymphatics from the gall-bladder.

nn, Lymphatics from the liver.

o, Lacteals from the œſophagus.

pq, A large and intricate plexus of the trunks formed by all the above-mentioned lymphatics and lacteals, which runs upwards and forwards between the œſophagus and ſpine connected to the cæliac and meſenteric arteries.

TABLE III*.

THIS Table repreſents the muſcular coat of the root of the ſuperior meſenteric vein of an Ox, where it is about to join with the other veins, to form the vena portarum.

A, The outer ſurface of the root of the ſuperior meſenteric vein of an ox.

B, The external layer of the muſcular coat, which conſiſts of longitudinal fibres; raiſed from C, the internal layer of the muſcular coat, which conſiſts of tranſverſe or circular fibres.

TABLE IV.

IN this Table the lungs, the heart, and large veſſels of a ſea-tortoiſe or turtle, are repreſented. The heart and blood-veſſels were filled with wax, and the cells of the lungs with air, and dried before the drawing was made.

A, The trunk of the trachea divided into two branches B C.

D, The lungs on the right ſide entire, and E the cells of the lungs on the left ſide cut open.

F, The right auricle of the heart.

G, The left auricle.

H, The right ventricle.

I, The left ventricle.

K K, The left pulmonary artery.

L, The right pulmonary artery.

MNO,

M N O, Three arteries which ſupply the place of our aorta.

P, Branches of the coronary artery which comes off from M.

Q R, The right and left pulmonary veins.

The two venæ cavæ, with the coronary vein, open into the back part of the right auricle.

TABLE V.

THIS Table repreſents, in a cod fiſh, the upper end of a large lymphatic veſſel ſituated on the ſide of the fiſh; and likewiſe mucous ducts, from which branches are ſent off that terminate on the ſurface of the ſkin.

1, 2, 3, The upper and under jaws and the mouth.

4, The right eye,

5, The gill-flap.

6, The fin on the ſide.

7, The fin on the back.

8, The termination of a large lymphatic, which begins at the tail, and runs upwards on the ſide of the fiſh, receiving its branches from the ſkin and muſcles of the trunk at nearly right angles. The pairs of its branches are here ſeen.

9, The upper end of a mucous duct, which runs upon the ſide of the fiſh nearly parallel with the laſt lateral lymphatic, and which has numerous ſhort branches, with open mouths, which pour out mucus upon the ſurface of the ſkin.

10, 11, 12, 13, 14, 15, 16, 17, Show the continuation of the ſame mucous duct cut open, dividing at 11 into two great branches, which have blind ends at 15 and 17, and at 12 communicate with ſimilar ducts on the other ſide of the head.

18, 18, 18, &c. Are ſhort branches, with open mouths, which pour out mucus upon the ſurface of the ſkin.

19, 19, 19, Another large mucous duct, which is ſhut at both ends, and has no communication with the former; and which diſcharges its mucus upon the ſurface of the ſkin of the under jaw by nearly the ſame number of open mouthed ſhort branches 20, 20, 20, 20, 20, &c. as have been ſhown under the eye terminating on the ſurface of the upper jaw.

TABLE VI.

THIS Table repreſents chiefly the mucous ducts on the fore part of a Skate.

1, 1, The noſe.

2, 3, The two jaws with the teeth.

4, 5, 6, 7, 8, Five openings or ſpiracula on the left ſide, to wit, one under each of the gills.

9, The centre from which innumerable mucous ducts come out, like rays from the centre of a circle.

10, 11, 12, Bundles of mucous ducts running outwards to different parts of the ſurface of the body.

13, 14, A large bundle of the mucous ducts running inwards, to open on the ſurface of the ſkin of the breaſt. At 14 many of their openings appear with briſtles introduced into them.

ABCCCCDEFGHIKL, Large and picturesque canals, which naturally contain mucus, injected with wax; and which are ſo diſtinctly ſeen, that it is needleſs to be very particular in the deſcription of them. A, is a blind end. CCC, are a few ſhort branches, which by open mouths pour out mucus on the ſurface of the ſkin. From H a large branch is ſent to the back part of the ſnout. From K the mucous duct makes a turn to the upper and back part of the fiſh.

TABLE VII.

THIS Table repreſents the mucous ducts on the back part of a Skate, and its meatus auditorii externi.

FIG. 1. AB, Two round holes, which make the beginning of the paſſage into the ear. Behind theſe the head is joined to the ſpine.

FIG. 2. Repreſents in a ſkate the paſſage through the ſkin into the concha of the ear; the concha laid open, and the beginning of the meatus from it to the internal ear, all ſeen from the under or anterior ſide.

a a, Probes in two holes through the ſkin, leading into the conchæ of the ear.

b b, The beginnings of the conchæ, of a funnel-like ſhape.

c c, The winding of the conchæ.

d, A probe paſſed from the right concha into the beginning of the meatus from the concha to the internal ear.

e, The beginning of the left meatus cut open.

f, The ſeptum between the conchæ or external ears.

FIG. 3.

1, The ſnout.

2, 2, The eyes, in which a digitated portion of the iris is imperfectly ſeen; which, like a curtain, may darken the pupil.

3, 3, Two large paſſages into the throat.

4, 5, Two ſmall holes, which make the beginning of the paſſage into the ear.

6, 7, At 6 a probe is put in; at 7 an inciſion is made, where the end of that probe is directed outwards and downwards; by which means a large cavity and winding paſſage from it are ſeen, reſembling the ſcapha and concha of our ear. A thick membrane ſeparates the two conchæ from each other.

8, A ſmall hole, capable of receiving a briſtle; which is the beginning of a canal that reſembles our meatus auditorius, and leads into the internal ear.

9, The centre at which all the bundles of ſmall mucous ducts begin on the left ſide.

10, 11, 12, 13, 14, The bundles of mucous ducts in their courſe to diſtant parts of the ſurface of the body.

15, 15, 15, &c. The open mouths of the mucous ducts, with probes put into many of them.

16, 17, A large nerve, dividing into a great number of ſmaller nerves; moſt of which are ſpent upon the ſhut beginnings of the mucous ducts.

Theſe ſmall nerves are white and opaque till they are connected to the beginnings of the mucous ducts, when the nerves become tranſparent like theſe ducts, and ſo diſappear.

G K H, Show the beginning of the ducts G K at H, repreſented in the fore view of the large mucous ducts Tab. VI.

I, Likewiſe repreſents the ſame duct as the fore view did; being ſeen on both ſides from the thinneſs and tranſparency of the dried ſnout of the fiſh.

O, Repreſents a large branch reflected from H, upwards and backwards, and terminating by half a dozen ſmall branches, which have mouths opening upon the ſurface of the ſkin at the fore part of the orbit.

L, Is the mucous duct marked with the letter L in the fore view, and which is here ſeen reflected and ſending off at M M N about ten ſmall branches, which diſcharge themſelves upon the ſurface of the ſkin.

TABLE VIII.

THIS Table, of ſome parts of a Sturgeon, is chiefly intended to ſhow two holes or canals placed at the ſides of the anus, through which liquors effuſed into the cavity of the abdomen may be readily diſcharged; and two other holes, at the bottom of funnels, by which the cavity of the abdomen communicates with the pelves of the kidneys.

In FIGURE 1ſt,

A, Repreſents the upper and B the under part of the milt or teſtis of the male.

C, The inteſtinum rectum entire, and D the anus ſlit open.

EFG, The pelvis of the left kidney cut open in three places, and the orifices of the infundibula, which diſcharge the urine into it, ſeen.

HI, The lower end H of the pelvis of the left kidney, joined with I, the lower end of the pelvis of the right kidney.

K, An outlet or urethra common to the two kidneys.

LM, A membrane, which forms the fore part of a funnel NO, and which, by a hole P at its under part, communicates with the middle part of the pelvis of the kidney.

QR and S, Two probes paſſed from the cavity of the abdomen, out at two holes placed at the ſides of the inteſtinum rectum.

FIG. 2.

In this figure CD repreſent the inteſtinum rectum.

G, Part of the pelvis of the kidney cut open.

QR, A probe put into the hole or outlet from the abdomen which is at the right ſide of the anus.

TABLE IX.

THIS Table repreſents principal parts of the ſtructure of the abdominal bowels in a ſmall female Skate.

FIG. 1.

AA, The fore part of the body.

B, The lower end of the ſtomach.

C, A plexus of the lacteals and cellular receptacle of the chyle.

D, The

D, The valve of the pylorus.

E E, Many doublings or valvulæ conniventes within the ſmall gut, which was ſlit open lengthwiſe.

F, The appendix vermiformis.

G, The right lobe of the liver.

H, The middle lobe of the liver.

I, The left lobe of the liver.

K, The gall-bladder and beginning of the cyſtic duct cut open.

L, A principal hepatic duct.

M, The ductus communis choledochus.

N, Its termination a little under or behind the pylorus.

O, Part of the ſpleen.

P, The opening of the pancreatic duct at ſome diſtance from that of the biliary duct.

Q, An oval mouth, common to the two uterine or Fallopian tubes R R.

S, A ligament which ties that mouth to the diaphragm.

T, The vena cava inferior or poſterior of the right ſide.

U, The place where the two inferior or poſterior venæ cavæ are ſenſibly enlarged, and communicate with each other.

V, One of two large receptacles of blood which communicate with the poſterior venæ cavæ, and behind cover part of the ovaria.

FIG. 2.

In this figure the appendix vermiformis of a very large ſkate is repreſented cut open lengthwiſe.

A A, The ſides of it very thick, compoſed of a fibrous and glandular-looking matter.

B, Cells which ſeem to receive a viſcid mucous liquor prepared by the glandular ſubſtance.

C, The opening from the cavity of the appendix into the cavity of the great inteſtine.

TABLE IX*.

THIS Table is intended to ſhow a beautiful reticular ſtructure of the pancreas, and of the villous coat of the inteſtines, of a Sturgeon.

A, A ſmall part of the ſtomach cut open, and a probe paſſed from it through B the pylorus.

C D, A portion of the duodenum laid open, to ſhow the reticular texture of its villous coat.

E F,

EF, The pancreas laid open, to ſhow the reticular texture of its inner ſide, and the manner in which the ducts from it are conjoined.

At E a layer of muſcular ſubſtance is delineated, covering and incloſing the reticular part.

GHI, Smaller ducts ending in larger.

K, The edge of a large circular opening, by which the pancreas diſcharges its liquor into the duodenum.

TABLE X.

In this Table are repreſented the biliary ducts of a Cod; with the termination of their inteſtinula cæca, which are analogous to our pancreas.

A, Part of the ſtomach ſlit open.

B, The pylorus ſlit open.

C, The duodenum or firſt gut.

DDDD, The mouths of the inteſtinula cæca, analogous to our pancreas.

EEEE, Four hepatic ducts.

GGG, Terminations of the hepatic ducts in a ſpheroidal bag H.

I, The gall-bladder.

K, The cyſtic duct.

LL, A probe in the ductus communis choledochus, terminating in the duodenum.

TABLE X*.

This Table repreſents the liver and biliary ducts of the Wolf or Cat Fiſh, or G. 146. Anarhichas of Linnæus.

AB, The right and left ſides of the liver.

C, The gall-bladder.

D, The ductus communis choledochus running down to the duodenum.

EF, Numerous hepato-cyſtic ducts.

G, Biliary hepatic ducts, terminating in the neck of the gall-bladder and upper part of the ductus communis choledochus.

TABLE XI.

THIS Table repreſents the organs of generation and urine in the male Skate.

A A, The containing parts of the abdomen.
B, The diaphragm.
C, The ſpine.
D, The appendix vermiformis.
E, The common cloaca.
F, A large branch of the left inferior vena cava.
G, A large cavernous receptacle common to the two venæ cavæ inferiores, but communicating chiefly with the right cava.
H, A large probe paſſed from the right cava into the cavernous receptacle.
I I, The two teſticles.
K, A white medullary part of the right teſticle.
L L, Lobes in the teſticles.
M, Threads or tubes, by which the teſtis is connected to the epididymis,
N, Which is compoſed chiefly of convoluted tubes.
O, Part of the epididymis which is not evidently tubular.
P, The ſerpentine vas deferens.
Q, The termination of the dilated end of the vas deferens, or veſicula ſeminalis.
R, A ſac, which contains a viſcid dark green-coloured humour.
S, An opening from R, contiguous to the opening from the vas deferens.
T, The kidney.
U, The ureter.
V, The termination of the ureter.
W X, A ſection of the lobular or glandular part of the teſticle L, viewed with a magnifying glaſs, which is compoſed of minute ſpherical portions.

TABLE XII.

THIS Table repreſents the organs of urine and part of the organs of generation in the male Skate.

A, The bodies of the vertebræ.
B B, The loins, and containing parts of the abdomen.
C, The left kidney.
D, A briſtle put into the ureter on the left ſide.
E, The left vas deferens greatly enlarged at its inferior or poſterior end.

FF,

FF, The termination of the vas deferens, entire on the right ſide, but ſlit open on the left ſide.

G G, A large ſac on each ſide, which contained a green-coloured liquor, and which diſcharges itſelf at the ſame place with the vas deferens.

H, The ſeptum between it and the vas deferens on the left ſide.

I, A funnel or papilla, analogous to the penis, by which the urine, the ſemen, and liquor of the two ſacs G G are diſcharged into K K, the termination of the rectum or common cloaca.

L L, The terminations of two outlets from the cavity of the abdomen.

M, A probe paſſed from the cavity of the abdomen on the right ſide through the outlet L.

TABLE XIII.

In this Table are repreſented the openings of the two uteri of the Skate, and the opening of the veſica urinaria into the common cloaca.

A, The end of the rectum.
B, The common cloaca.
C, The verge of the anus.
D D, The ends of the paſſages from the cavity of the abdomen.
E E, The lower ends of the two uteri.
F F, The openings of the uteri into the common cloaca.
G, The bladder of urine cut open.
H, The termination of the urethra with a probe in it.

TABLE XIV.

In this Table, which repreſents the fœtus of a Skate, with its pericardium and abdomen cut open, the yolk is ſhown connected to the inteſtinal tube.

A, The ſnout of the fœtus.
B, Its left ſide.
C, Its tail.
D D, Fins near the anus, which are large, and armed in the male.
E E, The noſtrils.
F, The mouth.
G, The heart.
H H, The abdominal muſcles and peritonæum cut and turned back.
I I I, Three lobes of the liver,
K, The ſtomach near the pylorus.
L, The ſmall inteſtine.

M, The

M, The appendix vermiformis or cæcum.

N, The anus.

O, The yolk of the ovum.

P, The duct by which the yolk paſſes into the alimentary canal under the pylorus, and near the beginning of the inteſtinal tube or ſmall inteſtine.

TABLE XIV*.

THIS Table repreſents the yolk and young fœtus of a very large Skate.

A, The mouth of the fœtus.

B, Its left eye.

C, The fleſhy ſide of the fœtus.

D, The tail of the fœtus.

E, Numerous veſſels, which were full of red blood, and floated looſe in the glaire or albumen of the egg. Theſe veſſels ſupply the place of the gills, and ſeem to be afterwards covered and converted into the gills.

F, The duct which connects the yolk to the ſmall gut of the fœtus.

GHI, Numerous veſſels conveying red blood, elegantly diſperſed in the yolk; their trunks running along the duct F, and connecting the veſſels of the fœtus with thoſe of the yolk.

TABLE XV.

THIS Table repreſents, in the Salmon, the Carp, and the Herring, a duct, by which the ſwimming-bladder communicates with the œſophagus or ſtomach: and in the Cod a red foliated organ, placed on the inner ſide of the ſwimming-bladder.

FIG. 1. From the Salmon.

A, The upper part of the right roe.

B, The œſophagus cut open.

C, The anterior or upper end of the ſwimming-bladder cut open.

D, A probe paſſed from the ſwimming-bladder into the œſophagus, through a large duct E, by which they communicate.

FIG. 2. From a Carp.

A, The ſuperior or anterior ſwimming-bladder.

B, Part of the poſterior ſwimming-bladder.

CD,

CD, A paſſage or duct by which theſe two bladders communicate with each other.

EF, A large tube, by which the poſterior ſwimming-bladder communicates with,

G, The œſophagus or upper part of the ſtomach. In ſeveral ſpecies of carp, and in the perca arenaria, I found the ſtructure ſimilar.

FIG. 3.

Repreſents a Herring, with the containing parts of the abdomen on the right ſide cut and turned back. The right roe is cut away; the left roe L extends the whole length of the abdomen.

A, Is the œſophagus.
B, The ſtomach.
C, The duodenum.
D, The appendices cæcæ.
EF, The poſterior part of the gut and the anus.
GH, The ends of the ſwimming-bladder.
I, The poſterior part of the ſtomach, of the ſhape of a funnel, and terminating in a duct K; by which the ſtomach and the ſwimming-bladder communicate with each other. This funnel and duct are placed between the roes in the female, and between the milts in the male.

FIG. 4.

Repreſents the red, vaſcular, foliated ſubſtance placed on the inner ſide of the air-bag of a Cod.

FIG. 5.

Repreſents a ſmall portion of the above-mentioned red, vaſcular, foliated ſubſtance, viewed with a magnifying glaſs.

TABLE XV*.

THIS Table repreſents the heart, ſtomach, air-bag and air-duct, of the Conger or Sea Eel.

A, The pericardium opened.
BB, The auricle of the heart.
C, The ventricle of the heart.
D, The branchial artery.

E, Ligaments which connect the ventricle of the heart to the pericardium.

FG, The lower part of the œſophagus and upper part of the ſtomach laid open.

H, The under end of the ſtomach.

I, The pylorus.

K, The beginning of a duct from the lower end of the œſophagus to the air-bag.

LM, A probe paſſed from the lower end of that duct into O the air-bag.

NN, Two red ſpheroidal bodies placed at the ſides of the entrance of the air-duct into the air-bag.

TABLE XVI.

THE three firſt figures of this Table repreſent, of its natural ſize, the communication of the air-bag with the upper part of the ſtomach in the Sturgeon.

FIG. 1.

A, Repreſents the lower end of the œſophagus.

BC, The inner ſide of the back or upper part of the ſtomach.

D, A very large hole in the ſeptum between the ſtomach and air-bag, by which theſe two cavities communicate with each other.

FIG. 2.

In this figure the villous coat of the ſtomach is diſſected off from the edges of the hole by which the ſtomach communicates with the air-bag.

EE and FF, The villous coat raiſed by diſſection.

GHIK, A thin muſcular coat; the fibres of which form an oval around the hole D, and decuſſate each other at its upper part.

FIG. 3.

Shows the ſame hole, by cutting open the back part or upper part of the air-bag.

D, The hole.

ML, The inner ſide of the air-bag.

N, Doublings of the inner membrane of the air-bag at the ſide of the hole D.

FIG. 4.

Repreſents a portion of the inteſtine of the Sturgeon cut open, in order to ſhow

ſhow an elegant reticular texture of its inner coat and large branches of the meſenteric veins, which have very thick coats placed in a ſingular manner on the villous coat.

OPQR, The reticular texture of the villous coat.

STUW, Branches of the meſenteric vein.

TABLE XVII.

THIS Table repreſents the abdomen laid open in a female Frog.

FIG. 1.

A, The mouth.

B, The cartilago enſiformis.

C, The heart and pericardium ſeen through the membranous diaphragm.

D, The two air veſicles or lungs collapſed.

EF, The ſeveral lobes of the liver.

G, The gall-bladder.

H, The pancreas.

I, The ſpleen.

K, Fatty pelotons, which ſeem to ſupply the office of omentum.

L, The ſtomach.

M, The ſmall inteſtines.

N, The end of the ſmall and beginning of the great inteſtine.

OO, The ovaria full of ova.

P, The mouth or beginning of the right oviduct or Fallopian tube fixed to the diaphragm. A probe is put into it.

QR, The continuation and convolutions of the uterine tube.

S, The termination of the uterine tube in T the uterus.

FIG. 2.

Repreſents, with a magnifying glaſs, the ſhape and different ſizes of the ova. The larger are black-coloured; the ſmall ones are not black.

TABLE

TABLE XVIII.

In this Table, the abdominal viſcera of a Skate, with the lacteal and lymphatic veſſels injected with wax, and their termination on the right ſide, are repreſented.

FIG. 1.

1, 1, The two noſtrils and organs of ſmell.

2 and 3, The two jaws and teeth.

4, 5, 6, 7, 8, The five gills on the right ſide.

9, The œſophagus.

10, 11, 12, A funnel, with a probe in it, from the bottom of the pericardium, dividing into two pipes; which, upon the ſide of the œſophagus, open into the cavity of the abdomen.

13, The ſtomach.

14, The pylorus.

15, The ſmall inteſtine.

16, The appendix vermiformis or cæcum.

17, The common cloaca and anus.

18, 19, 20, Three lobes into which the liver is divided.

21, The gall-bladder.

22, The place at which the ductus communis choledochus terminates.

23, The ſpleen.

24, The pancreas.

25, The ovarium.

26, Part of the Fallopian tube or oviduct.

27, A glandular white body through which the oviduct paſſes.

28, The uterus containing an ovum.

29, 29, A probe paſſed from a hole at the ſide of the anus into the abdomen.

30, A kind of valve, which renders the entrance of a probe from without difficult, but allows it to paſs readily from the cavity of the abdomen outwards.

31, The kidney.

32, The ſpine.

A, Lacteals from the upper part of the great gut, the cæcum, and ſmall inteſtine.

B, Lacteals from the pylorus, and lymphatics from the pancreas.

C, Lacteals from the leſſer curvature and right ſide of the ſtomach.

D, A trunk which receives lymphatics from the ſpleen and ſome lacteals from the ſtomach.

E,

E, A bundle of lacteals from the leſſer curvature and anterior flat ſide of the ſtomach.

F G, Numerous lymphatics from the liver and gall-bladder.

H, Their joining with the before-mentioned lacteals and lymphatics.

I K, A large plexus of the lacteal and lymphatic veſſels in their way upwards along the œſophagus. From I, many branches paſs over to the left ſide; or, at this place, there are numerous anaſtomoſes between the lacteals and lymphatics of the right and left ſides.

L, Other lacteals, making a net-work on the œſophagus, and joining with the large plexus at K.

M, Lymphatics, running upwards along the ſpine from the great gut and organs of urine and generation, and lower parts in general, and ending in the plexus K.

N O P, Lymphatics from the back and ſides of the fiſh.

R S T U V W, The branches and trunk of a very large lymphatic veſſel, which brings the lymph from the brain, ear, eye, noſe, cranium, both jaws, the gills and neighbouring muſcles.

Y, Other ſmall deep-ſeated lymphatics coming out from behind the heart.

X, The meeting of all the lacteal and lymphatic veſſels, and termination of that ſyſtem in the vena cava, as ſhown in Tab. II. fig. 36.

Z, A large cavernous plexus of the lacteals on the great curvature of the ſtomach.

Explanation of Figure 2.

This Figure ſhows the appearance and anaſtomoſes of the lymphatics running on the back part of the muſcles at the ſides of the head, and which terminate in the trunk of the great lymphatic veſſel in fig. 1. marked with the letters R S W.

A, A centre from which the mucous ducts come out; which are fully repreſented in Table IX.

B, The trunk of the lymphatic, diſtinguiſhed in fig. 1. by the letter S.

C C, Smaller branches in a regular way, or nearly at right angles.

D D, Other branches joining the former together. Several branches are larger than thoſe from which they proceed, or appear varicoſe, yet have no valves.

TABLE XIX.

In this Table are repreſented the heart and abdominal viſcera of a Skate, with their lacteal and lymphatic veſſels injected with wax, and their termination on the left ſide.

1, 1, The noſe.
2, 3, The upper and under jaws.
4, The place of the gills.
5, The auricle of the heart.
6, The ventricle of the heart.
7, The root of the branchial artery.
8, The œſophagus.
9, The cardia.
10, The body of the ſtomach.
11, The pylorus.
12, The ſmall inteſtine.
13, The place at which the great gut begins.
14, The appendix vermiformis.
15, The anus, and common cloaca within it.
16, 17, 18, The three lobes of the liver.
19, The ſpleen.
20, The pancreas.
21, The ovarium.
22, The glandular body, which is connected to the uterine or Fallopian tube.
23, The body of the left uterus.
24, The os uteri going into the common cloaca.
25, The left kidney.
26, A probe paſſed from the cavity of the abdomen into a hole at the ſide of the anus.
27, The ſpine.
A, A bundle of large lacteal veſſels paſſing upwards from the ſmall inteſtine towards the pancreas.
B, Lymphatics from the pancreas joining theſe.
C, D, The lacteals from the great curvature of the ſtomach, forming a reticular cavernous ſubſtance.
E, Other lacteals from the pylorus and top of the ſmall gut added to the above, and forming a plexus of branches, which runs upwards along the upper end of the pancreas.
F, The joining of the lacteals from the great curvature of the ſtomach with the

the lacteals from the ſmall inteſtines and the lymphatics from the pancreas; at which place their branches form a very beautiful but very intricate plexus.

GH, Numerous lacteals from the poſterior flat ſide of the ſtomach.

I, Numerous lymphatics from the ſpleen.

K, The place behind the cardia, at which the lacteals from all parts of the ſtomach and ſmall inteſtines, and the lymphatics from the pancreas, the ſpleen, and the liver, meet and communicate freely; and from which large and intricate plexuſes, of nearly equal ſize on the right and left ſides, are ſent upwards along the œſophagus.

L. Lacteals from the œſophagus added to the continuation of the left plexus.

M, A bundle of lacteals from the appendix vermiformis and large inteſtine, and lymphatics from the kidney and uterus running upwards along the ſpine, to join the above-mentioned plexus.

N, Other lymphatics from the top of the ovarium, and from the muſcles of the back added to the plexus.

O, Numerous ſmall lymphatics added from the parts behind the pericardium.

P, Large lymphatics from the muſcles and other parts in the ſide of the fiſh.

Q, Some nerves left, which reſemble thoſe of our ſubclavian plexus, and which conceal the termination of the great lymphatic trunk from the upper parts of the fiſh, repreſented in Table XVIII. at the letters R S W.

R, The termination, on the left ſide, of the lacteal and lymphatic veſſels in the ſubclavian vein or left vena cava. At this place a pair of valves, repreſented at R, is conſtantly found.

S, The end of the left internal jugular vein, at which there is always a pair of valves, exactly like to thoſe at the termination of the lymphatic ſyſtem.

If the Reader will now take the trouble of comparing R S of this Table with X, Table XVIII. or with Table II. numbers 36 and 33, he will find that the lymphatic abſorbent veins, as well as the circulating red veins, terminate in nearly the ſame manner on both ſides of the Skate.

TABLE XX.

This Table repreſents the ſtructure of the vaſcular and cellular receptacle of the chyle, ſituated on the large curvature of the ſtomach of a Skate.

Fig. 1.

A, The upper, and B the under, end of the ſtomach of a ſmall Skate, moderately filled with air.

CD, The vaſcular and cellular receptacle of the chyle cut open, after it had been kept inflated till it was dried.

Fig.

FIG. 2.

Repreſents a part of the ſame as it appears through a magnifying glaſs. In both, C repreſents lacteal veſſels cut lengthwiſe.

D, Cells ſurrounding and communicating with lacteal veſſels.

TABLE XXI.

THIS Table repreſents the injected lymphatic veſſels of the brain, the ear, the eye, and ſkin of the Skate.

FIG. 1.

Repreſents the lymphatic veſſels of the ſkin injected.

FIG. 2.

Repreſents the ſame viewed with a magnifying glaſs. Their branches communicate every where by innumerable lateral anaſtomoſes.

FIG. 3.

Repreſents the upper part of the brain, the eye, and ear, of a Skate dried; the lymphatics of which had been previouſly well injected.

A, Part of the ſnout of the ſkate.

B, The left eye, on the adnata and iris of which many lymphatics are injected.

CDE, The brain and cerebellum, on which, and on the dura mater or membrane lining the cranium, many lymphatic veſſels are injected. At D, particularly, an intricate plexus of the lymphatics is found.

EF, Lymphatic veſſels of the ſpinal marrow.

G, Numerous lymphatic veſſels on the ſac of the ear which contains cretaceous matter.

H, A large cutaneous thorn.

FIG. 4.

D, Repreſents, with a magnifying glaſs, the anaſtomoſes of the lymphatic veſſels of the brain, which form the plexus D in fig. 3.

H, The thorn H of fig. 3.

FIG.

FIG. 5.

Repreſents, viewed with a magnifying glaſs, lymphatic veſſels diſperſed on the ſac of the ear or labyrinth which contains cretaceous matter.

TABLE XXII.

IN this Table are repreſented the heart and abdominal viſcera of a Cod Fiſh, with the lacteals and termination of the lymphatic ſyſtem injected with wax.

FIG. 1.

1, Repreſents the eye.
2, 3, The upper and under jaws.
4, The pectoral fin.
5, The flap which covers the gills.
6, The œſophagus.
7, The ſtomach.
8, The appendices cæcæ, which ſeem to ſupply the place of the pancreas. A great number of ſmall round worms were fixed to theſe appendices, and are drawn by the painter in the interſtices of the appendices.
9, The beginning of the ſmall inteſtine.
10, 11, 12, 13, The whole tract of inteſtines.
14, The anus.
15, The gall-bladder.
16, 17, The lacteals from the lowermoſt part of the inteſtines.
18, The lacteals from the upper part of the inteſtines.
19, The large trunks which all the above-mentioned branches form.
20, Other deep-ſeated branches are here added.
21, Numerous lymphatics added from the gall-bladder.
22, 23, 24, Lacteals from the œſophagus.
25, The end of a trunk formed by the lacteals from the ſtomach, and which is in part covered by the firſt turn of the ſmall gut, and then by the gall-bladder.
26, A very large receptacle of the chyle.
27, A large opening ſurrounded by a circular valvular membrane, which leads from the receptacle of the chyle into a very large receptacle of the lymph.
28, 29, 30, 31, Are the principal lymphatic trunks ending in the receptacle of the lymph. At their termination in the receptacle, their diameter is leſſened by circular membranes, which in ſome meaſure have the effect of valves.
32, Is the horn of the air-bag, which paſſes upwards into the receptacle of the lymph.

33, Seems to be the termination of the lacteal and lymphatic veſſels, or the opening by which the chyle, after being blended with the lymph, paſſes into the vena cava on this ſide; but as ſome part of theſe large receptacles is generally torn in catching this fiſh, I found it very difficult to trace with certainty their terminations in the red veins.

34, 34, Repreſent the two venæ cavæ. From the receptacle of the chyle there are large paſſages upwards to the left ſide, which lead to the lymphatic receptacle on the left ſide.

35, Repreſents the venæ cavæ hepaticæ.

36, The meeting of the two venæ cavæ, and the opening from them into the auricle of the heart.

37, The auricle of the heart.

38, The ventricle of the heart.

39, A bulb at the beginning of the branchial artery.

40, The branchial artery continued from that bulb.

FIG. 2.

This Figure repreſents a magnified portion of the ſmall gut, meſentery, and lacteals of the Cod, injected with wax.

AA, A portion of the ſmall inteſtine.

BB, A portion of the meſentery.

CC, Lacteal veſſels injected.

1, Small branches of lacteals anaſtomoſing in the gut like blood-veſſels.

2, Arches which the anaſtomoſes of the larger veſſels form.

3, Some ſmall parallel lacteals are joined by croſs branches.

4, Other ſmall parallel lacteals want ſuch croſs joinings.

6, 7, 8, 9, In general, the large neighbouring lacteals are joined, in a very regular and ſingular manner, by tranſverſe ſhort ſmall branches entering them at right angles.

10, 11, 12, 13, 14, There are likewiſe large branches, by which the large neighbouring lacteals communicate with each other.

TABLE

TABLE XXIII.

In this Table portions of the lacteal veſſels of the inteſtines of a Cod, injected with wax, are repreſented of their natural ſize, and alſo viewed with a magnifying glaſs.

FIG. 1.

AB, A portion of the ſmall inteſtine.
C, Its meſentery.
D, The injected lacteal veſſels delineated of their natural ſize.

FIG. 2.

In this figure the lacteals, delineated of their natural ſize in fig. 1. are repreſented as they appear through a magnifying glaſs.

FF, The net-work formed by their ſmall branches.
E, A larger branch, or larger branches, in which chiefly theſe terminate: for when we examine accurately, we perceive two veſſels joined together by many tranſverſe canals.

FIG. 3.

The injected lacteals in the inverted extremity of the rectum of a Cod are here repreſented.

A, The verge of the anus.
B, The inverted portion of the rectum, or its villous coat, which appears quite red from the injection filling its lacteal veſſels.
C, A portion of its villous coat, in which the lacteals are delineated of their natural ſize.

FIG. 4.

Shows the net-work C of fig. 3. magnified with a glaſs.

TABLE XXIV.

This Table is intended to ſhow the joining of the lacteal and lymphatic veſſels in the Cod.

A, The right eye.

B C, The upper and under jaws.

D, The gill flap.

E, The undermoſt gill.

F, A bone reſembling our ſternum.

G, H, The pectoral and ventral fin.

I, A bone reſembling our clavicle, cut off from the ſternum, and turned upwards.

J, A large mucous duct.

K, The œſophagus.

L, The bottom of the ſtomach.

M, The pylorus.

N, The gall-bladder.

O, The air-bag.

P, The right cornu of the air-bag, ending in a blind ſac.

Q Q, Nerves.

R, The meeting of the two venæ cavæ at the auricle of the heart.

S, The termination of the right vena cava, which is incloſed in cellular ſubſtance, ſlit open.

T, A part of the right vena cava ſlit open, which, with the cornu P of the air-bag, and the nerves Q Q, are contained in a large and irregularly-ſhaped cavity, ſituated between the undermoſt gill and the clavicle, in which the chyle is mixed with the lymph.

U, The internal jugular vein, with a pair of valves at its termination.

V, The vein analogous to our cava inferior.

W W, The receptaculum chyli.

X X, Two openings from the receptaculum chyli into the great cavity in which the chyle and lymph are blended. The anterior opening is by much the largeſt, and has in its circumference a circular membrane or valve.

Y Y, The termination of the lymphatics from the linea recta of the abdomen, the ſternum, pericardium, ventral and thoracic fins.

Z, A paſſage by which the laſt-mentioned lymphatics communicate with the great cavity.

a a, A large lymphatic trunk, which runs on the ſide of the fiſh, and receives its branches at right angles, and terminates at *b*.

c, The termination of the lymphatics from the vertebræ, ſpinal marrow, and upper part of the head.

d, The

d, The termination of lymphatics from the under part of the head and gills.

f g h, The ends of lymphatic veſſels paſſing chiefly behind the heart and œſophagus, by which the right and left receptacles of the chyle and lymph communicate.

TABLE XXV.

In this Table the receptacle of the chyle and lymph in a Haddock is repreſented.

In both FIGURES of this Table,

A, Repreſents the mouth.
B, The noſtrils.
C, The eye.
D, The anus.
E, The pectoral fin.
F, The jugular fin.
G, The lateral mucous duct.
H, The gill flap, cut at its root and turned up.
I, A red body ſimilar to the human amygdala.
K, The ſternum.
L, A bone reſembling the clavicle.
M, A probe ſupporting the gills, paſſed through a natural hole.

In FIG. 1. O P Q repreſent the receptacle of the chyle and lymph inflated.

In FIG 2. The membranes O P Q of the receptacle of the chyle and lymph are cut, and the cavity of the receptacle is thereby laid fully open.

On the inner ſide of the receptacle the following parts appear, covered only by the thin pellucid membrane of the receptacle, to wit, R R R, muſcles of the gills.

S, A muſcle ſimilar to the human ſubclavian.

T U V, The bulb of the branchial artery, the pericardium, and the left vena cava.

W, Nerves reſembling thoſe of our eighth pair, paſſing through the receptacle to the gills.

X, A cut made in the containing parts of the middle of the abdomen a little above the anus and acroſs a principal lymphatic veſſel, into which a probe is put.

The lymph conveyed by X paſſes through an opening, into which a pin Y is put.

Z, A probe, ſhowing the termination of a principal lymphatic trunk on the ſide of the fiſh.

a, A probe paſſed from the receptacle of the chyle upwards into the receptacle of the chyle and lymph.

b, A portion of the receptacle on the upper ſide of the root of the gills.

TABLE XXVI.

In this Table are repreſented the heart, branchial artery, venæ cavæ, and terminations of the lymphatic ſyſtem in a Salmon.

Fig. 1.

1, The mouth.

2, The gill flap.

3, 4, 5, 6, 3, 4, 5, 6, Four pairs of gills.

7, 7, The pectoral fins.

8, The liver.

9, The gall-bladder.

10, 10, The two venæ cavæ.

11, 11, The places at which the lymphatic ſyſtem and internal jugular veins end.

12, The auricle of the heart.

13, The ventricle of the heart.

14, The bulb at the beginning of the branchial artery.

15, The trunk of the branchial artery.

16, 17, 18, 19, 16, 17, 18, 19, Four pairs of branches into which the branchial artery divides, which are ſpent on the four pairs of gills.

Fig. 2.

1, The liver.

2, 2, The two venæ cavæ.

3, 3, The right and left terminations of the lymphatic ſyſtem, which are ſimilar, contracted by membranes which perform the office of valves.

4 4, The right and left internal jugular veins, terminating contiguous to the terminations of the lymphatic ſyſtem, and having each a pair of valves.

N. B. The terminations of the lymphatic ſyſtem, and of the internal jugular veins, appear more diſtinctly in this figure than at numbers 11, 11, of fig. 1. becauſe the orifices 11, 11, were kept on the ſtretch whilſt the painter was drawing theſe terminations.

5, 6, 7, The terminations of the venæ cavæ hepaticæ.

8, A vein which comes from the parts behind the heart.

9, The paſſage from the meeting of the cavæ into the auricle of the heart.

10, 10, The auricle of the heart.

11, The ventricle with its point turned upwards.

12, The trunk of the branchial artery ſending off its two firſt pairs of branches to the gills.

TABLE XXVII.

THIS Table repreſents in a Salmon the joining of the principal lymphatic veſſels, and the terminations of the lymphatic ſyſtem in the venæ cavæ.

A, The middle under part of the lower jaw, ſomewhat reſembling our os hyoides.

B, The ſide of the ſternum.

C, The right pectoral fin.

D, The gill flap turned back.

E F G H, The four gills.

I, An opening under the fourth gill.

K, The clavicle turned back.

L, The ſcales on the ſide of the fiſh.

M M, A large lateral lymphatic trunk ſlit open.

N, A large lymphatic covered by the inner end of the clavicle joining with M.

O, A large lymphatic from the head.

P, A receptacle of the lymph conveyed by the lymphatics M N O.

Q, A paſſage from P into another receptacle R.

S, A probe paſſed from R into the right vena cava, in which the whole ſyſtem terminates.

At the termination of the lymphatic veſſels M N and O, and at Q, the paſſages are contracted and ſurrounded with a circular membranous edge, which has in ſome degree the effect of a valve. The termination of the lymphatic ſyſtem at S is ſurrounded with a thick membrane, which ſtill more accurately performs the office of a valve.

TABLE XXVIII.

THIS Table ſhows chiefly the terminations of the lymphatic ſyſtem, and the hepato-cyſtic ducts, in the Salmon.

A, The middle part of the lower jaw.
B, The gill flap.
C, The pectoral fin.
D, The diaphragm or partition between the thorax and abdomen.
E F G, The lobes of the liver.
H, The gall-bladder.
I, Hepato-cyſtic ducts opening into the neck of the gall-bladder.
K, The upper part of one of the roes.
L, A large lateral lymphatic veſſel cut open.
M N, A probe paſſed from the receptacle of the chyle and lymph into the right vena cava. The thick circular membrane, which performs the office of a valve, is ſeen diſtinctly.
O, The right vena cava.
P, The termination of the internal jugular vein.
Q, A probe paſſed from the joining of the two venæ cavæ into the auricle of the heart.
R, The ventricle of the heart.
S, The root of the branchial artery.

TABLE XXIX.

THIS Table repreſents chiefly, in a ſmall Salmon, the receptacle of the chyle, and the terminations of the lacteal and lymphatic veſſels in the venæ cavæ. It likewiſe ſhows the opening of the duct of the air-bag into the œſophagus.

A, The lower jaw.
B B, The gill flaps.
C C, The gills.
D, The œſophagus cut tranſverſely.
E, The lower or poſterior part of the œſophagus ſlit open.
F, A probe put into a large duct, by which the air-bag and œſophagus communicate.
G, The upper part of the left roe.
H, The gall-bladder inflated.

I K, The

IK, The lacteal veſſels from the ſtomach and inteſtines joining to form the receptacle of the chyle L, which was filled with quickſilver.

M, A plexus of lacteals, which terminate in the right vena cava.

N, Another plexus of lacteal veſſels, which run to the left ſide, behind or above the œſophagus; which was cut acroſs in order that they might be ſeen.

O, The continuation of the plexus of lacteal veſſels N, with an addition of a plexus of very large lymphatic veſſels which came from the left roe.

P, The laſt receptacle of the lymph cut open, into which the lacteal veſſels pour the chyle, or P is the chief receptacle of the chyle and lymph blended.

Q, A probe paſſed from the receptacle P into the left vena cava, ſeen by cutting it open. R, the meeting of the two venæ cavæ before they terminate in the auricle of the heart.

TABLE XXX.

In this Figure, which I publiſhed in 1770, the meſenteric artery and vein of a Sea Tortoiſe or Turtle was filled with wax, and the lacteals with quickſilver, before the drawing was made by Dr Palmer of Peterborough in 1765.

GG, Repreſents a portion of the inteſtinum ilium.

MMM, A portion of the meſentery.

AAA, &c. The branches of the meſenteric artery diſtinguiſhed by tranſverſe lines.

VVV, The branches of the meſenteric vein diſtinguiſhed by longitudinal lines.

LLL, &c. The lacteal veſſels.

PL, A plexus or net-work formed by the lacteal veſſels at the root of the meſentery.

TABLE XXXI.

FIGURE 1. Repreſents the upper part of the brain and ſpinal marrow of a Haddock; and figures 2. and 3. the top of the ſpinal marrow of a Cod, with the nerves iſſuing from theſe, and certain ſpheroidal bodies looſely connected to the brain, but cloſely to the nerves.

FIG. 1.

A, The fore part of the upper jaw.

BB, Two noſtrils in each ſide, with probes in them.

CC, The eye-balls.

DE, Lobes or hemiſpheres of the brain.

F, The hemiſpheres of the cerebellum. Numerous ſpheroidal bodies are ſlightly connected to the brain by viſcid matter between it and the cranium; others are more looſely attached to the dura mater.

G, The ſpine and ſpinal marrow cut tranſverſely.

I, The olfactory nerves.

K, Two ſpherical cineritious bodies, with which the olfactory nerves are intimately conjoined.

LL, The branches of the olfactory nerves ending in the bottom of the noſe.

MM, A pair of large nerves reſembling the fifth pair in man.

OO, Small branches are here detached towards the back part of the noſe, reſembling the naſal branches of the fifth pair in man.

PP, Anterior maxillary branches of the fifth pair.

NN, The optic nerves entering the eye-balls.

Q, Spheroidal bodies attached ſlightly to the medulla oblongata and top of the ſpinal marrow.

R, The back part of the ſpine, with ſeveral pairs of nerves iſſuing from it, covered by ſpheroidal bodies firmly connected to the nerves and to each other.

HH, The pectoral fins; on one of which theſe nerves are ſeen dividing into ſmall branches.

SS, Nerves, running lengthwiſe on the ſides of the body, to which no ſpheroidal bodies are attached.

FIG. 2.

Repreſents, in a Cod, the upper part of the ſpinal marrow, of the natural ſize. And fig. 3. repreſents part of fig. 2. magnified.

A, The

A, The ſpinal marrow.

B, Spheroidal bodies looſely attached to the ſpinal marrow.

C, In fig. 2. ſpheroidal bodies, covering and cloſely connected to the nerves and to each other.

Within the ſpheroidal bodies, which are tranſparent, white ſerpentine bodies are ſeen, as in fig. 3.

TABLE XXXII.

THIS Table repreſents the nerves of the fin of a Haddock, with ſpheroidal bodies connected to them, magnified to ſix diameters.

FIG. 1.

AB, Two nerves which join and ſeparate again, or form a plexus, which is covered by ſpheroidal bodies, adhering cloſely to it.

B, About the middle of the fin theſe ſpheroidal bodies are not contiguous to each other, but between them the pure nerve is ſeen.

C, Near the extremity of the fin, where the nerves are ſubdivided into ſmall branches, the ſpheroidal bodies are wanting.

FIG. 2.

Shows the ſpheroidal bodies ſeparated from the nerve and from each other, and magnified to ſix diameters.

They conſiſt of a tough tranſparent membrane or ſkin, containing a tranſparent viſcid liquor; in the centre of which one or two white or opaque ſerpentine bodies are lodged. Theſe ſerpentine bodies are ſeen very diſtinctly, not only when the nerve is recent, but after drying it.

FIG. 3.

Repreſents the ſpheroidal veſicles looſened a little from each other by diſſection, and magnified to ſix diameters.

TABLE XXXIII.

FIGURE 1. of this Table repreſents the ſpinal marrow and nerves in the tail of a ſmall Haddock, diſſected and magnified to four diameters.

Fig. 2. Shows the natural ſize of the tail.

FIG. 1.

A, The upper, and B the under, part of the Haddock in its horizontal ſituation.

CC, The bodies of the vertebræ.

DD, The ſpinal marrow, with the ſpinal nerves iſſuing from it.

Theſe nerves, as they proceed, form plexuſes GG, which are covered by ſpheroidal bodies, that adhere firmly to the nerves and to each other. In the fin of the tail, the ſpheroidal bodies gradually become leſs numerous; then are ſeen ſingle, or at a diſtance from each other, with the nerve appearing bare between them, as at HH, where the nerves are ſupported on pins; at laſt, near the edges of the fin of the tail, where the nerves are divided into ſmall parts, the ſpheroidal bodies are not found.

TABLE XXXIV.

IN this Table are repreſented, in a Skate, the upper ſurface or back part of the brain and the top of the ſpinal marrow, with the nerves riſing from theſe, the muſcles of the right eye, and a general view alſo of the internal parts of both ears.

A, The ſnout of the fiſh.
B, The eye-balls.
CCCO, The muſcles of the eye-ball.
DD, Paſſages into the throat.
EFG, EFG, The ſemicircular canals of the ear ſlightly ſketched.
H, A broad thin ligament which ſupports the ſemicircular canal G.
I, The bottom of the meatus auditorius imperfectly repreſented.
J, A cavity in the fore part of the cranium filled with viſcid fluid.
KK, Two anterior lobes of the brain.
L, A middle lobe of the brain.
MM, Two poſterior lobes of the brain.
NN, Two lobes of the cerebellum.
OO, Subſtances reſembling our corpora olivaria.

PP, The

P P, The ſpinal marrow.

Q R, Bags containing a tough pellucid fluid, and likewiſe cretaceous matter, and which evidently reſemble our veſtible, and have alſo ſome reſemblance to the cochlea of our ear.

1, 1, 1, The olfactory nerves, much larger when they enter the noſe than where they riſe from the brain, owing to thick coats they receive in their courſe.

2, 2, The optic nerves.

3, 3, 4, Nerves reſembling our third and fourth pairs.

5, 5, 6, 6, Nerves which reſemble our fifth pair.

7, 7 Nerves which reſemble our ſeventh pair.

8, 8, Nerves reſembling our eighth pair.

9.....28, The ſpinal nerves; each of which conſiſts of two bundles of fibres, which paſs through different holes of the dura mater.

29, 29, 30, 30, The ſpinal nerves, forming plexuſes, and appearing much larger without than within, reſembling our brachial or crural plexus.

TABLE XXXV.

The ſeveral figures of this Table repreſent the noſe, mouth, ear, and larynx of a Porpeſs *.

Fig. 1.

A B, Repreſent the two jaws and mouth.

C, A ſmall portion of the right pectoral fin.

D, The entry into the noſe or ſpiraculum.

E, The eye.

F, The entry to the meatus auditorius externus.

Fig. 2.

Repreſents the lips or entry to the ſpiraculum.

A, The anterior, and B the poſterior, lip.

Fig. 3.

Shows the ſpiraculum and noſe cut open on the right ſide.

A, A probe introduced into the ſpiraculum.

B, Its inner membrane, of a black colour, with a number of folds or valves.

* Lin. Syſt. Nat. Cete; Delphinus; Phocæna.

C, A frænum fixed above a chink between two ligamento-cartilaginous bodies D and E. Theſe bodies reſemble the human epiglottis, and the frænum is like the membrane which ties the epiglottis to the tongue.

F G, Two large ſacs ſeparated from each other by the frænum. The right ſac is laid open, and a probe is paſſed into the left one. The membrane lining theſe ſacs is of the ſame colour, and has the ſame kind of folds or valves, as were ſeen at B. Theſe ſacs conſtitute the organ of ſmell.

H, A thimble-like cavity, lined with a thin ſmooth membrane, under the right ſide of the epiglottis, or rather under the right epiglottis.

I K, Probes paſſed into the right and left noſtrils or air-paſſages, which are divided from each other by a ſeptum L.

FIG. 4.

THIS Figure ſhows the continuation of the ſpiraculum or air-paſſage and the larynx, after cutting open the mouth and throat on the right ſide, and inverting the head.

A, The edges of the tongue ſerrated.

B, The upper ſurface of the tongue.

C, The top of the larynx; the upper part of which conſiſts of one cartilage, but the under part is compoſed of two cartilages.

D, A muſcle for ſhutting the top of the larynx.

E F, Two muſcles for opening the larynx.

G, The right ſide of the larynx is cut into, to ſhow G, a ligament in the middle of its under part.

H, The termination of the ſpiraculum, over the mouth of the larynx, ſurrounded by a muſcle I.

K, The right ſide of the ſpiraculum cut open, to ſhow the back part of the ſeptum K.

L M, The lower ends of the two probes, ſeen in fig. 3. at I K.

N, A cylindrical tube from K to H.

O, A probe put into the mouth of the right Euſtachian tube, or iter à palato ad aurem.

FIG. 5.

THIS Figure ſhows the outſide of the os petroſum, with the meatus auditorius externus and the Euſtachian tube laid open their whole length.

F, The entry to the meatus auditorius externus.

G, The meatus auditorius externus laid open its whole length, and crooked at its back part G.

H, The

H, The outſide of the os petroſum; the point of which, H, reſembles our maſtoid proceſs.

I, The membrane of the drum, concave on the outer ſide.

K, The right noſtril cut farther open, to ſhow L, the mouth of the Euſtachian tube.

M, The Euſtachian tube laid open from its origin to its termination within the ear or os petroſum at N. It is gradually enlarged in its courſe from the noſe to the ear.

FIG. 6.

THE inner ſide of the os petroſum H, and of the adjoining bones being cut away this figure repreſents the cavity of the tympanum, its contents, and the parts with which it communicates.

I, The bottom of the meatus auditorius externus, and membrana tympani concave on the outer ſide.

K L, A red-coloured ſubſtance and chain of ſmall bones, by which the membrane of the drum is drawn inwards, and connected to the bottom of the cavity of the tympanum.

M, A ſmall muſcle fixed to the laſt of the ſmall bones, reſembling our ſtapes and its muſcle.

N, A probe paſſed from the Euſtachian tube into the cavity of the tympanum.

O, A ſubſtance within the os petroſum or cavity of the tympanum, which in ſhape reſembles our os ſpongioſum inferius.

P, A large paſſage leading from the cavity of the tympanum forwards to caverns Q and R; the latter of which leads to the frontal ſinus.

FIG. 7.

Repreſents the inner ſide of the os petroſum S, with the auditory nerve T entering it.

FIG. 8.

Repreſents the inner part of the os petroſum; from which the auditory nerve and part of the ſubſtance of the bone are cut off, in order to ſhow the holes by which the nerves enter, and part of the cochlea and ſemicircular canals.

S, The inner ſide of the os petroſum.

U V, The holes by which the branches of the auditory nerve enter.

W, A ſmall portion of the cochlea cut open.

X, One of the ſemicircular canals cut open.

FIG.

FIG. 9.

Shows the cochlea further cut open.

W, A tube which fills one of the ſcalæ of the cochlea.
Y, Part of the ſeptum between the ſcalæ of the cochlea.
Z, The ſecond turn of the cochlea cut perpendicularly in two places.

TABLE XXXVI.

THE ſeveral figures of this Table repreſent the organ of hearing of the Sea Tortoiſe or Turtle.

FIG. 1.

IN this Figure the roof of the mouth is delineated, with the mouths of the Euſtachian tubes of the ears.

A B C, The teeth of the upper jaw.
D E, The condyles with which the lower jaw is articulated.
F G, The holes by which the cavities of the noſe communicate with the mouth.
H I, Probes put into the Euſtachian tubes of the ears.
K, Part of the right Euſtachian tube cut open.

In Figures 2. and 3. the upper part of the organ of hearing is repreſented.

FIG. 2.

A, Repreſents the hollow outer part of the head, on the right ſide, analogous to our right temple.
B, A large cavity within this place laid open by a horizontal ſection.
C, The termination of the Euſtachian tube in that cavity, ſhown by a probe introduced into it.
D, A white tendinous-looking ſubſtance, which connects the hollow part of the temple to the inner part of that cavity.
E, The outer end of a long cartilaginous body, which, like the oſſeo-cartilaginous ſubſtance in birds, ſeems to ſupply the place of the malleus, incus, os orbiculare, and ſtapes, in man; or which connects the hollow part of the temple to the labyrinth of the ear.

FIG.

FIG. 3.

A, A thin plate of cartilage, which is found on the inner ſide of the temple.

B, The cavity in which the Euſtachian tube terminates laid open.

D, The tendinous-like ſubſtance which connects the temple to the inner ſide of that cavity.

F, The outer end, and F the inner end, of the long cartilaginous body, which connects the temple to the labyrinth of the ear, having its inner part F connected to a membrane reſembling that of our feneſtra ovalis.

GHI, Three ſemicircular canals, to wit, an anterior, a poſterior, and a middle horizontal canal.

In FIG. 4.

The organ of hearing is ſeen from below.

A, Repreſents the right condyle for the articulation with the lower jaw.

B, The under part of the inner end of the cartilaginous body, which connects the ſkin of the temple to the membrane of the feneſtra ovalis, or to the labyrinth of the ear.

C, A ſac which contains a ſoft cretaceous matter, like to that found in the ear of a ſkate fiſh.

D, Nerves reſembling the portio mollis of our ſeventh pair, ending on this ſac.

TABLE XXXVII.

IN this Table are repreſented, in a Skate, the baſis of the brain, cerebellum, and top of the ſpinal marrow, with the nerves coming out from theſe; and the different parts of the ear are likewiſe accurately ſhown.

FIG. 1.

1, 1, The noſe.

2, The cavity in the fore part of the cranium, which is filled with viſcid fluid.

3, 3, The anterior lobes of the brain.

4, 4, Two ſmaller lobes behind theſe.

5, A round lobe compoſed of vaſcular and cineritious ſubſtance.

6, 6, Medullary lobes under the lobes of the cerebellum.

7, 8, Medulla oblongata and medulla ſpinalis.

9, The uppermoſt branchial vein.

10, 11, 12, An artery continued from the uppermoſt branchial vein, which ſupplies the noſe and external part of the head.

13, A bundle of ſmall arteries from branch 12th, which run upwards to the brain.

14, 15, 16, 17, 18, 19, Veins from the ſecond and third gill, which ſend off,

20, 21, The principal artery of the brain, cerebellum, and top of the ſpinal marrow.

23, The olfactory nerve.

24, 24, The two optic nerves.

25, 25, 26, 26, Nerves reſembling our third and fourth pairs.

27, 27, Large nerves reſembling our fifth pair.

28, A large branch of 27 entering the orbit.

29, A branch of 27 paſſing within the cartilages, which contain the parts of the internal ear.

30, A ſmall twig of 27 loſt on a ſmall bag of the ear, which contains cretaceous matter.

31, Another twig of 27 loſt in a bulb or enlarged part of the anterior ſemicircular canal of the ear.

32, A large branch from 27, which paſſes onwards on the fore part of the cartilage incloſing the ear.

33, A twig from 27 to the bulb of the middle ſemicircular canal of the ear, or horizontal canal.

34, Part of a large branch of 27 adhering to and loſt in the large bag which contains cretaceous matter.

35, A nerve ſomewhat like to our ſeventh pair.

36, A nerve ſent to the large bag which contains cretaceous matter, from the joining of 27 with 35.

37, Another branch from the joining of 27 with 35, loſt on the bulb of the poſterior perpendicular ſemicircular canal of the ear.

N. B. As ſoon as the nerves reach the bulb of the ſemicircular canals, they become pellucid, and are loſt.

38, 39, The remainder of the branch formed by the joining of 27 and 35 paſſes through the cartilage at the back of the ear, to be diſperſed on the external parts, and may perhaps be compared to our portio dura of the ſeventh pair.

40, A briſtle entered from the meatus auditorius externus into the internal ear.

41, A branch of 35, which runs upwards.

42, 42, Large nerves, which have ſome reſemblance to our eighth pair.

43, 44, 45, 46, 47, 48, Nerves reſembling our ſub-occipital and cervical nerves. The anterior and poſterior bundles which compoſe theſe nerves paſs through different holes of the dura mater.

FIG.

FIG. 2.

1, 2, 3, 4. Repreſent the thickneſs and ſhape of the cartilages which incloſe the internal ear.

5, The anterior ſemicircular canal of the ear.

6, A dilatation or bulb in that canal.

8, 9, The middle or horizontal ſemicircular canal and its bulb, to which a bit of its nerve adheres. Near to their bulbs theſe two ſemicircular canals join together, ſo that they have but three ends; in this reſpect reſembling the ſemicircular canals of our ear.

10, 11, 12, The poſterior ſemicircular canal.

13, A flat aponeuroſis, ſtretched between the upper part of the poſterior ſemicircular canal and the poſterior part of the horizontal or middle canal.

14, The great bag that contained the cretaceous matter cut open, and the chalk taken out of it; or it is repreſented empty and collapſed.

15, A ſmall bag, or appendix to the large bag, which likewiſe contains chalk.

16, 17, The meatus auditorius with a briſtle in it, laid open its whole length. 16, Shows the external opening, and a larger cavity or concha within it. 17, Shows a narrow paſſage between cartilages, reſembling the deep oſſeous part of our meatus auditorius.

18, Repreſents the briſtle entering the large ſac which contains the chalk. No Euſtachian tube is found here, one paſſage ſupplying the place of both external and internal meatus auditorius of man.

Behind the concha there is a large ſoft part, which is ſhown by a pin ſtuck through it.

FIG. 3.

THIS Figure repreſents the communication of the external meatus auditorius of a Skate with the large ſac which contains cretaceous matter; and the communication of the large ſac with a ſmaller, and with the ſemicircular canals, ſeen obliquely from the inferior ſide.

a, A briſtle paſſed from the concha of the external ear, through the meatus auditorius externus, into *b*, a large pyramidal ſac, which contains a viſcid pellucid humour, with a regularly-ſhaped cretaceous ſubſtance, and ſeems to ſupply the place of our veſtible.

c, An oblong opening is found, at a dotted line here, by means of which the large ſac communicates with a ſmall ſac *d*, which likewiſe contains cretaceous matter and a viſcid humour, and is ſituated on the upper or fore part of the large ſac.

e, A canal leading from *d* into *f*.

f, A

f, A canal common to the horizontal ſemicircular canal *g*, and the ſuperior or anterior ſemicircular canal *h*.

i, The place at which the canals *e f g* and *h* meet and communicate.

k, A canal from the poſterior part of the great ſac, which communicates with *l*, the uppermoſt end of the inferior or poſterior ſemicircular canal *l m*. Hence *k l m* communicate with each other at *n*.

o o o, The cartilaginous ſubſtance which contains the ſemicircular canals and cochlea.

p p, Two ligaments, over which the ſuperior and inferior, or anterior and poſterior, ſemicircular canals paſs.

FIG. 4.

Repreſents the ſemicircular canals of the ear and bags, which reſemble our veſtible, or perhaps cochlea and veſtible, with their nerves, ſeen from their under part, in a very large Skate.

ABCDEF, Repreſent the cartilage which incloſes the ear.

27, 29, 30, 31, 33, 34, 35, 36, 37, 38, Repreſent the ſame parts as in fig. 1. but more accurately, and in a much larger ſkate.

a, Repreſents a ſmall bag which projects from the large bag.

b c d e f, Repreſent a cellular texture filled with fluid, which connects the ſacs and ſemicircular canals with the membrane which lines the cartilage, and conducts nerves from the ſacs and ſemicircular canals to that membrane. Veſſels conveying red blood are likewiſe diſperſed upon it and lymphatic abſorbents; a great number of which I have injected.

TABLE XXXVIII.

THIS Table repreſents the upper or back part of the head, and the ſtructure of the ear, of the Squalus Squatina or Angel Fiſh.

A, The mouth.

B B, The noſe.

C C, The eyes.

D D, The paſſages into the gills.

E E, The roots of the muſcular flaps, which are compared to wings.

F, The place at which the head is articulated with the ſpine.

G, A ſmall ſpace of the occiput between the meatus auditorii externi HH, into the right one of which a briſtle is introduced.

I, A ſmall gutter marked in the external ſurface of the ſkin, and running obliquely forwards and inwards from the meatus auditorius externus.

K, Is

K, Is placed over the ſeptum which ſeparates from each other two cavities, which may be compared to our conchæ auris.

L, A briſtle paſſed from the concha auris into the continuation of the meatus auditorius externus, and from it into M, a ſac which contains a ſoft body compoſed of cretaceous matter.

NOP, Three ſemicircular canals, which communicate with each other and with the ſac M.

Q, A tendinous ſubſtance, which happened to be laid in view in diſſecting the ear.

TABLE XXXIX.

In this Table the optic nerves and parts of the ear of a Cod are repreſented. In fig. 1. and 4. ſimilar parts are pointed out by the ſame letters; ſo that one explanation may ſerve for both.

A A, The fore or under part or bodies of the vertebræ.

B, The fore part of the cranium.

C C D, Tubercles of the brain.

E, The root of the optic nerves where they are conjoined.

F, The right optic nerve paſſing over the left one G.

H H, The two eye-balls.

I, The left ſac which contains the principal ſtone of the ear, with a large nerve elegantly ramified upon it.

K, The point at which three ſemicircular canals of the ear meet, and communicate with each other.

L, The joining of the ſuperior or anterior ſemicircular canal M with N the middle horizontal ſemicircular canal.

O, The inferior or poſterior ſemicircular canal.

P, The joining of the horizontal canal with the poſterior.

Q, The trunk of the auditory nerve.

R, A branch from it to the capſule of the large ſtone.

S, Another branch from it, which ſends branches to join R and other branches to the ſemicircular canals.

T, Small nerves from the ſame nerve Q are diſperſed, with minute blood-veſſels, upon membranes and a viſcid matter which fills the ſpace between the ſemicircular canals. Some of the nervous threads are fixed to minute ſpheroidal bodies diſperſed in this viſcid matter, and which reſemble bodies found on the outſide of the brain, and alſo adhering to moſt of the nerves.

V, A ſmall bag which contains viſcid matter and receives a nerve, which ſeems to make a part of the organ of hearing.

FIG. 2.

Shows the large ſtone of the ear taken out of its ſac.

FIG. 3.

Shows one of the ſmall ſtones of the ear taken out of the dilated portion, where the anterior ſemicircular canal joins with the horizontal one.

FIG. 5.

Shows the ſituation of the ſemicircular canals and large ſtone of the ear, with reſpect to each other and to the brain, after cutting off the upper part of the cranium.

A B, The lobes of the brain ſeen on their upper part.
C, The cerebellum.
D, The ſpinal marrow.
E, A branch of nerves, which reſemble our fifth pair.
F G, A perpendicular canal, connecting, or common to, the ſuperior and inferior ſemicircular canals of the ear.
H, The ſuperior, and I the inferior, ſemicircular canal. At this place they receive branches from nerves which reſemble our fifth and ſeventh pairs.
K, The upper part of the ſac which contains the large ſtone of the ear.
L, A nerve which reſembles our ſeventh nerve, and likewiſe in a great meaſure ſupplies the place of our eighth.

TABLE

TABLE XL.

FIGURES 1. and 2. of this Table repreſent the noſe; and figures 3. and 4. the ear of a Sturgeon.

FIG. 1.

Repreſents the noſe on the right ſide, as it appears without diſſection.

A, The upper and anterior opening into the noſe.
B, The under and poſterior opening.
C, An intermediate covering of the noſe.

In FIG. 2.

The letters A and B are oppoſed to the natural openings into the noſe.
C, The intermediate covering is cut and turned forwards.
D, The noſe is fully ſeen, conſiſting of nineteen doublings of membranes of unequal length, which, like radii, iſſue from one centre.

FIG. 3.

Repreſents the outer ſide of the three ſemicircular canals of the right ear, laid in view by diſſection.

AB, The anterior ſemicircular canal, in which there is a dilated portion at B,
CD, The poſterior ſemicircular canal.
EF, The horizontal ſemicircular canal, in which there is a dilated part at E.

FIG. 4.

Repreſents the joining of the three ſemicircular canals on the inner ſide, or ſide next to the brain, and their communication with a large ſac containing a ſtone.

AB, The anterior ſemicircular canal, and B its dilated part.
CD, The poſterior ſemicircular canal, and D its dilated part.
EF, The horizontal ſemicircular canal, and E its dilated part.

G, A large common canal or veſtible, by which the three ſemicircular canals communicate.

H, A bag which communicates with the veſtible at I.

K, A ſtone taken out of the bag H, repreſented of its natural ſize, and likewiſe magnified.

TABLE XL*.

FIG. 1.

THIS Figure repreſents an horizontal ſection of the cryſtalline lenſes of an Ox and of a Cod enlarged to four diameters; one-tenth part of an inch in the figure repreſenting one-fortieth part of an inch in theſe lenſes.

ABCD, The lens of the Cod.

E, The middle of the greateſt diameter of the lenſes.

FA, The radius of the anterior part of the lens of the cod BAC.

N.B. F ſhould have been placed at the twentieth of an inch from E.

ED, The radius of the poſterior convexity of the lens of the cod.

IL, The greateſt tranſverſe diameter of the lens of the ox.

IKL, The anterior convexity of the lens of the ox.

GK, The radius by which the anterior convexity of the lens of the ox was deſcribed.

IML, The poſterior convexity of the lens of the ox.

HM, The radius of the poſterior convexity of the lens of the ox.

I*k*L*m*, A dotted figure, repreſenting the ſection of a lens of the breadth of that of the ox, and deſcribed with ſuch radii as Dr Petit aſſigns to the ſpheres which compoſe the lens of the ox.

FIG. 2.

ABCD, Repreſents the ſection of a hollow ſphere of glaſs, *d* its centre.

F, The focus of parallel rays of light, after being tranſmitted through ſuch a ſphere filled with water.

A*bcd*, A lens, formed of the anterior and poſterior portions of the ſame hollow ſphere; the length of the axis of which is equal to the radius of the ſphere.

D, The focus of parallel rays, after they have paſſed through ſuch a lens filled with water.

A*idk*, The ſection of a lens; the breadth of which is exactly equal to the diame-

diameter of the ſphere ABCD, and its thickneſs or length of its axis equal to the radius of the ſphere.

g d and *b* A, The radii by which the ſection of this lens was deſcribed.

3. The focus of parallel rays, after paſſing through ſuch a lens filled with water.

Hence the focus of ſuch a lens is nearer to the fore part of it than the focus of the ſphere is to its fore part by the length 3 F; and the focus D of the lens A *b d e* is only a diameter of the ſphere ABCD diſtant from its fore part: whereas the focus of the ſphere itſelf is diſtant from its fore part A a diameter and a half *.

TABLE XLI.

In this and in the next Table, the ſtructure of the Sepia Loligo is repreſented.

Fig. 1.

A A, The tail of a triangular ſhape.
B B, A hollow muſcular ſheath, which incloſes the body, cut open.
C, A fleſhy funnel, with its conical point turned forwards.
D D D, &c. Ten fleſhy arms ſurrounding its mouth.
E, A few cups painted, of which there are many on each arm.
F, The mouth, which has a beak reſembling that of a parrot.
G, Part of the œſophagus.
H, The ſtomach.
I, Part of the upper end of the inteſtinal canal.
K K, The rectum and anus.
L L, A cluſter of glandular-like bodies, which probably is the ovarium.
M M, A very large liver.
N, The ink-bag.

* In Chapter XI. I alleged that the veſſels of the iris in man and quadrupeds are not lymphatic, as Dr Ferrein and Dr Haller have taught, but convey red blood. In full confirmation of which, I would here add, that in the iris of the living white rabbit, where the pigment is wanting as well as in their choroid coat, I have ſeen with the naked eye, and ſtill more diſtinctly with a magnifying glaſs, numerous veſſels full of red blood.

If it ſhall ſeem neceſſary to have ſtill clearer proof than was given in Ch. XI. of the inaccuracy of Dr Petit's Table, of the breadth, thickneſs, and radii of the human cryſtalline lens, as well as of that of the ox, I would obſerve, That the breadth and thickneſs of N° 1. 2. 8. 13. 17. 18. 21. of that Table are ſaid to be the ſame; yet both radii of N° 21. are repreſented as greatly longer than thoſe of the other numbers. In like manner, both radii of N° 1. are longer than in N° 2. and the radius of the anterior convexity of the lens in N° 1. is longer than that of N° 13. 17. 18; while the radius of the poſterior convexity is the ſame in all theſe. But it is demonſtrable, and indeed at firſt ſight evident, that if the breadth of lenſes, compoſed of portions of different ſpheres, be the ſame, their thickneſs muſt vary according to the radii of thoſe ſpheres.

O, A duct from the ink-bag runs between the liver and rectum, in which it terminates near the anus, where, at K, a probe is introduced.

P, The back part of a thin coated large ſac, which ſeems to be the urinary bladder.

Q Q, The two branchiæ, gills or lungs.

R, The anterior vena cava, which receives blood from the head and arms at S, and from the liver at T. Veins likewiſe join it from the ſtomach and inteſtines U U, and upper back parts of the muſcular ſheath V V.

W W, The anterior vena cava dividing into two equal branches.

X X, Two poſterior venæ cavæ.

Y Y, Two auricles, one on each ſide.

Z Z, Two ventricles correſponding with the auricles.

a a, *a a*, Two branchial or pulmonary arteries.

FIG. 2.

R, W W, X X, Y, Z Z, *a*, Repreſent the ſame parts as in Fig. 1. On the left ſide, the ventricle L and the branchial artery *a* are ſlit open.

b, Repreſents the opening from the auricle Y into the ventricle Z.

c, A valve at that opening.

d, Three ſemilunar valves at the beginning of the branchial artery.

FIG. 1.

e e, *e e*, Two branchial veins.

g, A third ventricle, in which the branchial veins terminate.

h, The anterior or aſcending aorta.

i, The poſterior or deſcending aorta, which is much ſmaller than the anterior.

FIG. 2.

In this Figure the third ventricle and the aortæ are ſlit open.

k k, A pair of valves, where each of the branchial veins terminates in this ventricle.

h i, The aortæ ſlit open.

l l, Valves at the beginning of both aortæ.

FIG. 1.

m, The anterior aorta runs up to the muſcles of the back bone, the arms, head, &c.

n, Bran-

n, Branches to the alimentary canal.

op, Branches from the poſterior aorta, which run to the branchial hearts and ink-bag.

rq, The poſterior aorta running along a membranous ſeptum towards the under and poſterior part of the muſcular ſheath and tail.

FIG. 3.

DD, &c. The roots of the arms.

GG, A probe paſſed into the œſophagus and out at the beak.

v, An organ which ſeems analogous to the brain.

yy, The optic nerves.

xx, Organs of a firmer texture than *v*.

z, A bulb in texture ſimilar to *v*, which perhaps reſembles a hemiſphere of the cerebellum; for on the other ſide there is a ſimilar knob.

x, A thread produced from *z*, analogous perhaps to the ſpinal marrow.

t, A hard plate by which the cryſtalline lens is firmly connected to the cornea.

v, A ſubſtance ſofter than that of the cryſtalline lens, in which the lens is lodged.

TABLE XLII.

THIS Table is chiefly intended to repreſent the organs of generation and urine of the Sepia.

AB, Part of the muſcular ſheath.

C, The inner muſcular funnel.

D, The liver.

E, The rectum.

F, The right gill or lung.

GH, The right and left branchial veins.

I, The third heart, in which theſe veins terminate.

KL, The aſcending and deſcending aorta.

MN, The organ of generation, through which, at M, the turns of the alimentary canal appear.

O, The end of the duct from the organ of generation.

At the ſide of the large figure is delineated, of the natural ſize, and alſo magnified, one of the bodies which on preſſure is diſcharged from the organ of generation.

P, A large organ, ſuppoſed to be the kidney; from which a duct, Q, ſeems to come out, to terminate in a large bag S, ſuppoſed to be the urinary bladder.

At the upper part of the Table is delineated, of the natural ſize and magnified, a ſtone, ſuppoſed to make part of the ear of the ſepia.

TABLE XLIII.

In this and in the following Table, the parts of the Sea Egg or Echinus Marinus Eſculentus are repreſented.

The two Figures of this Table repreſent chiefly the ſockets of the teeth, the alimentary canal and roe of the Echinus, with their circulating veſſels injected with quickſilver.

In Fig. 1. and 2.

ABC, Thorns or feet on the edges of the ſhell; the middle part of which is cut away, in order to ſhow its cavity, and the turns of the alimentary canal.

D, A circle from which the muſcles of the teeth E take their riſe.

F, The œſophagus.

G, A turn of the œſophagus, which is tied by a ligament to the oppoſite ſide of the ſhell near the anus, as is repreſented at G in Fig. 2.

H, The œſophagus terminating in the ſide of the inteſtine.

IKLM, The firſt waving circle the inteſtine and meſentery deſcribe.

NOP, A ſecond or reverſed circle theſe deſcribe.

Q, The inteſtine cut away from the anus. Its termination is ſeen at Q in Fig. 2.

Two veſſels filled with quickſilver are delineated, almoſt contiguous, running along the meſentery from H to P.

RSTUV, In both figures repreſent five internal ducts, which receive fluids from vaſcular plexus placed on the inner ſide of the ſhell.

XYZ, In Fig. 2. repreſents the roe ſubdivided into five lobes.

TABLE XLIV.

SEVENTEEN figures of this Table repreſent the origin, courſe, and termination of the abſorbent veſſels of the Sea Egg or Echinus. The four laſt figures repreſent certain moveable organs articulated with the outer ſide of the ſhell, in the interſtices of the thorns.

FIG. 1.

Repreſents a part of the outer ſide, And,

FIG. 2.

Part of the inner ſide of the ſhell pierced with a pair of rows or phalanges of holes, into which briſtles are introduced, which are marked with the ſame figures or letters on both ſides of the ſhell.

FIG. 3.

A, The mouth of the echinus with five teeth.

B, The outſide of the ſhell, to which the ſockets of the teeth are connected by a ſtrong membrane.

CD, One row or phalanx of open-mouthed abſorbent tubes, which lead to the holes delineated in Figures 1. and 2.

EF, Some of the thorns, which ſerve as feet, delineated.

FIG. 4.

B, The outer ſide of the ſhell.

CD, Some of the abſorbent veſſels dried after filling them with quickſilver.

FIG. 5.

One of the abſorbent veſſels in its collapſed ſtate, viewed through a magnifying glaſs, which enlarges it to five diameters, after ſlitting open the root of it, and introducing a couple of briſtles into it, and into the holes which lead from it through the ſhell.

FIG. 6.7.8.

The perforated plates on the mouths of the abſorbent veſſels, viewed with the ſame glaſs.

AAA, A tough and firm, jointed plate, perforated in its middle, and ſerrated at its edges like the wheel of a watch.

BB, The hole in it, into which, in Fig. 7. a briſtle is introduced.

CC, Circular muſcular fibres which compoſe the abſorbent veſſel.

FIG. 9.

Shows the appearance theſe abſorbent veſſels make when they fix themſelves to the inner ſide of a glaſs veſſel.

A, The glaſs veſſel ſuppoſed to contain the animal.

B, Some of the thorns.

CD, The abſorbent veſſels bended in various directions, with the perforated plate at the beginning of theſe veſſels applied flat to the glaſs.

FIG. 10.

One of the ſame veſſels viewed with a magnifying glaſs.

A, The glaſs veſſel.

B, The ſide of the abſorbent veſſel.

C, The plate at the beginning of it, with the hole appearing in its centre.

FIG. 11. and 12.

Show, with the ſame magnifying glaſs, the abſorbent veſſels as they appear when the animal elongates them in water. On their upper and under ſides two ſmall faſciculi of longitudinal muſcular fibres are ſeen, which were overlooked by the painter in the former figures. The circular fibres are ſeen within and between theſe faſciculi.

The fleſhy part of the abſorbent contracts to a ſmaller diameter than that of the plate at its beginning.

The plate is puſhed out into a conical form; and the hole in its centre is ſcarcely diſtinguiſhable.

The abſorbent tubes, acting in the manner repreſented, become above an inch and a half long; or, with the magnifying glaſs employed, appear to be above ſeven inches long. Hence the end of them alone is repreſented.

FIG. 13.

Repreſents the inner ſide of the ſockets of the teeth and jaw, and part of the inner ſide of the ſhell, with the continuation of the abſorbent veſſels; the plexus they form on doubled membranes within the ſhell; and their whole courſe and termination in the ſockets of the teeth.

A,

A A, A circular plate from which muſcles are ſent to B B, the roots and ſockets of the teeth.

C, A ſection of the œſophagus.

D E, Two rows of leaves or doubled membranes connected to the inner ſide of the ſhell. On theſe membranes the abſorbent veſſels, after piercing the ſhell, divide into a plexus of veſſels, which communicate freely with each other; and which are here delineated of their natural ſize when filled with quickſilver.

F, A large ſtraight veſſel, which receives at a right angle a branch from every plexus. There are nearly, if not exactly, the ſame number of plexus or of ſuch branches as of external abſorbent veſſels. The veſſel F, after paſſing through a large hole or arch in the circular plate A A, divides into two branches, which terminate in round ſacs G G G G G, which are placed over large cavities in the ſockets of the teeth.

FIG. 14. and 15.

Repreſent two of the leaves or doubled membranes with their plexus of veſſels filled with quickſilver, viewed with the magnifying glaſs.

A B, Two branches from different external abſorbent veſſels, after piercing the ſhell, entering the ſame plexus.

C, The veſſels of the plexus communicating freely with each other.

A B D E F, A veſſel which may be traced in a circle on the outer edge of the plexus.

F G, The duct conveying the liquor from the plexus to the common duct H, which was repreſented at F in Fig. 13. and at R S T U V in Tab. XLIII. Fig. 1. and 2.

FIG. 16.

Shows one of the teeth with its ſocket, which is cavernous, and through it a briſtle is paſſed.

FIG. 17.

Shows three of the teeth with their ſockets A A, B B, C. On their inner ſide the œſophagus D is repreſented ſlit open.

A briſtle E E is paſſed from one of the round ſacs G G G G G, repreſented in Fig. 13. through the cavity of the ſocket of one of the teeth, and is brought out between the beginning of the œſophagus and the ſide of the tooth.

FIG.

FIG. 18. 19. 20. 21.

Repreſent parts which are diſperſed over the outſide of the ſhell in the interſtices of the thorns or feet. They are articulated with it by muſcular ligaments, and ſupported on ſolid cretaceous foot-ſtalks. Beyond the foot-ſtalks theſe bodies are ſoft and moveable; and at their points ſome cretaceous particles are intermixed with the ſoft parts.

There are three varieties of theſe bodies. Two of the varieties agree nearly in ſhape, but differ in ſize.

In FIG. 18.

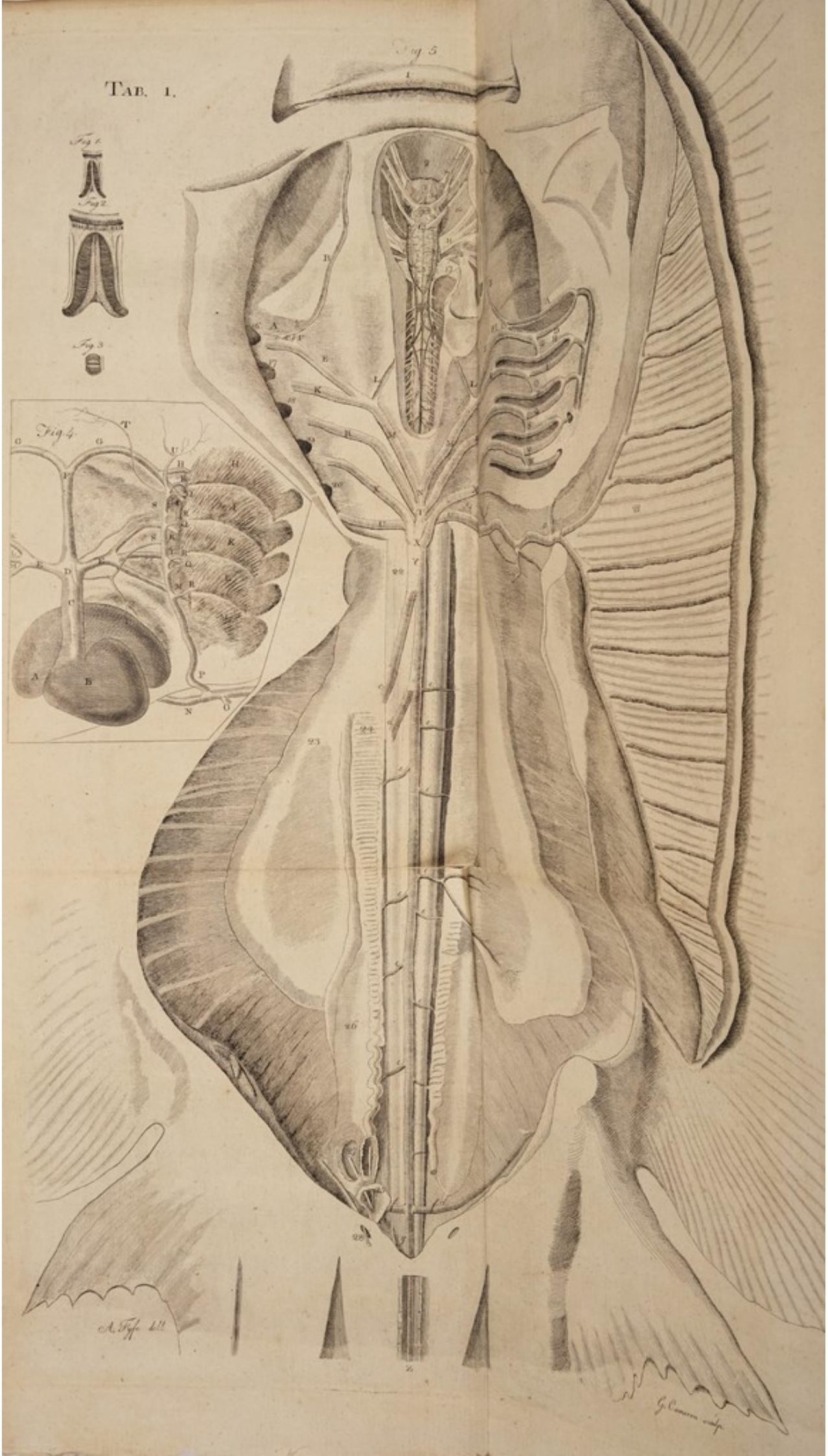
A B, Repreſent the thorns or feet. C D E repreſent the three varieties of theſe moving bodies.

FIG. 19. 20. 21.

Show the ſame bodies apart; and they are magnified to about two diameters in all theſe figures.

FINIS.

TAB. 1.



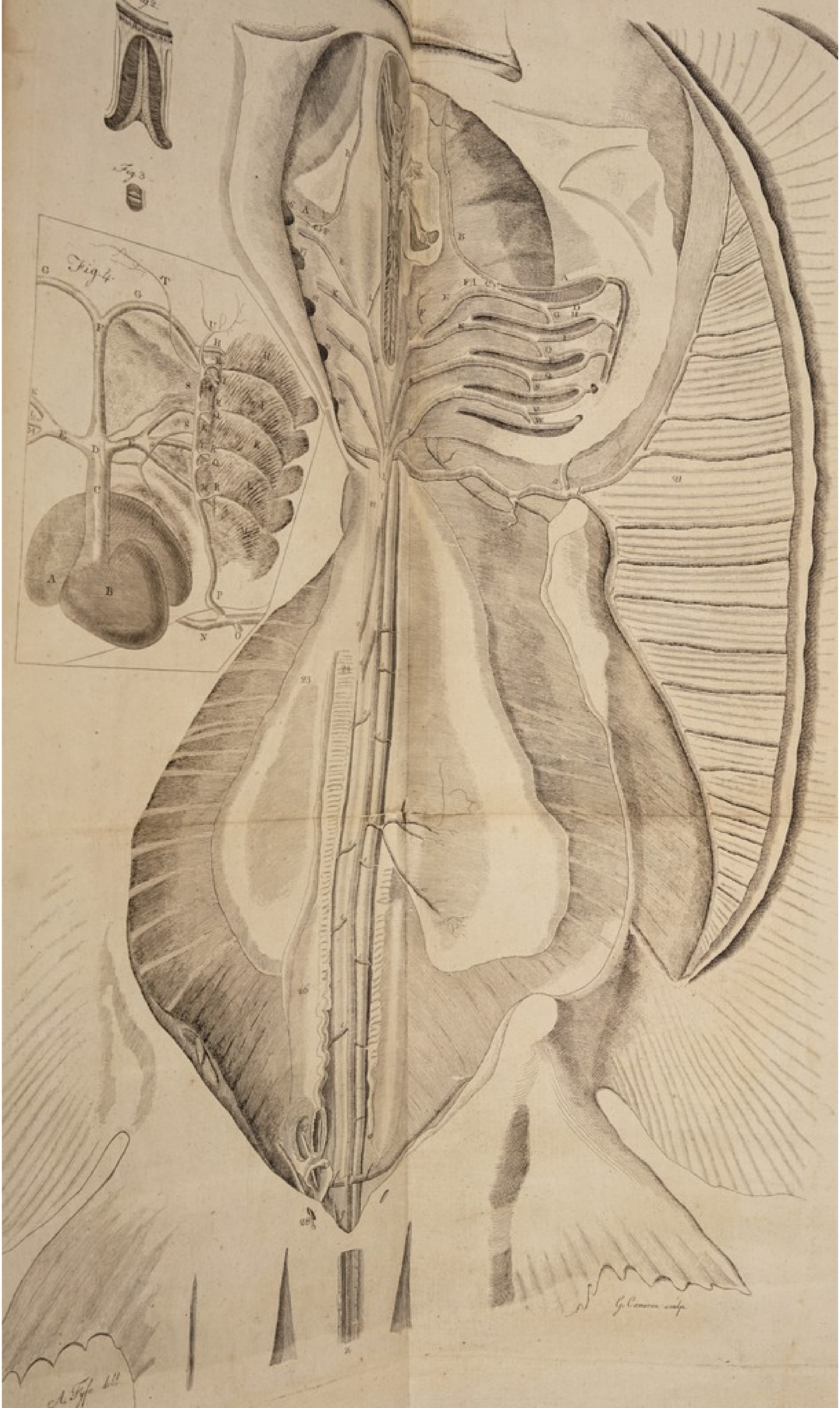
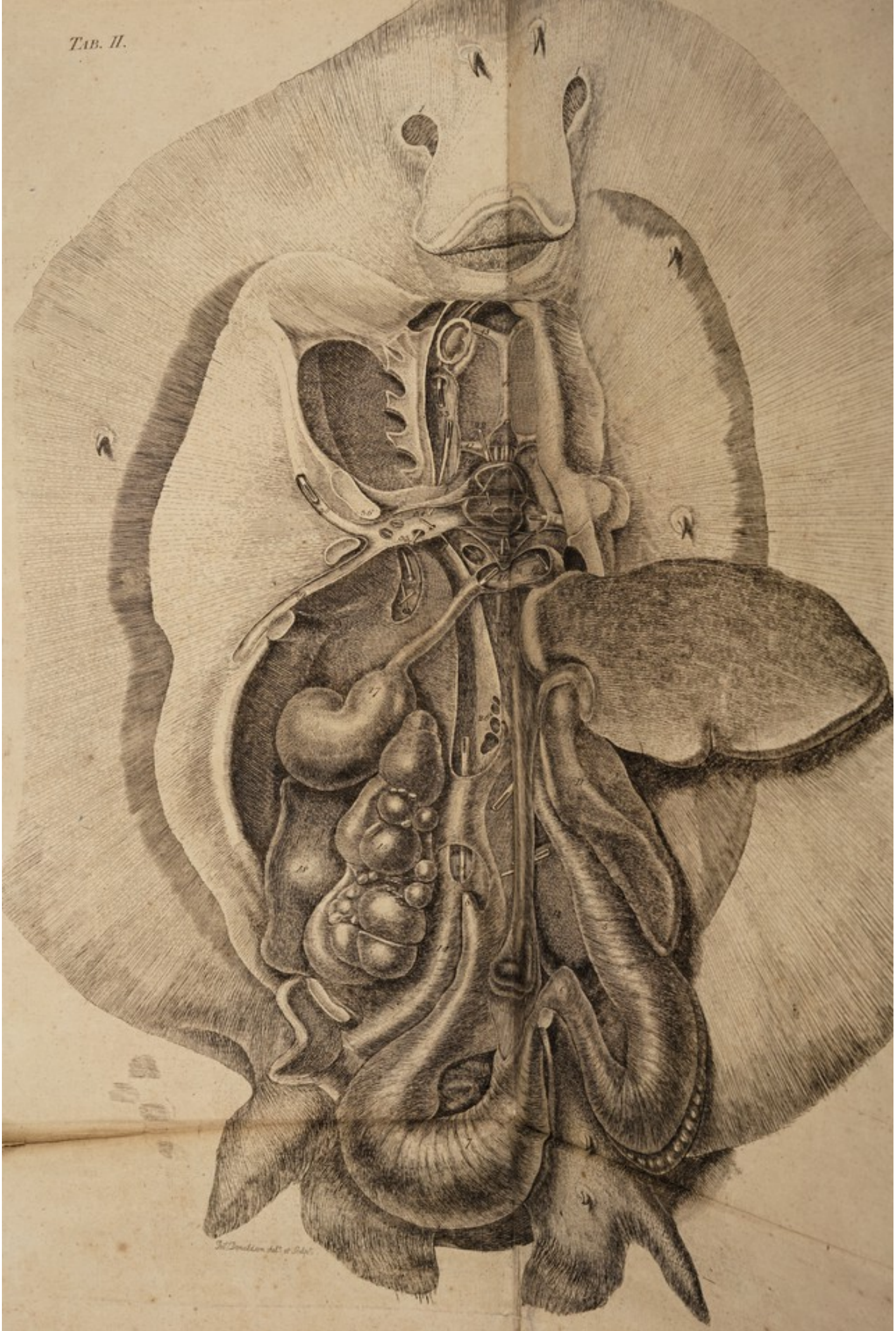
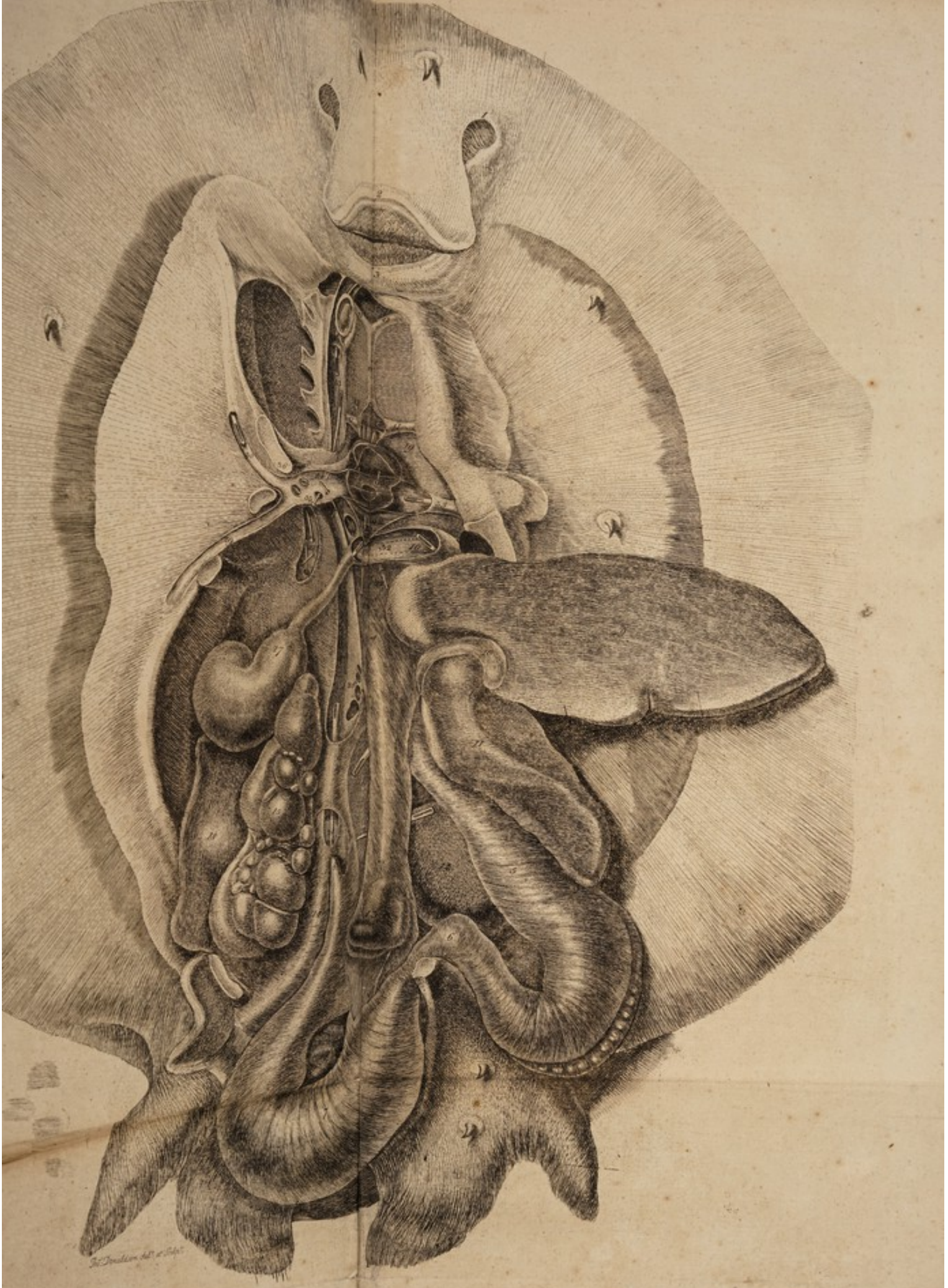


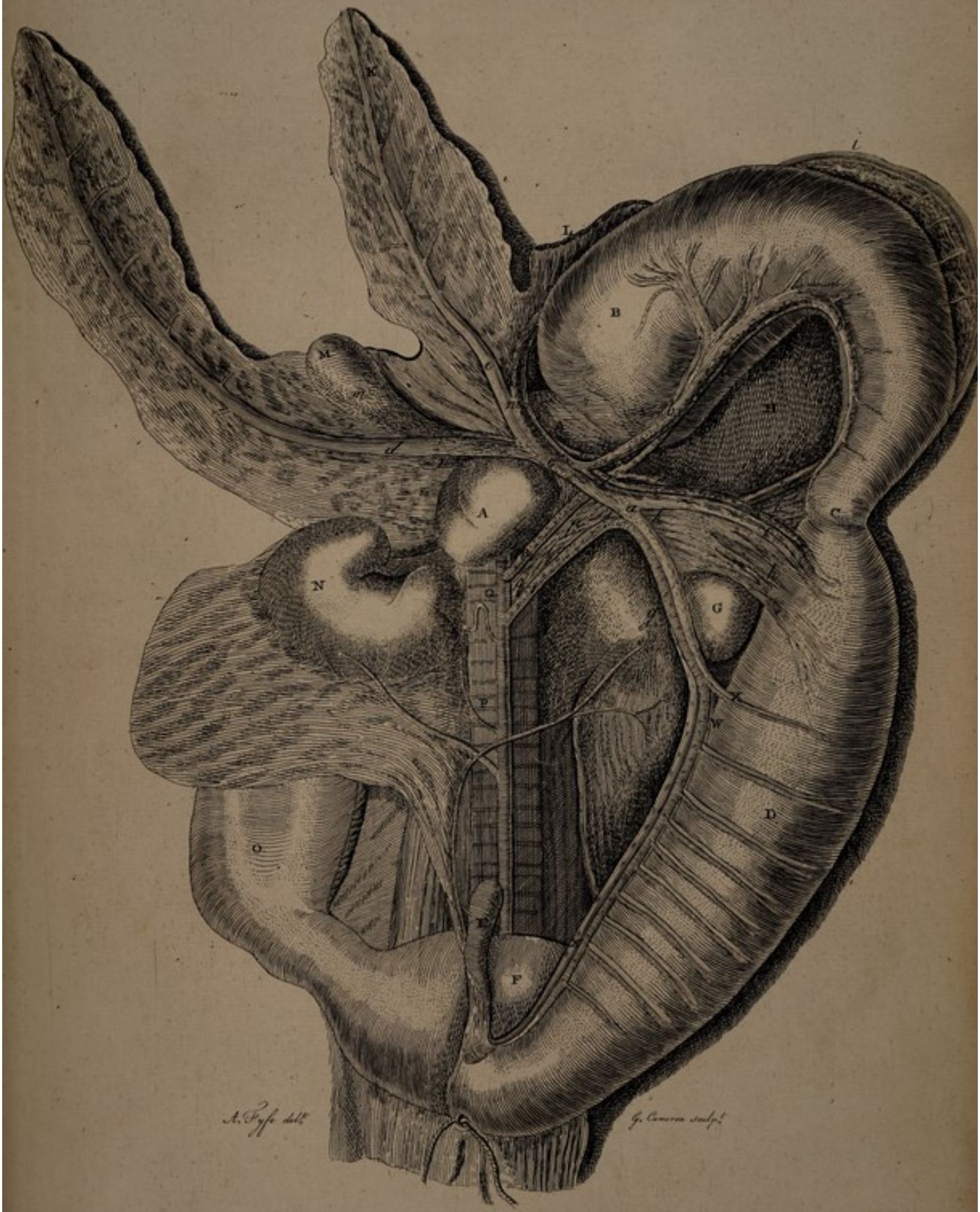
Fig. 3
Fig. 4
A. Fyfe del.
G. Cameron sculp.

TAB. II.

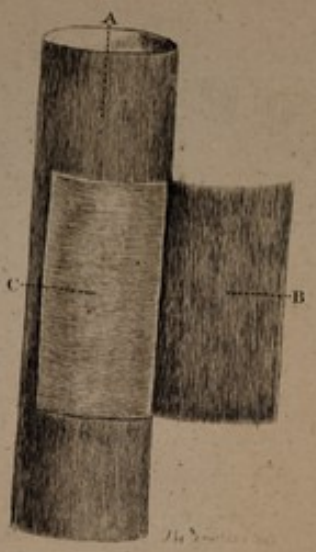




TAB. III.



TAB. III.



TAB. IV.

TAB. V.

A. Fyfe del.

G. Cameron sculp.

TAB. VI

TAB. VI

TAB. VII.

Fig. 2.

Fig. 1.

Fig. 3.

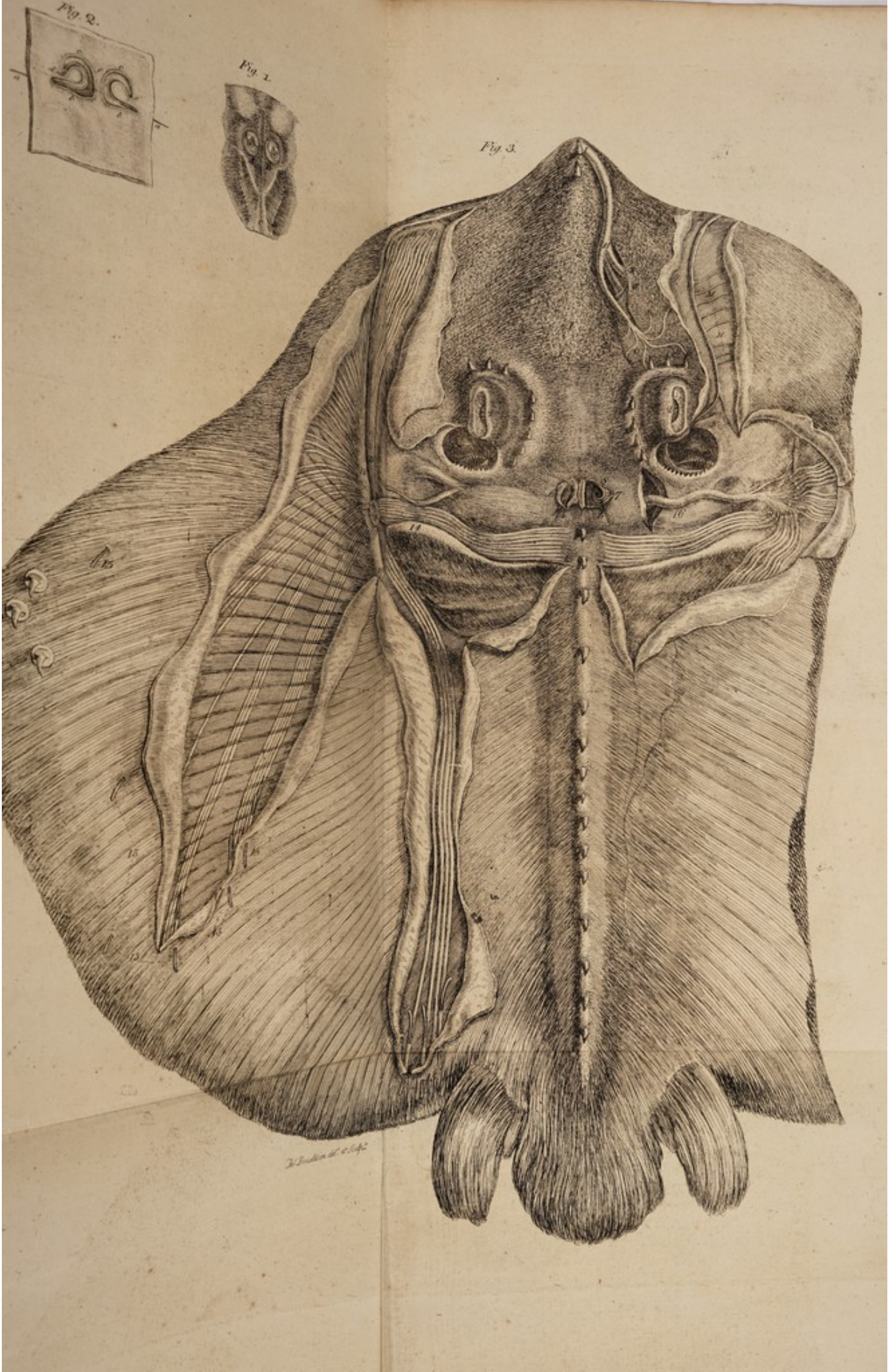


Fig. 2.
Fig. 1.
Fig. 3.

TAB. VIII.

Fig. 1.

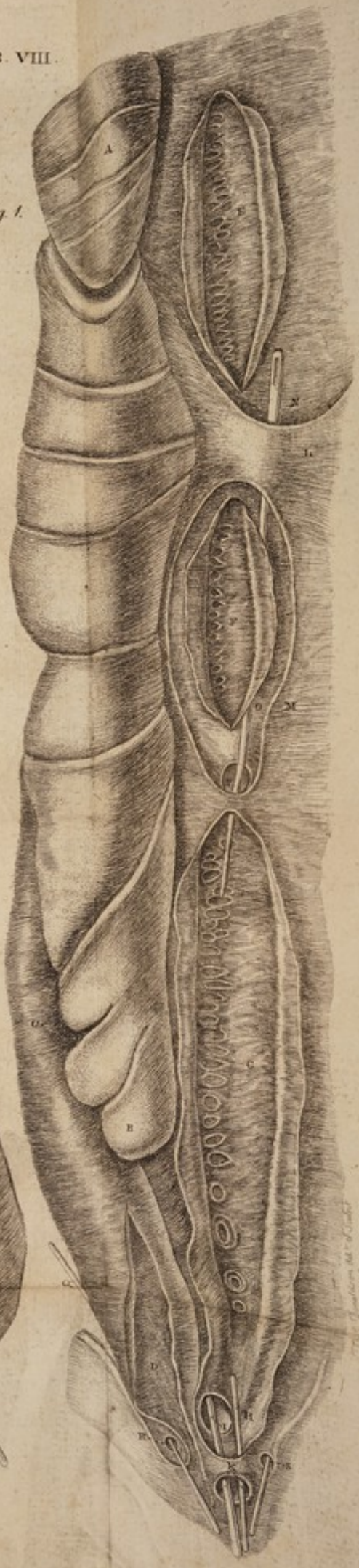


Fig. 2.

TAB. VIII.

Fig. 1.

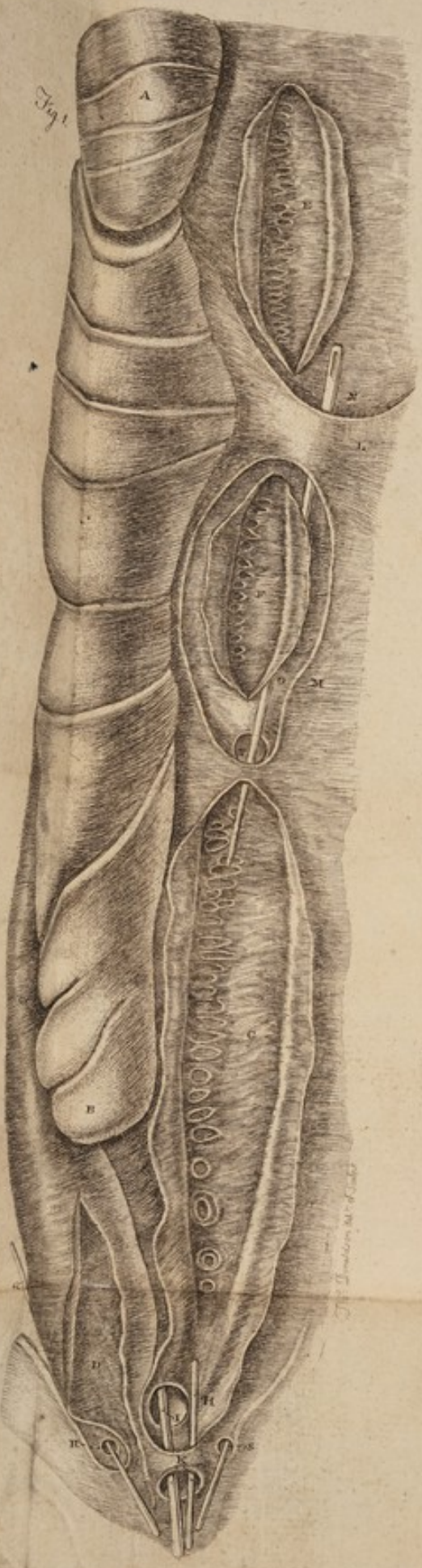


Fig. 2.

TAB. IX

Fig. 1.

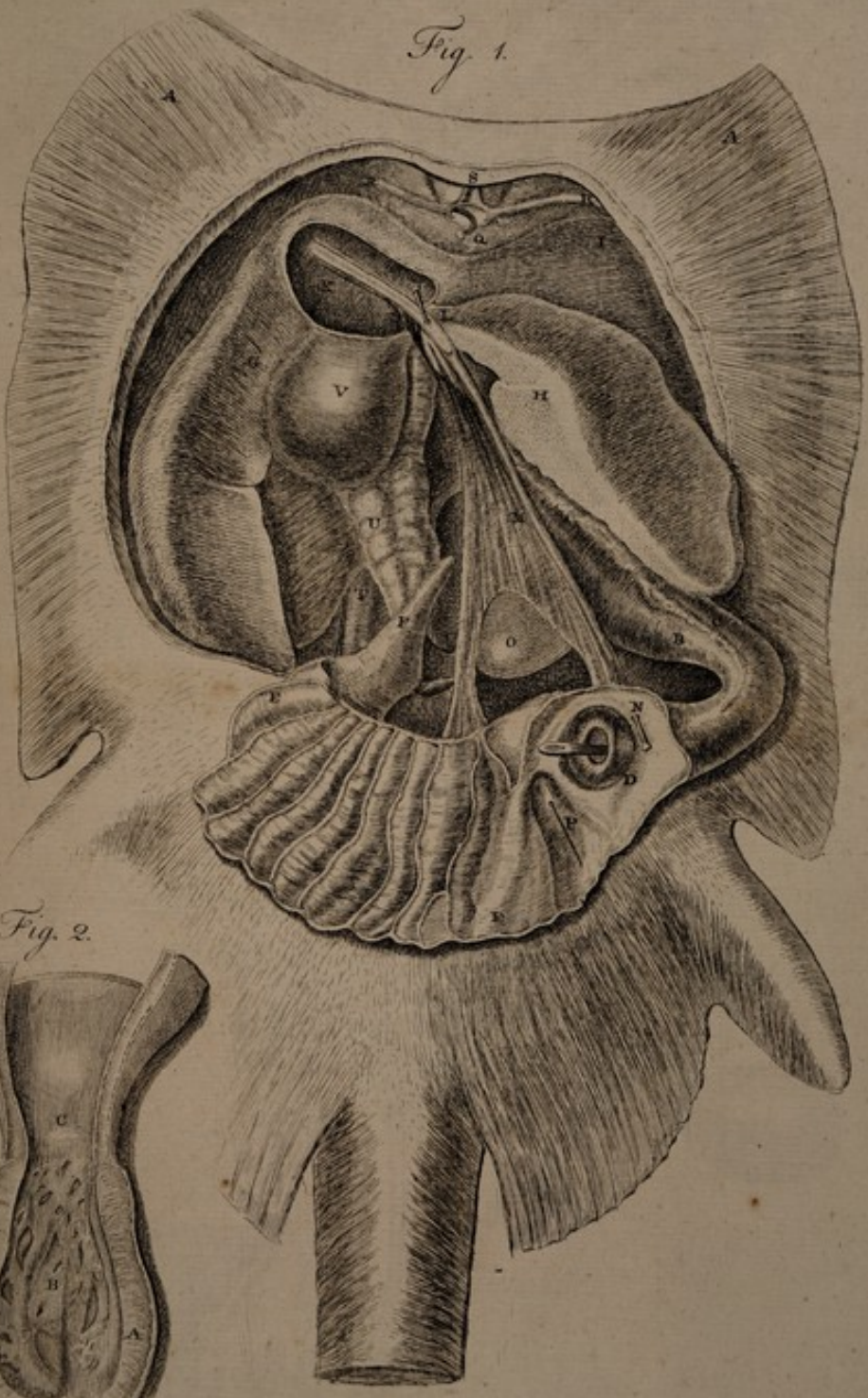
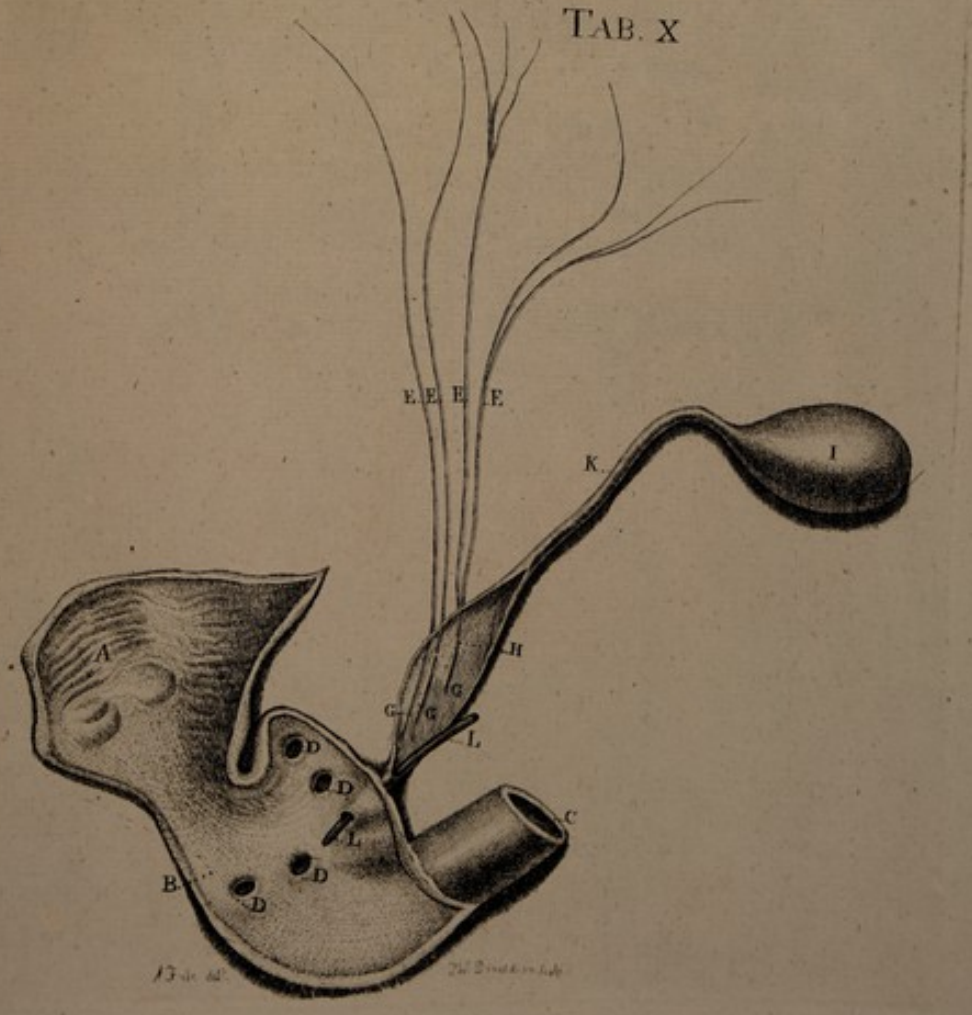


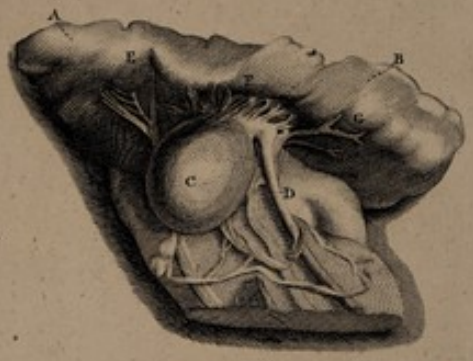
Fig. 2.

TAB. IX.

TAB. X

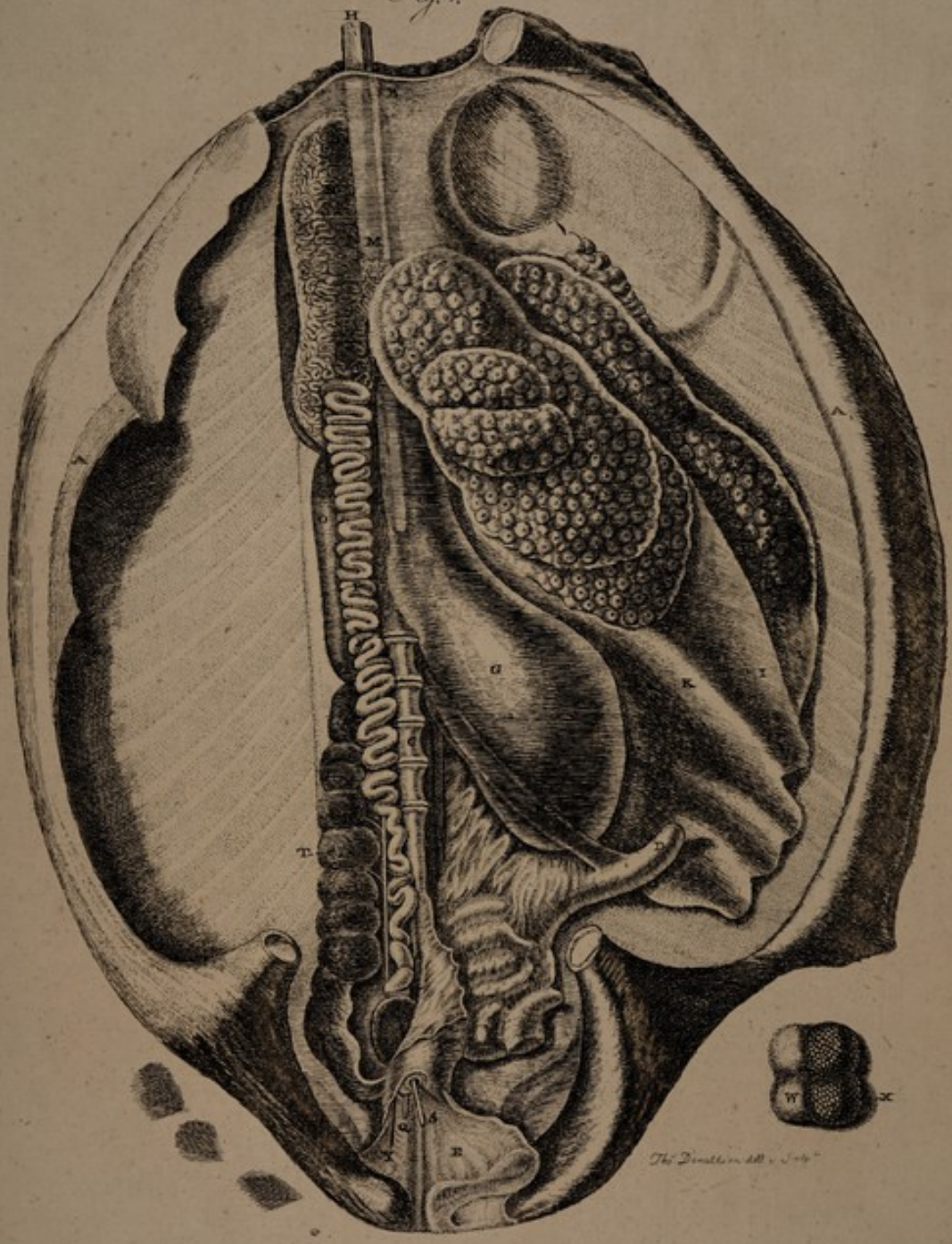


TAB. X. ✻

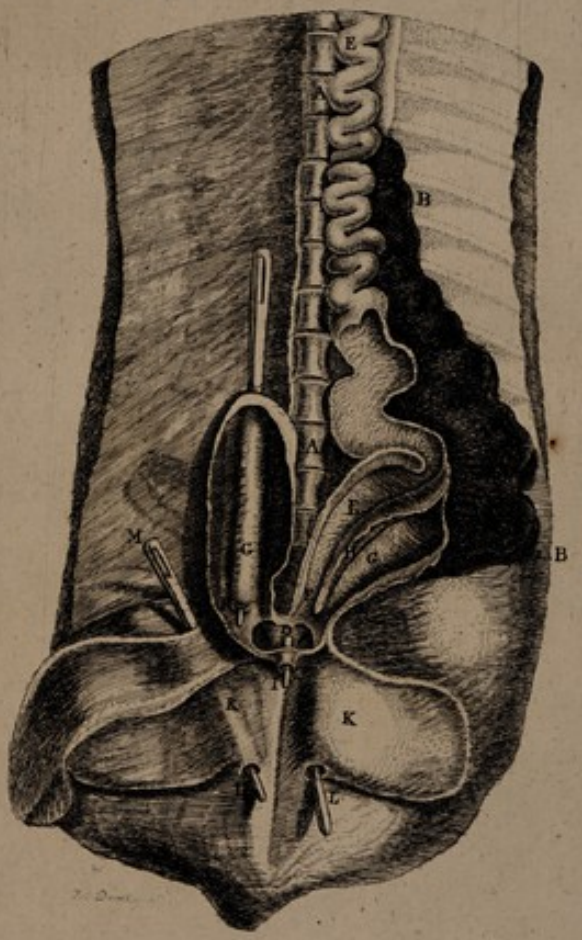


TAB. XI

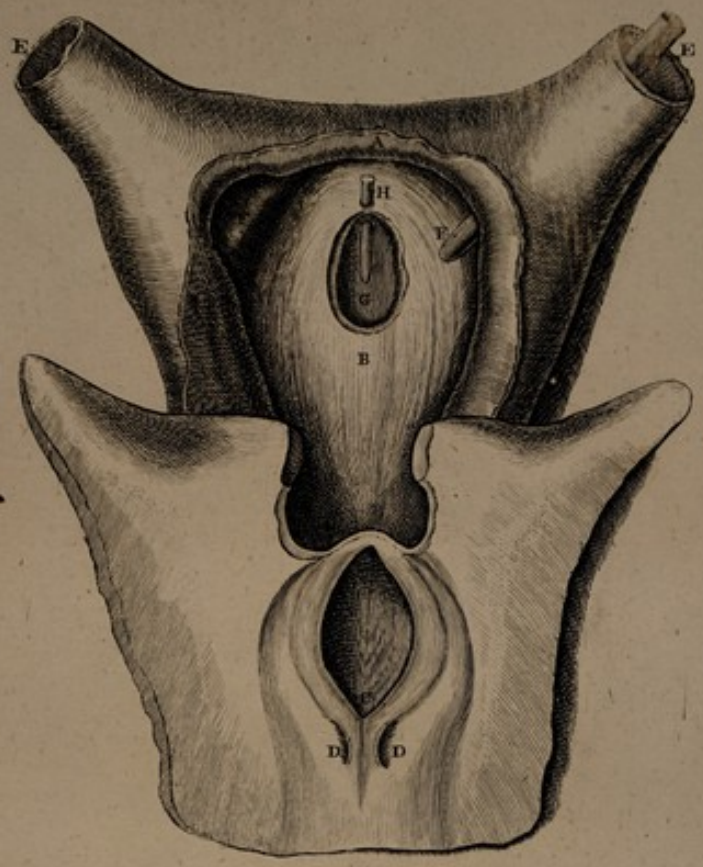
Fig. 1.



TAB. XII



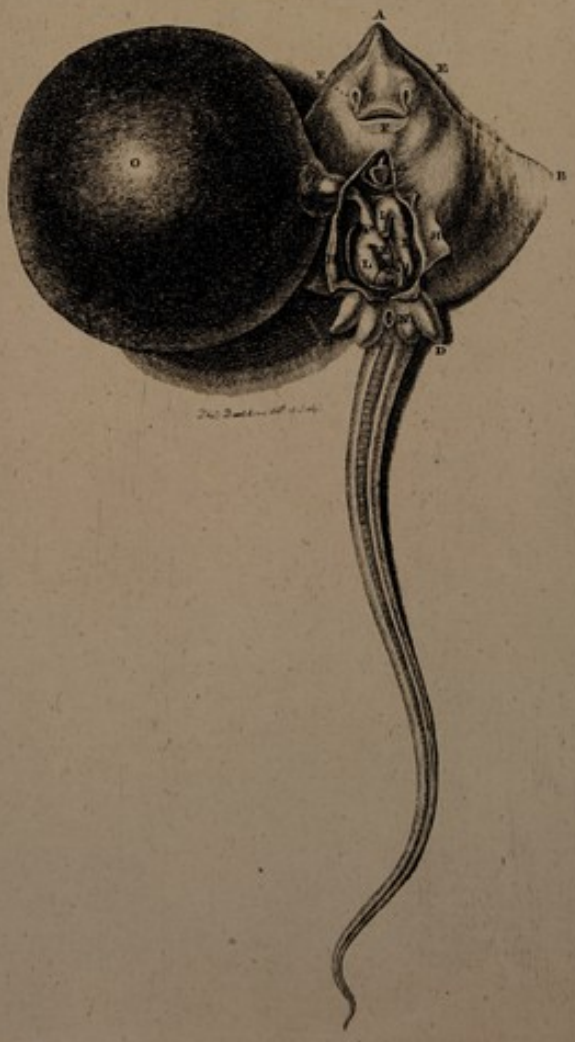
TAB. XIII



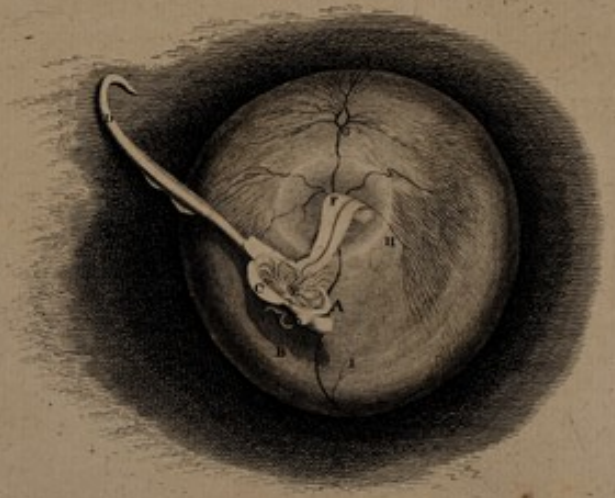
A. Fyfe delt.

G. Cameron sculpt.

TAB XIV



TAB. XIV.



TAB. XV.

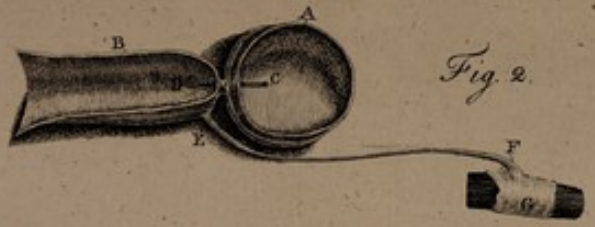


Fig. 2.

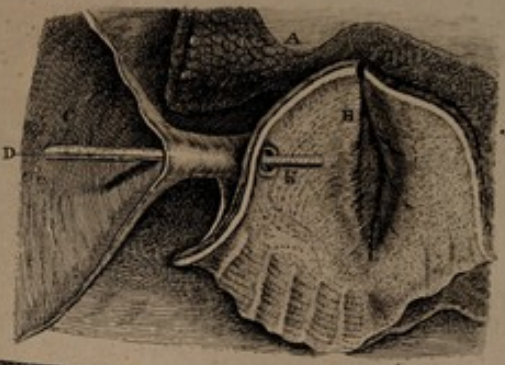


Fig. 1.

Fig. 3.

Fig. 4.

Fig. 5.

A. Fyfe delt.

G. Cameron sculp.


D
A
B
C
B
E
F
G
L
O
N
N
M
H
Jno.s Donaldson del.t et sculp.t

TAB. XVI

Fig. 1.

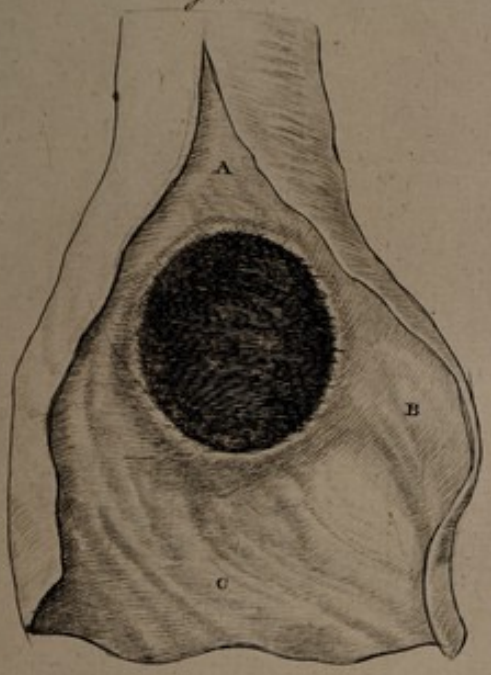


Fig. 2.

Fig. 3.

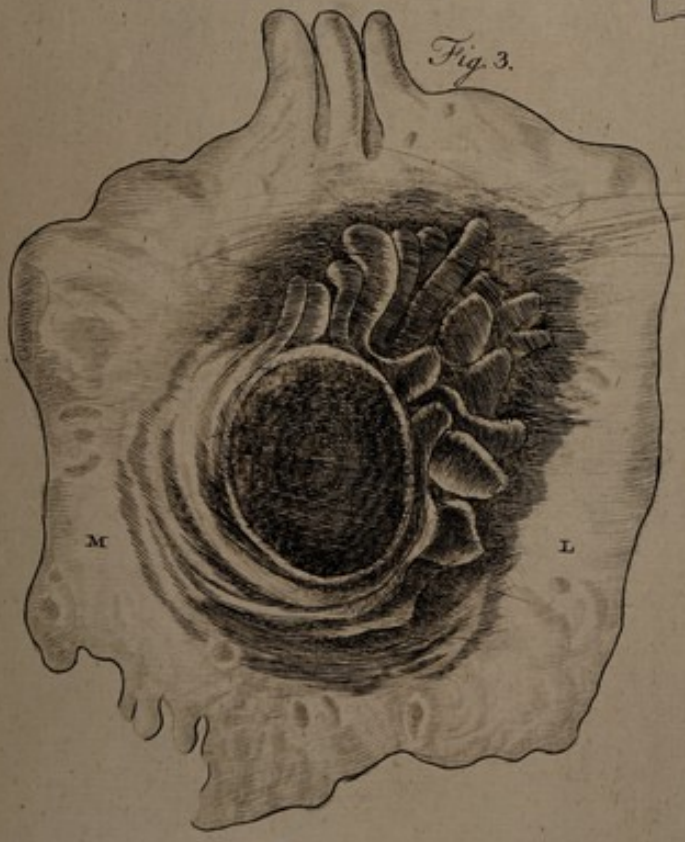
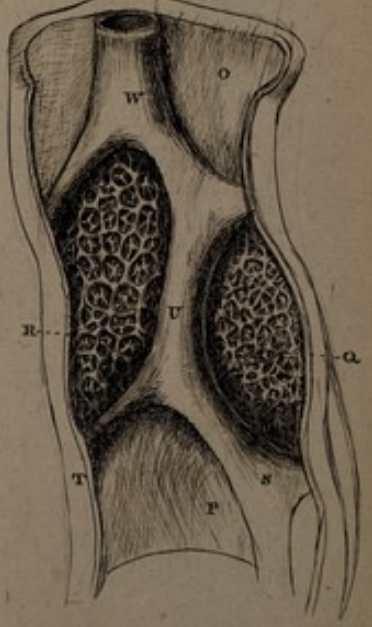


Fig. 4.



TAB. XVII

T. Donaldson delt.

G. Cameron sculp.

TAB. XVIII.

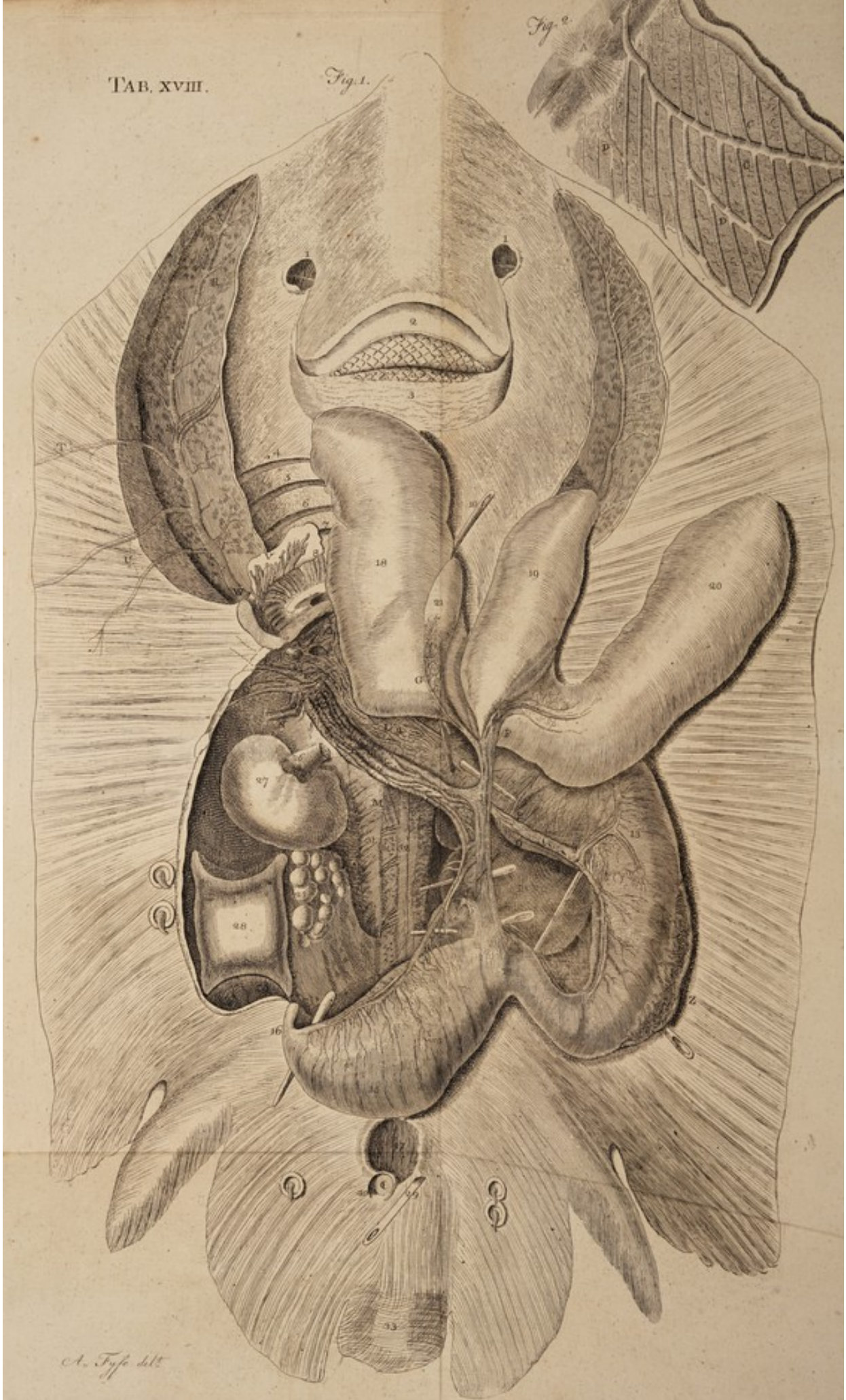
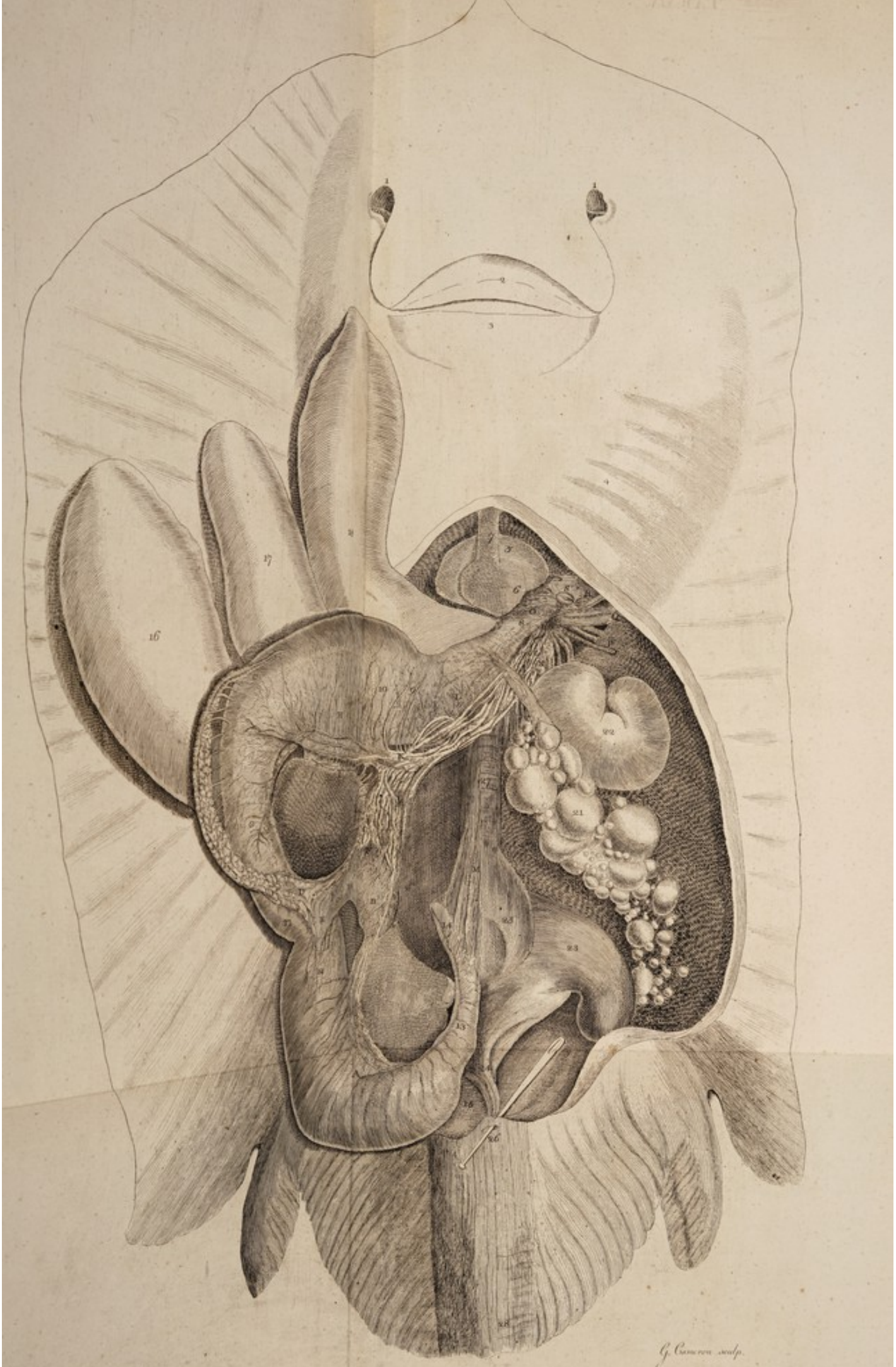



Fig. 1.
Fig. 2.
A
B
C
D
E
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
G. Cameron sculp.
A. Fyfe del.

TAB. XIX.

A. Fyfe del.

G. Cameron sculp


16
17
G. Cameron sculp.

TAB. XX

Fig. 1.

Fig. 2.

T. Donaldson delt.

TAB. XXI.

Fig. 3.

Fig. 2.

Fig. 1.

Fig. 4.

Fig. 5.

Thos. Donaldson delt. et Sculpt.

TAB. XXII.

Fig. 1.

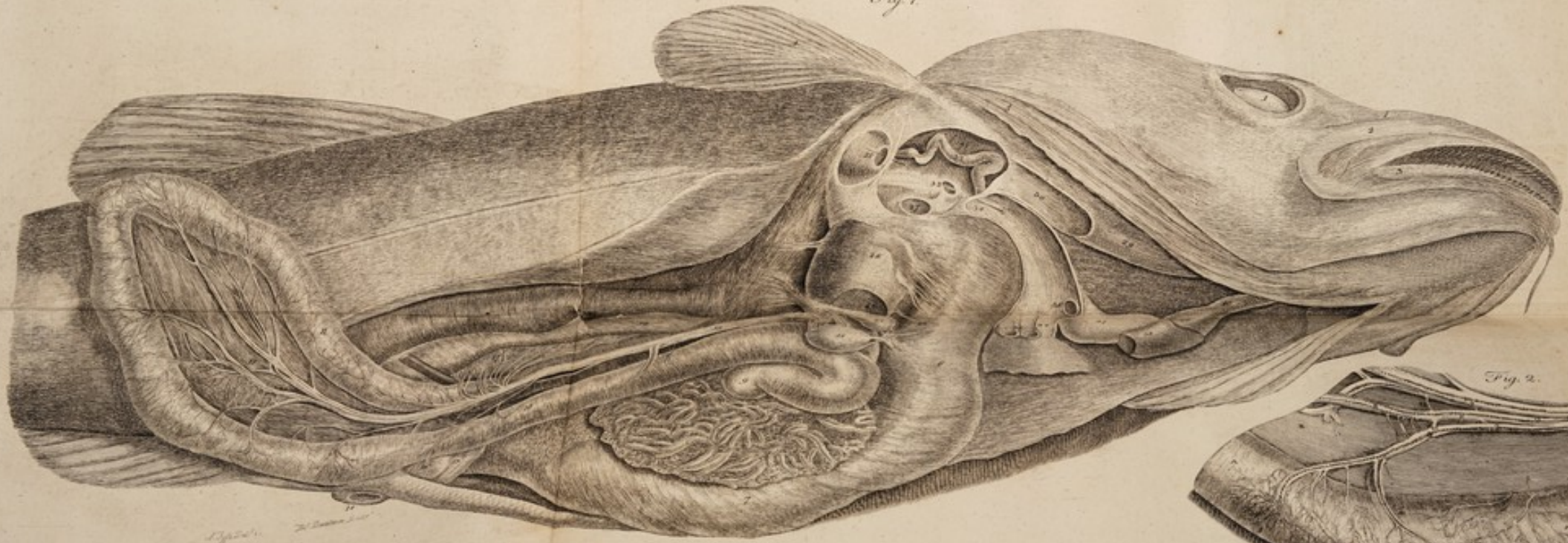
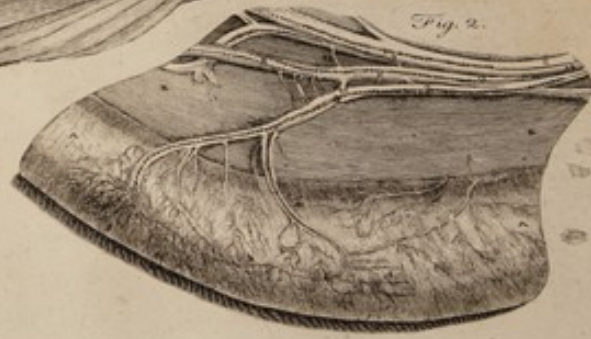


Fig. 2.

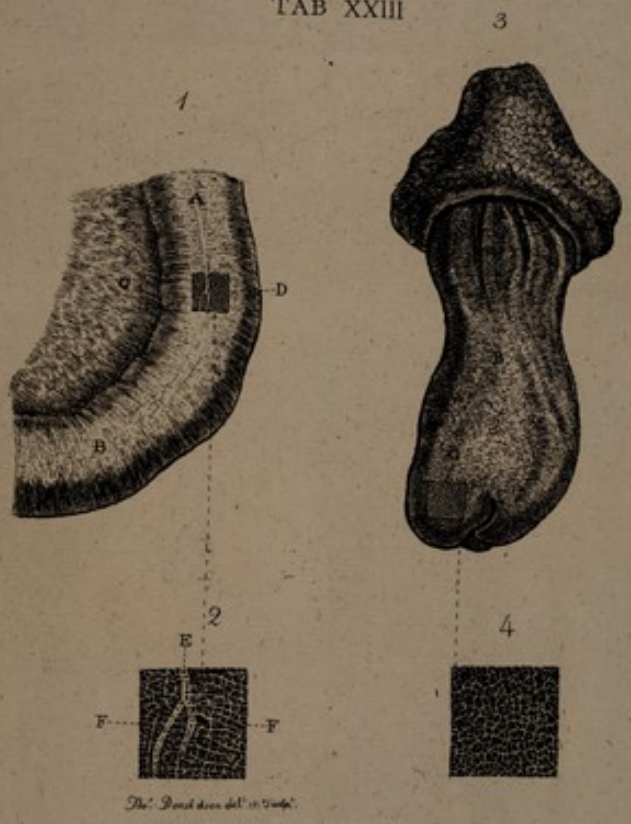


Tab. XXII.

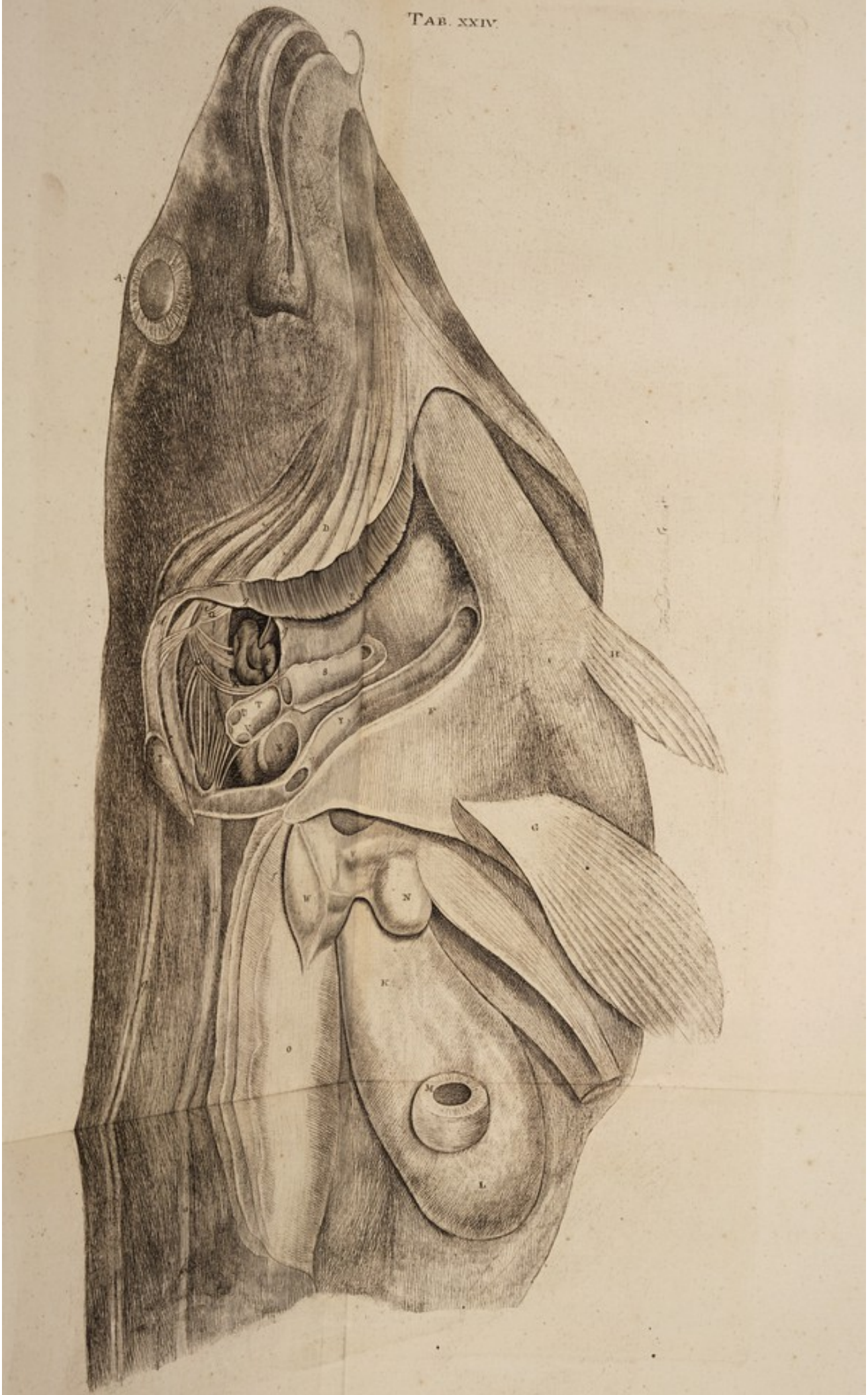
Fig. 1

Fig. 2.

TAB XXIII



TAB. XXIV.

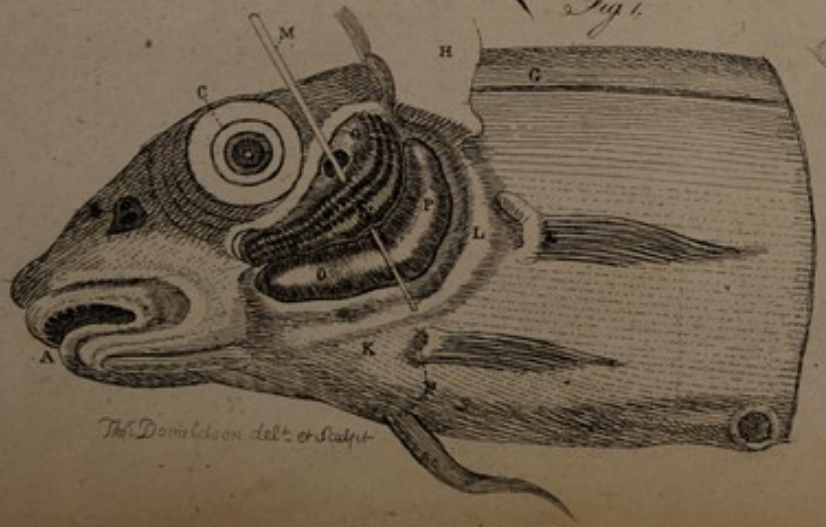


TAB. XXV.

Fig. 1.

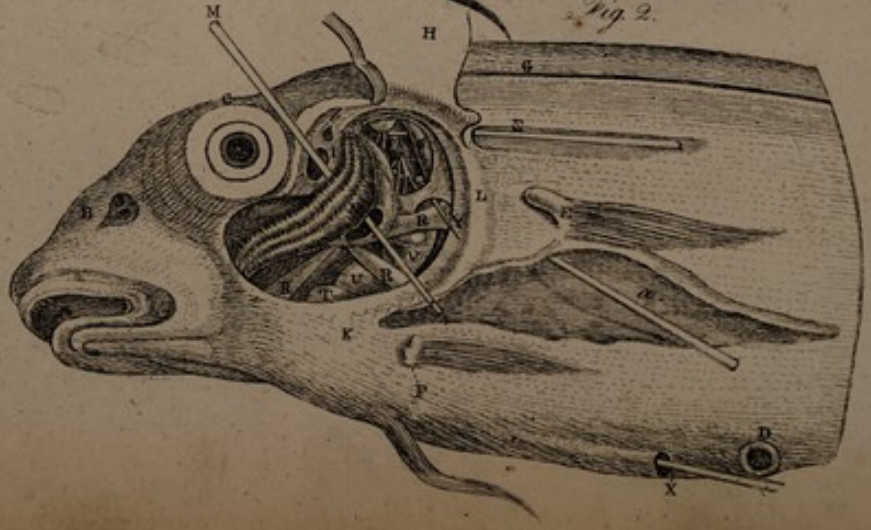
Fig. 2.

Fig. 1.



Th. Donaldson del.t et Sculpt.

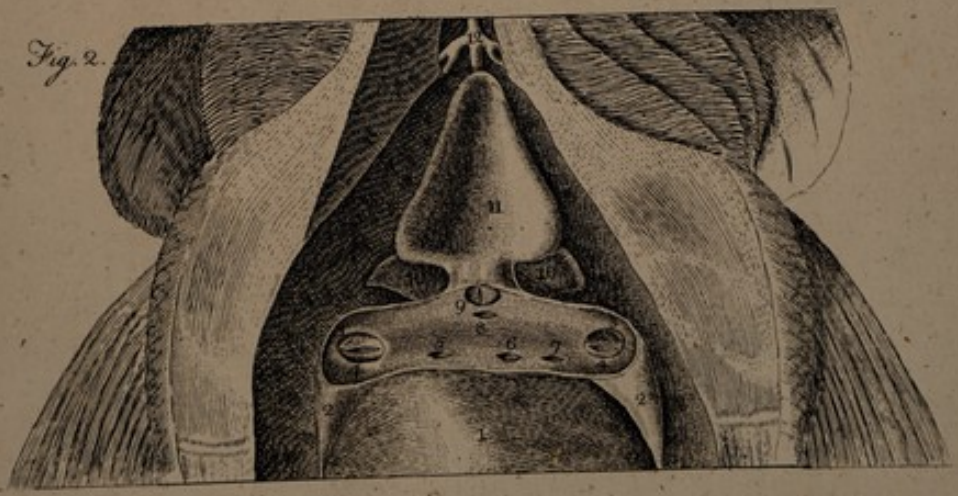
Fig. 2.



TAB. XXVI.

Fig. 1.

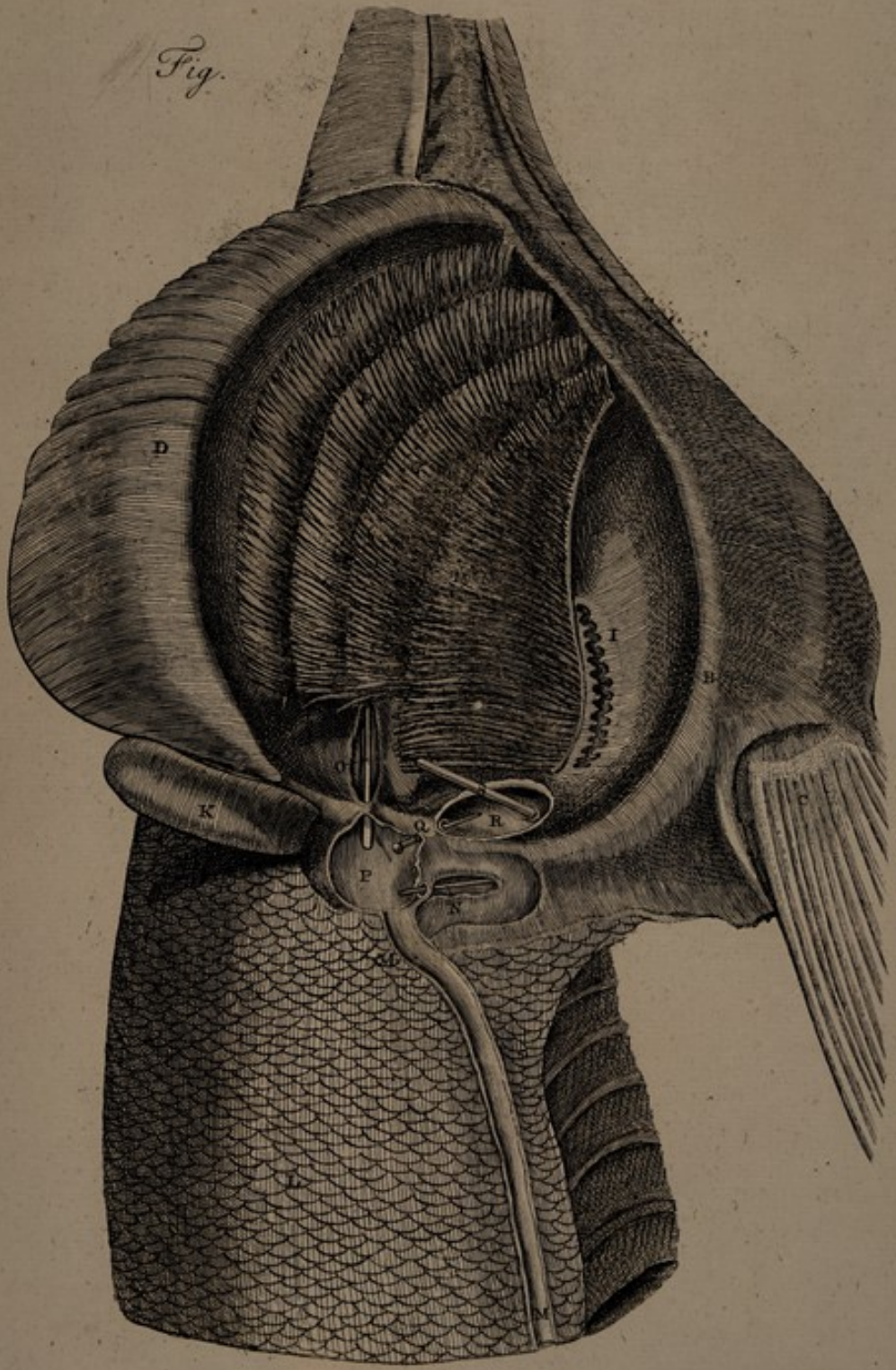
Fig. 2.



A. Fyfe delt. *G. Cameron sculp.*

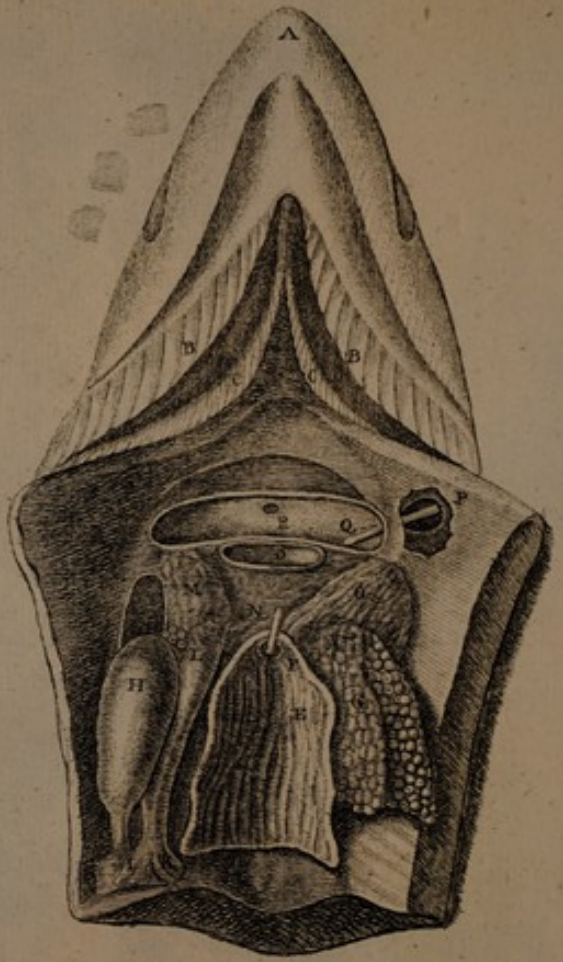
TAB. XXVII

Fig.



TAB. XXVIII.

TAB. XXIX



TAB. XXX.

TAB. XXXI.

Fig. 1.

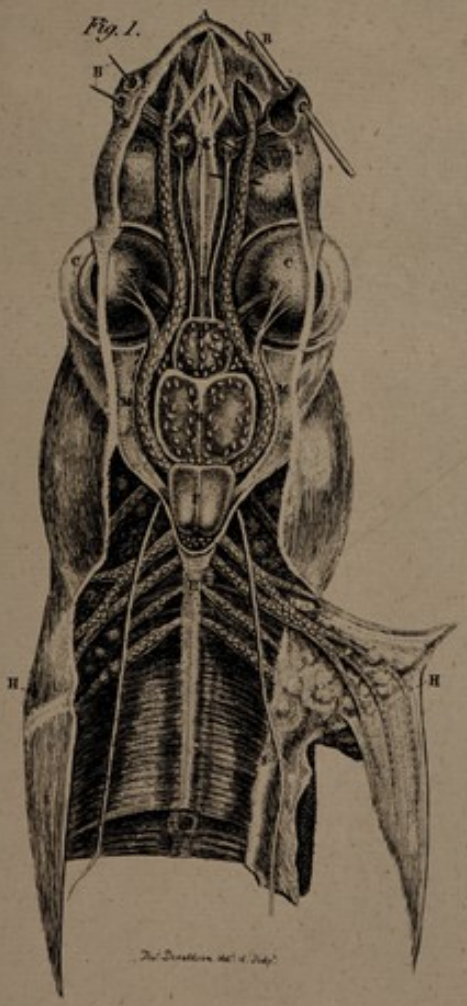


Fig. 2.

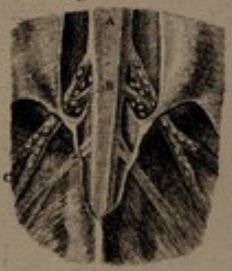
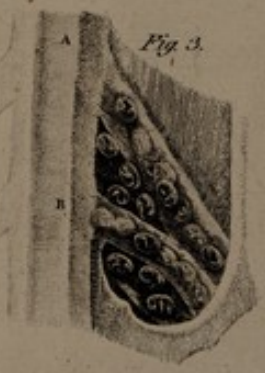
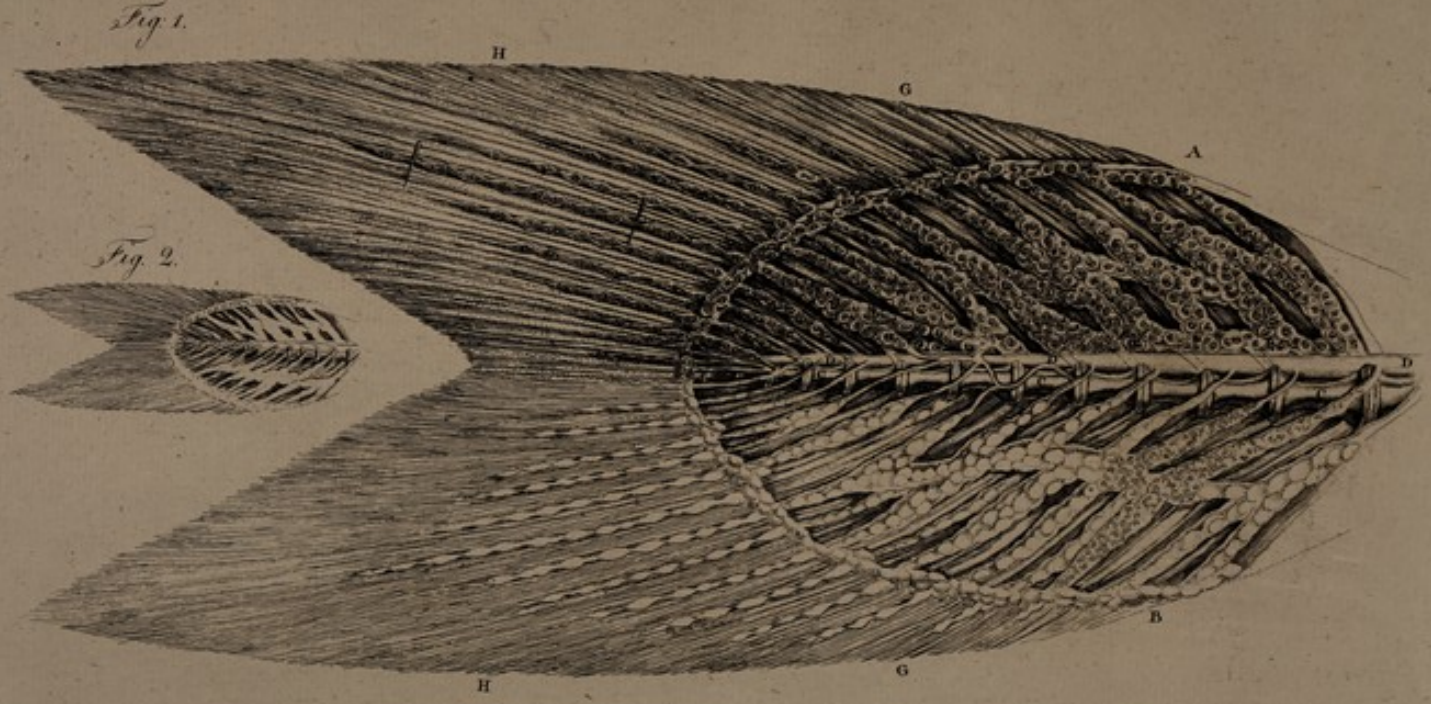


Fig. 3.

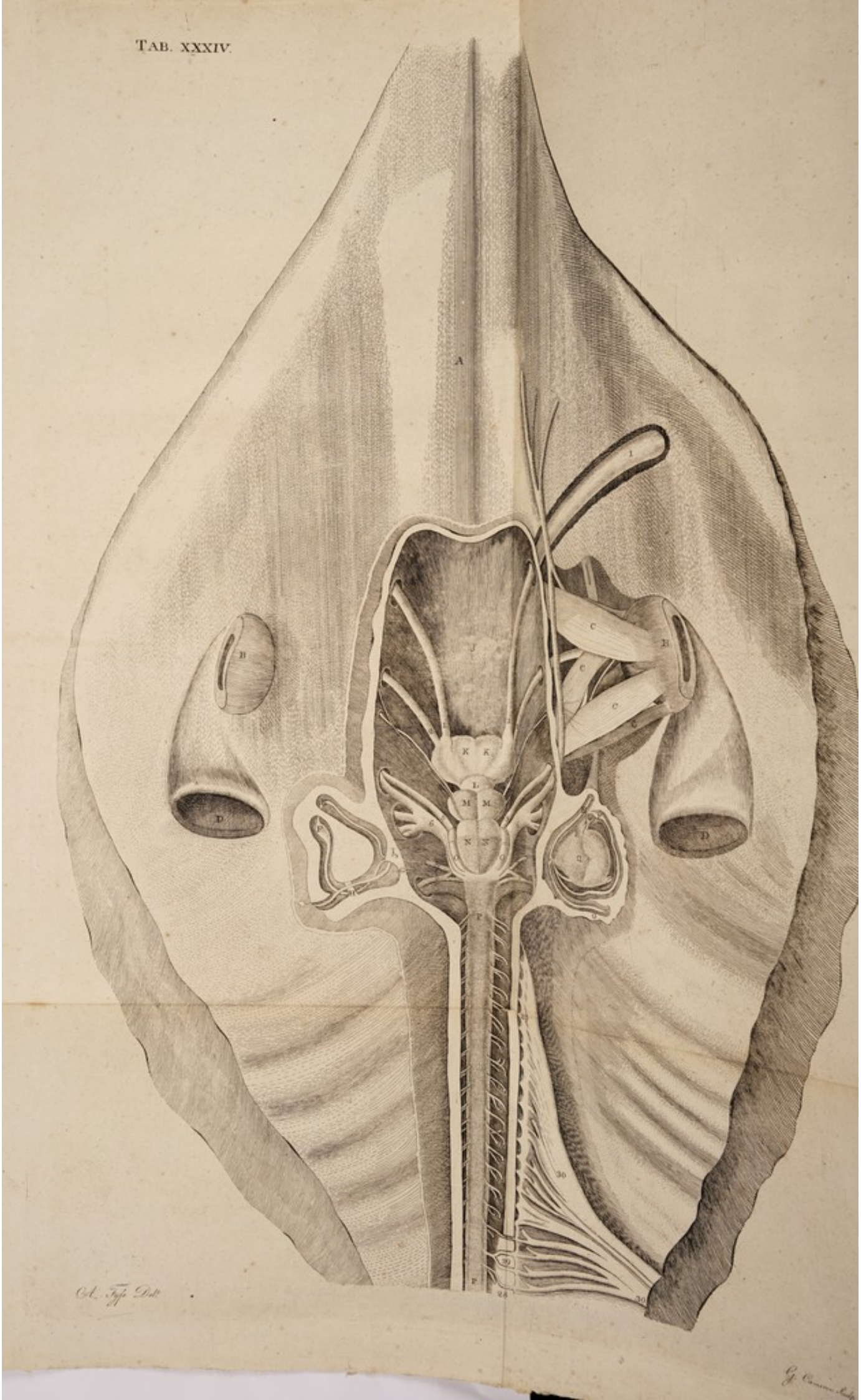


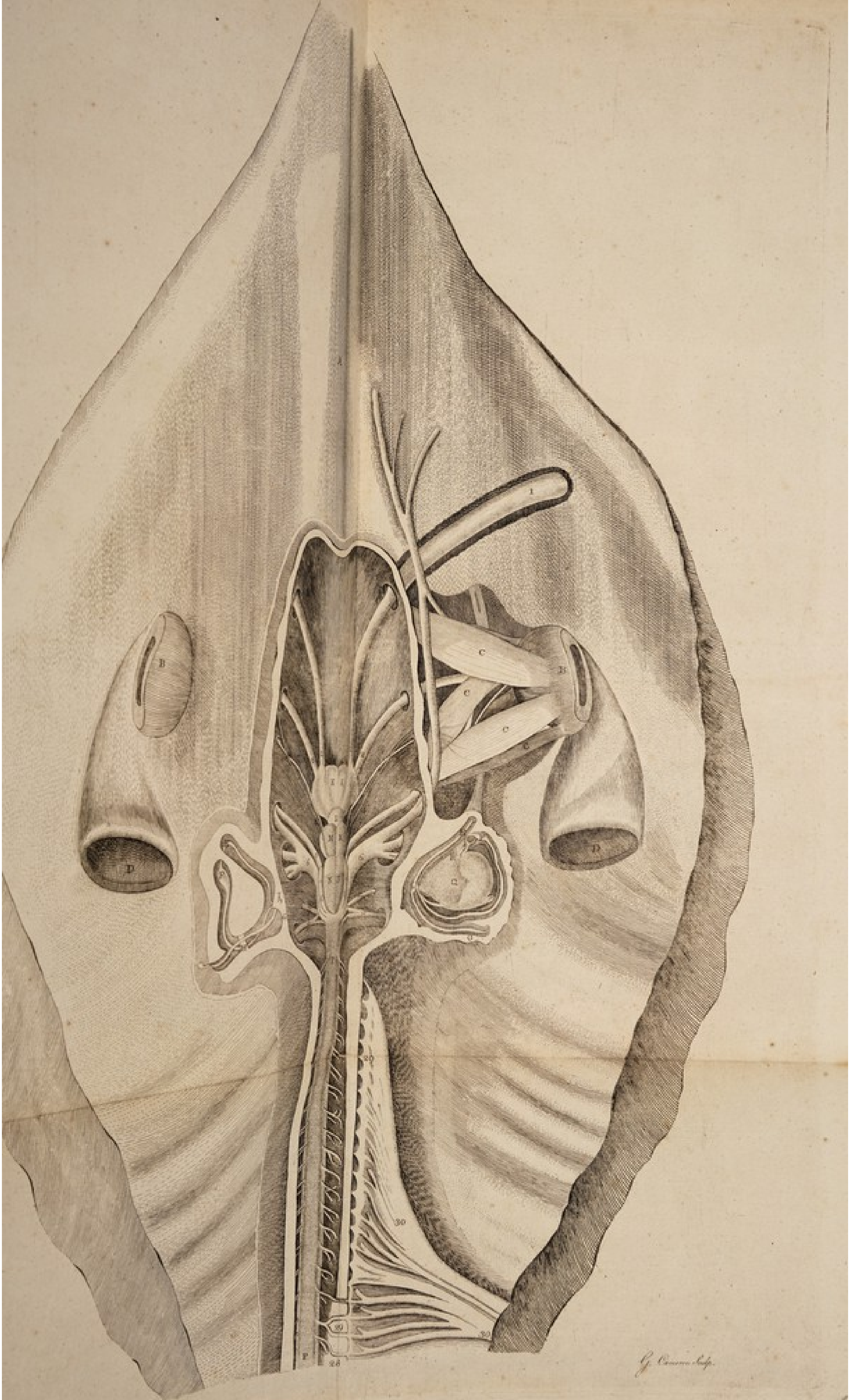
TAB. XXXII

Tab. XXXIII.



TAB. XXXIV.





G. [illegible] sculp.

TAB. XXXV

Fig 1.

Fig 2.

Fig 3

Fig 4

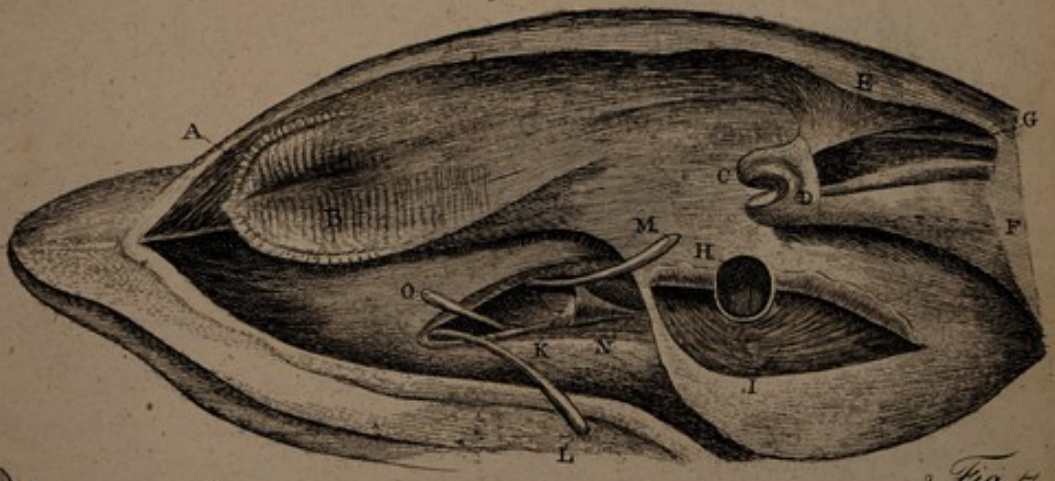


Fig 5

Fig 6

Fig 7.

Fig 8.

Fig 9.

TAB. XXXVI

Fig. 1.

Fig. 2.

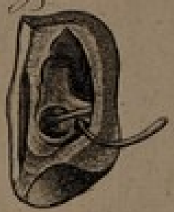


Fig. 2.

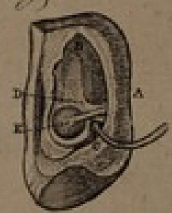
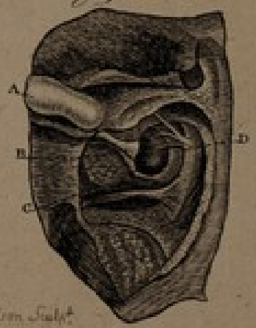


Fig. 3.

Fig. 3.

Fig. 4.



A. Fyfe delt. Jas. Donaldson Sculpt.

TAB. XXXVII.

Fig. 1.

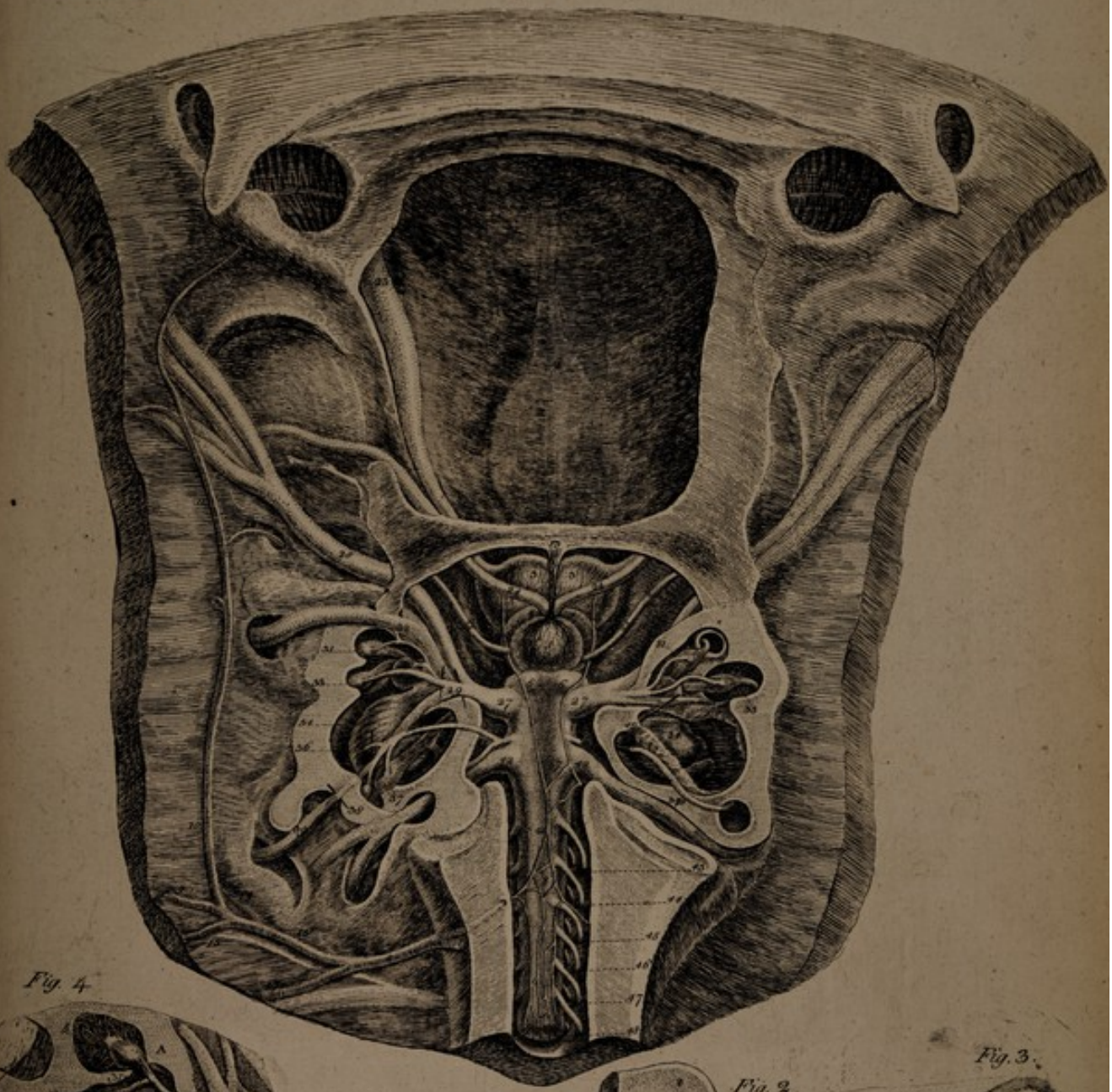


Fig. 4

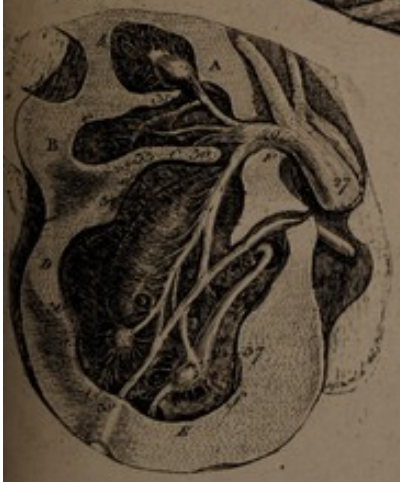


Fig. 2

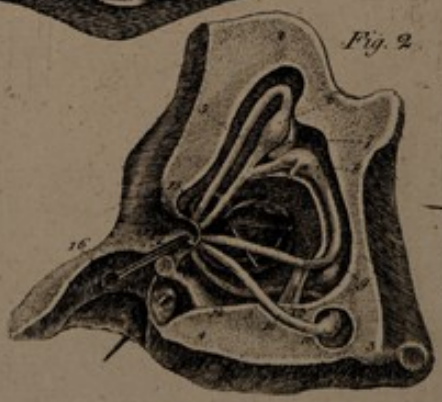
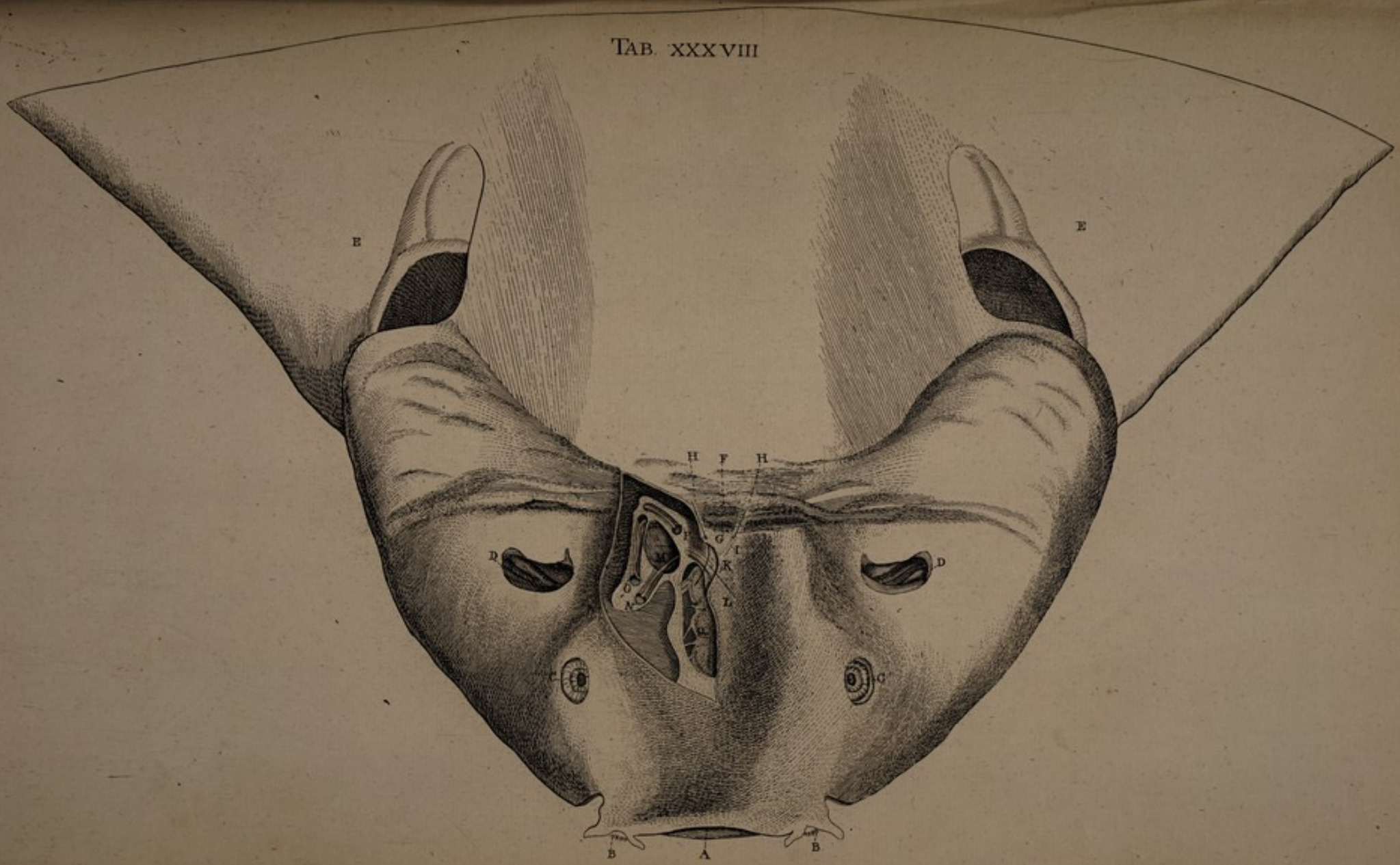


Fig. 3.

TAB. XXXVIII



A. Fyfe del.

G. Cameron sculp.

TAB. XXXIX.

Fig. 1.

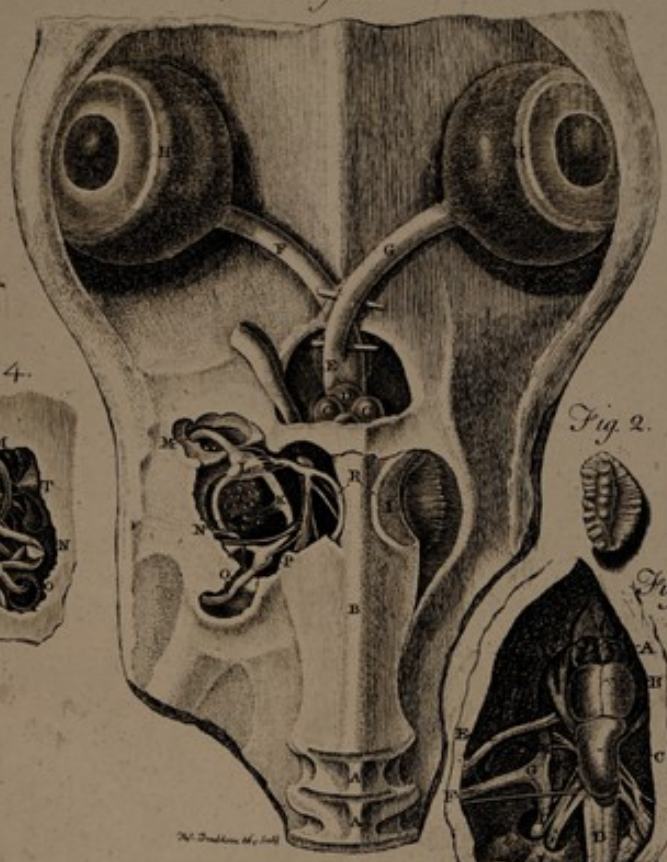
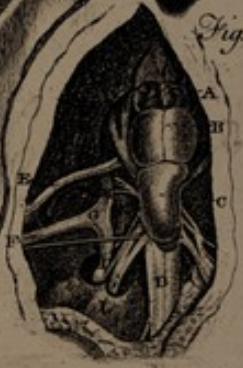


Fig. 3.

Fig. 4.

Fig. 2.

Fig. 5.



TAB. XL.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

TAB. XL. ✳

Fig. 1.

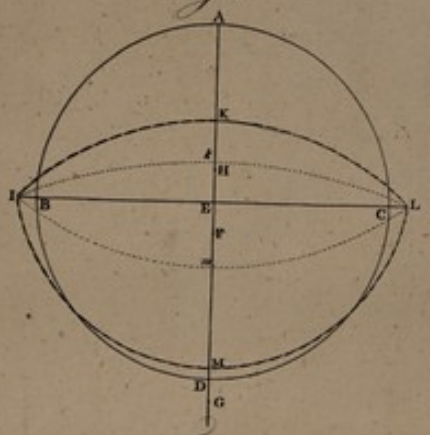
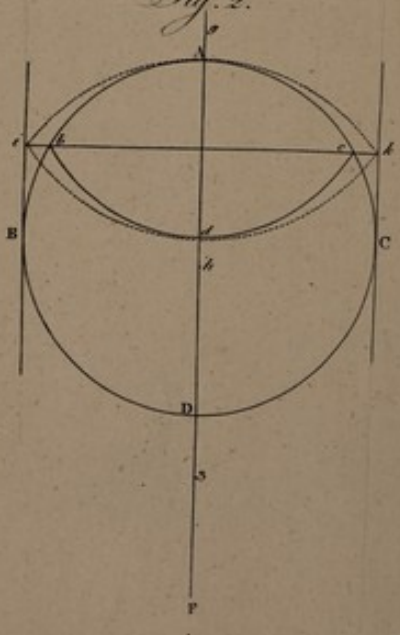


Fig. 2.



TAB XLI.

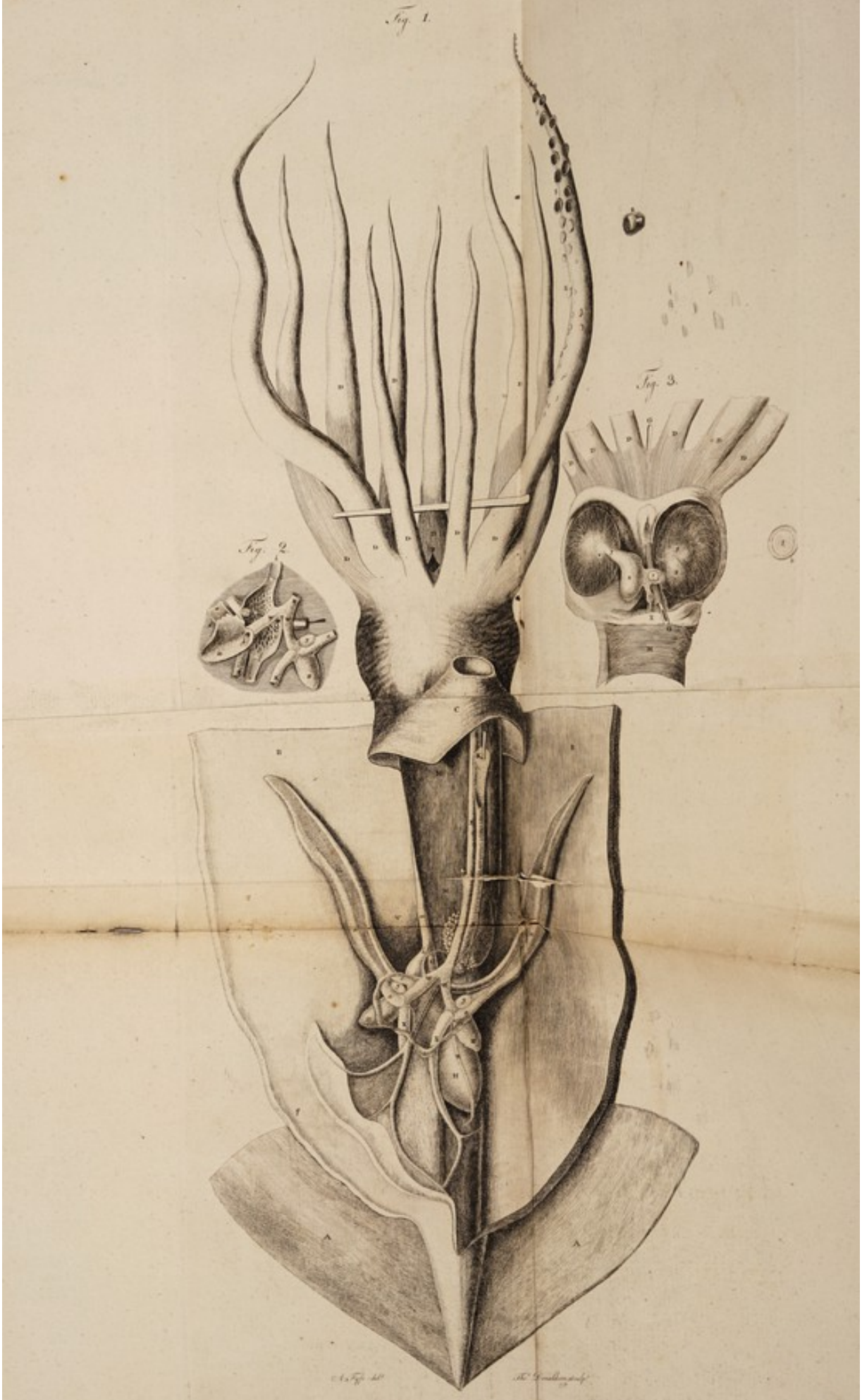
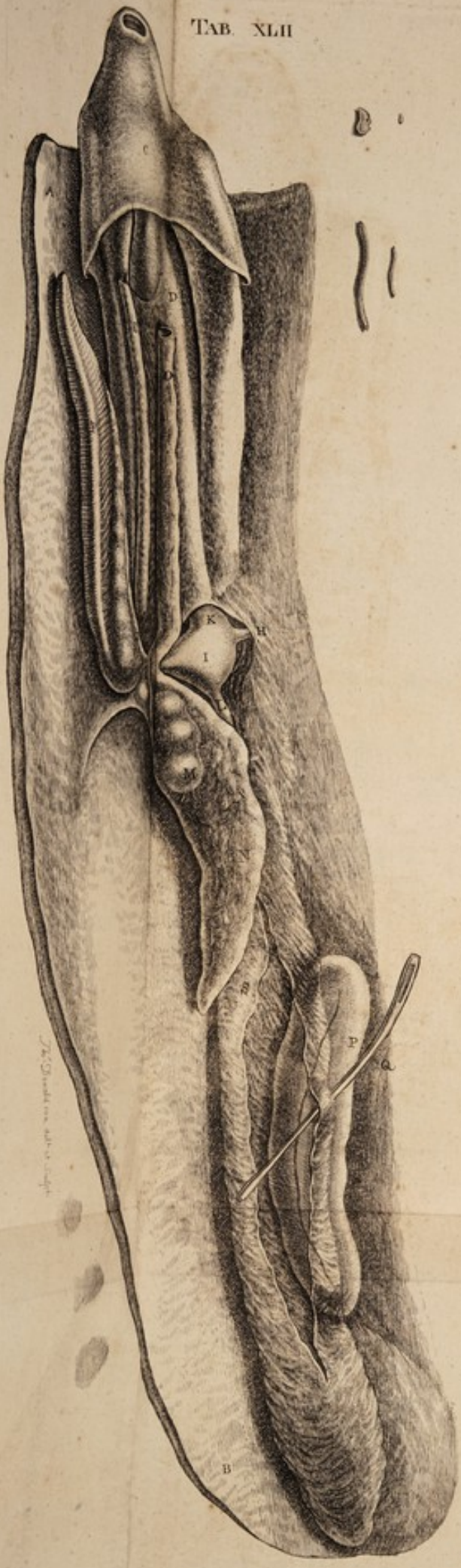



Fig. 3.

TAB XLII

TAB. XLII



TAB. XLIII.

Fig. 1.

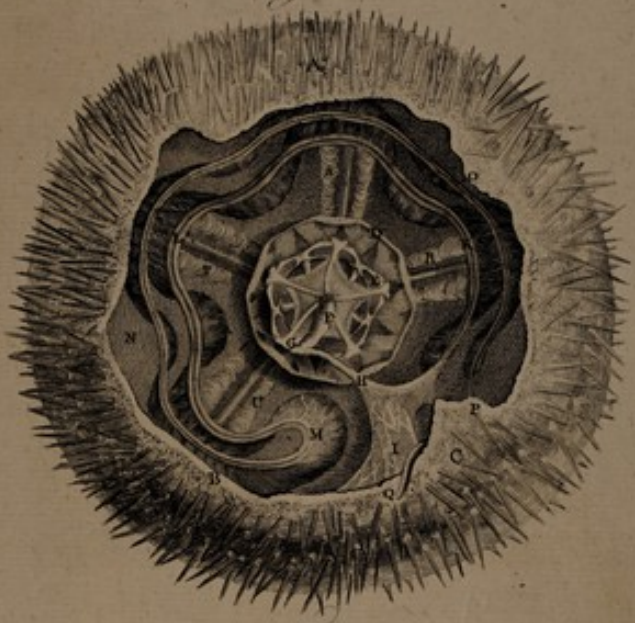


Fig. 2.

TAB. XLIV

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11

Fig. 12

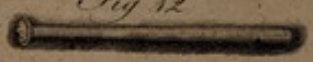


Fig. 13

Fig. 14

Fig. 15

Fig. 16

Fig. 17

Fig. 18

Fig. 21

Fig. 19

Fig. 20