XL. *Anatomical Obſervations on the Torpedo.* *By* John Hunter, *F. R. S.*

Read July 1, 1773.

I WAS deſired ſome time ſince, by Mr. Walſh, whoſe experiments at La Rochelle had determined the effect of the Torpedo to be electrical, to diſſect and examine the peculiar organs by which that animal produces ſo extraordinary an effect. This I have done in ſeveral ſubjects furniſhed to me by that Gentleman.

I am now deſired by him to lay before the Society, the obſervations I have made; and for the better underſtanding of them, to preſent, on his part, a male and female Torpedo in ſpirits; in the latter of which the electric organs are expoſed in different views and ſections; likewiſe a copper-plate, which he took care to have engraved, exhibiting thoſe organs.

Of the general ſtructure and anatomy of the Torpedo I ſay nothing, ſince the animal does not differ very materially, excepting in it's electric organs (as they have been properly named by Mr. Walſh) from the reſt of the Rays, of which family it is well known to be. I will only premiſe, that the Torpedo, of which I treat, is about eighteen inches long, twelve broad, and in it's central or thickeſt part two inches thick; which is nearly the ſize of

the female ſpecimen, now preſented to the Society, as well as of that from which the plate was taken: but where there is any difference in the organ ariſing from difference in ſize, notice will be taken of it in this account.

The electric organs of the Torpedo are placed on each ſide of the *cranium* and gills, reaching from thence to the ſemicircular cartilages of each great fin, and extending longitudinally from the anterior extremity of the animal to the tranſverſe cartilage, which divides the thorax from the abdomen; and within theſe limits they occupy the whole ſpace between the ſkin of the upper and of the under ſurfaces: they are thickeſt at the edges near the center of the fiſh, and become gradually thinner towards the extremities. Each electric organ, at it's inner longitudinal edge, is unequally hollowed; being exactly fitted to the irregular projections of the *cranium* and gills. The outer longitudinal edge is a convex elliptic curve. The anterior extremity of each organ, makes the ſection of a ſmall circle; and the poſterior extremity makes nearly a right angle with the inner edge. Each organ is attached to the ſurrounding parts by a cloſe cellular membrane, and alſo by ſhort and ſtrong tendinous fibres, which paſs directly acroſs, from it's outer edge, to the ſemicircular cartilages.

They are covered, above and below, by the common ſkin of the animal; under which there is a thin *faſcia* ſpread over the whole organ. This is compoſed of fibres, which run longitudinally, or in the direction of the body of the animal: theſe fibres appear to be perforated in innumerable places; which

gives the *faſcia* the appearance of being faſciculated; it's edges all around, are cloſely connected to the ſkin, and at laſt appear to be loſt, or to degenerate into the common cellular membrane of the ſkin.

Immediately under this, is another membrane, exactly of the ſame kind, the fibres of which in ſome meaſure decuſſate thoſe of the former, paſſing from the middle line of the body outwards and backwards. The inner edge of this, is loſt with the firſt deſcribed; the anterior, outer, and poſterior edges are partly attached to the ſemicircular cartilages, and partly loſt in the common cellular membrane.

This inner *faſcia* appears to be continued into the electric organ, by ſo many proceſſes, and thereby makes the membranous ſides or ſheaths of the columns, which are preſently to be deſcribed; and between theſe proceſſes the *faſcia* covers the end of each column, making the outermoſt or firſt partition.

Each organ, of the fiſh under conſideration, is about five inches in length, and at the anterior end three in breadth, though it is but little more than half as broad at the poſterior extremity.

Each conſiſts wholly of perpendicular columns, reaching from the upper to the under ſurface of the body, and varying in their lengths, according to the thickneſs of the parts of the body where they are placed; the longeſt column being about an inch and an half, the ſhorteſt about one fourth of an inch in length, and their diameters about two tenths of an inch.

The figures of the columns are very irregular, varying according to ſituation and other circumſtances. The greateſt number of them are either irregular Hexagons, or irregular Pentagons; but from the irregularity of ſome of them, it happens that a pretty regular quadrangular column is ſometimes formed. Thoſe of the exterior row are either quadrangular or hexagonal; having one ſide external, two lateral, and either one or two internal. In the ſecond row they are moſtly pentagons.

Their coats are very thin, and ſeem tranſparent, cloſely connected with each other, having a kind of looſe network of tendinous fibres, paſſing tranſverſely and obliquely between the columns, and uniting them more firmly together. Theſe are moſtly obſervable where the large trunks of the nerves paſs. The columns are alſo attached by ſtrong inelaſtic fibres, paſſing directly from the one to the other.

The number of columns in different Torpedos of the ſize of that now offered to the Society, appeared to be about 470 in each organ, but the number varies according to the ſize of the fiſh *. Theſe columns increaſe, not only in ſize, but in number, during the growth of the animal: new ones forming perhaps every year on the exterior edges, as there they are much the ſmalleſt. This proceſs may be ſimilar to the formation of new teeth, in the human jaw, as it increaſes.

* In a very large Torpedo, the number of columns in one electric organ were 1182.

Each column is divided by horizontal partitions, placed over each other, at very ſmall diſtances, and forming numerous interſtices, which appear to contain a fluid. Theſe partitions conſiſt of a very thin membrane, conſiderably tranſparent. Their edges appear to be attached to one another, and the whole is attached by a fine cellular membrane to the inſide of the columns. They are not totally detached from one another: I have found them adhering, at different places, by blood-veſſels paſſing from one to another.

The number of partitions contained in a column of one inch in length, of a Torpedo which had been preſerved in proof ſpirit, appeared upon a careful examination to be one hundred and fifty: and this number in a given length of column appears to be common to all ſizes in the ſame ſtate of humidity, for by drying they may be greatly altered; whence it appears probable that the increaſe in the length of a column, during the growth of the animal, does not enlarge the diſtance between each partition in proportion to that growth; but that new partitions are formed, and added to the extremity of the column from the *faſcia*.

The partitions are very vaſcular; the arteries are branches from the veins of the gills, which convey the blood that has received the influence of reſpiration. They paſs along with the nerves to the electric organ, and enter with them; then they ramify, in every direction, into innumerable ſmall branches upon the ſides of the columns, ſending in from the circumference all around upon each partition ſmall arteries,

arteries, which ramify and anaſtomoſe upon it; and paſſing alſo from one partition to another, anaſtomoſe with the veſſels of the adjacent partitions.

The veins of the electric organ paſs out, cloſe to the nerves, and run between the gills, to the auricle of the heart.

The nerves inſerted into each electric organ, ariſe by three very large trunks from the lateral and poſterior part of the brain. The firſt of theſe, in it's paſſage outwards, turns round a cartilage of the *cranium*, and ſends a few branches to the firſt gill, and to the anterior part of the head, and then paſſes into the organ towards its anterior extremity. The ſecond trunk enters the gills between the firſt and ſecond openings, and, after furniſhing it with ſmall branches, paſſes into the organ near it's middle. The third trunk, after leaving the ſkull, divides itſelf into two branches, which paſs to the electric organ through the gills; one between the ſecond and third openings, the other between the third and fourth, giving ſmall branches to the gill itſelf. Theſe nerves having entered the organs, ramify in every direction, between the columns, and ſend in ſmall branches upon each partition where they are loſt.

The magnitude and the number of the nerves beſtowed on theſe organs, in proportion to their ſize, muſt on reflection appear as extraordinary as the phænomena they afford. Nerves are given to parts either for ſenſation or action. Now if we except the more important ſenſes of ſeeing, hearing, ſmelling, and taſting, which do not belong to the electric organs, there is no part even of the moſt perfect animal, which, in proportion to it's ſize, is

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ſo liberally ſupplied with nerves; nor do the nerves ſeem neceſſary for any ſenſation which can be ſuppoſed to belong to the electric organs. And with reſpect to action, there is no part of any animal, with which I am acquainted, however ſtrong and conſtant it's natural actions may be, which has ſo great a proportion of nerves.

If it be then probable, that thoſe nerves are not neceſſary for the purpoſes of ſenſation, or action, may we not conclude that they are ſubſervient to the formation, collection, or management of the electric fluid; eſpecially as it appears evident, from Mr. Walſh's experiments, that the will of the animal does abſolutely controul the electric powers of it's body; which muſt depend on the energy of the nerves.

How far this may be connected with the power of the nerves in general, or how far it may lead to an explanation of their operations, time and future diſcoveries alone can fully determine.

An EXPLANATION of the Engraving of the TORPEDO.

TAB. XX.

Fig. I. The upper ſurface of the electric organ.

AA. The common ſkin of the animal.

B. The inſpiratory opening.

C. The eye.

D. The part in which the gills are incloſed.

EEE. The ſkin diſſected off from the electric organ, and turned outwards; the honeycomb appearance on it's internal ſurface correſponding with the upper ſurface of the organ.

F. The part of the ſkin which covered the gills, with ſome ramifications of an excretory duct upon it.

GGG. The upper ſurface of the electric organ, formed by the upper extremities of the perpendicular columns.

Fig. II. The right electric organ divided horizontally into nearly two equal parts at the place where the nerves enter; the upper half being turned outwards.

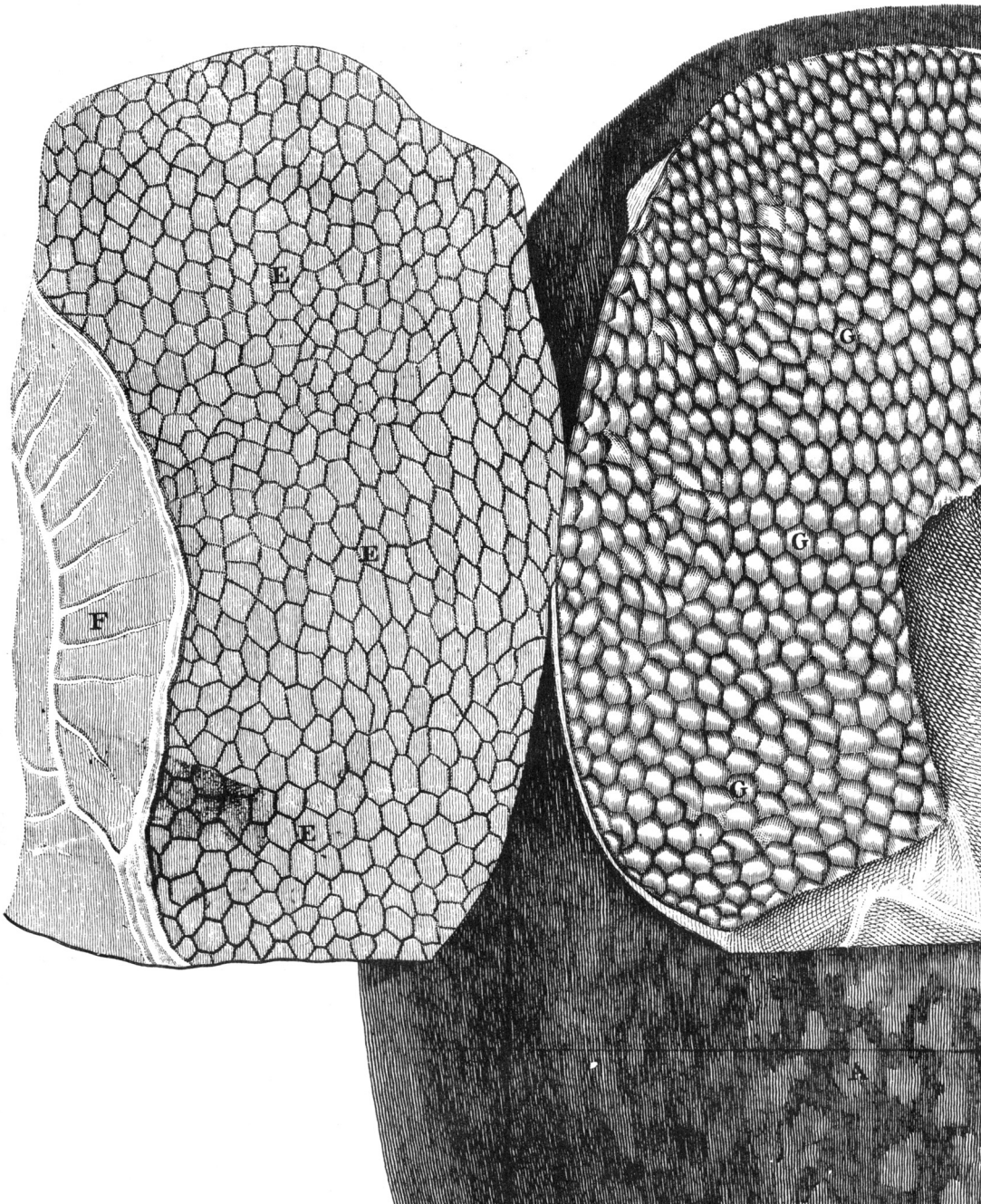
AA. BB. CC. DD. The correſponding parts of the trunks of the nerves, as they emerge from the gills, and ramify in the electric organ.

AA. The firſt or anterior trunk ariſing juſt before the gills.

BB. The ſecond or middle trunk ariſing behind the firſt gill.

E. The

Fig. 1.



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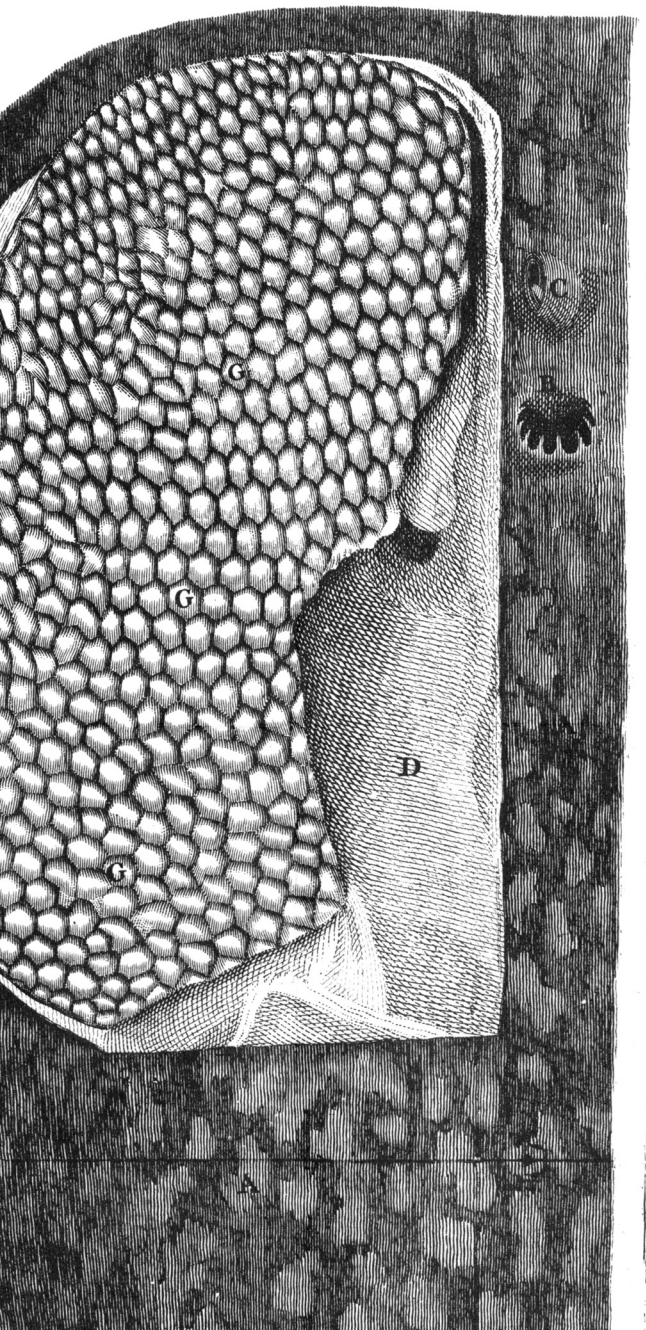

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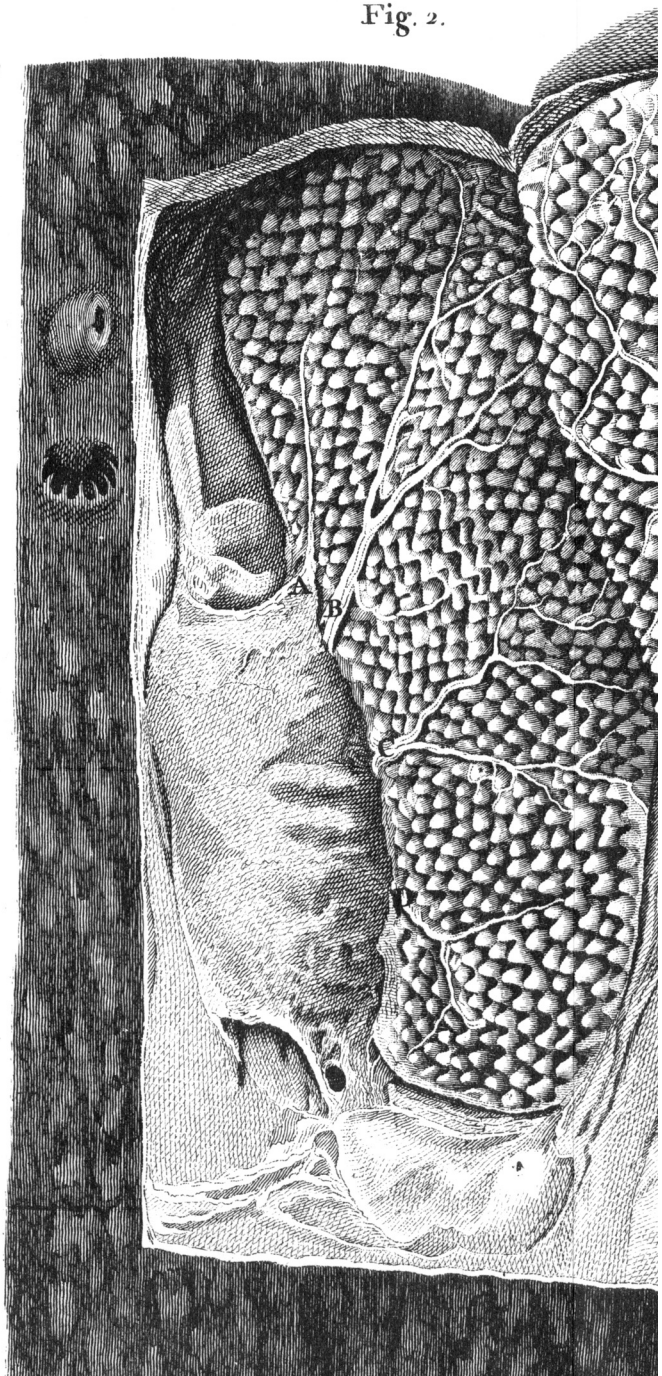

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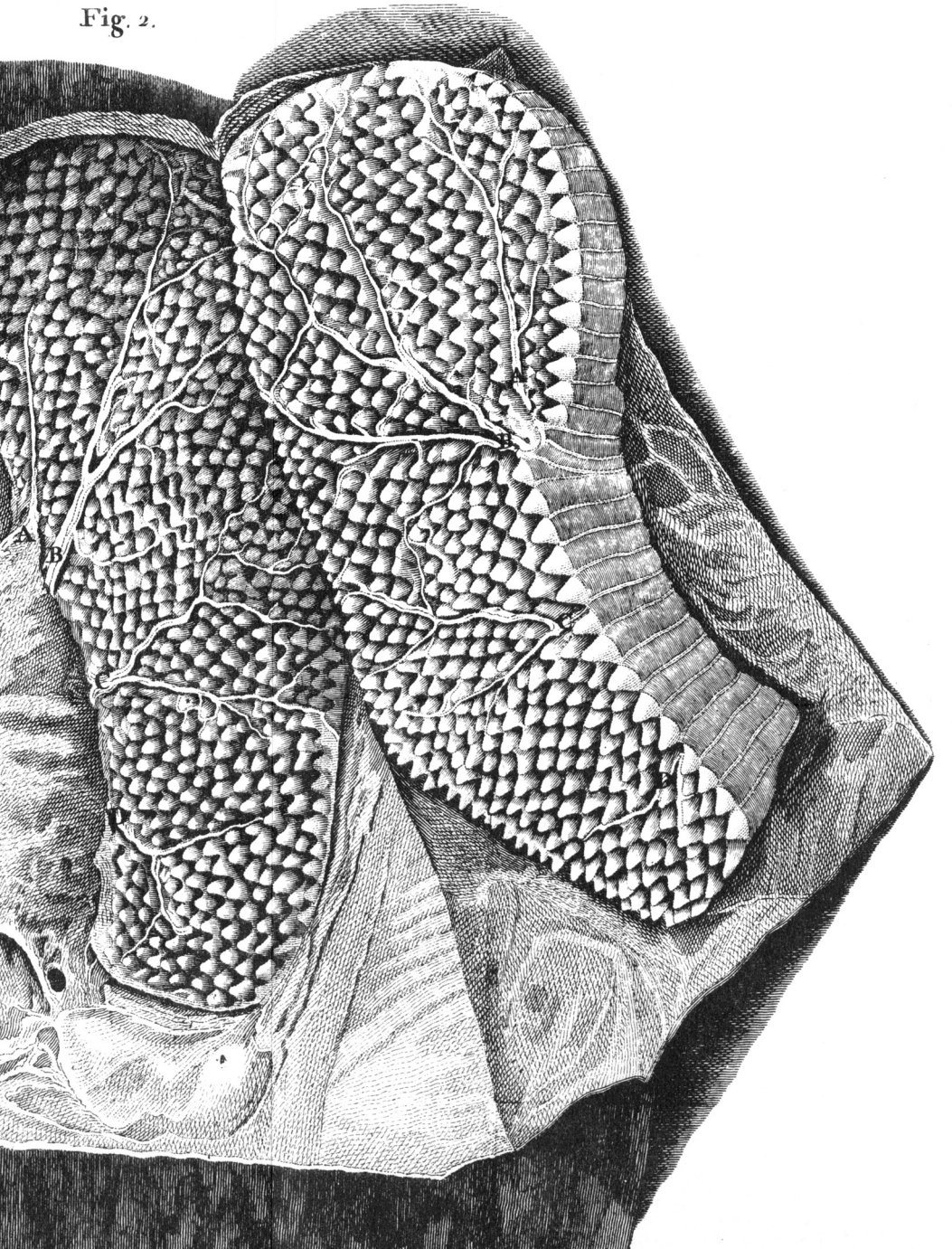

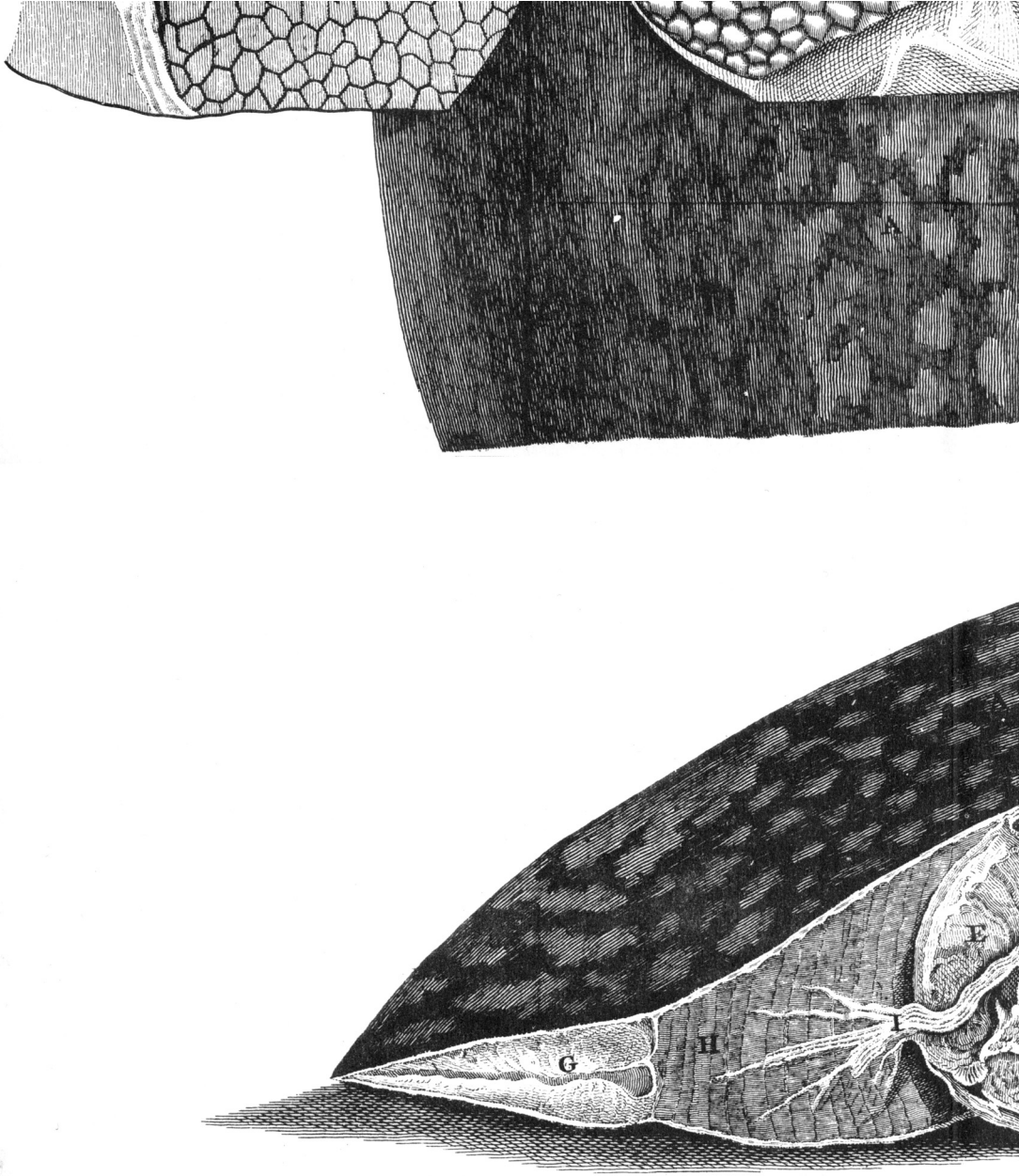
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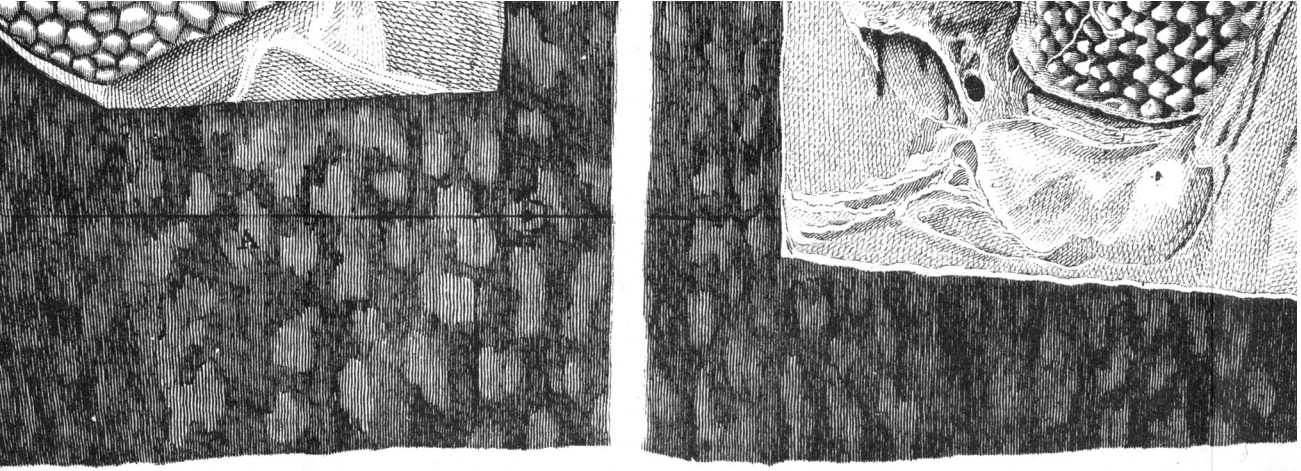
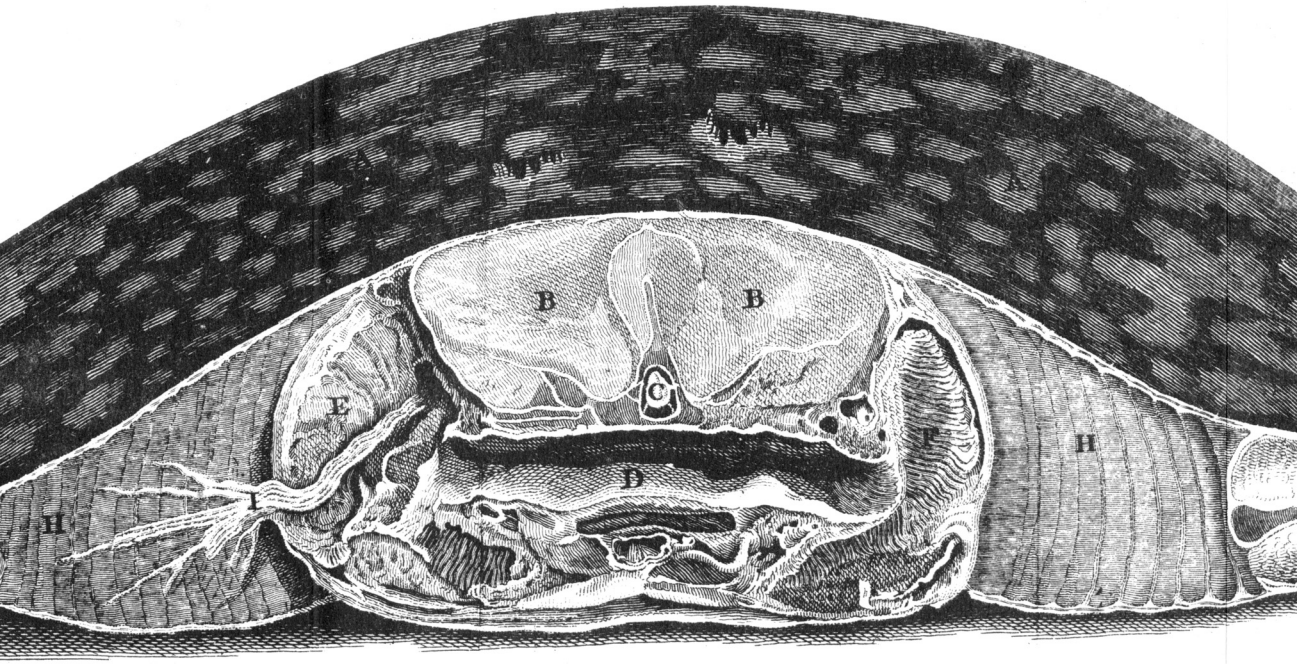


Fig. 3.



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CC. The anterior branch of the third trunk ariſing behind the ſecond gill.

DD. The poſterior branch of the third trunk ariſing behidd the third gill.

Fig. III. A perpendicular ſection of the Torpedo a little below its inſpiratory openings.

AA. The upper ſurface of the fiſh.

BB. The muſcles of the back as divided by the ſection.

C. The Medulla Spinalis.

D. The Oeſophagus.

E. The left gill ſplit, to expoſe the courſe of a trunk of the nerve through it.

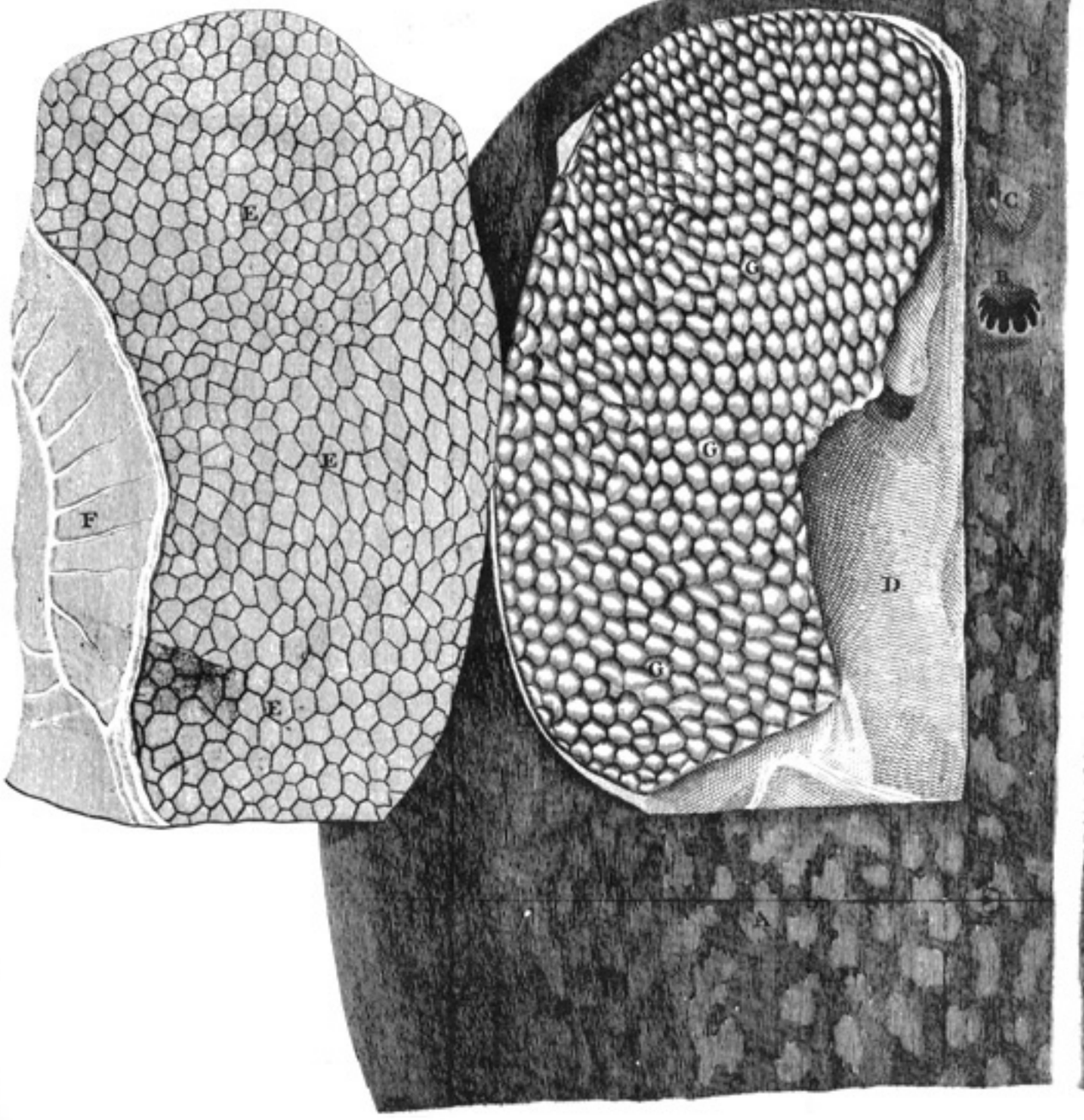
F. The breathing ſurface of the right gill.

GG. The fins.

HH. The perpendicular columns which compoſe the electric organ, with a repreſentation of their horizontal partitions.

I. One of the trunks of the nerves, with its ramifications.

Fig. 1.



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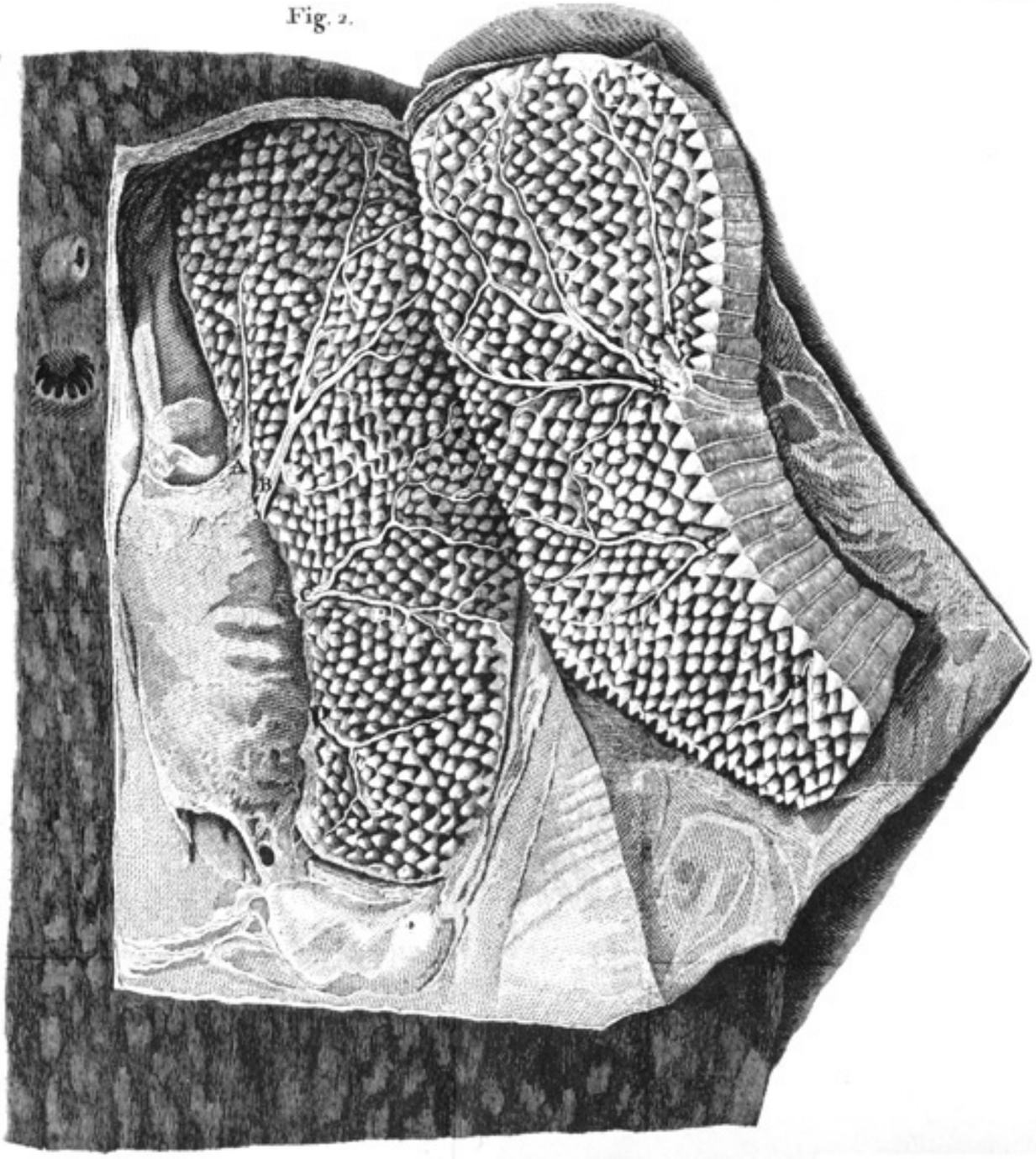

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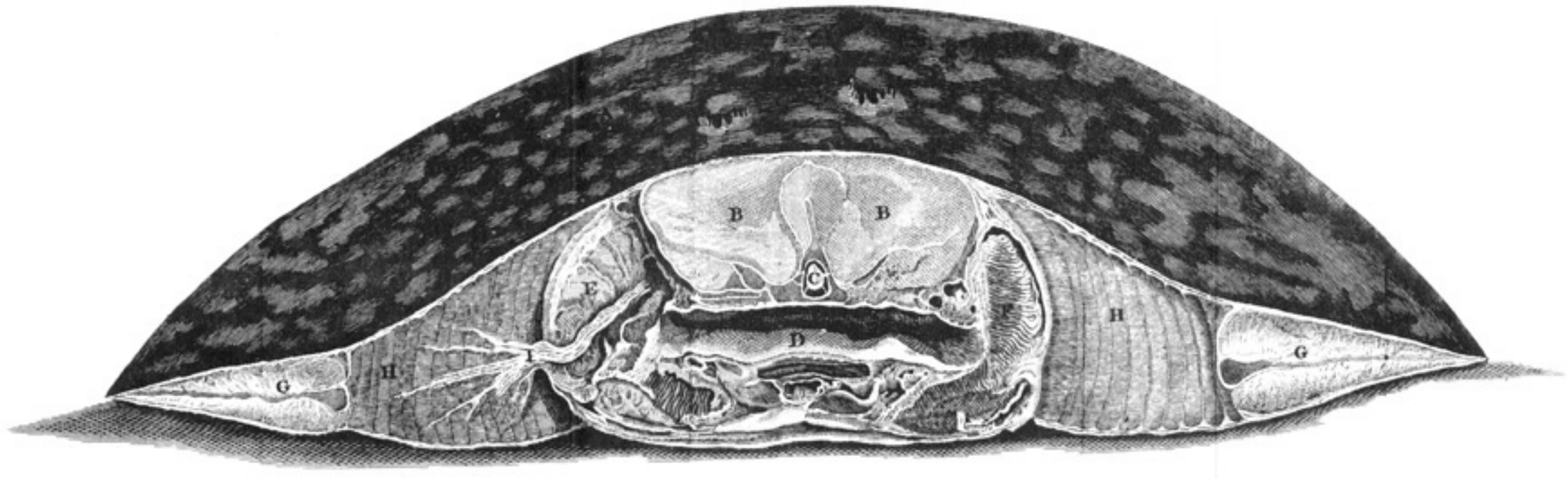

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