IX. *On the Nature of the intervertebral Substance in Fish and Quadrupeds.* *By* Everard Home, *Esq. F. R. S.*

Read February 23, 1809.

In examining the internal structure of a Squalus maximus of Linnæus, that lately came under my observation, a description of which will be the subject of a future paper, I met with a peculiarity in the intervertebral substance of the spine not hitherto made known to the public.

The fish is thirty feet six inches long, the diameter of the larger vertebræ near the head, seven inches. The intervertebral substance was cut into by Mr. Clift four days after the fish was brought on shore, and a limpid fluid rushed out with so much velocity, that it rose to the height of four feet.

At the end of twelve days, I had an opportunity of examining a portion of the spine, the intervertebral joints of which were preserved entire; upon sawing through two of the vertebræ, a fluid was met with, of the consistence of liquid jelly with clots of different sizes floating in it, so that in eight days a considerable tendency to coagulation had taken place, although the fluid was entirely excluded from the external air.

The form of the cavity thus exposed by a longitudinal section being made of it, is nearly spherical, capable of containing three pints of liquid, the lateral parts are ligamentous and elastic, uniting together the edges of the concave surfaces of

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the two contiguous vertebræ. When the liquid is evacuated, the elasticity of the lateral ligaments brings the ends of the vertebræ within an inch and half of each other; in this state the inner layers of the ligaments, which are less firm in texture than the outer, project into the cavity, and may be mistaken for a part of its natural contents; this portion when soaked in water swells out to a considerable size, the water readily insinuating itself between the membranous layers of which it is composed.

The whole thickness of the lateral ligaments is about one inch, the external half of which is compact and elastic, the other appears to possess a very slight degree of elasticity. The appearance of the joint is shewn in the annexed drawing, and an account of the analysis of the fluid by Mr. W. BRANDE forms a postscript to this paper. Every part of the mechanism is formed upon so large a scale, that it is rendered conspicuous, and nothing is left to doubt or conjecture; the nature of the joint is different from every other that is met with in animal bodies, and there are many circumstances respecting it, which render it uncertain whether human ingenuity can ever make any resemblance to it, that can be applied to the purposes of mechanics.

These would have been sufficient grounds for bringing this subject before the Society; but there are others of still greater importance which have induced me to make it a separate communication; it enables us to explain the general principle upon which all intervertebral joints are formed, which has been hitherto but imperfectly understood. With this view, I will first describe the principle upon which this particular joint is formed, and then shew the resemblance that it bears to

those of other animals, in which the parts are not so readily distinguished from one another, and consequently their precise use has not been accurately ascertained.

The fluid contained in the cavity being incompressible, preserves a proper interval between the vertebræ to allow of the play of the lateral elastic ligaments, and forms a ball round which the concave surfaces of the vertebræ are moved, and readily adapts itself to every change which takes place in the form of the cavity.

The elasticity of the ligaments, by its constant action, renders the joint always firm, independent of any other support, and keeps the ends of the vertebræ opposed to each other, so that the whole spine is preserved in a straight line, unless it is acted on by muscles or some other power. When a muscular force is applied to one side of the spine, it stretches the elastic ligament on the opposite side of the joint, and as soon as that force ceases to act, the joint returns to the former state. This is one of the most beautiful instances in nature of elasticity being employed as a substitute for muscular action.

The extent of the motion in each particular joint is undoubtedly small, but this is compensated by their number, and the elasticity of the vertebræ themselves.

Fish in general have their vertebræ formed with similar concavities to those of the squalus maximus; these, when examined after death, contain a solid jelly, but in the living fish it is found in a fluid state. This fact was ascertained in the skate, the smallness of the quantity of fluid in any one joint, and the readiness with which it coagulates after death, prevented it from being before observed: the fluid in the

skate is found by Mr. W. BRANDE to have the same properties, as far as the small quantity that can be collected admits of examination, with that in the squalus maximus.

Although this structure of the intervertebral joint appears to be common to fish in general; the form of the cavity is not in all exactly the same; in the skate it is very similar to that in the squali, but in the common eel, it is more oblong, the longitudinal diameter being about one third longer than the transverse one.

It is evidently contrived for producing the quick vibratory lateral motion, which is peculiar to the back bones of fish while swimming, and enables them to continue that motion for a great length of time, with a small degree of muscular action.

In the sturgeon, there are some curious peculiarities in the structure of the spine. Externally there is the common appearance of regular vertebræ, but these prove to be only cartilaginous rings, the edges of which are nearly in contact, and are united together by elastic ligaments, forming a tube the whole length of the spine, this is lined throughout its internal surface with a firm compact elastic substance, about the thickness of the cartilaginous tube, within this is a soft flexible substance in a small degree elastic; in the centre there is a chain of cavities in the form of lozenges, containing a fluid, and communicating with one another by very small apertures bearing a slight similarity to the intervertebral cavities of the spine in other fish.

As all the different parts of which this spine is composed are more or less elastic, except the central fluid, it must have great flexibility adapting it to the motions of this particular

fish. The structure of the spine in the lamprey eel resembles that of the sturgeon.

The intervertebral joint which is common to fish, is not met with in any of the whale tribe, whose motion through the water is principally effected by means of their horizontal tail; in them the substance employed to unite the vertebræ together is the same as in quadrupeds in general, and from the size of the vertebræ it is on a larger scale, and rendered more conspicuous.

The external portion is very firm and compact, is ranged in concentric circles with transverse fibres uniting the layers together, it becomes softer towards the middle, and in the centre there is a pliant soft substance without elasticity, but admitting of extension more like a jelly than an organized body, corresponding in its use to the incompressible fluid in the fish.

To ascertain whether this structure was generally met with in the spines of quadrupeds, Mr. BRODIE, at my request, examined the intervertebral substance in a great many animals, and found, what, undoubtedly, was very little to be expected, that in the hog and rabbit, in the central part, there is a cavity with a smooth internal surface of the extent of half the diameter of the vertebra, in which is contained a thick gelatinous fluid, so that in some quadrupeds there is an approach towards the intervertebral joint in fish; but whether this is to answer any essential purpose to these animals, or is only to form an intermediate link in the chain of gradation of structures, which is so uniformly adhered to in the productions of nature, cannot at present be determined.

In the bullock, sheep, deer, monkey, and man, the struc-

ture corresponds with that of the whale; in the three last, the central substance appears to be the most compact. Besides the structures already mentioned, there is in some animals one of a very different kind; in the alligator the vertebræ through the whole length of the spine, have regular joints between them, the surfaces are covered with articulating cartilages; and there is synovia and a capsular ligament. In the snake, there is a regular ball and socket joint between every two vertebræ; so that the means employed for the motion of the back bone in different animals, comprehends almost every species of joint with which we are acquainted.

Having mentioned a sufficient number of facts to point out the animals, in which the different structures of the intervertebral substance are to be found, I have abstained from being more particular in my account; as it would in no respect elucidate the principal object of the present communication.

From the facts and observations which have been stated, it appears that the intervertebral substance of the human spine does not consist entirely of elastic ligament, dense in its texture at the circumference, and becoming gradually softer towards the centre; but that the middle portion is composed of materials which render it very pliant, though not at all elastic, fitting it to keep the vertebræ at the proper distance from each other, so as to admit of the action of the lateral elastic ligaments.

When this knowledge is applied to the treatment of curvatures of the spine, a complaint so commonly met with in young women, whose strength does not bear the necessary proportion to the growth of the body, it will show the great impropriety of overstretching the intervertebral ligaments,

since in that state the central substance no longer supports the vertebræ, and the joints must lose their proper firmness, which will be attended with many disadvantages.

As the principal motive which induces me to prosecute the laborious researches of comparative anatomy, is to attain a more complete knowledge of the structure and functions of the human body, than can be acquired in any other way, and to apply that knowledge to the most useful of all purposes, the cure of diseases, the success which has attended my labours, in the present instance, affords me particular satisfaction; it encourages me in the pursuit of those inquiries, and holds out an invitation to others, by showing them that the paths of nature, however frequently they have been traced, are not yet sufficiently explored.

EXPLANATION OF THE PLATE.

A longitudinal section of one of the intervertebral joints of the squalus maximus, after the fluid had been evacuated, and the parts had been steeped in water.

a a a a. The section of the vertebra to show its shape and the two concave surfaces which form the intervertebral cavities. The vertebra itself is partly bone, and partly transparent cartilage; the bony portion forms the two cup-like cavities, and the intermediate substance consists of bony cells in form of lozenges filled with cartilage.

The cavity of the joint is in its contracted state, and the inner portion of the lateral ligaments, which is made up of thin layers of a loose texture, has its interstices loaded with water,

which makes it project into the cavity of the joint more than it could do in a natural state.

The external portion of the ligament, to the thickness of half an inch, is the only truly elastic part on which its strength depends.

A chemical Analysis of the Fluid contained in the intervertebral Cavity of the Squalus maximus. By Mr. William Brande.

The fluid found in the intervertebral cavities is of an opal colour; it is semi-transparent, and has a strong fishy smell and taste.

Its specific gravity is ,1027.

In the first instance it does not readily mix with water; but is easily diffused through that fluid by agitation.

When heated in a water bath to a temperature of 212°, it becomes more transparent, but undergoes no farther apparent change.

Infusion of galls and of catechu produce no alteration in it.

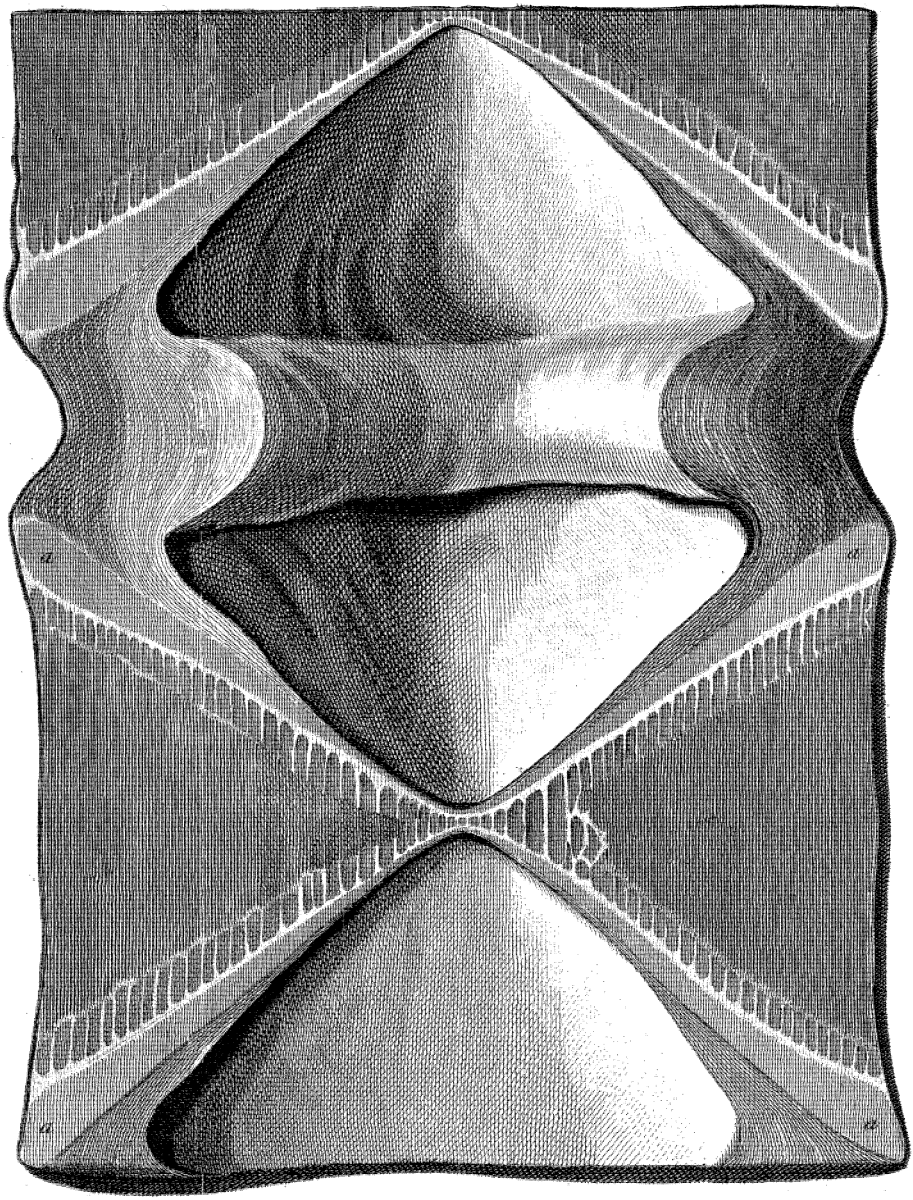
Solution of oxymuriat of mercury occasioned a very copious white precipitate, and a similar effect was produced by a solution of nitro-muriat of tin.

Nitrat of silver and acetat of lead threw down precipitates of muriat of silver and of lead.

Muriatic acid occasioned a slight cloud after two hours had elapsed, and after twenty-four hours, a small quantity of white flaky matter separated.

Alcohol produced no change.

The fluid readily mixed with a solution of pure potash, a



Scale two thirds of an Inch to one Inch.

small quantity of ammonia being at the same time evolved. Muriatic acid did not produce any immediate precipitation in this alkaline solution.

The effect of these re-agents, evidently proves the non-existence of gelatine in this fluid; it would also appear that it contains no albumen, unless the effects produced by muriatic acid and by the oxymuriat of mercury and of tin, be regarded as indications of that substance.

It seems to approach nearer to *mucus* or *mucilage*, than to any other animal fluid.*

When the fluid is evaporated in a temperature not exceeding 220° to half its bulk, an opaque substance in the form of bluish white filaments, gradually separates. A thin semi-transparent pellicle forms at the same time upon the surface, which, when removed, is soon succeeded by another. These pellicles were dried on bibulous paper.

The fluid part, remaining after the separation of the filamentous substance and pellicles, afforded a very distinct yellowish cloud, with solutions containing tannin. It was somewhat turbid, but did not form any deposit. In other respects, it nearly resembled the original fluid before evaporation.

The filaments which appeared during evaporation, were separated by passing the fluid through a piece of fine muslin. They resembled albumen imperfectly coagulated, not only in appearance, but in most of their chemical properties.

When the fluid began to putrify, a considerable quantity of the same substance separated spontaneously.

* By *mucus of animals*, I mean a glary fluid, which does not mix readily with water, which is neither coagulated by heat or acids, and which does not form a precipitate with solutions containing tannin.

This substance was insoluble in water, and when boiled for a few minutes in that fluid, it became whiter, harder, and more opaque.

It underwent the same change in alcohol, and when boiled in alcohol, or in dilute muriatic acid, it became still more firm, and appeared like perfectly coagulated albumen.

In this state it was soluble in a solution of pure potash, forming a saponaceous compound, which was decomposed by dilute muriatic acid, a white flaky precipitate being formed. It possessed the other properties which Mr. HATCHETT has enumerated as belonging to coagulated albumen.*

When the pellicle, which had formed on the surface of the fluid during evaporation, was nearly dry, it became somewhat tough and elastic; it was semi-transparent, and of a dirty white colour.

When boiled for some time in water, about three fourths of it were found to be soluble in that fluid, the remainder, when separated by filtration, possessed the properties of the albuminous substance already mentioned.

The solution afforded a copious precipitate with solutions containing tannin. It was not at first affected, either by oxy-muriat of mercury, or of tin; but after twenty four hours, a slight deposit took place.

Although these re-agents indicated the presence of a substance having the properties of pure gelatine in solution, yet it could not be brought to gelatinize by the usual method of evaporation.

From these experiments it would appear, that the inter-vertebral fluid, is of a peculiar nature; that in its original

* Vide Phil. Trans. 1800.

properties it resembles mucus, but that under certain circumstances it is capable of being converted into modifications of gelatine and albumen.

The intervertebral fluid of the skate was found to resemble mucus; it did not exhibit any traces of albumen, but the quantity which I procured for examination being very small, I was unable to ascertain its further analogies to the fluid found in the intervertebral cavities of the Squalus maximus.

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