On the viscera of the common swordfish, (Xiphias gladius, Lin.) / by Robert E. Grant.

for the Roy. College of Physicians of Edin.r

from the Author.

ON THE

VISCERA

OF THE

COMMON SWORDFISH,

(Xiphias gladius, Lin.*)*

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From the Edinburgh Medico-Chirurgical Transactions.

A full-grown male specimen of the common swordfish, more than 7 feet in length, was taken in the Frith of Forth, in September last (1826). It was observed at low water, with its sword sticking in a muddy part of the coast near Alloa, by Mr Slight, one of the assistant engineers under Robert Stevenson, Esq.; and being quite entire, and in a fresh state, it was immediately sent to Edinburgh for the University Museum, where it is now preserved stuffed. It is somewhat remarkable, that although this powerful and gigantic animal has been known from a very remote antiquity to abound in the Mediterranean, and has been long

used as an article of food, both in the Old and the New World, we do not yet possess any account of its anatomy. The following observations on its viscera are taken from the specimen above mentioned, the carcass of which, after the removal of the skin, was kindly presented to me, for dissection, by Professor Jameson. I have given an account of the remarkable structure of the eyes of this animal, which were 3 inches in diameter, in a paper lately read before the Wernerian Society, and published in their Transactions. The dimensions of the entire animal were, from the extreme point of the sword, to a line drawn between the tips of the tail, 7 feet 2 inches; from the point of the lower jaw to the hollow of the tail 4 feet 10 inches; circumference of the neck before the dorsal fin 2 feet 4 inches; length of the sword 2 feet; tail perpendicularly, 18 inches broad.

The swordfish is sometimes found 20 feet in length in the Mediterranean, and I am informed by M. Audubon, that it is frequently harpooned in the Gulf of Mexico, measuring more than 10 feet, exclusive of the sword. The body is covered with a strong smooth skin without any visible scales. Cuvier and some other writers have described this animal as covered with small scales. The dorsal fin is sometimes figured and described as forming a continuous fin along the back. In this specimen the dorsal fin was divided into two portions, placed at a considerable distance from each other, and connected only by an almost imperceptible ridge along the spine. The singular cartilagi-

nous expansion on each side of the tail, projected nearly 3 inches from the surface.

Almost every part of the body was infested with intestinal worms; the muscles covering the skeleton were perforated in every direction and contained them alive, and they abounded in the abdominal viscera, particularly between the coats of the intestinal canal. The bright red coloured *Tristoma coccineum* is said by Cuvier and Fleming to infest the gills of the sword-fish. In a putrid specimen of this animal, more than 8½ feet long, seen by Dr Fleming on the side of the Tay, he found the *Ascaris incurva*, *Tetrarhyncus attenuatus*, and *Bothriocephalus plicatus* of Rudolphi, lodged about the stomach. The internal organs of the specimen from the Forth, exhibited no other diseased appearance than the small ulcerations and cysts produced by these worms. The body was in a very fat condition, and abounded, particularly in the muscular and cellular parts, with a soft oily matter, having very much the appearance and smell of whale oil. The venous system in the internal cavities, was turgid with red blood; and the abundance of red vessels throughout the muscular system, at a great distance from the heart, showed an unusually extensive distribution of the red globules of the blood in this animal. This appearance may have been produced by the struggles of the animal before death, and by the unusual strength of its heart and large arterial trunks. Both cavities of the heart and the great trunk of the branchial artery contained black coagula of blood,

as consistent as those of a quadruped; and the firm adipose substance in many parts of the body, more resembled that of the mammalia than the soft matter we usually find in fishes.

The venæ cavæ formed a distinct fleshy sinus before entering the auricle of the heart. The inner surface of this sinus is deeply marked with strong fleshy columns like those of the auricle, disposed in various directions. As this sinus is contracted at the opening into the auricle, and as the cavæ enter very obliquely into its cavity, it can almost perform the functions of an auricle. The opening from the sinus into the auricle admitted the fore-finger, and was provided, on the auricular side, with two strong tendinous semilunar valves, which completely prevented the return of the blood from the auricle. The free margins of these two valves met in a straight line across the middle of the passage, and their extremities on each side were bound closely together by a very distinct small white tendon. The auricle, when moderately inflated, was more than double the size of the ventricle, and of a quadrangular form. Its parietes were a quarter of an inch thick, covered internally with fleshy columns disposed around its axis, and nowhere membranous, as we frequently find the auricles of fishes. The numerous deep round pits between the fleshy pillars of the auricle, showed a free communication with each other, when inflated by the blowpipe. The passage between the auricle and ventricle admitted the finger, and was likewise provided with semilunar valves. The two thick

white crescentic membranes forming this valve, were beautifully supported on the ventricular side, by numerous thin, radiating tendinous cords. As the ends of these two membranes were not bound closely together by ligament, like those of the auricular valve, a small supplementary valve was seen on each side, which shut up the two angular spaces and completed the entire valve. The ventricle had the form of a triangular pyramid, with a very oblique base. Its apex terminated in the branchial artery, and the auricle opened into its back part near the apex. The ventricle measured four inches from the base to the beginning of the branchial artery, and its parietes were more than half an inch thick. The sides of the ventricle were firm and compact, and the pits between the fleshy pillars were smaller and fewer in number than in the auricle. On the outside of the ventricle there were considerable patches of white firm adipose substance beneath the membranous coat, and many strong twigs of nerves were seen passing loosely from the surface of the ventricle to the auricle. The semilunar valves, which are sometimes placed, as in the skate, so far from the ventricle as the bifurcation of the branchial artery, were here placed at the origin of that vessel from the ventricle, as in the aorta of quadrupeds. The pits on the inside of the ventricle communicated with each other, like those in the auricle. The valves at the origin or pedunle of the branchial artery consisted of two strong crescentic membranes, bound together at their ex-

tremities by a firm white ligament on each side. To the distance of an inch and a-half beyond this valve, the parietes of the great bronchial vessel were nearly as thick and muscular as those of the ventricle, and had the same fleshy pillars and round pits on its inner surface, as we observe in many of the larger fishes. The vessel had been divided at this distance from the heart, in removing the skin and gills for the preparation of the specimen, so that I could not observe whether additional valves were placed at the bifurcation of the artery, as is sometimes the case. The heart of the swordfish appears stronger and better provided with valves, than almost any other in this class of animals, and is admirably constructed for maintaining an undisturbed circulation of the blood, during the violent efforts it must frequently exert in plunging and extricating its sword.

The sword-fish agrees, in many of its internal characters, with the sturgeon, whose structure has already been examined and described by authors. Like that animal, it has no teeth. There are two rough bony projections at the sides of the fauces. The œsophagus was of great width, muscular, corrugated, and covered with a thick white mucous secretion. Although fishes want salivary glands, we always find an abundant secretion in their mouth and œsophagus. This appears to be partly derived from their capacious stomach, which is always at a very short distance from the mouth. The entrance of the œsophagus into the stomach was much more

contracted than usual, and the sphincter muscle of the cardiac orifice of very great strength. The stomach had the form of a long compressed narrow flask, and was fourteen inches long from the cardiac sphincter to its lower shut extremity. It was four inches broad in the middle, and tapered towards each end. The large coronary arteries, and veins gorged with red blood, passed along the outer margins, and sent branches irregularly to both the flat surfaces. The parietes of the stomach were more than half an inch thick, remarkably muscular, firm, much contracted, and the cavity contained no solid food. The muscular coat a third of an inch thick, and consisting of strong fibres disposed in every direction round the cavity, was connected to the internal villous coat by a soft white fatty substance, apparently of a glandular nature. The honeycomb plicæ of the inner coat were raised about two lines from the surface, and the whole cavity presented a villous appearance. It contained only a viscid white mucous secretion like that found in the œsophagus. The pylorus was so small and contracted as not to admit the fore-finger. It opened on the upper and right side of the long shut sac of the stomach, immediately beneath the cardiac sphincter. The muscular coat at the beginning of the pylorus was very thick, but did not form so regular a sphincter as that of the cardia. The pyloric valve, formed in most fishes by a loose circular fold of the inner coat, was placed at the distance of nearly two inches from the stomach, and completely prevented the return of

food, bile, or the pancreatic fluid from the duodenum into the stomach. The whole intestinal canal, from the pylorus to the anus, measured 5 feet 2 inches. It was only 1 inch in diameter, excepting the lowest 5 inches, which had double the diameter of the rest, and formed a short cylindrical rectum. The first 8 inches of the intestine from the pyloric valve were much thinner and softer in their coats, and presented a smooth glistening internal surface, without any villous appearance. This part was very slightly marked with the honeycomb plicæ, found in the stomach, and in the rest of the small intestines. About 9 or 10 inches from the pylorus, the inner surface of the intestine re-assumed its villous covering, and the villi became gradually longer and closer, to the lower extremity of the rectum. The upper half of the canal made six turns in a zigzag manner on itself, and the lower half made four complete spiral turns before terminating in the short wide rectum or colon. The whole intestine below the duodenum was very muscular, and appeared much contracted. It contained a thick white opaque chyme, which had a flocculent appearance, like the digested muscular parts of fishes. But although the whole digestive canal was carefully laid open, no portion of bone or other hard substance could be found, to indicate the kind of food that had been last taken. Dr Fleming found many remains of the *Loligo sagittata* in the stomach of his specimen. The short wide cæcum, which terminated the intestinal canal, did not com-

municate, like a cloaca, either with the organs of urine or those of generation. The small intestine entered its upper part obliquely, and a projecting fold of the inner villous coat round the entrance formed a complete valve, like that of the colon in higher animals, to prevent the return of matter into the ilium. The rectum is lined with long and close-set villi, and terminates immediately before the anal fin, where it is surrounded with a strong circular sphincter.

Immediately beyond the pyloric valve, the ductus communis choledocus passes in an oblique direction through the coats of the duodenum, and enters beside the great duct of the pancreas. The liver is comparatively small, somewhat triangular, not divided into lobes, convex above, and concave beneath, of a reddish brown colour externally, grey within, and occupies the left side, as in other fishes. The two trunks of the hepatic veins issued from a deep sulcus on the upper margin of the liver, and entered the wide muscular sinus of the vena cava before reaching the heart. The venæ portarum and hepatic ducts occupy the middle of the concave surface, as in man. The weight of the liver was 19 ounces. Its upper margin measured 10 inches ; the right 8 ; and the left 9. Its thickness in the middle was 1 inch and a-half. The gall bladder was large, thin, irregularly pear shaped, curved once on itself, capable of containing 4 ounces of bile, and placed at a considerable distance from the liver. Three hepatic ducts issued separately from the concave

surface of the liver, and entered very obliquely into the cystic duct, about an inch from its termination in the duodenum. From the fundus of the gall-bladder to the termination of its duct in the intestine, measured exactly 14 inches. The oblique entrances of the three hepatic ducts into the cystic, rendered it impossible to press back the bile from the cystic into the hepatic ducts.

The pancreas of this animal was the most remarkable for its size and form I have yet met with. It was the heaviest organ in the abdomen, weighing $25\frac{1}{2}$ ounces; it was $6\frac{1}{2}$ ounces heavier than the whole mass of the liver, which is generally the largest organ in the abdomen of fishes. The form of the pancreas was like that of the human kidney, but more rounded; and its enormous duct issued from the part corresponding to the pelvis of that organ. The length of the organ was 8 inches, the breadth 6 inches, and the thickness $2\frac{1}{2}$ inches. Externally, it was of a bluish white colour, of a firm consistence, and enveloped in a strong fibrous membrane, besides the peritoneal coat. Through the pellucid coats we could perceive, that the whole outer part of the organ was formed of small white shut sacs, nearly a line in diameter. On removing the coverings from the pancreas, the white tubular sacs covering the whole surface, were found to be the shut extremities, of innumerable small appendicula cœca, which united into larger and larger trunks, as they proceeded towards the centre of the organ. These small cœca, and the

trunks formed by their union, were not merely in contact with each other within the enveloping membranes, but were firmly united together into a regular reniform mass, by interposed cellular substance, and the ramifications of bloodvessels and nerves. They had the same glandular structure, and secreted the same milky white fluid, as the analogous detached pyloric cœca we find in most osseous fishes. The numerous trunks or ducts formed by the union of these ramified cœca, became gradually fewer and larger as they approached the hollow margin of the pancreas, next to the curvature of the duodenum. They at length opened into this part of the intestine by one large orifice, an inch and a-half in diameter, without exhibiting any prolonged duct; and this orifice was placed, along with that of the ductus communis choledocus, close to the anal side of the pyloric valve. These ramified tubes were filled to their minutest extremities, with a thick white fluid, very much resembling the chyme which filled the intestine. It is quite obvious, from the wideness and unprotected state of the entrance into these cœca, which was half an inch wider than the duodenum, and without either valve or sphincter, that the food must enter freely into this singular organ, after passing the pyloric valve. I have observed the food to enter freely into the substance of the liver, by similar wide orifices in the stomach of some molluscous animals, as in the Doris argus. The only example hitherto described of a pancreas approaching to that of the swordfish, is that observed

by Monro in the sturgeon, where the cœca likewise form a ramified mass opening by one orifice, and surrounded by a fibrous membrane, which he considers as a muscle destined to compress the pancreas, and force its contents into the duodenum. The glandular appendicula cœca constitute the simplest form of the pancreas met with in animals; and I have elsewhere shewn, that it distinctly occurs in this simple form, so low as the gasteropodous mollusca.

The spleen of the swordfish was not divided like that of the sturgeon, but formed a single oblong mass, of a deep red colour, 3 inches long and 2 broad, placed below the liver, among the small intestines behind the stomach. Monro found seven spleens in the sturgeon, the largest of which was only equal in size to a garden bean, and the other six were as small as peas, although the animal to which they belonged was nearly six feet long. In the swordfish, the great size of this organ corresponds with the very abundant distribution of red blood through the body of this animal.

The air-bag formed a long and entirely shut sac, placed between the kidneys and the testicles, and connected with the fore-part of the bodies of the vertebræ. When moderately inflated, it was 14 inches long and 3 broad, and it tapered regularly, from the middle towards each end. The remarkable red coloured glandular bodies of the air-bag, and the passage of communication between this sac and the stomach, or the œsophagus, which we

frequently find in osseous fishes, were wanting in this animal. This large fusiform sac had no aperture whatever, and contained about 15 ounces of gas *, which was probably secreted by the vessels ramified on the coats. In the sturgeon, the red glandular bodies of the air-bag are likewise wanting, but we find in that animal a large oval aperture, an inch

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* A quantity of this gas, collected under water, was carefully analyzed by my friend Dr Turner, Lecturer on Chemistry, &c., who has kindly favoured me with the following account of its properties and chemical composition. M. Brodbelt found the composition of this gas to vary considerably in different specimens of the swordfish, sometimes he observed only carbonic acid, and in others pure oxygen.

"The gas (from the air-bag of the Xiphias gladius) is colourless and inodorous. It extinguishes a burning taper, and is not kindled on the approach of flame. With lime-water it yields a precipitate of the carbonate of lime, indicative of the presence of carbonic acid. It does not form an explosive mixture with oxygen, and therefore does not contain hydrogen, carburetted hydrogen, or carbonic oxide gas. When previously mixed with hydrogen, spongy platinum causes a diminution in volume, owing to the formation of water; and consequently oxygen is present.

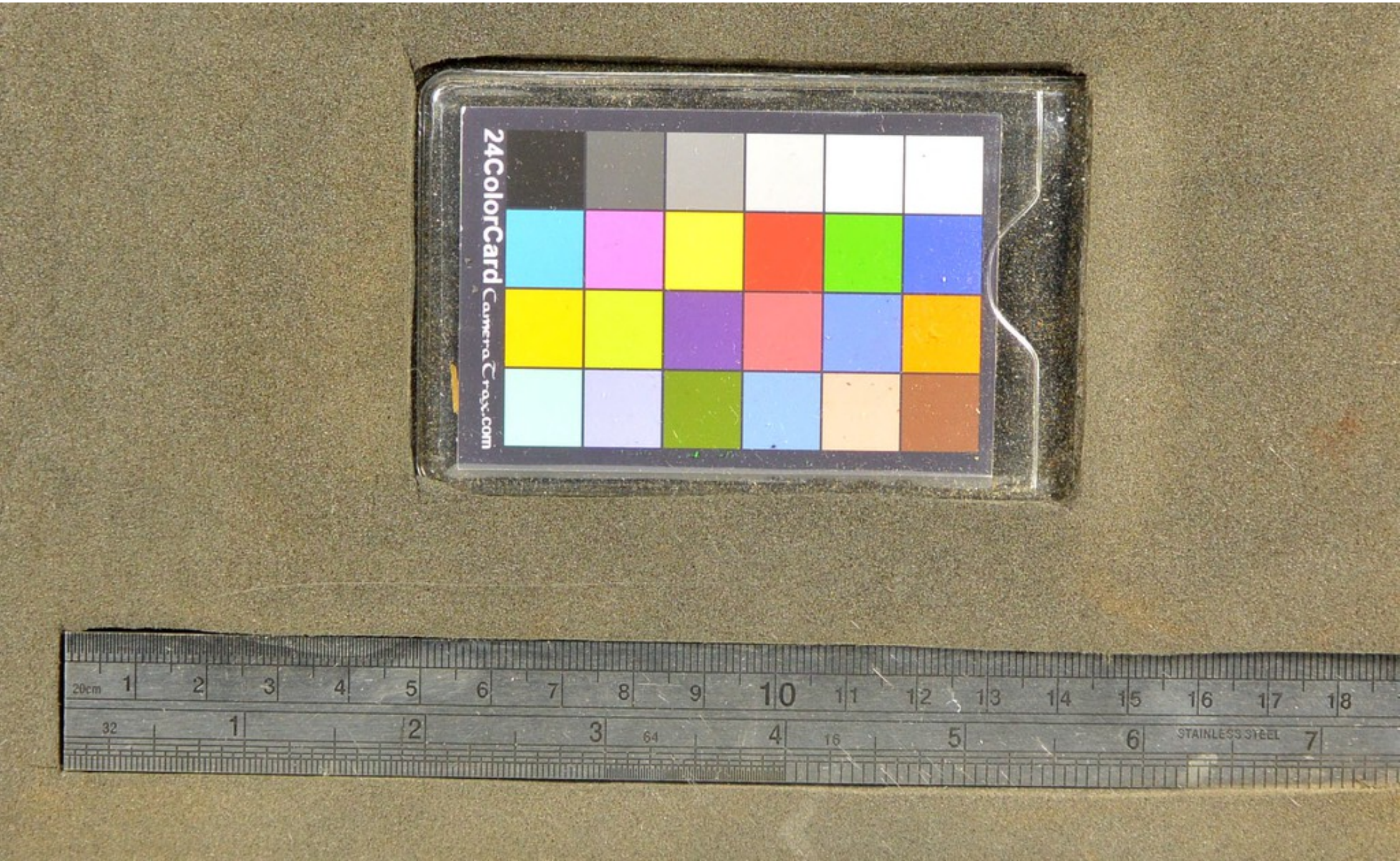
"By means of a concentrated solution of pure potash, I find that the carbonic acid amounts to 23 per cent.; and, by the aid of hydrogen and spongy platinum, I have ascertained that the gas contains 6 per cent. of oxygen. The residue has all the properties of nitrogen. It hence appears that 100 measures of the gas, submitted to examination, consist of

Nitrogen,	-	71
Oxygen,	-	6
Carbonic acid,	-	23
		100"

and a-half in diameter, opening from the air-bag into the upper part of the stomach. The inner surface of the air-bag in the swordfish is smooth and glistening, without either the septa or plicæ, which frequently occur in other fishes.

The kidneys were two feet long, as soft, and nearly of the same colour, as a coagulum of venous blood, and were firmly connected with the sides of the vertebræ by the peritoneum, and by cellular substance. On cutting open the long narrow membranous pelvis placed along the mesial side of each kidney, numerous and very large infundibula were seen opening into its cavity. The two ureters which descended from these pelves terminated in a large urinary bladder, lying, as usual, behind the rectum, and capable of containing eight or ten ounces of urine. The bladder was nearly spherical, composed of strong white muscular parietes, with a glistening internal surface, and opened by a round muscular aperture on the back part of the anus. On each side of the anus there was a circular aperture, capable of admitting a goose quill and opening into the cavity of the peritoneum, as described by Willoughby and Monro, in many other fishes. The two testicles were 8 inches long and about $1\frac{1}{2}$ in breadth, and were placed longitudinally between the kidneys and the small intestines. They were of a pale flesh-red colour, slightly lobed on the surface, a little compressed, and tapered from the middle towards each end. They were of a firm and almost homogeneous texture, covered with a very

delicate transparent membrane, and gave out a white milky fluid, when a cut portion of them was pressed between the fingers. Their two vasa deferentia converged and terminated in the urinary passage at the back part of the anus, as in other osseous fishes.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