ZOOLOGY.—*(Continued.)*

ART. LX.—*On the Venous System of the Skate* (Raja nasuta).

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IN making a series of injections of the Skate's vascular system a few months since, I was struck with one or two instances in which the facts, as I made them out, were either directly contradictory of the statements usually made about the vascular system of Elasmobranchs, or showed very interesting deviations from the normal state of things. In bringing forward my observations, I think it will be as well to give a general connected account of the whole venous system in the Skate, since, as far as I know, this has not yet been done. Many of the more important veins are, however, figured by Monro in his classical monograph on "The Anatomy and Physiology of Fishes," and, as I shall have occasion to point out, the veins in connection with the kidneys are described in detail by Jourdain. It may also be as well to mention, for the benefit of any who may be interested in the matter, that the arteries of the Skate are described by Hyrtl,* his paper being illustrated by a series of very beautiful coloured plates.

The heart consists, as usual in elasmobranch fishes, of sinus venosus (fig. 1, *s.v.*), auricle (*au.*), ventricle (*v.*), and truncus arteriosus (*c.a.*, *b.a.*). The sinus venosus with which we are especially concerned, as it receives the venous blood from all parts of the body, is a transverse vasiform chamber, situated in the postero-dorsal region of the pericardium, to the walls of which it is attached by a strong sheet of fibrous tissue. At each end, just outside the pericardium, it becomes connected with a chamber (*pc. s.*) situated at the anterior end of the abdominal cavity, and in close relation with the coracoid portion of the shoulder-girdle. The chamber receives all the chief veins of the body; it answers evidently to the vessel called *Ductus Cuvierii* in bony fishes, which again is known to be hormologous with the anterior vena cava, or precaval vein of the higher animals; it may therefore be called the *precaval sinus*.

The precaval sinus is an irregularly ovoidal chamber, about two centimetres long by a trifle over one centimetre in width; when laid open from

* Wien. Sitz. Ber., XXV., 1857; and Wien. Denkschr., XV., 1858.

the ventral side, its walls are seen to be perforated with a number of apertures, by one of which (*s.v'*), situated at its anterior end, it pours its blood into its sinus venosus, while by the remaining six it receives either blood or lymph from the various parts of the body. One, on the inner wall and somewhat dorsal in position, leads into the jugular vein, by which the blood is brought back from the head (*ju'*): a small aperture just anterior to this leads into the inferior jugular vein (*i.ju'*): a large one just posterior to that of the jugular is connected with the cardinal veins, by which the blood is returned from the hinder parts of the body (*cd'*); on the ventral wall is the entrance of the hepatic sinus (*h.s'*); and on the outer wall that of the brachial vein (*br'*). Lastly, on the dorsal wall is a transverse slit, guarded by a pair of valves, and leading into a large lymph sinus (*ly'*).

The jugular *(ju.)* is a large vein lying to the dorsal side of the gills, and receives the greater part of the blood from the head, the small inferior jugular *(i.ju)* receiving mainly that from the floor of the mouth and the pericardium. The brachial *(br.)* is a large vein, and receives all the blood from the great pectoral fins; at its distal end it is connected with the veins belonging to the posterior part of the body, in a way presently to be described.

The portal vein returning the blood from the abdominal viscera (fig. 2) is made up of two chief factors, the *gastric* (fig. 2*g*.) from the stomach and the *mesenteric* (*ms.*) from the intestines. The latter is made up of a main trunk *(ms')* from the colon—*i.e.*, that part of the intestine in which the spiral valve is contained, a *duodenal vein (du.)* from the *bursa entiana* or duodenum, a *splenic vein (spl.)* from the spleen, and about three small veins *(pn.)* from the pancreas. The main portal vein *(p.)* enters the liver, and the blood taken by it to that organ, along with that from the hepatic artery, is poured by several veinlets into the *hepatic sinus* (fig. 1, *h.s.*), a large transverse chamber, just anterior to the liver, and opening at either end into the precaval sinuses.

So far, everything, with the exception of the inferior jugular vein, is just as I have learned it from Prof. Huxley's lectures, and as it is, if my recollection serves me, described by Monro.

The unpaired caudal vein (*c.*), bringing the blood from the tail, divides immediately on leaving the hæmal canal of the caudal vertebræ into two vessels, the *renal portal veins (r.p.)* which pass, one to each kidney, running up to the greater length of its inner border. Into each renal portal vein open a number of lesser trunks *(r.p.')* from the pelvic and lumbar regions as well as from the region of the vertebral column as far forward as the anterior end of the kidneys; while from it numerous offshoots *(r.p.'')* pass into and break up in the substance of the kidneys; so that all the blood

from the tail, as well as part of that from the hinder part of the body, is taken to the kidney and passed through the renal capillaries on its way back to the heart.

From the kidneys the blood is returned by numerous small *renal veins (r)* into the two large *cardinal veins (cd)*, which lie, one on the ventral face of each kidney, and, uniting with one another by a cross-branch *(cd'')* posteriorly, pass forwards and outwards to the aperture *(cd')* already mentioned in the precaval sinus. After leaving the kidneys the two cardinal veins run together, and form a spacious *cardinal sinus (cd. s)*, capable of containing fully an ounce of blood, and connected on either side with two almost equally extensive *spermatic sinuses (sp. s.)*, which receive the blood from the reproductive organs.

The general diposition of the cardinal veins, as here described, is perfectly well known, but their relation to the caudal vein is, I think, not generally recognized. In fact, it is distinctly stated in Huxley's "Anatomy of Vertebrated Animals," in Gegenbaur's "Elements of Comparative Anatomy," and in Claus's "Grundzüge der Zoologie," that both in Marsipobranchii and in Elasmobranchii, the two branches of the caudal vein are directly continued into the cardinals. I therefore thought, at first, not unnaturally, that the true condition of the renal circulation in the skate had been overlooked, but on consulting M. Jourdain's memoir on the renal portal system, in the "Annales des Science Naturelles,"* I find that he has described and figured the real state of things with great exactness, except for the fact that he gives a wrong account of the relations of the veins from the hind limbs.

The skate has thus a true "renal portal system," quite of the same nature as that of Amphibia and Reptilia: in these latter the renal portal veins receive not only the blood from the tail and pelvis, but also that from the hind limbs, and in the skate also the veins of the hind limbs or pelvic fins are described by Jourdain as opening into the renal portal vein. But I find that he has mistaken the principal pelvic vein for the femoral. The latter takes a quite different and very remarkable course.

The femoral vein *(fm)*, in fact, debouches into a spacious trunk *(il. h., epg)*, which lies, for a considerable part of its course, in the ventral wall of the abdomen, near its outer boundary. Both anteriorly and posteriorly it passes dorsalwards, becoming connected in front with the distal end of the brachial vein, and behind, curving along the posterior wall of the pelvic cavity, then passing on to the lateral wall of the cloaca, along which it takes its course as far as to the rectal gland, where, with its fellow of the opposite side, it enters a hinder prolongation of the cardinal sinus, first receiving numerous

* Ser. IV., Tom XII., 1859.

small veins *(hæ)* from the cloaca and rectum. These latter, I have no doubt, although I have not actually proved it, anastomose with factors of the portal vein.

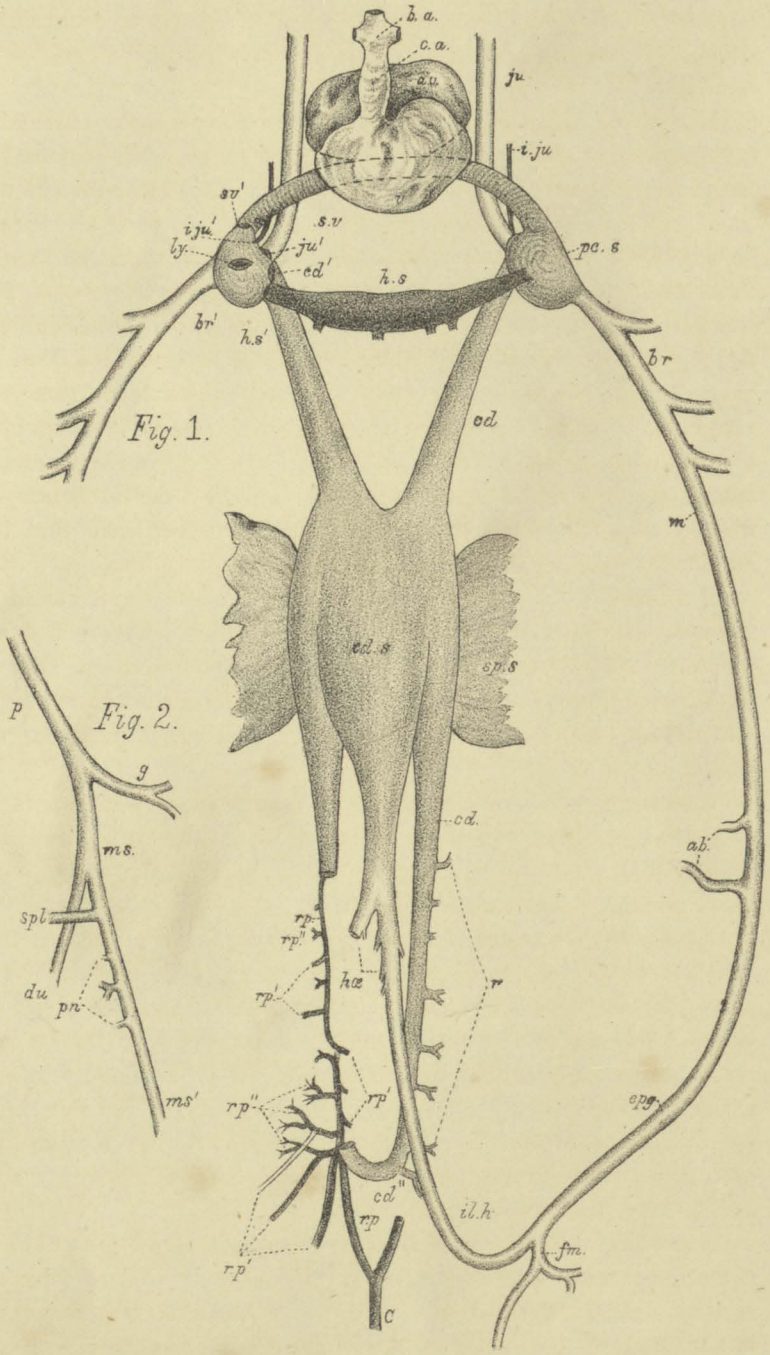
It is by no means easy to find a correct nomenclature for this vein, as it differs so markedly from anything hitherto known. The part between the entrance of the femoral vein and the cardinal sinus *(il. h)* seems to correspond in all essential respects to the iliac vein; or, as it also receives the hœmorrhoidal veins (*hæ*) from the rectum and cloaca, it may perhaps be best called the *ilio-hæmorroidal* vein. The part continued forwards, from the junction of the femoral (*ep.g*) receives veins (*ab.*) from the abdominal walls, and therefore answers functionally as well as topographically to the epigastric or anterior abdominal vein. Similarly, the anterior part (*m*)—that continuous with the brachial vein, seems to answer to the mammary vein of the higher animals. So that it may be said, that the mammary and epigastric veins are of great size, as large in fact as the subclavian and iliac, into which they respectively pour their blood, and that they are continuous with one another, instead of merely anastomosing.

But it is obvious that there is another and more natural way of describing these vessels, namely, by considering the veins I have called brachial, mammary, epigastric, and ilio-hœmorrhoidal, as forming—as they actually do—one continuous lateral trunk, into which debouche the veins from the fore and hind limbs and abdominal walls, as well as from the rectum and cloaca.

Certain theoretical considerations invest this mode of interpretation with great interest. The theory of vertebrate limbs, now very generally received, is that of Mr. Balfour, who regards the limbs as being detached portions of an originally continuous lateral fin.

It seems to me that an argument distinctly in favour of this theory, is afforded by the case now under consideration. The ancestral vertebrate possessing the continuous lateral fin must presumably have had a large lateral vein, into which opened numerous veinlets from the fin, and it is reasonable to suppose that, as certain portions of the fin developed at the expense of the rest, the anterior and posterior ends of the vein, in relation with them, would take on a greatly increased size, the intermediate part becoming proportionately reduced, and supplying finally, only the body-wall between the fore and hind-limbs.

According to Professor St. George Mivart, the skate presents us with a nearer approach than any known type, to the primitive form of limb-skeleton—the archipterygium. If this view be correct it is very interesting to find the limb possessing what we may consider as an almost primitive venous supply. But it must be remembered that, the skate being in many



VENOUS SYSTEM of RAJA NASUTA.

T.J.P. ad. nat. del. J.B. lith.

respects an extremely specialized fish, certainly far more specialized than the sharks or dog-fish, it may be that the primitive arrangements of its limb-skeleton and veins should be looked upon as re-acquired, rather than as retained.

There is one general point about the skate's venous system to which I may, in conclusion, direct attention, and that is the extraordinary number of transverse anastomoses it presents, the result being to produce numerous "venous circles," comparable to the circle of Willis in the arteries of the mammalian brain, and the *circulus cephalicus* in the arterial system of bony fishes. Thus there is a direct passage from the sinus venosus and back again, in four different ways, namely: (1) by the the hepatic sinus; (2) by the anterior part of the cardinal vein and the cardinal sinus; (3) by the whole length of the cardinal veins and their posterior anastomosis; (4) by the lateral veins (brachial, ilio-hœmorrhoidal, etc.) and the prolongation of the cardinal sinus, into which they open. Other *circuli venosi* can, of course, be made by taking the hepatic sinus, or the cardinal sinus, as a starting point; and lastly, two great paired circles are formed by the lateral veins, each in connection with the corresponding precaval sinus, anterior portion of cardinal vein, and cardinal sinus.

EXPLANATION OF PLATE XV.

Fig 1. General view (somewhat diagrammatic) of the veins of *Raja nasuta*, from the ventral side (half nat. size). The portal vein is not shown; the renal portal vein *(rp)* is supposed to be removed on the left side (right in the figure), and the femoral *(f.m.)* ilio-hœmorrhoidal *(il.h.)*, etc., veins as well as part of the cardinal *(cd.)* on the right. The right precaval sinus *(pc.s.)* is cut open, so as to show the apertures in its walls. The outlines of those portions of the auricle *(au.)* and sinus venosus *(s.v.)*, which lie behind (dorsal to) the ventricle *(v.)*, are dotted.

ab., veins from abdominal walls.
au., auricle.
b.a., bulbus anteriosus.
br., brachial vein.
br'., opening of brachial vein into precaval sinus.
c., caudal vein.
c.a., conus arteriosus.
cd., cardinal vein.
cd.', opening of cardinal vein into precaval sinus.
cd.", posterior anastomosis of cardinal veins.
cd.s., cardinal sinus.
epg., epigastric vein.
fm., femoral vein.
h.s., hepatic sinus.
i.ju.', opening of inferior jugular into precaval sinus.
ju., jugular vein.
ju.', opening of jugular vein into precaval sinus.
ly., opening of lymphatic trunk into precaval sinus.
m., mammary vein.
pc.s., precaval sinus.
r.p., renal portal vein.
r.p.', factors of renal portal vein from pelvic and lumbar regions.
r.p.", branches of renal portal veins entering kidney.
sp.s., spermatic sinus.
s.v., sinus venosus

h.s.', opening of hepatic sinus into precaval sinus.
hæ., hæmorrhoidal veins.
i.ju. inferior jugular vein.
s.v.', aperture leading from precaval sinus into sinus venosus.
v., ventricle.

Fig. 2. The portal vein of *Raja nasuta* (half nat. size).
du., duodenal vein.
g., gastric vein.
m.s., mesenteric vein.
m.s.', main factor of mesenteric vein from colon.
p. main trunk of portal vein.
pn., pancreatic veins.

ART. LXI.—*On a new Holothurian* (Chirodota dunedinensis, n.sp.).

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THIS representative of a genus and family hitherto unknown in New Zealand appears to be extremely common in Otago harbour. I found it first between Logan's Point and Ravensbourne, and afterwards, in great abundance, at Broad Bay, both times entangled in the red seaweed between high and low water marks.

As I hope to have the opportunity of working at the anatomy of the species, I confine myself now to recording the discovery, and giving the sytematic characters of the genus and species.

Genus *Chirodota*, Eschscholtz.

Worm-like; calcareous spicules in the form of wheels imbedded in the skin; tentacles shield-shaped, produced at the edges into finger-like processes *(Tentacula peltato-digitata)*.

C. dunedinensis, T.J.P.

Tentacles ten, each with about ten processes, which increase in size progressively from the proximal to the distal end. Integument quite smooth, there being no tentacles or papillæ. Colour yellowish (owing to the bright yellow viscera shining through the translucent skin) with small crimson spots which disappear in spirit; tentacles whitish, with dark spots on the inner side at the base; these spots are unaffected by spirit. Length, in the extended condition, about 4 cm.

Otago harbour: littoral.