THESIS

1860.

OBSERVATIONS AND EXPERIMENTS

ON THE

CARCINUS MŒNAS.

BY

WILLIAM CARMICHAEL McINTOSH.

St ANDREWS.

Observations and Experiments on the C. mænas.

Introduction.

The object of the Medical Faculty in demanding a Thesis from every graduate is - not that he should read a vast amount on the subject he has undertaken, and thence gather the most striking features and combine them, perhaps with a few additional remarks of his own, so as to form a concise compilation, but - that he should exercise his own powers of observation and research, and thus train and strengthen those faculties on which the successful pursuit of his profession depends. Perhaps the former is the more easy, especially when the student has no inclination for pursuing the study of Anatomy (always including Comparative Anatomy), Natural History, or Botany, and thus may it be, why so few attempt the latter subjects, while the great majority keep within the limits of Medicine and Surgery proper, concerning which, in most cases, so much has been written by others before them. It may be argued that few have the opportunity of studying Anatomy, Natural History &c; but, surely there are few so situated as not to have it in their power to dissect or observe some animal or vegetable structure, in the close scrutiny of which - they may invigorate their minds and benefit science far more than by confining themselves mostly to the gleaning of others' ideas. The position in which the student is placed is doubtless disadvantageous to such pursuits; between Competitions, Examinations, and mastering his manifold subjects, the short autumnal month or two affords little relaxation, although class attendance is over. It is not to be supposed, however, that all those who attempt such a subject have been privileged with more time than their neighbours; in the case of the writer, the very opposite can be shown - in the brevity of his course, and the greater amount of work which had therefore to be gone through in it. It would rather seem that Medical & Surgical Theses have found more favour with Graduates than those of Anatomy, Botany, or Natural History: but it does not follow that because one writes on any of these latter topics, he is deficient in the others; it more frequently happens that he who writes on Medicine and Surgery proper is deficient in Anatomy, Natural History, and Botany.

The following observations were begun in the middle of August 1859 and carried on under peculiar difficulties, with the prospect, and soon the reality, of two years classes and their competitions in one, with Dispensary Practice and Laboratory besides. The nigh impossibility of experimenting on the living animals in Edinr, even if there had been time, almost limited this to the autumn weeks.

Under these circumstances then, it is hoped that the few remarks here stated in regard to the Carcinus mænas, or Common shore crab, will not be thought unfit to appear as the Thesis of a Graduate.

Remarks on Habits, &c.

Introductory Remarks on the haunts, habits &c of the C. mænas.

To every inhabitant on the sea coast, especially where rocks abound, the Carcinas mænas, or Common Shore Crab, is familiar. But few places can equal the shipwrecking Bay and rocky fringed shore of St. Andrews, where these observations were made, for the abundance of this animal, as well as hosts of other marine productions of a much rarer description. Here the Carcinas mænas is lord of the sunny pool and shady clefts. Here he may be seen, in some still pool whose edges and bottom are mantled with dark algæ of luxuriant growth, interspersed with lighter tufts of arborescent Sertularidæ, scuttling along some sandy spot, uncovered by the vegetation, and seeking a secure retreat under the shelving rock; and he does so with astonishing rapidity. There, tide being ebb, he is shrouded under some protecting shelf in dirty mud _ scarce a morsel of his body appearing above ground, and oftentimes totally submerged, his dingy coat on ejection bearing slight resemblance to the clean mottled green which so closely figures the vegetation and rocks which he haunts. Again, when the tide has far receded, and you tread over the rocks which ocean mostly covers, in those regions where the Uraster and Solaster hang on the dingy dripping rocks in fantastic attitudes, now suspended by the tiny ambulacra of one ray, now by more, their gaudy bodies contrasting with the dark background of a deep recess or bunch of Fucus. Here too _ upturned flags reveal rich treasures, Galathea's Hairy Porcelain crabs, Nereis', Terebella's, Ophiocoma's, Pycnogonon's, &c and hosts of young C. mænas'; and stooping down you see under the ledge the well grown Doris lazily feeding on one of many sponges, the pretty little Grantia compressa, occasionally accompanied by an Aplysia, while a touch of your hand brings a squirt of water from numerous Anemone's, some hanging from the rock, others protruding from the sand. It may happen that you are at a part where the soft blue shale affords a favourite site for the Pholas crispata, which here abounds, and whose fleshy siphon betrays the lurking inmate of the circular aperture, and a touch on which is followed by the tiny jet of water, perhaps into your eye, and its withdrawal into the wondrous retreat, which often, grooved and empty, with a projecting point at the bottom, lies broken by the waves on the sand.

But it would be endless to mention the numerous and interesting hosts which here engage as well as instruct the marine Zoologist, for they abound amongst those rocks + pools: and the apology for introducing them here is that they are the companions of the Carcinus mœnas in those retreats of the deep.

It is in those parts then that you get fine specimens, whose powerful telæ have not acquired those colossal dimensions by one moulting or by two, and numbers - male + female - line the fissures, quite secure from vision, but not so from the rod + crooked iron. After a storm, especially, great numbers are found crowded together. It sometimes happened that, at this season, you ejected a group of half a-dozen females, without a single male, each bearing its subabdominal burden of ova. Again a large old male might be dislodged from some lonely nook - quite a bachelor crab. More frequently, however, you found a few together at low water mark; and, if single, it generally had been moulting lately, & was in the condition vernacularly termed 'soft back'. The females were frequently of a reddish or purplish hue, even where no ova adhered to the abdominal feet. Lastly, he may want a tela, or several of his smaller limbs, or both, or may have them in various stages of growth, and may be subject to other mutilations, or may have several additions in the shape of a bunch of Sertularia, Balani, or Sponge clustered on his back, or numerous white shelled Serpulæ.

In activity the Carcinus mænas is preeminent; his body is not too ~~long~~ bulky for his long & powerful limbs; by nature he is savage, few animals caring for his company - and he fights constantly with those of a similar sex, (of his own species), mutilating each other often to a great extent. He hangs on by a tela, when enraged, often to its destruction, but he is more cautious of the one remaining. When in danger, he elevates the telæ & makes off, if not prevented, with great alacrity, whether on land or in water, and is quick in detecting enemies. He stands in marked contrast to another of his kindred occasionally dislodged in the search, the Cancer pagurus, whose motions do not display anything like the remarkable activity of the Carcinus m., nor is his nature so fierce. The Cancer p. is easily injured & dies, whereas the Carcinus m. survives great harm. The latter lives in a glass globe for 10 or 12 days - away from all moisture but that which he has in his own branchiæ, or comes from those of a fellow prisoner. The Cancer Paguros scarce lives a day or two.

Towards the latter days of Octr. the weather was cold & frosty & it could be observed that the activity of the C. mænas was considerably diminished, especially in the morning, before the sun became strong, & when pulled out of his retreat his motions were much more sluggish than usual, showing that the cold evidently exercised a sedative effect both on his activity and ferocity. At Christmas the animals were in considerable numbers in the same haunts, and, the weather being mild, they were rather active. The females of course still carried their ova, and frequently too were accompanied by males in their retreats.

From the foregoing considerations then it may be premised that the nervous system of the C. mænas is highly developed and concentrated, and the consideration of this (Anatomically) brings us to the first part of this Thesis.

Observations on the Nervous System &c

Before proceeding to the chief subject of the Thesis, it may not be out of place to give a short description of the leading anatomical features of the Nervous System of the higher Crustacea, principally that of the Crabs.

The Nervous System of the great Division of the animal Kingdom to which Crustacea belong is characterised by generally appearing as a double gangliated chain. In the Crustacea, this bilateral symmetry is well shown in those whose dermoskeleton presents us with the most regular & distinct segments. It may be generally described as consisting of a series of ganglia placed on the ventral aspect of the animal, communicating with the cephalic ganglion and each other by a pair of nerve filaments, and supplying the various organs around. The Talitrus exhibits this arrangement. Further up the scale we find that the ganglia diminish, and do not correspond in number to the segments of the body. The scale of centralization is traced with great distinctness from the Talitrus, before mentioned, through the Oniscus, Phyllosoma, and Cymothoa, where the ganglia have coalesced transversely, — to the Lobster — in which the longitudinal filaments are united completely in the abdomen, though still double in the thorax. The first thoracic ganglion and the last abdominal also are evidently composed of several united; the former being composed

Nervous
System i
Higher
Crustace

of the five pairs of ganglia belonging to the five rings bearing the accessory masticatory apparatus, the latter consisting of the two ganglia pertaining to the sixth and seventh segments of the abdomen. In the Palæmon the three lowest thoracic ganglia are united, in fact, the nervous system of the cephalo-thorax consists of four closely approximated ganglia. In the Palinurus the thoracic ganglia are in a single mass, with a cleft for the sternal artery. Through intermediate stages we come to the C. mænas – where the single thoracic centre is in the form of a ring, and the abdominal filament is rudimentary and single, in consonance with the state of the abdomen itself. The centralisation is completed in the Maia where the thoracic ganglion is without aperture or break, & where even the nerves themselves bear evidence of concentration, as several pairs are distributed conjointly to one segment.

Nervous Syste
of Carcinus
mænas -

As it is chiefly on the C. mænas that the following observations and experiments have been conducted, a somewhat minute description of the distribution and structure of the nerves in this animal may be advantageously placed here.

Mode of preparing specimen.

In the C. mænas, as already stated, the centralisation of the nervous system is far advanced. The best way, so far as we know, of preparing the crab for examination is as follows, – Snip off the legs with powerful scissors close to the body, except in those specimens intended for a special examination of the nerves in those organs, divide the carapace to the exterior of the orbits

† See Drawing I.

and connect the two longitudinal fissures by another which courses transversely ¼ of an inch or less behind the blunted rostrum. By a few more touches along the back and sides the whole carapace can be removed on the dorsal aspect. The liver, generative organs, and other soft parts, not necessary for the examination, are then to be removed under running water, with the assistance of the forceps. The body is then to be placed in weak spirit for some days; this is requisite on account of the softness of the nervous texture, which, being at the same time translucent, is much the better of being so hardened before the minute branches are traced. In those intended for microscopic examination such preparation in spirit is prejudicial; fresh specimens being the best.

The greater part of the nervous matter then in this animal is found in the Cephalic + Thoracic ganglia, and from these, branches are given off to supply the organs of the special senses – those of loco-motion – digestion – reproduction &c &c.

Description of Cephalic Ganglion

† The Cephalic mass of nervous matter is situated at the anterior part of the cephalo-thorax over a deep sulcus divided into two by a prominent median ridge, and behind it is a projecting spike to which a strong ligament is attached. This sulcus is marked externally by a pale triangular surface just beneath the two internal antennae + in the mesian line. The ganglion does not lie in contact with the oesophagus, but is distinctly placed anterior to it, although the connecting cords with the thoracic ganglion embrace

|| See. Drawings III. IV. & V.

it. It is about ¼ or ⅕ of the size of the thoracic ganglion, and together with the latter is easily distinguished by its opalescent aspect, arising from the thickness of the nervous matter there accumulated. It has a nodulated appearance when fresh, probably from bunches of grey matter. This, with other ganglia, assumes a yellowish tinge after hardening in spirit; while the nerve tubes have their white opalescent appearance intensified. The nerves given off from this centre are the following;- Optic, Oculo-motor, Nerves for the internal antennae, Integumentary, Nerves for the external antennae, connecting filaments with the Thoracic Ganglion. The origins of these nerves are not all seen on examining the dorsal aspect of the ganglion, some being placed on the ventral surface. The most conspicuous are the Optic and Fourth pair.

Nerves from Ganglion

II Microscopically the cephalic ganglion is a most beautiful object, and well repays observation. White and transparent though it be, fibres, cells, nuclei, and nucleoli, can all be made out most distinctly. When taken from a recently Killed animal, + put under the microscope, a mingled array of nerve tubes, nerve cells, + granules, present themselves. The nerve tubes are of the usual structure, pale, transparent and soft, yet of considerable tenacity, and run here and there apparently throughout the whole ganglion. Their ending, though difficult to trace, appears to be in masses of nerve cells. The nerve cells are good specimens, + vary in size – some large and filled

Microscopic Examination.

* Others of course were continuous with the unipolar and bipolar cells.

§ See Drawing IV.

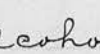
with granules, apparently the germs of a new race; others small & in immense abundance. They present a similar appearance to the same structures in vertebrates, having a granular aspect – with a nucleus and nucleolus. A singular appearance sometimes was observed, viz. – that of two nerve cells joined together by a flattened margin, similar to the Desmideæ, and evidently caused by the fissure of a single cell. Groups might also be seen which from their flattened sides seemed the products of the bursting of a well filled parent cell. Some might be seen in masses, while nerve fibres coursed through & over them, or were lost in the granular mass. Polyclonic nerve cells we did not see, and if they are present at all are certainly excessively rare. Bipolar cells we observed several times, Unipolar often. The connection of the fibre with the cell in this animal is in a very rudimentary condition, most of the fibres seemed to be lost in masses of granular matter & cells, with no distinct connection.* The primary and simple cell seemed so predominant throughout the whole ganglion that the notion, that it must have some effect on the fibres without direct continuity, in vain could be got rid of. X

Ending of fibres –

8 If you examined the cephalic ganglion a day or two after the death of the animal, a remarkable appearance met the eye – in the shape of multitudes of needle shaped crystals scattered over the field of the microscope. They must therefore have been the result of of decomposition of certain of the nervous elements. They seemed of fatty origin, and

‖ These crystals belonged to the ganglion & were not extraneous structures.

* Drawing I.

were most likely crystals of Margarin, since they resembled them most closely. They were entirely absent in newly killed specimens, neither did they appear in those kept in alcohol, which latter substance either prevented their formation, by arresting decomposition, or dissolved them when formed. They could be detected at once by altering the focus so as to make them contrast (dark reddish) with the light colour of the (transparent) translucent field. Some had the shape of long needles sharp at both ends, others were truncated at one or both extremities. Sometimes they radiated from a long central stalk like a brush or fan, at others, two opposite radiations met in a single point – . Acetic acid dissolved them, & so did alcohol. They decidedly seemed of fatty origin, & bore a marked resemblance to crystals of margarin."

Effects of decomposition on Ganglion

The first branch of this ganglion that * falls under consideration is the Optic Nerve, which, proceeding on each side from the anterior horn of the nervous mass, courses obliquely forwards and outwards for about ¼ of an inch, then, coming in contact with the eye peduncles, they it enters the tubes of the latter in company with the small muscular nerve afterwards to be mentioned. They do not appear to be increased in size in the Carcinus mænas after they enter this tube. Passing on, & keeping to the inner side of the horny tube, they plunge amongst the soft textures constituting the eye-ball proper, and not much, if any, lessened, can be

Course of Optic Nerves

‡ See Drawings VII. VIII. & for shape of pockets - I & II.

* A row of hairs in addition protects the small portion of the cornea not completely turned in. They are occasionally absent.

traced to the middle of the same, there becoming more indistinct.

A short description of the Visual Apparatus will tend to elucidate the further distribution of the Optic nerve. In the C. mænas the eyes, as in allied Genera, are supported on pedicles or stalks, and are of the kind termed compound. They are moved in this animal with striking vivacity and acuteness, and are a good index to the state of the animal and its intentions. Their sockets # are wide and present an admirable curve, whereby the crab enjoys an extensive field of vision so necessary to his active and marauding habits. In this he stands in marked contrast again with the Cancer pagurus, whose eyes are set in deep & narrow sockets, and are sluggish in motion. While the ey sockets in the C. mænas thus admit of great scope of vision, they do not render the organ defenceless, but by their exquisite curve adapting itself to that of the eyeball permits the latter to sink beneath a protecting ledge. The organ is complex, and its varied movements are not less so. By a beautiful provision, the most delicate part, the combined cornea, is almost ~~completely~~ wholly turned in towards the hard shell, when the eye is retracted, thus completely protecting it from external injury, while still addmitting of useful vision*. The force with which the eye is retained, when withdrawn, is very great, and it would seem that atmospheric pressure as well as muscular tension combined to keep it. When turned out, the cornea are made prominent by a revolving movement, and the more the eye

Orbits of Eyes.

Provision in retraction

* Drawing VIII

‡ See also D. VIII. VII. r–

is inverted (towards the middle line) the more prominent does it become, while at the same time it is moved in a backward direction.

* The shape of the compound eyeball is peculiar, in consonance with the structure of the rest of the animal. It is a sort of cone with a deep depression extending $\frac{3}{4}$ of its middle circumference. The peduncle, coming from the junction with that of the opposite side, enters the base of the cone towards the inner side, in a position analogous to the entrance of the optic nerve in vertebrata. The soft parts of the eye are invested by the usual dermo-skeleton, with the exception of the cornea, which are situated at the outer side of the cone near the apex, but not quite, a part of the ordinary dermo-skeleton forming the projecting extremity. This has its functional importance, the cornea being (alike) saved from the danger of extreme prominence, whether in protrusion or retraction. The curves of the eye shell are various and merit close observation. But the calcareous coat of the eyeball is not of one continuous smoothness; there is a remarkable circlet of hairs near the base of the cone on the outer or convex side, which seems specially adapted to assist in the sucker power hinted at previously. A short notice of these may not be uninteresting.

Shape of eyeball.

‡ Hairs of Eyes. The circlet of hairs on the calcareous coat of the eyeball, and also in other parts of this animal, present a most remarkable microscopic appearance, differing from those of any other animal with which we are acquainted. This peculiarity

* Drawing IX.

of structure is not so much in the actual hair itself, (confining this description now solely to the hairs of the circlet on the eyeball), as in certain curious appendages which admirably assist in adapting it for the somewhat odd function which it exerts. The hair itself is fibrous & pale, with a light coloured central * space which seems filled with a semigelatinous substance. The surface of the hair is almost everywhere clothed by growths of a fungoid appearance; some presenting the form of a floating mass attached to the surface of the hair by a filiform pedicle, others being of a delicate, filmy, structure, not tapering, of a pale greenish hue, and having the aspect of pigmy algæ. Others hairs are thickened and roughened with a black substance, which entirely obscures the normal structure of the hair, allowing it to glance through only at intervals, and the dark parent mass appearing in striking contrast with the filmy hairs which glisten as they stretch from it. Many other forms cluster around the hair, bodies of a cellular nature, some of a beautiful shape, large & soft, Infusoria or other Protozoa, as well as hosts of other anomalous structures of no distinct shape. The whole together making up an impervious & adhesive mass of hairs, which, with the mud particles, cannot but form an arrangement by which the compound eyeball may be most powerfully retained in its socket. Other minor functions may be performed by this circlet, as that of an elastic buffer, &c.

Microscopic structure of hairs on eyeball.

Growths on hairs.

Function of hairs

† Drawing VIII.

* Drawing X.

Anatomy of compd. eye. contind. Enclosed in the calcareous sheath lie the visual apparatus and its accessory muscles.

Cornea. The Cornea, as already mentioned, are clustered
+ on the convex side of the apex, and their extent is well defined by the dark pigment which shines through them, and lending a black, glistening, and almost metallic appearance to their surface. Microscopically they present the appearance of hexagonal
* plates accurately united at their margins, and this form, it is well known, admits of the greatest number being clustered in the smallest space. They are perfectly transparent, as those similar structures are in vertebrates, & they have apparently the same texture & chemical composition.

Microscopic structure of Cornea.

Behind the cornea, by unaided dissection, we find a mass of pigment corresponding to them in shape, and of some thickness: posterior to this the soft mass of muscles, optic nerve, nutrient arteries, &c. The usual description given in Comparative Anatomy works of the eyes of Crustacea is "that behind the cornea we find gelatinous transparent cylinders bounded by layers of pigment, each cylinder and layer corresponding to one of the hexagonal corneal segments." We could trace the optic nerve quite easily through the mass of muscles forward to the vicinity of the pigment border, but at this, and sometimes before arriving at it, numerous branches radiated from the parent trunk, and, when followed, seemed to end in a granular

Anatomy of Eye.

layer (formed by pressure between the glasses). This granular layer was very pale and translucent, and composed of an aggregation of minute cells of somewhat irregular shape and mingled with granules. It probably was formed originally by pressure on the cylinders, the pigment having been previously dislodged to prevent obscurity.

Ending o
Optic Nerv

The pigment is granular, and of a very intense black colour en masse under the microscope, but brownish when somewhat isolated. No hexagonal, or other regular cell formation could be detected.

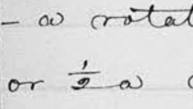
Pigment
Granules

In connection with the external configuration and functions of the eyeball, a diseased condition very frequently presented itself, not primarily any defect of the visual apparatus, but total disorganisation of structure and function caused by the pressure of a foreign body. This condition consists in the introduction and growth of the young of the Mytilus edulis, the Common mussel, whereby the eyeball is wedged gradually out of its socket, and ultimately drops off, or thus projecting is removed by the tela of an adversary. The mussels seem to have been introduced in the condition of ova, and lodged in a fissure at the inner angle of the socket, close to the insertion of the peduncle. In this position they could not be easily dislodged, while in growing it gave them full purchase on the broad base of the conical mass. When small, you

Introduct
and growth
of Mussels
in orbits

Effects of these foreign bodies!

might see many, but, after a time, one took the precedence, as in polypus of the nares, and growing apace appropriated the situation for himself. At first they caused little interference, but soon the eye protruded, and, as the foreign animal grew, it did so in a most characteristic manner – presenting the convex outer surface on the dorsal aspect of the animal. The ova of the mussel did not attach themselves to the circlet of hairs before mentioned, and, when the disease was not far advanced, these hairs might be seen still in situ; after a time, however, approximation being denied, they gradually disappeared by friction or other injury. In being thus pushed out, the



eye underwent a rotatory movement as well, – a rotation from below upwards, to the extent of $\frac{1}{4}$ or $\frac{1}{2}$ a circle. Whether the animal in the water while feeding on the ova of the Mytilus had in some of its varied movements got them floated into its sockets, the eyes being extended, I do not know, but the sudden retraction of the eyes would only fix the intruder more firmly in its seat, behind & inside the cone's broad base. This lesion was frequently noticed, sometimes affecting both eyes, at others one. It must have caused considerable pain and annoyance to the crab, and he certainly paid dearly for his destruction of the mussel ova, if the former supposition is correct. I observed this state in many animals say 15 to 20 out of the 100, (keeping rather under the real number) yet in only one of these

Frequency of this accident-did I witness an attempt at the renewal of this important organ. In this case a soft mass of an elongated nature grew from the peduncle, & doubtless was an effort of nature to reproduce the eyeball. In many the socket was found quite empty, this condition probably resulting from the removal of the projecting eye by accident or the tela of an enemy, and the subsequent detachment of the mussel, as none were found of any size in the empty sockets. While thus describing the injury caused by the Mytilus in the orbit of the eye, it may be stated that they occur occasionally attached to the abdominal feet in females, & I have found them there of large size, ¾ to 1 inch in the long axis, altogether preventing the approximation of the abdomen to the thorax, and sometimes surrounded in their novel site by the ova of the crab. It is curious that an animal, on which, when unshelled (and probably in the state of ova) the C. maenas feeds with great zest, should thus frequently be the source of great annoyance & injury to it.

Other parts frequented b the mussel

Second pair – These are two small nerves springing also from the anterior part of the cephalic mass, and, proceeding outwards & forwards, accompany the optic nerve. They also enter the tube of the peduncle, and are distributed to the motor apparatus of the eyeball.

Muscular nerve of eye

* See Drawing I. where, however, these nerves are scarcely to be seen, as they arise from the ventral surface of the ganglion.

§ Drawings - VII + XII.

† Drawing XI.

Branches

* Third pair_ These nerves arise from the ventral aspect of the ganglion, immediately behind the optic and oculo motor, and, bending forwards, enter the internal antenna & divide into three branches; one supplying the peculiar organ endowed with motor and tactile sensibility, called the internal antenna, another coursing along the inner margin, and supplying the membranous and muscular structures around the sac, and a third could be traced into the soft textures within the calcareous elevation in the interior of the sac.

Antennula

Hairs of -

§ The Internal Antenna in the C. maenas is of a similar structure with that of its immediate allies, so far as we have examined. It consists of a jointed limb with a peculiar & delicate arrangement at its † extremity, consisting of two jointed appendages, one strong and bearing beautiful hairs, the other slender and capable of approximation. The hairs on the larger appendage have distinct transverse markings, bearing a distant resemblance to those of the sheep, though not so slated: it seemed as if there were gentle undulations rather than deep notching. They slope to a point, but this is somewhat short_ without much tapering, and are of a light or straw yellow tinge. The extremity of the thicker appendage tapers much more than that of the more slender, and both are usually tipped with fine hairs. The great joints of the organ are articulated to the distal segments of the limb, and are capabable of

Drawings XII & XIII

Structure of large segments

Nerves of Int. Ant.

Ending-

considerable and varied motions. These two segments are of the usual structure externally, and are articulated with the basal swelling, so characteristic of this organ, by a long ligamentous connection, which permits them to protrude or sink with great ease; acting, in fact, as a sort of long elastic buffer and pad, by the shortening of which the horny segments can be better packed, and by whose elasticity & softness great and delicate motion is allowed. This, of course, diminishes the power, of little consequence, and increases the delicacy and sensibility, a matter of great moment. This is liberally supplied with muscles and nerves. I traced the nerves, by softening the external shell of the jointed limb, but could not detect any peculiar mode of distribution; it seemed to end in minute branches. In the beautiful terminal antennulae, no peculiar distribution was observed; though it may have been overlooked for want of time. There seemed ~~to~~ no trace of nerve fibres in the terminal joints, & they appeared to be filled with pale granular matter. The hairs at the tip of both, & those of the side of the thick one, appeared to dip in on this, and as if their every motion would affect the matter in the interior

H The Basal Swelling of this organ presents a remarkable structure. Outside, we have a calcareous coating dense and strong in front and edges, where exposed, but horny and yielding behind, the line of suture between the two being well marked. There is a

§ Drawing XIV.

ridge of pretty strong hairs in front. Beneath the calcareous shell, we find the ordinary soft pigmentary layer of the derma, enveloping a glistening white sac. The sac is of an irregular heart shape (like the heart of a turtle), and is firmly attached to the hard walls on its lower and outer surface (when in situ). On its under surface, looking obliquely towards the limb of the organ, is an oblong or somewhat elliptical depression, with a central fissure, which was invariable in all specimens. This fissure makes a communication between the interior of the sac and the general cavity of the organ. A process of the sac, too, juts into an irregularity of the external shell. The microscopic § structure of the membrane or wall of the sac is beautifully cellular, presenting no distant resemblance to a finely prepared specimen of the cartilage of the ear of a mouse. Every part of the membrane was composed of these cells, and they varied in size to a slight extent. Completing this membrane at the base is a hard smooth prominence, with a ridge which runs towards the anterior. No nervous expansion is visible on the sac, only the cutaneous nerve supplying the integuments and membranes. On opening the smooth prominence, it was found exceedingly hard and brittle, and a soft pulpy mass could be pulled from this and the interior of the ridge, and when subjected to examination it was proved to be composed chiefly of muscular tissue finely striated,

Cartilaginou
sac of Baca
Swelling -

Microscopic
Structure

Calcareous
prominence
in sac.

and the nervous filaments traced there before, and which seemed to give most of their branches to the muscles. No peculiar formation was seen here to warrant the supposition that this was the important part of the organ, though there was a considerable amount of nervous tissue. Besides this projection in the interior of the sac, there is another exterior, jutting from the upper wall. In the hollow between the sac and the internal edge lie the muscles and other structures pertaining to the limb of the organ.

Ending of nerves.

As to the function of this basal apparatus; there remains no doubt in my mind but that such a complex structure is intended for an important end. Now as we have the senses of Sight and Hearing provided for by other parts, and since no part of it (the basal swelling) can lead us to think that it has any connection whatever with Touch or Taste, we are confined to the sense of Smell alone. It is pretty certain that the animal is endowed with that sense, in whatever organ it is placed; and since no other structure in this animal bears so close resemblance to such (an organ of smell) we are again restricted to this. It is certainly in a very modified form, but this will not exclude it from being the analogue of such an organ. The way in which its immediate ally, the Cancer pagurus, is caught, also supports this idea, the garbage in the traps being more accessible to Smell than Sight. Its superiority in activity

Function of Basal Swelling.

* Drawing I.

|| See Drawing VII.

and acuteness of every organ, when compared with the C. Pagurus, would of course lead us to the conclusion that the senses are also of greater delicacy, or at least of greater acuteness. It is a fact well known to those engaged in catching the C. Pagurus that stinking garbage will not entice it, & certainly sight would not discriminate between stinking & fresh bait suspended, at a distance from the animal, in the netted cage. The angler amongst the rocks is familiar with the C. maenas which eagerly attacks his fresh bait, often to ~~his~~ its own destruction. From the above remarks it would thus seem pretty evident that the Car. maenas possesses an organ or rather organs of Smell, and that these are situated in the basal swellings of the internal antennae.

Case of C. pagurus.

* Fourth pair. These nerves, arising from the dorsal aspect of the ganglion, sweep outwards to supply the tough membranous structures at the anterior part of the animal. They have no further function.

Nerves for membranes

Fifth pair. They proceed from the centre (nervous) forwards & slightly outwards to the external antennae, supplying them and the special organ at their base. The basal part of the External Antenna is firmly anchylosed to the external skeleton, and
11 supports the slender jointed antenna proper through the intervention of a flexible hinge, not so lax

Nerves for External antennae.

x Drawing XVI.

and delicate as those of the internal antennæ, and the jointed segments decrease regularly in size to the tips. These are endowed with great tactile sensibility, and their various motions, indicating the state of the animal, are interesting. In danger, the crab lays them along the lower curve of the orbits, & thus shields them from injury. One of these antennæ is frequently awanting, which seldom happens with the internal.

Jointed Segments-

Auditory apparatus- At the root of the basal portion, which is firmly attached to the rest of the dermoskeleton, is an ovoid and moveable piece of shell, transverse in its long axis, and connected internally with a calcareous rod, bifid at its attachment, by the traction of which the lid is either pushed up or retracted. A somewhat tough membrane connects the margin of the lid to the rim of the cavity, and protects the important contents, as well as performs other useful functions. On dissecting this further, the under surface of the lid is found cup shaped; it moves, hinge-like, at its external end, which is therefore somewhat fixed, while its internal end is capable of considerable motion (flexion and extension only). It is connected to the calcareous stalk, before mentioned, by two cornua which x belong to the rod, thus conferring on the latter no small resemblance to the stapes of the human ear, at least when connected with the lid (The rod and cap are continuous). In the cup shaped hollow of the lid, or between the forks of the stalk, is found a pulpy mass

Structure of auditory organ.

✓ Drawings I & II.

into which nerve fibres can be traced, and in which nerve cells are distinguishable. It would seem then that the vibrations in air or water acted through this membrane on the nerve cells in the hollow. This apparatus, though it seems to be of a very simple nature, unquestionably performs the office of an ear. Various experiments and observations may prove that this animal does hear, and since there is no other organ which can by anatomy or analogy be made one, the case is undoubted. By making a noise in the proximity of the crab, hid in some narrow fissure amongst muddy water, and in such a position that sight was useless, you might hear the grating of his shell as he pushed further inwards between the meeting sandstone. When a step approached the room, in the dark, in which they were confined in a closely fitting vasculum, an immediate commotion of the prisoners resulted, and the same occurred when any sudden noise alarmed them. When their eyes were removed, they also showed much more acuteness than such an animal would if hearing were awanting, and, in fact, if it were not pretty nice.

function of parts.

Confirmation by observation

v Connecting Trunks. The two Trunks, connecting the cephalic with the great Thoracic ganglion, are of large size, larger than the optic nerve by much, a sign of their great functional import. They do not continue as cylindrical cords, but whilst encircling the oesophagus, a gangliform

* Drawing I

† Drawing VI

‡ Drawings I & XV

enlargement takes place on each side, and a branching of the trunk ensues. This ganglion * is easily distinguished as such, and is of an oblong aspect. It contains a collection of nerve cells, at one side of the mass, and gives off — from its under side, nerves for the Mandibles, and from its upper, a large nerve which covers the stomach with its ramifications. This latter † may be termed the Pneumogastric.

Gangliform enlargement at œsophagu

Less than $\frac{1}{8}$ of an inch behind the œsophagus we have a considerable nervous cord (not noticed previously in this animal so far as we know) connecting the trunks of communication, and steadied by membranous folds of fibrous tissue. This cord does not arise at each side from the œsophageal ganglion, ‡ but is placed $\frac{1}{4}$ of an inch further back. There does not appear to be any gangliform enlargement where it meets the cords, and no nerve cells were evident; it seems to be solely a commissure of fibres between the cords. From all we could observe microscopically, the arrangement of the fibres has somewhat the appearance of the fibres of the Optic Commissure in man. Some of the fibres from the Cephalic centre go right on to the Thoracic, others curve through the commissure & return, through the other cord, to the former ganglion again, while a third set, not so easily made out, cross from the one cord to the other still continuing in their pristine direction. A similar arrangement ensues with the fibres from the Thoracic

Cord joining the nerves of communicati

Direction of commissural fibres.

§ Drawing II.

ganglion.

Proceeding backwards under the stomach, the nerves of communication gradually converge through masses of the liver, and, passing beneath a ligamentous archway connecting two jutting portions of the skeleton, come close together so as to appear as one cord. This takes place just at the posterior part of the ligamentous band before mentioned, and they then plunge into the thoracic ganglion. While tracing these connecting cords backwards, we come in close contact with the nerves for the foot jaws which run forwards by their side.

Course and Termination of the Cords.

§ Thoracic Ganglion. The Thoracic Ganglion is a slightly ovoid mass of nervous matter, the longest diameter being antero-posterior, and having in its centre a circular aperture. This shape gives grounds to the appellation of a "nervous ring"; the aperture, however, is small, while the surrounding nervous substance is of great thickness. It lies on part of the muscular apparatus of the limbs, and has above it part of the intestinal canal, liver and generative system, and amid these various organs it enjoys comparative immunity from danger. From this great nervous centre radiate on all sides trunks for the supply of the foot jaws, telæ, limbs, and abdomen, which give to the arrangement here a stellate aspect. It is best reached by a dissection from the ventral aspect, whether after hardening

Form of.

Branches—

in spirit, or during the life of the animal. Microscopically, it presents a similar structure with the cephalic, abounding in nerve cells &c, but the nerve cords of course are more prominent at the edges from their great number and radiated arrangement.

Structure of ganglion

The only observation we have worthy of note in regard to the distribution of the nerves of the limbs, is their arrangement in the young or growing limb of the animal, when the old one has been lost. By this means, when the limb is fully grown, an entire nerve & branches are furnished to it, differing in no respect from those of the original limb. On dissecting a very young limb, ⅛ of an inch or less, & quite soft, no new nerve was visible, the amputated parent trunk being little altered; as older limbs were examined, however, a complete nerve was easily detected. It could be traced to the end of the growing limb, and microscopically became lost in a tough fibrous cicatrix which protected the delicate parts at the end of the stump (the latter is always of a conical shape, & very smooth). When you tried to separate the tough cicatrix with needles into its constituents, the nerves adhered strongly and could not be detached without laceration. At the extreme end of the nerve, a granular and faintly cellular appearance was visible under pressure, and the fibres could be traced up to and amongst this. Whether the nervous tissue was reproduced

Nerves of growing limbs.

Ending of nerves in the stumps.

by the nerves themselves, or was formed by the general cellular matrix, is a question somewhat nice. We are inclined to think that the nervous tissue reproduced itself.

Operations

1. Removal of Thoracic Ganglion. This operation was effected by raising the abdomen & snipping out a portion of the shell over the ganglion, then clearing it from the now superincumbent muscles of the limbs &c. Before the ganglion was injured, the slightest irritation applied to any external part of the animal caused it to struggle violently, and, as large and active specimens were generally chosen, they were sometimes difficult to hold. The nervous matter, when cleared, is of the usual pale colour, not contrasting forcibly with the surrounding tissues. The ganglion being seized with the forceps was entirely removed by snipping its branches. As each nerve was cut the limb was twitched convulsively for a second or two, and then ~~they~~ it relapsed into complete paralysis, exhibiting not the slightest motion but such as was caused by the force of gravity. Repeated irritations to the external surface, after a time, had no effect, and they remained powerless. If, however, the trunks supplying the limbs were irritated at the point of division, the corresponding limb of each nerve was flexed once or twice, and the distal segment (propodite) oftener and longer. On applying the stimulus (forceps) again to the same nerve, the movements were not distinct unless it was applied beyond the point formerly irritated: this may be accounted for by the fact

that the forceps probably destroyed the conducting power of the excident fibres by pressure. The posterior foot jaws were also deprived of motion, and when displaced did not return altogether to their original position, the inherent contractility of their flexor muscles not accomplishing so much. The smaller foot jaws, however, retained a certain degree of motion, probably from the circumstance of a ganglion being situated somewhere on their nerves. The Mandibles of course were active, and closed sharply when forced open. The abdomen for a time held a certain degree of motion (probably from some ganglionic connection too), but on severe irritation it remained extended, its distal segments alone exhibiting slight contractions. No frothy matter escaped from the anterior branchial openings. The lesser or internal antennae remained in full action, being sharply folded when extended, and undergoing other motions when irritated. When at rest they were always closely doubled up and drawn in. The eyes were drawn back to the utmost into their orbits, and when forcibly drawn out immediately sank back on removal of the restraint, unless their muscles were torn or otherwise disabled. Occasionally the animal would protrude one eye to reconnoitre, but quickly retracted it when danger seemed imminent. The external antennae were generally laid along the orbital groove, this being the least exposed and most convenient situation. On irritation, they underwent their usual motion, & generally finished off by being laid along the orbital notch again. If anything they seemed more languid in performing their function than either the eyes or internal antennæ. Sometimes they remained standing out as if in stupor after the shock of so great an injury.

By the wound made in removing the ganglion, the heart could be seen beating, but irregularly, and always with increased vigour if irritated. Sometimes the contractions ceased suddenly, and as suddenly began again. They occasionally continued or could be excited for 14 or 16 hrs. after the operation of removing the ganglion. The movements of the heart continued for about an equal period, on the whole, (of the after the removal of either ganglion, (cephalic or thoracic); at least they could be excited for nearly the same length of time in either mutilation.

On the whole then the general condition of the crab after removal of the Thoracic centre was the following:- loss of sensation and motion in all the locomotive organs (the motions which the limbs afterwards exhibited taking place when altogether removed from the body as well as when adherent); almost complete loss of motion of the abdomen, this, however, evincing slight contractions; loss of motion of most of the foot jaws; impairment of respiration, since no air bells gurgled to denote an active state of the branchiæ; irregularity of motion of the heart, with frequent suspension of function, unless under direct stimulus; integrity of function in the eyes, two pairs of antennae, and other parts supplied by the cephalic ganglion, except so far as might be accounted for by shock.

2. Removal of Cephalic Ganglion. This was accomplished by cutting out a portion of the shell on the dorsal aspect over the situation of the ganglion. The muscles of the stomach, cellular tissue &c are then removed, & the mass exposed. The animals seemed to suffer great pain on irritating this ganglion, and their struggles were violent. It was excised, as formerly, by seizing it and snipping its branches &c. During the excision the antennae and eyes, as might be expected, underwent various jerking movements, although sometimes, but rarely, the animal lay in a sort of stupor during the operation.

The following effects were evident in most cases after the injury. A general stupor pervaded the animal, but which appeared less marked than in the former operation, since it retained the use of its limbs. When the limbs were irritated or injured the animal could crawl in an opposite direction, and avoided the object of pain, but there was a want of controul manifested in its actions, a stumbling gait, the anterior part of the cephalo-thorax being frequently depressed to the surface on which it moved, and it often turned itself on its back. Sometimes it evinced no tendency to move, except slight contractions of the smaller limbs, and swinging of the telson to the site of injury probably from irritation of certain parts supplied by the great thoracic ganglion, as the stomach &c; at others, it would crawl considerably. The abdomen was very irritable, as in the normal state of the animal, and it resented interference accordingly. The foot jaws retained their motion with the mandibles, and so with the respiratory organs, as the frequent escape of frothy air bubbles attested. The larger foot jaws moved vigorously, the smaller ones vibrating most rapidly. The heart continued to beat for a long time, as in the former case. The eyes and two pairs of antennæ &c, of course, were deprived of sensation and motion, and the former often remained protruding in a characteristic manner.

On comparing the one operation with the other, it would seem that the removal of the Cephalic mass had a greater influence on the regularity of the animal's movements than the thoracic, since any motions exhibited after the removal of the latter evinced more want of purpose and controul than regularity. More motion could be excited in this than in the former case from the large expanse of tissue supplied by the thoracic ganglion.

3. Division of the two Connecting Cords. When these were cut the animals at once started and moved ~~its~~ their limbs convulsively; some then assuming that peculiar position with the anterior part of the cephalo-thorax pointing downwards & carried forwards in that position; others wheeling round & raising high the posterior part so as to fall on their backs. Again, some moved little after the injury, elevating the posterior part of the cephalo-thorax, bending the forceps underneath it, and denoting pain by biting at the oral region, then relapsing into a motionless condition with scarcely a twitch of a limb, the silence being only broken by the gurgling air bells from the branchial aperture. In some cases, especially if the incision was close to the cephalic ganglion, the eyes, when pulled out, no longer sank back from slight irritation, and only were drawn in when the optic nerve was injured by direct puncture; in others the eyes retained considerable power. They were seldom protruded spontaneously. The internal antennae when drawn and pinched showed contractility, sometimes they were even protruded spontaneously. The external showed less activity. Irritation of any of the foregoing was followed by no movement of the forceps or limbs (smaller). The foot jaws were in full power, and the feathery margin of one of the small anterior pairs was often kept in vibratile motion. The large posterior pair were also often moved in the usual manner, but slowly. The forceps retained most of their powers of motion, but wanted precision in regard to direction; the other limbs also lost little of their mobility, and there was only a want of coordination in their movements. The abdomen retained full sensibility and motion, and the slightest irritation of this part, in both male and female, caused the crab much annoyance. The distal segment was also often put in motion, as was noticed before. A striking effect of this operation was the tendency of the crab to turn on its back, more especially if the maxillary palps were injured by the points of the scissors, and often, although repeatedly put in its normal position, it persisted in turning itself on its dorsal aspect. Some remained midway, standing on edge with the assistance of the large forceps; these formed two points of the tripod, the third being the anterior margin of the cephalo-thorax; some did not accomplish so much, but had intermediate positions. Occasionally one died in the former position. These attitudes were characteristic of this lesion. Often they started their limbs in a peculiar manner some time after the operation, as if a sudden paroxysm of pain compelled them to do so. Wherever these cords were divided, similar effects ensued, though most of the divisions took place nearer the cephalic than thoracic ganglion.

This operation then was followed by these general effects_ Complete loss of regular progression; more or less impairment in the function of the parts supplied by the cephalic ganglion (partly from shock); power, but also stupor, in the parts to which the thoracic ganglion is distributed. That the Thoracic ganglion performs the part of a complete nervous centre, when separated from the cephalic, is demonstrated by this operation. Irritation of any of the organs supplied by it speedily brought the defensive forceps to that part, and with considerable certainty of direction. That the Cephalic also exerts a certain amount of influence on the thoracic, is equally plain, for, though the limbs retained motor power, the animal never progressed one inch, and there was a torpor in all its motions. Pain too formed a prominent feature in this operation, as indicated by the frequent motion of the forceps towards the wounded part.

Division of the Cephalic nerves on one side. This was done by removing a small portion of the shell over the ganglion, but placed on one side of the mesian line. The animals generally remained stationary for a time after the first convulsive movements. In these it might be observed that it most frequently saw to the side opposite to that on which the nerves were cut. The eye and antennæ on that side were of course paralyzed, and remained motionless. The anterior part of the cephalo-thorax was not much depressed in general, as in removal of the entire ganglion. The animal defended itself vigorously. When the limbs were pinched sharply, the animals sometimes wheeled around and around without moving far from the spot, in a manner seen in no experiment or operation before. Some, after recovering from the shock of so dangerous an operation, moved about, and generally with the sound side foremost, as before mentioned. When arrested and turned round with the wounded side foremost, and the limbs on the sound side pinched, they did not stir; but when again placed with the sound side first, they often decamped without irritation. When the limbs were irritated on the sound side, their motions were more sudden and lasting, as if that side were the more sensible.

Experiments with Gases

1. Chloroform. The experiments with the vapour of this substance were conducted in a large glass jar with closely fitting top, and the chloroform was either put on a piece of cloth or poured in loosely. The first effect observable was the active motion of the crab, clambering up the jar &c, and apparently in some cases with evident intent to escape the rag saturated with the liquid. (another argument for the presence of an organ of smell). In many of the experiments, the jar was entirely filled with the vapour, & would speedily have anæsthetised a mammal of almost any dimensions. After the chloroform took effect the animal sunk into a paralysed state, every limb hanging as if dead. Out of many expts. the following are selected. In almost every instance (in all narrated below) large sized crabs of both sexes were the subjects of the experiments.

In a jar thoroughly saturated with the vapour a crab was immersed for 1½ mts.; its motions had not ceased when it was removed. It ran about actively and hid itself at once in a dark corner. The chloroform had no effect. Another was kept in 2½ mts., when removed, cold affusion was applied, and it had slight twitchings; it then crawled about and like the former avoided the light. After 4 minutes immersion, with the usual scrambling &c, occasionally one would crawl; they were generally convulsed on pouring the cold water on them, and afterwards their limbs moved slowly & feebly; they recovered entirely after a time, however, as we shall see. Having one afternoon left my room door open, and there being on the floor several crabs supposed to be dead or dying, I got no small surprise when returning upstairs in the dark of the evening to hear a heavy body strike on the rail of the stair within an inch of my face which was spluttered with moisture, this was followed by a second and a third crash in the immediate neighbourhood, with a scrambling and crunching (as two had fallen together) which revealed the intruders. It was found afterwards that they belonged to the Chloroform series, (which were supposed dead or dying, (having been immersed respectively – 4 – 4½ and 6 mts.) but they had recovered entirely, and only one was the worse of the fall. The series of phenomena in this experiment (with) may be stated as follows– On first immersion the animal clambered and endeavoured to escape; foot jaws in active motion both large and small; limbs gradually grew weaker and respiration embarrassed; eyes often staring, or one retracted and one staring; attempts to clear branchial apertures. In 10 mts– no, or little, motion, and frequently though removed they did not recover. On being violently shaken at this time, there was slight motion of foot jaws, and terminal segments of the small limbs. Sometimes there were spasmodic twitchings about the 6th or 7th minute. If the chloroform jar was in proper condition they seldom recovered after the 10th or 12th mnt.

* This remarkable agent then has a precisely analogous effect on these animals to what we witness in man & the higher mammalia. Operations of any kind could be conducted on the crabs when anaesthetised, just as in man. Of all the vapours experimented with it had the pre-eminence, just as Corrosive Sublimate amongst the poisons. It will be observed too that the series of phenomena occurring on its application are almost exactly those we see in the mammals. We have first a period of stimulation, towards the end of this irregular motions sometimes of a spasmodic (convulsive) character, and then a state of anaesthesia becoming more & more intense till at last it merges without a sign into death.

though they might exhibit a twitch or two of the propodite in the smaller limbs after the cold affusion.*

2. Mineral Naptha. A jar similar to the former was used, and the liquid poured on the bottom, or on cloth there placed. Their movements at first resembled those in the last experiment, but they soon grew more violent; the animal evincing an intensity of action, its every limb being thrown about with convulsive effort. These motions lasted much longer than in the former case, those of the foot jaws especially attracting attention, as if the animal wished to clear the anterior branchial aperture from some irritating & offensive substance. It placed the animal in high nervous excitement of a spasmodic or convulsive character. If taken out in ½ an hour or so, and the cold douche applied, they slowly recovered. When they were kept longer, and especially if there were two together, they threw off many of their limbs, in some cases leaving only a single small limb. Their motions were very violent, but after such a catastrophe as last mentioned they were not so. There was generally little sign of life at the end of 1 hour.

3. Ammonia – With Ammonia there was only one experiment. A very large Carcinus mænas was immersed in a jar of NH_4O vapour, made by the evaporation

of the liquor am. fortissimus of the shops. For a time it did not move, and it seemed that the gas had a soothing effect, at least did not cause such pain as to irritate the animal into motion. In ¼ of an hour the crab moved about, but these and all the subsequent motions did not seem to be the result of so much inconvenience as in the foregoing case. It continued to move till it was taken out at the end of 1 hour, quite as lively as ever, & using its forceps with fierceness. A sudden and accidental fall put an end to this, and it lay motionless – stunned by an amount of injury which would have been a trifle under ordinary circumstances. It lay with its limbs contracted in a peculiar style for 2 or 3 hrs., but afterwards recovered entirely. This experiment shows some of the preliminary effects of NH_4O, and that sufficient time had not been given for the gas to develope its full effects.

4. Hydrosulphuric acid – This gas was made by enclosing in a perforated tin box some FeS and HO,SO_3; the addition of a little of the acid could thus always command a supply of the gas; once only was a filling tube used. Some of the general effects were these – The animal often avoided the generating apparatus. There was no violence of motion at any period of its immersion. Change of colour of the dermo-skeleton from the deposition of sulphur. As an example, the following case will show how little effect this gas has on this crustacean's

comfort, and indeed this is not to be so much wondered at, since the animal in its free rocky haunts is often enveloped in very stinking mud, and where HS forms a large proportion of the efferent gases.
A large male was thus placed in the gas, and its first motions were quiet (i.e. slight). On shaking the jar ¼ of an hour after, (as it was quiet), there followed – retraction of the eyes, the usual motions of the limbs, and elevation of the forceps. The external antennae moved upwards and downwards, and sometimes one eye would be retracted and again extruded, the other remaining still. No motion of the foot jaws. Occasionally there occurred slight clambering & movements of the terminal claws. It remained thus for 2½ dys – with only an occasional scramble. At this time there was bubbling at the branchial aperture; when shaken, tele feebly raised, but soon sank down again. Taken out in 3¼ dys, the jar still strongly scenting of HS; the limbs were moved slightly. There were still evident traces of vitality on 4th dy – although the crab never stirred from the spot.
The most striking feature in this experiment was the remarkable vitality of the crabs in so deadly a gas, which was kept in continual abundance too by the arrangement before mentioned. X

5. Hydrocyanic acid. Cyanide of potassium was placed in a perforated vessel & sulphuric acid poured in, and the jar soon filled with the HCy – On first

insertion, the animals immediately exhibited violent motion, with attempts to escape from the deadly vapour, and spasmodic twitchings of the limbs. After this, they generally remained quiet for a time. No motion of the foot jaws. In ¼ of an hour, when shaken, claws raised, but not fiercely; eyes still drawn in when a body approached them; they had no tendency in general to move much after this, though some when shaken at the ½ hr. made pretty active motions, which, however, did not last long. After the half hour motion slight – perhaps separation of the external foot jaws. They died on the average in about 1 hour & a ½, overcome by the fatally sedative action of the Hydrocyanic vapour.

6. Chlorine – produced by the action of Hydrochloric acid on the Binoxide of Manganese – in the same apparatus. The Crabs struggled violently at first, as from a sharp irritant. The motions of the foot jaws were slight at first, became a little more active, and then declined. Air bells were few, occurring only once or twice. The foot jaws often remained separate from each other, and apart from the body for a time, and the external antennae were swung round in a peculiar manner. During the first and second hours some movements of limbs and foot jaws, and when irritated they resented interference vigorously. It was astonishing to witness the time these animals could be immured in a jar, containing an amount of chlorine that would speedily have suffocated most other animals, without much impairment of function. The gas too must have been absorbed in large quantity by the fluids of the animal

and diffused through its respiratory system &c. It was generally 5 or 6 hrs. before life was extinct, at least before its external manifestation ceased. Motion throughout was not of a convulsive character.

7. Sulphurous acid. The jar was filled with this, the crab or crabs being inside, by burning S in a capsule. After the vapour began to get dense, active motions ensued, sometimes convulsive twitchings of the limbs. No striking appearance from ½ to 1 hr. except contractions of the limbs as if from pain, and sometimes active air bubbling and slight frothing. In 1½ hrs. scrambling movements, and considerable action of smaller foot jaws, with air bells; the larger foot jaws stuck out from body, and the external antennae were swung round. The foot jaws could be noticed to be increasing in action after this, thus showing return of function to the respiratory organs. On smelling the jar the SO_2 odour was quite gone, nothing but the saltish smell of the crabs remaining in some cases. The crabs recovered entirely from the apparently depressing action of the gas, as the stupor and langour of motion, (from 10 mts. to 20 mts. or thereabout) showed. The acid vapour was probably taken up by the fluids of the animal & producing a temporary effect afterwards negatived by the active play of the respiratory organs. The animals, however, after undergoing this trial, were much more easily injured by external violence or other gases than those not similarly circumstanced.

8. Phosphoric acid. Only one experiment was made with the vapour of this substance. Phosphorus was burned in a capsule placed in the jar beside the crab. After the usual clambering, the limbs became weaker and it sank into a quiet state, unless irritated. No action of the foot jaws, the animal feeling the irritation and closing its ~~foot~~ respiratory organs. In 1 hr. motions exhibiting pain and not very active. The dark surface of the crab rendered grey by a deposit of PO_5. In 2 hrs. bubbling at branchial aperture, but motions sluggish; 5 hrs. feeble action, when shaken, no movement of the foot jaws, and great tendency of the telæ to hang drooping. In 7 hrs. slight motion, drooping of telæ, and foot jaws in action with frothing. The jar had long lost smell of vapour, & the crab was removed. It was some time before it recovered itself entirely. In a day it crawled as actively as when inserted, its back white with the PO_5 whose acid action in a little HO at the bottom of the jar had also reddened the terminal joint of the limbs. It lived many days, and crawled about as if nothing had happened.

Exp^{ts} with Poisons &c.

I. Tartar Emetic – This substance was introduced in poisonous quantities by various means. of First, by raising a portion of shell over the cardiac region. In this, & in the experiments with $As\,O_3$, some observations were made on the heart. Every pulsation of the heart raised the detached portion of shell, which was carefully replaced over the wound after the introduction of the Tartar Emetic. Immediately after the operation the no of beats was 80 p. minute; in ½ an hr. afterwards 112. The animal moved little during this period but sharply resented irritation. It also emitted a large quantity of frothy matter from the branchial apertures. In 1 hour hearts action slightly increased (115); spontaneous motion slight, branchiae in action. After more than 2 hrs. hearts beat 109. In 6 hrs. it fell to 69. After the 2d hour the crab did not move except when irritated; the limbs got rigid and whole functions weak, and animal gradually sank. Eyes and antennae retained their irritability for a considerable time. Secondly, by making an aperture in the cephalo-thorax beneath the folded abdomen. The animals moved actively when freed, and then generally remained quiet for a time. Their motions soon became sluggish, and they had no tendency to move much. No frothing. In 1 hr. they resented interference actively, but did not crawl far. In 2 hrs. resented irritation, & branchiae often in action. In 6 hrs. when strongly irritated moved telae, but did not stir from spot; small limbs often stretched towards telae. After this they gradually

* The powdered Tartar Emetic was not strictly dry, as it was immediately soaked by the fluids of the crab. It must be remembered that an impervious (or nearly so) shell forms the covering of this animal, on removal of which we cannot expect to find a surface very amenable to absorption, if it exerts such at all for a time. This may even hold to a certain extent although we remove all the tegumentary structures, as was done in every, or nearly every, case. The foreign function at least then took some time to develope itself in these wounds, while the mucus canal set to work at once.

became weaker and weaker and perished often without moving. When Tartar Emetic was injected p. anum in solution and mechanical mixture in water, the crabs moved about as usual after being let loose; but not far. They then remained at rest. When irritated, struck with chelæ; eyes and antennæ active; no tendency to get to secret place. In ½ an hour struck actively when irritated; eyes and antennæ functionally perfect. In 1¼ hr. not much defence unless strongly disturbed. No motion beyond the slight heaving of the cephalo-thorax, when let alone. In 3 hrs. no spontaneous motion, & limbs feeble; eyes still retracted on being pulled out. At the 4th hour the eyes were seldom retracted, and the majority were lifeless, not even twitching of the internal antennæ.

Injection into a mucous canal was thus more speedily fatal than insertion of the dry * poison almost in contact with the heart in the one case, and in close proximity to the great Thoracic ganglion in the other. It would seem that absorption of the solution mixed with the powder was more rapidly perfected on the mucous surface (accustomed to such work) than the dry powder in the others.

II. Arsenious acid. A square portion of shell was removed from the dorsum, over the heart, as formerly, and a grain or two inserted. It moved about actively after the injury. Beats of heart 60, and in ½ an hour 76; but the organ did not seem to carry on its function regularly, as it frequently could not be seen beating at all. Branchiæ in action, but no frothy matter; resented irritation. Internal antennæ moved jerkingly. At the end of 1 hr. heart 79.

showing slight increase. The animal was very active at the end of 3 hrs. with its vigour scarcely diminished. On seeing so small an effect produced by such a dose of this deadly irritant, I made an aperture then in the cephalo-thorax beneath the abdomen, and inserted at least a grain more of the powder. It crawled about as before, and seemed little affected by the further direct application of the poison, when the shock of the fresh injury was taken into account. In 6 hrs. animal very lively and keen with forceps. It did not crawl much from the spot after the fourth hour, although, as before mentioned, it was not from want of power. In 7 hrs. pulsation 59; eyes, antennæ, and limbs, pretty active. There was no frothing - but only an occasional gurgle from the branchial aperture. After this, it gradually sank and died.

When the AsI_3 was injected p. anum the following effects ensued. The animals were immediately tetanically convulsed, and often consciousness seemed lost, as they crunched at the anterior part of the shell or anything that came in their way with their chelæ. Limbs were often relaxed for a time. External antennæ were swung in a peculiar manner, eyes pretty active, and so with internal antennæ. Foot jaws sluggishly moved. In 4 hours vitality in some cases in internal antennæ and eyes, though the crab did not move from its position. No attempt to defend itself in any case at this time; only slight twitchings on irritation.

This poison as applied to wounds, generally thought so deadly a practice, was very long comparatively in producing its effects. The former substance was more speedily fatal by this method, although it was about equally fatal by injection. To see a crab running about almost unhurt after the manipulations narrated in the first experiment was most astonishing, and this was but one case out of many. Wherever the wound was made & the poison inserted, invariably the crabs, labelled accordingly, were found amongst the list of effectives, after numbers of their neighbours had sunk by other poisons. The wonder of the experiment when the poison was applied to the vicinity of the heart is somewhat diminished - when we recollect that the crab can live for a pretty long time without a heart at all, as several trials showed.

3. Bichloride of Mercury. A grain or less was placed in general in the wounds, either in the cephalo-thorax, beneath the abdomen, or otherwise. Sometimes they crawled about after the operation, but seemed labouring under some severe injury. Often the forceps were moved irregularly towards the cephalo-thorax, indicative of pain. Eyes and antennae moved actively for a time. After the first attempt to escape the limbs gradually became numb and answered their summons to action tardily; this was well seen in the smaller limbs as they assumed abnormal positions in their efforts to progress. From its proximity to the Thoracic Ganglion, its action might be more speedily fatal in some instances, but its insertion at other points proved that the seat of its application mattered little.

The injection, in the usual manner, of a pretty strong solution of the $HgCl$, further corroborated its destructive influence on those animals. For a few seconds the limbs were most violently contorted & convulsed, and the animal raised high on them, then it generally sunk into repose, and in 4 mts. little life was exhibited, & soon none. The eyes, internal & external antennæ soon lost all traces of vitality.

As an agent of destruction to these animals, Corrosive Sublimate far exceeded either of the former substances, killing, as it did, the crabs in a few minutes (10 to 15), when inserted in a wound, while the others took many hours. By injection too it far surpassed them in activity, proving fatal in about 4 mts. while the others took 4 hrs.

4. Muriate of Morphia. This was introduced by the usual incision on the under surface of the cephalo-thorax. It moved actively at first, then rested & moved alternately. No action of the foot jaws. One of the two expts., performed with this substance inserted into wounds (tho) was remarkable in that the crab threw off one of its legs, a rare occurrence. The limbs responded to irritation in 1 hr. not moving much if in a quiet position. In 3 hrs. crawled feebly & slight action of branchiæ. Did not move much after 5th hour. Lived 8 hrs.. When Mo HCl was injected, after the first scramble the limbs became weak & refused to carry it. Eyes and and antennæ sluggish. It lived 2 hrs. A comparatively large quantity of morphia was used in each experiment, but its effect was not striking.

5. Cyanide of Potassium. 7 or 8 m of a saturated solution of the KCy, & often a grain or more of the solid, were placed in the wound. The animals moved actively at first, then some remained at rest for a time, often with forceps elevated as

if in readiness for an attack. In an hour they resented injury rather slowly, and small limbs weak & trailing. They had often a tendency to keep one position, perhaps remaining with ~~one~~ a tela elevated. They did not move much from one site after 1¼ hrs. or so, & soon were unable to crawl, & all their organs feeble. They sank on an average in 2 hrs. or so.

14 or 15 ♏ in a little HO formed the usual injection, the former strong solution being used. At first they ran about, though in a short time they came to rest very easily. Eyes not very active. In 8 mts. after, motion perfect on irritation, and the crabs were very savage. In ½ an hour crawling languidly when irritated, & only for a short distance. In 1 hr. when strongly irritated, moved telae with reluctance, limbs feeble and motions dull. No gurgling or action of foot jaws. In 2½ hrs. slight trace of vitality in some cases in eyes and external antennae, but internal antennae still sensitive. Animals soon sank.

It was curious to observe the length of time this poison took to kill the crabs, considering too its extreme deadliness. When injected onto a mucus surface its action did not seem to be increased in quickness. It also was much slower than the $HgCl$ in producing its effects.

6. Oxalic acid - in crystals was inserted into the wounds. The crabs seemed entirely unaffected and crawled swiftly about as usual. Sometimes, however, they manifested a tendency to rest at any convenient place, if undisturbed. Generally smart bubbling at the branchial apertures. After many hours 8 or 9 they were still active and defended themselves accordingly.

Some lived for a day others longer, and some even seemed to recover, & scrambled off to secret corners where they were found months after, mummied, and labelled. It seemed to have only a slight dulling effect on the animals, at first, & its further action was somewhat uncertain.

7. Nux Vomica & Strychnine. Nux vomica was pushed into the wounds, when the animals crawled sharply and showed pain by biting at the injured part; and ~~showed~~ tendency to rest if undisturbed. Defended themselves most actively on irritation. In 3 hrs. resented interference strongly, but did not crawl far; slight bubbling, but no frothing. Sometimes a peculiar raising of the cephalo-thorax on the tips of the legs was observed. In 7 hrs. could crawl, and defend ~~itself~~ themselves when irritated, but spontaneous motion was seldom apparent otherwise. No motion of the foot jaws or gurgling. Traces of life in 10 hrs. in most cases, but they soon sank after this.

Strychnine made into a mixture with water was injected in the usual manner. At first, the animals made violent efforts with spasmodic contractions of the limbs. The bubbling at the branchial apertures often commenced immediately, & continued. After these first violent efforts, the animals generally remained quiet, perhaps with their (small) limbs sticking in the air. In ¼ of an hour, gurgling, but no spontaneous motion, and that even when irritated slight. Eyes generally feebly irritable, external and internal antennae in a similar condition. In 1 hour all retained traces of vitality, some even crawled. Limbs often spasmodically stretched, and in a few—frothing. Eyes retracted in some; not so in others. Limbs twitched, & they sank soon. The tetanic spasms, usually the result of poisonous doses of the foregoing substances, were by no means conspicuous in crabs at least. Twitchings there certainly were, but they were observed frequently before. It was somewhat more fatal than Tartar Emetic & Arsenious acid (that is, the 1st injections).

8. Benzoic acid— When the wounds were filled with this substance, very little marked effect ensued. The animals continued active, and crawled about; air bubbling. It seemed to be a very inert substance in its action on crabs, as they would have lived as ~~long~~ short a time with the wound only, as with the wound and the BzO.

9. Iodine— This was inserted in scales into the wounds. The animals continued active; frothing at branchial apertures. In 2½ hrs. not much affected. In 6½ hrs. slightly sluggish, and rested anywhere, instead of running into a dark corner. After this, they seldom changed position. Next day—plenty of vitality in eyes and antennae. Some crabs were subject to a sort of tetanic contraction of the smaller limbs with a stretching of the telae. It proved fatal in abt 2 dys. Action therefore slow. A considerable no. of scales were inserted into the wounds.

10. Acetate of Lead – This substance though inserted into the wounds in quantities varying from 1 to 3 or 4 grains or more produced no marked effect, the animals moving vigorously & defending themselves as in ordinary circumstances. The crabs labelled $PbO\bar{A}$ &c were the pests of the room for days, and many met a mummy's fate – wedged in some dark nook. From the salt water in the animal, part of the Acetate may have been changed into the Chloride, but whether this had any influence on the result or not I do not know; it would rather appear not from the following expts. as salt water must certainly have been more plentiful in the intestines of the animal than in its other tissues.

Far different results ensued when the $PbO\bar{A}$ was injected on its mucous surface. The limbs were strongly contracted, and there was no attempt to crawl. There was slight or no gurgling, and the animals sank rapidly, so that in ½ an hour there was only a trace of vitality in the eyes and internal antennae, and none in the limbs.

This experiment was remarkable for the wide difference between the results in the two modes of application. By the latter method it was most deadly, while by the former it was often inert.

11. Camphor. The solid was used for insertion into the wounds, which were made in the usual manner. A marked effect at once seemed to follow this. Motion was sometimes much impaired. Often, after a time, the crabs showed little tendency to move from the spot, although they defended themselves vigorously. The smaller limbs in a few seemed most affected. Gurgling often very slight.

The limbs often appeared more irritable than usual especially the smaller. One crab while striking at the boot, shortly after the operation, threw off the terminal segment of the great tela, an occurrence which was not witnessed before, although the crab might be under the influence of poisons more speedily fatal. In 3hrs. the smaller limbs moved slightly on strong irritation, but the tela could not be used with any power in most cases. Eyes and antennae also weak. They perished speedily after this.

When a solution of Camphor in alcohol was injected p. anum, the operation in all cases proved speedily fatal. The animal was immediately and violently contorted, & frequently some crabs bit the opposite tela. In 3 or 4 minutes the eyes got dull & motionless, and the internal antennae were extruded most significantly. Motion of the limbs on irritation scarcely perceptible. The large foot jaws were generally protruded in a peculiar manner, not laterally, but pushed from the cephalo-thorax in front of the maxillae ½ an inch or more, and permanently so after death, which ensued immediately.

Camphor then proved a virulent poison to these animals, and without exception. The presence of the al in the injections must also be taken into account, though the crab died much more speedily than by the injection of Al alone. On injection too, the camphor must have been precipitated from its solution in al by the water contained in the intestinal canal of the crabs, and applied to their mucous surface in the solid form, as in the case of the wounds.

12. Alcohol. (Methylated) - Many experiments were conducted with this substance introduced by injection into these animals. Its effects were well marked, and, for its most part ~~generally~~, were the following. The animals were generally spasmodically convulsed, and reeled about; sometimes throwing off a limb or two, more especially if irritated. The motions were desperate, and the crunching of the forceps was a common accompaniment; ~~or~~ in some, they were stiffly stretched out. Frothing at branchial apertures frequently great. Eyes and antennæ pretty active. In 6 or 8 mts. the crabs sometimes recovered partially, and were able to crawl about. They often assumed a defensive attitude & struck with the forceps where no enemy was near. In ¾ of an hour, when irritated, moved tele and cephalo-thorax, but seldom stirred from the spot. Posterior limbs seemed weakest, and all often contracted. In 1 hr. Eyes active, considerable frothing, but motion of limbs slight. After this, the effects of the al seemed to be mitigated, and though pernicious were rather long in producing death. Care must be taken in these experiments not to confound true & successful injection with injection and extravasation, which latter accident swept off its victims in a minute or two, with desperate convulsions. Some showed a peculiar tendency to turn on their backs, as was witnessed when the communicating cords of the ganglia were cut, though scarcely so well marked in this instance. The crabs did not move far from their position after the 2d hour, and if they did not live so long, it is probable that extravasation accelerated their fate, unless the dose was too large. 8, 9, or more, hours after, eyes feebly responded to irritation, slight motion of limbs with waving

of the posterior pair. Some lived a few hours and a small no. even to the 2d day after this, but the greater majority perished in 12hrs.

The alcohol then seemed to act as a powerful stimulant and irritant at first, throwing the crab into the most violent convulsions and tetanic spasms, and apparently seemed to be about to finish it at once. This was followed, however, in general, by a partial recovery, and then a subsidence into a state of quiltude, the animal remaining for the rest of its hours as if under a depressing agency. The violence of the motions, when extravasation occurred, may be easily accounted for by the anatomy of the parts, the smallest escape of this baneful substance being applied directly to the great Thoracic ganglion. It is curious too, that some crabs, often powerful ones, with the same quantity of al that produced the foregoing results perhaps in a weaker, died very speedily after the first convulsions.

13. Turpentine. After the injection of this, the animals frequently rushed about wildly for a second or two or more, as if unhurt & fierce, and then remained motionless. Opposite & forceps were bitten, with wriggling, and occasional upheaving of the cephalo-thorax. Sometimes the legs were drawn in in a spasmodic manner & knuckled underneath, cephalo-thor. resting on telso, and inversion sometimes supervening with desperate motions of the limbs; or it stood on the tripod of the forceps and rostrum, with the small limbs sticking out in all directions. Sometimes motions of the foot jaws, and often gurgling at the branchial apertures. Eyes and

antennæ pretty active. In 10 mts. vermicular motions of limbs, and often peculiar positions. When turned on their dorsum a few showed spasmodic contractions of the limbs. In 20 minutes little or no motion in most; the parts most sensitive being the eyes. Some showed little or no sign of life after this, others – with gurgling at the branchial apertures – got a little more active, though they also soon sank. The latter condition* was rarest. After the animal was incapable of moving, to slight irritation by striking smartly on the dorsal aspect the eyes could be made to move about wildly in some instances.

* gurgling &c

Turpentine then seemed irritant and depressant (since the crabs after running a short distance almost always came suddenly to a dead stop); in the first case, then, if the dose was sufficient, the latter predominated and the animals sank speedily.

14. Mineral Naptha. – This was introduced in two ways; first by snipping the mandibles on both sides – it was sent into the stomach by means of a glass pipette. Immediately the crabs ran actively about and seemed little affected. Gradually, however, they came to rest, and in about ¼ of an hour, peculiar spasmodic motions of the limbs ensued; progression was in most cases impossible. In ½ an hour, though strongly irritated, only slight motion was exhibited. No action of foot jaws from the beginning. Death soon resulted. Secondly – by the usual method of injection – The animals drew up limbs spasmodically, and they remained so for a few minutes and then relaxed

and began to crawl with considerable alacrity. In ¼ of an hour swinging of posterior limbs, and little attempt at progression, seemingly from want of power. ¾ of an hr. little sign of life, small limbs especially powerless. Eyes and antennæ only faint traces of vitality. Very slight motion of the large foot jaws towards the end, in some cases. Life ceased to be manifested in about an hr.

By either method, Mineral Naptha thus seemed equally destructive. The vapour of this substance killed in about 1 hr. too, so that this would appear to be the pretty exact time in which this substance proves fatal to crabs. Pain was apparent in no small degree in almost all the experiments, whether as vapour or liquid. When a drop or two was let fall in a box containing a number of young animals, there was an immediate scramble to escape from this especial object of detestation and dread.

15. Collodion–, when poured on maxillæ and into mouth, had a very perceptible effect. The animals sometimes rushed about for a short time, and then rested, or else they began tumbling on their backs at once. Contractions and waving of the limbs occurred frequently; bubbling at branchial apertures not often. Sometimes the limbs were shaken curiously. If the animal was not very powerful and got a good dose, it seldom moved much from the spot, but lay as if under some severe shock, evincing life only by the occasional twitchings of the limbs. Some died in 2 or 3 hrs., but some lived much longer, and seemed to recover, if powerful, from the first destructive effect

of this compound substance. The ether probably had most effect here, and some of the motions of the animals seemed akin to those in which Al was given.

Collodion, when injected, had the following effects. The crabs were instantly affected, the limbs being contracted, and sometimes moved around and around. Eyes and antennae active. After a while it crawled about not much worse ~~like~~ in some cases. Bubbling at branchial apertures. Twitching of terminal segments of the smaller limbs. Frothing often continued active for a long time. The animals rarely died in 4 hrs, most living for a day or two, though perhaps they did not move far from the spot. The gurgling and frothing on the 2d day often told of the animal's recovery, at least to a certain extent. Some became motionless, and their limbs when they were lifted from the ground hung powerless. They often recovered after this, and lived their day or two longer.

Collodion seemed irritant at first, then had some peculiar effect on the motions of the limbs, and lastly, proved in most cases a slow poison. It was decomposed into ether, and flakes of what was gun cotton, on injection, by the HO in the intestinal canal.

16. Colchicum.- (Acetous extract)- This was introduced into wounds in two specimens. The crabs, though seemingly not much affected, did not crawl far, and even when irritated did not move many inches from the original spot. There was bubbling at branchial apertures. ~~in some~~ In two hours, the eyes on irritation moved out and in

smartly, and motion in the external and internal antennae. No action of the foot jaws. They were unable to move from spot, at least no attempt to do so. At 4 hrs. on irritation, only traces of vitality and one soon died; the other lived a little longer. Colchicum was thus pretty active in its effects.

17.—Atropine.— Atropia was injected in the usual manner into three crabs. One ran about as if nothing had happened—and was exceedingly fierce in using his forceps, striking at any approaching object with great alacrity. The eyes and both antennae active, even more than usually so. Another was convulsed at first, but by and by recovered and used his forceps also actively, but did not move far from spot; eyes and antennae active. The third, with the latter parts in similar activity, did not move far either, but crawled more than the former. In 1 hr. first—active still, and moving about in all directions; the 2d—not so active, but still also very vigorous; 3d somewhat similar. The two latter were obviously dull, with no tendency to crawl unless irritated. In all there was bubbling and frothing at the branchial apertures, and this continued with intermissions. They all continued active for many hours. In 16 hrs. two dead, and the other (first—above) very feeble, with most motion in eyes and antennae. It too soon followed the others.

It should have been mentioned above that Atropia was used in the form of a solution in water, and also mechanically mixed to increase its strength. Its action as a poison to crabs did not seem (from these 3 expts at least) to be very virulent. A stronger solution in other medium than HO might have different results, although from the mechanical mixture the strength of the liquid was much increased.

18. Cannabis indica.—(Acetous Extract)—. This was placed in the usual wounds, generally on the under part of the cephalo-thorax. The animals manifested no spasmodic action. The motions did not seem to be materially weakened, and they crawled about, but were not difficult to stop, when they remained quiet for a time. Eyes and antennae active, no, or slight, gurgling at branchial apertures, nor was there motion in foot jaws, which remained in situ. In 1 hour active as before, and in most gurgling had commenced. They continued in a similar state for many hours, with only a slight dulling visible. The wound must be taken into account itself, of course. Some lived 16 hrs. others about 2 dys. When turned on their backs some were liable to spasmodic actions of the small limbs. It was observed in all the different expts that females were more liable to this than males, some assuming the contracted state without irritation or injury. This substance, though slow, proved an agent of destruction to these animals. There were no spasms until near the end of the animal's life, and at this time they would probably have occurred independently of any such administration.

19. **Stramonium.** (Acet. Extract) This was pushed into the wounds of two crabs, (male and female). There appeared no visible effect at first, as the animals moved about as before, though as usual they rested more easily. Their action became duller; and they had not much inclination to move. No gurgling or frothing. Eyes and antennae became dull, the internal protruding characteristically. Two males were then similarly treated, and the combined effects were as follows: In only one of the crabs, and which was gurgling before the operation, did gurgling continue. Six hours after, animals were sluggish + little able to move, and the foot jaws were much more irritable than either the eyes or antennae. No movement at branchiae. Two died in 5 hrs. one in 8 hrs. and one retained a trace of vitality next day. (12 hrs after). It was a female. This poison then was moderately active, so far as can be judged from 4 expts., and produced mainly a sluggishness when applied to the crabs as above. No pain seemed to be caused by the Stramonium.

20. **Digitaline.** in solution + mixture in HO was injected as usual. The limbs were immediately contracted and doubled up. Frothing began and became intense; eyes and antennae dull. The animals seemed in great pain; some moved scarcely from the spot, and held that peculiar position with the forceps knuckled in and supporting the elevated cephalo-thorax, Frothing was generally great; others crawling a little, but easily

arrested, their limbs being weak and unfit for steady progression. In ½ an hour no attempt at motion, the animals in general remaining without sign of life except occasional swinging of the foot jaws. Frothing had ceased before this. The animals soon sank, and all died within the hour. This poison, when so injected, was thus very speedily fatal; its action probably accelerated by its ready solubility to a great extent in water. A striking feature, in most cases, was the frothing from the anterior branchial openings.

In the foregoing experiments, injection, as above described, was preferred to the method of introducing the substance by the mouth, both from the greater celerity of operating – and the greater safety to delicate instruments so employed). The subject or subjects of this Thesis are of such vast dimensions that they may be considered to be only touched on here, and so far from being exhausted – are capable of immense extension. As before mentioned, our very brief period of observation was the result of as brief time, and return to winter duties put an end to such engaging work for a season.

W C McIntosh
St. Andrews

— Description of Drawings. —

I. View of the Cephalic Ganglion and its branches from a dorsal dissection. The optic and 4th nerves being the most conspicuous branches — along with the great connecting cords of the ganglia. Tracing these latter backwards as they encircle the dark tinted oesophagus, we see the gangliform enlargement and pneumogastric branch; and a good way behind the gullet is the commisural cord of the connecting trunks, which are soon lost in undissected tissues. We cannot omit to mention the beautiful heart, so well worthy of minute observation, as it lies between the branchiae further back. The specimen had been in spirit for some time, which accounts for the wrinkling and notching in these latter organs.

II. — The Thoracic Ganglion with its lateral branches to the limbs, — its anterior to the foot jaws &c, and the communicating cords, — its posterior to the abdomen, its filaments to the various parts of that region being better seen with the help of the hooks. It may be noticed that the internal antennae are here in their ordinary position, when at rest.

III. Microscopic view in the Cephalic Gang. of a recently killed specimen. Fibres — cells in various forms — pigment &c. all speak for themselves.

IV. Drawing from the Cephalic g. of a crab which had been dead a day or 2. The dark focussed crystals of margarin(?) contrast strikingly with the translucent cells and fibres.

V. View in the same ganglion where by careful dissection in a fitting specimen the ending of the nerve fibres had been attempted to be traced.

VI. The pneumogastric branch magnified, the arrangement of the fibres is shown, but no nerve cells are visible in this view.

VII. The eyes, external and internal antennae in their usual position, the eyes being retracted, as seen by their relation to the peduncles. This dissection is easily made by raising off the dorsal plate and its pointed projection from the notch and surfaces.

VIII. The external shell of the compound eye, with its dark coloured cornea, circlet of hairs, and beautiful curves. Perhaps the corneal margin should approach the apex a very little more. The eye is enlarged.

IX. Hairs from circlet of eye, very characteristic of their general appearance. See descrip. of hairs. page 8.

X. Beautiful hexagonal divisions of the cornea, freed from all pigment.

XI. Terminal antennulae of the Internal Ant. magnified, the delicate hair tipped ends, and the stronger bristles of the larger with their peculiar setting are shown.

XII. The entire apparatus of the Internal antenna shown; the lighter tinted pyramidal portion at the root of the two large segments being the mobile & elastic joint. It is viewed on its ventral surface.

XIII. Section and dissection of the contents of the basal organ of the Int. Antenna. It is principally for the peculiar cartilaginous sac that the interior is here shown.

It is in the same position as in the last specimen, or nearly so, and the elliptical depression sloping to the central fissure is also exhibited. This is the supposed organ of smell.

XIV. Cellular structure of the cartilaginous sac enclosed within the basal part of the internal antenna. The whole sac is seen in – XIII.

XV. Sort of semi-diagramatic view of the commisural band of the connecting trunks of the Cephalic & Thoracic ganglia. The varied arrangement of its fibres is shown.

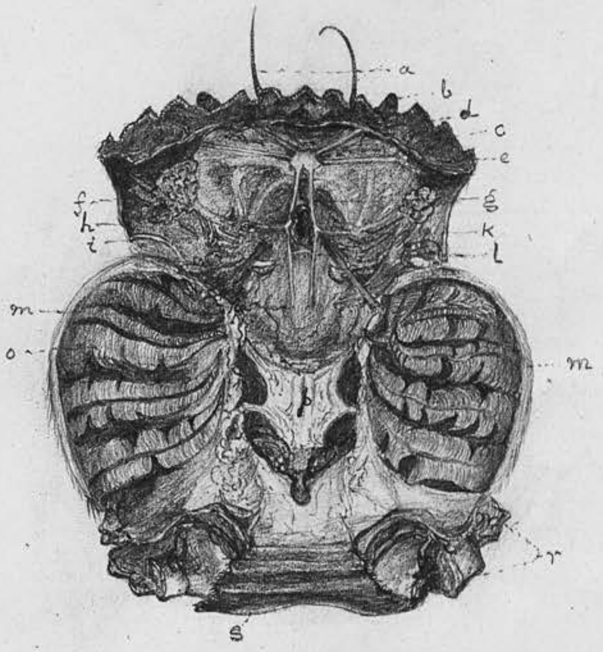
XVI. The cap and bifid stalk of the Auditory apparatus. This is prepared by dissecting off the muscles &c from the lid and rod when a structure of this appearance is obtained, bearing a striking resemblance to the human stapes.

XVII. Large transparent crystals seen in examining a the nerves of a specimen kept for months in methylated al. They resembled crystals of cholesterin. Traces of the margaric form were also visible. The spirit was somewhat weak. It is probable that they did not come from the interior of the pressed mass.

HCll

Drawing
I

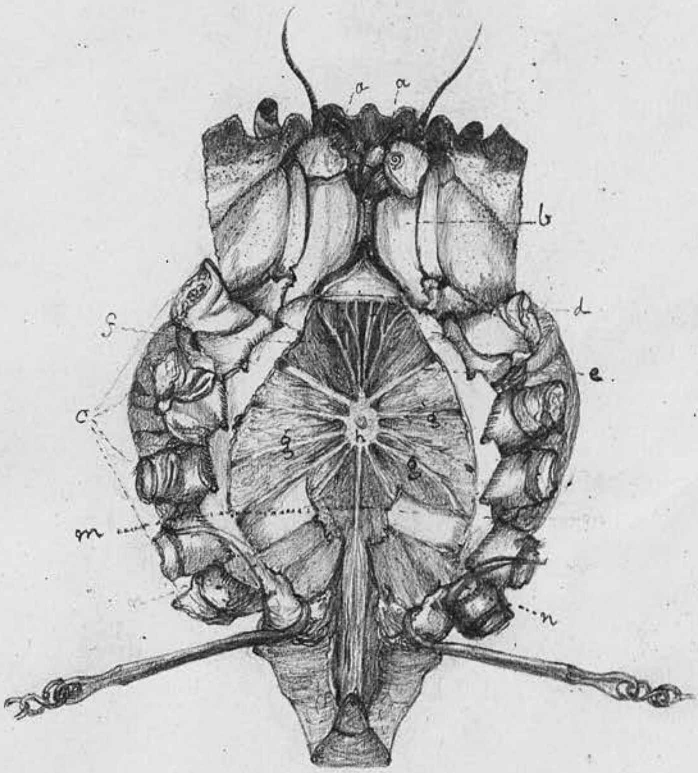
Pl. I. fig. 1.



View of the Cephalic Ganglion and Branches from a dorsal dissection

Drawing
II

Pl. IV. fig. 3.

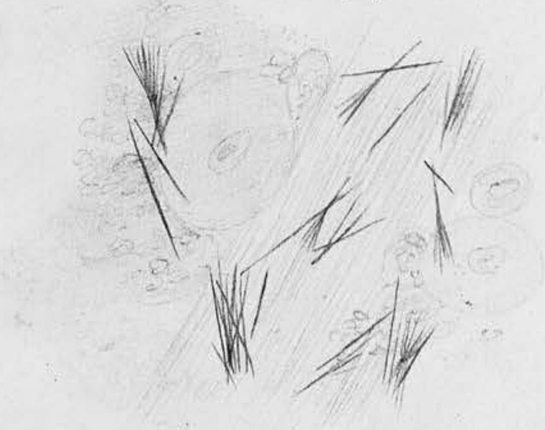


View of the Thoracic Ganglion from the ventral surface

Drawings
III. IV. V. & VI.

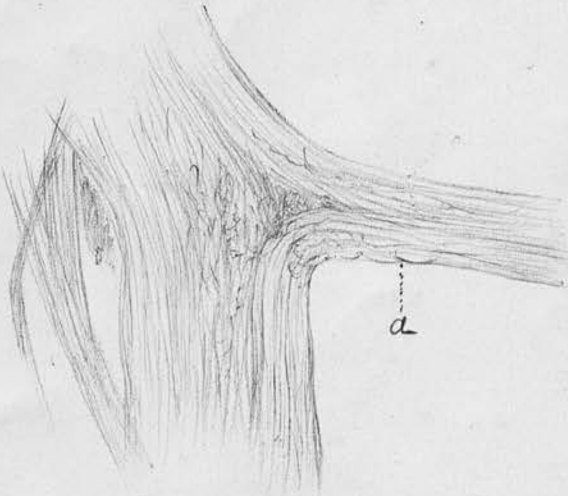
III.
Pl. II. fig 1.

IV
Pl. II. fig. 3.



V.
Pl: II fig. 2.

VI.
Pl. II. fig. 4.

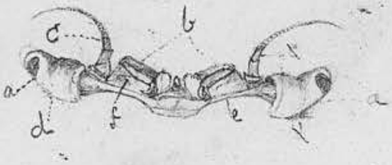


Drawings.

VII. VIII. IX. & X.

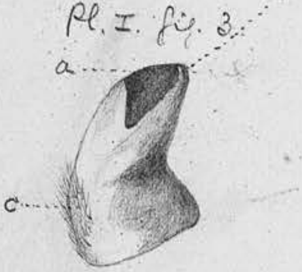
VII

Pl. I. fig. 2.



VIII.

Pl. I. fig. 3.

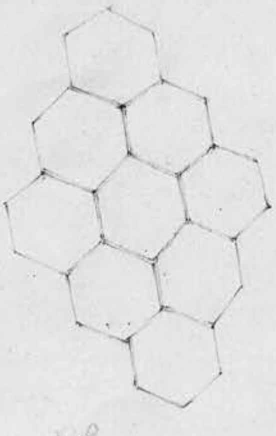


IX

Pl. III. fig. 1.

X.

Pl. I. fig. 4.

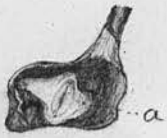


Drawings
XI . XII . & XIII .

XI
Pl. III. fig. 4.

XII
Pl. III. fig. 2.

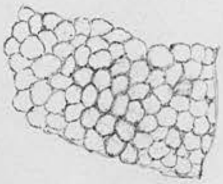
XIII.
Pl. III. fig. 3.



Drawings
XIV. XV. XVI. & XVII

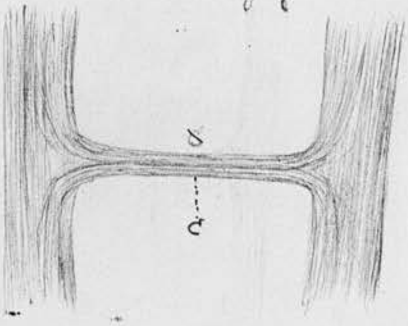
XIV

pl. III. fig. 5



XV.

pl. IV. fig. 2.



XVI

pl. III. fig. 6.

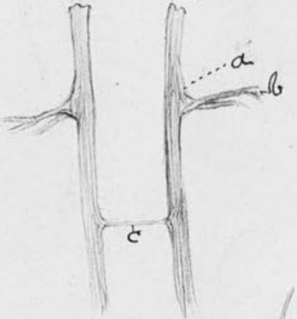
XVII

Pl. II. fig. 5.

seen laterally

Pl. I. fig. 5.

Pl. IV. fig. 1.



Pl. IV. fig. 4.

Pl. IV. fig. 5.

Pl. IV. fig. 6