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On the Organs of Locomotion in the different Classes of Animals

By

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On Locomotion in the different Classes of Animals

Sunt vero alia animalia gradiendo,
alia serpendo, ad pastum accedunt,
alia volando, alia nando.

Cicero, De Nat. Deor.

The progressive movements of animals, and the organs by which these are performed form an interesting subject of inquiry. During some period of life every animal is capable of locomotion. The continued existence of the individual and species alike render this necessary. Some animals move about freely in the larva state, but become fixed, like plants, on reaching maturity; while others, again, are fixed in the early stage of their existence and become afterwards endowed with powers of locomotion.

To produce locomotion fulcra furnished by external objects, and power in the animal of exciting movements in certain of its textures are required. In some animals appendages to the body, formed of a series of jointed levers, devoted to locomotory purposes, exist;

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in others progression is performed by the alternate contraction and dilatation of fibrous, or some other texture; and a third class of animals is propelled through water by the vibrations of little filaments called cilia. Besides these there are other modes of locomotion in animals which will be afterwards referred to.

Muscles. In many animals muscular fibre by its contraction furnishes the means of progression. From the direction into which the muscles of locomotion move the levers where they are inserted the muscles are divided into adductors, abductors and rotators, flexors, and extensors. When another, or an additional function has to be performed by a limb, the forms, and actions of its muscles are modified accordingly. These variations will be noticed hereafter. The Adductor muscles move the limbs towards the mesial line of the trunk of the body. The Abductor and Rotator muscles of the extremities make the limb perform a movement outwards and around a part of an imaginary cone of which the apex is formed by the joint at its proximal end. ~~of the limb~~. Flexors and Extensors are in their actions antagonistic

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to each other. The former set of muscles bend one of the levers of the extremity upon another, or the whole limb upon the trunk; the extensors bring these back to their former position.

Joints. The bones of the extremities in the Vertebrata are articulated to each other in two ways chiefly. The first of these is the ball and socket joint in which the head of the bone is globular and received into a socket in another bone, where it is retained by ligaments and muscles. This form of articulation admits of great freedom of motion.

The second kind of articulation is that commonly termed the ginglymoid or hinge joint. It only admits of the movements of extension and flexion.

The articulating surfaces of the bones are held together by ligaments and synovial membranes. The form and position of the ligaments vary in different joints. Frequently the ends of the bones are connected by a tubular investing ligament called the Capsular Membrane.

Throughout sacs, Synovial membranes are present in every moveable joint

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cilia. The little processes called cilia are the only organs of locomotion in some of the inferior animals. By the vibration of these the animal is propelled through the water. The cause of ciliary motion is unknown. It does not appear to depend upon nervous influence nor muscular contraction. The movements of these filaments are diminished by cold and increased by heat.

Organs of Locomotion in the Vertebrata.

The vertebrate skeleton may be considered as composed of a series of double rings which being placed end to end form two canals, The ~~most~~ superior of these enclose the nervous system, and the ~~most~~ inferior the organs of circulation, respiration, digestion, and generation. The upper canal is the only part constantly present. The ribs by their union with the sternum in front form the middle portion of the lower series of rings; the bones of the face -as the superior and inferior maxillary bones the anterior, and the haemolysis of the caudal vertebrae the posterior portion of the same series. In serpents and fishes the ribs

do

do not meet in front; and in the frog they do not exist at all.

Besides the vertebral column, in most animals of this subkingdom there exist the bones of two pairs of extremities, or organs of progression. Oken, in his profound and curious book Naturphilosophie, was the first if I mistake not, who promulgated the theory that the limbs or rather their bony framework, are liberated ribs

The bones and muscles of both extremities closely resemble each other. Both pairs of members consist of four parts. In some cases however, these are reduced to a rudimentary state. The divisions of the anterior member are the shoulder, arm, forearm and hand. In quadrupeds this member is termed the foreleg.

The parts of the hinder extremity are the haunch, thigh, leg and foot. The subjoined list shows the corresponding bones of both extremities in man and the higher mammalia:

Anterior Extremity	Posterior Extremity
Shoulder. Scapula	Haunch. Os innominatum
Clavicle	

Anterior Extremity	Posterior Extremity
Arm. Humerus	Thigh. Femur.
Forearm. Radius	Leg. Tibia
Ulna	Fibula.
Hand. Scaphoid, Semilunar, Cuneiform. Trapezium. Trapezoid. Os magnum Unaform.	Foot. Os Calcis. Astragalus Scaphoid. Ossa Cuneiformia
Metacarpus. Ossa quinque. Phalanges.	Metatarsus. Ossa quinque Phalanges.

The following table shows the corresponding Muscles of each pair of extremities.

Anterior Extremity	Posterior Extremity
Rotators & Abductors. Deltoid.	Glutei. Gemelli. Quadratus femoris. Pyriformis.
Trapezius. Latissimus Dorsi Teres. Major et Minor.	
Adductors	Adductors.
Pectorales major. Minor.	Adductores. Magnus longus & brevis. Pectineus. Gracilis. Sartorius
Extensors. Triceps Cubiti	Quadriceps femoris.
Extensor digit.	Extensor digitorum pedis
Extensor pollicis manus.	E. pollicis pedis
&c &c &c	&c &c &c
Flexors. Coraco Brachialis. Biceps. Flexor Cubiti.	Biceps cruris. Semitendinosus Semi Membranosus.

Anterior Extremity
Flexors. F. digitor. sublim.
F. —— profundus
&c &c &c

Posterior Extremity
Flexors. F. d. pedis longus
F. d. pedis brevis
&c &c &c

Supinators
Supinator longus
brevis
Pronators. P. radii teres.
P. quadratus.

1. Locomotive organs of Man. In Man the pectoral members are adapted for organs of prehension, and consequently he moves on the inferior limbs alone,

The shoulder is formed of the scapula and clavicle

The scapula is placed parallel to the spinal column, and its cavity for articulating with the humerus is situated at its upper and external angle. This glenoid cavity forms a shallow depression, surrounded by a cartilaginous ring. The scapula is provided with three processes for the attachment of muscles, the spine, coracoid process, and the acromion

The clavicle connects the acromion with the upper bone of the sternum. It forms the only means of attachment between the bones of the superior extremity and the rest of the skeleton. This bones affords attachment to portions of the great pectoral and deltoid muscles - the former of which draws the arm forward to the front of the body; the latter serves to raise and abduct it.

From the posterior surface of the scapula arise the muscles that abduct and rotate* the arm, and extend the forearm†.

As the glenoid cavity of this bone is shallow the humerus admits of great variety of movement. The globular head of this bone is retained in the cavity by a ligamentous capsule. The head of the bone is distinguished by a small circular groove called the neck. Near it are two tuberosities, of which that one which is posterior is the larger. On each side of the inferior extremity of the bone are two projections, termed respectively the external and internal condyles. Between these are a surface

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* Deltoid, Latissimus Dorsi &c &c

† Triceps Extensor Cubiti.

for articulating with the cavity in the head of the radius, and a trochlear surface for the ulna.

The ulna has a cavity, called from its resemblance to the Greek letter Σ, the Sigmoid cavity; which moves upon the pulley, at the lower end of the humerus. The small projection in front of this hollow is called the Coronoid process; the large projection behind the Olecranon. The latter is received into a deep depression at the posterior aspect of the lower end of the humerus. This form of articulation admits only of simple extension and flexion. The forearm is extended by the Triceps Extensor Cubiti, which rises from the Scapula & humerus, and is inserted into the olecranon process; and flexed by the Biceps and Brachialis anticus. The former is inserted into the radius.

The radius in addition to its movement along with the ulna is capable of rotating upon its axis, and bringing the hand along with it. Its head is cupped shaped and fits to the eminence on the humerus. When this bone becomes the internal border of the forearm, and the palm of the hand is turned downwards, the movement

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is termed pronation; when it forms the outer border, and the palm is turned upwards the movement is called supination. Pronation is produced by the Pronator radii teres, and P. quadradus; Supination by Supinator radii longus and S. brevis.

The radius is enlarged at its lower extremity for the attachment of the carpus. Hence in rotation the hand is carried along with it. The muscles by which the movements of the hand are produced have their origin from the condyles of the humerus, and from the radius and ulna. The extensor muscles arise from the outer condyle, and the posterior surfaces of these bones.

The hand consists of three parts, the carpus, metacarpus, and phalanges. The bones of the carpus are eight in number, and are disposed in two rows with four bones in each.

The bones of the metacarpus follow. In Man there are five, one for each finger. The metacarpal bone of the thumb is not on the same plane, nor parallel with the others.

The phalanges are fourteen in number; the thumb has two, the other fingers have each three.

In addition to the muscles which arise from from the condyles of the humerus, and the bones of the forearm, the hand is furnished with a number of other smaller muscles. The thumb in particular is provided with a series of muscles by the help of which it can be opposed to each of the fingers. Although several Monkeys have the power of opposing the thumb to the other fingers, yet they cannot, like man, grasp minute objects.

The lower extremities of Man are as well suited for locomotion, as the superior members are for prehension. The bones corresponding to the scapula and clavicle are more firmly attached to the skeleton, and form a cavity called the pelvis. The acetabulum, the part which corresponds to the glenoid cavity of the scapula, is much deeper than that cavity, and consequently the femur is not capable of such variety of movement as the corresponding bone of the upper extremity. The ilium, os pubis, and ischium form one bone to which the term os innominatum is applied. These bones & the sacrum are directed backwards. From the different surfaces and processes of

of this bone arise the muscles analogous to the rotators and abductors, flexors, and extensors of the superior member. The great size of the Gluteus maximus one of the abductor muscles of the thigh serves to maintain the body in the erect posture.

The femur articulates with the os innominatum by a rounded head. This is connected with the shaft of the bone by a process called the neck. which it joins at an obtuse angle. At the upper extremity are two processes for the attachment of muscles termed respectively the greater and less trochanters. At its lower extremity the humerus becomes enlarged, and has two eminences, the external and internal condyles for articulating with the tibia.

The leg ~~is formed~~ consists of two bones, the tibia and fibula. The head of the tibia is large, and has at its upper surface two depressions for the condyles of the humerus. The superior end of the fibula is attached to the side of the tibia, and does not reach the knee joint.

These two bones do not admit of rotation, but simply of extension and flexion

By joining at their inferior extremities the tibia and fibula form a cavity which articulates with the astragalus, one of the tarsal bones. The os calcis, cuboid, scaphoid, and cuneiform bones, with the metacarpal bones, and phalanges, are all nearly on the same plane, and covered with several layers of muscles, & form broad surfaces for supporting the body in the erect posture. The metacarpal bones are five in number, and are unlike ~~the~~ those of the hand all parallel to each other. The phalanges do not differ essentially from those of the fingers.

The bony framework of the foot is placed at nearly right angles to the leg. The os calcis stretches backwards behind the leg, and thus enlarges the general surface of support. As the metatarsal bones are all on the same plane none of the toes can be opposed to another.

One of the most characteristic features of the leg of man is the great size of the Calf. The powerful muscles of this part (Gastrocnemius, & Soleus) raise the os calcis from the ground, so that the foot is made to represent

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"an inclined plane. By this action an impulse
"is communicated to the body, and a direct ten-
"dency is given to progression.

The extensor muscles of the foot have their origin in front of the leg, and from the dorsum of the foot: the flexor ~~muscles~~ adductor muscles arise from the posterior surfaces of the tibia and fib-ula, and from the plantar surface of the bones of the tarsus.

From the structure of his extremities it is evident that Man is intended for pro-gression in the erect posture. The size of the foot, forming an expanded surface of sup-port, the length of the lower extremities com-pared with that of the superior members, shew that he could walk only with great discomfort on all fours. To do so he would either require to heave his Knees on the ground in which case his legs would be entirely useless, or if he moved with his lower limbs extended the pelvis would be higher than the Shoulders and the Knee and ankle joints of unnecessary and inconvenient. I have formerly referred to the great size of the glutei muscles as a proof of the adaptation of Man for the erect

posture

posture.
As compared with the foot the hand admits of a much greater degree of motion, and though admirably suited for an organ of prehension would be very inefficient as a support for the body in locomotion.

2. Quadrumana. Man is at the same time bimanous and biped; the four extremities of Monkeys are on the contrary organs of prehension. Owing to this conformation of their organs of progression they climb trees with great facility.

The bones of the extremities in their configuration closely resemble those of Man. The radius is capable of rotating, and consequently of producing the movements of pronation and supination.

The carpus of the the animals of this Order has an additional bone. The number of these small bones is consequently nine. It is placed between the cuneiform and os magnum. The number of the metacarpal bones, and phalanges is the same as in man.

The bones of the arm, in Quadrumena, are

of

of extreme length. The thumb has not a complicated series of muscles. Though some species of Quadrumana resemble man yet they are incapable of moving about in the erect posture without inconvenience. In Man the most secure position for walking is when the the head of the thigh bone is pressed on in a vertical direction; but in the Monkey tribe the most secure position is when the vertebral column is bent at an angle to the limbs.

The pelvis of monkeys is unlike that of Man almost in a straight line with the spine. The ossa ilia are straighter than those of Man. The bone, and muscles of the thigh & leg closely resemble those of man

Monkeys do not rest on the sole of the foot, but on its external border. This results from the form of the articulating surfaces of the astragalus, - that for the fibula being vertical, while the facette for the internal malleolus is placed rather obliquely. The calcaneum has a large tuberosity at its posterior extremity, As in Man.

The metatarsal bones and phalanges of

The sternum has a keel like projection in front to which are attached the powerful pectoral muscles required to produce flight. The humerus is long in proportion to the size of the animals.
The ulna exists only in a rudimentary state at the side of the radius. This is the case in the Galeopitheus also.
The carpus is formed of six bones, two in the first row, and four in the second.
It is by the excessive development of the metacarpal bones and phalanges, and the expansion which covers these that bats are enabled to move through the air. The metacarpal bones of the four inner fingers are of great length. The phalanges are also somewhat long, and their number varies in different genera. The bones of the thumb are not extended in length, but are short, & not included in the membrane. The parachute is an extension of the cuticle, is not covered with hair, and is expanded from the sides over the upper limbs, with the exception of the thumb, & the lower members with the exception

of Monkeys are longer than the correspond-ing bones in Man; and the hands of the inferior extremities admit of consid-erable freedom of motion.

The Ouran Outang (Pithecus Satyrus.) lives among trees. The legs do not form a straight line with the thighs, but are bent outwards, so that the soles of the feet are turned towards each other. This position makes them main-tain the erect position with difficulty, but is well suited for moving among trees.

The Chimpanzee (Troglodytes niger.) lives chiefly on the ground. The arms are very long. In walking upon the hinder extremities the body is bent considerably forwards.

In the Gibbons the soles of the feet are turned even more inwards than those of the ouran outang. They live among trees, and cannot maintain the erect posture.

The Cebidae have their thumbs never opposable to the other fingers, and in many cases they are entirely wanting. The tail is endowed with powers of prehension, and by it they suspend themselves to branches of trees. From the length & feebleness of their limbs

limbs they walk, even on all fours, with difficulty. "They tread on the inner edge of the "fore-paws, and on the outer edge of the hind "edge of the hind paws, and endeavour to "assist themselves by attaching the tail to "any object as they proceed".
One species of this group is distinguished by the absence of the forefingers of the hands.

Another species, the Tarsius, has the tarsal bones so much elongated that it rests on the points of the toes

In the Galeopithecus the anterior and posterior limbs of each side are connected by an expansion of the skin which is also prolonged to join the hinder members to the tail. Both pairs of paws are free, not being enveloped in the membrane investing the rest of the limbs.

Cheiroptera. The animals belonging to this order present us with a new mode of locomotion, that of flight, and their anterior limbs are curiously modified for that purpose.
The clavicle is very thick and strong.

feet.

The lower limbs as regards their osseous structure do not present any peculiarity.

When the animal walks, it folds its wings, and moves upon the thumbs & feet. The thumbs are provided with claws.

In one species Dysopus the thumbs of the hands and feet can be opposed to the other toes.

Insectivora. Of the animals belonging to this group, the mole, as regards its organs of locomotion, is the most remarkable. It has very strong and powerful anterior members which are well suited for digging.

The scapula is a long narrow bone placed parallel to the spinal column. The spine is reduced to a rudimentary state; and the acromion is a mere tubercle.

The clavicle is short and thick. It is attached to the acromion by a ligament, and is articulated with the humerus by a facette.

The fore feet are very large and strong, and are

are covered by a thick cuticle. Their soles are directed outwards. On each of the feet there is a rudimentary toe. The number of toes is therefore six on each foot. The hinder members present no peculiarity of structure. They are very small

Rodentia. The locomotive organs of the Rodentia may now be considered. Some rodents possess clavicles, and are enabled to use their anterior members as organs of prehension; many species on the contrary want this bone. The clavicular species require to use both their paws to raise an object to the mouth. The bones of the forearm are not moveable upon each other.

In many species of this order the hind legs are much longer than the anterior members.

The pelvis is in the same line with the spinal column, and its outlet is directed backwards. This forms one distinguishing character between the pelvis of man & that of the lower animals.

Several rodents as the beaver &c are aquatic

aquatic in their habits; and in these the toes are united by webs.

Marsupialia. The animals belonging to this order vary greatly from each other. The species arranged in the family Didelphidae have an opposable thumb to each of the four feet. They are provided with clavicles, and like the Rodentia are enabled to grasp objects between their jaws.

Some species of this family have prehensile tails like the Cebidae, and suspend themselves by it with the head below.

The Kangaroos are remarkable for the large size of the tail and posterior extremities. The anterior members are comparatively short and weak. The hinder feet are of extreme length, and with the tail form a tripod on which the animal rests. By means of these it is enabled to take long leaps.

The metatarsal bones are of great length. There are four toes of which the two inner ones are very small, and compacted together so as to appear like one; the third or middle toe is large and powerful, and armed with a strong

strong hoof like nail; the external toe is smaller than the middle one, but larger than the two inner ones together, and it also has a large hoof like nail. The under surface of the foot has a callous pole along its whole length.

The family Phalangeridae have opposable thumbs to their hind feet. The flying Phalanger*, like the Galeopithecus has its extremities on each side connected by an expansion of skin. Like that animal it can take long leaps, but it appears to have the power of changeing the direction of its movements while suspended in the air which the Galeopithecus cannot do.

The Koala an animal of this family, is remarkable as the only instance among the Mammalia having two of the toes of the forefeet opposable to the other three. The internal toes of the forepaws are separated from the others, but cannot be opposed to them.

Plantigrade and Digitigrade Carnivora

A considerable number of animals have the bones of the foot all placed horizontally under

the legs; other species again have the phalanges alone so placed, and the carpal, & metacarpal bones, and the corresponding bones of the posterior member, placed more or less in line with the bones of the legs. Man, monkeys, bears, &c lay the whole under surface of the foot upon the ground, and are consequently called plantigrade.

The family Ursidae forms the plantigrade division of the Carnivora.

The clavicle in the animals of this tribe is suspended in the muscles, and is attached neither to the sternum, nor the acromion. In some species of Carnivora it is entirely wanting.

The feet are very large and powerful, and provided with strong claws.

The digitigrade Carnivora have the carpus, tarsus, metacarpus, and metatarsus raised at an angle from the toes which alone touch the ground. The toes have strong & sharp claws. In order to protect them from being blunted by attrition while the animal is walking they are retracted. To effect this the last phalangeal bones to which the claws are attached are

are capable of being turned upon the ones before it by powerful muscles. The claws of the bears are not retractile "When the "animal is walking, running, leaping, the "claws are drawn in, without any exertion "on the part of the animal, by the simple "elasticity of the ligament."
On the soles of the feet are soft pads which enable the animals to come noiselessly on their prey.
In the lion one of the arteries of the fore-limb passes through a hole in the humerus. If this were not the case the vessel would be liable to be ruptured during the contraction of the powerful muscles.
The toes of the otter are webbed; the soles of the feet, unlike those of the other carnivora are naked. In the construction of its limbs, and in its aquatic habits the otter lead us towards the next group of Carnivora, the Phocidae.

Amphibious Carnivora. From the general conformation of their bodies & limbs the Phocidae, or Amphibious Carnivora, are of

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all fourfooted mammals the best adapted for aquatic progression.

In seals there are no clavicles. The fore legs, or arms are very short: the humerus, radius, and ulna are short and hid by the skin. The hand is formed of five metacarpal bones, and the usual number of phalanges; and is so arranged that either the whole surface, or the edge alone, can be exposed in swimming.

The hind legs are very small, and much modified to suit the peculiar habits of the animals. Instead of being placed at right angles to the body as in most quadrupeds, from the knees downwards they are almost parallel with it. The femur is very much bent. The toes are covered by the skin. In some species detached pieces of membrane called by the sailors flippers extend beyond the toes and claws.

Cetacea. From the limbs of the phocidae the transition to those of the Cetacea is easy. In this tribe we find the anterior limbs reduced to a very imperfect state; and abdominal members do not exist at all, except as two very small appendages. The humerus is anchylosed with the radius

and

and ulna, and these again are firmly compacted with the wrist. The limb consequently admits of no movement except at the shoulder joint.

In the Cheroptera the tail is employed as a rudder for directing the flight; and in the Kangaroo, and some other animals it is useful in enabling the animal to leap, yet in no tribe of mammalia is it of so much importance in progression as in the Cetacea. Greatly expanded and moved by powerful muscles it is the chief organ of locomotion. Unlike the corresponding organ of fishes it is expanded in a horizontal direction. This powerful member supplies the want of the posterior extremities. The animal moves most rapidly when the tail is alternately moved up and down; but frequently the strokes are directed obliquely as an oar in sculling. The paws serve rather to preserve the equilibrium than act as organs of progression. For this purpose they are placed near the centre of gravity of the animal.

The swimming paws of the Herbivorous Cetacea

Cetacea admit of greater freedom of motion than those of the ordinary whales. The bones are not anchylosed together, and the claws can easily be felt under the skin

The Edentata includes some animals which unite the unguiculata and Ungulated Mammalia. The animals usually associated together in this order differ considerably from each other. In their organs of locomotion, and other parts of their structure the Sloths present some resemblance to the Quadrumana. They scarcely ever walk on the ground, but employ their extremities as prehensile organs in moving among the branches of trees. They suspend themselves to the branches with the back under.

The anterior limbs are much longer than the posterior pair. The wrist and ankle joints are so constructed that the plantar surfaces are turned towards the body; and consequently the animal if it attempts to walk on a level surface is obliged to rest on the elbows & the sides of the hinder feet

feet. In this ungainly and awkward posture it walks with even more difficulty than the bat. Among trees, however, it moves with considerable facility. One species (Bradypus didactylus) has two toes only on each of the forefeet; and three on each of the hinder feet. Another species (B. tridactylus) has three toes on each of its feet.

Some extinct animals allied to the Sloth were of gigantic size, and had limbs adapted for digging. The Megatherium was one of these. Its limbs were of immense size. Its thigh bone was twice the thickness of that of the elephant, and the foot was a yard in length, and plantigrade. The bones of the legs were of corresponding size, and admitted of movement upon each other. The toes were terminated by enormous claws. Both pairs of limbs were about the same length. The Mylodon was another animal of this group. It formed the link of connection between the unguiculate and ungulated

Mammalia

Mammalia for it had hoofs and claws on the same feet.

The shaft of the humerus of the Pangolin, another animal of this order, is furnished with a number of hook like processes for the attachment of muscles

True Pachydermata. The limbs of the elephant are massive. The glenoid cavities look directly downwards, and each of the other bones of the leg prep vertically upon those under them. The humerus is short and thick; and its Condyles prep directly on the heads of the radius and ulna. The lower head of the ulna is remarkable as being larger than the corresponding part of the radius. There are generally five toes covered with a thick horny skin on each foot. The ligamentum teres of the hip joint does not exist in the elephant.

In the rhinoceros, Tapir, hippopotamus, hog & the radius placed directly in front of the ulna. The fore feet of the Tapir have four, and the posterior feet three toes. The Rhinoceros has three toes on each foot. The Anoplotherium an animal of this order found in a fossil

state

state is remarkable for having had two toes on each foot, the phalanges of which were attached to separate metacarpal and metatarsal bones. — The hog is distinguished by possessing four toes enclosed in separate hoofs, the two central toes being largest, and divided by a deep cleft. Each toe has its distinct metacarpal or metatarsal bone. The Peccaries are distinguished from the other Suidae by having the metacarpal and the metatarsal bones of the two middle toes of each foot consolidated into one.

Solidungula. The Solidungula are so termed from their extremities terminating in single hoofs. We have already seen approaches to this reduction in the normal number of the bones of the limbs. In the Sloth, and in several animals of the order Pachydermata, the metacarpal, metatarsal, and phalangeal bones are considerably reduced in number. This depended simply upon the absence of the bones; but in the peccaries, Solidungula, & Ruminantia there is a still further reduction arising from the

the consolidation, or union of several bones into one. That this is the case is shown by monstrosities in which the ordinary bone is split up into two, and on each side of these are smaller bones representing the metacarpal or metatarsal bones of the absent toes.

In many animals the toes alone are placed on the ground, and the other bones of the foot are placed more or less obliquely upon these. This digitigrade form of the extremities reaches its full developement in the Solidungula and Ruminantia. In these animals the metacarpus and metatarsus are almost vertical. The extremities of the last phalanges alone reach the ground.

In the horse the scapula is turned obliquely forwards; the humerus is directed backwards; the united radius and ulna are almost in a perpendicular line with the condyles which are turned in the direction opposite that of the shaft of the bone. The carpus consists of seven bones disposed in two rows, and forms a continuous line with the radius and ulna. The metacarpus is represented by

by the canon bone, which is formed by the union of two bones. The limb is terminated by three phalanges placed one above the other and in a line with the other bones. The last of these alone touches the ground, and is covered by a horny hoof. Like the canon bone the bones of the hoof consist of a double row consolidated into one. Occasionally the canon bones and phalanges present a mesial line, and sometimes even are completely divided into two ranges. The rudiments of the other bones of the foot exist by the side of the canon bone and phalanges.
Each part of the posterior limb of the horse is inclined in opposite directions The acetabulum looks backward, being the contrary direction to that of the glenoid cavity of the scapula; the femur inclines forwards, the tibia backward, and the canon bone & phalanges forward.

The ulna which in the rhinoceros, tapir &c, is placed behind the radius, is in the horse inseparably attached to the upper and posterior

posterior surface of that bone. The fibula is reduced to a splinter bone which does not reach half way down the tibia

Rumuantia. The limbs of the Ruminantia differ from those of the Solidungula in having two toes on each foot. These are attached to a canon bone as in that tribe. The toes are formed each of three bones arranged as in the horse. The ulna is consolidated with the radius. In some species a groove runs along the whole radius marking the division between the bones; in others the ulna does not appear to extend much below the head of that bone. The fibula can scarcely be said to exist. "That bone appears replaced by a small fragment placed at the external border of the astragalus, and forming the external malleolus."

In the Musk deer there are two small accessory toes attached to the splint bones, or rudimentary metacarpus and metatarsus.

The toes of the Camel are elongated, and their extremities alone are covered by hoofs

The

The supporting part of the hoof is a cushion formed of a pulpy substance covered by a hard callous integument. Owing to the elasticity of this cushion the animal is enabled to bear great burdens over sandy ground treading as lightly as one of the Felidae

From the conformation of its foot the Llama is as well suited for living among the Andes, as the Camel in the arid deserts of Arabia. Each toe is furnished with a cushion, and the small hoofs which tip their ends are hooked like claws. These enable the animal to take a firmer step in the rugged pathways of the mountains.

The Camelopard in the extreme lengths of the anterior limbs reminds one of the Rodentia

Monotremata. Through the curious species belonging to the order Monotremata the Mammalia are connected to Birds and Reptiles. The bones of the shoulder in all Mammalia, with the exception of this group, are two, the scapula and clavicle. In the Ornithorhynchus and Echnida the two genera composing this order the clavicles are united into one Y shaped bone of which the body is continuous with the upper end of the

Sternum

sternum, and the branches are joined to the scapulae. Under this bone, called the furcula, are two other bones connecting the shoulder blade with the sternum. These are the coracoid bones the enlarged representatives of the coracoid processes of the scapula. Besides these the scapulae send forward two processes to join the sternum. In those curious animals there are thus three osseous connections between the shoulder and breast bones instead of one as in most mammals.

The feet of the Ornithorhynchus closely resembles those of natatorial birds. There are five toes armed with claws, and united by a web. On the posterior foot of the male there is a spur as in birds.

Locomotive Organs of Birds.

The majority of birds are capable of progression through the air. They are enabled to effect this by the general conformation of the body, anterior limbs, and their covering. The skeleton is so formed as to present strength with lightness. To accomplish this air is contained in cavities in the bones, and in sacs distributed through out the body. The lumbar and sacral

vertebrae

vertebrae are united into a single bone, and the dorsal vertebrae do not admit of so much movement as the corresponding bones in mammals. The ribs are connected to the sternum by bone. The cervical vertebrae are very numerous.

The bones of the shoulder resemble those of the Ornithorhynchus. The scapulae are long narrow bones placed parallel to the spinal column, and are connected with the sternum by the coracoid bones and the furcula. The former unite the shoulder blades to the sides of the sternum, and the latter connect them with the anterior part of that bone. The furcula is a V shaped bone, and the body is merely a thin lamina from which the two rami diverge. The sternum is a large bone, generally convex before and concave behind. In most birds it presents in front a large keel like projection for the attachment of muscles. The anterior members of birds cannot be employed in walking or as organs of prehension. They are exclusively devoted to flight. The humerus is articulated with the scapula and coracoid bone. The radius and ulna cannot turn on each other. The carpal bones are two in number, and the metacarpus consists of two long bones united at their ends

At

At the radial sides are rudimentary thumbs, and their anterior extremities are terminated by the phalanges of two fingers, and the rudiments of a third.

The muscles moving the wings are very powerful. It is by the pectoral muscles chiefly that flight is performed. These are three in number, and have their origin from the projecting keel of the sternum.

By means of the covering of feathers the anterior limbs are converted into expansions suitable for propelling the animal through the air. The power of flight depends more on the length of the wing feathers than upon that of the bone. They are termed primaries, secondaries, or tertiaries, according as they are placed on the hand, forearm, or humerus.

The posterior, or inferior limbs are always suited for walking; and besides in many species are organs of prehension, and of swimming. The ossa ilia are anchylosed with the lumbar and sacral vertebrae. The ossa pubis do not meet in front. The femur is short and thick, and is inclined forwards. The tibia and fibula are anchylosed together at their inferior ends.

The

The tarsus and metatarsus are consolidated into one bone, continuous with the leg, and almost at right angles to the phalanges which are placed upon the ground. The number of toes varies in different species.
As birds exhibit a much greater degree of uniformity in their structure than mammals only a few remarks on the organs of locomotion of each group are necessary. The principal variations occur in the lower extremities; and these form the chief characters by which the class is subdivided into orders.

Raptores. In the Raptores we observe a powerful muscular frame well adapted for flight. There are four toes on each foot. One toe is directed backwards. They are armed with powerful claws. The legs are rather short, and are not very well suited for walking. An exception to the usual shortness of the lower limbs in this order is seen in the Serpentarius or Secretary, in which the legs approach in length to those of Grallatores.

In the Falconidae the vanes of the wing feathers cohere firmly together, and prevent air from passing through.

In the Owl the rami of the furcula are united by cartilage.

Incessores. The Incessores may be regarded as the typical order of birds. The toes are four, which are turned backwards; and being long and slender are well suited for grasping the small branches of trees on which they rest. To enable them to maintain this posture without falling, even while asleep there is a peculiarity in the arrangement of one of the muscles of the lower extremity. The muscle arises from the back of the leg, and sends long tendons along the metatarsus to the toes. When the leg is bent upon the tarsus, the tendons retract the toes, and enable them to clasp the branch on which the bird is perched. This muscle exists in all birds, but is best seen in those belonging to this order.

The middle toe of the Goatsucker (Caprimulgus Europaeus) is furnished with a brush shaped appendage —.

Scansores. The Scansorial, or climbing birds, are distinguished by having two toes on each foot turned backwards, a conformation which renders them important organs of prehension.

The

The family Psittacidae possess the most powerful prehensile feet. — The Love birds, a group of Psittacidae, have no furcula.
In the Toucans the clavicles do not unite in front so as to form a furcula.

Rasores. The wings of the Rasores are small in comparison to the size of the birds. The feet are short and thick. Some of the Tetraonidae have the tarsi and toes feathered.
The Phasianidae have the hind toe on a higher level than the others, so that the tips alone reach the ground. One or more spur like projections are attached to the tarsus.

Grallatores. In the Grallatorial, or Wading birds, the legs and tarsi are of extreme length. The fourth toe is frequently wanting. In many species the toes are partially connected by a membrane, by which they are enabled to swim. — In the Coot the toes are furnished with expansions, or fins, on each side.

Cursores. The Cursores present in the structure of their limbs a greater deviation from the class than any tribe. Their superior extremities are never

Capable

capable of raising them into the air, and in some cases are reduced to a rudimentary state The inferior extremities are, on the contrary highly developed.

The sternum wants the large keel like projection which exists in other birds. The clavicles are not united in front. In the Ostrich they are large, but do not reach the sternum In the Rhea Americana and Casuary they are represented by slender pointed processes.

The wings in the Ostrich are larger than those of any other species of this order. The plumage is loose, and does not prevent the air from passing through. By flapping its wings it is materially assisted in running. The lower extremities are of considerable length. There are two toes on each foot. — In the Casuary the wings are reduced to a very small size, and do not assist it in progression — Of all birds the Apteryx is that in which the general characteristics of the class are most widely departed from. The superior members are reduced to mere rudiments so hidden beneath the skin as not to be easily found. The feet are each furnished with three toes armed with strong claws

Natatores. In consequence of the union of their toes by membranes the Natatores are capable of swimming. The lower limbs are in general placed farther back than in other birds. The three toes of each foot are connected together by a web. The Grebes have feet like those of the Coot. The three foretoes are united by a web which is deeply cleft, so that the greater part of each toe appears with a fin like projection on each side. The hindtoe has also a fin.
- The Pelicanidae have the four toes united by the web.

In some species the wings are large & powerful equalling in that respect most land birds, while on others, as the Penguin, they are so short as to be useless as organs of flight, but are employed as fins, in swimming. They also assist the bird in walking. Darwin says, "in diving its little plumeless "wings are used as fins, but on the land as front "legs: when crawling it may be said on four "legs, through the tussocks, or on the side of the "grassy cliff, it moved so very quickly that "it might readily have been mistaken "for a quadruped."

Organs of Locomotion of Reptiles

Reptiles present considerable variations in their organs of locomotion. This is more evident on taking the fossil species of the groups into consideration.

The scapular belt resembles that of Monotremata and Birds. The scapula has no spine. The coracoid bone unites it with the sternum. The clavicles do not exist in all species. As in birds, the humerus is articulated with the scapula and coracoid.

Sauria. Clavicles do not exist in all the animals of this order. There are generally five toes on each foot.

The Crocodiles are the most aquatic of the order, and have the posterior feet webbed. — The Chamaelons have two toes on each foot directed backwards and opposable to the other three. Thus their feet become organs of prehension. Like that of many Mammals, the tail is also prehensile. — The Geckos are enabled to walk on a smooth perpendicular surface, or even suspended with the back downwards. This is effected by means of expansions of skin near the ends of the fingers which act as suckers. — The Draco volans has a fold of skin spread from the false ribs on each

each side, but not connected with the limbs. By means of these parachutes it is enabled to take long leaps. — Many species of this order in the rudimentary state of their limbs, and the length and tenuity of their bodies approach to the Ophidia. Among these is the Sauophis which has a lengthened snake like body and four minute limbs, with four toes on each. In another species of the same group the legs are still smaller, and have only one toe on each. In some species the anterior and in others the posterior limbs are absent, while the Amphisbaena & Anguis Eryx are entirely devoid of members. In these apodal species, however, "traces of scapular and clavicular bones" are found beneath the skin.

Enaliosauria. The extinct Marine Lizards Ichthyosaurus & Plesiosaurus had four limbs closely resembling externally the swimming paws of the Cetacea. These were however more complete, and would admit of a greater variety of motion. Like some other reptiles the Ichthyosaurus and Plesiosaurus had scapulae, coracoids, and clavicles. The coracoid bones were large & broad The humerus, radius, and ulna were short and thick, and admitted of more movement

on

on each other than the corresponding bones of the Cetacea. The carpus, metacarpus, and phalanges consisted of a great number of small bones closely united together by ligaments.
The hinder paddle had a similar conformation.

Pterosaura. The limbs of the extinct Pterodactyle were as much modified for aerial progression as those of the Ichthyosaurus and Plesiosaurus were for swimming. We have already seen in the Cheiroptera the phalanges of the forelimbs greatly elongated so as to act as a framework for the expansion of skin, employed in flight. In the animal now under consideration the framework consisted of an immense development of the phalanges of the forefinger, equal to double the length of the trunk. From this a membrane extended along the side, and embraced the hinder limbs, with the exception of the feet. The four fingers of the fore limb were of medium size, and furnished with claws. The bones of the hinder extremities bore considerable resemblance to the corresponding bones of birds, and show that the reptile could have stood, and walked

walked on the ground.

Chelonia. The humerus in this tribe is very much bent, and its arched surface looks backwards. The radius and ulna exist in the forearm; the latter is placed externally and anteriorly. The carpus consists of two rows of bones. "The Land Tortoises appear to have no meta-carpal bones, and the phalanges are very short. The feet are small, and somewhat resemble those of the elephant, the toes not being separated, and the claws alone appearing."

The ilia, ischia, and ossa pubes remain permanently separated, and unite at the acetabulum. This structure reminds us of the cavity for the head of the humerus, in birds and reptiles, being formed by two bones. The ilium is moveable on the vertebral column. The ischia unite in front like the pubic bones. This structure also exists in other reptiles. The femur is strongly curved.

The feet of the Marsh and River Tortoises are webbed; and in the Turtles they resemble the paddle of the Cetacea.

Batrachia. The different species of Batrachia differ very much from each other, and present affinities

affinities to other reptiles and to fishes
The typical Batrachia, as the frog & toad have no ribs. The sternum is connected to the vertebral column by clavicles and coracoid bones. There is only one bone in the forearm. There are from 5 to 7 phalanges. The carpus is formed of three rows.

The hinder limbs are the largest, and the toes are united by a web.

The Blind worms resemble serpents in the absence of limbs, but are distinguished from that tribe by the undevelopement of the ribs. Their mode of progression, as in the Articulata, depends on the dilatation and contraction of their muscles. — The Proteidae contains a number of animals whose peculiar locomotive organs and aquatic habits show them to form the connecting link between reptiles and fishes. The Siren closely resembles an eel, but has four short limbs — The Lepidosiren has four fin like limbs

Ophidia. The Ophidia have no limbs. This character is common to them with some Saurians Batrachians, and Fishes. In some of them rudiments of limbs exist under the skin

In the different tribes of animals formerly referred to, the ribs were merely a framework which covered by muscles and integuments, protected the organs of circulation, respiration, and digestion. Some of them were united in front. In the Ophidia the ribs are free at their anterior extremities, and admit of greater freedom of motion than those of the other Vertebrata. The animal moves by the aid of their ribs Consequently although Serpents have not, like other Vertebrata, four liberated ribs or limbs they yet possess many pairs of locomotive organs which are perhaps equally efficient These animals in the great number of their locomotive organs, and the extreme length of the bodies resemble the Articulata, & the Colubridae The tail is prehensile, and there are also two hook like claws, supported by bones corresponding to those of the hind extremities. Perhaps these are homologous to the claspers of Cartilaginous fishes.

Organs of Locomotion of Fishes.

Of all Vertebrata Fishes are best adapted for aquatic progression. To fit them for swimming they are provided with broad membranous expansions called

called fins which are modifications of different parts, - the limbs, tail, and spinal processes of the vertebrae. The fins corresponding to the limbs are four in number. The anterior pair are called Pectorals, and the posterior pair Ventrals. The caudal fin is placed vertically. The dorsal fins are expansions of the spinous processes of the vertebral column. The rays are articulated to a series of bones called from their position interspinous bones which in their turn are jointed to ~~the~~ the spinous processes.

In fishes the transposition of limbs takes place to a very large extent. In some, for example, the ventral fins, which correspond to the hind limbs of the other vertebrata, are placed directly under, or even in advance of the pectoral organs. One entire order, and many species of another, are thus distinguished. Some species, like serpents and Blind worms, are entirely destitute of fins, and move by gyration of the body. The bones and rays composing the fins are covered with skin.

Anterior Members. In many fishes the pectoral fins are articulated with the bones of the head. Many fishes have the ventral fins attached

to

to the same bony ring. The rays of this fin, corresponding to the phalanges have at their base a transverse series of small bones, homologous to the carpus, which are joined to two small, flat bones, the homologues of the radius and ulna. These are supported by the humerus which is united with its fellow of the opposite side, and with the hyoid bone. Connecting the humerus with the cranium are two bones corresponding to the scapula, and a third supposed to be the homologue of the coracoid. These bones form a bony girdle to which the gill cover is attached, and is placed immediately behind the ear

The ventral fin is not of such a complex structure as the anterior member. The rays are one one bone generally of a triangular shape which is frequently articulated to the scapular belt. When the ventrals are placed behind the pectoral fins, this bone is suspended in the muscles without any attachment to the skeleton

The Sharks and Rays have the pectoral fins placed in the normal position and attached to the vertebral column.

A few cartilaginous fishes have no fins.

The Acanthopterygii have the ventrals variously arranged. In some species they are attached to the Scapular belt, and in others they placed behind ~~these~~ it

The Malacopterygii Abdominales have the ventral fins placed behind the pectorals. The latter are attached to the cranium.

The Malacopterygii Sub Brachiati have the ventral fins attached to the Scapulen bels.

The Malacopterygii Apoda have no ventrae fins.

As in Cetacea the tail is the principal organ of progression. The pectorae and ventrae fins act chiefly in preserving the equilibrium of the animal. The caudal fin is of different forms. In almost all Osseous fishes the fin is homocercal, or equally lobed; in the Cartilaginous fishes with few exceptions it is heterocercal, or unequally lobed. In Homocercal fishes the Spinal column ends where the fin commences, while it does not do so in heterocercae fishes. Professor Owen supposes that the heterocercal tail enables the fish to rise from the bottom to the surface of the sea with greater facility

Organs of Locomotion of Articulata

In all Vertebrata the organs of locomotion are modifications of a similar structure. The limbs never exceed two pairs, and according to the views of the German Transcendental Anatomists are to be considered as liberated ribs. The organs of progression, on the contrary, in the Articulata are numerous. In those that are capable of aerial progression, the organs of flight are not homologous with the ordinary feet but are expansions of the organs of respiration. We are indebted to Oken for this view of their homology. Consequently, in some Articulated animals the locomotory organs are modifications of two entirely different structures. As these organs are so numerous they obviously cannot correspond to the limbs of the Vertebrata. They are probably the homologues of the ribs of vertebrated animals. Like these they are formed, in the embryonic state, from the serous layer of the ovum. Again, Serpents are assisted in progression by their ribs.

As Ophidia, some Batrachia and a few fishes have no limbs nor fins, so many animals of this subkingdom have no locomotory organs, and move by the alternate contraction and dilatation of the soft tissues of which their bodies are

composed

Insects. The majority of insects have two kinds of organs of locomotion - those adapted for flight, and the proper organs of progression. The wings exist in adult insects alone. The organs of larval insects will be afterwards noticed.

That the wings of insects are expansions of the respiratory organs does not appear so improbable when we consider that in many vertebrates the gills hang in tufts externally to the body. If we conceive these provided with muscles, and moveable we can form an idea of the wings of insects being respiratory, as well as locomotory organs. In some worms the gills are arranged in tufts, a pair of which is attached to each segment of the body. There is also, as we shall see, a close union between the respiratory and locomotory organs of some Crustaceas.

Both the aerial & terrestrial organs of locomotion are attached to the thorax. This consists of three rings. The legs are six in number, and a pair of these is attached to each of these. Each of these organs is formed of three jointed levers, corresponding to the thigh, leg, and foot of a vertebrated animal. The foot, in [illegible], consists of several joints.

There are generally two pairs of wings which are

are attached to the second and third thoracic ring In some orders there is only one pair of wings, and in others these are reduced to a rudimentary state, or do not exist at all. With these few general remarks I may pass on and notice the different forms which these organs exhibit in the different orders

Coleoptera. Coleopterous insects have the first pair of wings converted into hard, horny cases which lie over and protect the hinder wings. This provision is necessary as a great part of the insect's life is spent among stones where weak membranous wings would be every instant exposed to destruction. During flight these organs, termed elytra ~~but~~ are of no use in progression, as they are entirely motionless When the insect is at rest the elytra unite along the mesial line of the back. Some beetles are unable to fly in consequence either of the wings being reduced to a rudimentary state; or owing to the elytra being united along the dorsal suture, and the true wings being undeveloped. In some cases the elytra fold over each other, and in others do not meet at all. During repose the true wings are folded transversely.

Like other insects Coleoptera have six legs.

The tarsus consists of a variable number of segments. From these the celebrated entomologist Latreille subdivided the order into families Orthoptera. The locomotory organs of Orthoptera resemble those of beetles. The anterior wings are formed of a tough fibrous substance which do not meet along the back The anterior wings of some species are almost equal in density to those of the Coleoptera. The hinder wings are folded as fans

The legs of many species are not of equal size, the last pair being the longest. By means of these organs the insect is enabled to take long leaps.

Neuroptera. The insects belonging to the order Neuroptera have both pairs of wings membranous and transparent. The name of the order is derived from the nerve like ramifications on the wings. These form a network with small interstices.

Hymenoptera. In the Hymenoptera both pairs of wings are membranous, but the veins, or nerves are never so numerous as in the Neuroptera, nor do they form a network. During flight the two wings on each side are united by hook shaped processes, so that they form a continued expanse

The

The honey producing species have a peculiar conformation of the hind legs; "of which the "first joint is compressed and extended into the "form of a square plate, and provided on the "inside with brush like tufts; these organs are "employed for the purpose of collecting & carrying "the pollen of flowers which is destined for the "nourishment of the young."

Lepidoptera. The wings of the Lepidoptera are covered with minute scales of various forms. These may be rubbed off, and then the wing is seen to present the same form — that of a transparent membrane, as in other insects. The wings are never folded. While reposing one tribe of Lepidoptera have the wings placed horizontally; a second group have them inclined to the plane of the body, and the third group are placed vertically.

The legs are very weak. In a few species one pair of legs is undeveloped.

Strepsiptera. The curious insects of this order have only one pair of wings which are attached to the third segment of the thorax. On each side of the second segment there are two twisted processes which are the rudiments of the absent wings. The wings are folded in a fan like manner.

Diptera. The Diptera have only two wings which are

are placed on the third segment of the thorax
On the second segment there are four long horned
processes, two on each side, which are kept
in incessant motion during the animal's flight
and serve as balancers
Aptera. Several insects have no wings,
and thus form the connecting link between
this order and the Myriapoda and Arach-
nida
Larvae of Insects. In the larval
state insects have entirely different organs
of locomotion. The larvae are destitute
of wings, and their feet generally are more numerous.
The larvae of the Lepidoptera, Hymenoptera
and Diptera differ greatly from the adult in-
sects. Some posess no locomotory organs, while
others have a considerable number.
The larvae of the Coleoptera generally have only
six legs. Some, instead of legs have thick fleshy
tubercles; and when such is the case a pair
exists on the last segment of the abdomen.
The larvae of the Hymenoptera are the
most inactive of any of the class. They are not
provided with members, and move by sim-
ple contraction and dilatation of the muscles.
The larvae of the Lepidoptera,
or Caterpillars, have in addition to the six true
legs.

legs corresponding to those of the adult insect, tubercles attached to the abdominal segments. These prolongations are armed at their extremities with a great number of minute hooks. Those which have tubercles on nearly every segment walk by means of them. The larvae that have a few prolegs only walk in a different manner. They take a firm hold of the object on which they are placed and compactly the body into an arch bring the segments to which the prolegs are attached near the fore part, when they take another hold. The body is then extended to its full length, and the same manoeuvre is performed. The muscular system of caterpillars is very complicated Lyonnet counted 4041 distinct muscles of a species of moth

Myriapoda. The Myriapoda differ from insects in the possession of a great number of extremities. There is no marked distinction between the head, thorax, and abdomen. A pair of legs are attached to each segment

Arachnida. The Arachnida have eight legs, each of which is, for the most part, terminated by two hooks. The extremities are attached

attached to the cephalo-thorax, a part equivalent to the head and thoracic segments of insects, and somewhat resemble the feet of that class Crustacea. In their organs of locomotion the Crustacea present a greater variety both in number and form than insects or arachnida. In some tribes of this class the organs of respiration and locomotion are closely connected together. The legs are in many species, organs of prehension. Each extremity is formed of a considerable number of joints. In the most highly organised species of this class - those belonging to the order Decapoda, the first pair of legs is usually transformed into a pair of powerful claws, by which they seize their food, and convey it to their mouth.

The body of a crustacean is formed of a number of segments to each of which appendages conducive to some function are attached. Thus, the eyes, the masticatory and prehensile organs, the true feet, and perhaps the branchiae, may be considered as ribs or limbs modified so as to perform different functions. The jaws of the Mammalia are considered by Oken to be ribs. In the

Crustacea

Crustacea as we shall see here are organs employed in mastication which scarcely differ, except in position from those specially devoted to locomotion. We have already seen, in many Mammalia the limbs modified to act as organs of prehension. This peculiar modification also exists in the extremities of the Crustacea

As the wings of insects are respiratory organs adapted for locomotive purposes, so in this class a close relation exists between the organs of these functions. In a few instances the same organs perform both purposes, but in most cases they are only connected by their proximity

Decapoda. From the relative development of the abdomen and tail, the animals comprised in this order have been subdivided into two groups, - the Macroura, or long tailed, and the Brachyoura, or short tailed Decapods. The Macroura are distinguished by having a large abdomen & expanded tail. As in many larvae of insects the abdomen is furnished with false legs which assist the animal in swimming. The tail is formed of five ovate plates jointed to the abdomen by the smaller ends, and when the animal is at rest partially overlap each other. This, like the corresponding organ of Cetacea and fishes is the chief organ for propelling the animal through the water

The true feet, ten in number, are employed in walking, or prehension. In front of these are organs termed feet jaws, which are used in mastication. There is generally only one pair of these appendages, but in some species, as the Cray fish, there are three pairs. The two posterior pairs, however, approximate to the character of true feet. The extremities are composed of several jointed pieces, and are terminated by claws. One, or more feet, are rendered effective organs of prehension by means of an additional toe, which moves in a glenoid cavity in the lowest segment of the foot. The internal surface of each of these claws is furnished with blunt teeth or mammillae. The common Lobster has one pair of these organs which differ considerably in size, and general appearence from the other extremities. The corresponding organs of the Palinurus do not differ from the other feet, except in the possession of an opposable toe

The false legs appended to the abdomen cannot much assistance in locomotion. It is to be regrets homologous

homologons with those, that the respiratory organs of some of the lower Crustacea are attached to, or incorporated with

The Brachyurous Decapods are incapable of progression by swimming. The abdomen is rudementary, and not furnished with an expanded fin. The feetjaws and true feet do not differ in any marked peculiarity from those of the Macroura Stomapoda. In the Stomapoda the number of extremities is greater than on the Decapoda. The legs are generally 12 or 16 in number. The false legs of the abdominal segments are developed into ~~true~~ fins. The tail is large, and forms a powerful instrument of progression. Like the feetjaws the legs are turned towards the mouth. In some species the feetjaws & true feet closely resemble each other. — In the Squilla the feetjaws are very large, and are terminated by large hook shaped claws. Some of the true feet also share in this conformation

Amphipoda.

The organs of locomotion of the Amphipoda are closely connected with those of respiration. The respiratory organs consist of vesicles

vesicles which are attached to the base of the thoracic members. There are fourteen extremities - ten of which are homologous with the three feet of the Decapods, and four with the feet jaws of the same tribe. The false legs are kept in incessant motion, and serve to assist in swimming and in exciting currents for aerating the blood Isopoda. In this order the abdominal pedicles are expanded & serve as respiratory organs.

In the Phyllopoda the connection between the respiratory and locomotory organs is even more intimate. The incorporation of both organs is complete. The feet jaws are converted into true locomotory organs, and are employed in swimming. The antennae even, in some cases, are metamorphosed into locomotory organs. In general the number of legs is great.

Most of the other Crustacea are enclosed in bivalve shells. The extremities do not act as respiratory organs, but are devoted to swimming alone - In the Lernaeidae there is almost a complete absence of locomotory organs - these being merely fleshy lobes destitute of joints Cirrhopoda. It is only during the larva state that the Cirrhopoda are capable of locomotion In this state they bear some resemblence to the entymostracous Crustacea, while in the adult

adult state they are fixed, and so much resemble Mollusca that until lately they were considered to belong to that Sub Kingdom. The young of the Balanus is covered by a bivalve shell open at the lower surface through which a pair of strong prehensile limbs, with adhesive suckers, and hooks, and six pairs of swimming legs protrude. On reaching the adult state all these locomotory organs, as well as others, are thrown off, and the animal becomes sessile. —— The back of the larva of Lepas is covered by a shield. There are three pairs of members – the anterior of which is simple, and the two posterior bifid

In their adult state the Cirrhipoda possess appendages homologous to the limbs of the higher Articulata, on each side of the body. These are long tendril like arms, or cirrhi, fringed along the edges with cilia, by the vibration of which currents in the surrounding water are produced These little filaments are, as we shall afterwards see, the sole organs of locomotion in some animals

Annellida. In the Annellida we meet with many animals which do not possess special organs of progression and with others in which these are merely rudiments, and not articulated. As in some Crustacea, and Insects there is in this class a close

connection

connection between the organs of respiration and locomotion. The Dorsibranchiata resemble the Myriapoda In general, to each segment of the body there are attached two pairs of processes the superior of which are branchial tufts and the inferior tubercles furnished with a bundle of bristles and also the organs of progression. It is chiefly, however, by simple contraction and dilatation of the muscles that these animals move; and the bristles serve to take hold of the rough surfaces over which the worm creeps. In a terrestrial species of this order, the two organs on the same side of each segment are united into one. The Dorsibranchiate worm in its early state resembles a disk, and is surrounded by two rows of cilia, by the vibration of which the animal moves

Tubicolae & Suctoria. In the earth worm there is a row of bristles on each side, which catch hold of the inequalities in the ground when it creeps. The Suctoria have not the least vestige of locomotory organs. From the soft tissues of which these animals are composed they are capable of contracting and dilating themselves to a considerable extent. By the alternate performance of these manoeuvres performed either on solids or in water they are enabled to move. To assist these contractions the Leech has a sucker at each end of its body. In

Creeping

creeping the leech by means of its foremost sucker fixes itself firmly, and then bends itself till the posterior one is brought near the anterior part of its body & takes hold by it. It then loosens the first sucker & stretches itself forwards & fixes it again.

Planaria. These animals have no organs of locomotion. They move in water by moving the body up and down.

Rotifera. The nature of the locomotory organs of the Rotifera is shrouded in some mystery. On looking at one of these animals under the microscope a round wheel like disk is seen revolving rapidly round the extremity of the animal. This appearance is now believed to result from the rapid motion of circular rows of cilia which are the locomotory organs of the animal.

Organs of Locomotion of Mollusca.

The bilateral symmetry of the Vertebrata and Articulata does not exist in the other divisions of the Animal Kingdom. The Mollusca in their organs of organic life approach nearer the Vertebrate than the Articulate

do

do, yet in their organs of animal life they are inferior to the latter group. The celebrated Geoffroy Saint Hilaire believed that a mollusc was merely a vertebrate bent at the umbilicus. The locomotory organs of Mollusca are of a very inferior grade, and some in their adult state are entirely destitute of the power of progression. In many cases there is only one locomotory organ - a thick fleshy tubercle These are sometimes prehensile, or have suckers. Some species have fin like expansions. As regards their locomotory instruments this Sub Kingdom may be considered as divisible into four groups - the Cephalopoda - the Pteropoda, the Gasteropoda, & the Lamellibranchiata, Brachipoda, & Tunicata.

Cephalopoda. The true locomotive organ of the Cephalopoda is a fin which be considered homologous with the caudal fin of cetacea and fishes, and the tail of the Macrourous Decapods. The so called feet are tentacula or prolongations of the lips, similar to those which exist in a few fishes, as the Malapterurus electricus. The tentacula vary in number and form. In some species they are the chief organs of prehension and locomotion, while in others they are employed, like the antennae of insects as organs of sensation. The tentaculae differ remarkably in the two orders into which the

thus

this class is subdivided. In the Dibranchiata there are suckers attached along the sides of the arms; these appendages are not found on those of the Tetra branchiata. Although the tentaculae of the Octopus are arranged around the head, yet from the compact form of the body they appear regularly disposed on each side. These are not so long as in some other animals of the group, and are the only organs of locomotion. They are thick at the origin, but gradually taper to the extremities. By means of these organs the animal can walk on dry land. It swims with great celerity.

The suckers are little cup shaped processes attached to one side of each of the tentaculae — The Calamary is of a lengthened fish like form, & possesses ten tentaculae of which eight are of equal size, and directed forwards; the other two are much longer, and directed backwards. They are chiefly employed as organs of prehension. The locomotory organ is a fin, resembling the caudal fin of fishes

The tentaculae of the Tetrabranchiata are not organs of progression. The only locomotive organ is a large fleshy mass homologous to the fin of the higher Cephalopoda. The only existing animal of this order is the Nautilus which secretes a coiled shell. With the foot it is believed to move at the bottom of the sea. The

tentaculae

tentacula are numerous, and are employed as organs of sensation

Pteropoda. The animals belonging to this class exhibit bilateral symmetry and powers of motion to a greater degree than most Mollusca. Instead of having locomotory tentacula or a fin like expansion like the Cephalopoda, the Pteropoda possess two fins at the anterior part of the body. Perhaps these may be homologous with the anterior limbs of the Vertebrata. By means of these organs they can swim with considerable celerity

Gasteropoda. The Gasteropoda have not the bilateral symmetry which was more or less to be observed in the animals that have hitherto come under our notice. As the name of the class signifies the locomotive organ is a fleshy proluberance placed under the abdomen. By means of this foot the land species crawl, and the aquatic species swim. Many species, in the adult state, are almost incapable of locomotion. In swimming the mollusc has the foot above the surface of the water.

In the larva state the gasteropod has two ciliated lobes, by which it can move quickly through

through the water. We see here another example of the locomotory organs of the larvae admitting of greater powers of progression than those of the adult.

Heteropoda. In the Heteropoda the foot is more or less flattened, so as to form a vertical paddle or fin, suited for aquatic progression.

Lamellibranchiata. The locomotive powers of this class are feebler than that of the animals belonging to the groups previously mentioned. A considerable number of species are fixed during the whole period of their adult state. As in the Gasteropoda, there is never more than one locomotory organ. The foot is a soft, pulpy mass resembling the tongue of the higher animals. Many molluscs of this class are fixed to the rocks &c by their feet, or appendages arising from them. This is particularly the case in the Stylilaceae. — In the Cardiaceae the feet are large, and are used in excavating holes in the sand, in which the animals bury themselves. — In Mytilaceae & Margaritaceae the foot is small and provided with a number of thread like appendages called byssi, by which the animals are fixed. — In the Ostraceae the foot is entirely absent, and the animals, in the adult

state

state, are incapable of locomotion

Brachiopoda. Like some of the Lamellibranchiates, the Brachiopoda are fixed. They possess no organs of locomotion. Organs of prehension, however exist. These are two long spiral processes, one on each side of the mouth. In many species these can be unrolled and extended beyond the shell. These arms are furnished with numerous vibratile cilia which serve to excite currents in the surrounding water.

In the larval state these animals must have locomotory organs, but I am not aware if any naturalist has ever seen them.

Tunicata. In their adult state Tunicates are either fixed, or moved about by the waves. The young of the fixed Tunicate "when it first "issues from the egg, has active powers of locomotion, "being provided with a large tadpole like tail, "by the stroke of which it is propelled through the "water."[2]

Thus, in the Cirrhipedes, the Gasteropods, and some Tunicates, the young are provided with organs of locomotion, which they either lose, or have changed to a less powerful kind, on reaching maturity

Organs of Locomotion of Radiata

Radiated animals differ considerably in their organs and modes of progression. I may proceed at once to speak of the different classes into which this sub Kingdom has been divided.

Echinodermata. The Echinodermata have at least three distinct modes of progression, and organs of locomotion. Both these kinds of organs are extremely numerous. These organs are, first, a vast number of calcareous spines, articulated by a ball and socket joint to the integumument of the animal, and secondly, a series of long processes composed of two layers of muscular fibres. The shell, found in many animals of this class, is covered with rows of tubercles. To each of these a spine is attached. These are retained in situ by the membrane investing the shell. In the Cidaris there exists besides a round ligament. The investing membrane has some muscular power, and by it the spines can be moved. The spines of the Cidaris are large enough to support the animal on them. In most species of Echinidae however, the animals move chiefly by means of the fleshy processes.

processes formerly mentioned. There are on the shells portions in which the spines are few and weak, called ambulacral spaces. They are perforated by minute orifices through which the processes formerly noticed are protruded. These are slender tubes terminated by a sucker. The tube consists of two layers of fibres - the external forming the tube, and the internal being a longitudinal fibre.

Besides these two kinds of appendages there exists in some species a third. "Each consists of a stem "bearing at its summit a sort of forceps of calcareous matter, not unlike a crab's claw, except that the two (sometimes three) blades are "equal, and similar. The use of these prehensile organs is not evident. They are not "confined to the neighbourhood of the mouth, "but are disposed over the greater part of the "surface, often forming dense groups around "the spines."

In addition to the spines and suckers which the Asteriadæ possess in common with the Echinida, the majority of animals belonging to the order have the body prolonged into a number of branches, which are endowed with considerable flexibility, and are employed in propelling the animals

through

through the water.
The branches or rays are not homologous to the limbs of the higher animals. Their rays vary greatly in number. In some species the rays are again divided into branches.
The upper surface of the body is covered with small spines similar to those of the Sea Urchin. On the under surface are ambulacrae through the orifices of which tubular feet pass. By means of these the animal can crawl on hard surfaces.
In the Asterias, and allied genera, the intestines do pass into each of the rays.
In the Ophiura there is a distinct central portion, in which the intestines are confined, and the rays are appendages distinct from the body. — The arms are moveable by means of the general integument, and can be turned towards the mouth, or to either side.

I have already noticed several Animals which in the larva state have organs of locomotion, and are capable of considerable powers of locomotion, while they are fixed

in

in their adult state. In the group Crinoidea the adult animals can move, while the young are fixed by a stalk. Probably, however, on emerging from the egg they can move and only become subsequently attached by the stalk. It is possible that the fossil Encrinites are the remains of animals in an immature state. — The Comatula in its early stage is fixed to sea weeds &c by a stalk. It has five arms, each dividing into smaller branches. As in Ophiura, the central disc contains the whole viscera. The arms are composed of a number of jointed plates, and are very flexible.

In the general appearance of the body the Fistulida, the third order of Echinodermata, resemble the Articulata; but their internal structure shews that they belong to the Radiated sub kingdom. Their locomotory organs resemble those of the other Echinoderms. The body is not protected by a calcareous covering. It is like an Echinus deprived of its shell, and lengthened out. There are arranged round the mouth several

tentacula

tentacula resembling the arms of some Stellerida. Tubulen feet resembling those of the other Echinoderms are sometimes arranged in rows from one end of the body to another, and are other species are scattered irregularly over the surface of the skin. Owing to the flexibility of their body they can swim with facility; and they can crawl on solids by the help of their tubulen feet and integument.

Acalephae.

Most of the Acalephae have no special locomotory organs. They move chiefly by means of the undulations produced by the thin borders of their disks. The Cydippe resembles an oval ball. Running from one end of the body to another there are several ribs or fringes, placed at right angles to the body, which by their undulations serve as organs of locomotion.

As in the Cephalopoda the mouth, in many species, is surrounded by tentacula which may aid the progressive motion of the animal

Some, perhaps all, Acalephae undergo a curious metamorphosis. It is only necessary to mention here that the ova are furnished with cilia by means of which move through the water.

The Hydrostatic Acalephae are characterised by having one, or more large air sacs by which great buoyancy is given to these animals. It would appear that they exercise some considerable powers over these organs; either forcing out the air contained in them, or compressing it to a smaller compass when they sink, and distending the sac when they rise.

Polypifera

In the adult state most Polypifera are fixed, and the few free species, as Pennatula, are incapable of directing their movements through the water. The solitary Polyps are capable of moveing a little. The lower end of the Hydra forms a sucker or foot. It moves in a very peculiar manner. It bends itself so as to be able to take hold of the stalk or leaf to which it is attached, by the tentacula

tentacula. Then loosening its grasp, it draws the foot to the mouth, when it adheres again, and then expands itself — The body of the Actinia expands at its base so as to form a broad foot, by which it adheres to rocks. It is capable of progressive motion only while under water. Occasionally it frees itself, and turning with the under surface above, walks upon its tentacula. The weight of the animal is supported by the water. Most commonly however, like Gasteropods, it moves by the alternate contraction and expansion of its foot.

The young Polyps move by means of cilia

Polygastrica

Cilia are the permanent locomotory organs of Polygastrica. These animals may be considered to represent the ovum of the higher animals. Probably they do not (some) possess a higher degree of vitality than the ciliated epithelia of some mucous membranes. When these ciliated cells are

detached

detached from the membrane they move freely about in consequence of current being excited by the cilia. The ova of Sponges and algae move also by means of cilia.

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