HAND-BOOK

OF

ANIMAL CLASSIFICATION

FOR THE USE OF

MEDICAL AND SCIENCE STUDENTS

BY

VICTOR V. BRANFORD, M.A.

Author of "Atlas of Chemistry."


EDINBURGH: E. & S. LIVINGSTONE.

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PREFATORY NOTE.

In the following pages the most prominent characters of the larger groups have alone been given, in order to afford a bird's-eye view of the Animal Kingdom. In learning the characters, whether of Sub-Kingdoms, Classes, Orders, Families, Genera, or Species, the student has always to bear in mind that he is dealing with definitions which apply not necessarily to every individual in the group defined, but only to the bulk of the members composing it. The absence of lines of demarcation in Nature makes it impossible to frame rigid definitions. Thus, to affirm of the Protozoa that they are unicellular and do not reproduce sexually, while true of the class as a whole, is not true of every individual Protozoon, a few of the higher members violating the statement by shading off indefinitely into the Metazoa.

Common names have been given wherever possible.

A Genealogical Table, and a few other additions, have been made to the present Edition.

GENEALOGICAL TABLE.

The accompanying Genealogical Table (modified from Herdman after Haeckel) is an attempt to summarise diagramatically the theoretic history of the Animal Kingdom. The line traced from Protamæba up to the name of any animal or group of animals mentioned in the table, indicates the probable course of its evolution. The proportionate lengths and angles of the lines roughly show the amount and nature of the evolution in each case; a line drawn downwards representing degeneration. The larger groups are enclosed in dotted lines.

The student is advised to persistently copy the Table until he is able to reproduce, at least, the more important parts of it without help.
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HANDBOOK OF

ANIMAL CLASSIFICATION.

Class I.—PROTOZOA (First Animals).

Characters.—The lowest class of animals grouped together under the class-name of PROTOZOA agree in the following characters:—(1) Throughout life each animal remains a single cell; (2) they are all very minute, and mostly microscopic; (3) they never reproduce by sexual means.

SUB-DIVISIONS.

I. MONERA.—Amœba-like Protozoa without a nucleus—e.g., Pro- tamœba.

II. ENDOPLASTICA.—Protozoa with one or more nuclei, subdivided into three groups:—(1) Rhizopoda—e.g. Amœba; (2) Infusoria—e.g. Paramecium, Vorticella; (3) Gregarinidæ—e.g. Gregarina.

<table>
<thead>
<tr>
<th>RHIZOPODA.</th>
<th>INFUSORIA.</th>
<th>GREGARINIDÆ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Possess pseudopodia.</td>
<td>1. No pseudopodia, but cilia or flagellum.</td>
<td>1. No cilia; no pseudopodia.</td>
</tr>
<tr>
<td>2. No external cuticle; hence</td>
<td>2. There is a cuticle surrounding the cell; hence</td>
<td>2. Cuticle present.</td>
</tr>
<tr>
<td>3. The shape is irregular and inconstant.</td>
<td>3. The shape is definite and constant.</td>
<td>3. Regular shape, but no mouth or anus.</td>
</tr>
<tr>
<td>4. Often have a skeleton of lime or flint, which assumes various fantastic forms.</td>
<td>4. Special openings to serve for mouth and anus.</td>
<td>4. Parasitic.</td>
</tr>
</tbody>
</table>

The remaining nine classes of animals are included under the term METAZOA (after animals). The Metazoa all start life as a single cell (ovum), which, by a series of changes, becomes developed into a mass of numberless cells arranged in two or in three different layers (epiblast, ectoderm, or outer layer; mesoblast, mesoderm, or middle layer; and hypoblast, endoderm, or inner layer).
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Class II.—PORIFERA (Sponges).

Characters.—(1) Porifera, or Sponges, are the lowest Metazoa; (2) a sponge is a cup-like structure with a wall consisting of three layers outer, middle, and inner—all in apposition to one another; (3) the inner cells are ciliated; (4) the middle layer mostly develops a skeleton of lime, horn, or flint; (5) the walls of the body are perforated by innumerable small holes, through which water is taken in for nutritive purposes—the water is washed along channels in the body walls by the inner ciliated cells, and flows out through at least one large aperture (osculum); (6) a sponge “physiologically is a mere colony of Protozoa in which individual members are subordinated to the good of the whole.”

Class III.—COELENTERATA (Hollow-bodied Animals).

Characters.—Coeleterates are Metazoa—(1) In which there is neither a distinct alimentary canal, nor a distinct body cavity, but a single cavity which serves for both (hence coeleterates are practically permanent gastrulae); (2) they exhibit radial symmetry; (3) they have stinging cells; (4) there are organs ofprehension (tentacles) around the mouth.

SUB-DIVISIONS.

I. HYDROZOA (Hydra-like).—Coeleterates, of which a transverse section just behind the mouth shows a simple tube with a double layered wall (ectoderm and endoderm). Hydrozoa include Coeleterates, which may be roughly said to assume four different forms.—(1) Hydriform throughout life (e.g. hydra); or (2) medusiform throughout life; or (3) colonial animals, partly hydriform and partly medusiform (e.g. seafirs); or (4) hydriform in young stage, and medusiform in the adult (e.g. aurelia, jelly-fish). Types (3) and (4) exhibit alternation of generations, i.e. there is a successive alternation of sexual and asexual animals related as parent and offspring.

[A hydrozoon is said to be hydriform, when, like hydra, it is a simple sac, fixed at one end and open at the other (mouth end), around which is the circle of tentacles. It is said to be medusiform, when (like aurelia) it is a free swimming sac in the form of a bell with a clapper, or of an umbrella with a much thickened handle, the mouth being placed at the end of the clapper of the bell, or of the handle of the umbrella.]

II. ACTINIOZA (Actinia-like).—Coeleterates, in which a transverse section behind the mouth usually shows a double tube—one within the other, and separated from one another by six or more longitudinal partitions (mesenteries). The inner tube extends only a short way down from the mouth, and forms a rudimentary sort of oesophagus. Never alternations of generations. Usually colonial forms, and with a skeleton of lime (corals). e.g. Actinia (sea-anemone), which however is not colonial.

III. CTENOPHORA (comb-bearers).—Coeleterates, with 8 branches from the “alimentary canal” of comb-like appearance. A small group forming a link between Coeleterates and Worms.
Class IV.—VERMES (WORMS).

Characters.—Vermes form a “heterogenous mob” of animals amongst the lowest Metazoa, with no well-defined characters. The class Vermes includes nearly all the invertebrates that cannot be placed amongst Protozoa, Porifera, Cœlenterates, Echinoderms, Mollusces, or Arthropods. Each of the following sub-divisions of Vermes is, however, probably a class equivalent to the class Vertebrata, or to any of the just-mentioned classes:

I. PLATYHELMINTHES (Flat Worms).—Flattened; elongated; unsegmented. No distinct body cavity. Excretory system in the form of longitudinal vessels, with greatly ramifying branches. No ventral nerve cord.

1. TURBELLARIA (Planariae).—Non-parasitic. Soft skin externally ciliated, Mouth and gut. No anus. Often with a protrusible pharynx (proboscis). e.g. Planaria, Mesostomum.

2. NEMERTEA.—Non-parasitic. External cilia. Protrusible proboscis, in a sheath, independent of the gut. Nervous system in the form of two supra-oesophageal ganglia, and two lateral nerve cords. e.g. Nemertes.

3. TREMATODA (Flukes).—Ecto-parasitic or endo-parasitic. Skin not ciliated in adult. Sucker at anterior and (usually) at posterior end. Hermaphrodite. Life history, either complicated, and with alternation of generations (when endo-parasitic), or simple (when ecto-parasitic). e.g. Distomum (liver fluke, the cause of rot in sheep).

4. CESTOIDEA (Tape Worms).—Endo-parasitic. No mouth or gut. Adult is jointed, first joint being the “head,” from which are budded off the remaining (generative) joints. Head with suckers and hooks. Hermaphrodite. Complicated life history, with alternation of generations. e.g. Tænia (tape-worm), Bothriocephalus.

II. NEMATHELMINTHES (Nematoidea, Round or Thread Worms).—Rounded; often thread-like; elongated; thick horny skin. Intestine straight. Anus. Body-cavity. Free or parasitic. Mostly dioecious. e.g. Trichina (the worm of trichinosis).

III. ROTIFERA (Rotatoria, Wheel Animalcules).—Mouth surrounded by a ciliated disc (wheel organ). Excretory system in the form of tubes opening into body cavity, and into a cloaca. Males smaller and less developed than females. e.g. Rotifer.

IV. GEPHYREA (Spoon Worms).—Unsegmented. Excretory organs of the kind found in Chætopods, as well as those in Rotifers. e.g. Bonellia, which exhibits sexual dimorphism, females being larger and more numerous than males, which are carried about by the females.

V. CHÆTOPODA (Annelida, Bristle-footed or Ringed Worms).—Non-parasitic. Segmented. Nervous system of paired supra-œsophageal ganglia,
and two (usually) approximated ventral cords. Closed vascular system. Excretory organs—paired tubes in each segment, opening externally and into body cavity.

1. Polychoeta (many-bristled).—Marine forms. Outgrowths of body wall form limbs (parapodia), on which are placed numerous horny bristles (setae). Outgrowths of body walls form respiratory organs (gills). e.g. Arenicola (log-worm), Aphrodite (sea-mouse).

2. Oligocheta (few-bristled).—No gills. No parapodia. Never more than eight setae in each bundle. Hermaphrodite. e.g. Lumbricus (earth-worm).

3. Achetza.—No setae. No parapodia. e.g. Polygordius.

VI. Hirudinea (Discophora, Leeches).—Elongated. Segmented. Sucker at one or both ends. No setae or parapodia. Gut is pouchcd. Body-cavity filled up with spongy tissue. Excretory and nervous systems as in Chaetopods. Hermaphrodite. e.g. Hirudo (Leech).

Class V.—Echinodermata (Spiny-skinned Animals).

Characters.—Echinoderms are exclusively marine Metazoa—(1) in which a bilateral symmetry (apparent in the young) is obscured by an acquired radial (usually pentamerous) symmetry; (2) skin is hardened by limy deposits, which may be so abundant as to form a continuous skeleton; (3) a water-vascular system with "tube feet" is present; (4) nervous system in the form of a ring round the gullet and branches to the "arms" (rays).

SUB-DIVISIONS.

I. Crinoidea (Lily Stars).—(1) Echinoderms, with a skeleton (calyx), which is a cup-like structure mostly prolonged at one end into a jointed stem, by which the animal is mostly attached, and at the other (the mouth and anus end) forms (usually) branching arms, into which the water-vascular, vascular, and nervous systems extend. e.g. Rosy-feather Star (which is stalked only in the larval form).

II. Asteroidea (Star-fishes).—(1) Flattened bodies, either star-shaped or a pentagonal disc; (2) special ambulacral ossicles or plates protect and support the tube-feet, and form the ambulacral groove, along which run branches of the vascular, water-vascular, and nervous systems; (3) tube-feet confined to under surface; (4) mouth ventral. Anus dorsal. e.g. Asterias (star-fish).

III. Ophiuroidea (Brittle Stars).—(1) Star-shaped Echinoderms, formed of a central disc and moveable, often branched, arms; (2) ambulacral groove closed in below; (3) tube-feet confined to under surface; (4) anus absent; (5) more concentrated than star-fishes since alimentary canal is confined to the central disc, and does not, as in star-fishes, extend into the arms.
IV. **ECHINOIDEA** (Sea Urchins).—(1) Mostly spheroidal; (2) skeleton composed of fixed plates, which form a complete skeleton for the body, and which are studded over with moveable spines; (2) ambulacral (tube) feet extend from the mouth (ventral) to the apex of the shell. *e.g.* Echinus (sea urchin).

V. **HOLOTHUROIDEA** (Sea Cucumbers).—(1) Worm-like; elongated; (2) limy skeleton is greatly reduced, and often consists merely of scattered and minute limy plates; (3) tube-feet may be scattered irregularly over the ventral surface, or may disappear altogether, or may be radially arranged round anterior end; (4) tentacles around the mouth contain prolongations of the water-vascular ring round the gullet. *e.g.* Holothuria (sea cucumber).

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**Class VI.—MOLLUSCA** (Shell-fish).

Characters.— Mostly bilaterally symmetrical invertebrata, covered by a soft skin, a part of which (the mantle) usually secretes a shell, and the ventral surface is drawn out into a muscular outgrowth (the foot). Nervous system mostly in the form of three pairs of chief ganglia (triangular nervous system as opposed to linear type in Worms and in Arthropoda).

**SUB-DIVISIONS.**

I. **LAMELLIBRANCHIATA** (Leaf-like Gills).—Mollusca, with bilobed mantle, which secretes a bivalve shell. Head reduced or absent. A series of respiratory filamentous processes grow out on each side of the body (the leaf-like gills). Heart; two auricles; one ventricle. The valves of the shell closed by special (adductor) muscles. *e.g.* Anodon (fresh-water mussel), two adductors; Ostrea (oyster), one adductor.

II. **ODONTOPHORA** (Tooth-bearers).—Mollusca, mostly with a more or less distinct head, with sense organs (tentacles and eyes). In the mouth is a rasping organ (tongue or odontophore). Shell, if present, is univalve. The three chief ganglia more aggregated than in Lamellibranchiata.

1. **POLYPLACOPHORA**.—Primitive and worm-like mollusces. Breathe by gills. Shell consists of eight pieces arranged one behind the other. No cephalic ganglia. *e.g.* Chiton.

2. **SCAPHOPODA**.—No head. The shell is tubular, and open at both ends. *e.g.* Dentalium.

3. **GASTEROPODA**.—Head, with sense organs and well-developed foot. Heart; one auricle, and one ventricle (usually). Asymmetrical on account of body having undergone a twisting round its central axis.

   (a) **Prosobranchiata**.—Gasteropoda, with gills in front of heart. Foot well developed, and often with operculum. *e.g.* Patella (limpet).

   (b) **Opisthobranchiata**.—Gills behind the heart. Foot inconspicuous. Hermaphrodite. *e.g.* Doris.
(c) *Pulmonata*—Gills aborted. *Breathe air by a lung* formed by the apposition of a part of the mantle to the side of the body. Hermaphrodite. e.g. *Helix* (garden snail); *Limnaeus* (pond snail); *Limax* (slug).

(d) *Heteropoda.*—Well developed head and eyes. Foot fin-like, and well developed. e.g. *Atlanta.*

4. *Pteropoda* (Sea-butterflies).—Odontophora, in which the anterior portion of the foot surrounds the head, and the median part is converted into a pair of flapping organs used as fins. Hermaphrodite. e.g. *Clio.*

5. *Cephalopoda* (Cuttle-fishes).—Odontophora, with *two large and highly organised eyes* (the only invertebrate eyes which structurally resemble those of the vertebrates). The *anterior part* of the foot produced into long *tentacular arms.* The *middle parts* of the foot fold over and unite, giving rise to a *funnel-like tube* (the *siphon*), which serves as the chief organ of locomotion. Hermaphrodite. e.g. *Clio.*

(a) *Tetrabranchiata.*—*Four gills.* Two pairs of auricles. Tentacles, short and numerous, without suckers. Funnel is incompletely closed. Shell is external, divided into chambers and coiled. e.g. *Nautilus.*

(b) *Dibranchiata.*—*Two gills.* Two auricles. Eight or ten tentacular arms with numerous suckers. Funnel completely closed. Ink bag always present. e.g. *Sepia* (cuttle-fish), eight short and two long arms, and internal shell; *Octopus,* eight arms, no internal shell.

Class VII.—*MOLLUSCOIDEA* (Mollusc-like Animals).

Characters.—Fixed, bilateral, unsegmented. A small group of unimportant mollusc-like forms.

SUB-DIVISIONS.

I. *POLYZOA* (Bryozoa).—Minute animals enclosed in a case ("cell") of horny or limy matter. The mouth of each animal is surrounded by a circle of tentacles, both nutritive and respiratory in function. Nervous system, a single ganglion between mouth and anus. The cells of different individuals become connected to form colonies of a plant-like (sea-weed) appearance. e.g. *Sea-mat* (*Flustra*).

II. *BRACHIOPODA.*—Fixed, non-colonial forms. Body is covered by two mollusc-like mantle lobes which secrete a limy bivalve shell, the valves being *dorsal* and *ventral* (not lateral as in Lamellibranchs). Mouth surrounded by two spirally coiled arms (nutritive and respiratory). Nervous system—*circum-oesophageal nerve ring* and two small supra-oesophageal ganglia. Worm-like excretory organs. e.g. *Lamp-shells* (*Terebratula*).
Class VIII.—ARTHROPODA (Joint-footed).

Characters.—Bilateral symmetry. Segmented, with a tendency for anterior segments to fuse to form a Head, and in some cases a Thoracic region. Numerous jointed appendages (mostly), some of which are converted into mouth organs (jaws) which move laterally (not vertically as in Vertebrates).

I. CRUSTACEA.

Characters.—Crustacea have the characters of Arthropoda and in addition the following:—They inhabit water. Breathe mostly by gills (branchiae). Body usually divided into head, thorax, and abdomen. Two pairs of antennae. Locomotory appendages usually attached to abdomen. Head and thorax often fused to form cephalo-thorax.

SUB-DIVISIONS.

(1) Entomostraca.—Crustacea, with slight amount of fusion of the separate segments of the exoskeleton. Never more than three appendages converted into jaws. Embryos make their appearance mostly at Nauplius (unsegmented larva with two or three pairs of appendages) stage.

1. Phyllopoda (Branchiopoda, Brine Shrimps).—A shell-like carapace or bivalve shell is formed by a reduplication of the skin. One pair of antennae (as in Nauplius) form swimming organs. e.g. Apus; Daphnia.

2. Copepoda.—No branchiae. One pair of antennae form swimming organs. e.g. Cyclops.

3. Cirripedia.—Retrograded, sessile forms. Hermaphrodite. Attached by anterior end. Body enclosed in a sac-like mantle formed by the skin, which may remain soft or become calcified. Leave the egg as a Nauplius. Anterior region is either broad (e.g. Balanus, acorn shell) or drawn out into a stalk (e.g. Lepas, barnacle). Huxley defines an acorn shell as a crustacean which is fixed by its head and kicks food into its mouth by its hind legs.

4. Ostracoda (Water-fleas).—Carapace forms a complete bivalve shelly covering for the body. Abdomen imperfectly developed.

(2) Malacostraca.—Almost always twenty segments (five cephalic, eight thoracic, six abdominal, and one telson), and all but one bear appendages; as many as six appendages may be converted into jaws. Larvae mostly set free at a stage [Zoea stage] later than the Nauplius stage.

1. Podopthalamata.—Eyes stalked.
   
   (a) Schizopoda.—Soft cephalo-thoracic shield. Thoracic appendages biramous.
   
   (b) Decapoda.—Large cephalo-thoracic shield, covering all cephalo-thoracic segments. Three thoracic appendages modified to form maxilipeds. Gills attached to thorax and appendages.
Abdomen large in Homarus (lobster), Nephrops (Norway lobster), and Astacus (crayfish); small in Cancer (crab). [Homarus larvae set free at shrimp stage.]

(c) Stomatopoda. — Short carapace, only covering part of thoracic segments.

2. HEDRIPHTHALAMATA. — Eyes sessile. No carapace. e.g. Gammarus (sand-hopper); Oniscus, wood-louse (land form).

II. TRACHEATA.

Characters. — Tracheata have the characters of Arthropoda and in addition the following: — They breathe air by tubes (tracheæ) or slight modifications of air-tubes. Never more than one pair of antennæ. Jaws greatly modified.

SUB-DIVISIONS.

1. PROTOTRACHEATA (Peripatidea). — Worm-like arthropods (especially with worm-like excretory organs), with appendages only slightly differentiated. e.g. Peripatus.

2. MYRIAPODA (Centipedes and Millipedes). — Terrestrial (i.e. not aerial) forms. The body segments numerous and nearly alike, and all have a pair of appendages. e.g. Julus; Scolopendra.

3. INSECTA (Hexapoda). — One pair of antennæ. Compound eyes. Head distinct. Thorax composed of three segments, with three pairs of legs, and mostly two pairs of wings. Abdomen without locomotory appendages. Respiration by tracheæ. Usually a larval asexual form, differing widely from the adult. e.g. Blatta (Periplaneta, cockroach), which, however, has an incomplete metamorphosis, and front wings only form wing covers. (For Sub-divisions see Genealogical Table.)

4. ARACHNIDA. — Air-breathing arthropods, usually with cephalo-thorax and abdomen. Antennæ wanting, but six pairs of locomotory appendages attached to cephalo-thorax. Abdomen without appendages. Respiration by tracheæ or respiratory sacks.

   (a) Scorpionidea (Arthrogastra). — Abdomen segmented. Breathe by respiratory sacks, i.e. respiratory lamellæ of the skin sunk into depressions of the body, and containing air. e.g. Scorpio. [The respiratory sacks are often called lung-books.]

   (b) Araneina (Spiders). — Abdomen unsegmented. Breathe by respiratory sacks.

   (c) Acarina (Mites). — Degraded forms. Abdomen unsegmented. Respiratory organs, when present, in the form of tracheæ.

LIMULUS (King Crab). Is a peculiar Arachnid-like Arthropod, the chief peculiarity of which is, that respiration is carried on by respiratory lamellæ, like those in Scorpion; but they contain blood, and are called gill-books. The hinder part of the body is fused into one mass, and the terminal part drawn out into a spine. Larvae resemble the extinct trilobites.
Class IX.—HEMICHORDATA (Half-chorded).

Characters.—Worm-like marine forms which breathe like a vertebrate by slits in the neck. A dorsal nerve-cord (like vertebrates), also a ventral one (like invertebrates). A dorsal skeletal rod resembling the notochord of vertebrates (Chordata). e.g. Balanoglossus (previously placed in the class Vermes, group Enteropneusta); Cephalodiscus.

Class X.—VERTEBRATA (Chordata).

The Vertebrates include the following groups:—UROCHORDA, CEPHALOCHORDA, CYCLOSTOMATA, ICHTHYOPSIDA (fishes and amphibia), SAUROPSIDA (reptiles and birds), MAMMALIA,*—all of which agree in the following characters:—(1) A dorsal nerve-cord, usually divisible into brain and spinal cord; (2) An axial skeletal rod—the notochord—which enters into the formation of the backbone of the adult (when the adult possesses one); (3) The heart is developed on the ventral blood-vessels, not dorsally as in invertebrates; (4) there are gill-slits in the neck, which, in the lower vertebrates (i.e. Urochorda, Cephalochorda, Clynostomata, fishes and young amphibians), form breathing organs,—but in the higher vertebrates (i.e. reptiles, birds, and mammals) close up in the adult, and are functionless; (5) the eye (when present) is an outgrowth from the brain (not a mere epidermal structure as in invertebrates); (6) bilateral symmetry.

UROCHORDA (Tail-chorded animals; Tunicata; Ascidians; Sea-squirts).

Characters.—Vertebrates, which in the young stage (larva) resemble, both externally and internally, the frog tadpole—i.e. they have (1) a notochord, which, however, is confined to the tail region of the body; (2) eye; (3) gill-slits in the neck, opening directly to the exterior; (4) well developed tail. The adult (except Appendicularia) becomes greatly degraded. It loses its tail, notochord, dorsal nerve-cord, and eye; becomes fixed (mostly), and develops a mantle around itself somewhat after the manner of the molluscs (hence the name Tunicata for the group), part of which forms an atrial chamber for the reception and escape of the water of respiration.

* The latter three—Ichthyopsida, Sauropsida, and Mammalia—are sometimes called the true Vertebrata (having well developed backbones), or the Craniata (having well developed heads); the previous three groups—Urochorda, Cephalochorda, and Cyclostomata—being designated Acroniata (head-less).
SUB-DIVISIONS.

1. **PERENNICHORDATA.**—Urochords which remain at the larval stage throughout life—*i.e.* they retain the dorsal nerve-cord and notochord of the larva. *e.g.* Appendicularia.

2. **CADUCICHORDATA.**—Urochords which become thoroughly degraded, as described above. Some remain solitary throughout life. *e.g.* Ascidia (common sea-squirt); Phallusia. Some become fused into a colony or a chain of colonies.

**CEPHALOCHORDA** (*Head-chorded*).

**Characters.**—Vertebrates in which the notochord remains in the adult and *extends into the so-called head region*. The dorsal nerve-cord is slightly swollen at anterior end to form a rudimentary sort of brain. Respiration by numerous (*i.e.* not four or five as in fishes, but about a hundred on each side) slits in the walls of the oesophagus, which open not directly to the exterior, but into a chamber (atrial chamber) which communicates with the exterior by a single aperture. There are no limbs, and practically no head. *e.g.* Amphioxus (Lancelet) the only genus.

**CYCLOSTOMATA** (*Round-mouthed*).

**Characters.**—Fish-like vertebrates, *without jaws*. Notochord persists, and forms the axial skeleton of the adult, as in Amphioxus. Respiration by branchial pouches. Kidneys worm-like and primitive. Limbs absent. *e.g.* Hagfish (Myxine); breathes by six pouches on each side of the oesophagus. Each pouch opens directly into the oesophagus at one end, and at the other the pouch is continued into a duct, which runs backwards and then opens to the exterior. All the ducts of the six pouches of each side have a common opening to the exterior. The single nostril opens into the oesophagus, and supplies respiratory water to the breathing pouches. Hagfish is parasitic on fishes, being the only true vertebrate parasite. Lamprey (Petromyzon) breathes by seven branchial pouches, which open directly to the exterior, and internally open into a tube lying under the oesophagus, which communicates directly with the mouth.

**ICHTHYOPSIDA.**

**Characters.**—Respiration by gills during part or whole of life. Heart never more than three-chambered, and always two aortic arches at least given off from it. The lower jaw is mostly compound, and does not articulate directly with the base of the skull, but is suspended by the quadrate or hyomandibular, or both. Cold-blooded. Sub-divided into—
<table>
<thead>
<tr>
<th>I.—PISCES.</th>
<th>II.—AMPHIBIA.</th>
</tr>
</thead>
</table>

I.—PISCES.

Characters.—Pisces have the characters of Ichthyopsida, plus those given in the middle column of Table at top of page.

**SUB-DIVISIONS.**

<table>
<thead>
<tr>
<th>I.—ELASMOBRANCHIEL (Cartilaginous Fishes.)</th>
<th>II.—GANOIDS.</th>
<th>III.—DIPSOD. (Air-Breathers.)</th>
<th>IV.—TELEGOSTETYL. (Bony Fishes.)</th>
</tr>
</thead>
</table>

II.—AMPHIBIA.

Characters.—Amphibia have the characters of Ichthyopsida, plus those given in third column of Table at top of page.

**SUB-DIVISIONS.**

1. URODELA.—Tailed Amphibia. Amphicoelous or opisthocoelous vertebra. Presacral vertebrae exceed nine. *e.g.* Proteus (external gills persist throughout life); Menopoma (gills drop off, gill-slits remain); Salamander (gills drop off, gill-slits close up).

2. ANURA.—Larva has a tail, a suckorial mouth, gills, gill-slits. In adult tail drops off, gills and gill-slits disappear. Presacral vertebrae prococelous, and do not exceed nine. *e.g.* Rana (frog, has tongue); Dactylethra (tongueless).

3. GYMNOPHIONA (Cecilia).—Body is serpent-like. Limbs absent. Skin is ringed, and has scales embedded in it. *e.g.* Cecilia.
SAUROPSIDA.

Characters.—Oviparous (birds) or ovoviviparous (reptiles are either) vertebrata. Single occipital condyle. The lower jaw is compound and does not articulate directly with the base of the skull, but is suspended by the quadrate. Vertebrae have no terminal epiphyses. Red blood corpuscles oval and nucleated. No corpus callosum. Embryo has amnion and allantois.* Gill-slits of embryo close up in the adult, and they never breathe by gills. Sub-divided into:

<table>
<thead>
<tr>
<th>I.—REPTILIA.</th>
<th>II.—AVES.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin, Teeth, Manus.</td>
<td>Scales or scutes, or both. Mostly present. Always more than three digits, three of which, at least, are clawed (if manus present).</td>
</tr>
<tr>
<td>Pes.</td>
<td>At least three digits. Metatarsals un-ankylosed.</td>
</tr>
<tr>
<td>Pubis, Ischium.</td>
<td>Both meet in a ventral synphysis.</td>
</tr>
</tbody>
</table>

I.—REPTILIA.

Characters.—Reptilia have the characters of Sauropsida, plus those given in middle column of above Table.

SUB-DIVISIONS.

<table>
<thead>
<tr>
<th>I.—OPHIDIA.</th>
<th>II.—LACERTILIA.</th>
<th>III.—CHELONIA.</th>
<th>IV.—CROCODILIA.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin.</td>
<td>Scales.</td>
<td>Scales or spines.</td>
<td>Scales (horny plates), and scutes (bony plates).</td>
</tr>
<tr>
<td>Teeth.</td>
<td>Present; recurved; solidified to jaws.</td>
<td>Present, not in sockets.</td>
<td>Absent.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tortoises (land forms); turtles (water forms).</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Present.</td>
</tr>
</tbody>
</table>

* See page 16, under Placenta.
II. AVES.

Characters.—Aves have the characters of Sauropsida, plus those given in third column of Table at top of previous page.

SUB-DIVISIONS.

<table>
<thead>
<tr>
<th>I.—RATITE (Running Birds)</th>
<th>II.—CARINATA (Flying Birds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not form a functional wing. Keel-less. Absent or rudimentary.</td>
<td>Keel. Present. Form the furculum (merry thought). Make an acute or slightly obtuse angle.</td>
</tr>
<tr>
<td>Long axis of adjacent parts of scapula and coracoid parallel or identical. Disunited. Absent.</td>
<td>Parrots, owls, eagles, geese, pigeons, gulls, singing birds.</td>
</tr>
<tr>
<td>Cassowary, ostrich (struthio), rhea (South American ostrich).</td>
<td></td>
</tr>
</tbody>
</table>

MAMMALIA.

Characters.—Mammary glands. Epidermic exoskeleton of hair (mostly). Heart is four-chambered. Blood warm. Left aortic arch only remains (others present in embryo, but disappear in adult). Coloured blood corpuscles, circular (oval in camel) and non-nucleated. Skull has two occipital condyles. Lower jaw is simple and articulates directly with the base of the skull (i.e. with the squamosal). Quadrate and hyo-mandibular become internal ear-bones (malleus and incus). Seven cervical vertebrae (sloth has nine, manatee six). The vertebrae have terminal epiphyses between the centra. Cerebral hemispheres are united by a corpus callosum. Embryo has amnion and allantois and branchial clefts (gill-slits), but never branchio. Teeth are present (absent in spiny ant-eater), and fixed in sockets.

[The following terms are used in dentition:—Homodont: teeth all of one sort—e.g. dolphin. Heterodont: having different sorts of teeth—e.g. dog, rabbit, horse, man, etc. Monophyodont: having one set only—e.g. dolphin, sloth. Diphyodont: having two sets of teeth—a temporary (milk) set, and a permanent set—e.g. dog, horse, etc. Upper Incisor: a tooth in the premaxilla. Upper Canine: foremost tooth in the maxilla, provided it be not far from the suture. Premolar: a tooth replacing a milk molar. Lower Canine: a tooth that bites in front of an upper canine.]

Mammalia are divided into the following twelve orders, arranged under the sub-groups (a), (b), and (c):—


I. MONOTREMATA.—The only order of ornithodelphian mammalia. Monotremata have the characters of ornithodelphia, plus the following:—A cloaca is present. Coracoids reach the sternum. Clavicles and a T-shaped inter-clavicle. Epicoracoids. Found only in Australia. E.g. Ornithorhynchus (duck-mole); Lekidna (spiny ant-eater).
(b) Didelphia (Metatheria).—Characters. — Teats present. No placenta. 
Marsupial bones. Young born immaturity. Coracoids rudimentary. 
True teeth. Usually more upper than lower incisors.

II. MARSUPIALIA (pouched animals). — The only order of didelph 
mammalia. Marsupials have the characters of Didelphia, plus the following: 
— Marsupial pouch, into which the teats project; and young are attached to 
teats for considerable time after birth. Two uteri; two vaginas. Scrotum 
in the male in front of the penis. Angle of the mandible is inflected (except 
in one case). Radius and fibula separate from ulna and tibia. All, except 
the opossums (Didelphidae), are confined to Australasia. Australasia was cut 
off from connection with the other continents by the sea before the higher 
mammals appeared. In the struggle for existence, the higher mammals 
afterwards exterminated the marsupials, except in South America (opossums). 
In Australasia no higher mammals were developed; the marsupials there 
survived, and, owing to freedom from external competition, were able to 
undergo specialisation. They specialised and developed along lines curiously 
resembling those of the higher mammals. Thus there are marsupial 
rodents (e.g. Wombat, Phascolomys), marsupial insectivores (e.g. Perameles), 
marsupial carnivores (e.g. Dasyurus, Tasmanian Devil).

(c) Monodelphia (Eutheria).—Mammalia with teats. Placenta. No 
Marsupial bones. Coracoids rudimentary. Young born highly 
developed.

[The Placenta is an organ for the nutrition and respiration of the fetus 
during its development in the uterus; it enables the mother to nourish the 
young before birth, hence the placenta is a structure partly maternal and partly 
foetal. The embryo of Sauropsida and Mammalia is invested by two sac-like 
membranes—(1) the amnion, (2) the allantois. In Sauropsida the allantois 
forms the embryonic respiratory organ. In Mammals the allantois serves a 
nutritive function, helping to form along with a portion of the amnion the 
foetal part of the placenta, in the following manner:—The amnion is a double 
envelope. The inner envelope of the amnion is the true amnion; the outer, 
the false amnion. A part of the amnion fuses with the false amnion to give 
rise to the chorion. The placenta consists of vascular villi, i.e. fine small 
fibres (foetal portion), which grow out from the chorion into corresponding pits 
in the walls of the uterine (maternal portion). If at birth the foetal villi 
simply escape from the uterine pits, the placenta is called non-deciduate. If 
the connection between the foetal villi and maternal pits is so intimate as to 
make escape impossible, the greater portion of the lining membrane of the 
uterine comes away at birth, and the placenta is called deciduate. If the foetal 
villi are scattered indefinitely around the embryo, the placenta is diffuse; if 
they are gathered into clumps, the placenta is cotyledonal; if in the form of a 
girdle round the embryo, zonary; if confined to a definite area, discoidal. 
Thus there are the following types of placenta:—1. Indeciduate, which 
may be—(a) Diffuse, e.g. Cetacea, Sirenia, most Ungulates, and Lemurs; 
(b) Cotyledonal, e.g. sheep, cow. 2. Deciduate, which may be—(a) Zonary, 
e.g. Carnivora, Proboscidea; (b) Discoidal, e.g. Insectivora, Rodents, Cheiroptera, 
and Primates, except Lemurs.

The monodelphs are called higher mammals, and include the following 
ten orders, of which the least differentiated are the Insectivores (hedgehog, 
mole, etc.), to which are most closely allied the Cheiroptera (bats) and the 
Rodents (rat, rabbit, etc.)
III. EDENTATA (toothless).—Frequently with toothless jaws. Central incisors and canines always wanting. Teeth, when present, are without enamel, rootless, and monophyodont. Premaxillae always small. Well-developed claws adapted for grasping (sloth), digging, or scratching. An ancient order, exhibiting great variety of forms. *e.g.* Bradypus (sloth—confined to South America); Ant-eater; Armadillo. Distribution—South America, South Asia, South and East Africa.

IV. UNGULATA (hoofed).—Limbs used only for progression (never for prehension), for which they are adapted by (1) absence of pollex and hallux; (2) metacarpal and metatarsal regions elongated and upright in position; (3) digits are enclosed in hoofs; (4) absence of clavicles. Herbivorous in diet; hence alimentary canal is long, and molars have broad flat crowns, the enamel folds of which are characteristic. Placenta indeciduate.

1. PERISSODACTyla (odd-toed).—Ungulates with an odd number of digits in the pes, the middle digit being the most developed. Horns, when present (*e.g.* rhinoceros), are epidermal structures, and situated medially on the nose, one before the other if two horns. A knob (third trochanter) on the femur. Stomach simple. *e.g.* Tapir (S. America, Malay, Sumatra, and Borneo), Rhinoceros (Oriental), Horse.

[Orohippus the oldest fossil horse, found in Eocene strata was about the size of a fox, had four complete digits and a fifth rudimentary one. Miohippus (in Miocene strata) and Pliohippus (in Pliocene strata) are intermediate forms.]

2. ARToDACTyla (even-toed).—Ungulates with an even number of digits in the pes. The two outer digits usually rudimentary, and the two middle ones of equal size, and rest on the ground. Horns, when present, paired (one on each side), and have a bony core—an outgrowth from the frontal bone. No third trochanter. Complex stomach.

   (a) Bunodontia (tubercle-toothed).—Non-ruminating Artiodactyls. Molar teeth, with tuberculate enamel crowns or transverse enamel ridges. *e.g.* Pig, Hippopotamus (Africa), Peccary.

   (b) Selenodontia (crescentic-toothed).—Artiodactyls which ruminate. Molar teeth have crescentic enamel ridges on the crowns, and incisors usually 0 upon 3. Upper incisors and canines often absent. *e.g.* Sheep (ovis), Ox, Goat, Camel, Llama, Giraffe (Africa), Deer (horns in the form of antlers—solid bone, outgrowth from the frontal bone—which can be shed).

V. SIRENIA.—Marine mammals, adapted to an aquatic herbivorous (seaweed-eating) life by (1) thick, almost hairless skin; (2) fish-like tail, horizontally flattened; (3) fore-limbs converted into paddles—no hind limbs; (4) dentition incomplete. Molars have flattened crowns. The nostrils are far forwards, not at the top of the head as in whales. *e.g.* Manatee (original
of the mermaid, hence the name Sirenia). Six cervical vertebrae. No incisors. (S. Atlantic). Dugong, two upper incisors. Cleft in heart, separating the ventricles. (Indian Ocean.)

VI. CARNIVORA (flesh-eaters).—Mammals adapted to seizing and killing prey, and to a flesh diet, by (1) sharp claws (mostly); (2) characteristic dentition, long sharp canines, molars with ridges and sharp edges, especially the "sectorial" tooth—teeth enamel coated and diphysodont; (3) simple stomach and short intestine (as in flesh-eating animals generally); (4) prominent sagittal crest between the parietals for attachment of jaw muscles. Complete covering of hair. No clavicles. Manus and pes always with five digits. Placenta zonary and deciduate.

1. FISSIPEDIA (cleft-footed).—Carnivores adapted to a terrestrial life by (1) digits being free, i.e. not webbed, and with long claws; (2) hind legs free from the tail. Incisors 3 upon 3.

[Marsupial Carnivores never have incisors 3 upon 3.]

(a) Cynoidea (Dogs).—Digitigrade fissipedia. Claws bluntish and not retractile. Dentition, 3 upon 3, 1 upon 1, 4 upon 4, 2 upon 3. e.g. Dog (Canis).

(b) Arctoidea (Bears).—Plantigrade. Molars tuberculated, suitable for a mixed diet. e.g. Bear, Weasel, Otter, Badger.

(c) Aeluroidae (Cat family).—Digitigrade. Claws sharp and retractile. e.g. Cat and Tiger (Felidae), Lion, Hyæna (claws not retractile), Civet.

2. PINNIPEDIA (web-footed).—Carnivores (mostly marine) adapted to an aquatic fish-eating life by (1) all the limbs fin-like; (2) hind limbs united to the tail to form a propeller; (3) digits webbed; (4) canines recurred. e.g. Seal (Phoca), Walrus (canines form large tusks). Otario (Sea-Lion).

VII. CETACEA (Whales).—Mammals, externally fish-like, adapted to an aquatic life by (1) smooth skin almost hairless, with a thick layer of fat (blubber) underneath; (2) tail in the form of a horizontally flattened fin, used as a propeller; (3) fore limbs converted into fins (flippers), hind limbs absent; (4) nostrils (blow-holes) on the top of the head, and valular; (5) no external ears (absent or rudimentary in all aquatic mammals). Stomach complex. Placenta diffuse.

1. MYSTACOCETI.—Whale-like cetacea. Teeth in the adult are replaced by horny plates of "whalebone" (fringed with bristles), which hang from each side of the palate. e.g. Baleen (Right Whale).

2. ODONTOCETI. —Dolphin-like cetacea. Homodont, monophyodont, teeth in the adult, and never "whalebone." The skull is often asymmetrical. e.g. Sperm Whale, Narwhal (with horizontal tusk), Porpoise (Phocoena), Dolphin (Delphinus).
VIII. PROBOSCIDEA (Elephants).—Mammals in which the nose is prolonged into a long double-barrelled prehensile trunk (proboscis). Thick skin almost hairless. The incisors form tusks (ivory), and are without enamel. Molars twenty-four altogether throughout life, but never more than eight present at a time. Five hoof-covered digits on each foot. Skull is modified to carry the tusks by development of large air spaces in the bones. Herbivorous. Placenta deciduate and zonary. e.g. Indian Elephant (parallel enamel ridges on the molars). African elephant (lozenge-shaped enamel folds on the crowns of the molars).

IX. RODENTIA (gnawing Mammals).—Largest order of mammals. Very old and widely distributed group. Dentition adapted to gnawing, and is exceedingly characteristic. Incisors are chisel-shaped, and consist of hard enamel in front, and less hard dentine behind, so that a permanent edge is preserved. Canines absent. Long gap (diastema) between the incisors and the premolars. Molars have flattened crowns with transverse enamel folds. Stomach simple, but intestine very long (as in herbivorous animals generally). Condyles of lower jaw elongated longitudinally, so as to admit of longitudinal motion. Placenta discoidal deciduate.

1. Duplicidentata (Double-toothed).—Incisors 2 upon 1. e.g. Lepus (Rabbit).

2. Simplicitidentata (Single-toothed).—Incisors 1 upon 1. e.g. Squirrels, Mice, Beavers, “flying” Squirrels, Porcupines, Guinea-pigs.

[Xyrracoidea, a small rabbit-like group of one genus, may be considered as a sub-group of Rodentia.]

X. INSECTIVORA (Insect-eaters).—Plantigrade terrestrial mammals of small size. Digits on hind and fore limbs all clawed. Long tapering snout. Canines small or absent. Molars sharp pointed. Clavicles well developed. Placenta discoidal deciduate. Feed on insects, worms, and small animals. e.g. Hedgehog (Erinaceus), Mole, Shrew (the smallest mammal—about two inches long), Flying Lemur (frugivorus and arboreal).

XI. CHEIROPTERA (hand-winged).—The only true flying mammals (other so-called flying mammals merely take long leaps). The fore limbs are modified for flight. The flying membrane extends between the limbs and the side of the body, and between the elongated fingers of the fore limb. Sternum is keeled for attachment of flying muscles. Clavicles well developed. Dentition complete. Incisors smaller than the canines. Mammals thoracic. Mostly nocturnal, hence eyes are poorly developed. Placenta discoidal.

1. Megachiroytera (great bats).—Fruit-eating bats. e.g. Pteropus (flying fox). Shores of Indian Ocean.

2. Microchiroytera (small bats).—Insect-eating or blood-sucking bats. Universal distribution. e.g. Common Bat (Vespertilio), Vampyre Bat.
XII. PRIMATES.—The characters of the order Primates may be gathered from the following table:—

<table>
<thead>
<tr>
<th>Habitual position.</th>
<th>1.—LEMURIDÆ.</th>
<th>2.—SIMIADÆ.</th>
<th>3.—ANTHROPIDÆ.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quadripedal.</td>
<td>Quadripedal, except anthropoid apes—semi-</td>
<td></td>
</tr>
<tr>
<td>Big toe (Hallux).</td>
<td>Opposite, and has a flat nail.</td>
<td>erect. Opposable, and flat nail.</td>
<td>Erect.</td>
</tr>
<tr>
<td>Thumb (Pollex).</td>
<td>Opposite, and has a flat nail.</td>
<td>Opposable, and flat nail, except in arctopithicini, platyrrhini, and one catarhine.</td>
<td>Has a flat nail, but not opposable. Opposable, and has flat nail.</td>
</tr>
</tbody>
</table>

1. Lemuridæ (Lemurs).—In addition to those gathered from above Table, note the following characters:—Lemurs are without a closed orbit. Claw-like nails on all the digits except hallux and pollex. Mostly nocturnal in habit. Arboreal. Fruit and insect eaters. Once a widely distributed order, now confined to Madagascar and other Indian Ocean islands. e.g. Lemur (Madagascar) dentition i. 2, c. 1, pm. and m. 5 or 6, above and below, lower incisors are almost horizontal.

2. Simiadæ (Monkeys and Apes).—In addition to characters in above Table, note also closed orbit. Dentition i. 2, c. 1, p. 2, m. 3, above and below (except in Platyrhini). Canines large. Diastema in front of upper and behind lower canines. Flat nails on all digits (except Marmosets). Face mostly naked, though fringed with hair. Frugivorous.

1. Arctopithicini (Marmosets).—South America squirrel-like forms. Claws on all digits except pollex and hallux. Pollex not opposable. Broad nasal septum between the outwardly-directed nostrils.

2. Platyrhini (broad-nosed).—New World monkeys. Nostrils wide apart, and nose flat. Pollex non-opposable. Dentition i. 2, c. 1, p. 3, m. 3, above and below. Frontal bone extends backwards to form V-shaped coronal suture. Tympanic bone has a wide oval mouth. e.g. Mycetes (howling monkey), lower jaw is enlarged to support howling apparatus. Ateles.
3. Catarrhini (narrow-nosed).—Old World monkeys. Nostrils close together. Tympanic bone has a long tubular mouth.

(a) Cynomorphae (Dog-like).—Long, often dog-like muzzles. Ischial callosities are present. Usually cheek pouches. Some arboreal, others not, hence adapted both for climbing and walking. e.g. Baboons and Mandrils (Cynocephali), Africa and Arabia. Macaque (Macacus) is terrestrial; E. Asia, N. Africa, Gibraltar. Colobus is thumbless; Africa. Sacred monkey of India (Semnopithecus).

(b) Anthropomorphae (Man-like).—The anthropoid apes. Semierect. Tail-less. Fore-limbs longest. Ischial callosities and cheek pouches absent. Spinal column nearly straight. Arboreal. Brain approaches in form the brain of man, but is relatively smaller. e.g. Gibbon (Hylobates), has cheek pouches; S. Asia. Orang-utan (Simia); Borneo and Sumatra. Chimpanzee (Troglydotes Niger); W. Africa. Gorilla (Troglydotes Gorilla); W. Africa, largest and most highly developed ape.

3. Anthropidae.—Partially hair clad. Hallux non-opposable. Teeth in one continuous arch with no gaps. Erect. Spinal column exhibits a series of curves (four), so constructed that the centre of gravity falls between the feet. e.g. Man (homo).

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