

Outline of a course of lectures on the structure and classification of animals / [Robert Edmond Grant].

Contributors

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Dr. Grant.
arrangement—
for a course of
Lecture

Wm Yarrell
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OUTLINE
OF
A COURSE OF LECTURES

ON THE
Structure and Classification of Animals,

TO BE DELIVERED TO

THE MEMBERS OF THE ZOOLOGICAL SOCIETY OF LONDON,

In their Museum,

TO COMMENCE ON TUESDAY THE 15TH OF JANUARY, 1833, AND TO CONTINUE ON THE
SUCCEEDING TUESDAYS AND THURSDAYS, AT HALF-PAST SEVEN O'CLOCK P.M.

BY

ROBERT E. GRANT, M.D.

FELLOW OF THE ZOOLOGICAL SOCIETY OF LONDON, &c.; PROFESSOR OF COMPARATIVE ANATOMY AND ZOOLOGY
IN THE UNIVERSITY OF LONDON.

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INTRODUCTION.

THE design of this Course of Lectures is to lay before the Members of the Zoological Society an outline of the principles of comparative anatomy and zoology, as applied to every class of the animal kingdom. The classes of animals will be examined in zoological order, commencing with those which approach nearest to man, and terminating with the simplest known forms. It is not designed in this Course to enter into the history or the geological relations of fossil species.

Comparative anatomy treats of the structure of animals. It makes us acquainted with the forms and connexions of the internal organs, and traces their mode of development, their uses in the economy, and the laws which regulate their co-existence. It points out the relations which exist between the internal structure of animals and their living functions and habits, and explains the analogies which can be traced between the structures of animals belonging to different classes. It compares the organizations of inferior animals with the successive stages of the development of higher species and of man, and traces a unity of plan in the organization of the whole animal kingdom.

Zoology, in so far as it relates to existing species, considers animals in their entire and living state, and describes their external forms and distinguishing characters, their habits and instincts, their food and climates, the changes they undergo by age, season, latitude, domestication or other causes, their uses to man or in the economy of nature, their geographical distribution, their periodical migrations, the origin, limits, and duration of species, and every other circumstance connected with the history of their

life. It explains the principles of zoological classification, and the distinguishing characters of the various classes, orders, genera, and other subdivisions of the animal kingdom.

In the ensuing Course these two departments will be constantly combined, so that the peculiarities of structure of each species or group of animals will be illustrated along with the history of their living phenomena. The zootomical details will be illustrated by numerous preparations belonging to the Society, which the Council for this purpose have kindly placed at our disposal, by specimens obtained from the private collections of members who have liberally promised their aid, and from other sources, and occasionally by drawings, diagrams, and recent parts. For the zoological department the Society possesses ample resources in its valuable and extensive Museum, and of these the Council have liberally granted unlimited use. For the sake of illustration in this part of the subject, it may be occasionally advantageous to introduce living specimens from the Society's Menagerie. The following pages present an outline of the plan which will be followed in every department of the subject, but the length of time to be devoted to each will depend much on the means of illustration at our command, which alone can give interest or usefulness to these demonstrations.

Although the most interesting peculiarities of structure belonging to the species will be pointed out while treating of the history of those selected for illustration, it will in general be necessary to enter more fully into the anatomical details of each class of animals in commencing its separate history, in order to take a survey of the characters common to the whole class, and to form a juster conception of the nature and relations of the beings it comprehends, and of the principles of classification as applied to them. In taking a view of the organization of the higher classes of animals, we shall first consider their organs of relation or of animal life; the bones and hard parts which form the solid frame-work of the body, the ligaments which connect them together, the muscles which move them, the nervous system which gives energy to the muscles, and the organs of the senses which direct their motions. The organs of vegetative or organic life will next be examined; the digestive organs which prepare the food, the lacteals which convey it to the blood, the circulating system which conveys it to all parts of the body, the respiratory organs which renovate and prepare the circulating fluids, the organs of secretion

which form new compounds from the blood, the lymphatics which take up the decayed materials of the organs and convey them to the circulating mass, and the tegumentary organs which cover and protect the whole system. The third class of organs, connected with the preservation of species, will be entirely reserved for a few supplementary lectures at the conclusion of the Course.

An acquaintance with the internal mechanism of animals, the chief subject of the present Course, and of the general laws of organization, is important, as forming the basis of all distinctions and arrangements in zoology. It is the foundation of physiology, and is highly illustrative of human anatomy, and other departments of medical science. The successful application of its facts and laws has largely contributed to the rapid progress of geology in our times, and the discoveries of the geologist have reflected a kindred light on the gradual development of animal forms on this earth, and on many of the connecting links of existing species. It has materially assisted in the improvement of the fine arts, by giving truth, animation, and vigour of expression, to many of the finest productions of the poet, the painter, and the sculptor. It throws light on some of the most obscure parts of the philosophy of mind, and by the innumerable instances of design and wisdom which it presents in the minutest and most recondite parts of the creation, it is eminently calculated to awaken correct moral feelings and reflections, and to improve and strengthen the principles of ethics and religion. The study of zoology tends to methodise the mind, to strengthen the memory, and to improve our powers of observation; its details enrich the imagination, and store the mind with useful knowledge; and its constant comparisons agreeably exercise and improve the judgment. An extended acquaintance with the animal kingdom has also many important applications in domestic economy, and in the useful arts and manufactures, and is not without its advantages to the traveller, the navigator, the geographer, the historian, and even the legislator.

which form new compounds from the blood, the lymphatics which take up the decayed materials of the organs and convey them to the circulating mass, and the tegumentary organs which cover and protect the whole system. The third class of organs, connected with the preservation of species, will be entirely reserved for a few supplementary lectures at the conclusion of the course.

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OUTLINE
OF
A COURSE OF LECTURES.

Design and Plan of the Course. Principles of Classification as applied to the Animal Kingdom. General View of the Primary Divisions according to the following Table.

ANIMALIA.

1. SUB-REGNUM VERTEBRATA VEL SPINI-CEREBRATA.

Classis 1. Mammalia.

2. Aves.

3. Reptilia.

4. Amphibia.

5. Pisces.

2. SUB-REGNUM MOLLUSCA VEL CYCLO-GANGLIATA.

Classis 6. Cephalopoda.

7. Pteropoda.

8. Gasteropoda.

9. Conchifera.

10. Tunicata.

3. SUB-REGNUM ARTICULATA VEL DIPLO-NEURA.

Classis 11. Crustacea.

12. Arachnida.

13. Insecta.

14. Myriapoda.

15. Annelida.

16. Cirrhopoda.

17. Rotifera.

18. Entozoa.

4. SUB-REGNUM RADIATA VEL ACTIN-NEURA.

- Classis 19. Echinoderma.
 20. Acalepha.
 21. Polypifera.
 22. Porifera.
 23. Polygastrica.
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FIRST SERIES, OR SUB-REGNUM VERTEBRATA OR SPINI-CEREBRATA.

Characters common to all the classes of this division taken from their different systems of organs. Principles of the sub-division into classes. Differences of internal structure, on which are founded the distinctions of the classes—

Mammalia,
 Aves,
 Reptilia,
 Amphibia,
 Pisces.

CLASS MAMMALIA.

General characters of the class. Principles according to which it is subdivided into orders. Distinguishing characters of the orders illustrated by specimens, according to the following table :—

Order 1. Bimana.	7. Rodentia.
2. Quadrumana.	8. Edentata.
3. Chiroptera.	9. Monotrema.
4. Insectivora.	10. Pachyderma.
5. Carnivora.	11. Ruminantia.
6. Marsupialia.	12. Cetacea.

1st Order—BIMANA.

Brief account of the Zoological characters, the varieties, and the distribution of our species.

2d Order—QUADRUMANA.

Characters of the various systems of their organization. Peculiarities of the skeleton. Different measurements of the cranium. Cause of the permanence and similarity of the

cranial sutures in quadrumana and man. Parallelism of the orbits giving perfection of vision. Permanent separation of the intermaxillary bones of the lower quadrumana compared with the fœtus of man and oranges. Importance of these bones in relation to the dental formulæ of quadrupeds. Forms and characters of the teeth considered physiologically and zoologically. Different parts of the osseous system considered with relation to the semi-erect position of these animals. Occipital foramen, scapulæ, clavicles, hands, pelvis, feet. Peculiarities presented by their nervous system and organs of the senses, the digestive system, organs of circulation and of respiration, secreting glands, and other organs. Cheek-pouches, sacs of glottis, nocturnal eyes, prehensile tail, callosities, and other characters used to discriminate quadrumana. Subdivisions of quadrumana, and history of the species.

1. Catarrhini. Simiæ of the old continent.

Genera.—Pithecus, Hylobates, Cercopithecus, Semnopithecus, Macacus, Cynocephalus.

2. Platyrrhini. Simiæ of the new continent.

Genera.—Mycetes, Ateles, Lagothrix, Cebus, Pithecia, Callithrix, Nocthora, Jacchus, Midas.

3. Lemures or Makis.

Genera.—Lemur, Lichanotus, Loris, Galago, Tarsius.

3d Order—CHIROPTERA.

Structure and peculiarities of the skeleton of Bats, compared with that of other Mammalia, of Birds, and of Pterodactyli. Form of the cranium, characters of the teeth, moveable intermaxillaries, use of the clavicles, form of the scapulæ and their coracoid process, crest of the sternum, bone of the fore-arm, structure of the hand, opposable thumbs, direction of the feet backwards. Peculiarities of their muscular, nervous, respiratory, and other systems, considered with relation to their power of flight, their nocturnal habits, their food, their hybernation, their mode of rearing their young. Air-sacs between the skin and body. Subdivisions and history of, 1. Vespertilionides; 2. Galeopithecii.

4th Order—INSECTIVORA.

Insectivorous without wings. Skeleton of Hedge-hogs, Shrews, and Moles. Structure of the Erinaceus with relation to its spiny covering, its food, its hybernation. Singular structure of Moles in their skeleton, organs of the senses, and abdominal and pelvic viscera, considered with relation to their burrowing habits. Subdivisions, 1. with long incisors and short canines. 2. With short incisors and long canines.

5th Order—CARNIVORA.

Necessity for the existence of carnivorous animals of various classes. General characters of Carnivorous Mammalia. Structure and proportions of the skeleton and muscular system. Orbits imperfect. Large temporal fossæ. Occipital ridge. Glenoid cavity deep. Form of the condyles of the lower jaw considered with relation to the teeth, and to the general structure of the skeleton and soft parts. Characters of the incisor, canine and molar teeth. Tuberculated, carnivorous, and false molar teeth, their forms with relation to the carnivorous propensities of the species. Transverse processes of the atlas and spinous process of the axis. Rudimentary clavicles. Dimensions of the thorax. Characters of the long bones of the extremities compared with those of Herbivorous quadrupeds. Perforated humerus. Direction of the ilio-sacral articulation. Subdivided character of the hands and feet. Structure for the support of the claws. Characters of their nervous system and of their organs of the senses. Structure of their digestive organs, and peculiarities of their circulating, respiratory and other systems. Subdivisions of Carnivora. Characters, peculiarities and history of the Plantigrade and Digitigrade carnivorous quadrupeds of the old and of the new continent, illustrated by numerous specimens from the Society's Museum. General structure, characters, and history of the Amphibious Carnivora; new genera of these founded on differences of the dental formulæ.

6th Order—MARSUPIALIA.

Isolated and remarkable character of the Mammalogy of New Holland. That continent connected with Asia by its fossil quadrupeds, as Europe is with America. Characters, structure and peculiarities of Marsupial quadrupeds. Marsupial bones, structure of the pouch, muscular apparatus connected with the mammary glands. First discovery of Marsupialia, their distribution, their diversities as to form, food and habits. Their inferior grade of development marked by their uterine, vascular and osseous systems. Their relations to other orders of Mammalia, particularly Carnivora, Insectivora, Ruminantia and Rodentia. Characters and history of the most interesting genera and species.

7th Order—RODENTIA.

Characters of the order. Structure, growth and forms of the teeth of Rodentia. Size of the intermaxillaria. Long separation of the tympanic bone. Longitudinal direction of the condyle of the lower jaw, and of the glenoid cavity, corresponding with the transverse direction of the laminae of enamel of the molar teeth, as in the proboscidian *Pachyderma*. Forms of the clavicle. Partially divided stomach, large cæcum-coli, long intestinal canal of Rodentia. Gastric glands and other glandular cryptæ in its course. Numerous analogies between Rodentia and Birds in their osseous, muscular,

nervous, digestive and uterine systems. Distinguishing characters, peculiarities of structure, living habits and instincts, and useful applications of the most interesting genera and species of this order.

8th Order—EDENTATA.

Remarkable peculiarities of structure, particularly in the osseous, vascular and digestive systems of the Sloths, Armadillos and Ant-eaters. Jaws, molar teeth, intermaxillary bones, cervical vertebræ and bones of the extremities of Sloths. Effects of the subdivision of their brachial and femoral arteries. Forms of the bones of the head, trunk and pelvis of Armadillos and Ant-eaters. History of the genera and species of this order, and observations on the general character of the Mammalogy of the New Continent.

9th Order—MONOTREMA.

Analogies of the Ornithorhynchus and Echidna, with other quadrupeds and with birds. Structure and form of the cranium and face. Teeth horny. Coracoid bones reaching to the sternum. Sternal ribs ossified. Clavicles united. Marsupial bones. Serrated horny mandibles. Digestive and circulating organs belonging to the type of Mammalia. Uterine system oviparous. Mammary glands. Insectivorous character and living habits of the land and aquatic genera of this remarkable type of quadrupeds.

10th Order—PACHYDERMA.

Forms of Pachyderma now apparently isolated, are connected by fossil species. Relations of the Proboscidian Pachyderma. Skeleton of the Elephant. Nature and object of the cells of the cranium. Growth of the incisor teeth. Structure and shedding of the molar teeth; their differences in the Asiatic and African species. Indications taken from the infra-orbitary foramen. General structure, habits and uses of these animals. Structure and habits of the Hippopotamus, Rhinoceros, Tapir and other ordinary Pachyderma, and of the Solidungulous species. Affinities of the Solidungula to Ruminantia. Structure and determination of the bones of the feet. Character of the digestive, circulating, respiratory and other systems of Pachyderma.

11th Order—RUMINANTIA.

Structure of the skeleton. Cause of the separation of the frontal bones and union of the parietals. Composition, structure, forms, and modes of growth of the deciduous and permanent horns. Shedding of Deers' antlers. Structure, mode of growth, shedding, and varieties of the teeth. Transition in the dental formula from that of Solidungula to that of the regular Ruminantia, in passing through the Camels, Lamas, and Musk Deers. Uses of the long spinous processes of the dorsal, and transverse processes of

the lumbar vertebræ. Compressed thorax. Absence of the clavicle as in *Pachyderma*. Structure of the articulations of the extremities contrasted with those of *Carnivora*. Peculiarities of their muscular, nervous, digestive, respiratory and vascular systems. Structure of the stomach and mechanism of rumination. Water-cells in the stomach of the Camel. Subdivisions, characters, living habits and various uses of the animals of this extensive order. Changing of the colour, shedding and renewing of the fleece. Influence of domestication. Uses in the economy of nature.

12th Order—CETACEA.

Skeleton of Cetacea compared with that of other *Mammalia* and of *Fishes*. Peculiarities of the skull and dentition of *Herbivorous Cetacea*. Singular cranial and cerebral development of the *Dolphins*. Forms and position of the bones of the skull and face of the *Piscivorous Cetacea*. Extraordinary development of the intermaxillary bones raising the nostrils to the crown of the head. Prehensile teeth compared with those of *Reptiles* and *Fishes*. Horny laminæ of the upper jaw of the *Balæna*. Teeth in the lower jaw of the embryo of that animal. Position of the foramen occipitale. Elements of the temporal bone long separate. Cervical vertebræ mostly anchylosed and compressed. No sacrum. Articulations of the ribs allied to those of *Reptiles* and *Fishes*. Ossified sternal ribs, as in *Monotrema*, *Birds*, and *Reptiles*. Structure of the arms, compared with those of extinct *Sauria* and of *Fishes*. Disposition of the muscles of the vertebral column with relation to the horizontal position of the tail. Muscular apparatus of the nostrils or blow-holes. Peculiarities of the organs of vision, hearing, and smell. Remarkable structure of the digestive organs. Peculiarities of the circulating system. Use of the subcutaneous adipose substance in preserving the high temperature of the body. Mode of rearing the young. Subdivisions, habits, and uses of the *Cetacea*. Whalebone, ambergris, spermaceti, ivory, and oil. General remarks on the zoology of the ocean.

CLASS AVES.

General characters of the class of *Birds*. A great natural family of animals. The remarkable similarity of the plan of their whole organization rendering it unnecessary to enter, as in the classes of *Quadrupeds* and *Reptiles*, into separate anatomical details for each order. Composition, texture, and general characters of the bones of birds compared with those of other vertebrate classes. Development and regions of the skeleton. Rapid disappearance of the sutures of the cranium. Face moveable on the cranium. Magnitude and smoothness of the cranial parietes corresponding with the development and want of convolutions of the brain. Nature and relations of the air-cells of the cranium. Magnitude and imperfect separation of the orbits considered with relation to their power of vision. Advantages of the single occipital condyle. Importance and relations of the moveable tympanic bone. Various forms of the jaws and mandibles of birds connected

with the difference of their food and habits. Forms, mode of articulation, and numbers of the cervical vertebræ with relation to the position and nature of their food. Means employed to fix the vertebræ of the trunk. Analogies of the sternal apparatus of birds traced and explained. Forms, structure, and articulations of the ribs compared with those of other classes. Structure of the pelvis of birds compared with that of Edentulous quadrupeds and of reptiles. Consequences of the separation and elasticity of the pubic bones. Differences in the rapidity with which the air is substituted for the marrow in the long bones of different orders of birds, and in the extent to which this takes place. Determination of the bones of the wing, and adaptation of the arm, as an organ of flight. Bones of the hand of birds compared with those of bats and of flying reptiles, with a view to the identification of fossil remains. Bones of the leg, and determination of the metatarsal bone. Constancy of the numerical relations of the bones of the toes. Analogies of the spur. Peculiarities of the skeleton of the Ostrich. Mechanism of the flight of birds. Peculiarities of their muscular system connected with the motions of the bills, the claws, the head, the neck, the organs of voice and respiration.

Structure of the brain of Birds compared with that of Reptiles, and of Rodentia and Chiroptera, and with the embryo condition of that organ in man. Spinal cord, nerves of the face, and other parts of the nervous system. Condition of the organs of vision, hearing, and smelling in Birds, and also of taste and touch, considered in relation to their instincts and habits. Digestive organs of birds compared with those of other classes. Structure of the crop, ventriculus succenturiatus, gizzard, intestine, double cæcum-coli, cloaca, and varieties presented by these parts in different orders of birds according to the difference of the food. Condition of the lacteals and their contents in birds. Peculiarities of the circulating system. Use of the fleshy tricuspid valve. Venous circulation of the kidneys and liver. Complex respiratory apparatus of birds considered in relation to flight, temperature, irritability, migration, incubation, and singing. Secreting and excreting organs. Tegumentary organs of birds considered anatomically, physiologically, and zoologically. Consequences of the impeded development of the right ovary and oviduct throughout the class of birds. Development of the embryo. Nidification and rearing the young.

Organization of birds considered with relation to their zoological distribution. Methods of classification compared. System of Temminck explained and illustrated by specimens from the rich and extensive ornithological collection of the Society.

Order 1. Rapaces.

2. Omnivoræ.

3. Insectivoræ.

4. Granivoræ.

5. Zygodactyli.

6. Anisodactyli.

7. Alcyones.

8. Chelidones.

9. Columbæ.

10. Gallinæ.

11. Alectorides.

12. Cursoræ.

13. Grallatores.

14. Pinnatipedes.

15. Palmipedes.

16. Inertes.

CLASS REPTILIA.

Characters common to the Class. Division of the class into the orders—

- | | |
|--------------|-------------|
| 1. Chelonia. | 3. Ophidia. |
| 2. Sauria. | |

Illustrated by specimens.

1st Order—CHELONIA.

Composition and texture of the bones compared with those of other classes. Regions of the skeleton, as modified in the land, fresh-water and marine Chelonia. Elements of the cranial vertebræ remaining permanently detached, illustrated by a comparison with those of the human foetus. Structure of the occipital condyle with relation to the gradual passage of the articulation of the head from the basilar part of the bone to its condyloid portions, as we ascend in the vertebrate classes. Cause of the vertebral form and structure of the occipital bone. Reason why the head of the cold-blooded Vertebrata does not vary in its relative magnitude, according to age, as in the warm-blooded classes. Use of the extraordinary development of the parietal bones in Turtles. Advantage of the fixed condition of the tympanic portion of the temporal bone in Chelonia, as in the Crocodilida. Structure of the jaws, and various forms of the horny mandibles. Singular forms and articulations of the cervical vertebræ. Vertebræ of the trunk considered with relation to the consolidation of the carapace, the attachments of the ribs, and the protection of the spinal cord. Continuation of the ball and socket articulation through the sacrum to the extremity of the coccyx. Structure of the sternum, and variety presented by its nine elements in different genera of Chelonia. Ossified sternal appendices. Determination of the bones of the shoulder. Structure of the pelvis. Varieties presented by the bones of the arms and legs in the land and aquatic species.

Mechanism of respiration where the ribs and sternum are immovable. Muscular apparatus of swimming and walking compared. Vigour of muscular contractions compared with those of warm-blood animals. Structure and development of the spino-cerebral axis and nerves compared with that of birds and fishes. Peculiarities of the organs of the senses. Organs of vision compared with those of Birds, and of extinct and existing Sauria. Digestive and chylopoietic organs considered with relation to their different kinds of food. Circulation of Chelonia, systemic, pulmonic, hepatic, and renal. Structure of the lungs compared with that of other orders and of other classes. Magnitude of the cells of the lungs of Turtles, and of other Reptiles, considered with relation to their aquatic habits. Secreting and excreting organs. Tegumentary organs considered with relation to the low temperature of the blood, to their living habits, to their economical uses, and to the distinction of species. Arrangement of the genera of Chelonia. Characters and habits of the land, the fresh-water, and the marine species.

2nd Order—SAURIA.

Skeletons of Crocodiles, Gavials, and Alligators. Determination of the bones of the head, by a comparison with the centres of ossification of Mammalia. Small diameter of the cranial cavity compared with that of the head. Occipital condyle. Temporal fossa. Tuberculated surface of the bones of the face with relation to the living habits of the species. Fixed condition of the tympanic bone, of all the bones of the head and face, and of the teeth, contrasted with these parts in other Sauria and in Ophidia. Forms, structure, and growth of the teeth, with relation to the discrimination of recent and extinct species. Structure and peculiarities of the cervical vertebræ. Sternal apparatus compared with that of other Reptiles. Analogies of the abdominal ribs. Forms and positions of the pelvic bones. Skeletons of Monitors and other Lacertida contrasted with those of the Crocodilida. Ribs of the Flying Dragon. Hand of the Pterodactylus. Mechanism of respiration and of other vital movements of Sauria. Nervous system compared with that of Chelonia. Organs of the senses. Osseous laminæ of the sclerotic of recent and extinct Sauria. Varieties in the structure of the heart and distribution of the bloodvessels. Digestive organs in carnivorous and phytophagous Sauria. Analogies of the gizzard of Crocodilida. Varieties in the form and extent of subdivision of the lungs. Organization of Sauria with relation to their zoological distribution. Characters and history of the most interesting genera of the different families of Sauria.

3d Order—OPHIDIA.

Simple structure of the skeleton of Serpents compared with that of higher animals. Bones of the head compared with those of Lizards. Advantages resulting from the magnitude and separation of the tympanic bone, the separation of the lower jaws, and the numerous moveable articulations of the head of Serpents. Disposition of the teeth of innoxious Serpents in the upper jaw and palatine bones, illustrated by those of the Boa Constrictor. Structure of the poison-fangs, and disposition of the teeth in poisonous Snakes. Forms and secure articulations of the vertebræ. Object of the large transverse processes of the anterior coccygeal vertebræ. Advantages of the extensive motions of the ribs from want of a sternum in Serpents. Means of compensating for the want of atlantal and sacral extremities in Serpents. Rudiments of the shoulder and pelvic bones in some genera. Mechanism of creeping, hissing, leaping, strangling their prey, respiration, swimming, swallowing undivided prey many times the diameter of their own body. Nervous and vascular systems. Elongated forms of all their digestive and secreting organs. Analogies of the numerous ducts from their subdivided pancreas. Inferences from the constancy of their gall-bladder. Their lobed kidneys compared with the embryo condition of these organs in the most perfect Mammalia. Poison glands. The structure of Ophidia considered with a view to their systematic arrangement. Characters and habits of the most interesting genera of the different families of Serpents.

CLASS AMPHIBIA.

Varieties of external form in the animals of this class. Bones of the head compared with those of Reptiles and of Fishes. Changes in the form of the os hyoides during the metamorphosis of the larva. Cause and advantages of the non-development of the ribs. Remarkable changes in the structure of the bodies of the vertebræ during the growth of the tadpole. Absorption, anchyloses, and obliteration of the canal, of the coccygeal vertebræ. Sternal apparatus compared with that of recent and extinct Sauria. Bones of the shoulder compared with those of cartilaginous fishes and of reptiles. Moveable rib-like pelvis attached to a single vertebra. Structure of the extremities with relation to their aquatic habits. Structure of the tail compared in some with that of fishes, and in others with that of reptiles. Changes in the proportions of the hemispheres, optic lobes, and cerebellum, during the development of the tadpole. Entire double circulation in the tadpole, and remarkable changes in the vascular system during the absorption of the branchiæ, and the development of the lungs. New destination of the posterior branchial artery. Mechanism of respiration and structure of the lungs in different genera of Amphibia, considered with relation to their aquatic life. Analogies of the air-sacs of the *Proteus* with the air-bag of fishes and the lungs of higher Vertebrata. Mode of development of the branchiæ in the larva, and the new destination of the branchial arches on the disappearance of the branchiæ. External parts lost during the metamorphosis. Nakedness, sensibility, secretions, and respiration of the skin. Casting of the epidermis. Colours of the surface with relation to the living habits of the species. Economical and other uses of Amphibia. Distribution of the class. Characters of the orders—

1. Caducibranchia.

2. Perennibranchia.

Zoological distinctions and history of the most interesting genera and species of these orders.

CLASS PISCES.

On the study of Ichthyology considered zoologically and anatomically. First vertebrate condition of the various systems of human organization. Composition, texture, and general characters of the bones of fishes, compared with their embryo condition in the higher Vertebrata. Regions and general conformation of the skeleton in osseous and cartilaginous fishes. Structure of the skull in osseous fishes with relation to its centres of ossification, its squamous sutures, its surface for muscular and ligamentous attachments, and its cavity for the developed arachnoid, the organs of hearing,

the cerebral nerves, and the small brain lying at its base. Bones of the face determined and compared with those of other Vertebrata. Structure, various forms, and disposition of the teeth with relation to their food and defence. Relations and uses of the opercular bones, os hyoides, branchial arches, pharyngeal bones, sternum and bones of the shoulder. Structure of the vertebral column and parts developed from it, ribs, inter-spinous bones, and rays of the fins. Structure of the arms and legs, or pectoral and ventral fins compared with the corresponding parts in other classes. Peculiarities of the skeleton and parts of it in different orders of fishes, considered with relation to the various living conditions of the species.

Mechanism of respiration, swimming, flying, leaping, and various other motions of fishes. Conditions of the hemispheres, optic lobes, cerebellum, medulla oblongata, and cerebral nerves in different orders of fishes, and compared with their embryo condition in Mammalia and man. General distribution and varieties in the nervous and vascular systems. Enlargements of the vena cava, hepatica, and abdominalis. Valves of the auricle, ventricle, and bulbus arteriosus. Analogies of the bulbus arteriosus and various modes of distribution of the branchial artery. Varieties in the extent of the venous circulation through the kidneys and vena portæ. Nature, uses, and contents of the air-bag, its relations to hearing, swimming, respiration. Structure and uses of the electrical organs of many species. Organs of secretion and excretion compared with those of higher and lower classes. Composition, structure, mode of growth, and analogies of the scales of fishes, and the changes of colour they exhibit at different periods. Structure of fishes with relation to their zoological distribution. Ichthyological abbreviations explained. Classification of fishes, according to the last views of Baron Cuvier, explained. Characters and habits of the most interesting genera of the orders—

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|--------------------------------|--------------------------------|
| 1. Acanthopterygii. | 5. Lophobranchii. |
| 2. Malacopterygii abdominales. | 6. Plectognathi. |
| 3. M. subbrachiales. | 7. Chondropterygii operculati. |
| 4. M. apodes. | 8. Ch. tectibranchii. |

SECOND SERIES, OR SUB-REGNUM MOLLUSCA OR CYCLO-GANGLIATA.

General view of the characters, and the relations to each other, of all the classes of this great division of the animal kingdom, particularly as regards their skeleton and their nervous system. Connexions of the study of the molluscous classes, with geology,

zoology, physiology, and other sciences. Differences of organization and form which serve for the distribution of this series into the classes

Cephalopoda,
Pteropoda,
Gasteropoda,
Conchifera,
Tunicata,

illustrated by specimens and diagrams.

CLASS CEPHALOPODA.

Characters of the Class, and relations of the Cephalopods to Fishes and to the molluscos Invertebrata. Internal skeleton compared with that of Cyclostomatous Chondropterygii. Rudimentary vertebral column, occipital bone, and extremities. Relations of the calcareous and cartilaginous dorsal laminae to polythalamous shells. Structure, mode of growth, and position of the shell of the Sepia. Probable position of the inhabitants of polythalamous shells, from the structure of their shells, and the analogy of Gasteropoda. Mechanism of respiration, swimming, creeping, seizing prey, and other motions of Cephalopods. Structure and peculiarities of their nervous system and organs of the senses. Analogies of the ante-retinal pigment, ciliary processes, pedunculated eyes, cretaceous substance of the vestibule, and cephalic arms. Sheathed tentacula of Nautilus compared with those of Pteropoda and Gasteropoda. Structure of the digestive organs compared with that of Gasteropods, and with that of Reptiles and Birds. Calcareous dentiform mandibles of Nautilus, and horny bills of naked Cephalopods. Structure of the salivary, pancreatic and biliary organs compared with those of other classes. Termination of the hepatic ducts compared with that of other molluscos classes. Structure, uses, and relations of the ink-gland. Differences in the circulating system of the naked and testaceous Cephalopods. Appendix of the branchial hearts of the naked Cephalopods, and glandular sacs and perforations of the venæ cavæ. Position of the branchiæ compared with those of Gasteropods. Double branchiæ of Nautilus compared with those of Pectinibranchiate Gasteropods. Use of the power possessed by Cephalopods of changing the diameter of the coloured spots of the skin. Characters and history of the most interesting genera of the orders—

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|----------------------|------------------|
| 1. Cryptodibranchia, | 3. Foraminifera, |
| 2. Siphonifera. | |

Relations of the recent Foraminifera to Gasteropods in the want of cephalic arms, and in the imperfect separation of the chambers of the shell.

CLASS PTEROPODA.

Characters of the class and its affinities to the classes of Cephalopoda and Gastropoda. Structure, forms, and relations of the shells. Disposition of their œsophageal ganglia, compared with that of Gastropods and of testaceous Cephalopods. Fin-like organs of motion. Sheathed cephalic tentacula. Eyes. Structure and termination of the intestinal canal. Liver and salivary glands. Heart and bloodvessels. Positions and forms of the branchiæ. Characters, habits, and uses of the species belonging to the orders—

1. Thecosomata.

2. Gymnosomata.

CLASS GASTEROPODA.

Characters of the class, and variety of forms and organizations it comprehends. General forms and situations of the skeleton. Composition, structure, mode of growth, and parts of univalve turbinated shells. Development, causes of the revolution, and changes at maturity of these shells. Mechanism of respiration, creeping, swimming, prehension, retraction. Cilia of the embryo. Teeth of the tongue, proboscis, jaws, teeth in the stomach. Analogies of the operculum. Mode of growth and filling of spines on extravascular shells. Aperture, canal, umbilicus, upper and lower lip, apex, base, spire, columella, and other parts of univalves explained. Structure, disposition and nature of the supra-and infra-œsophageal ganglia. Distribution of the nerves. Structure of the organs of the senses. Circumstances which influence the position of the heart and respiratory organs. General structure of the heart and its valves. Analogies of the systemic auricle and ventricle of Gastropoda. Distribution of the bloodvessels, systemic, pulmonic, and branchial. Structure and positions of the respiratory organs with relation to the zoological distribution of the genera. Remarkable varieties of structure in the digestive organs of carnivorous and phytophagous species. Structure, position, and relations of the salivary, pancreatic, and biliary organs, compared with those of vertebrate and articulated classes. Principles of classification and characters of the orders of Gastropoda, illustrated by specimens. History of the most interesting genera of the following orders :—

1. Pulmonata.

5. Nucleobranchia.

2. Nudibranchia.

6. Pectinibranchia.

3. Inferobranchia.

7. Scutibranchia.

4. Tectibranchia.

8. Cyclobranchia.

CLASS CONCHIFERA.

Characters of the animals inhabiting bivalve shells. Composition, structure, mode of growth, and parts of bivalve shells. Growth and mode of advancement of the extravascular epidermis and ligament. Functions of the ligament. Laws of the periodical development of spines and processes on the exterior of the extravascular shells of Conchifera, and their mode of formation. Structure of the hinge and teeth of bivalves and multivalves. Nature and growth of pearls, mother-of-pearl or nacre, Byssus. Mechanism of respiration, creeping, and swimming. Muscles of attachment and foot of Bivalvia, and mode of advancement of the muscular impressions and muscles of attachment. Disposition of the ganglia and nerves. Labial appendices or tentacula. Structure of the digestive organs. Analogies of the hepatic ducts. Structure and distribution of the circulating system. Structure of the branchiæ, and analogies of the permanent vibratile cilia. General structure compared with that of other classes, and considered with relation to classification. Characters of the orders,

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|----------------|-----------------|
| 1. Monomyaria, | 3. Brachiopoda, |
| 2. Dimyaria, | 4. Rudista, |

illustrated, and history of the most interesting species. Destruction of strata by Pholades. Formation of shelly strata. Commerce of pearls. Ravages of the Teredo.

CLASS TUNICATA.

Structure of tunicated Mollusca compared with that of Conchifera. Analogies, structure, and uses of the exterior tunic and muscular sac. Motions of respiration, retraction, swimming. Ganglia, nerves, and tentacula. Digestive organs, and hepatic lobes and ducts. Circulating system. Structure and position of the heart and pericardium. Branchial sac. Peculiarities of structure in the compound Tunicata. Luminosity and movements of the Pyrosoma. Characters and history of the genera of the orders—

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| 1. Ascidaria. | 2. Salparia. |
|---------------|--------------|

 THIRD SERIES, OR SUB-REGNUM ARTICULATA OR DIPLONEURA.

General considerations on the articulated classes of Animals, and on the characters common to this division taken from the nervous system, the organs of circulation, the locomotive organs, and the general form of the body. Differences of structure, on which are founded the distinctions of the classes—

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|---------------|----------------|
| 1. Crustacea. | 5. Annelida. |
| 2. Arachnida. | 6. Cirrhopoda. |
| 3. Insecta. | 7. Rotifera. |
| 4. Myriapoda. | 8. Entozoa. |

Affinities of the Entomoid and Helminthoid Classes of Animals.

CLASS CRUSTACEA.

Characters of the class. Composition, structure, mode of formation, periodical shedding and renewing, colouring of the surface, and various parts of the skeleton of Crustacea. Formation of new epidermis and colouring matter within the old shell. Structure of the articulations, and general disposition of the muscles. Cerebral, abdominal, and sympathetic ganglia. Structure and disposition of the nerves. Development of the nervous system in the embryo of the Decapoda, and in the permanent forms of that system in the inferior orders. Structure of the ear or vestibule, compound eye, and antennæ. Structure of the mandibles, maxillæ, palpi, feet, and abdominal appendices. Convertibility of these organs. Digestive and secreting organs. Structure of the heart, and circulating system in the Decapoda. Development of this system in the Decapoda compared with the permanent forms in inferior orders. Characters of distinction taken from the organs of motion and of respiration, and from the shell. Subdivision of the Malacostracous and Entomostracous Crustacea into the orders—

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|----------------|------------------|
| 1. Decapoda. | 5. Isopoda. |
| 2. Stomapoda. | 6. Branchiopoda. |
| 3. Amphipoda. | 7. Pœcilopoda. |
| 4. Læmodipoda. | 8. Trilobita. |

Characters and habits of the interesting genera of these orders. Economical and other uses of Crustacea. Parasitic species. Ravages of the *Limnoria terebrans* on the British coasts. Affinities of Crustacea to Vertebrata.

CLASS ARACHNIDA.

Characters of the class. Skeleton and external parts of Scorpions and other Arachnida contrasted with those of Crustacea. Conditions of the nervous system and organs of the senses. Varieties in the extent of development of the circulating system. Respiration of the pulmonated, tracheated, and aporobranchiate Arachnida. Structure of the digestive organs and liver. Poison-instruments, cephalic and caudal. Filamentous secretions of Spiders. Structure and habits of the principal genera of the orders.

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|---------------|-------------------|
| 1. Pulmonata. | 3. Aporobranchia. |
| 2. Tracheata. | |

CLASS INSECTA.

Characters and relations of the class. Skeleton and external conformation. Analogies and changes of the several parts. Metamorphoses of insects. Muscles of the larva. Muscular system of the imago compared with that of Crustacea. Mechanism

of respiration, flying, creeping, swimming, stinging, mastication, sucking. Nervous system of the larva. Changes effected in the structure and disposition of the ganglia and nerves during the changes to the perfect state. Varieties in the extent of concentration of the nervous system in perfect Insects, and analogies of its different parts. Organs of the senses. Structure of the compound eyes. Structure and forms of the digestive and glandular organs in the larva, pupa, and imago states, in Mandibulate and Sucking species. Analogies of the insect conditions of the salivary, pancreatic, hepatic, renal, and other secreting organs. State of the circulating system at different periods of life. Structure of the heart and uses of its median and lateral valves. Distribution of the blood through the external and internal parts. Structure of insects with a view to classification. Last classification of Latreille. Characters and history of the orders, illustrated according to the following table :

1st Division.—*APTERA*. Without wings.

(^a) No metamorphosis.

1. *Order*—*THYSANOURA*.

2. *Order*—*PARASITA*.

(^b) With complete metamorphosis.

3. *Order*—*SIPHONAPTERA*.

2nd. Division.—*ALATA*. With wings.

(^a) *ELYTROPTERA*. With elytra.

* With Mandibles and Maxillæ.

4. *Order*—*COLEOPTERA*.

5. *Order*—*DERMAPTERA*.

6. *Order*—*ORTHOPTERA*.

** Without Mandibles or Maxillæ.

7. *Order*—*HEMIPTERA*.

(^b) *GYMNOPTERA*. Without elytra.

* With 4 wings.

8. *Order*—*NEUROPTERA*.

9. *Order*—*HYMENOPTERA*.

10. *Order*—*LEPIDOPTERA*.

** With 2 wings.

11. *Order*—*RHIPIPTERA*.

12. *Order*—*DIPTERA*.

CLASS MYRIAPODA.

Character and general structure of Myriapods contrasted with those of Insects and Arachnida. Structure and relations of the external parts. Permanent forms of the

nervous system compared with the embryo-forms in higher articulated classes, and with the forms in Annelida and Entozoa. Eyes, antennæ, palpi. Digestive, circulating, respiratory and secreting organs. Characters and history of the genera belonging to the orders—

1. Chilognatha.

2. Chilopoda.

CLASS ANNELIDA.

Affinities of the Helminthoid classes to each other, and to those possessed of articulated members. Characters of the red-blooded worms. Composition, structure and mode of formation of the calcareous, sandy and flexible exterior tubes. Organs of motion. Nervous system and organs of the senses. Organs of circulation, digestion, and secretion. Varieties of the respiratory organs with relation to the subdivisions of the class. Characters and habits of the genera of the orders—

1. Cephalobranchia.

3. Cryptobranchia.

2. Dorsibranchia.

CLASS CIRRHOPODA.

Characters of the class, and affinities of the Cirrhopoda to the Annelida and entomostracous Crustacea. Structure, composition, and growth of the shells. Lateral maxillæ. Articulated, ciliated cirrhi. Sub-abdominal series of ganglia. Dorsal heart. Lateral branchiæ. Analogies of the structure of the liver, and its mode of communication with the stomach. Characters and history of the genera of the orders—

1. Pedunculata.

2. Sessilia.

CLASS ROTIFERA.

Characters of the class and affinities of these minute animals to the other Helminthoid classes. Structure, function, disposition, and analogies of vibratile cilia. Structure of the cerebral and œsophageal ganglia. Distribution of the abdominal nervous cord. Eyes with red choroid. Lateral maxillæ. Dorsal ramified artery with colourless blood. Various forms of the alimentary canal and their analogies with those of Annelida. Analogies of the two glandular lobes opening near the head. Structure and nature of the tubes of the covered species. Characters and habits of the genera of the orders—

1. Nuda.

2. Loricata.

CLASS ENTOZOA.

Characters, structure and affinities of Entozoa. Organs of attachment, suction, and locomotion. Muscular and nervous systems. Antennæ and eyes. Circulation in vessels. Various forms of the digestive organs. Zoological distribution of intestinal worms. Characters and history of the genera of the orders—

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|--------------------|---------------|
| 1. Entomoida. | 4. Trematoda. |
| 2. Nematoidea. | 5. Cestoidea. |
| 3. Acanthocephala. | 6. Cystica. |

FOURTH SERIES, OR SUB-REGNUM RADIATA OR ACTIN-NEURA.

General considerations on the radiated division of the animal kingdom, and on the characters and affinities of the classes it comprehends. Division of the Radiata into the classes—

Echinoderma.
Acalepha.
Polypifera.
Porifera.
Polygastrica.

CLASS ECHINODERMA.

Characters of the class. Composition, structure and mode of growth of the exterior shells, teeth, alveoli, spines and other hard parts. Gradations of form. Tubular feet, respiratory tubes and vessels, tentacula, pedicellariæ. Structure and distribution of the nervous system. Circulation in vessels. Internal organs for aquatic respiration. Various forms of the digestive organs. Powers of reproduction. Divisions of the class. Characters and history of the genera of the orders—

- | | |
|---------------|-----------------|
| 1. Echinida. | 4. Holothurida. |
| 2. Asterida. | 5. Apoda. |
| 3. Crinoidea. | 6. Anthoidea. |

CLASS ACALEPHA.

Characters and organization of the Acalepha. Composition, structure and mode of growth of the internal calcareous laminæ. Mechanism of locomotion, respiration,

imbibition. Structure of cilia and tentacula. Distribution of the nervous system in Beroë. Air-sacs of Physalida. Different forms of the alimentary cavity and its ramified appendices. Luminosity and stinging property. Cilia, motions, and bright colours of the gemmules. Characters and history of the genera of the orders—

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| 1. Aphysaria. | 2. Physaria. |
|---------------|--------------|

CLASS POLYPIFERA.

General characters and organization of Zoophytes. Structure and mode of growth of the calcareous and horny external and internal skeletons. Various forms of the skeleton. Organization and vital properties of the general fleshy body, and its connexion with the skeleton. Structure and various forms of the polypi, and their connexion with the body of the Zoophyta. Tentacula, cilia, cells, vesicles. Growth, forms, properties, motions, and development of the reproductive gemmules. Geographical distribution, economical and other uses, and zoological classification of polypiferous animals. Characters and living habits of the genera of the orders—

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|-----------------|----------------|
| 1. Calamoida. | 4. Retiformia. |
| 2. Corticifera. | 5. Vaginata. |
| 3. Lamellifera. | 6. Carnosa. |

CLASS PORIFERA.

Characters and organization of Poriferous animals. Forms, structure, and arrangement of their horny, calcareous, and siliceous parts. Structure and vital properties of the general fleshy body. Pores, canals and vents. Formation, escape, motions, cilia, structure and development of the gemmules. Geographical distribution, economical and other uses, and zoological distinctions of poriferous animals. Characters and history of the genera of the orders—

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|---------------|--------------|
| 1. Keratosa. | 3. Halinida. |
| 2. Leuconida. | |

CLASS POLYGASTRICA.

Characters, organization and vital phenomena of infusory animalcules. External appendices, vibratile cilia. Various forms of the digestive organs. Stomachs, intestine, cæca. Circulation in vessels. Eyes with red choroid. Often monocular. Taste acute.

Reticulate granular ovaria. Fissiparous, gemmiparous, oviparous and ovo-viviparous.

Division of the class into the orders —

1. Anentera.

2. Enterodela.

Characters and habits of the species, their geographical distribution, and their uses in the economy of nature.

Concluding observations on the unity of plan, discoverable in the organization of the whole animal kingdom.