P5

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LECTURES

— ON —

INVERTEBRATE ZOOLOGY

GIVEN BEFORE THE STUDENTS OF

CORNELL UNIVERSITY.

BY

PROF. J. HENRY COMSTOCK.

ITHACA,
ANDRUS & CHURCH.
1886.

Wm. A. White,
Cornell University,
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ZOOLOGICAL CLASSIFICATION.

Necesssity for classification owing to the wonderful variety of animals. Aim of naturalists to work out a natural classification, one which will express the relations of organisms to each other. Popular attempts at natural classification. *Ex.* Birds, Beasts, Fishes, Insects.

Zoological classification regarded by many naturalists as merely a convenience. They believe that only the individual exists in nature. This follows logically from the theory of Evolution. For our purposes it makes little difference whether the theory be true or false if we will remember, what is undoubtedly true, that it is difficult to exactly define groups on account of intermediate forms.

Different kinds of groups. Names and sequence of these. Animal Kingdom, Branches or Sub-Kingdoms, Classes, Orders, Families, Genera, Species, (*Varieties*), Individual.

The criteria of these groups are not well settled.

Species.—In general a species is a collection of individuals which resemble each other as closely as the offspring of a single parent. As a rule the pairing of sexes of different species will not be fertile. But many hybrids are known. Hybrids are very liable to be sterile.

Ex.—Pitch Pine, White Pine, Norway Pine. (Plants are used for illustration in this connection on account of the probable greater familiarity of the members of the class with plants than with animals).

Genera.—Genus is the term applied to the next higher group than a species. Usually a genus is a collection of species which resemble each other in all of the more important characters and differ in only what are known as specific characters. But there are genera which contain only a single species.

Ex—Pines (*Pinus*), Oaks (*Quercus*).

Families.—A family is the next higher group than a genus.

Ex.—The Pine Family (*Abietineæ*) includes the pines (*Pinus*), the spruces (*Abies*), and the larches (*Larix*).

Orders.—An order is the next higher group than a ~~genus~~ family.

Classes.—A class is the next higher group than a ~~family~~ order.

Branches.—A branch or sub-kingdom is one of the principal divisions of the animal kingdom, and is the next higher group than a class.

ZOOLOGICAL NOMENCLATURE.

The nomenclature now employed by zoologists and botanists was introduced by Linnaeus (Carl von Linné), a Swede, who lived from 1707 to 1787.

The following are some of the more important rules of this nomenclature :

The name of a species must consist of two words and only two, one indicating the genus to which the species belongs, and the second used to designate that particular species.

The name of a group may be followed by the name of the author who first described that group.

The names must be Latin in form.

Only those names are recognized which are defined in some published work.

A name once given must be permanently retained, with the following exceptions:

(a). *Specific* names published before 1766.

(b). Changes due to subdivision of groups.

(c). A generic name which has been used before in zoology or botany, or a specific name which has been used before in the same genus.

BIBLIOGRAPHICAL REFERENCES.

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BRANCH PROTOZOA.

πρῶτος, first; ζῶον, animal.

Animals generally of minute size; composed of a nearly structureless jelly-like substance, termed sarcode or protoplasm; without organs or tissues composed of distinct cells; having no definite body cavity; presenting no trace of a nervous system: and having either no differentiated alimentary apparatus or but a very rudimentary one.

I. Class Rhizopoda.

(ῥίζα, root; πούς, foot.)

The Rhizopoda are Protozoa which possess the power of giving out pseudopodia, and which are not enveloped in a membrane and have no mouth. Many Rhizopods are furnished with either a calcareous shell or a flinty skeleton. The following named forms will serve as illustrations of this class:

Protamoeba primitiva Haeckel.—Found in fresh water, in mud, among decayed leaves. When transferred to the microscope it commonly appears as a homogeneous plasma ball, .03 mm.—.04 mm. in diameter (1 mm.=.0397 inch). If undisturbed it flattens; and its diameter increases to .06 mm. Blunt cone-shaped or wart-shaped projections soon appear. These are *pseudopodia* (singular, *pseudopodium.*) In Protamoeba there are seldom more than five or six pseudopodia; and they are always short and simple. The whole body is absolutely structureless and homogeneous; there is no division of it into ectosarc and endosarc. Mode of nourishment probably as in *Protomyxa*. Protamoeba reproduces by the simplest mode of non-sexual reproduction, *i. e.*, by division without being preceded by a passive state.

See Haeckel in Quarterly Journal of Microscopical Science, Vol. IX, p. 219–222;

Protomyxa aurantiaca Haeckel.—This species appears as red flakes on the surface of certain marine shells (*Spirula*). Diameter of body .12 mm.–.2 mm. The active adult is irregular in form and possesses forked and anastomosing pseudopodia. Sarcode currents. Manner of nourishment. Vacuoles. Sensation. Artificial division. Concrescence. Four phases in mode of reproduction: 1. The reticulated state. 2. The encysted state. 3. The free swimming flagellate state. 4. The creeping state.

See Haeckel, *l. c.*, p. 34–42, 113–123.

Amoeba proteus.—This species is common in the superficial ooze of ponds and ditches almost everywhere, both in the Old World and the New. They are often found on the under surface of leaves of aquatic plants floating on the surface of the water. Form. Pseudopodia. Division of body into ectosarc and endosarc. The endosarc may contain: 1, granules and granular corpuscles; 2, food balls; 3, minute crystals; 4, nucleus; and 5, contractile vesicle. Different theories respecting the function of the contractile vesicle. Reproduction: 1, by fission; 2, by the separation of a pseudopodium. Compare Amoeba with the colorless blood-corpuscles of the higher animals. Note that contractile vesicles have been observed in the colorless blood corpuscles of Amphibia (Huxley, Anat. of Invert., p. 86).

See Nicholson, p. 30–32 and especially Leidy, Fresh Water Rhizopods, p. 35–55, plates I, II.

Diffulgia.—The species of this genus differ from Amoeba in having the body inclosed in a case composed chiefly of grains of sand. The case is open at one end, and the pseudopodia are protruded from this aperture.

See Leidy, *l. c.*, p. 95–128, plates X–XIX.

The shelled Foraminifera.—Organisms found in chalk, sand, Nummulitic limestone, etc., and in the ocean. Forms of shells. Old ideas concerning their place in the animal kingdom. Nucleus. Results of deep sea dredging. Manner of growth of compound shells. Distribution in space and in time. The part Foraminifera have played in the history of the globe.

See Leidy, *l. c.*, p. 14–19; Nicholson, 33–37. Examine the plates in Carpenter, Introduction to the Foraminifera, and in Wiliamson, Foraminifera.

Actinophrys sol.—This is the common sun-animalcule. See Leidy, *l. c.*, p. 235–241, Plate XL.

II. Class Infusoria.

The infusoria are so called because they are found in infusions. They are Protozoa of definite form, with an outer membrane which bears cilia or flagella or both. The body is usually composed of three distinct layers, and is furnished with a mouth and short gullet.

Paramecium.—Form. Body consists of three layers. Cilia. Locomotion. Disc. Mouth and gullet. Contractile vesicles. Nucleus. Taking of food; its circulation; and the ejection of the indigestible matter. Reproduction, 1, by fission; 2, by conjugation.

See Nicholson, p. 46, 47.

Vorticella.—These are the so-called Bell-animalcules. Form of body and stalk. Compare with *Paramecium.*

Noctiluca miliaris.—This is a representative of the flagellate Infusoria. Form of body. Phosphorescence. See Huxley, Anatomy of Invertebrated Animals, p. 91.

BRANCH COELENTERATA.

κοιλος, hollow; *ἔντερον*, intestine.

This branch includes the animals which are sometimes termed *Zoöphytes* on account of their resemblance in form to plants. This resemblance is merely superficial. The Coelenterata are animals having a body composed of many cells, and of radiate structure, and in which the alimentary canal is not completely separated from the body cavity. The radiating parts of the body are usually four or six or some multiple of one of these numbers.

This branch includes four classes: *Spongia*, *Anthozoa*, *Polypomedusae*, and *Ctenophora.*

I. Class Spongia.

(*Spongia*, a sponge).

This class includes the Sponges. That which is commonly called a sponge is merely a skeleton. Appearance of a living sponge. Diagram illustrating the structure of a sponge. Each of the cells lining the cavities of the sponge resembles an Amoeba or a Monad, each containing a nucleus and one or more contractile vesicles, and being able to take into its interior foreign substances. Hence the opinion formerly held that sponges were compound Protozoa.

The zoological rank of sponges is best indicated by their development. This may be divided for convenience into the following stages: 1. Fertilization of a true egg by genuine zoosperms; both eggs and sperm cells arising from the middle germ layer (mesoderm). 2. Total segmentation of the yolk, or protoplasmic contents of the egg. 3. The formation of an embryo in which the cells become separated into two kinds, a few remaining round, forming the entoderm, the majority becoming long and ciliated, forming the ectoderm. 4. The embryo becomes sessile, the mesoderm separates from the entoderm, spicules are developed in the mesoderm, a gastrovascular cavity is formed, an exhalant osculum and inhalant side openings appear, and the true sponge characters are assumed.

The simplest form of a sponge is a hollow, vertical cylinder, fastened by its base, with the osculum opening upwards from a central gastro-vascular cavity and with many lateral inhalant pores. The body consists of three layers of cells: an outer layer (ectoderm), an inner layer (entoderm), and a middle layer (mesoderm). The inner layer consists of ciliated cells, which possess a surprising degree of individuality. In the mesoderm is developed a framework of horny fibre, or of siliceous or calcareous spicula, which support the body. This simple form is seldom seen except in young individuals; from it is usually developed a compound organism. The skeleton of a sponge may be either horny, siliceous, or calcareous. In one order there is no skeleton.

Nicholson, p. 39–44; Huxley, Anat. of Invert., p. 102–110.

II. Class Anthozoa.

ἄνθος, flower; ζῷον, animal.

To the Anthozoa belong the creatures commonly called Polyps. This class is the *Actinozoa* of authors.

Take a sea-anemone (*Actinidae*) *as a type of the class:*—External form,—cylindrical outline, base, disc, mouth, tentacles. Internal structure,—walls of the body composed of an outer layer or membrane, the *ectoderm*, an inner layer or membrane, the *entoderm*, and an intermediate tissue, the *mesoderm*, division of body into compartments, six principal septa (mesenteries), development of other septa, extension of chambers into tentacles,—muscular fibres of the mesoderm. Contraction and expansion of body. Size. Color. Habitat. Keeping specimens in aquaria. Preparation of specimens for preservation by picric acid. Locomotion of sea-anemone. Mode of taking nutrition, thread cells, craspeda or mesenterial filaments. Modes of reproduction, fission, budding at side, sexual reproduction, reproductive organs internal, attached to mesenteries, young escape sometimes as planula, sometimes as small sea anemones. Reproduction of lost parts.

Nicholson, p. 84–87.

Characters of the Anthozoa.—Coelenterata in which the digestive cavity is suspended within the body cavity but communicates freely with it. The body cavity is divided into a number of vertical compartments by a series of partitions (mesenteries), to the faces of which the reproductive organs are attached. There is usually a fixed mesodermal calcareous skeleton. Some Anthozoa are simple; but most of them are compound.

The term polyp is applied to the single individual of a simple Anthozoön or to the separate zoöids of a compound Anthozoön.

The Anthozoa comprises three orders: *Rugosa*, *Alcyonaria*, and *Zoantharia*.

1. Order Rugosa.—To this order belong certain fossil corals, with numerous, symmetrically arranged septa, which are in multiples of four. Not discussed in this course.

2. Order Alcyonaria.—Anthozoa in which each Polyp is furnished with eight fringed tentacles, and eight mesenteries. The mesenteries do not become calcified.

The following named genera will serve as illustrations of the principal variations in structure which occur in this order:

Alcyonium.—Commonly called "Dead-men's-fingers." Compound. (In most of the Anthozoa the simple polyp gives rise by budding to many zoöids which form a coherent whole, termed *zoanthodeme;* ζῶον, animal; ἄνδος, flower; δέμας, body.) Form of zoanthodeme,—a thin crust or an elevated irregularly lobed mass, with stellate pits or protruding polyps scattered over the surface. Form of polyp. Coenosarc (κοινός, common; σάρξ, flesh), spicules, canals. Muscular system. Thread cells.

See Pouchet-et Myèvre, Journal de l'Anatomie, 1870, p. 285–315.

Penatula.—"Sea pens." Zoanthodeme more or less feather-like in form (Nicholson, fig. 28, p. 91). Base naked, serves as a support in sand or mud. Internal skeleton in form of a simple rod.

Corallium rubrum.—"Red coral." Form of Zoanthodeme. Central calcareous axis. Coenosarc,—longitudinal canals,—superficial, irregular, reticulated canals,—spicula. Relation of coral to body of polyp.

Corallium rubrum is a representative of the family *Gorgonidae.* Many members of this family are well known as sea-fans or sea-shrubs. The axis of the zoanthodeme may be calcareous, as in the red coral; or horny, as in the common sea-fans and sea-shrubs; or alternately horny and calcareous, as in *Isis.*

Tubipora.—"Organ-pipe-coral." Each polyp secrets a calcareous tube. These tubes are nearly parallel, and are joined at intervals by horizontal plates.

ORDER ZOANTHARIA.—Anthozoa in which the polyps are furnished with smooth, simple, usually numerous tentacles, which, like the mesenteries, are six or some multiple of six.

This order is divided into three sections:

1. *Antipatharia.*—Polyps usually with only six tentacles and a horny skeleton (not discussed in this course).

2. *Actiniaria.*—Non-coral making Zoantharia. Here belong the sea-anemones already described. Note other forms of sea anemonies. Association of sea anemones with other animals.

3. *Madreporaria.*.—Coral making Zoantharia. Relation of coral to body of polyp. Absence of base. Modes of reproduction. Forms of coral communities as resulting from different modes of increase or growth. Distribution in latitude and in depth. Rate of growth of corals. Formation and growth of coral reefs and islands.

III. Class Polypomedusae.

The class *Polypomedusae* includes those Coelenterata in which there is no digestive cavity suspended within the body cavity. The mouth opens directly into the body cavity; which serves as a digestive cavity also. Usually the reproductive organs are external; and in most cases the reproduction is by medusae or by medusoid buds.

The Polypomedusae comprises three orders; *Hydromedusae*, *Siphonophorae*, and *Scyphomedusae*.

1. ORDER HYDROMEDUSAE.—This order includes *Hydra*, the Hydroids, and certain medusae closely related to the Hydroids.

Hydra.—Habitat. Form and structure,—cylindrical outline,—disc-shaped base or sucker,—mouth,—tentacles,—absence of stomach,—ectoderm and entoderm,—mesoderm (?),—thread cells. Mode of nourishment. Reproduction by budding. Sexual reproduction. Reproduction of lost parts.

See Nicholson, p. 57–60.

The coral making Hydroids.—(1). *Millepora*,—secretion of coral. Former views as to zoological position. Structure of coral,—spongy mass traversed by tortuous canals,—numerous pores opening on surface (hence name),—arrangement of pores in circular groups in certain species. Two forms of zoöids, long tentacle-like ones (dactylozoöids) and shorter mouth bearing ones (gasterzoöids). Structure of zoöids,—absence of mesenteries. Union of zoöids. Formation of coral. Sexual reproduction not yet observed.

(2). *Stylaster.*—Closely allied to Millepora. Note form of coral.

The Tubularian Hydroids.—(See *Corynida*, Nicholson, p. 60–66). Closely related to Hydra; but differ in manner of reproduction. Some are simple; but the majority are compound. They are fixed. The coenosarc usually develops a firm outer layer or polypary, which, however, is never so prolonged as to form little cups in which each nutritive zoöid is contained. Different forms of hydrosoma.*

Modes of reproduction: 1. By simple budding. 2. By the production of generative buds. These generative buds differ greatly in different species. Three kinds may be distinguished: 1, simple closed sacks; 2, bell-shaped buds, or medusoids; 3, freely swimming medusae, or jelly-fishes.

The Campanularian Hydroids.—(See *Sertularida*, Nicholson, p. 66–69). In these the nutritive zoöids are invariably protected by little cup-like expansions of the polypary. Note form of hydrosoma in *Campanularia;* also in *Sertularia.*

There are certain jelly-fishes which resemble in their more important structural characteristics the medusae produced by various Hydroids; but which produce young which develop into jelly.fishes without passing through a hydroid stage. These are classed as one of the sub-orders (*Trachymedusae*) of the *Hydromedusae.*

2. Order Siphonophorae.—This order includes the forms of life commonly known as Oceanic Hydrozoa. The

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* In the Polypomedusae the entire compound organism developed from a single ovum is termed the hydrosoma (ὕδρα, hydra: σῶμα, the body); each zoöids is termed a polypite.

hydrosoma is free swimming; and consists of a contractile stem bearing zoöids which differ greatly in form and function. In addition to nutritive and reproductive zoöids, some forms are furnished with locomotive zoöids, (swimming bells), covering pieces (reduced medusoids) and dactylozoöids. The principal end of the stem is often terminated by a flask-like air sac. See Nicholson, p. 70–73. Packard, 68–70.

3. ORDER SCYPHOMEDUSAE.—In this order are included the larger jelly-fishes known as Acalephs. These in the adult state always have four or eight groups of gastral filaments. The reproductive elements are always developed from the entoderm. The young are not hydroids; but are polypites which give rise to medusae by transverse fission or develop the reproductive elements directly.

Take *Chrysaora* as type of this class. See Nicholson, p. 79–80, Fig. 23.

IV. Class Ctenophora.

Medusae of globular, cylindrical, or rarely ribbon-like form. They are freely swimming marine animals which never become compound by budding. They are furnished with eight vertical meridianal series of comb-like locomotive organs; and usually with two long tentacles which may be withdrawn into sacs. The body cavity is usually if not always furnished with two aboral openings. See Nicholson, p. 93–94.

BRANCH ECHINODERMATA.

(*ἐχῖνος*, hedge-hog; *δέρμα*, skin.)

Radiate animals with integument composed of numerous calcareous plates joined together, or leathery and having grains, spines, or tubercles of calcareous matter developed in it. Alimentary canal suspended in a distinct abdominal cavity, from which it is completely shut off. Nervous and water vascular systems well-developed. No lasso-cells. In these highly organized animals it is not possible to recognize in the adult the two fundamental cell layers, ectoderm and entoderm. They still appear, however, in the embryo.

Take a sea-urchin as a type of the branch. External anatomy,—test or shell,—plates,—ambulacral areas,—inter-ambulacral areas,—tubercles,—spines,—oral region,—aboral region,—genital plates,—ocular plates,—growth of plates and spines,—pedicellariae. Internal anatomy,—alimentary canal,—nervous system,—reproductive system,—ambulacral tubes,—madreporic plate,—madreporic canal,—circumoral canal,—polian vesicles,—radial canals,—pedal vesicles (ampullae),—tube feet.

The Branch *Echinodermata* includes four classes *Crinoidea*, *Asteroidea*, *Echinoidea*, and *Holothuroidea*.

I. Class Crinoidea.

The body is spherical or cup-shaped ; and is generally fixed by a jointed stem. A few species are free in the adult state. Wall of body composed of many plates. Body furnished with jointed, simple or branched arms. Arms bear lateral expansions termed pinnulae. Tube-feet in the form of tentacles. Furrows on arms and disk. Cilia. Mouth. Vent. Distribution of Crinoids in time.

II. Class Asteroidea.

The body is flattened and pentagonal or star-like in outline. This class is divided into two orders :

1. ORDER STELLERIDEA.—This order includes the star-fishes. These are star-shaped Echinoderms in which the arms, normally five in number, are true prolongations of the body and contain lobes of the stomach. No test but a coriaceous integument in which are imbedded calcareous pieces. No teeth. Sometimes no vent. Mode of taking food. Ambulacral grooves. Tube feet. Madreporic plate. Bilateral symmetry of body. Compare star-fish with sea-urchin. Internal anatomy:—Digestive system,—folds of stomach,—hepatic coeca, a pair attached to the aboral wall of each ray,

—communication of hepatic coeca with stomach. Reproductive organs, two in each ray; and their ducts may be traced into the sides of the interradial partitions. Ambulacral or water vascular system,—ampullae or pedal vesicles, within the body,—radial water tube, on ectal surface,—circumoral tube,—madreporic canal. Nervous system, on lower or outer surface of circumoral and radial water tubes.

2. ORDER OPHIURIDEA.—The members of this order are known as "brittle stars." They are Echinoderms resembling star-fishes, with long snake-like arms not forming prolongations of the disk and containing no portion of the viscera except the nerve cords and ambulacral vessels. Arms five in number, simple or branching. Ambulacral furrow covered by a series of plates. Tube-feet projecting from the sides of the arms. No vent. Power of self mutilation.

III. Class Echinoidea.

The body is globular, heart-shaped, or disk like, with a solid shell of immovable plates. The surface of the body is clothed with spines which are attached by a movable articulation. The sea-urchin already described is a type of this class. Note other forms. Compare star-fish and sea-urchin.

IV. Class Holothurioidea.

These animals are commonly called "sea-cucumbers." They are Echinoderms which are worm-like, or plano-convex in form. The integument is leathery, sometimes with imbedded calcareous spicules, mouth surrounded with tentacles which are usually retractile. Caudal end of body with vent. Note form of alimentary canal, respiratory tree, water vascular system, and modes of respiration.

BRANCH VERMES.

(*Vermis*, a worm.)

The worms are bilaterally symmetrical animals, with the body composed of similar segments, without jointed legs.

In the classification which has been adopted for the arrangement of specimens in our museum, the Vermes includes the *Scolecida* and the *Anarthropoda* as given in Nicholson's Text book of Zoology. As will be seen by reference to the text books, this branch includes a vast number of forms differing widely in structure. The time at our disposal will admit of our discussing only a few of the more important species. The species selected are those which directly affect the welfare of man.

I. Tape Worms.

Taenia solium (The Pork Tape-worm of Man).—Adult state known only in man. Adult 10–15 ft. or more in length; 800 or more joints. Form of head, neck, and joints. Independent life of the free joints. Eggs $\frac{1}{694}$ inch in diameter. Development of embryo in either hogs or man. Formation of cysts, "measles," in various organs but especially in the muscles, liver, brain, eyes, lungs, and heart. Development of adult from the cystic state.

Taenia mediocanellata (The Beef Tape-worm of Man).—Worm longer than *T. solium* (20 ft.). Head furnished with neither central proboscis-like prominence nor hooks. Joints thicker, having a plump look, instead of being thin and flat. Cysts much smaller than those of *T. solium*, seldom larger than a small pea. Young cattle more liable to be infested with them. This species can live only a year in the cystic state ; if not liberated, it then dies. The adult worm if left undisturbed will live ten or twelve years constantly dropping joints.

In this country persons generally obtain this parasite by eating dried beef and Bologna sausages uncooked. The best and perhaps only sure evidence of tape-worm is the passage of the joints from the intestine.

By a study of the above-named species of tape-worms, we learn that they exhibit in their development the following series of stages : 1. Ovum in all stages. 2. Six-hooked embryo or boring larva. 3. Resting or encysted larva. 4. Immature tape-worm in all stages. 5. Sexually mature tape-worm colony. 6. Free-joint or segment.

Taenia echinococcus.—This in the adult state infests dogs. Its young are the hydated tumors of man, sheep, and cattle. The most dangerous of all tape-worms. Adult state found in dogs and wolves; very small, one-eight inch long with only three sexual joints; but thousands of them often live together in the intestine of one dog. The young are the hydatid tumors found in the liver, lungs, kidneys, or other parts of man, sheep, and cattle. These cysts or tumors become compound by budding either upon the outside or inside or both, sometimes becoming as large as a child's head. Formation of the heads of the future tape-worms. When the cysts are swallowed by a dog each head becomes a perfect worm.

Summary of development of *Taenia echinococcus:* 1. Ovum in all stages. 2. Six-hooked embryo or boring larva. 3. Hydatid tumor (a roundish cyst or membranous sac, enclosing a watery fluid). 4. Formation of secondary and tertiary cysts by budding. 5. Development of tape-worm heads attached to the cysts. 6. Development of young tapeworms in the alimentary canal of dog. 7. Sexually mature tape-worm colony (only three sexually perfect zoöids). 8. Free-joint or segment.

II. Round Worms.

Trichina spiralis.—The most dangerous of all human parasites. In the larval state, it lives in the muscles of man, swine, dogs, cats, rats, mice, rabbits, and many other animals; and in the mature state it inhabits the intestines of the same animals.

Summary of development of *Trichina spiralis:* 1. Ovum, which is developed within the uterus of the mother. 2. Wandering embryo. 3. Encysted state. 4. Development of adult.

The gape-worm of chickens and the vinegar-eel are closely allied to Trichina.

For good accounts of the parasites observed in this lecture see *Entozoa*, by T. Spencer Cobbold, and *The Internal Para-*

sites of Domestic Animals, by Prof. Verrill, in Report of the Conn. Board of Agri. for 1869.

BRANCH ARTHROPODA.

(ἄρθρον, joint ; πού'ς, foot.)

This branch includes a part of the great assemblage of species which was known as the *Branch Articulata*.

The articulate type is an elongated cylinder composed of many rings. The alimentary canal is central, the circulatory system, when present, dorsal, and the nervous system ventral.

By variations in the number, size, form, and grouping of the rings, or segments, and their appendages are produced all the forms of Articulates.

The Arthopoda includes those Articulates which have jointed appendages (*i. e.* antennae, jaws, maxillae, palpi, and legs), articulated to the body.

I. Class Crustacea.

This class includes those Arthropoda which breathe by true gills.

Take cray-fish as type of class. Body invested by a strong shell or exoskeleton which is the product of the subjacent epidermis. Exoskeleton consists of layers of membrane which remain soft and flexible in the interspaces between the segments of the body and limbs but are rendered hard and dense elsewhere by the deposit of calcareous salts. Molting of exoskeleton. Division of body into cephalothorax and abdomen. Each segment, except the last, bears a pair of appendages. Number of segments in the cephalothorax is most easily determined by counting the appendages. The appendages of the cephalothorax are one pair each of eye-stalks, antennules, antennae and mandibles, two pairs maxillae, three pairs maxillipedes, one pair chelae, and four pairs ambulatory legs. The abdomen bears six pairs of swimmerets. The caudal segment which bears no appendages is called the telson. Reproduction of lost parts. Mouth. Vent. Eyes. Auditory organ. Openings of reproductive organs ; those of the male in the last thoracic legs ; those of the female in the last but two of the thoracic legs. Modified swimmerets of male. Stalked eggs. Branchiae. Circulatory system. Alimentary canal, mouth, stomach, teeth, liver, intestine. Reproductive organs. Nervous system.

The class Crustacea includes a large number of species; among which are found great variations in structure. The class is consequently divided into many subordinate groups. The characters of these groups can not be given in this course. A few forms illustrating the more striking variations in structure will be briefly discussed.

I. Entomostraca.

1. ORDER PHYLLOPODA.—The Phyllopod Crustacea are so called on account of their broad, leaf-like feet. They are minute creatures living in fresh or brackish water. Body usually covered by a large carapace. This in many species is bent down so as to form two shell-like valves. Valves sometimes connected by a true hinge and adductor muscle. Most species live in pools liable to dry up in summer. The eggs remain in the dry earth of the bottom of the ponds till the autumn rains refill them.

2. ORDER OSTRACODA.—In this order are included minute crustacea which, like the Phyllopods, have bivalve shells; but differ from them in the form of their feet. *Cypris* is a common fresh water genus. Nicholson, p. 136, fig. 56, a.

3. ORDER COPEPODA.—This order includes other minute crustacea many of which live in fresh water. The members of this order do not possess shell-like expansions of the carapace. *Cyclops* is a very common and well known genus. Nicholson, fig. 56, c.

4. ORDER CIRRIPEDIA.—The members of this order are known as Barnacles. For figures and descriptions see Nicholson, p. 139.

II. Malacostraca.

1. ORDER ARTHROSTRACA.—The sow-bugs or wood-lice are probably the most familiar representatives of this order. Nicholson, p. 133, fig. 52.

2. Order Thoracostraca.—The cray-fish already studied and the lobster are familiar examples of this class. Here belong the Hermit Crabs, and the marine forms commonly known as crabs.

III. Gigantostraca.

1. Order Merostomata.—This order includes certain fossil species some of which are of great size.

2. Order Xiphosura.—The King Crab or Horse-shoe Crab is a representative of this order.

II. Class Arachnoidea.

(*αραχνη*, spider; *εῖδος*, form.)

Air breathing Arthopoda in which the head and thorax are united so as to form a cephalothorax. There are no antennae, only one pair of maxillae, and only four pairs of legs.

1. Order Linguatulida.—This order includes elongated vermiform animals, the bodies of which in the adult state, are divided by close-set transverse constrictions, into numerous short segments, and bear no appendages except two curved hooks on each side of the jawless mouth. The Linguatulida exhibit a parasitism very similar to that of tapeworms, being found in the sexless condition in the lungs and liver of herbivorous mammals and of reptiles, and in the sexual state in the nasal cavities of Carnivores. See Huxley Anat. of Inv., pp. 334-336.

2. Order Acarina.—This order includes the mites. These are Arachnoidea in which there is no separation between the abdomen and thorax. The mode of life of the different members of this order varies greatly. Some are parasitic; the Itch mite, and the various Ticks are examples of this. Others attack living plants, as the "Red Spider" which infests house plants. Many of those which live upon plants form galls. Many species feed upon decaying animal or vegetable matter, thus acting as scavengers.

3. Order Araneida.—In the spiders the abdomen is sac-like, being rounded and presenting no distinct division into segments. It is joined to the thorax by a slender pedicil.

4. ORDER PHALANGIIDA.—In this order the abdomen is segmented and broadly joined to the thorax. The legs are very long and slender; and there is no spinning apparatus. The Harvest-men or Grandfather-gray-beards, are the most common representatives.

5. ORDER PEDIPALPI.—This order includes the Whip-scorpions. None are found in the northern part of the United States.

6. ORDER SCORPIONIDEA.—The scorpions are easily recognized by the large forceps-like maxillae, and the segmented abdomen which is prolonged into a slender tail. At the caudal extremity of the body is a powerful sting.

7. ORDER PSEUDOSCORPIONIDEA.—The Pseudoscorpions resemble the scorpions in form except that there is no tail-like prolongation to the abdomen. They are small animals, which are found in dark places, frequently in houses. They are said to feed on mites.

8. ORDER SOLIFUGAE.—Not discussed in this course.

III. Class Malacopoda.

(μαλακός, soft; πούς, foot.)

Air breathing Arthropoda with elongated worm-like bodies, and many legs. The integument of the body and appendages is soft. The head is not separate from the body. Respiratory system consists of numerous simple spiracular openings with isolated tracteal twigs. This class includes a single genus *Peripatus*.

IV. Class Myriopoda.

(μυριος, numberless; πούς, foot.)

Air breathing Arthropoda in which the head is distinct from the thorax, and the thorax and abdomen form a continuous region, with from six to two hundred segments, each bearing a pair of legs. This class inlcudes the Centipedes and Millipedes.

V. Class Hexapoda.

(ἕξ, six: πούς, foot.)

Air breathing Arthropoda with distinct head, thorax, and abdomen, one pair of antennae, two pairs of maxillae (the second usually so united as to form a lower lip to the mouth), six thoracic legs, and usually wings.

The members of this class are commonly known as Insects. The study of insects is termed Entomology. There will be a course of two lectures per week during the spring term on this subject, and a more extended course during the summer vacation.

BRANCH MOLLUSCA.

(*Mollis*, soft.)

The Mollusks are bilaterally symmetrical Invertebrates, in which the body is not divided into segments.

This branch includes the animals properly known as clams, oysters, snails, slugs, cuttle-fishes, squids, and other allied forms. It comprises three classes.

I. Class Lamellibranchiata.

(*Lamella*, a plate ; *βράγχια*, gills.)

This class is represented by clams, mussels, oysters, and other "bivalve mollusks." The name of the class was suggested by the form of the respiratory organs. These animals have no distinct head, no teeth. The body is bilaterally symmetrical; and enclosed in a bivalve shell. There are one or two leaf-like gills on each side of the body.

Take a clam as type of the class : Shell,—valves, hinge,—hinge ligament,—beak,—lines of growth,—three layers, (epidermis, prismatic, pearly),—muscular impressions,—pallial line,—siphonal impression. Mantle, bilobed, one lobe in each valve,—united along dorsal line,—ventral edges of lobes free,—band of small mantle muscles attached to pallial line. Branchial chamber. Siphons. Foot Gills. Labial palpi. Mouth. Muscles,—anterior adductor,—posterior adductor,—anterior foot retractor,—posterior foot retractor. Rectum and vent. Pericardium. Heart,—ventricle,—auricles, aortic bulb. Minute structure of gills. Liver. Kidney (Organ of Bojanus). Nervous system.

Growth of shell. Formation of pearls. Uses of foot. Formation of byssus. Reproduction. Various forms of Lamellibranchs.

II. Class Gastropoda,

(γαστήρ, belly; ποῦς.)

This class is represented by snails, slugs, etc. These animals have a distinct head, which bears tentacles, eyes and ears. The mouth is furnished with paryngeal teeth and a lingual ribbon (odontophore). The body is naked in some; but usually it is furnished with a shell which consists of a single piece (univalve); in one group (Chitonidae) the shell consists of a number of pieces, not exceeding eight, arranged in longitudinal series along the middle line. Locomotion effected by creeping about on the flattened under surface of the body.

Take a snail as type of the class:—Shell. Foot. Head. Tentacles. Eyes. External orifices of body (mouth, vent, opening of reproductive organs, opening to respiratory cavity, opening of slime gland). Liver. Respiratory chamber. Circulatory system. Slime gland. Reproductive organs. Alimentary canal. Nervous system.

III. Class Cephalopoda.

(κεφαλή, the head; πους.)

This class includes the squids, cuttle-fishes, Pearly Nautilus, Paper Nautilus, etc. They are mollusks with eight or more arms placed in a circle around the mouth. Mouth armed with jaws and a toothed tongue. Two or four plume-like gills. In front of the body a muscular tube (funnel) through which is expelled the water which has been used in respiration. An external shell in some, an internal skeleton in others. The Cephalopods are all marine, carnivorous, and possess considerable powers of locomotion.

Take a squid as type of the class: Form of body,—head, —eyes,—arms,—acetabola or suckers,—mouth, beak,—fin, —muscles of fin,—olfactory organ,—margin of mantle,—mantle chamber,—siphon,—internal skeleton or pen,—attachment of mantle to dorsal wall of body,—dorsal mantle cartilages,—two siphonal cartilages,—lateral chambers,—funnel-shaped ventral chamber (siphon),—valve at external opening of siphon,—attachment of head to mantle by a neck composed chiefly of four large muscles,—ganglia stellata, —rectum,—anus and its ear-like valve,—ink bag,—opening of reproductive organs,—gills,—circulatory system (branchial hearts, branchial arteries, branchial veins, systemic heart, venae cavae),—cartilaginous cranium,—brain.

Various forms of squids and cuttle-fish. Uses of squids and cuttle-fish for food on the Mediterranean coast and in China, and for bait on our own coast. Cuttle-fish bone. Sepia.

The Argonaut or Paper Nautilus (*Argonauta argo*).

The Pearly Nautilus (*Nautilus pompilius*).

Spirula.

Ammonites.

Orthoceras.

BRANCH MOLLUSCOIDEA.

(The Mollusk like animals.)

Like the Mollusca the members of this branch are bilaterally symmetrical Invertebrates, in which the body is not divided into segments. In the Molluscoidea the body is usually fixed to some object; there is either a crown of ciliated tentacles around the mouth, or a pair of coiled arms which bear ciliated tentacles.

Doubts respecting the zoological position of this Branch.

I. Class Polyzoa or Bryozoa.

(πολύς, many, ζῶον, animal; βρύον, a kind of mossy sea-weed, ζῶον.

Animals minute, compound, growing in communities of cells. Cells merely united externally. Different forms of colonies. The single polyzoon is termed a polypide.

Structure of a polypide. Alimentary canal suspended in a double-walled sac, from which it may be partially protruded by a process of evagination and into which it may be again retracted by invagination. Mouth surrounded by a circle or crescent of hollow ciliated tentacles. Anus situated near the mouth. Nervous system consisting of a single or double ganglion situated between the mouth and vent, with nerves proceeding from it. Hermaphroditic. Reproduction by budding and by eggs.

Habitat. Modes of nourishment. Avicularia. Compare Polyzoa with Hydroids.

II. Class Brachiopoda.

(βραχίων, arm ; πούς, foot.)

This class includes the Lamp shells. Animals simple; furnished with bivalve shell. All marine ; many in deep water ; many fossil. Importance of this class Palaeontologically. Nearly two thousand fossil species. Formerly classed with Mollusca on account of shell. Structure of animal allied to Polyzoa. Shell with valves dorsal and ventral. Valves unequal. Ventral valve usually largest ; and often with perforated beak for passage of muscular stalk. In some cases the stalk simply passes between the valves. In other cases the shell is attached by surface of one valve. The valves of the shell are equilateral. Note that the valves of the shell of an ordinary bivalve mollusk are right and left, are usually of the same size, and are inequilateral. In the Brachiopods the valves of the shell are articulated by teeth and sockets or are jointed by muscles alone. Valves lined with expansions of integument, the mantle lobes. The viscera occupy a small space near apex of shell. This space is partitioned off. The remainder of the cavity is nearly filled with a pair of coiled arms. Arms arise from a cartilaginous base, and bear ciliated tentacles. In some genera the arms can be unwound and protruded. In many other genera the the arms are supported by loop-like processes of the dorsal valve. The tentacles or cirra on the arms are used to convey food to the mouth. They are also respiratory, there being a rapid circulation of blood in each tentacle, which is hollow and communicates with the blood sinus or hollow in each arm. The mantle is also respiratory. Digestive system with one or two openings. Liver very large. Nervous system with ganglia above and below alimentary canal. The sexes distinct.

BRANCH TUNICATA.

(*Tunica*, a tunic.)

This Branch includes the Tunicates or Ascidians. These animals are characterized as follows: The alimentary canal suspended in a double walled sac, but not capable of protrusion and retraction. Mouth opening into the bottom of a respiratory sac, whose walls are more or less completely lined by a network of blood vessels. An imperfect heart in the form of a simple tube open at both ends. Usually hermaphroditic. Animals simple or composite.

THE ORIGIN OF SPECIES.

INTRODUCTION.

The general interest felt in the question of the Origin of Species. Object of this lecture merely to state certain theories respecting this question, and a few of the more important reasons that have led to the adoption of these theories. Time at our disposal too short for a discussion. Division of the subject of the lecture into three heads.

I. EVOLUTION.

Long ago naturalists began to believe that the higher forms of animals and plants had been developed from lower forms. Goethe in Germany, Dr. Erasmus Darwin (the grandfather of Charles Darwin) in England, and Geoffroy Saint-Hilaire in France, came to this conclusion about the same time, 1794–95. But the first naturalist whose conclusions respecting this matter excited much attention was Lamarck (1801, 1809, 1815). The doctrine of evolution has gained ground until now the great majority of eminent naturalists accept it.

The facts which have led to the acceptance of this theory are found in each of the principal departments of Biology.

1. The mutual affinities of organic beings.

Examples.—Difficulties in establishing systems of classification arising from presence of intermediate forms. The identity of plan of structure of homologous organs (limbs of Vertebrates, mouths of insects). The close resemblance of different species belonging to the same genus (oaks, pines). Rudimentary organs (rudimentary mammae of the males of Mammalia, rudimentary lobe of a snake's lung, teeth in foetal whales, and teeth which never cut through the gums in the upper jaws of calves).

According to the theory of special creation, we can only say that these facts are so; that it has pleased the Creator to construct all the animals or plants of each great class on a uniform plan. According to the theory of evolution, these affinities indicate community of descent.

2. The embryological relations of organic beings.

Examples.—The identity of the first phases of development of all animals above the Protozoa. The resemblance at a later stage of embryos of very different animals. The fact that embryos of higher animals pass through stages which seem to correspond to the adult condition of the lower forms (branchial fissures and vascular arches of the human embryo, metamorphoses of Amphibians, gills of the embryo of Salamander atra).

3. The geological succession of organic beings.

Examples.—Appearance first of lowest forms, and then successively of higher forms. Eozoon is the oldest fossil; Algae (Fucoids) are the oldest plants; Worms and Crustacea were the first Articulates; and fishes were the first Vertebrates. What was the necessity for this sequence in rank if species were created independently?

4. The geographical distribution of organic beings.

Examples.—Insufficiency of climatic and other physical conditions to account for the similarity and dissimilarity of the inhabitants of various regions.

"In the southern hemisphere, if we compare large tracts of land in Australia, South Africa, and western South America, between latitudes 25° and 35°, we shall find parts extremely similar in all their conditions, yet it would not be possible to point out three faunas and floras more utterly dissimilar. Or, again, we may compare the productions of South America south of latitude 35° with those north of 25°, which consequently are separated by a space of ten degrees of latitude, and are exposed to considerably different conditions, yet they are incomparably more closely related to each other than they are to the productions of Australia or Africa under nearly the same climate. Analogous facts could be given with respect to the inhabitants of the sea."

II. Natural Selection.

There are many theories to explain the way in which species have originated. The most noted one is the Darwinian theory of Natural Selection.

It is due Mr. Darwin to state that he was not merely a theorist, but one of the greatest naturalists that the world has ever known.

The theory of Natural Selection has been briefly stated as follows:

1. "Every kind of animal and plant transmits a general likeness with individual differences to its offspring."

2. "Every individual may present minute variations of any kind and in any direction."

3. "Past time has been practically infinite."

Note formation of beds of chalk and of Nummulitic limestone; Agassiz's estimate of the age of the coral reefs of Florida; formation of stratified rocks, the estimated thickness of which is twenty miles.

4. "Every kind of animal and plant tends to increase in a geometrical progression."

Note number of seeds produced by a single plant, or of eggs produced by a single animal.

5. "Every individual has to endure a very severe struggle for existence, owing to the tendency to geometrical increase of all kinds of animals and plants, while the total animal and vegetable population (man and his agency excepted) remains almost stationary."

6. "Thus, every variation of a kind tending to save the life of the individual possessing it; or to enable it more surely to propogate its kind, will in the long run be preserved, and will transmit its favorable peculiarity to some of its offspring, which peculiarity will thus become intensified until it reaches the maximum degree of utility. On the other hand, individuals presenting unfavorable peculiarities will be ruthlessly destroyed. The action of this law of Natural Selection may thus be well represented by the convenient expression, "Survival of the Fittest."

Examples.—Strength to procure food and overcome enemies. Fleetness. Development of hair. Long neck of giraffe. Nectaries of flowers. Colors of flowers.

Sexual Selection.—The result of this is not death to the unsuceessful competitor, but few or no offspring.

Examples.—Horns of stags. Spurs of cocks. Mandibles of males of stag beetles. Beautiful colors of male birds. Songs of male birds.

Mimicry and other Protective Resemblances among Animals.

Examples.—Colors of desert animals. Colors of polar animals. Animals which are white only in winter. Forms and colors of certain Floridian grasshoppers. Flies which resemble bees or wasps. Apathus and bumble-bees. Form and attitudes of rove-beetles (Staphylinidae). Katydid and leaf. Limenitis disippus and Danais archippus. Specimens of L. dissippus from Florida which resemble in color Danais berenice.

III. Objections to the Theory of Natural Selection.

1. That Natural Selection is incompetent to account for the incipient stages of useful structures.

As bearing on this note the following points: [*a*] The probable change in function of organs during the development of the species (lungs of higher Vertebrates developed from a swim bladder; tracheae of insects, from dermal glands; and wings of insects from tracheae. Thus indirectly the wing of an insect may have been developed from a dermal gland). [*b*] The different uses to which the same organ is put by different animals (anterior limbs of Vertebrates and especially those of birds, as the logger-headed duck, the penguin, the ostrich, and the Apteryx.

2. Absence or rarity of transitional varieties.

Note that according to the theory of Natural Selection the common progenitor of two forms is not necessarily *directly* intermediate between them; that species with transitional grades of structure are less likely to be preserved as fossils, from their having existed in lesser numbers; and the poorness of our Palæontolgical collections.

3. It is frequently urged that we do not know of a single case in which a new species has been developed.

The instances in which two or more forms that were at one time considered to be specifically distinct have been found to be connected by a series of varieties are innumerable. It is answered that such forms are not "good species." This kind of reasoning would uphold the theory of special creation so long as a single organized being was known between which and all other organisms every connecting link had not been found.

Man has been able to produce from the same form by artificial selection varieties of animals or plants which, if found in Nature, would not only be considered specifically distinct but would be placed in a different genus. It is claimed by some that all these varieties, if left to themselves, would revert to the original stock. Improbability of this in certain cases, as fowls. The non-reversion of the great herds of horses in South America. The hybridity of certain domestic animals as the ox. To which of the three aboriginal species would our cattle revert? "The variety which has been evolved in Paraguay from our domestic cat pairs no longer with its ancestral stock, nor does the tame European guinea-pig with the wild ancestral stock of Brazil."

Would not, however, the reversion of a species in consequence of a reversion in the conditions of the environment be in accordance with the theory of Natural Selection, rather than in opposition to it?

4. That the theory is unchristian and necessarily atheistic.

As bearing on this point, the members of the class are earnestly advised to read *The Warfare of Science*, by President White.

"In all modern history, the interference with science in the supposed interest of religion, no matter how conscientious such interference may have been, has resulted in the direst evils both to religion and to science—and invariably. And, on the other hand, all untrammeled scientific investigation, no matter how dangerous to religion some of its stages may have seemed for the time to be, has invariably resulted in the highest good of religion and of science."

Works of Reference.

Charles Darwin—The Origin of Species.
—The Variation of Animals and Plants under Domestication.
—The Descent of Man.
—The Expression of the Emotions in Man and Animals.
Alfred Russell Wallace—On Natural Selection.
Oscar Schmidt—Descent and Darwinism.
St. George Mivart—The Genesis of Species.