m = 14, Si. Cu. Cd. and one of Mendelejeff's hypothetical ones.

m = 15 only Antimony, 120.

m = 16 S. Te. Hg.

m = 17 Se. Ce.

m = 20 Ca. Zr.

It must be remembered that with this large value for m, only three or four calculations are possible without obtaining numbers quite beyond any known atomic weights; for instance, when m = 20, only three calculations can be made, two of which are atomic weights.

With 66 serial computations, 49 elements are determined; 74 per cent. and more than that if Mendelejeff's hypothetical elements may be counted.

If there be any underlying truth in this theory of calculation, then the conception of the elements will be much simplified, for it will dispense at once with complexity in the atom, and substitute a common form for all, differing arithmetically from each other in size and velocity. The only conception I have of the term m corresponding to *mass*, is a relative *volume* of ether in rotation with certain velocity.

TUFTS COLLEGE, MASS. A. E. DOLBEAR.

RECENT ADDITIONS TO THE E. M. MUSEUM AT PRINCETON COLLEGE.

HENRY F. OSBORN, S. D.

The E. M. Museum of Geology at Princeton has recently purchased Messrs. Ward & Howell's well-known collection of fossil animals and plants. Under the partial supervision of these gentlemen the collection has been unpacked and hastily arranged in the cases, and as it has never been fully displayed before, it now appears to very great advantage and possesses peculiar interest. The east wing of the museum already contains the collections made by the Princeton western parties during the summers of 1877 and '78. These include several hundred specimens of fossil insects preserved in the delicate Miocene shales of Florissant, Colorado, and leaves from the same neighborhood. The former have already passed into the hands of Dr. Scudder for identification. Still more valuable is a large collection of fossil leaves from Strata closely overlying the Lower Eocene Lignitic Beds, near Black Butte, Wy. Terr. These have been studied by Dr. Lesquereux; he pronounces them of great novelty as contributing largely to our knowledge of the extent of the Eocene Flora, and they will form the subject of a special memoir to be published by the museum.

Among the western Vertebrate collections are nearly complete skeletons of various members of the Dinocerata family, parts of which have been figured and described in bulletins from the museum. These, together with numerous specimens of *Palæosyops* and allied genera, from the now classical beds of the Henry's Fork and Bitter Creek country, Wy. Terr., together with a great variety of carnivorous, rodent, lemurine and perhaps insectivorous forms, many of which are undescribed, give an admirable idea of the fauna inhabiting the Lower Eocene. In addition to these are many complete turtles and remains of lizards, snakes and birds. Representing the Miocene is a collection from Colorado including widely different forms. Prof. Cope, who has kindly glanced over the whole collection, pencil in hand, pronounces several of these forms new to science.

The Ward collection is, however, of much greater value to the general student, as it includes representative specimens from almost every age and country—from the disputed *Eozoon canadense* of the Laurentian to the Post Pliocene cave bear and Irish elk. It is the result of seventeen years of intelligent travel, purchase and selections. Mr. Ward's theory being to perfect the collection by constantly substituting the best obtainable examples of each type, not aiming at a complete series for each age, but giving a synoptic view from the dawn of life upwards. In this he has succeeded, we have little doubt, far beyond his own expectations at the outset, and although his catalogues have made this collection familiar to many palæontologists in this country, it well deserves a brief description here.

The Silurian corals, crinoids and trilobites fill the first cases. The latter are very fine. Among them is the outline of an *Asaphus gigas* indicating an animal over 12 inches long. On large stone slabs are other Crustacea, *Eurypterus* and *Pterygotus*. These are the earliest of a series represented in the Jurassic by a fine collection from the Solenhofen Beds and throughout by numerous Trilobites. The Solenhofen crustacea include, among others, *Peneus, Glyphea, Eryon, Limulus, Æger*, and a very perfect *Megachirus*, while from the English chalk are some fine fossil crabs, *Enoploclytea, Hoploparia*, etc.

The remains of Devonian Ganoids are very numerous; *Osteolepis, Cheirolepis, Pterichthys, Cephalaspis* and other genera characteristic of the middle and lower Devonian. Most interesting, however, is a fine block containing a number of *Holoptychii* from the old red sandstone, which specimen comes direct from Hugh Millers's collection. From the Lias beds of Lyme Regis are well preserved specimens of *Dapedius, Lepidotus, Eugnathus* and others varying in length from one to three feet. There are fish remains from each epoch. The Solenhofen beds have furnished a very beautiful group, including *Cakuras, Lepidotus, Leptolepis, Aspidorhynchus* and others, imbedded in a clear yellow shale.

There are fine examples of *Lepidodendron* and *Sigillaria* from the English, Prussian and American coal measures; also, many ferns. Among these are perfect remains of *Sphenopteris* and *Pecopteris* from the Scottish coal measures, with a full series from Mazon Creek, Illinois. The fossil flora throughout is numerous, with good collections from the German, Italian and French Tertiary deposits.

From the Jurassic are eleven entire Saurians marked for their exceptional beauty, rather than great size. An *Icthyosaur*, over 11 feet in length, is the largest of a number of skeletons of this genus, and is finely preserved. One complete skeleton and several parts give a very correct idea of *Plesiosaurus*. A head of *Mistriosaurus* complete, rare in this country. From the Wurtemburg Lias is a large *Teleosaur* with the ventral scales in position. There is also a humerus of *Pliosaurus*. Besides these are many fragments; the ossified Sclerotic of Icthyosaurus and parts of the neck, pelvic and shoulder girdles affording a complete study. Probably belonging to the saurians, too, are the so-called bird tracks from the Triassic sandstone of the Connecticut River Valley, including tracks assigned to *Brontozoum, Anisopus* and other genera. Also of the five-toed *Cheirotherium*, supposed to mark the steps of *Labyrinthodon*.

The Echinoderms can be studied almost without interruption. In the earlier crinoid series are *Periechocrinus* and *Pentacrinus* from the older strata. The latter are represented beautifully and in profusion from the Lyme Regis locality, England. Among later forms are *Apiocrinus* and Eucrinus Lilliiformis, a rare specimen from the Brunswick Muschelkalk. In the Echinoid series are perfect specimens of *Periaster, Holaster* and *Hemiaster*, in addition to many others. Beautiful specimens of *Asterias* and *Astropecten* and *Ophiorderma* from the English Lias represent in part the Star Fishes.

The Cephalopods are a great feature of the collection,

beginning with *Endoceras, Gyroceras, Phragmoceras* and others characteristic of the Silurian merging into the more elaborate and coiled *Goniatites, Nautilus* and *Orthoceratites* of the Carboniferous, and into these forms and the *Ammonites* in the Cretaceous. The latter appear in great elegance and profusion from the Lias. In this and the two succeeding ages in which this family reached its maximum the Ammonite and Nautilus group are represented by a number of genera. The series closes in the multiplicity of Cretaceous forms *Ancyloceras, Crioceras, Scaphites, Hamites, Toxoceras* and many others. A heavy slab covered with Trigonia is noticeable among the Lamellibranchs. But a mere enumeration of these series and other Invertebrates that have not been mentioned gives but an inadequate impression of their value as a typical collection, which rests so largely, not upon their number but upon their exceptional perfection and completeness.

From New Zealand are the recent struthious birds, the collection containing many incomplete skeletons of *Meinornis, Dinornis* and *Palapteryx*, and completing the series are three fine Moas, one of them standing 8 feet high. There are important remains of *Halitherium, Titanotherium* and *Rhinoceros*, the latter from the Black Hills. From the Pleistocene shell marl underlying the peat beds near Limerick is a tall Irish elk, *Megaceros Hibernicus*, quite rare in this country. A cave bear from the south of France is one of the most perfect specimens that has been found. It is mounted complete, the ribs and a few vertebræ alone having been restored. These, with a large mastodon from Hudson, N. Y., a skull of Bos Primigenius, and many scattered Mammalian remains give an admirable idea of the Post Pliocene fauna of Europe and America.

The east wing of the museum is almost entirely filled by the collection. It contains no plaster, but the originals of over 130 of Ward's series of casts. It reflects the greatest credit upon the intelligence and energy of its collector. It will come into immediate service in connection with a lately instituted course of lectures upon Palæontology, and give new impetus to the general interest in Biology at Princeton.

THE CLASSIFICATION OF SCIENCE.

REV. SAMUEL FLEMING, LL. D., PH. D.

II.

PRINCIPLES OF CLASSIFICATION.

Science may be properly classified with respect to either the order and facts of nature, or the laws of thought and methods of obtaining the knowledge of facts. In respect to the first basis, the classification may proceed upon the twofold method of arranging the order and laws of phenomena, separately considered, or of considering these in their immediate connection. And while either special method involves the complex process of nature, which is the province of philosophy in the discovery of laws,—the object of classification is to set forth the order of facts and laws which have already been discovered. It is a statement of their connections as brought within the scope of observation, as they stand in their completeness of order, while many facts may still remain unknown. Processes are continually going on in the physical realm, as exhibited in the heavens and in the earth. It is hence not a statement of historical development of each particular science, nor of the body of sciences. It is not an arrangement according to the chronological order of discovery of the facts. It is not a curriculum or course of study for discipline and acquisition. Such a course is arranged with reference to a harmonious development of mind, and requires the prosecution of diverse studies pursued simultaneously. Yet a proper classification proceeds upon the method of arranging or grouping the subordinate sciences according to both the order of philosophic inquiry, and of the subordination of facts and principles to the divisions and uses of science from the lower to the higher, and from phenomena to laws and applications.

Further, any scheme of clasification, founded upon material existences and relations irrespective of the immaterial entities which give qualities and motion to the material, must be radically defective. The fact of an order of succession in respect to the modification of the primary Force which inheres in matter, is too obvious to need more than a statement of the fact. Thus, in organic existence, the all-related force of Gravity is *general*, being applied to all bodies, whatever their constituents or mode of combination, while modified forms of this principle are limited to specializations. As at every step in the gradation of material existences, the order of nature is from the inorganic to the organic, so these terms involve the general and the special, and the addition proceeds from the lower and more general forms of force to the higher, more limited and special. Thus, also, in organic being we find Life as a common or general substance or entity, forming the basis of the general division of science denominated Biology. The lowest specialized form of life pertains to Botany,—the science of organic unconscious vegetal life, including many classes; the next higher pertains to Zoology, which is the science of that form of organic life, which has consciousness and animation, including many classes, and subordinate orders, kinds and species. The highest in gradation of being pertains to Anthropology, the science of the form of organic life which is conscious and rational, limited to mankind. In every higher order a new capacity has been added. It has been a "life unto life."

This natural order of classification from generals to specials, and from the lower to the higher, may be illustrated by the following diagrams, commencing with the lower, or gravitation, as in reading the scheme of classification accompanying this paper:

Life, { Man=organization+sensation+rational mind. / Animal=organization+consciousness and sensation. / Plant=organization.

Force, { Special: Chemical affinity. / Special: Cohesion. / General: Gravitation.

The fundamental distinctions of this classification are those which pertain to the body of sciences included in the scheme given. They are first, *Ontology*, the science of being, or the material or immaterial substances, qualities and attributes of universal being. This properly includes not only the general divisions given, but those which relate to the superior orders of being not given, viz.: Angeology, Christology and Theology. A classification of all Science, therefore, embraces these subjects. Ontology includes three general divisions: Cosmology, Biology and Anthropology. These are arranged in their natural order, as based upon the succession of immaterial or spiritual entities united with their respective material forms. Such order is essentially *serial*: in other words, there is a gradation of existences, as just noticed, and as indicated by the branch and group-descriptive terms given in the body of the scheme, as *Physico-dynamic*, etc.

Each general division includes its subordinate divisions or departments. Cosmology, the science of inorganic nature, includes three departments: Physical, Mechanical and Chemical Philosophy. The general term, Dynamology, formed upon the Greek etymon *dunam*, is used to designate the science of the immaterial principle, Force, as Biology designates the science of the vital principle, or Life. Biology and Anthropology include the several branches or departments as given. Individuals of a group are allied by some mode, principle or law distinguishing them from others in special respects.