SCIENCE

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CONTENTS:

The American Association for the Advancement of Science:—

The History of Ichthyology: PRESIDENT DAVID STARR JORDAN 241

Joint Meetings of the Geological Society of America, Section E, and the National Geographic Society: DR. F. P. GULLIVER 258

Dr. J. G. Cooper: PROFESSOR WM. H. DALL. 268

Scientific Books:—

Ostwald's Principles of Inorganic Chemistry: PROFESSOR H. L. WELLS. *New Textbooks in Physics:* PROFESSOR W. LEC. STEVENS 269

Societies and Academies:—

Research Club of the University of Michigan: PROFESSOR FREDERICK C. NEWCOMBE. 272

Discussion and Correspondence:—

Six New Species: F. H. KNOWLTON 273

Geological Excursions in the Pittsburgh Coal Region: AMADEUS W. GRABAU 274

Scientific Notes and News 276

University and Educational News 280

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*THE HISTORY OF ICHTHYOLOGY.**

SCIENCE consists of human experience, tested and placed in order. The science of ichthyology contains our knowledge of fishes, derived from varied experience of man, tested by methods or instruments of precision and arranged in orderly sequence. This science, in common with every other, is the work of many men, each in his own field, and each contributing a series of facts, a series of tests of the alleged facts of others, or some improvement in the method of arrangement. As in other branches of science, this work has been done by sincere, devoted men, impelled by a love for this kind of labor, and having in view, as 'the only reward they asked, a grateful remembrance of their work.' And in token of this reward it is well sometimes, in grateful spirit, to go over the names of those who made even its slight degree of completeness possible.

We may begin the history of ichthyology with that of so many others of the sciences, with the work of Aristotle (383–322 B.C.). This wonderful observer recorded many facts concerning the structure and habits of the fishes of Greece, and in almost every case his actual observation bears the closest modern test. These observations

* Address of the Vice-President and Chairman of Section F, Zoology, American Association for the Advancement of Science, Pittsburgh Meeting, 1902.

were hardly 'set in order.' The number of species he knew was small, about 115 in all, and it did not occur to him that they needed classification. His ideas of species were those of the fishermen, and the changing vernacular supplied him with the necessary names.

As Dr. Günther wisely observes, 'It is less surprising that Aristotle should have found so many truths as that none of his followers should have added to them.' For about 1,800 years the scholars of the times copied the words of Aristotle, confusing them by the addition of fabulous stories and foolish superstitions, never going back to nature herself, 'who leads us to absolute truth whenever we wander.' A few observations were made by Caius Plinius, Claudius Ælianus, Athenæus and others. About 400 A.D. Decius Magnus Ausonius wrote a pleasing little poem on the Moselle, setting forth the merits of its various fishes. It was not, however, until the middle of the seventeenth century that any advance was made in the knowledge of fishes. At that time the development of scholarship among the nations of Europe was such that a few wise men were able to grasp the idea of species.

In 1553, Pierre Belon published his little book 'De Aquatilibus,' in which numerous (110) species of fishes of the Mediterranean were described, with tolerable figures, and with these is a creditable attempt at classification. At about this time Ulysses Aldrovandus, of Bologna, founded the first museum of natural history and wrote on the fishes it contained. In 1554, Salviani (1514–1572), a physician at Rome, published 'Aquatilium Animalium Historia,' with good figures of most of the species, together with much general information as to the value and habits of animals of the sea.

More important than these, but almost simultaneous with them, is the great work of Guillaume Rondelet (1507–1557), 'De Piscibus Marinis,' later published in French and enlarged under other titles. In this work the different species, 244 in all, chiefly from the Mediterranean, are fairly described, and the various fables previously current are subjected to severe scrutiny. Recognizable woodcuts represent the different species. Classification, Rondelet had none, except as simple categories for purposes of convenience. More than usual care is given to the vernacular names, French and Greek. He closes his book with these words.

"Or s'il en i a qui prennent les choses tant à la rigueur, qui ne veulent rien apparouver qui ne soit du tout parfait, je les prie de bien bon cueur de traiter telle, ou quelque autre histoire parfaitement, sans qu'il i ait chose quelconque à redire et la receverons é haut louerons bien voluntiers. Cependant je sçai bien, et me console * * * avec grand travail * * * qu'on pourra trouver plusieurs bones choses é dignes de louange ou proufit é contentement des homes studieux é à l'honneur é grandissime admiration des tres excellens é perfaits œuvres de Dieu."

And with the many 'bones choses' of the work of Rondelet, men were long too well satisfied, and it was not until the impulse of commerce had brought men face to face with the new series of animals not found in the Mediterranean that the work of the science of fishes was again resumed. About 1640 Prince Moritz (Maurice), of Nassau, visited Brazil, taking with him two physicians, George Marcgrav and Wilhelm Piso. In the great work 'Historia Naturalis Brasiliæ,' published at Leyden, 1648, Marcgrav described about one hundred species, all new to science, with a good deal of spirit and accuracy. This work was printed by Piso after Marcgrav's death, and his colored drawings—long afterwards used by Bloch—are in the 'History of Brazil' reduced to small and crude woodcuts. This is the first study of a local fish

fauna outside the Mediterranean region, and it reflects great credit on Marcgrav and on the illustrious prince whose assistant he was.

There were no other similar attempts of importance in ichthyology for a hundred years, when Per Osbeck, an enthusiastic student of Linnæus, published (1757) the records of his Chinese cruise under the name of 'Iter Chinensis.' At about the same time another of Linnæus' students, Hasselquist, published his 'Iter Palestinum,' the account of his discoveries of fishes in Palestine and Egypt. More pretentious than these and of much value, as an early record, is Mark Caterby's (1679–1749) 'Natural History of Carolina and the Bahamas,' published in 1749, with large colored plates, which are fairly correct except in those cases where the drawing was made from memory.

About this time, Hans Sloane (1660–1752) published his 'Fishes of Jamaica,' Patrick Browne (1720–1790) wrote on the fishes of the same region, while Father Charles Plumier (1646–1704) made paintings of the fishes of Martinique, long after used by Bloch and Lacépède. Dr. Alexander Garden, of Charleston, S. C., collected fishes for Linnæus, as did also Dr. Peter Kalm in his travels in the northern parts of the American Colonies.

With the revival of interest in general anatomy, several naturalists took up the structure of fishes. Among these Günther mentions Borelli, Malpighi, Swammerdam and Duverney.

The basis of classification was first fairly recognized by John Ray (1628–1705) and Francis Willughby (1635–1672), who, with other and varied scientific discoveries, undertook, in the 'Historia Piscium,' published in Oxford in 1686, to bring order out of the confusion left by their predecessors. This work, edited by Ray after Willughby's death, is ostensibly the work of Willughby with additions by Ray. In this work 420 species were recorded, 180 of these being actually examined by the authors, and the arrangement chosen by them paved the way to a final system of nomenclature.

Direct efforts in this direction, with a fairly clear recognition of genera as well as species, were made by Lorenz Theodor Gronow, called Gronovius, a German naturalist of much acumen, and by Jacob Theodor Klein (1685–1757), whose work, 'Historia Naturalis Piscium,' published about 1745, is of less importance, not being much of an advance over the catalogue of Rondelet.

Far greater than any of these investigators was he who has been justly called the father of ichthyology, Petrus Artedi (1705–1734).

He was born in Sweden, was a fellow student of Linnæus at Upsala, and devoted his short life wholly to the study of fishes. He went to Holland to examine the collection of East and West Indian fishes of a rich Dutch merchant in Amsterdam, named Seba, and there at the age of twenty-nine he was, by accident, drowned in one of the canals. 'His manuscripts were fortunately rescued by an Englishman, Clifford,' and they were edited and published by Linnæus in a series of five parts or volumes.

Artedi divided the classes of fishes into orders, and these orders again into genera, the genera into species. The name of each species consisted of that of the genus with a descriptive phrase attached. This cumbersome system, called polynomial, was a great advance on the shifting vernacular, which in the works of Artedi, Gronow, Klein and others, it was now replacing. But the polynomial system as a system was of short duration. Linnæus soon substituted for it the very convenient binomial system which has now endured for 150

years, and which, with certain modification, must form the permanent substructure of the nomenclature in systematic zoology.

The genera of Artedi are in almost all cases natural groups, although essentially equivalent to the families of to-day, a division which in ichthyology was first clearly recognized by Cuvier.

The following is a list of Artedi's genera and their arrangement:

ORDER MALACOPTERYGII.

Syngnathus (pipe-fishes) (4 species).
Cobitis (loaches) (3).
Cyprinus (carp and dace) (19).
Clupea (herrings) (4).
Argentina (argentines) (1).
Exocœtus (flying-fishes) (2).
Coregonus (white fishes) (4).
Osmerus (smelts) (2).
Salmo (salmon and trout) (10).
Esox (pike) (3).
Echeneis (remoras) (1).
Coryphœna (dolphins) (3).
Ammodytes (sand launces) (1).
Pleuronectes (flounders) (10).
Stromateus (butter-fishes) (1).
Gadus (cod-fishes) (11).
Anarhichas (wolf-fishes) (1).
Muræna (eels) (6).
Ophidion (cusk-eels) (2).
Anableps (four-eyed fish) (1).
Gymnotus (carapos) (1).
Silurus (cat-fishes) (1).

ORDER ACANTHOPTERYGII.

Blennius (blennies) (5).
Gobius (gobies) (4).
Xiphias (sword-fishes) (1).
Scomber (mackerels) (5).
Mugil (mullets) (1).
Labrus (wrasses) (9).
Sparus (porgies) (15).
Sciœna (croakers) (2).
Perca (perch and bass) (7).
Trachinus (weavers) (2).
Trigla (gurnards) (10).
Scorpœna (scorpion-fishes) (2).
Cottus (sculpins) (5).
Zeus (john dories, etc.) (3).
Chœtodon (butterfly-fishes) (4).
Gasterosteus (stickle-backs) (3).
Lepturus (cutlass-fishes) (=*Trichiurus*) (1).

ORDER BRANCHIOSTEGI.

Balistes (trigger-fishes) (6).
Ostracion (trunk-fishes) (22).
Cyclopterus (lump-fishes) (1).
Lophius (anglers) (1).

ORDER CHONDROPTERYGII.

Petromyzon (lampreys) (3).
Acipenser (sturgeons) (2).
Squalus (sharks) (14).
Raja (rays) (11).

In all 47 genera and 230 species of fishes were known from the whole world in 1738.

The cetaceans, or whales, constitute a fifth order, Plagiuri, in Artedi's scheme.

As examples of the nomenclature of species I may quote:

'*Zeus ventre aculeato, cauda in extremo circinata.*' This polynomial expression was shortened by Linnæus to *Zeus faber*. The species was called by Rondelet 'Faber sive Gallus Marinus' and by other authors '*Piscis jovii.*' 'Jovii' suggested *Zeus*, and Rondelet's name, *faber*, was the specific name chosen by Linnæus.

'*Anarhichas Lupus marinus nostras.*' This became with Linnæus '*Anarhichas lupus.*'

'Clupea, maxilla inferiore longiose, maculis nigris carcus: Harengus vel Chalcis Auctorum, Herring vel Hering Anglis, Germanis, Belgis.' This became *Clupea harengus* in the convenient binomial system of Linnæus.

The great naturalist of the eighteenth century, Carl von Linné, known academically as Carolus Linnæus, was the early

associate and close friend of Artedi, and from Artedi he obtained practically all his knowledge of fishes. Linnæus, the head of the University of Upsala, primarily a botanist, was a man of wonderful erudition, and his great strength lay in the orderly arrangement of things. In his lifetime, his greatest work, the 'Systema Naturæ,' passed through twelve editions. In the tenth edition, in 1758, the binomial system of nomenclature was first consistently applied to all animals. For this reason, most naturalists use the date of its publication as the beginning of zoological nomenclature, although the English naturalists have generally preferred the more complete twelfth edition, published in 1766. This difference in the recognized starting point has been often a source of confusion, as in several cases the names of species were needlessly changed by Linnæus and given differently in the twelfth edition.

In Linnæus' system (tenth and twelfth editions), all of Artedi's genera were retained save *Lepturus*, which name was changed to *Trichiurus*. The following new genera were added: *Chimæra, Tetraodon, Diodon, Centriscus, Pegasus, Callionymus, Uranoscopus, Cepola, Mullus, Teuthis, Loricaria, Fistularia, Atherina, Mormyrus, Polynemus, Amia, Elops.* The classification was finally much altered; the Chondropterygia and Branchiostegi (with *Syngnathus*) being called *Amphibia Nantes*, and divided into 'Spiraculis compositis' and 'Spiraculis solitariis.' The other fishes were more naturally distributed according to the position of the ventral fins into Piscis Apodes, Jugulares, Thoracici and Abdominales. The Apodes do not form a homogeneous group, as members of various distinct groups have lost their ventral fins in the process of evolution. But the Jugulares, the Thoracici and the Abdominales must be kept as valid categories in any natural system.

Linnæus's contributions to zoology consisted mainly of the introduction of his most ingenious and helpful system of bookkeeping. By it naturalists of all lands were able to speak of the same species by the same name in whatever tongue. Unfortunately, ignorance, carelessness and perversity brought about a condition of confusion. For a long period many species were confounded under one name. This began with Linnæus himself. On the other hand, even with Linnæus, the same species often appeared under several different names. In this matter it was not the system of naming which was at fault. It was the lack of accurate knowledge, and sometimes the lack of just and conscientious dealing with the work of other men. No system of naming can go beyond the knowledge on which it rests. Ignorance of fact produces confusion in naming. The earlier naturalists had no conception of the laws of geographical distribution. The 'Indies,' East or West, were alike to them, and 'America' was a sufficiently exact record of the origin of any specimen.

Moreover, no thought of the geological past of groups and species had yet arisen, and, without the conception of common origin, the facts of homology had no significance. All classification was simply a matter of arbitrary pigeon-holing the records of forms, rather than an expression of actual blood-relationship. To this confusion much was added through love of novelty. Different authors changed names to suit their personal tastes, regardless of rights of priority. *Amia* was altered to *Amiatus* because it was too short a name. *Hiodon* was changed to *Amphiodon* because it sounded too much like *Diodon*, and other changes much more wanton were introduced, to be condemned and discarded by the more methodical workers of a later period. With all its abuses, however, the binomial nomenclature made possible sys-

tematic zoology and botany, and with the 'Systema Naturæ' arose a new era in the science of living organisms.

In common with most naturalists of his day, the spirit of Linnæus was essentially a devout one. Admiration for the wonderful works of God was breathed on almost every page. 'O Jehovah! quam ampla sunt opera Tua' is on the title-page of the 'Systema Naturæ,' and the inscription over the door of his home at Hammarby was, to Linnæus, the wisdom of his life. This inscription read: 'Innocue vivito: Numen adest' (Live blameless: God is here).

The followers of Linnæus are divided into two classes, explorers and compilers. To the first class belonged his own students and others who ransacked all lands for species to be added to the lists of the 'Systema Naturæ.' These men, mostly Scandinavian and Dutch, worked with wonderful zeal, enduring every hardship and making great contributions to knowledge, which they published in more or less satisfactory forms. To these men we owe the beginnings of the science of geographical distribution. Among the most notable of these are Per Osbeck and Frederick Hasselquist, already noted; Otto Fabricius, author of a 'Fauna of Greenland'; Carel Thunberg, successor of Linnæus as head of the University of Upsala, who collected fishes about Nagasaki, entrusting most of the descriptive work to the less skillful hands of his students Jonas Nicolas Ahl and M. Houttuyn, Martin Th. Brunnich, who collected at Marseilles the materials for his 'Pisces Massiliensis'; Petrus Forskål, whose work on the fishes of the Red Sea (Descriptio Animatium,' etc.), published posthumously in 1775, is one of the most accurate of faunal lists, and one which shows a fine feeling for taxonomic distinctions, scarcely traceable in any previous author. George Wilhelm Steller, naturalist of Bering's expedition, gathered amid incredible hardships the first knowledge of the fishes of Alaska and Siberia, his notes being printed after his tragic death, by Pallas and Krascheninnikow. Petrus Simon Pallas gives the account of his travels in the North Pacific in his most valuable volumes, 'Zoographia Russo-Asiatica.' S. T. Gmelin and Güldenstadt, like Steller, crossed Siberia, recording its animals. Johann David Schöpf, a Hessian surgeon stationed at Long Island in the Revolutionary War, gave an excellent account of the fishes about New York.

Other naturalists accompanied navigators around the globe, collecting specimens and information as opportunity offered. John Reinhold Forster and Solander sailed with Captain Cook. Commerson accompanied Bougainville and furnished nearly all the original material used by Lacépède. Other noted travellers of the early days were Sonnerat and Mungo Park.

Still other naturalists, scarcely less useful, gave detailed accounts of the fauna of their own native regions. Ablest of these was Anastole Risso, an apothecary of Nice, who published in 1810 the 'Ichthyologie de Nice,' an excellent work afterwards (1826) expanded by him into a 'Histoire Naturelle d'Europe Meridionale.'

Contemporary with Risso was a man of opposite character, Constantine Samuel Rafinesque (1784–1842), who wrote at Palermo in 1810 his 'Caratteri di Alcuni Nuovi Generi' and 'Ittiologia Sciliana.' Later he went to America, where he was for a time professor in the Transylvania University in Kentucky. Brilliant, erudite, irresponsible, fantastic, he wrote of the fishes of Sicily and later ('Ichthyologia Ohiensis,' 1820) of the fishes of the Ohio River, with wide knowledge, keen taxonomic insight and a hopeless disregard of the elementary principles of accuracy. Always eager for novelties, restless and credulous, his writings have been among the most diffi-

cult to interpret of any in ichthyology. Earlier than Risso and Rafinesque, Thomas Pennant wrote of the British fishes, Oscar Fredrik Müller of the fishes of Denmark, J. E. Gunner, Bishop of Thröndhjem, of fishes of Norway, Duhamel du Monceau of the fisheries of France, D. J. Cornide of the fishes of Spain, and Meidinger of those of Austria. Most of these writers knew little of the Linnæan system, and their records are generally in the vernacular. Most important of this class is the work of Antonio Parra, 'Descripcion de Diferentes Piezas de Historia Natural de la Isla de Cuba,' published in Havana in 1787. In 1803, Patrick Russell gave a valuable account of 'Two Hundred Fishes Collected at Vizagapatam and on the Coast of Coromandel.' Following this was a work on the fishes of the Ganges, well illustrated, by Francis Buchanan-Hamilton.

Bering Sea and Japan were explored by William Theophilus Tilesius (1775–1835), whose papers are published in the transactions of the early societies of Russia. Stephan Krascheninikov (1786) wrote a history of Russia in Asia, and other geographical writers, as Krüsenstern, contributed something to our knowledge of the fishes in regions visited by them.

Other notable names among the early writers are those of Auguste Broussonet, of Montpelier, whose work, too soon cut short, showed marked promise, B. A. Euphrasen, Fr. Faber, who wrote of the fishes of Iceland, Everard Home, E. Blyth, who studied the fishes of the Andamans, J. T. Kölreuter, J. Lepechin, John Latham, W. E. Leach, A. G. Desmarest, G. Montague, C. Quensel, H. Storm and M. Vahl.

The compilers who followed Linnæus belonged to a wholly different class. These were men of large learning, methodical ways, sometimes brilliant, sometimes of deep insight, but more often, on the whole, dull, plodding and mechanical.

Earliest of these is Antoine Goüan, whose 'Historia Piscium' was published in Paris in 1770. In this work, which is of fair quality, only genera were included, and the three new ones which he introduces into the 'System' (*Lepadogaster, Lepidopus* and *Trachypterus*) are still retained with his definition of them.

Johann Friedrich Gmelin published in 1788 a thirteenth edition of the 'Systema Naturæ' of Linnæus, adding to it the discoveries of Forskål, Forster and others who had written since Linnæus' time. This work was useful as bringing that of Linnæus to a later date, but it is not well done, the compiler having little knowledge of the animals described and little penetration in matters of taxonomy. Very similar in value, although more lucid in expression, is the French compilation of the same date (1788), 'Tableau Encyclopédique et Méthodique des Trois Règnes de la Nature,' by the Abbé J. P. Bonnaterre. Another 'Encyclopédie Méthodique,' of still less merit, was published as a dictionary in Paris in 1787, by Réné Just Haüy.

In 1792, Johann Julius Walbaum, a German compiler of a little higher rank, gathered together the records of all known species, using the work of Artedi as a basis, and giving binomial names in place of the vernacular terms used by Schöpf, Steller, Pennant and Krascheninnikow.

Far more pretentious and more generally useful, as well as containing a large amount of original material, is the 'Ichthyologia' of Mark Eliezer Bloch, published in Berlin in various parts from 1782 to 1795. It was originally of two parts in German, 'Oeconomische Naturgeschichte der Fische Deutschlands' and 'Naturgeschichte der Ausländischen Fische.' Bloch was a physician, born at Anspach in 1723, and at the age of fifty-six began to devote himself to ichthyology. In his great work is contained every species which he had himself seen,

every one which he could purchase from collections, and every one of which he could find drawings made by others.

That part which relates to the fishes of Germany is admirably done. In the treatment of East Indian and American fishes there is much guess work, and many errors of description and of fact, for which the author was not directly responsible. To learn to interpret the personal equation in the systematic work of other men is one of the most delicate of taxonomic arts.

After the publication of these great folio volumes of plates, Dr. Bloch began a systematic catalogue to include all known species. This was published after his death by his collaborator, the philologist, Dr. Johann Gottlob Schneider. This work, 'Systema Ichthyologiæ M. E. Blochii,' contains 1,519 species of fishes, and is the most creditable compilation subsequent to the death of Linnæus.

Even more important than the work of Bloch is that of the Comte de Lacépède, who became with the progress of the French Revolution 'Citoyen Lacépède,' his original full name being Bernard Germain Etienne de la Ville-sur-Illon, Comte de Lacépède. His great work, 'Histoire Naturelle des Poissons,' was published originally in five volumes, in Paris, from 1798 to 1803. It was brought out under great difficulties, his materials being scattered, his country in a constant tumult. For original material he depended chiefly on the collection and sagacious notes of the traveler Commerson. Dr. Gill sums up the strength and weakness of Lacépède's work in these terms:

"A work by an able man and eloquent writer even prone to aid rhetoric by the aid of the imagination in absence of desirable facts, but which because of undue confidence in others, default of comparison of material from want thereof and otherwise, and carelessness generally, is entirely unreliable."

The work of Lacépède had a large influence upon subsequent investigators, especially in France. A large portion of the numerous new genera of Rafinesque was founded on divisions made in the analytical keys of Lacépède.

In 1803 and 1804, Dr. George Shaw published in London his 'General Zoology,' the fishes forming part of Volumes IV. and V. This is a poor compilation, the part concerning the fishes being largely extracted from Bloch and Lacépède. In 1807, Constant Duméril published an analytical table of classification of some merit as 'Ichthyologie Analytique,' and about 1815, H. Ducrotay de Blainville wrote the 'Faune Française' and contributed important studies to the taxonomy of sharks.

With Georges Chrétien Léopold Dagobert Cuvier and the 'Règne Animal Arrangé après son Organization' (1817–1826) we have the beginning of a new era in ichthyology. This period is characterized by a recognition of the existence of a natural classification based on the principles of morphology. The 'Règne Animal' is, in the history of ichthyology, not less important than the 'Systema Naturæ' itself, and from it dates practically our knowledge of families of fishes, and the interrelations of the groups themselves. The great facts of homology were clearly understood by Cuvier. Their significance as indications of lines of descent was never grasped by him, and this notwithstanding the fact that Cuvier was almost the first to bring extinct forms into the proper relations with those now living.

Dr. Günther well says that the investigation of anatomy of fishes was continued by Cuvier until he had succeeded in completing so perfect a framework of the system of the whole class that his immediate

successors could content themselves with filling up those details for which their master had no leisure. Indefatigable in examining all the external and internal characters of the fishes of a rich collection, he ascertained the natural affinities of the infinite variety of fishes, and accurately defined the divisions, orders, families and genera of the class, as they appear in the various editions of the 'Règne Animal.' His industry equaled his genius; he opened connections with almost every accessible part of the globe; not only French travelers and naturalists, but also Germans, Englishmen, Americans, rivaled one another to assist him with collections; and for many years the Museum of the Jardin des Plantes was the center where all ichthyological treasures were deposited. Thus Cuvier brought together a collection the like of which had never been seen before, and which, as it contains all the materials on which his labors were based, must still be considered to be the most important.

The greatest contributions of Cuvier to ichthyology are contained in the great 'Histoire Naturelle des Poissons,' the joint work of Cuvier and his pupil and successor, Achille Valenciennes. Of this work 22 volumes were published, from 1828 to 1847, containing 4,514 nominal species, the larger number of volumes appearing after the death of Cuvier (1832), the work closing, not quite complete, with the death of Valenciennes in 1848.

This is a most masterly work, still indispensable to the student of fishes. Its descriptions are generally exact, its statements correct, its plates accurate and its judgments trustworthy. But with all this it is very unequal. Many of the species are treated very lightly by Cuvier; many of the descriptions of Valenciennes are very mechanical, as though the author had grown weary of the endless process, 'a failing commonly observed among zoologists when attention to descriptive details becomes to them a tedious task.' As Günther observes, the number of nominal species is almost doubled because the authors neglected to give proper attention to the changes in different species due to age and sex.

After the death of Valenciennes (1848) Dr. Auguste Duméril (son of Constant Duméril) began a continuation of this work, publishing two volumes (1865–1870) covering sharks, ganoids and other fishes not treated by Cuvier and Valenciennes. The death of Duméril left the great catalogue still incomplete. Duméril's work is useful and carefully done, but his excessive trust in slight differences has filled his book with nominal species. Thus among the ganoid fishes he recognizes 135 species, the actual number being not far from 40.

We may anticipate the sequence of time by here referring to the remaining attempts at a record of all the fishes in the world. Dr. Albert C. L. G. Günther, a German naturalist resident in London, and long the Keeper of the British Museum, published in eight volumes the 'Catalogue of the Fishes of the British Museum,' from 1859 to 1870. In this monumental work, the one work most essential to all systematic study of fishes, 6,843 species are described and 1,682 doubtful species are mentioned. The book is a tremendous example of patient industry. Its great merits are at once apparent, and those of us engaged in the same line of study may pass by its faults with the same leniency which we may hope that posterity may bestow on ours.

The publication of this work gave a remarkable stimulus to the study of fishes. The number of known species had been raised from 9,000 to about 12,000, and some hundreds of species even accepted by the conservatism of Günther have been erased from the system.

A new edition of this work has been long in contemplation, and in 1898 the first volume of it, covering the percoid fishes, was published by Dr. George Albert Boulenger. This volume is one of the most satisfactory in the history of ichthyology. It is based on ample material. Its accepted species have been subject to thorough criticism and in its classification every use has been made of the teachings of morphology and especially of osteology. Its classification is distinctly modern, and with the writings of the contemporary ichthyologists of Europe and America, it is fully representative of the scientific era ushered in by the researches of Darwin. The chief criticism which one may apply to this work concerns most of the publications of the British Museum. It is the frequent assumption that those species not found in the greatest museum of the world do not really exist at all. There are still many forms of life, very many, outside the series gathered in any or all collections.

We may now turn from the universal catalogues to the work on special groups, on local faunas or on particular branches of the subject of ichthyology. These lines of study were made possible by the work of Cuvier and Valenciennes and especially by that of Dr. Günther.

Before taking up the students of faunal groups, we may, out of chronological order, consider the researches of three great taxonomists, who have greatly contributed to the modern system of the classification of fishes.

Louis Agassiz (born in western Switzerland in 1807; died at Cambridge, Massachusetts, in 1873) was a man of wonderful insight in zoological matters and possessed varied range of scientific information, scarcely excelled in any age—intellectually a lineal descendant of Aristotle. His first work on fishes was the large folio on the fishes collected by Jean Baptiste Spix in Brazil, published at Munich in 1827. After his establishment in America in 1846, at which time he became a professor in Harvard University, Agassiz published a number of illuminating papers on the fresh-water fishes of North America. He was the first to recognize the necessity of the modern idea of genera among fishes, and almost all of the groups so designated by him are retained by later writers. He was also the first to investigate the structure of the singular viviparous surf-fishes of California, the names *Embiotoca* and *Holconoti* applied to these fishes being chosen by him.

His earlier work, 'Recherches sur les Poissons des Eaux Douces,' published in Europe, gave a great impetus to our knowledge of the anatomy and especially of the embryology of the fresh-water fishes. Most important of all his zoological publications was the 'Recherches sur les Poissons Fossiles,' published at Neufchâtel from 1833 to 1843. This work laid the foundation of the systematic study of the extinct groups of fishes. The relations of sharks were first appreciated by Agassiz, and the first segregation of the ganoids was due to him. Although he included in this group many forms not truly related either to the ganoids or even to the extinct arthrognaths, yet the definition of this order marked a great step in advance.

The great, genial, hopeful personality of Agassiz and his remarkable skill as a teacher made him the 'best friend that ever student had' and gave him a large following as a teacher. Among his pupils in ichthyology were Charles Girard, Frederick Ward Putnam, Alexander Agassiz, Samuel Garman, Samuel H. Scudder and the present writer.

Johannes Müller (1808–1858), of Berlin, was one of the greatest of comparative anatomists. In his revision of Cuvier's 'System of Classification' he corrected many errors in grouping, and laid founda-

tions which later writers have not altered or removed. Especially important is his classical work, 'Ueber den Bau und die Grenzen der Ganoiden.' In this he showed the real fundamental characters of that group of archaic fishes, and took from it the most heterogeneous of the elements left in it by Agassiz. To Müller we also owe the first proper definition of the Leptocardii and the Cyclostomi, and, in association with Dr. J. Henle, Müller has given us one of the best general accounts of the sharks ('Systematische Beschriebungen der Plagiostomen'). To Müller we owe an accession of knowledge in regard to the duct of the air-bladder, and the groups called Dipneusti (Dipnoi), Pharyngognathi and Anacanthini were first defined by him, although now usually restricted within narrower limits than those assigned by him.

In his work on the Devonian fishes, the great British comparative anatomist, Thomas Henry Huxley, first distinguished the group of Crossopterygians, and separated it from the Ganoids and Dipnoans.

Theodore Nicholas Gill is the keenest interpreter of taxonomic facts yet known in the history of ichthyology. He is the author of an immense number of papers, the first bearing date of 1858, touching almost every group and almost every phase of relation among fishes. His numerous suggestions as to classification have been usually accepted in time by other authors, and no one has had a clearer perception than he of the necessity of orderly methods in nomenclature. Among the orders first defined by Gill are the Eventognathi, the Haplomi, the Xenomi and the group called Teleocephali, which included all the bony fishes except those which showed peculiar eccentricities or modifications. Dr. Gill's greatest excellence has been shown as a scientific critic. Incisive, candid and friendly, there is scarcely a scientific man in America who is not directly indebted to him for critical aid of the highest importance. The present writer cannot too strongly express his own obligations to this great teacher, his master in fish taxonomy, as Agassiz was in fish ecology. Dr. Gill's work is not centered in any single great treatise, but is diffused through a very large number of brief papers and catalogues, those from 1861 to 1865 mostly published by the Academy of Natural Sciences in Philadelphia, those of recent date by the United States National Museum. For many years Dr. Gill has been identified with the work of the Smithsonian Institution at Washington.

Closely associated with Dr. Gill was Dr. Edward Drinker Cope, of Philadelphia, a tireless worker in almost every field of zoology, and a large contributor to the broader fields of ichthyological taxonomy as well as to various branches of descriptive zoology. Cope was one of the first to insist on the close relation of the true ganoids with the teleost fishes, the nearest related group of which he defined as Isospondyli. In breadth of vision and keenness of insight, Cope ranked with the first of taxonomic writers. Always bold and original, he was not at all times accurate in details, and to the final result in classification his contribution has been less than that of Dr. Gill. Professor Cope also wrote largely on American fresh-water fishes, a large percentage of the Cyprinidæ and Percidæ of the eastern United States having been discovered by him, as well as much of the Rocky Mountain fauna. In later years his attention was absorbed by the fossil forms, and most of the species of the Cretaceous rocks and the Eocene shales of Wyoming were made known through his ceaseless activity.

The enumeration of other workers in the great field of ichthyology must assume something of the form of a catalogue. Part of the impulse received from the great

works of Cuvier and Valenciennes and of Günther was spent in connection with voyages of travel. In 1824, Quoy and Gaimard published in Paris the great folio work on the fishes collected by the corvettes *L'Uranie* and *La Physicienne* in Freycinet's voyage around the world. In 1834, the same authors published the fishes collected in Dumont D'Urville's voyage of the *Astrolabe*. In 1826 Lesson published the fishes voyage around the world. In 1834, the great works lie at the foundation of our knowledge of the fishes of Polynesia. In 1839, Eydoux and Gervais published the fishes of the voyage of *La Favorite*. In 1853, also in Paris, Homborn and Jacquinot gave an account of the fishes taken in Dumont D'Urville's expedition toward the South Pole. In England, Sir John Richardson, a wise and careful naturalist, wrote of the fishes collected by the *Sulphur* (1845), the *Erebus* and *Terror* (1846) and the *Herald*. Lay and Bennett recorded the species taken by Beechey's voyage on the *Blossom*. More important than any of these is the account of the species taken by Charles Darwin on the voyage of the *Beagle*, prepared by the conscientious hand of Rev. Leonard Jenyns. Still more important and far ranging is the voyage of the *Challenger*, including the first important work in the deep seas, the stately volume and parts of other volumes on fishes being the work of Dr. Günther. Other deep-sea work of equal importance has been accomplished in the Atlantic and the Pacific by the U. S. Fish Commission steamer *Albatross*. Its results in Central America, Alaska and Japan, as well as off both coasts of the United States, have been made known in different memoirs by Goode and Bean, Garman, Gilbert, Gill, Jordan, Cramer and others. The deep-sea fish collections of the *Fish Hawk* and the *Blake* have been studied by Goode and Bean and Garman.

The deep-sea work of other countries may be briefly noticed. The French vessels, *Travailleur* and *Talisman*, have made collections chiefly in the Mediterranean and along the coast of Africa, the results having been made known by Leon Vaillant. The *Hirondelle* about the Azores and elsewhere has furnished material for Professor Robert Collett, of the University of Christiania. Dr. Decio Vinciguerra, of Rome, has reported on the collections of the *Violante*, a vessel belonging to the Prince of Monaco. Dr. A. Alcock, of Calcutta, has had charge of the most valuable deep-sea work of the *Investigator* in the Indian seas. Dr. James Douglas Ogilby and Dr. Edgar R. White, Sydney, N. S. W., have described the collections of the *Thetis*, made on the shores of New South Wales.

From Austria the voyage of the frigate *Novara* has yielded large material which has been described by Dr. Rudolph Kner. The cream of many voyages of many Danish vessels has been gathered in the 'Spolia Atlantica' and other truly classical papers of Christian Frederik Lütken, of the University of Copenhagen, one of the great naturalists of our times.

F. H. von Kittlitz has written on the fishes seen by him in the northern Pacific, and earlier and more important we may mention the many ichthyological notes found in the travel records of Alexander von Humboldt in Mexico and South America.

The local faunal work in various nations has been very extensive. In Great Britain we may note Parnell's 'Natural History of the Fishes of the Firth of Forth,' published in Edinburgh in 1838, William Yarrell's 'History of British Fishes' (1859), the earlier histories of British fishes by Edward Donovan and by William Turton, and the works of J. Couch (1862) and Dr. Francis Day (1888), which possess similar titles. The work of Day, with its excellent plates,

will long be the standard account of the relatively scant fish fauna of the British Islands. H. G. Seelye has also a useful 'Synopsis of the Fresh-water Fishes of Europe.'

We may here notice without praise the extensive work of William Swainson (1839). W. Thompson has written of the fishes of Ireland, and Rev. Richard T. Lowe and J. Y. Johnson have done most excellent work on the fishes of Madeira. F. McCoy, better known for work on fossil fishes, may be mentioned here.

The fish fauna of Scandinavia has been described more or less fully by Kröyer (1840), Nilsson (1855), Fries and Ekström (1836), Collett, Lilljeborg and F. A. Smitt, besides special papers by other writers, notably Reinhardt, L. Esmarck, Japhetus Steenstrup, Lütken and A. W. Malm. Reinhardt, Kröyer, Lütken and A. J. Malmgren have written of the Arctic fishes of Greenland and Spitzbergen.

In Russia, Nordmann has described the fishes of the Black Sea ('Ichthyologie Pontique,' Paris, 1840) and Eichwald those of the Caspian. More recently, S. Herzenstein, Warpachowsky, K. Kessler, B. N. Dybowsky, Kamensky and others have written of the rich fauna of Siberia, the Caucasus and the scarcely known Sea of Okhotsk. Stephan Basilevsky has written rather unskillfully of the fishes of northern China. A. Kowalevsky has contributed very much to our knowledge of anatomy.

In Germany and Austria the chief local works have been those of Heckel and Kner on the fresh-water fishes of Austria (1858), and those of C. Th. von Siebold on the fresh-water fishes of Central Europe (1863). German ichthyologists have usually extended their view to foreign regions where their characteristic thoroughness and accuracy has made their work illuminating. The two memoirs of Edouard Rüppell on the fishes of the Red Sea and the neighboring parts of Africa, 'Atlas zu der Reise im Nördlichen Afrika,' 1828, and 'Neue Wirbelthiere,' 1837, rank with the very best of descriptive work. Günther's finely illustrated 'Fische der Südsee,' published in Hamburg, may be regarded as German work. Other papers are those of Dr. Wilhelm Peters on Asiatic fishes, the most important being on the fishes of Mozambique. J. J. Heckel, Rudolph Kner and Franz Steindachner, successively curators of the Museum of Vienna, have written largely on fishes. The papers of Steindachner cover almost every part of the earth and are absolutely essential to any serious systematic study of fishes. No naturalist of any land has surpassed Steindachner in industry or accuracy and his work has the advantage of the best illustrations of fishes made by any artist, the noted Edouard Konopicky. Other German writers are J. J. Kaup, who has worked in numerous fields, but as a whole with little skill, Dr. S. B. Klunzinger, who has given excellent accounts of the fishes of the Red Sea, and Dr. Franz Hilgendorf, of the University of Berlin, whose papers on the fishes of Japan and other regions have shown a high grade of taxonomic insight. Other writers of earlier date are Johann Marcusen, who studied the Mormyri, W. von Repp, who wrote on the fishes of the Lake of Constance, and J. F. Brandt.

In Italy, Charles Lucien Bonaparte, Prince of Canino, has published an elaborate 'Fauna Italica' (1838), and in numerous minor papers has taken a large part in the development of ichthyology. Many of the accepted names of the large groups (as Elasmobranchii, Heterosomata, etc.) were first suggested by Bonaparte. The work of Rafinesque has been already noticed. O. G. Costa published (about 1850) a 'Fauna of Naples.' In recent times G. Canestrini, Decio Vinciguerra, Enrico Hillyer Giglioli, Luigi Döderlein and others

have added largely to our knowledge of Italian fishes, while Carlo F. Emery, F. de Filippi, Luigi Facciola and others have studied the larval growth of different species. Camillo Ranzani, G. G. Bionconi, G. D. Nardo and others have contributed to different fields of ichthyology.

Nicolas Apostolides and, still later, Horace A. Hoffman and the present writer have written on the fishes of Greece.

In France, the fresh-water fishes are the subject of an important work by Emile Blanchard (1866), and Emile Moreau has given us a convenient fauna of France. Leon Vaillant has written on various groups of fishes, his monograph of the American darters (Etheostominæ) being a masterpiece so far as the results of the study of relatively scanty material would permit. The 'Mission Scientifique au Mexique,' by Vaillant and F. Bocourt, is one of the most valuable contributions to our knowledge of the fishes of that region. Dr. H. E. Sauvage, of Boulogne-sur-Mer, has also written largely on the fishes of Asia, Africa and other regions.

Important among these are the 'Poissons de Madagascar,' and a monograph of the sticklebacks. Alexander Thominot and Jacques Pellegrin have also written, in the Museum of the Jardin des Plantes, on different groups of fishes. Earlier writers were Alphonse Guichenot, L. Brissot de Barneville, H. Hollard, an able anatomist, and Bibron.

In Spain and Portugal, the chief work of local authors is that of J. V. B. Bocage and F. de Brito Capello on the fish of Portugal. So far as Spain is concerned, the chief memoir is Steindachner's account of his travels in Spain and Portugal. The principal studies of the Balkan region have also been made by Steindachner.

In Holland, the chief great works have been those of Schlegel and Pieter van Bleeker. Professor Schlegel, of the University of Leyden, described the fishes collected about Nagasaki by Ph. Fr. de Siebold and Bürger. His work forms a large folio illustrated by colored plates, the 'Fauna Japonica Poissons,' published in Leyden from 1844 to 1850. Schlegel's work in every field is characterized by scrupulous care and healthful conservatism, and the 'Fauna Japonica' is a most useful monument to his rare powers of discrimination.

Pieter von Bleeker (1819–1878), a surgeon in the Dutch West Indies, is the most voluminous writer in ichthyology. He began his work in Java without previous training and in a very rich field where almost everything was new. With many mistakes at first he rose to the front by sheer force of industry and patience, and his later work, while showing much of the 'personal equation,' is still thoroughly admirable. At his death he was engaged in the publication of a magnificent folio work, 'Atlas Ichthyologique des Indes Orientales Neerlandaises,' illustrated by colored plates. This work remains about two thirds completed. The writings of Dr. Bleeker constitute the chief source of our knowledge of the fauna of the East Indies.

Dr. Van Lidth de Jeude, of the University of Leyden, is the author of a few descriptive papers on fishes.

To Belgium we may assign part at least of the work of the eminent Belgian naturalist, George Albert Boulenger, now long connected with the British Museum. His various valuable papers on the fishes of the Congo are published under the auspices of the 'Congo Free State,' itself largely a creation of the government of Belgium. To Belgium also we may ascribe the work of Louis Dollo on the morphology of fishes, and on the deep-sea fishes obtained by the 'Expedition Antarctique Belge.'

The fish fauna of Cuba has been the life-long study of Dr. Felipe Poey y Aloy (1799–1891), a pupil of Cuvier, for a half cen-

tury or more the honored professor of zoology in the University of Havana. Of his many useful papers, the most extensive are his 'Memorias sobre la Historia Natural de la Isla de Cuba,' followed by a 'Repertorio' and an 'Enumeratio' on the same subject. Poey devoted himself solely to the rich fish fauna of his native island, in which region he was justly recognized as a ripe scholar and a broad-minded gentleman. A favorite expression of his was 'Comme naturaliste, je ne suis pas espagnol: je suis cosmopolite.' Before Poey, Guichenot, of Paris, had written on the fishes collected in Cuba by Ramon de la Sagra. His account was published in Sagra's 'Historia de Cuba,' and later Philip H. Gosse (1810–1888) wrote on the fishes of Jamaica. Much earlier, Robert Hermann Schomburgh (1804–1865) wrote on the fishes of British Guiana. Other papers on the Caribbean fishes were contributed by Johannes Müller and F. H. Troschel, and by Richard Hill and J. Hancock.

Besides the work in South America of Marcgrave, Agassiz, Reinhardt, Lütken, Steindachner, Jenyns, Boulenger and others already named, we may note the local studies of Dr. Carlos Berg in Argentina, Dr. R. A. Philippi in Chile, and special records of Humboldt, Garman, J. F. Abbott and others in recent times. Carl H. Eigenmann and also Jordan and Eigenmann have studied the great collections made in Brazil by Agassiz. Steindachner has described the collections of Johann Natterer, and Gilbert those made by Dr. John C. Branner. The most recent extensive studies of the myriads of Brazilian river fishes are those of Dr. Eigenmann. Earlier than any of these Francis de Castelnau (1855) described many Brazilian fishes and afterwards numerous fishes of Australia. Guichenot, of Paris, contributed a chapter on fishes to Claude Gay's 'History of Chile,' and J. J. von Tschudi, of St. Gallen, published an elaborate but uncritical 'Fauna Peruana' with colored plates of Peruvian fishes.

In New Zealand, F. W. Hutton and J. Hector have published a valuable work on the fishes of New Zealand, to which Dr. Gill added valuable critical notes in a study of 'Antipodal Faunas.' Later writers have given us a good knowledge of the fishes of Australia. Notable among them are W. Macleay, James Douglas Ogilby and Edgar R. Waite. Clarke has also written on 'Fishes of New Zealand.'

The most valuable work on the fishes of Hindustan is the elaborate treatise on the 'Fishes of India' by Surgeon Francis Day. In this all the species are figured, the groups being arranged as in Günther's catalogue, a sequence which few non-British naturalists seem inclined to follow. Cantor's 'Malayan Fishes' is a memoir of high merit, as is also McClelland's work on the fishes of the Ganges, and we may here refer to Andrew Smith's papers on the fishes of the Cape of Good Hope and to R. I. Playfair and A. Günther's 'Fishes of Zanzibar.' T. C. Jerdon, John Edward Gray, E. Tyrwhitt Bennett, J. Bennett and others have also written on the fishes of India.

In Japan, following the scattering papers of Thunberg, Tilesius and Houttuyn and the monumental work of Schlegel, numerous species have been recorded by James Carson Brevoort, Günther, Gill, Edouard Nyström, Hilgendorf and others. About 1884 Steindachner and Döderlein published the valuable 'Fische Japans,' based on the collections made about Tokyo by Dr. Döderlein. In 1881, Motokichi Namiye, then as now Assistant Curator in the Imperial University, published the first list of Japanese fishes by a native author. In 1900 Dr. Chiyomatsu Ishikawa, in a paper on the 'Fishes of Lake Biwa,' was the first Japanese author to venture to name a new species of fish (*Pseudogobio zezera*). This

reticence was due not wholly to lack of self-confidence, but rather to the scattered condition of the literature of Japanese ichthyology. For this reason no Japanese author has ever felt sure that any given undetermined species was really new. Other Japanese ichthyologists of promise are Dr. Kamakichi Kishinouye, Dr. Shinnosuke Matsubara and Keinosuke Otaki, and we may look for others among the pupils of Dr. Kakichi Mitsukuri, the distinguished Professor of Zoology in the Imperial University.

The most recent, as well as the most extensive, studies of the fishes of Japan were made in 1900 by the present writer and his associate, John Otterbein Snyder.

The scanty pre-Cuvieran work on the fishes of North America has been already noticed. Contemporary with the early work of Cuvier is the worthy attempt of Professor Samuel Latham Mitchell (1764–1831) to record in systematic fashion the fishes of New York. Soon after followed the admirable work of Charles Alexander Le Sueur (1780–1840), artist and naturalist, who was the first to study the fishes of the Great Lakes and the basin of the Ohio. Le Sueur's engravings of fishes, in the early publications of the Academy of Natural Sciences in Philadelphia, are still among the most satisfactory representations of the species to which they refer. Constantine Samuel Rafinesque (1784–1842), the third of this remarkable but very dissimilar trio, published numerous papers descriptive of the species he had seen or heard of in his various botanical rambles. This culminated in his elaborate but untrustworthy 'Ichthyologia Ohiensis.' The fishes of Ohio received later a far more conscientious though less brilliant treatment at the hands of Dr. Jared Potter Kirtland (1793–1877), an eminent physician of Cleveland, Ohio. In 1842 the amiable and scholarly James Ellsworth Dekay (1799–1851) published his detailed report on the 'New York fauna,' and a little earlier (1836) in the 'Fauna Boreali-Americana' Sir John Richardson (1787–1865) gave a most valuable and accurate account of the fishes of the Great Lakes and Canada. Almost simultaneously, Rev. Zadock Thompson (1796–1856) gave a catalogue of the fishes of Vermont, and David Humphreys Storer (1804–1891) began his work on the fishes of Massachusetts, finally expanded into a 'Synopsis of the Fishes of North America' (1846) and a 'History of the Fishes of Massachusetts' (1867). Dr. John Edwards Holbrook (1794–1871), of Charleston, published (1860) his invaluable record of the fishes of South Carolina, the promise of still more important work, which was destroyed by the outbreak of the Civil War. The monograph on Lake Superior (1850) and other publications of Louis Agassiz (1807–1873) have been already noticed. One of the first of Agassiz's students was Charles Girard (1822–1895), who came with him from Switzerland, and, in association with Spencer Fullerton Baird (1823–1887), described the fishes from the United States Pacific Railway Surveys (1858) and the United States and Mexican Boundary Surveys (1859). Professor Baird, primarily an ornithologist, became occupied with executive matters, leaving Girard to finish these studies of the fishes. A large part of the work on fishes published by the United States National Museum and the United States Fish Commission has been made possible through the direct help and inspiration of Professor Baird. Among those engaged in this work, James M. Milner, Hugh M. Smith and Marshall Macdonald may be noted.

Most eminent, however, among the students and assistants of Professor Baird was his successor, George Brown Goode (1851–1899), one of the most accomplished of American naturalists, whose greatest

work, 'Oceanic Ichthyology,' published in collaboration with his associate of many years, Dr. Tarleton Hoffman Bean, was barely finished at the time of his death. The work of Theodore Nicholas Gill and Edward Drinker Cope has been already noticed.

Other faunal writers of more or less prominence were William Dandridge Peck (1763–1822) in New Hampshire, George Suckley (1830–1869) in Oregon, James William Milner (1841–1880) in the Great Lake Region, Samuel Stehman Holdeman (1812–1880) in Pennsylvania, William O. Ayres (1817–1891) in Connecticut and California, Dr. John G. Cooper, Dr. William P. Gibbons and Dr. William N. Lockington in California. Philo Romayne Hoy (1816–1893) studied the fishes of Wisconsin, Charles Conrad Abbott those of New Jersey, Silas Stearns (1859–1888) those of Florida, and Stephen Alfred Forbes those of Illinois.

Samuel Garman, at Harvard University, a student of Agassiz, is the author of numerous valuable papers, the most notable being on the sharks and on the deep-sea collections of the *Albatross* in the Galapagos region, the last illustrated by most excellent plates.

The present writer began a 'Systematic Catalogue of the Fishes of North America' in 1875, in association with his gifted friend, Herbert Edson Copeland (1849–1876), whose sudden death, after a few excellent pieces of work, cut short the undertaking. Later, Charles Henry Gilbert (1860–), a student of Professor Copeland, took up the work and in 1883 a 'Synopsis of the Fishes of North America' was completed by Jordan and Gilbert. Dr. Gilbert has since been engaged in studies of the fishes of Panama, Alaska and other regions, and the second and enlarged edition of the 'Synopsis' was completed in 1898 as the 'Fishes of North and Middle America,' in collaboration with another of the writer's students, Dr. Barton Warren Evermann. A 'Monographic Review of the Fishes of Puerto Rico' was later (1900) completed by Dr. Evermann, together with numerous minor works. Other naturalists whom the writer may be proud to claim as students are Charles Leslie McKay (1854–1883), drowned in Bristol Bay, Alaska, while engaged in explorations, and Charles Henry Bollman, stricken with fever in the Okefenokee Swamps in Georgia. Still others were Dr. Carl H. Eigenmann, the indefatigable investigator of Brazilian fishes and of the blind fishes of the caves; Dr. Oliver Peebles Jenkins, first explorer of the fishes of Hawaii; Dr. Alembert Winthrop Brayton, explorer of the streams of the Great Smoky Mountains; Dr. Seth Eugene Meek, explorer of Mexico; John Otterbein Snyder, explorer of Mexico, Japan and Hawaii; Edwin Chapin Starks, explorer of Puget Sound and Panama and investigator of fish osteology. Still other naturalists of the coming generation, students of the present writer and of his lifelong associate, Professor Gilbert, have contributed in various degrees to the present fabric of American ichthyology. Among them are Mrs. Rosa Smith Eigenmann, Dr. Joseph Swain, Wilbur Wilson Thoburn, Frank Cramer, Alvin Seale, Albert Jefferson Woolman, Philip H. Kirsch, Cloudsley Rutter, Robert Edward Snodgrass, James Francis Abbott, Arthur W. Greeley, Edmund Heller, Henry Weed Fowler, and Richard Crittenden McGregor.

Other facts and conclusions of importance have been contributed by various persons with whom ichthyology has been an incident rather than a matter of central importance.

As students of the extinct fishes, following the monumental work of Louis Agassiz, some of the notable names are those of Pander, Asmuss, Heckel, Hugh Miller

and R. H. Traquair. An indispensable 'Handbuch der Palaeontologie' is that of Karl A. Zittel (1890), in which the knowledge of fossil fish is brought up to a recent date. The most valuable general work is the 'Catalogue of the Fossil Fishes in the British Museum,' in four volumes, by Dr. Arthur Smith Woodward, a most worthy companion of Günther's 'Catalogue' of the living fishes, and still more modern in the taxonomy and views of relationships. Important contributions are those of Huxley, F. McCoy, van den Marck, de Koninck, Davis, Nicholson, Charlesworth, Sir Philip Egerton, Rictet, Kner, von Meyer, Hasse, Thiollière, Jaekel, Rohon, Sauvage, Stolicza, Lawley, Molin, Gibbes, Probst, Karpinsky, Kipryanoff and many others.

In America, Dr. John Strong Newberry has studied the fossil fishes of Ohio. Professor Edward W. Claypole has worked largely in the same region. Edward Drinker Cope and Dr. Joseph Leidy have added to our knowledge of the Eocene and Cretaceous fishes of the Rocky Mountains. Numerous recent papers of great value have been published by Dr. Bashford Dean, of Columbia University, and Dr. Charles R. Eastman, of Harvard. Other important records are due to Orestes St. John, A. H. Worthen, Charles D. Walcott and the Redfields, father and son.

Still more difficult of enumeration is the long list of those who have studied the anatomy of fishes, usually in connection with the comparative anatomy or development of other animals. Preeminent among these are Karl Ernst von Baer, Cuvier, Goffrey St. Hilaire, Louis Agassiz, Johannes Müller, Carl Vogt, Carl Gegenbaur, Meckel, William Kitchen Parker, Francis M. Balfour, Thomas Henry Huxley, H. Rathke, Richard Owen, Kowalevsky, H. Stannius, Joseph Hyrtl, Gill, Boulenger and Bashford Dean. Other names of high authority are those of Wilhelm His, Köliker, Bakker, Rosenthal, Gottsche, Miklucho, Macleay, Weber, Hasse, Retzius, Owsjannikow, H. Müller, Stieda, Marcusen and Ryder.

Besides all this, there has risen, especially in the United States, Great Britain, Norway, Canada and Australia, a vast literature of commercial fisheries, fish culture and angling, the chief workers in which fields we may not here enumerate even by name.

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*JOINT MEETINGS OF THE GEOLOGICAL SOCIETY OF AMERICA, SECTION E, AND THE NATIONAL GEOGRAPHIC SOCIETY.**

The Geology of the Pittsburgh District: I. C. White.

The Appalachian coal field begins near the northern line of Pennsylvania, and extends in a canoe-shaped trough 900 miles southwestward, ending in western Alabama. Pittsburgh is situated near the center of the northern end of this great basin, and has, therefore, easy access to all of the coal formations.

To one of these beds, the great Pittsburgh seam, which overlooks the city from an elevation of 350 feet, and extends up the Monongahela for 200 miles, the industrial supremacy of the region is largely due.

Several years ago the gifted Blaine predicted that the Pittsburgh district would in time become the manufacturing center of the world because of its command of cheap fuel. This prophecy has become a reality within less than a decade of its utterance.

The Monongahela formation, of which the Pittsburgh coal is the basal member, caps all the hills around the city and stretches away to the south up the river which gave the beds a name, to be in turn covered up by the Dunkard formation at

* Pittsburgh, Pa., July 1 to 3, 1902.