comparatively new trade in spun silk goes far to compensate for the loss of the older trade, and has enabled the exports of silk manufactures from the country to be at least maintained and to show some signs of expansion. The spun-silk industry has chiefly developed in the Yorkshire and Lancashire textile centres,—Bradford, Halifax, Rochdale, &c. But it is highly significant that, while the exports of British silk manufactures have not decreased, the imports in the meantime have shown a marked expansion; and unquestionably, although the use of silken goods has increased very greatly within twenty-five years, the expansion of native silk manufactures has not kept pace with that growth.

Favoured by the operation of protective duties ranging from 50 to 60 per cent. *ad valorem*, the native manufacture of silk in the United States has been nursed into considerable activity and expansion, till now well-nigh one-half of the silken fabrics used in the country are of home manufacture. In 1860 the proportion of native manufacture was 13 per cent., in 1880 it reached 38 per cent., and in 1882 it was 40 per cent. of the entire consumption. Reeled silks are principally manufactured at Paterson and Hoboken, N. J., and Brooklyn and New York City, N. Y., and the spun silk industry flourishes at South Manchester and Hartford, Conn.

The following estimate of the relative importance of the silk manufacture of various countries was made in 1883 by Mr Peixotto, the United States consul at Lyons:—

France	$85,000,000	Russia	16,000,000
Germany	45,000,000	Austria	12,000,000
United States	35,000,000	Italy	12,000,000
Great Britain	25,000,000	Spain	5,000,000
Switzerland	18,000,000	Other countries	17,000,000

giving a total of $270,000.000. (J. PA.)

SILLIMAN, BENJAMIN (1779–1864), American chemist and geologist, was born in 1779 at Trumbull (then called North Stratford), Connecticut. His father, Gold Selleck Silliman, was brigadier-general in the war of the revolution, and had also held important civil positions. The history of the family points to an Italian origin, but Daniel Silliman, the first to settle in the United States, came from Holland. Silliman received his early education at Fairfield, Connecticut, at that time the residence of his father's family, and in 1792 he entered Yale College, where he graduated in 1796. He then studied law, and was admitted to the bar in 1802, while a tutor in Yale College, to which position he had been appointed in 1799. In 1802 a professorship of chemistry and natural history was established in the college, and he was at once elected to fill it. He spent portions of 1801 and 1802 in Philadelphia in preparation for his work, and the year 1804 he spent in Europe, chiefly in England and Scotland, where he attended the lectures of Hope and Gregory, and also formed the acquaintance of Davy, Wollaston, Brewster, Leslie, and other eminent men of science. As a result of this visit he published *A Journal of Travels in England, Holland, and Scotland, and of Two Passages over the Atlantic in the years 1805 and 1806* (2 vols., 1810), which had a marked success. In 1813 he began service with the medical department of Yale College as professor of chemistry and pharmacy, and continued to give instruction there for many years. In 1818 he founded the *American Journal of Science and Arts*, a periodical devoted to the physical sciences, which has been, and is, the most important American scientific serial. In 1851 he made a second journey to Europe, of which he likewise published an account in two volumes, edited by his son, who had accompanied him. In 1853 he became professor *emeritus*, but he continued to lecture for a year or two longer. His closing years were quietly spent in unabated mental activity at New Haven until his death in 1864. Though devoted to scientific pursuits, he interested himself in the public movements of the time.

One of Silliman's earliest scientific publications was an account of the famous meteorite which fell in Weston, Conn., December 14, 1807. This account, which excited great public interest in the country, was reproduced abroad, and was read before the Royal Society of London, and also before the French Academy. Among his other scientific labours may be mentioned his experiments upon the fusibility of various substances in the flame of the compound blowpipe of Hare, then a novelty in science, and upon the vaporization and transference of the carbon in the voltaic arc from the positive to the negative pole, which he was the first to observe. He also repeated the experiment by which Gay-Lussac had separated potassium from its hydrate, and obtained the element in its metallic form, doubtless for the first time in the United States. Other professional labours were an exploration of the coal formations of Pennsylvania in 1830, and an examination of the gold mines of Virginia in 1836. In 1832 and 1833, by appointment of the United States Government, he made a scientific investigation of the culture and manufacture of sugar, embodying his results in a voluminous report published by the Government. Though Silliman published a large number of scientific papers upon chemical and geological subjects, his reputation was more especially due to the courses of public lectures which he delivered in the college and in various cities and towns of the United States. The happy combination of a graceful and interesting style with unwonted splendour of experimental illustration gave these lectures an unprecedented popularity, and they exerted a powerful influence in awakening and developing a taste for scientific matters throughout the country.

Besides the works already mentioned, Silliman published in 1808 an American edition of Henry's *Chemistry*, with notes, in 1827 an edition of Bakewell's *Geology*, and in 1830 *Elements of Chemistry*, in two volumes. An account of his life, by Prof. George P. Fisher, of Yale College, was published in two volumes in 1866.

SILLIMAN, BENJAMIN (1816–1885), American chemist and physicist, son of the preceding, was born in 1816 at New Haven, Connecticut, and educated at Yale College, where he graduated in 1837. He then became assistant to his father in chemistry, mineralogy, and geology, working in his laboratory at the college, and pursuing original investigations. He began teaching in the laboratory soon afterwards. The school thus informally established was shortly afterwards recognized by a formal act of the corporation of the college, and ultimately developed into the Sheffield Scientific School of Yale College. In 1838 he became associate editor with his father of the *American Journal of Science and Arts*, and he continued in the editorship of the journal until the close of his life, Prof. J. D. Dana (his brother-in-law) having joined him in 1846. In the winter of 1845–46 he gave a course of lectures on agricultural chemistry in New Orleans, which is believed to have been the first course of lectures upon that subject ever given in the United States. In 1849 he was appointed professor of medical chemistry and toxicology in the medical department of Louisville university, Louisville, Kentucky, which position he held for five years. In 1854 he succeeded his father as professor of chemistry, and continued to give instruction in this science, first in the academical and afterwards in the medical department of Yale College, until his death in 1885. In 1853 he was connected with the exhibition at the Crystal Palace in New York, having charge of the departments of chemistry, geology, and mineralogy. As a result of this work he edited a large quarto volume, *The World of Science, Art, and Industry* (1853), followed in 1854 by *The Progress of Science and Mechanism*. He also published in 1846 *First Principles of Chemistry*, a text-book which had a wide sale and passed through three editions. In 1858 he published a manual of physics entitled *First Principles of Physics or Natural Philosophy* (2d ed. 1861). In 1864 and again in 1867 and 1872 Silliman visited California, being engaged in professional work connected with various mines and in mineralogical and geological explorations. Still later he made several visits to the mining regions of the western States and Territories, and the results of his observations formed the subjects of numerous scientific papers. In 1874, the centennial anniversary of Priestley's discovery of oxygen, he delivered at Northumberland, Pa., where Priestley had resided during the later years of his life, an historical address on "American Contributions to Chemistry," which he afterwards expanded into a considerable volume.

SILO. A modern silo is a pit or erection in which green crops are preserved in an undried condition for fodder. The term is derived from the Greek σιρός (Lat. *sirus*), a pit for holding grain. It is only of recent years that *ensilage*, *i.e.*, the preservation of green food for cattle by partial fermentation in silos, has become an important feature in agricultural economy. In various parts of Germany a method of preserving green fodder precisely similar to that used in the case of sauerkraut (see vol. iv. p. 618) has prevailed for upwards of a century. Special attention was first directed to the practice of ensilage by a French agriculturist, M. Auguste Goffart of Sologne near Orleans, who in 1877 published a work (*Manuel de la Culture et de l'Ensilage des Mais et autres Fourrages Verts*) detailing the experiences of many years in preserving green crops in silos. An English translation of M. Goffart's book by Mr J. B. Brown was published in New York in 1879, and, as various experiments had been previously made in the United States in the way of preserving green crops in pits, M. Goffart's experience attracted considerable attention. The conditions of American dairy farming proved eminently suitable for the ensiling of green maize fodder; and the success of the method was soon indisputably demonstrated among the New England farmers. The favourable results obtained in America led to much discussion and to the extensive introduction of the system in the United Kingdom, where, with different conditions, success has been more qualified, but still highly encouraging.

It has been abundantly proved that ensilage forms a wholesome and nutritious food for cattle. It can be substituted for root crops with advantage, because it is succulent and digestible; milk resulting from it is good in quality and taste; it can be secured largely irrespective of weather; it carries over grass from the period of great abundance and waste to times when none would otherwise be available; and a larger number of cattle can be supported on a given area by the use of ensilage than is possible by the use of green crops.

A silo should have a depth of at least 15 feet, and may either be a pit or a building above ground, provided it is water-tight and, as far as possible, air-tight. The crops suitable for ensilage are the ordinary grasses, clovers, lucerne, vetches, oats, rye, and maize; but various weeds may also be stored in silos with good results, notably spurrey (*Spergula arvensis*), a most troublesome plant in poor light soils. As a rule the crop should be mown when in full flower, and deposited in the silo on the day of its cutting. Fair dry weather is not essential; but it is found that when moisture, natural and extraneous, exceeds 75 per cent. of the whole, good results are not obtained. The material is spread in uniform layers over the floor of the silo, and closely packed and trodden down. If possible, not more than a foot or thereby should be added daily, so as to allow the mass to settle down closely, and to heat uniformly throughout. When the silo is quite filled a layer of straw or some other dry porous substance is spread over the surface, then it is covered with boards, and a pressure of not less than 100 lb per square foot is applied by weighting or other mechanical means.

A silo thus contains, to begin with, a mass of living vegetable cells surrounded with a minimum of oxygen. The activity of the cells continuing, oxygen is absorbed and carbonic acid evolved, and part of the starch of the plants is converted into sugar. In the atmosphere of carbonic acid thus created the acid ferments manifest their vitality, and acetic, lactic, and butyric acids are developed at the expense of the starch and sugar. These chemical changes are accompanied with an evolution of heat, and the temperature of the mass rises, till, when it attains 122° Fahr., the action of the ferments is arrested. Should the heat rise to 150° the vitality of the vegetable cells themselves is destroyed; and also when the available oxygen is exhausted chemical change ceases and sweet silage is produced. When from excess of moisture or other cause the temperature of the silo does not reach 122° Fahr., the acid ferments are not killed, and they go on evolving chiefly acetic and lactic acids, the results being sour silage. These ferments, requiring nitrogen for their existence, act on the nitrogenous constituents of the plants, rendering the albuminoids partly soluble, evolving peptones, and by further splitting up producing amides, urea, and ammonia. The production of sour silage is accompanied by much greater transformation and loss than is incident to sweet silage; and in extreme action the material acquires a most disagreeable odour. There is, however, no sharp line of distinction between the two, and both varieties are eaten freely by stock. Frequently a considerable loss occurs around the edges, and at other points where air gets access to the mass, by mildewing. See *Report* of Select Committee.

SILURIDÆ, a large family of freshwater Fishes, flourishing in the present epoch, and represented by a great variety of forms in all the tropical and temperate regions, many of them reaching back into the Tertiary age. The principal characters of this family (termed a "suborder" by some), its position in the system, its geographical distribution, and some of the most remarkable points in the structure and life-history of its members have been already sufficiently noticed under ICHTHYOLOGY, but we have here to notice more fully the sections into which it has been divided, and certain remarkable forms which were referred to nominally only in that article.

The modifications of the vertical fins, or rather the specialization of certain portions at the expense of others, and the greater or less extent of the branchial aperture form excellent characters for subdividing the Siluroids.

I. In the *Siluridæ Homalopteræ* the vertical fins are exceedingly long, occupying nearly the whole extent of the embryonal fin, and in one genus (*Heterobranchus*) a great part of the dorsal portion retains its embryonic character, being a rayless adipose fin. All the Siluroids of this section belong to the fauna of the Old World and Australia. The rivers and lakes of tropical Africa harbour many species of the genera *Clarias* and *Heterobranchus*,—those of the Nile being known under the name of "Carmoot." One of the Nilotic species, *Clarias macracanthus*, occurs abundantly in the Lake of Galilee, and, being a long, scaleless, eel-like fish of black colour, with eight long barbels round its broad mouth, was certainly included among those which the Jews were forbidden to eat by the Mosaic law. These fish grow to a length of from 4 to 6 feet, and are eaten by the natives of tropical Africa.

II. In the *Siluridæ Heteropteræ* the dorsal fin has almost or entirely disappeared; only its foremost portion and a small adipose remnant may be preserved; on the other hand the anal portion is retained in its whole extent. The gill-membranes remain separate and overlap the isthmus. This section likewise belongs to the fauna of the Old World, and includes, among many others, the species which has given the name to the whole family *Silurus glanis*, the "Wels"

FIG. 1.—The "Wels" (*Silurus glanis*).

of the Germans. It is the only representative of the family in Europe, and with the exception of the sturgeon, is the largest freshwater fish of the Continent. It was known to Aristotle, who described it under the name of *Glanis*. It inhabits more the central and eastern portions of Europe than the western, being absent in Italy, Greece, southern Switzerland, France, and those parts of Germany which are drained by the Rhine and its affluents. In general appearance it somewhat resembles the burbot. Its head is large

and broad, its mouth wide, furnished with six barbels, of which those of the upper jaw are very long. Both jaws and the palate are armed with broad bands of small closely-set teeth, which give the bones a rasp-like appearance. The eyes are exceedingly small The short body terminates in a long, compressed, muscular tail, and the whole fish is covered with a smooth, scaleless, slippery skin. Specimens of 4 and 5 feet in length, and of 50 to 80 lb in weight, are of common occurrence. Its food consists chiefly of other bottom-feeding fishes, and in inland countries it is considered one of the better class of food fishes. Stories about children having been found in the stomach of very large individuals are probably inventions.

III. The *Siluridæ Anomalopteræ* are a small section from tropical America, in which the dorsal and adipose fins are very short and belong to the caudal vertebral column, while the anal is very long, and the gill-membranes are entirely separate, overlapping the isthmus.

IV. The *Siluridæ Proteropteræ* are a section extremely numerous in species, and represented throughout the tropics. The dorsal fin consists of a short-rayed and an adipose portion, the former belonging to the abdominal vertebral column; the anal is always much shorter than the tail. The gill-membranes are not confluent with the skin of the isthmus; they have a free posterior margin. When a nasal barbel is present, it belongs to the posterior nostril. This section includes among many others the genus *Bagrus*, of which the "Bayad" (*B. bayad*) and "Docmac" (*B. docmac*) frequently come under the notice of travellers on the Nile; they grow to a length of 5 feet, and are eaten. Of the "Cat-Fishes" of North America (*Amiurus*), locally called "bull-heads" or "horned-pouts," with eight barbels, some twenty species are known. Some of them are valued as food, especially one which is abundant in the ponds of New England, and capable of easy introduction into other localities (*A. nebulosus*). Others which inhabit the great lakes (*A. nigricans*) and the Mississippi (*A. ponderosus*) often exceed the weight of 100 lb. *Platystoma* and *Pimelodus* people the rivers and lakes of tropical America, and many of them are conspicuous in this fauna by the ornamentation of their body, by long spatulate snouts, and by their great size. The genus *Arius* is composed of the greatest number of species (about seventy), and has the widest distribution of all Siluroids, being represented in almost all tropical countries which are drained by large rivers. Some of the species enter salt water. They possess six barbels, and their head is extensively osseous on its upper surface; their dorsal and pectoral spines are generally developed into powerful weapons. *Bagarius*, one of the largest Siluroids of the rivers of India and Java, exceeding a length of 6 feet, differs from *Arius* in having eight barbels, and the head covered with skin.

V. In the *Siluridæ Stenobranchiæ* the dorsal fin consists of an adipose portion and a short-rayed fin which belongs to the abdominal vertebral column, and, like the adipose fin, may be sometimes absent. The gill-membranes are confluent with the skin of the isthmus. The Siluroids belonging to this section are either South-American or African. Among the former we notice specially the genus *Doras*, which is distinguished by having a series of bony scutes along the middle of the side. The narrowness of their gill-openings appears to have developed in them a habit which has excited the attention of all naturalists who have visited the countries bordering upon the Atlantic rivers of tropical America, viz., the habit of travelling during seasons of drought from a piece of water about to dry up to ponds of greater capacity. These journeys are occasionally of such a length that the fish have to travel all night; they are so numerous that the Indians fill many baskets of them. Hancock supposes that the fish carry a small supply of water with them in their gill-cavity, which they can easily retain by closing their branchial apertures. The same naturalist adds that they make regular nests, in which they cover up their eggs with care and defend them,—male and female uniting in this parental duty until the eggs are hatched. *Synodontis* is

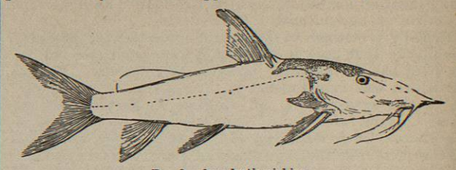

Fig. 2.—*Synodontis xiphias.*

an African genus and common in the Nile, where the various species are known by the name of "Shal." They frequently occur among the representations of animals left by the ancient Egyptians. The upper part of their head is protected by strong osseous scutes, and both the dorsal and pectoral fins are armed with powerful spines. Their mouth is small, surrounded by six barbels, which are more or less fringed with a membrane or with branched tentacles. Finally, the Electric Cat- or Sheath-Fishes (*Malapterurus*) also belong to this section. Externally

Fig. 3.—*Malapterurus electricus.*

they are at once recognized by the absence of a rayed dorsal fin, of which only a rudiment remains as a small interneural spine concealed below the skin. The entire fish is covered with soft skin, an osseous defensive armour having become unnecessary in consequence of the development of a powerful electric apparatus, the strength of which, however, is exceeded by that of the electric eel and the large species of *Torpedo*. It has been noticed in vol. xii. p. 650. Three species have been described from rivers of tropical Africa, of which one (*M. electricus*) occurs in the Nile; it rarely reaches a length of 4 feet.

VI. The section of *Siluridæ Proteropodes* contains small forms, some of which are of interest by the degree of specialization to which they have attained in one or the other direction. Many of them are completely mailed; but all have in common a short-rayed dorsal fin, with the ventrals below or rarely in front of it. Their gill-openings are reduced to a short slit; their pectorals and ventrals have assumed a horizontal position; and their vent is before, or not much behind, the middle of the length of the body. The first group of this section comprises alpine forms of the Andes, without any armature, and with a very broad and pendent lower lip. They have been referred to several genera (*Stygogenes*, *Arges*, *Brontes*, *Astroplebus*), but are collectively called "preñadillas" by the natives, who state that they live in subterranean craters within the bowels of the volcanoes of the Andes, and are ejected with streams of mud and water during eruptions. These fishes may, however, be found in surface waters at all times, and their appearance in great quantities in the low country during volcanic eruptions can be accounted for by numbers being killed by the sulphuretted gases which escape during an eruption and

by their being swept down with the torrents of water issuing from the volcano. The lowland forms have their body encased in large scutes, either rough, scale-like, and arranged in four or five series (*Chætostomus*), or polished, forming broad rings round the slender and depressed tail (*Loricaria*, fig. 4), or polished and large, so as to form two series only along the body and short tail (*Callichthys*, fig. 5). In India this sec-

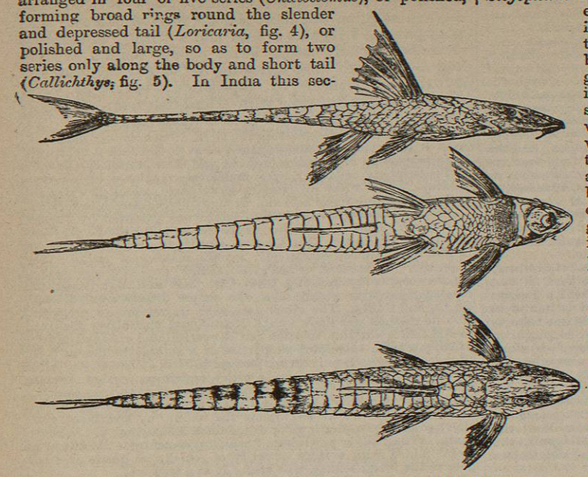

Fig. 4.—*Loricaria lanceolata*, from the upper Amazons. Natural size.

tion is but sparsely represented, chiefly in mountain-streams, by small loach-like Siluroids, in which various kinds of peculiar apparatus are developed to enable them to hold on to stones, this preventing their being swept away by the current; in *Pseudecheneis* the adhesive apparatus consists of transverse plaits of the skin on the thorax between the pectoral fins; in *Exostoma* the mouth is modified into a suctorial organ, probably with the same function. Finally, the South-American genus *Aspredo*, which is remarkable for the peculiar mode of protecting its eggs, as mentioned in vol. xii. p. 660, belongs also to this section.

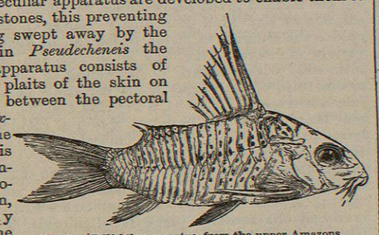

Fig. 5.—*Callichthys armatus*, from the upper Amazons. Natural size.

VII. The small section of *Siluridæ Opisthopteræ* comprises South-American forms, the majority of which inhabit waters at high altitudes up to 14,000 feet above the level of the sea. All have a short-rayed dorsal fin, placed above or behind the middle of the length of the body, above or behind the ventrals, which may be absent. Also the anal is short. The nostrils are remote from each other, and the gill-membranes are not confluent with the skin of the isthmus. These little fishes, of which *Trichomycterus* and *Nematogenys* are the principal genera, replace in the Andes the loaches of the northern hemisphere; they resemble them in appearance and habits, and even in coloration, offering a striking illustration of the fact that similar forms of animals are produced under similar external physical conditions.

VIII. Finally, the *Siluridæ Brunchicolæ* comprise the smallest and least developed members of the family; they are referred to two genera only from South America, *Stegophilus* and *Vandellia*, the smallest of which does not exceed the length of 2 inches. Their body is soft, narrow, cylindrical, and elongate; the dorsal and anal fins short; the vent far behind the middle of the length of the body; gill-membranes confluent with the skin of the isthmus. Each maxillary is provided with a small barbel; and the gill-covers are armed with short stiff spines. Their small size notwithstanding, these Siluroids are well known to the Brazilians, who accuse them of entering and ascending the urethra of persons while bathing, causing inflammation and sometimes death. They certainly live parasitically in the gill-cavity of large Siluroids, probably entering those cavities for places of safety, but without drawing any nourishment from their hosts. (A. C. G.)

SILVANUS, an ancient Italian god of the woods (*silvæ*), closely allied to Faunus. Virgil speaks of him as a god of fields and cattle, and says that the Pelasgians dedicated a grove to him near Cære. Horace calls him the god of boundaries. Pigs were sacrificed to him, and at harvest festivals he received offerings of milk. He appears sometimes, especially in inscriptions, as a domestic god, and is occasionally associated with the Lares and Penates. Virgil describes him as crowned with fennel and lilies or carrying an uprooted cypress in his hand. On a relief he appears with a crown of pine branches in his hair, a pine branch in his left hand, a skin filled with fruits hanging about his neck, a pruning-knife in his right hand, and a dog by his side. On votive tablets he is oftener represented as the god of planting and gardening than as the rough woodland deity.

SILVER[1] is widely diffused throughout the earth's crust, including the ocean, which contains a trace of the noble metal—minute, it is true, in a relative sense, but in absolute amount approaching 10,000 million tons. Of the varieties of silver ores, the following chiefly are metallurgically important:—(1) *Reguline Silver*, generally alloyed with mercury or gold, and if with the latter including sometimes a trace of platinum; (2) *Horn Silver*, native chloride, AgCl; (3) *Silver Glance*, native sulphide, Ag_2S; (4) *Silver-Copper Glance*, $(Ag,Cu)_2S$; (5) *Pyrargyrite* ("Rothgültigerz"), Ag_3SbS_3; (6) *Stephanite*, Ag_5SbS_4; (7) *Polybasite*, $9(Ag_2Cu_2)S + (Sb_2,As_2)S_3$. Silver is also frequently met with in base-metallic ores, *e.g.*, in lead ores and many kinds of pyrites. Unmixed silver minerals nowhere present themselves in large continuous masses. What we call "silver ores" are all more or less complex mixtures in which the non-argentiferous components are usually decidedly in the majority. Their metallurgic treatment depends chiefly on the nature of these admixtures, the state of combination of the silver being as a rule irrelevant in the choice of a process, because some at least of the noble metal is always present as sulphide, and our modes of treatment for it include all other native forms.

Amalgamation.—If a given ore is relatively free of base "metals" (metallurgically speaking), some process of "amalgamation" may be, and often is, resorted to.

In the *Freiberg process* the first step is to roast the (ground) ore with common salt, which converts the sulphide of silver into

[1] Compare CHEMISTRY, vol. v. p. 528–530; also MINING, MINT, and MONEY.