

subsequent years would alone account for the high rank he obtained as a mathematician. . . . The mastery which he had obtained over the mathematical symbols was so complete that he never shrank from the use of expressions, however complicated—nay, the more complicated they were the more he seemed to revel in them—provided they did not sin against the ruling spirit of all his work, symmetry. To a mind imbued with the love of mathematical symmetry the study of determinants had naturally every attraction. In 1851 Mr Spottiswoode published in the form of a pamphlet an account of some elementary theorems on the subject. This having fallen out of print, permission was sought by the editor of *Crelle* to reproduce it in the pages of that journal. Mr Spottiswoode granted the request and undertook to revise his work. The subject had, however, been so extensively developed in the interim that it proved necessary not merely to revise it but entirely to re-write the work, which became a memoir of 116 pages. To this, the first elementary treatise on determinants, much of the rapid development of the subject is due. The effect of the study on Mr Spottiswoode's own methods was most pronounced; there is scarcely a page of his mathematical writings that does not bristle with determinants." The Royal Society's *Catalogue of Scientific Papers* (vols. i. -viii.) shows a list of 49 papers by Spottiswoode, to which must be added about 66 more, the titles of which have not yet been printed in that catalogue. These were published principally in the *Philosophical Transactions*, *Proceedings of the Royal Society*, *Quarterly Journal of Mathematics*, *Proceedings of the London Mathematical Society*, and *Crelle*, and one or two in the *Comptes Rendus* of the Paris Academy. Another list of his papers, arranged according to the several journals in which they originally appeared, with short notes upon the less familiar memoirs, is given in *Nature*, vol. xxvii. p. 599.

SPRAIN. See SURGERY, p. 682, *infra*.

SPRAT, a marine fish (*Clupea sprattus*), named "garvie" in Scotland, one of the smallest species of the genus *Clupea* or herrings, rarely exceeds 5 inches in length, and occurs in large shoals on the Atlantic coasts of Europe. It is found also in the southern hemisphere, on the coasts of Tasmania and New Zealand, where, however, it seems to be less abundant, since its presence at the antipodes has been discovered only recently, and it does not seem to be the object of a regular fishery. Sprats are very often confounded with young herrings, which they much resemble, but can always be distinguished by the following characters: they do not possess any teeth on the palate (*vomer*), like herrings; their gill-covers are smooth, without the radiating striæ which are found in the shad and the pilchard; the anal fin consists of from seventeen to twenty rays, and the lateral line of forty-seven or forty-eight scales. The ventral fins are even with the origin of the dorsal fin; and the spine consists of from forty-seven to forty-nine vertebrae. The sprat is one of the more important food-fishes on account of the immense numbers which are caught when the shoals approach the coasts. They are somewhat capricious, however, as regards the place and time of their appearance, the latter falling chiefly in the first half of winter. They are caught with the sein or with the bag-net in the tideway. Large quantities are consumed fresh, but many are pickled or smoked, and others prepared like anchovies. Frequently the captures are so large that the fish can be used as manure only.

SPREMBERG, a small town of Prussia, in the province of Brandenburg, is situated about 75 miles to the south-east of Berlin, partly on an island in the river Spree and partly on the west bank. It carries on considerable manufactures of woollen cloth, and has greatly advanced in importance and population since the beginning of the 19th century. In 1885 its population numbered 11,011. The only building of note is the château, built by a son of Elector John George about the end of the 16th century.

SPRENGEL, KURT (1766-1833), German botanist and physician, was born on 3d August 1766 at Boldekow in Pomerania. His father, a clergyman, provided him with a thorough education of wide scope; and the boy at an early age distinguished himself as a linguist, not only in Latin and Greek, but also in Arabic. He appeared as an author at the age of fourteen, publishing a small work

called *Anleitung zur Botanik für Frauenzimmer* in 1780. In 1784 he commenced in the university of Halle to study theology and medicine, but soon relinquished the former. He graduated in medicine in 1787. In 1789 he was appointed an extraordinary professor of medicine in his *alma mater*, and in 1795 was promoted to an ordinary professorship. He devoted much of his time to medical work and to investigations into the history of medicine; and he published several very valuable works in this department of knowledge, and made himself well known as one of the ablest medical men in Germany. He held a foremost rank in medicine and in botany as an original investigator, and in both published works of great value, besides numerous articles in scientific journals and in the proceedings of learned societies. His accomplishments as a linguist probably, in part at least, determined him in the choice of the department to which he most fully devoted himself, and in which he stood *facile princeps*. Among the more important of his many services to the science of botany was the part he took in awakening and stimulating microscopic investigation into the anatomy of the tissues of the higher plants, though defective microscopic appliances rendered the conclusions arrived at by himself unreliable. He also made many improvements in the details of both the Linnæan and the "natural" systems of classification. His life passed quietly at Halle in the pursuit of the studies dear to him, and in the enjoyment of the honours bestowed upon him by over seventy learned societies, and also by monarchs. In 1828 the death of a son, professor of surgery at Greifswald, was felt by him very severely. He experienced several apoplectic seizures, and died in one on 15th March 1833.

Subjoined is a list of the more important of his works:—*Beiträge zur Geschichte d. Pulses*, 1787; *Galens Fieberlehre*, 1788; *Apologie des Hippokrates*, 1789; *Versuch einer pragmatischen Geschichte der Arzneikunde*, 1792-99; *Handbuch der Pathologie*, 1795-97; *Institutiones Medicæ*, 1809-16 (in 6 vols.); *Geschichte der Medicin*, completed in 1820; *Antiquitatum botanicarum specimen*, 1798; *Historia rei herbariæ*, 1807-8; *Anleitung zur Kenntniss der Gewächse*, 1802-4, and again 1817-18; *Geschichte der Botanik*, 1817-18; *Von dem Bau und der Natur der Gewächse*, 1812; *Flora Halensis*, 1806-15, and in 1832; *Species umbelliferarum minus cognite*, 1818; *Neue Entdeckung im ganzen Umfang der Pflanzenkunde*, 1820-22. He edited an edition of Linnæus's *Systema vegetabilium* in 1824 and of the *Genera plantarum* in 1830. His short papers are too numerous to be quoted; a list of those in botany, from 1798 onwards, will be found in the Royal Society's *Catalogue of Scientific Papers*.

SPRINGBOK. See ANTELOPE, vol. ii. p. 101.

SPRINGFIELD, a city of the United States, capital of Illinois and the county seat of Sangamon county, 185 miles south-west of Chicago and 95 north-east of St Louis, at the intersection of the main lines of the Chicago and Alton and the Wabash, St Louis, and Pacific Railways. It is situated in 39° 48' N. lat. and 89° 33' W. long., on a plateau 4 miles south of the Sangamon river. The State capitol (1868-1886) is constructed of Joliet marble in the form of a Greek cross, with porticos of granite; it is 385 feet long and 296 wide, and has a central dome surmounted by a lantern with a ball on the pinnacle (360 feet). It contains a general library, a law library, geological and agricultural museums, and a memorial hall of the Civil War, as well as the usual Government offices. Other buildings of note are the United States executive mansion, custom-house and post-office (1866-68), and the house formerly occupied by Lincoln. In Oak Ridge cemetery, adjacent to the city, is the Lincoln monument (1874), beneath which that president was buried. The monument, designed by Larkin G. Mead, consists of a granite obelisk, reaching a height of 98½ feet from the centre of a spacious basement (119½ feet long and 72½ wide), which contains a catacomb and a memorial hall,—the latter a museum of Lincolniana. A bronze statue of Lincoln and four groups

of figures in bronze, symbolizing the army and navy of the United States, are arranged round the foot of the obelisk. The town has a public library, two hospitals, two orphanages, and various other charitable institutions. Extensive deposits of bituminous coal occur in and near Springfield, which is the seat of extensive iron-rolling mills, watch factories, railway machine shops, plough works, and woollen, paper, and flour mills. It is also the headquarters of six of the principal live-stock associations of the country. The population was 4533 in 1850, 9820 in 1860, 17,364 in 1870, 19,743 (1328 coloured) in 1880, and in 1887 it was estimated at 25,000.

Laid out in 1822, Springfield was selected as State capital in 1837, and was made a city in 1840.

SPRINGFIELD, a city of the United States, the county seat of Hampden county, Massachusetts, on the east bank of Connecticut river, opposite West Springfield, with which it is connected by road and railway bridges. By rail it is 98 miles west by south of Boston on the route to Albany, and it forms a very important railway junction. The western part of Springfield is built on low and level ground, the eastern on the ascent from the river valley. The streets are wide and well shaded with elm and maple. A United States arsenal (founded 1777) and armoury (1794), employing some 460 hands, is the largest in the republic. The Springfield breech-loading rifle of 45 calibre has been the regulation pattern in the United States army since 1873. A pistol factory, car-works, manufactories of cotton and silk goods, buttons, needles, envelopes, paper, watches, skates, and brass-work may be mentioned among the industrial establishments. The city hall (1855), a Romanesque building with an audience-room capable of holding 2700 persons; the city free library (1871), a Gothic building of brick, which contains 56,000 volumes and a museum; the granite court-house; the Roman Catholic cathedral of St Michael; Christ Church, Episcopal; the Church of the Unity, a fine Gothic structure in brown stone; the South Congregational church; the office of the Boston and Albany Railroad, a massive granite block; and the high school are among the chief architectural features of the city. Races are held in Hampden Park by the river side. The population was 15,199 in 1860, 26,703 in 1870, 33,340 in 1880 (775 coloured), and 37,577 in 1885.

Springfield was settled in 1636 by William Pynchon and emigrants from Roxbury,—the determination of the founder being to limit the "town" to forty or at most fifty families. The name was at first Agawam; but the present designation was adopted in 1641 in memory of Springfield (Essex), Pynchon's residence in his native country, England, to which he was obliged to return in 1652 to escape the clerical persecution called forth by his book on the *Meritorious Price of Christ's Redemption*. The town was burned by the Indians in 1675; and in 1787 the arsenal was attacked by Shays's rebels. The opening of the Boston and Albany Railroad in 1839 was the beginning of rapid development, and the town was made a city in 1852. The manufacture of firearms carried on here during the Civil War, 1861-65, gave the city a great impulse.

SPRINGFIELD, a city of the United States, county seat of Greene county, Missouri, occupies a pleasant and healthy site on the Ozark Hills, 238 miles by rail south-west of St Louis by the St Louis and San Francisco Railroad, which here joins with the Kansas City, Fort Scott, and Gulf Railroad. Springfield is the chief commercial centre of south-west Missouri, one of the great lead and zinc mining districts of the States. It contains a number of factories (cotton, wool, waggons, furniture, tobacco, &c.), and is the seat of a court-house and of Drury College (1873), which provides scientific and classical training and has a musical conservatory attached. The population was 5555 in 1870, 6522 in 1880, and in 1886 was estimated at 18,000.

Originally an Indian trading post and frontier village, Springfield was incorporated in 1830 and began to be a prosperous place at the close of the Civil War, during which it had several times changed hands and been the scene of hostilities.

SPRINGFIELD, a city of the United States, county seat of Clarke county, Ohio, lies at the confluence of Mad river and Lagonda Creek (sub-tributaries of the Ohio through the Miami), 84 miles north-east of Cincinnati. It has a large trade in the agricultural produce of the fertile and populous district in which it is pleasantly situated, and is the seat of a very large manufactory of agricultural machinery, which turns out 75,000 reapers and mowers per annum, besides grain-drills, steam-engines, cider-mills, and a great variety of articles. In 1870 the population of the city was 12,652, in 1880 20,730 (township, 24,455), and 33,484 in 1886. Among the public institutions are Wittenberg College (Lutheran), founded in 1845, and a small public library.

SPRINGS. See GEOLOGY, vol. x. pp. 223, 269 *sq.*, and MINERAL WATERS.

SPRUCE. See FIR, vol. ix. p. 222.

SPURZHEIM, KASPAR, phrenologist, was born at Longwich near Treves on 31st December 1776, and died at Boston, United States, on 10th November 1832. See PHRENOLOGY.

SQUARING (or QUADRATURE) OF THE CIRCLE is the problem of finding a square equal in area to a given circle. Like all problems, it may be increased in difficulty by the imposition of restrictions; consequently under the designation there may be embraced quite a variety of geometrical problems. It has to be noted, however, that, when the "squaring" of the circle is especially spoken of, it is almost always tacitly assumed that the restrictions are those of the Euclidean geometry.

Since the area of a circle equals that of the rectilinear triangle whose base has the same length as the circumference and whose altitude equals the radius (Archimedes, *Κύκλου μέτρησις*, prop. 1), it follows that, if a straight line could be drawn equal in length to the circumference, the required square could be found by an ordinary Euclidean construction; also, it is evident that, conversely, if a square equal in area to the circle could be obtained, it would be possible to draw a straight line equal to the circumference. Rectification and quadrature of the circle have thus been, since the time of Archimedes at least, practically identical problems. Again, since the circumferences of circles are proportional to their diameters—a proposition assumed to be true from the dawn almost of practical geometry—the rectification of the circle is seen to be transformable into finding the ratio of the circumference to the diameter. This correlative numerical problem and the two purely geometrical problems are inseparably connected historically.

Probably the earliest value for the ratio was 3. It was so among the Jews (1 Kings vii. 23, 26), the Babylonians (Oppert, *Journ. Asiatique*, August 1872, October 1874), the Chinese (Biot, *Journ. Asiatique*, June 1841), and probably also the Greeks. Among the ancient Egyptians, as would appear from a calculation in the Rhind papyrus, the number $(\frac{256}{81})^4$, i.e., 3.16 . . . , was at one time in use.¹ The first attempts to solve the purely geometrical problem appear to have been made by the Greeks (Anaxagoras, &c.),² one of whom, Hippocrates,³ doubtless raised hopes of a solution by his quadrature of the so-called *meniscus*. As for Euclid, it is sufficient to recall the facts that the original author of prop. 8 of book iv. had strict proof of the ratio being < 4, and the author of prop. 15 of the ratio being > 3, and to direct attention to the importance

¹ Eisenlohr, *Ein math. Handbuch d. alten Aegypter*, übers. u. erklärt, Leipzig, 1877; Rodet, *Bull. de la Soc. Math. de France*, vi. pp. 139-149.

² Hankel, *Zur Gesch. d. Math. im Alterthum*, &c., chap. v., Leipzig, 1874; Cantor, *Vorlesungen über Gesch. d. Math.*, i., Leipzig, 1880; Tannery, *Mém. de la Soc., &c., à Bordeaux*; Allman, in *Hermathena*.

³ Tannery, *Bull. des Sc. Math.*, [2], x. pp. 213-226.

cernea, it would seem that Gregory was the first (in 1670) to make known the series for the arc in terms of the tangent, the series for the tangent in terms of the arc, and the secant in terms of the arc; and in 1669 Newton showed to Barrow a little treatise in manuscript containing the series for the arc in terms of the sine, for the sine in terms of the arc, and for the cosine in terms of the arc. These discoveries formed an epoch in the history of mathematics generally, and had, of course, a marked influence on after investigations regarding circle-quadrature. Even among the mere computers the series

$$\theta = \tan \theta - \frac{1}{3} \tan^3 \theta + \frac{1}{5} \tan^5 \theta - \dots,$$

specially known as Gregory's series, has ever since been a necessity of their calling.

The calculator's work having now become easier and more mechanical, calculation went on apace. In 1699 Abraham Sharp, on the suggestion of Halley, took Gregory's series, and, putting $\tan \theta = \frac{1}{3} \sqrt{3}$, found the ratio equal to

$$\sqrt{12} \left(1 - \frac{1}{3 \cdot 3} + \frac{1}{5 \cdot 3^3} - \frac{1}{7 \cdot 3^5} + \dots \right),$$

from which he calculated it correct to 71 fractional places.¹ About the same time Machin calculated it correct to 100 places, and, what was of more importance, gave for the ratio the rapidly converging expression,

$$\frac{16}{5} \left(1 - \frac{1}{8 \cdot 5^3} + \frac{1}{5 \cdot 5^5} - \frac{1}{7 \cdot 5^7} + \dots \right) - \frac{4}{239} \left(1 - \frac{1}{3 \cdot 239^3} + \frac{1}{5 \cdot 239^5} - \dots \right),$$

which long remained without explanation.² Fautet de Lagny, still using $\tan 30^\circ$, advanced to the 127th place.³

Euler took up the subject several times during his life, effecting mainly improvements in the theory of the various series.⁴ With him, apparently, began the usage of denoting by π the ratio of the circumference to the diameter.⁵ The most important publication, however, on the subject in the 18th century was a paper by Lambert,⁶ read before the Berlin Academy in 1761, in which he demonstrated the irrationality of π . The general test of irrationality which he established is that, if

$$\frac{a_1}{b_1} \pm \frac{a_2}{b_2} \pm \frac{a_3}{b_3} \pm \dots$$

be an interminate continued fraction, $a_1, a_2, \dots, b_1, b_2, \dots$

be integers, $\frac{a_1}{b_1}, \frac{a_2}{b_2}, \dots$ be proper fractions, and the value of

every one of the interminate continued fractions $\frac{a_1}{b_1} \pm \dots, \frac{a_2}{b_2} \pm \dots, \dots$ be < 1 , then the given continued fraction

represents an irrational quantity. If this be applied to the right-hand side of the identity

$$\tan \frac{m}{n} = \frac{m}{n} - \frac{m^3}{3n^3} + \frac{m^5}{5n^5} - \dots,$$

it follows that the tangent of every arc commensurable with the radius is irrational, so that, as a particular case, an arc of 45° , having its tangent rational, must be incommensurable with the radius; that is to say, $\frac{1}{4}$ is an incommensurable number.⁷ This incontestable result had no effect, apparently, in repressing the π -computers. Vega

in 1789, using series like Machin's, viz., Gregory's series and the identities

$$\frac{\pi}{4} = 5 \tan^{-1} \frac{1}{5} + 2 \tan^{-1} \frac{1}{7}, \quad (\text{Euler, 1779}),$$

$$\frac{\pi}{4} = \tan^{-1} \frac{1}{2} + 2 \tan^{-1} \frac{1}{5}, \quad (\text{Hutton, 1776}),$$

neither of which was nearly so advantageous as several found by Hutton, calculated π correct to 136 places.⁸ This achievement was anticipated or outdone by an unknown calculator, whose manuscript was seen in the Radcliffe Library, Oxford, by Baron von Zach towards the end of the century, and contained the ratio correct to 152 places. More astonishing still have been the deeds of the π -computers of the 19th century. A condensed record compiled by Mr Glaisher (*Messenger of Math.*, ii. p. 122) is as follows:—

Date.	Computer.	No. of fr. digits calcd.	No. of fr. digits correct.	Place of Publication
1842	Rutherford	208	152	<i>Trans. Roy. Soc., Lond.</i> , 1841, p. 283.
1844	Dase	205	200	<i>Crelle's Journ.</i> , xxvii. p. 198.
1847	Clausen	250	248	<i>Astron. Nachr.</i> , xxv. col. 207.
1853	Shanks	318	318	<i>Proc. Roy. Soc., Lond.</i> , 1853, p. 273.
1853	Rutherford	440	440	<i>Ibid.</i>
1853	Shanks	530	...	<i>Ibid.</i>
1853	Shanks	607	...	<i>W. Shanks, Rectification of the Circle</i> , London, 1853.
1853	Richter	333	330	<i>Grunert's Archiv</i> , xxi. p. 119.
1854	Richter	400	330	<i>Ibid.</i> , xxii. p. 473.
1854	Richter	400	400	<i>Ibid.</i> , xxiii. p. 476.
1854	Richter	500	500	<i>Ibid.</i> , xxv. p. 472.
1873	Shanks	707	...	<i>Proc. Roy. Soc., Lond.</i> , xxi.

By these computers Machin's identity, or identities analogous to it, e.g.,

$$\frac{\pi}{4} = \tan^{-1} \frac{1}{5} + \tan^{-1} \frac{1}{7} + \tan^{-1} \frac{1}{13},$$

$$\frac{\pi}{4} = 4 \tan^{-1} \frac{1}{5} - \tan^{-1} \frac{1}{7} + \tan^{-1} \frac{1}{13},$$

and Gregory's series were employed.⁹

A much less wise class than the π -computers of the 19th century are the pseudo-circle-squarers, or circle-squarers technically so called, that is to say, persons who, having obtained by illegitimate means a Euclidean construction for the quadrature or a finitely expressible value for π , insist on using faulty reasoning and defective mathematics to establish their assertions. Such persons have flourished at all times in the history of mathematics; but the interest attaching to them is more psychological than mathematical.¹⁰

It is of recent years that the most important advances in the theory of circle-quadrature have been made. In 1873 Hermite proved that the base e of the Napierian logarithms cannot be a root of a rational algebraical equation of any degree.¹¹ To prove the same proposition regarding π is to prove that a Euclidean construction for circle-quadrature is impossible. For in such a construction every point of the figure is obtained by the intersection of two straight lines, a straight line and a circle, or two circles; and, as this implies that, when a unit of length is introduced, numbers employed, and the problem transformed into one of algebraic geometry, the equations to be solved can only be of the first or second degree, it follows that the equation to which we must be finally led is a rational equation of even degree. Hermite¹² did not

⁸ *Nova Acta Petrop.*, ix. p. 41; *Thesaurus Logarithm. Completus*, p. 633.

⁹ On the calculations made before Shanks, see Lehmann, "Beitrag zur Berechnung der Zahl π ," in *Grunert's Archiv*, xxi. pp. 121-174.

¹⁰ See Montucla, *Hist. des rech. sur la quad. du cercle*, Paris, 1754, 2d ed. 1831; De Morgan, *Budget of Paradoxes*, London, 1872.

¹¹ "Sur la fonction exponentielle," *Comptes Rendus*, Paris, lxxvii. pp. 18, 74, 226, 285.

¹² See *Crelle's Journal*, lxxvi. p. 342.

succeed in his attempt on π ; but in 1882 Lindemann, following exactly in Hermite's steps, accomplished the desired result.¹ Mathematicians are agreed that the full demonstration leaves something to be desired in the matter of simplicity, and attempts at simplification have already been made by Markoff and Rouché.²

Besides the various writings mentioned, see for the early history of the subject, Montucla, *Hist. des Math.*, 6 vols., Paris, 1758, 2d ed. 1799-1802; Murhard, *Bibliotheca Mathematica*, ii. pp. 106-123, Leipzig, 1798; Reuss, *Repertorium Comment.*, vii. pp. 42-44, Göttingen, 1808. For a few approximate geometrical solutions, see Leybourn's *Math. Repository*, vi. pp. 151-154; *Grunert's Archiv*, xii. p. 98, xlix. p. 3; *Nieuw Archief v. Wisk.*, iv. pp. 200-204. For experimental determinations of π , dependent on the theory of probability, see *Mess. of Math.*, ii. pp. 113, 119; *Casopsis pro pistodant math. a fys.*, x. pp. 272-275; *Analyst*, ix. p. 176. (T. MU.)

SQUASH (*Cucurbita Meloepo*). See GOURD.

SQUILL, the name under which the bulbous root of *Urginea maritima*, Baker, is used in medicine. The plant was formerly placed in the genus *Scilla*, from which it has been separated because the seeds are flat and discoid instead of triquetrous, as in the latter genus. The name of "squill" is also applied by gardeners to the various species of *Scilla*. The medicinal squill is a native of the countries bordering the Mediterranean, and grows from the sea-level up to an elevation of 3000 feet. The bulbs are globular and of large size, often weighing more than 4 lb. Two varieties are met with, the one having white and the other pink scales. They are collected in August, when they are leafless, the membranous outer scales being removed and the fleshy portion cut transversely into slices and dried in the sun. These are then packed in casks for exportation. They are chiefly imported into the United Kingdom from Malta. When reduced to powder and exposed to the air the drug rapidly absorbs moisture and cakes together into a hard mass. Squill has been used in medicine from a very early period. The ancient Greek physicians prescribed it with vinegar and honey almost in the same manner as it is used at present. Its medicinal properties are expectorant and diuretic. It is chiefly prescribed in bronchitis when the phlegm is tenacious and expectorated with difficulty, and in cardiac dropsy. When given in large doses it acts as an irritant poison, and its use is therefore contra-indicated in active inflammatory conditions of the mucous membrane or of the kidneys. The fresh bulb rubbed on the skin causes redness and irritation, due in part to the presence of minute crystals of oxalate of calcium. The activity of the drug appears to be due to the active principles, scillipicin, scillitoxin, and scillin, which were first obtained by Merck in 1878. The first has a bitter and burning taste, powerfully irritating the mucous membrane of the nose. It is soluble in alcohol and ether and partly in alkalis, but insoluble in water; if mixed with sugar it dissolves readily and can then be absorbed if injected subcutaneously. Scillitoxin is hygroscopic, very soluble in water, and has a bitter taste. These two principles have an action on the heart resembling that of *Digitalis*; in large doses the former stops its action in systole and the latter in diastole. Scillin is crystalline, tasteless, and soluble in alcohol, though only with difficulty in water. It is present only in very small quantity in squill, and appears to be the cause of the subsidiary effects of that drug, such as vomiting, &c.

An allied species, *Urginea indica*, Baker, is used in India in the same manner as the Fair bean species. The true squills are represented in Great Britain by two species, *Scilla autumnalis* and *S. verna*. The former has a racemose inflorescence; the latter has the flowers arranged in a corymbose manner, and is confined to the seacoast. Several species are cultivated in gardens, *S. bifolia* and *S. sibirica* being remarkable for their beautiful blue flowers, which are produced in early spring. The name of Chinese squill is applied by gardeners to *Barnardia scilloides* and that of Roman squill to species of *Bellevalia*.

SQUINT. See OPHTHALMOLOGY, vol. xvii. p. 785.

SQUIRREL. In the article MARMOT (vol. xv. p. 559) an account was given of the three genera forming the

¹ See "Ueber die Zahl π ," in *Math. Annalen*, xx. p. 213.

² *Nouv. Annales*, 3d ser., ii. p. 5.

Arctomyia, or Marmot sub-family of the large family *Sciuridae*, and in the present article the members of the other and more typical sub-family, the *Sciurina*, are noticed. The systematic position of the *Sciuridae* as a whole and their relations to other rodents are shown in the article MAMMALIA (vol. xv. p. 418); so it is merely with the component genera of the group that we now have to deal.

Of the *Sciurina* six genera are commonly recognized, the first being the typical one, *Sciurus*, in which the common English squirrel is included. The characters of the genus are—form slender and agile; tail long and bushy; ears generally well developed, pointed, often tufted; feet adapted for climbing, the anterior pair with four toes and a rudimentary thumb, and the posterior pair with five toes, all the toes having long, curved, and sharp-pointed claws; mammae from four to six in number; skull (see fig. 1) lightly built, very similar in

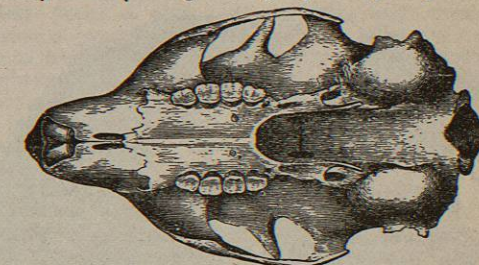


FIG. 1.—Skull of *Sciurus bicolor*; natural size.

shape throughout the genus; post-orbital processes long and curved; incisors narrow and compressed; premolars either one or two above and one below; when two are present above, the anterior one is quite minute and very different from the corresponding tooth in the marmots; molars three on each side above and below.

True squirrels are found throughout the greater part of the tropical and temperate regions of both hemispheres, although they are absent both from Madagascar and the Australian region. The species are both largest and most numerous in the tropics, and reach their greatest development in the Malay parts of the Oriental region.

Squirrels vary in size from animals no larger than a mouse, such as *Sciurus soricinus* of Borneo, or *S. minutus* of West Africa, to others as large as a cat, such as the black and yellow *S. bicolor* of Malaysia (see fig. 1). The very large squirrels, as might be expected from their heavier build, are somewhat less strictly arboreal in their habits than the smaller ones, of which the common English species may be looked upon as typical. The Common Squirrel, *S. vulgaris*, whose general habits are too well known to need special description, ranges over the whole of the Palearctic region, from Ireland to Japan, from Lapland to North Italy; but specimens from different parts of this wide range differ so much in colour as to have been often looked upon as different species. Thus, while the common squirrels of north and west Europe are of the bright red colour we are accustomed to see in England, those of the mountainous regions of southern Europe are nearly always of a deep blackish grey; those from Siberia again are a clear pale grey colour, with scarcely a tinge of rufous. These last supply the squirrel fur used for lining cloaks. The pairing time of the squirrel is from February to April, and after a period of gestation of about thirty days it brings forth from three to nine young. In addition to all sorts of vegetables and fruits the squirrel is exceedingly fond of animal food, greedily devouring mice, small birds, and eggs.

Although the English squirrel is a most beautiful little