absent. There is little or no pitting. (3) As regards complications and injurious results, these are rarely seen and the risk to life is insignificant.

Various circumstances affect the mortality in ordinary smallpox and increase the dangers attendant upon it. The character of the epidemic has an important influence. In some outbreaks the type of the disease is much more severe than in others, and the mortality consequently greater. Smallpox is most fatal at the extremes of life, except in the case of vaccinated infants, in whom there is immunity from the disease. Again, any ordinary case with discrete eruption is serious, and a case of confluent or even semi-confluent character is much more grave, while the hæmorrhagic variety is frequently and the malignant always fatal. Numerous and often dangerous complications, although liable to arise in all cases, are more apt to occur in the severer forms, and in general at or after the supervention of the secondary fever. The most important are inflammatory affections of the respiratory organs, such as bronchitis, pleurisy, or pneumonia, diphtheritic conditions of the throat, and swelling of the mucous membrane of the larynx and trachea. Destructive ulceration affecting the eyes or ears are well-known and formidable dangers, while various affections of the skin, in the form of erysipelas, abscess, or carbuncles, are of not infrequent occurrence. Persons of enfeebled health, and those whose constitutions are impaired by intemperance, readily succumb to attacks of smallpox, even of comparatively mild character, as do also pregnant women, to whom this disease is peculiarly dangerous.

The most important of all the conditions tending to affect the mortality from smallpox, alike in the individual and the community, is the protection afforded by VACCINATION (*q.v.*). During the first decade of life, if vaccination has been fully and successfully accomplished in infancy, the risk of death from smallpox is *nil*; but, should the disease be caught—which is improbable—it will in all likelihood show itself in the mild form of varioloid. As regards revaccination, it has been found in all smallpox hospitals that the attendants and nurses escape the disease when revaccinated. In the experience of the late Dr Waller Lewis in the case of an average of 10,504 persons permanently employed in the General Post Office, London, all of whom had to be revaccinated on admission, it was proved that in the ten years 1870-79 not a single fatal case of smallpox occurred, and only ten mild cases were seen during a period embracing two epidemics.

Treatment.—The treatment of smallpox is conducted upon the same general principles as that for the other infectious diseases (see CHOLERA, DIPHTHERIA, MEASLES, SCARLET FEVER). The establishment of smallpox hospitals separated as far as possible from populous localities, and the prompt removal of cases of the disease where practicable, as well as the diligent prosecution of vaccination and revaccination, are among the first requirements. The plan introduced into several large towns of compulsory notification of infectious diseases has much to recommend it. The special treatment applicable to a person suffering from smallpox includes in the first place the providing competent nurses, who, together with all others in the neighbourhood of the patient, should be duly protected by recent vaccination. The patient should lie on a soft bed in a well-ventilated but somewhat darkened room and be fed with the lighter forms of nutriment, such as milk, soups, &c. The skin should be sponged occasionally with tepid water, and the mouth and throat washed with a solution of chlorate of potash, Condy's fluid, or other safe disinfectant. In a severe case, with evidence of much prostration, stimulants may be advantageously employed. The patient should be always carefully watched, and special vigilance is called for where delirium exists. This symptom may sometimes be lessened by sedatives, such as opium, the bromides, or chloral. With the view of preventing pitting many applications have been proposed, but probably the best are cold or tepid compresses of light weight kept constantly applied over the face and eyes. The water out of which these are wrung may be a weak solution of carbolic or boracic acid. When the pustules have dried up the itching this produces may be much relieved by the application of oil or vaseline. Complications are to be dealt with as they arise and the severer forms of the disease treated in reference to the special symptoms presented. In cases where the eruption is tardy of appearing and the attack threatens to assume the malignant form, the writer has seen marked benefit attend the use of the wet pack. Disinfectants should be abundantly employed in the room and its vicinity, and all clothing, &c., in contact with the patient should be burnt.

Inoculation.—Previous to the introduction of vaccination the method of preventive treatment by what was known as inoculation had been employed. This consisted in introducing into the system—in a similar way to the method now commonly employed in vaccination—the smallpox virus from a mild case with the view of reproducing the disease also in a mild form in the person inoculated, and thus affording him protection from further attack. This plan had apparently been resorted to by Eastern nations from an early period in the history of the disease. It was known to be extensively practised in Turkey in the beginning of the 18th century, when, chiefly through the letters of Lady Mary Wortley Montagu, it became known and was speedily adopted in England. There is no doubt, both from the statistics of the Smallpox and Inoculation Hospital, London, and from the testimony of physicians throughout the country, that this practice made a marked impression upon the fatality of the disease, and was itself attended with extremely little risk to life. The objections to it, however, were great, for, although usually conveying the smallpox in a mild form, it not unfrequently took effect severely, and, while death might be averted, the disfiguring results of the disease remained. Further, each inoculated person upon whom the operation took effect became for the time being a possible source of infection to others, and in point of fact the practice tended to spread the disease and so to increase the general mortality. Although inoculation continued to be practised for a number of years subsequently to Jenner's great discovery, it gradually became displaced by that vastly superior and safer preventive. In 1840 an Act of Parliament was passed rendering smallpox inoculation unlawful in England. (J. O. A.)

SMART, CHRISTOPHER (1722-1771), English poet, was born at Shipbourne in Kent on 11th April 1722. The discovery that Smart was anything more than an unfortunate Bohemian of letters who wrote much uninteresting verse of second-rate 18th-century quality is quite recent. After one or another of his superseded translations or ineffective exercises in heroics had in turn been assigned the place of honour as his representative literary work, his real masterpiece was discerned in a poem which, except for a reprint issued in 1819, had been singularly overlooked, and even omitted from the collected editions of his poetry. The history of this poem, *A Song to David*, is somewhat remarkable. It was written in the saner moments of confinement for a fit of insanity, and was, it is said, on not unimpeachable authority perhaps, indented with an iron nail or a key on the wall of the cell in default of other means of writing. The real facts of the case would seem to be that the unfortunate poet inscribed one or two stanzas in the manner asserted, and that he either dictated or was given the materials wherewith to write the rest of the poem.

There is no internal evidence of any morbid origin, however, for the poem is full of a healthy and virile energy. As a boy he was delicate and precocious, with a facile gift of verse, which already won him a certain notoriety, of not the best effect haply, at Durham school, whither he had been sent on leaving a preparatory school at Maidstone. During a holiday visit to Raby castle his boyish gifts attracted the interest of the duchess of Cleveland, who made him an allowance of £40 a year, which was continued until her death, and which possibly served further to weaken his self-reliance. At Cambridge, where he was entered at Pembroke Hall in 1739, he led a rather dissipated life, getting heavily into debt, and, while he easily excelled in certain congenial branches of study, he paid little attention to the usual college routine. In spite of his irregularities, he was made a fellow of his college in 1745, and at a later date won the newly instituted Seaton prize for an English poem,—the subject each year being one of "the attributes of the Supreme Being." Smart gained this prize five times in all. Resorting then to London and marrying there a daughter-in-law of Newbery, the publisher, the poet attempted to make a living by literary hack-work and journalism, but sank gradually into difficulties through his improvident and dissipated habits, so that his wife and children were at last obliged to leave him. His misfortunes seem to have culminated in the fit of insanity associated with *A Song to David*, which was published in 1763, and in 1771 Smart died from the effects of poverty and disease.

Amid all his miseries Smart must have been fairly industrious if his journalistic work was at all proportionate to his more substantial literary productions. Of all that he wrote, however, *A Song to David* will alone bear the test of time. Unlike in its simple forceful treatment and impressive directness of expression, as has been said, to anything else in 18th-century poetry, the poem on analysis is found to depend for its unique effect also upon a certain ingenuity of construction, and the novel way in which David's ideal qualities are enlarged upon. This will be more readily understood on reference to the following verse, the first twelve words of which become in turn the key-notes, so to speak, of the twelve succeeding verses:—

"Great, valiant, pious, good, and clean,
Sublime, contemplative, serene,
Strong, constant, pleasant, wise!
Bright effluence of exceeding grace;
Best man!—the swiftness, and the race,
The peril, and the prize."

The last line is characteristic of another peculiarity in *A Song to David*, the effective use of alliteration to complete the initial energy of the stanza in many instances. But in the poem throughout is revealed a poetic quality which eludes critical analysis and gives its writer an exceptional interest hardly maintained by his other works.

A Song to David is found in somewhat shortened form in Ward's *English Poets*, vol. iii., and Smart's other poems are given in Anderson's *British Poets* (1794), vol. xi., which contains also a full account of his life.

SMEATON, JOHN (1724-1792), English civil engineer, the son of an attorney, was born at Austhorpe Lodge, near Leeds, on 8th June 1724. He received a good education at the grammar-school of Leeds, displaying special proficiency in geometry and arithmetic. At a very early age he evinced a great liking for the use of mechanical tools, and in his fourteenth or fifteenth year contrived to make a turning-lathe. On leaving school in his sixteenth year he was employed in his father's office, but, after attending for some months in 1742 the courts at Westminster Hall, he earnestly requested to be allowed to follow some mechanical profession. He became apprentice to a philosophical instrument maker, and in 1750 set up in business on his own account. Besides improving various mathematical instruments used in navigation and astronomy, he carried on several experiments in regard to other mechanical appliances, amongst the most important being a series on which he founded a paper—for which he received the Copley medal of the Royal Society in 1759—entitled *An Experimental Inquiry concerning the Native Powers of Water and Wind to turn Mills and other Machines depending on a Circular Motion.* In 1754 he made a tour of the Low Countries to study the great canal works of foreign engineers. Already by his papers read before the Royal Society and his intercourse with scientific men his abilities as an engineer had become well known, and in 1756 application was made to him to reconstruct the Eddystone lighthouse, which had been burnt down in December of the previous year (see LIGHTHOUSE, vol. xiv. p. 616). Smeaton now began to be much consulted in regard to all kinds of important engineering projects, including river navigation, the drainage of fens, the designing of harbours, and the repair and construction of bridges, owing to the thorough engineering skill he displayed in every operation he undertook. In judging of his achievements it ought to be remembered that he was the precursor of the great modern engineers. James Watt said of him, "His example and precepts have made us all engineers." He combined in a remarkable degree theoretical with practical skill, much of his success being due to the fact that, as Stevenson states, "he was an incessant experimenter." A considerable portion of his time was also devoted to astronomical studies and observations, on which he read various papers before the Royal Society. In order to prepare an account of the various works on which he had been engaged as an engineer, Smeaton resolved to retire from his profession, but he only lived to complete in 1791 his *Narrative of the Building of Eddystone Lighthouse.* He died at Austhorpe, 28th October 1792, and was buried in the old parish church of Whitkirk.

See *A Short Narrative of the Genius, Life, and Works of the late Mr John Smeaton*, 1793; and Smiles, *Lives of the Engineers.*

SMELL is a sensation excited by the contact with the olfactory region of certain substances, usually in a gaseous condition and necessarily in a state of fine subdivision. The sense is widely distributed throughout the animal kingdom. The lower animals, especially those breathing in water, become cognizant of the presence of odoriferous matter near them without touch, vision, or hearing, and we suppose that they do so by some sense of taste or smell, or a combination of both. In such cases smell has been appropriately termed "taste at a distance," by which is meant that particles of matter may be diffused through the water so as to come into contact with the terminal organ and give rise to a sensation such as would have been excited had the matter from which the particles emanated come directly into contact with the nerve-endings. It is therefore of no great importance whether such sensations in humble aquatic organisms are termed taste or smell. In the higher air-breathing animals, however, the senses are differentiated: that of taste is found at the entrance of the alimentary canal, whilst that of smell guards the opening of the respiratory tract. This view assists in the interpretation of various structures met with in the lower forms which have been fairly regarded by naturalists as olfactory organs.

Comparative View of Olfactory Organs.—In various *Medusæ* pit-like depressions, lined with ciliated epithelium, on the dorsal side of the excavation in which the "marginal" bodies are found, have been called olfactory regions. In many *Arthropoda* the sense of smell is located in delicate tubular structures, or conical projections, found on the antennæ and connected with nerves. Similar organs are met with in *Crustacea*. In *Cyclops* (*Copepoda*), *Isopoda*, and *Thoracostraca* olfactory hairs are present as delicate appendages of the anterior antennæ, chiefly in the male sex. In *Schizopoda* the anterior antennæ have a comb-like prominence bearing a great number of olfactory hairs. *Insecta* have olfactory organs largely developed, usually in the form of hairs, cones, or knobs on the antennæ, and connected with gangliated nerve-endings. Olfactory organs are also met with in *Mollusca*: in *Lamellibranchiata* they appear as hairs on the margin of the mantle; in aquatic *Gasteropoda* as tufts of hairs scattered over the surface of the body and specially aggregated in those parts where tactile sensibility is highly developed; in terrestrial *Gasteropoda* the antennæ have on their end plates a number of club-shaped cells with rods, which are held to be olfactory, and recently in the same class Sprengel has shown that an organ "which was supposed to be a rudimentary gill, and is innervated from the supra-intestinal ganglion," has an olfactory function. In *Ascidians* the olfactory region is believed to be a depression on the wall of the pharynx, situated in front of the ganglion, and lined with ciliated epithelium.

In *Fishes* the olfactory organs consist of a membrane (the pituitary membrane) lining one or two pits, to which the olfactory or first pair of cranial nerves are distributed. This highly vascular membrane is usually thrown into numerous folds, so as to admit of an extensive surface being packed into small space, and it is covered by ciliated epithelium. In the lowest vertebrate, *Amphioxus*, the olfactory organ is a simple unsymmetrical pit at the anterior end of the nervous system. In the hag fishes (*Myxinidæ*) the olfactory pit has a posterior opening which pierces the palate and can be closed by a valvular apparatus. In the lampreys (*Petromyzon*) the flask-shaped nasal sac opens on the top of the head, and from this a tube descends which expands into a blind sac towards the base of the skull. In all other fishes the olfactory organs are double and have no communication with the mouth. In osseous fishes the olfactory capsules or sacs are covered with skin which is usually pierced by two openings for each sac. Some, such as the wrasses, have a single nasal opening; and where there are two the anterior can be closed by a valve. The olfactory region may be extensive owing to the pituitary membrane being thrown into plaits or folds, and it may be divided into two portions, one quite smooth and the other plicated. The smooth portion, probably acting as a reservoir, may be large, extending down to the palate, as in the mackerel, or to the back part of the palate, as in the wolf-fish (Owen). The nasal cavities exist below the snout in sharks, near the angles of the mouth in the rays, and beneath the fore part of the head, behind the base of the rostrum, in the saw-fish. In such fishes the olfactory organ is guarded by valves, containing cartilaginous plates moved by muscles, and we may therefore conclude with Owen "that these fishes scent as well as smell, *i.e.*, actively search for odoriferous impressions by rapidly changing the current of water through the olfactory sac."

The olfactory organs of *Amphibia* are always paired cavities, opening internally either anteriorly within the lips or further back, as in the batrachians and salamandrines. In the *Perennibranchiates* (Siren, Proteus, Axolotl) there are no outward signs of olfactory organs, and the thick upper lip must be raised to bring the plicated sac with its two remote orifices into view (Owen). In the *Tritonidæ* (newts) and *Salamandrinæ* (salamanders) the olfactory membrane is smooth and lines an oval bag having an external nostril, guarded by a valvular fold of skin, and a palatal opening. Frogs and toads (*Batrachia*) have also an external nostril with a flap of skin, and the palatal opening is wide and near the fore part of the mouth. The skulls of extinct saurians of marine habits (*Ichthyosaurus* and *Plesiosaurus*) show that the external nostrils opened near the orbits at a distance from the muzzle. In snakes (*Ophidia*) the external nostrils are double, and the internal nostril is single and in the median line. In water snakes the external orifices can be closed by valves.

In *Chelonia* (turtles, tortoises) and in *Crocodilia* the external nasal opening is single and near the end of the snout; but in *Chelonia* the nostrils are really distinct, although their external apertures coincide. In the turtle the nasal cavity is large and contains a twisted shell-like cartilage, so as to give extent of surface to the darkly pigmented and highly vascular pituitary membrane. In the crocodiles and alligators the nostrils can be closed by a valvular lobe, and in the gavials (*Rhamphostoma gangeticum* and *Rhynchosuchus schlegelii*) the integument can be raised round the nostril in the form of a tube so as to bring the orifice to the surface of the water without exposing the other parts of the head (Owen). In all *Crocodilia* the nasal cavity is of great length, commencing at the fore part of the muzzle and ending beneath the occiput by a single aperture, and the surface of this long olfactory meatus is increased by the meatus communicating with large cells or sinuses. In snakes and lizards a second olfactory organ is found embedded between the turbinals and the vomer and is known as "Jacobson's organ." It has the form of a cup or depression round a cartilaginous papilla and is supplied by a nerve which arises from the end of the olfactory lobe.

The olfactory organs of *Birds* are somewhat similar to those of the cold-blooded reptiles and amphibians in that "the external nostrils are simple perforations, having no movable cartilages or muscles provided for dilating or contracting their apertures, as in mammalia" (Owen). The extent of the olfactory surface is increased by projections and folds of turbinated bones and not by large accessory cavities. With the exception of the apteryx and dinornis, the olfactory nerve passes out of the skull by a single foramen. The external nostrils are in the majority of birds placed at the sides of the upper mandible; but in some cases, as in the toucans, they are found at the base of the bill, and in the apteryx they open at the extremity of the long upper mandible. In herons the apertures are so small as scarcely to admit the point of a pin; and in the pelicans they are wanting, and odours get access to the olfactory organ from the palate. The *Rasores* (scratching birds) have the nostrils defended by a scale, and the crows (*Corvidæ*) have a bunch of stiff feathers for the same purpose. The septum or partition between the nostrils is usually complete and is formed of bone and cartilage. The outer wall of each nasal passage is furnished with three turbinal or twisted shell-like bones, of which the middle is the largest, thus affording a considerable extent of olfactory surface. In most birds there are two posterior nasal apertures communicating with the palate; but in some, as in the cormorant and gannet, the passages unite and there is only one opening. In birds the upper part of the nasal passage is more especially devoted to the sense of smell, whilst the lower part may be regarded as the beginning of the respiratory tract. This is indicated by the arrangement of the nerves, the olfactory nerve being distributed to the membrane covering the septum and the superior and middle turbinated bones, whilst the lower portion and lower turbinals are supplied by the fifth nerve,—a nerve of general sensibility. The upper turbinals reach their greatest development in the apteryx, where they are attached, according to Owen, to the whole outer part of the prefrontals. This bird has amongst birds the largest olfactory nerves in proportion to its size, and it would appear to be guided by the sense of smell to the worms that form its food. A contrast as regards the anatomical arrangements for the olfactory sense is well seen on comparing the turkey with the vulture. In the turkey the olfactory nerve is small, about one-fifth the size of that in the vulture, and is distributed over a small middle turbinal, there being no extension over a superior turbinal. The vulture, on the other hand, has a large nerve and the olfactory region is extensive, owing to the largely developed superior turbinal bone. There can be no doubt that the carrion-eating vulture is guided from great distances to its food by the sense of smell, although it will be assisted by its powerful sense of vision.

The sense of smell reaches its highest development in *Mammalia*. The anatomical surface is enormously extended in many cases, not only by the complication of the ethmoidal labyrinth, but also by the nasal passages communicating with spaces in the neighbouring cranial and facial bones. The olfactory nerves also are very numerous and arise from a special encephalic centre. They pass out of the skull by numerous holes in the cribriform or sieve-like plate of the prefrontal bone, which, on account of this peculiarity, is called the ethmoid bone. These nerves ramify on the olfactory membrane, covering the upper or ethmo-turbinal bones. The cavity containing the organ of smell is bounded by the prefrontal, vomerine, nasal, sphenoid, pterygoid, palatine, maxillary, and premaxillary bones, and it is usually in connexion with air-cavities or sinuses in many or all of the bones of the skull. The median partition by which the two nostrils are formed consists of bone and cartilage and is built up by processes of the prefrontals, the vomer, and by the ridges of the nasals, palatines, maxillaries, and premaxillaries with which the vomer articulates. Each passage thus formed is the beginning of the respiratory tract, and is continued forwards into a more or less mobile part called a nose, snout, or proboscis, whilst posteriorly it communicates with the upper part of the pharynx, into which opens the windpipe. On the outer wall there are three turbinal bones—superior, middle, and inferior—dividing partially the nasal cavity into three meatuses or passages. The superior meatus is between the superior and middle turbinated bones, the middle meatus between the middle and inferior turbinated bones, and the inferior meatus between the inferior turbinated bones and the floor of the nose (see ANATOMY, vol. i. p. 823, fig. 7; also vol. i. pl. XIX. fig. 2). Many of the lower mammals have in addition a process from the frontal and nasal bones, sometimes called the superior spongy bone, which is not the same as the superior turbinated, as described in the anatomy of the human being. The extent of olfactory surface is enormously increased by numerous plicæ or processes of bone which to a great extent mask the comparatively simple arrangement above described. In *Ornithorhynchus* there is a single olfactory nerve escaping through an aperture in the prefrontal bone; in *Echidna*, the other member of the *Monotremata*, there are numerous olfactory nerves and a large development of ethmo-turbinals. In many *Marsupials* the sense of smell is largely developed, and in some (*Osphranter*) the turbinated bones are so large as to cause a lateral bulging of the nasal cavity, forming a marked feature of the skull. In *Rodents* the ethmo-turbinals may be subdivided into lamellæ so as to increase the olfactory surface; such is the case in the common hare. In the porcupine the sinuses developed from the olfactory cavity are of large size, forming a spongy mass surrounding the cavity of the skull in which the anterior portion of the brain lies. In *Insectivora* the olfactory surface is very large. Thus in the mole the ethmo-turbinal has not fewer than eight lamellæ or plates and the external nose is developed into a snout capable of considerable movement. Such a snout is very large and mobile in the elephant shrews. Armadillos and ant-eaters (*Edentata*) have a strong sense of smell. Thus in *Dasypus* the nasal portion of the skull is about equal in

volume to all the rest, and in *Chlamydophorus* (dwarf armadillo) the frontals are raised "into a pair of domes" by sinuses in them communicating with the large olfactory cavity. In most armadillos the external nose is strengthened by small bones. The air sinuses in the sloth extend upwards into the frontals and downwards into the sphenoid bone. No *Cetaceans* have olfactory organs, except the baleen or whalebone whales, and thus are devoid of the sense of smell. In the manatee (*Sirenia*) the nasal openings are placed far forwards and have movable cartilages, and the bony walls of the nasal passages are not extensive in proportion to the size of the rest of the skull. The elephants (*Proboscidea*) have the part of the nasal cavity concerned in smell contracted and narrow, but the cavity is prolonged into the trunk, at the end of which are the nostrils; the nasal cavity communicates with sinuses permeating every bone of the cranium. The tapirs have a shorter but very mobile proboscis, and the development of the nasal passages is extensive. The horse has the power of dilating and contracting each nostril, and the cribriform plates transmit very numerous olfactory nerves from the olfactory bulbs, which are large in proportion to the size of the rest of the brain. The *Suidæ* (swine) have a large and complex olfactory region; the accessory sinuses or spaces attain a great development; the nose is prolonged and truncate, the cartilages forming a complete tube, which is a continuation of the bony nostrils, and these tubes open on a naked disk. In the ox and sheep the olfactory region is large, but not so large as in the horse. The external, glandular, and moist part of the nose is a linear tract running from the mid-furrow of the upper lip to the oblique nostril in the sheep, and this portion passes through many gradations in size, as seen in the roebuck, fallow-deer, red-deer, and the ox. The *Carnivora* have the ethmo-turbinal and maxillo-turbinal regions even more largely developed than in *Herbivora*, and the latter portion reaches its maximum in the seals, where "these turbinals seem to block up the entry of the nasal respiratory passages, and must warm the air in arctic latitudes as well as arrest every indication from the effluvia of alimentary substances or prey" (Owen). In *Quadrumana* the nasal chamber becomes shorter and gains in depth, but not proportionally. In the platyrhine monkeys the cartilage forming the septum becomes flattened anteriorly, pushing the nostrils outwards. In the catarrhines this flattening is much less, so that the nostrils are approximated. In both groups the nostrils are not terminal. In *Man* the chief characteristic is the prominence of the fore part of the chambers, with the nostrils on the lower surface, and the nose is supported by eleven pieces of cartilage, of which one is medial, the others lateral, in five pairs. The size and form of the septal or medial cartilage mainly determine the shape and prominence of the nose. It is least developed but thickest in the Negro and Papuan races. (For a description of the muscles of the nose in man, see ANATOMY, vol. i. p. 837.)

The interior of the nose is divided physiologically into two portions,—(1) the upper (*regio olfactoria*), which embraces the upper part of the septum, the upper turbinated bone, and a portion of the middle turbinated bone; and (2) the lower portion of the cavity (*regio respiratoria*). The olfactory region proper has a thicker mucous membrane than the respiratory; it is covered by a single layer of

3 2 1

Longitudinal section through the olfactory membrane of guinea-pig. × about 400. 1, Olfactory epithelium on free surface; 2, plexus of olfactory nerve-fibres; 3, pouches of serous glands containing epithelial cells. From Klein's *Atlas of Histology*.

epithelial cells, often branched at their lower ends and containing a yellow or brownish red pigment; and it contains peculiar tubular glands named "Bowman's glands." The respiratory portion contains ordinary serous glands. In the olfactory region also are the terminal organs of smell. These are long narrow cells passing to the surface between the columnar epithelium covering the surface. (See ANATOMY, vol. i. p. 885, fig. 76.) The body of the cell is spindle-shaped and it sends up to the surface a delicate rod-like filament, whilst the deeper part is continuous with varicose nerve-filaments, the ends of the olfactory nerve. In the frog the free end terminates in fine hairs.

Physical Causes of Smell.—Electrical or thermal stimuli do not usually give rise to olfactory sensations. Althaus states that electrical stimulation caused a sensation of the smell of phosphorus. To excite smell it is usually supposed that substances must be present in the atmosphere in a state of fine subdivision, or existing as vapours or gases. The fineness of the particles is remarkable, because if the air conveying an odour be filtered through a tube packed with cotton wool and inserted into the nose a smell is still discernible. This proceeding completely removes from the air organisms less than the $\frac{1}{100000}$th of an inch in diameter which are the causes of putrefaction and fermentation. A grain or two of musk will scent an apartment for years and at the end of the time no appreciable loss of weight can be detected. Substances exciting smell are no doubt usually gases or vapours. Only a few tentative efforts have been made to connect the sense with the chemical constitution of the substance. One of the most important of these is in an *Essay on Smell*, by Dr. William Ramsay of University College, Bristol. The following gases have no smell:—hydrogen, oxygen, nitrogen, water gas, marsh gas, olefiant gas, carbon monoxide, hydrochloric acid, formic acid vapour, nitrous oxide, and ammonia. (It is necessary, of course, to distinguish between the sensation of smell and the irritant action of such a gas as ammonia.) The gases exciting smell are chlorine, bromine, iodine, the compounds of the first two with oxygen and water, nitric peroxide, vapours of phosphorus and sulphur, arsenic, antimony, sulphurous acid, carbonic acid, almost all the volatile compounds of carbon except those already mentioned, some compounds of selenium and tellurium, the compounds of chlorine, bromine, and iodine with the above-named elements, and some metals. Chlorine, bromine, iodine, sulphur, selenium, and tellurium, which are volatile and give off vapour at ordinary temperatures, have each a characteristic smell. Ramsay points out that as a general rule substances having a low molecular weight have either no smell or simply cause irritation of the nostrils. He also shows that in the carbon compounds increase of specific gravity as a gas is associated to a certain point with a sensation of smell. Take the marsh gas or methane series commonly called the paraffins. The first two have no smell; ethane (fifteen times as heavy as hydrogen) has a faint smell; and it is not till butane (thirty times heavier than hydrogen) that a distinct sensation of smell is noticed. Again, a similar relation exists among the alcohols. Methyl alcohol has no smell. Ethyl, or ordinary alcohol free from ethers and water, has a faint smell; "and the odour rapidly becomes more marked as we rise in the series, till the limit of volatility is reached, and we arrive at solids with such a low vapour tension that they give off no appreciable amount of vapour at the ordinary temperature." Acids gain in odour with increase in density in the form of gas. Thus formic acid is devoid of smell; acetic acid has a characteristic smell; and the higher acids of the series—propionic, butyric, valerianic—increase in odour. It would appear also that "the character of a smell is a property of the element or group which enters into the body producing the smell, and tends to make it generic." Many compounds of chlorine, hydrogen, compounds of sulphur, selenium, and tellurium, the paraffins, the alcohols, the acids, the nitrites, the amines, the pyridine series, the benzene group, have each a characteristic odour. Ramsay has advanced the theory that the sense of smell "is excited by vibrations of a lower period than those which give rise to the sense of light or heat," and he points out a series of important facts in support of this view. He states that to produce the sensation of smell a substance must have a molecular weight at least fifteen times that of hydrogen. For instance, the specific gravity of marsh gas is eight (no smell), of ethane fifteen (faint smell), of propane twenty-two (distinct smell). Again, prussic acid has a specific gravity of fifteen, and many persons fail to detect its odour. Further, Ramsay supposes that smell may be excited by vibrations, and suggests that the period of vibration of the lighter molecules is too rapid to affect the sense; at last a number of vibrations is reached capable of exciting the sense organ; and beyond an upper limit the sense is again lost. Graham pointed out that odorous substances are in general readily oxidized.[1] Tyndall showed that many odorous vapours have a considerable power of absorbing heat. Taking the absorptive capacity of the air as unity, the following absorptions were observed in the respective cases:—

Name of Perfume.	Absorption per 100.	Name of Perfume.	Absorption per 100.
Patchouli	30	Lavender	60
Sandal-wood	32	Lemon	65
Geranium	33	Portugal	67
Oil of cloves	33·5	Thyme	68
Otto of roses	36·5	Rosemary	74
Bergamot	44	Oil of laurel	80
Neroli	47	Cassia	109

In comparison with the air introduced in the experiments the weight of the odours must be almost infinitely small. "Still we find that the least energetic in the list produces thirty times the effect of the air, whilst the most energetic produces 109 times the same effect."[2]

Venturi, B. Prévost, and Liégeois have studied the well-known movements of odoriferous particles, such as camphor, succinic acid, &c., when placed on the surface of water, and they have suggested that all odoriferous substances in a state of fine subdivision may move in a similar way on the moist surface of the olfactory membrane, and thus mechanically irritate the nerve-endings. This explanation is too coarse; but it is well known that the odours of flowers are most distinctly perceived in the morning, or after a shower, when the atmosphere contains a considerable amount of aqueous vapour. It would appear also that the odours of animal effluvia are of a higher specific gravity than the air, and do not readily diffuse,—a fact which may account for the pointer and bloodhound keeping their noses to the ground. Such smells are very persistent and are apparently difficult to remove from any surface to which they have become attached. The smell of a corpse may haunt a living person for days, notwithstanding copious ablutions and change of clothes.[3]

Special Physiology of Smell.—It is necessary that the air containing the odour be driven forcibly against the membrane. Thus the nostrils may be filled with eau de Cologne, or with air impregnated with sulphuretted hydrogen, and still no odour is experienced if the person does not breathe. When a sniff is made the air within the nasal passages is rarefied, and, as the air rushes in to equilibrate the pressure, it is forcibly propelled against the olfactory surface. The olfactory surface must be moist; if it is dry, or is covered with too thick a layer of mucus (as in catarrh), the sense is much weakened or lost. The first moment of contact is the most acute and the sense quickly becomes blunted. The first scent of a flower is the strongest and sweetest; and after a few minutes' exposure the intensity of even a fœtid odour may not be perceived. This fact may be accounted for on the supposition that the olfactory membrane becomes quickly coated with a thin layer of matter, and that the most intense effect is produced when the odoriferous substances are applied to a clean surface. The intensity of smell depends on (1) the area of olfactory surface affected, and (2) the degree of concentration of the odoriferous matter. It is said that musk to the amount of the two-millionth of a milligramme, and one part of sulphuretted hydrogen in 1,000,000 parts of air may be perceived. If the two nostrils are filled with different odorous substances, there is no mixture of the odours, but we smell sometimes the one and sometimes the other (Valentin). Morphia, mixed with sugar and taken as snuff, paralyses the olfactory apparatus, while strychnine makes it more sensitive (Lichtenfels and Fröhlich).

The delicacy of the sense is much greater in many of the lower animals than in man, and it is highly probable that the dog or cat obtain information by means of this sense which a human being cannot get. Odours may excite in the minds of many animals vivid impressions, and they have probably a memory of smells which the human being does not possess. Even in man the sense may be greatly improved by exercising it. A boy, James Mitchell, was born blind, deaf, and dumb, and chiefly depended on smell for keeping up a connexion with the outer world. He readily observed the presence of a stranger in the room and he formed his opinions of persons apparently from their characteristic smells. In some rare cases, the sense of smell is congenitally absent in human beings, and it may be much injured by the practice of snuffing or by diseases of the nose affecting the olfactory membrane. Subjective impressions of smells, like spectral illusions or sounds in the ears, are occasionally, but rarely observed in the insane. Finally, it may be observed that the sense of odour gives information as to the characters of food and drink and as to the purity of the air. In the lower animals, also, the sense is associated with the sexual functions.

See art. "Olfaction" by François Franck, in *Dictionnaire Encyclopédique des Sciences Médicales*, 2d series, where a full historical bibliography is given; Hermann's *Handbuch der Physiologie: d. Sinnesorgane: Zweiter Theil, Geruchsinne*, by Prof. V. Vintschgau, p. 226; Owen's *Comp. Anatomy and Physiol. of Vertebrates*; Bain, *op. cit.*, p. 147; Grant Allen's *Physiological Æsthetics*, p. 77; Ramsay, *Nature*, vol. xxvi. p. 187; and for James Mitchell's case, see Dugald Stewart's *Works*, vol. iv. p. 300. (J. G. M.)

SMELT. See SALMONIDÆ, vol. xxi. p. 1.

SMETHWICK, an urban sanitary district of Staffordshire, England, on the borders of Worcestershire and Warwickshire, is situated on the Birmingham, Dudley, and Wolverhampton Canal, and on branches of the London and North-Western and the Great Western Railway lines, 3 miles west from Birmingham, of which the town of Smethwick is a suburb. It possesses a public hall and a free library and reading-room. Within the limits of the district is the Soho foundry originated by James Watt; and since its origin numerous other industries have been concentrated in the suburb, the more important being the manufacture of glass, chemicals, hydraulic jacks, patent nuts and bolts, and patent tubes. Many of the works are of great extent. The population of the urban sanitary district in 1871 was 17,158, and in 1881 (area. 1882 acres) it had increased to 25,084.

SMIRKE, ROBERT (1752-1845), subject painter, was born at Wigton near Carlisle in 1752. In his thirteenth year he was apprenticed in London with an heraldic painter, and at the age of twenty he began to study in the schools

[1] Bain, *Senses and Intellect*, 3d ed., p. 152.

[2] Tyndall, *Contributions to Molecular Physics in Domain of Radiant Heat*, p. 99.

[3] Liégeois, *Archiv de Physiol.*, 1868.

of the Royal Academy, to whose exhibition he contributed in 1786 a Narcissus and a Sabrina, which were followed by many works, usually small in size, illustrative of the English poets, especially Thomson. In 1791 Smirke was elected an associate of the Royal Academy, and two years later a full member. In 1814 he was nominated keeper to the Academy, but the king refused to sanction the appointment on account of the artist's pronounced revolutionary opinions. He was engaged upon the Shakespeare gallery, for which he painted Katharina and Petruchio, Prince Henry and Falstaff, and other subjects. He also executed many clever and popular book-illustrations. His works, which are frequently of a humorous character, are pleasing and graceful, accomplished in draftsmanship and handled with considerable spirit. He died in London on the 5th of January 1845.

SMITH, ADAM (1723-1790), the greatest of political economists, was the only child of Adam Smith, comptroller of the customs at Kirkcaldy in Fifeshire, Scotland, and of Margaret Douglas, daughter of Mr Douglas of Strathendry, near Leslie. He was born at Kirkcaldy on 5th June 1723, some months after the death of his father. Of a weak constitution, he required and received during his early years the most tender care of an affectionate mother, which he repaid in after life by every attention which filial gratitude could dictate. When he was three years old he was taken on a visit to his uncle at Strathendry, and when playing alone at the door of the house was carried off by a party of "tinkers." Fortunately he was at once missed, and the vagrants pursued and overtaken in Leslie wood. He received his early education in the school of Kirkcaldy under David Miller, amongst whose pupils were many who were afterwards distinguished men. Smith showed as a boy great fondness for books and remarkable powers of memory; and his friendly and generous disposition made him popular amongst his schoolfellows. He was sent in 1737 to the university of Glasgow, where he attended the lectures of Dr Hutcheson; and in 1740 he went to Baliol College, Oxford, as exhibitioner on Snell's foundation, with a view to his taking orders in the English Church. He remained at that university for seven years. At Glasgow his favourite studies had been mathematics and natural philosophy; but at Oxford he appears to have devoted himself almost entirely to moral and political science and to the cultivation of the ancient and modern languages. He also laboured to improve his English style by the practice of translation, particularly from the French. He was not impressed with a favourable opinion of the system of education then pursued at Oxford. After his return to Kirkcaldy he resided there two years with his mother, continuing his studies; he had relinquished the idea of entering the ecclesiastical profession, but had not yet adopted any other plan for his future life. In 1748 he removed to Edinburgh, and there, under the patronage of Lord Kames, gave lectures on rhetoric and belles-lettres. About this time commenced his acquaintance with David Hume, which afterwards ripened into an intimate friendship, founded on mutual esteem; his relations with that great thinker must have powerfully influenced the formation of his opinions. In 1751 he was elected professor of logic at Glasgow, and in the following year was transferred to the chair of moral philosophy in the same university, which had become vacant by the death of Thomas Craigie, the successor of Hutcheson. This position he occupied for nearly twelve years, which he long afterwards declared to have been "by far the most useful, and therefore by far the happiest and most honourable period of his life." He was highly esteemed by his colleagues, of whom, on his side, he speaks as "very excellent men." His course of lectures, as Professor Millar informs us, was divided into four parts—(1) natural theology; (2) ethics; (3) a treatment of that branch of morality which relates to justice, a subject which he handled historically after the manner of Montesquieu, "endeavouring to trace the gradual progress of jurisprudence, both public and private, from the rudest to the most refined ages, and to point out the effects of those arts which contribute to subsistence and to the accumulation of property in producing corresponding improvements or alterations in law and government"; (4) a study of those political regulations which are founded, not upon the principle of justice, but that of expediency, and which are calculated to increase the riches, the power, and the prosperity of a state. Under this view he considered the political institutions relating to commerce, to finances, to ecclesiastical and military establishments He first appeared as an author by contributing two articles to the *Edinburgh Review* (an earlier journal than the present, which was commenced in 1755, but of which only two numbers[1] were published),—one on Johnson's *Dictionary* and the other a letter to the editors on the state of literature in the different countries of Europe. In 1759 appeared his *Theory of Moral Sentiments*, embodying the second portion of his university course, to which was added in the 2d edition an appendix with the title, "Considerations concerning the first Formation of Languages." After the publication of this work his ethical doctrines occupied less space in his lectures, and a larger development was given to the subjects of jurisprudence and political economy. Stewart gives us to understand that he had already, as early as 1752, adopted the liberal views of commercial policy which he afterwards preached with so much effect; and this we should have been inclined to believe independently from the fact that such views were propounded in that year in the *Political Discourses* of his friend Hume. His residence at Glasgow brought him into personal relations with many intelligent men from whose practical experience he could derive information on mercantile questions; and, on the other hand, we are told, his reasonings convinced several eminent merchants of that city of the soundness of the principles of free trade, which were at variance with their previous opinions.

In 1762 the senatus academicus of Glasgow conferred on him the honorary degree of doctor of laws. In 1763 he was invited to take charge of the young duke of Buccleuch on his travels. He accepted the proposal, and resigned his professorship. He went abroad with his pupil in March 1764; they remained only a few days at Paris and then settled at Toulouse, then the seat of a parliament, where they spent eighteen months in the best society of the place, afterwards making a tour in the south of France and passing two months at Geneva. Returning to Paris about Christmas of 1765, they remained there till the October of the following year. The period was one of intellectual and social ferment, and Smith was brought into relation with the most eminent persons of the time. He lived in the society of Quesnay, Turgot, D'Alembert, Morellet, Helvétius, Marmontel, and the duke de la Rochefoucault. It was the regard he entertained for the young nobleman[2] last named that dictated the omission in the later editions of his *Moral Sentiments* of the name of the celebrated ancestor of the duke, whom he had associated with Mandeville as author of one of the "licentious sys-

[1] These two numbers were reprinted in 1818. Smith's letter to the editors is specially interesting for its account of the *Encyclopédie* and its criticism of Rousseau's pictures of savage life.

[2] The duke undertook a translation of the *Theory of Moral Sentiments*, but the Abbé Blavet's version appeared (1774) before his was completed and he then relinquished the design. An earlier French translation had been published (1764) under the title *Métaphysique de l'Âme*; and there is a later one—the best—by the marquis de Condorcet (1798, 2d ed. 1830).