tion took place in 1841; and his father, who was minister at Bathgate, and other two ministers being deposed not long afterwards for similar opinions, the four met at Kilmarnock in May 1843, and, on the basis of certain doctrinal principles, formed themselves into an association under the name of the Evangelical Union, "for the purpose of countenancing, counselling, and otherwise aiding one another, and also for the purpose of training up spiritual and devoted young men to carry forward the work and 'pleasure of the Lord.'" The doctrinal views of the new denomination gradually assumed a more decidedly anti-Calvinistic form, and they began also to find many sympathizers among the Congregationalists of Scotland. Nine students were expelled from the Congregational Academy for holding "Morisonian" doctrines, and in 1845 eight churches were disjoined from the Congregational Union of Scotland and formed a connexion with the Evangelical Union. In 1858 the Evangelical Union issued a new doctrinal statement superseding that of 1843. The Union exercises no jurisdiction over the individual churches connected with it, and in this respect it adheres to the Independent or Congregational form of church government; but while the affairs of those of its congregations which originally belonged to the Independent denomination are managed by meetings of all the communicants, those congregations which originally were Presbyterian vest their government in a body of elders. The churches connected with the Evangelical Union number nearly 90, only a few of which are in England. Its ministers are eligible for Congregational churches in England, and for some time negotiations have been in progress for an amalgamation of the denomination with the Congregational Union of Scotland. See *Evangelical Union Annual*, and *History of the Evangelical Union*, by F. Ferguson, D.D. (Glasgow, 1876).

EVANS, Sir De Lacy (1787–1870), a distinguished British soldier, son of John Evans of Milltown, Limerick, Ireland, was born in 1787. He was educated at Woolwich Academy, and entered the army in 1807 as ensign in the 22d regiment of foot. His regiment was immediately afterwards gazetted for India, and during his stay of three years in that country he served with distinction in various actions. In 1812, as lieutenant of the 3d Dragoons, he joined the Peninsular army of Wellington; and in the Portuguese and Spanish campaigns of 1812, 1813, and 1814 he acquired a high reputation both for military skill and for personal bravery. He was rapidly promoted by merit, and in 1814 received the rank of lieutenant-colonel. The same year, in command of the 5th West India Regiment, he was sent to take part in the war against the United States, where he specially distinguished himself at the capture of Washington, and shared in the attack on Baltimore and the operations before New Orleans. He returned to England in the spring of 1815 in time to accompany the expedition of Wellington to Flanders, and was assistant quartermaster-general at Quatre Bras and Waterloo. As a member of the staff of the duke of Wellington he accompanied the English army to Paris, and remained there during the occupation of the city by the allies. In 1831 Evans entered the House of Commons as Liberal member for Rye; but in the election of 1832 he was an unsuccessful candidate both for that borough and for Westminster. For the latter constituency he was, however, returned in 1833, and, with the exception of the parliament of 1841–46, continued to represent it till 1865, when he retired from political life. His parliamentary duties did not, however, interfere with his career as a soldier. In 1835 he was sent in command of 10,000 men (the "Spanish Legion") to aid the queen of Spain against Don Carlos. He remained two years, and gained several brilliant though bloody victories; and on his return in 1839 he was, in recognition of his achievements, created Knight Commander of the Bath. In 1846 he attained the rank of major-general; and in 1854, on the breaking out of the Russian war, he was appointed to the command of the second division of the army of the East. At the battle of the Alma his quick comprehension of the features of the combat largely contributed at various critical periods to the victory. On the 26th October, by the skilful manner in which he handled his troops, he brilliantly defeated, at a nominal loss, a large division of Russian forces which had attacked his position on Mount Inkerman. Illness and fatigue compelled him a few days after this to leave the command of his division in the hands of General Pennefather; but he rose from his sick-bed on the day of the battle of Inkerman, November 5, and declining to take the supreme command of his division from General Pennefather, he generously aided him in his long-protracted struggle by his countenance and advice. On the return of Evans to England in the following February invalided, he received for his services in the Crimea the thanks of the House of Commons, and the same year he was made Knight Grand Cross of the Order of the Bath, and the university of Oxford conferred on him the degree of D.C.L. In 1856 he received the Grand Cross of the Legion of Honour, and in 1861 he was gazetted general. He died 9th January 1870.

EVANS, Oliver (1755–1819), an American mechanician, was born at Newport, Delaware, in 1755. He was at an early age apprenticed to a wheelwright, and at the age of twenty-two he invented a machine for making card-teeth in lieu of the old method of making them by hand. In 1780 he became partner with his brothers, who were practical millers; and two years later he completed an invention which totally changed the structure of flour mills. About the same time he discovered the application of steam to land carriages, and in 1786 he endeavoured to obtain patents for the two inventions from the State of Pennsylvania. A patent for the former was granted in 1787, but the latter request was considered too absurd to merit consideration. It was granted, however, in 1797 by the State of Maryland. About this time he sent drawings and specifications of his plans to England, but they were received there with the same incredulity as in America. Meantime he made use of the engine he had invented—the first constructed on the high-pressure principle—for his flour mill; and in 1803 he constructed a steam dredging machine, which also propelled itself on land. Evans used all his means in experiments on his invention; and though he did not live to see its full application, he was confident that its results would be as great as they have actually turned out to be. In 1819 a fire broke out in his factory at Pittsburg, and its consequences were so disastrous to his immediate hopes that he did not long survive its occurrence, dying April 21, 1819.

EVANSON, Edward (1731–1805), a theological writer whose views gave rise to much controversy, was born at Warrington, in Lancashire, April 21, 1731. At the age of seven he was placed under the care of an uncle, vicar of Mitcham, in Surrey. At fourteen he entered Emmanuel College, Cambridge, where he graduated B.A. in 1749. In 1753 he took his degree of M.A.; and, after being ordained, he officiated for several years as curate at Mitcham. In 1768 he became vicar of South Mimms near Barnet; and in November 1769 he was presented to the rectory of Tewkesbury, with which he also held the vicarage of Longdon. In the course of his studies and inquiries after truth he discovered what he thought important variance between the teaching of the Church of England and that of the Bible, and he did not conceal his convictions. He allowed himself in reading the service to alter or omit phrases which seemed to him untrue, and in reading the Scriptures to

point out errors in the translation, a practice which was offensive to many of his congregation. A crisis was brought on by his sermon on the resurrection preached at Easter 1771; and in November 1773 a prosecution was instituted against him in the Consistory Court of Gloucester. He was charged with "depraving the public worship of God contained in the liturgy of the Church of England, asserting the same to be superstitious and unchristian, preaching, writing, and conversing against the creeds and the divinity of our Saviour, and assuming to himself the power of making arbitrary alterations in his performance of the public worship." A protest was at once signed and published by a large number of the parishioners against the prosecution. The case was carried by appeal to the Court of Arches and the Court of Delegates, and was ultimately quashed on merely technical grounds in 1777. Meanwhile Evanson had made his views generally known by several publications. In 1772 appeared anonymously his *Doctrines of a Trinity and the Incarnation of God, examined upon the Principles of Reason and Common Sense.* This was followed in 1777 by *A Letter to Dr Hurd, Bishop of Worcester, wherein the Importance of the Prophecies of the New Testament and the Nature of the Grand Apostasy predicted in them are particularly and impartially considered.* The author had before this time retired to Longdon, leaving his curate in charge at Tewkesbury. In 1775 he was appointed domestic chaplain to the solicitor-general, and at the close of 1777 he resigned both his livings, and retired to Mitcham. In 1786 he married. He soon after wrote some papers on the Sabbath, which brought him into controversy with Dr Priestley, who published the whole discussion (1792). In the same year appeared Evanson's work entitled *The Dissonance of the four generally received Evangelists*, to which replies were published by Dr Priestley and D. Simpson, M.A. (1793). Evanson rejected most of the books of the New Testament as forgeries, and of the four gospels he accepted only that of St Luke. In 1802 he published *Reflections upon the State of Religion in Christendom*, in which he attempted to explain and illustrate the mysterious foreshadowings of the Apocalypse. This he considered the most important of his writings. Shortly before his death he completed his *Second Thoughts on the Trinity*, in reply to a work of the bishop of Gloucester. The story of the life, investigations, and conflicts of this heretical churchman of a hundred years ago is full of interest, especially for its anticipations of some of the momentous discussions of the present day. He died at Coleford, in Gloucestershire, September 25, 1805. A narrative of the circumstances which led to the prosecution of Evanson was published by N. Havard, the town-clerk of Tewkesbury.

EVANSVILLE, a city of America, capital of Vanderburg county, Indiana, is situated on a high bank of the Ohio river, 200 miles below Louisville, Kentucky—measuring by the windings of the river, which double the direct distance. On account of the peculiar bend of the river at this point, Evansville is built somewhat in the shape of a crescent, and is sometimes called the "Crescent City." It has railway communication in various directions; and the Wabush and Erie Canal, completed in 1853, extends from it to Toledo, Ohio, a distance of 400 miles. Evansville is a busy commercial and manufacturing town, and is rapidly increasing. It is the principal shipping port for the grain and pork of south-western Indiana; and among its other articles of export are lime, cotton, dried fruit, and tobacco. It has flour mills, breweries, iron founderies, tanneries, machine shops, and woollen and cotton factories. Coal and iron ore are found in the vicinity. The principal buildings are the court-house, the city hall, the high school, the marine hospital, and a new building in which are included the post-office, the United States courts, and the custom-house. The population, which in 1860 was 11,484, had increased in 1870 to 21,830.

EVAPORATION is that process by which liquids and solids assume the gaseous state at their free surfaces. The rate at which evaporation takes place depends upon the temperature of the liquid or solid, the extent of the exposed surface, and the facility with which the gaseous particles can escape from the neighbourhood of the surface either by diffusion through the air or by the motion of the air itself. Hence a strong wind will generally accelerate the process of drying. The passage from the gaseous into the liquid condition, or *condensation*, and into the solid condition, or *sublimation*, are processes the converse of evaporation. The evaporation of a liquid is a phenomenon which we observe daily, and that of a solid sometimes presents itself to our notice, as when snow vanishes by evaporation during a long frost though the temperature never rises to the freezing point. Camphor and iodine also readily evaporate at ordinary temperatures without liquefying, and sublime on the surfaces of the vessels in which they are placed.

A gas is a substance a finite portion of which will distribute itself through any space, however great, to which it has free access. A substance which can exist in the liquid or solid state at ordinary temperature and under ordinary atmospheric pressure is usually, when in the gaseous condition, called a vapour; but, though it is easy to give arbitrary definitions, no satisfactory distinction between gases and vapours has yet been made. In fact, the word "vapour" is rapidly giving place to "gas" in most instances. The greatest amount of any substance which can exist in the gaseous condition in the unit of volume depends upon the temperature, but is almost independent of the presence of any other vapour or gas, provided that such gas or vapour possess no chemical affinity for the substance in question. When a portion of space contains as much of any vapour as can exist in it at the temperature, it is said to be *saturated* with that vapour. Any reduction of temperature will then be accompanied by condensation of part of the vapour, and the space will remain saturated at the new temperature; while if any increase of temperature occur, the space will cease to be saturated with the vapour it contains, and further evaporation will take place if any of the corresponding liquid be present, but if not the space will remain unsaturated, and the vapour it contains is then said to be *super-heated.* If the fall of temperature be caused by the introduction of a solid body sufficiently cold, condensation will first take place in the layer of air next the body, forming *dew* upon its surface if the temperature be above that at which the vapour solidifies, but *hoar-frost* if the temperature be below that point, in which case we have an example of *sublimation.* If the reduction of temperature be occasioned by the introduction of a quantity of cold air or other gas, or by the rapid expansion of the vapour itself, together with any other vapours or gases which may occupy the same space, the condensed liquid assumes the state of cloud, fog, or mist. The temperature at which a portion of space is saturated with the aqueous vapour which it actually contains was called by Dalton the *dew-point.* Some vapours, like steam at 100° C., if allowed to expand without receiving heat, and in expanding to do the full amount of work corresponding to the greatest pressure they can exert, suffer partial condensation, because the increase in the space occupied does not compensate for the reduction of temperature; but there are other vapours which become super-heated by expansion, because the increase in volume more than compensates for the reduction of temperature.

When the temperature of a liquid is such that, the pressure of its vapour is less than that to which the liquid is exposed, evaporation will go on at its free surface only; but if the temperature is raised so that the pressure of the vapour is greater than that exerted upon the liquid, bubbles of vapour can exist within the liquid itself, and if once formed will rise through the liquid and escape at the surface. This phenomenon is called *ebullition* or *boiling;* and the temperature at which the pressure of the vapour of a substance is equal to the standard atmospheric pressure is called its *boiling-point.* The standard atmospheric pressure generally adopted is that exerted by a column of mercury 760 millimetres in height at 0° C. at the sea level in latitude 45°. This is equivalent to about 29·905 inches of mercury at 0° C. at the sea-level in the latitude of London. The pressure of a megadyne per square centimetre has been proposed as the standard atmosphere, but this has not yet been generally adopted.

When a quantity of water is heated from the lower surface, the water near the bottom is at a higher temperature than the superincumbent layers, and the bubbles of steam formed there on rising are surrounded by water at a temperature below the boiling-point, and, being consequently unable to sustain the pressure to which they are exposed, they collapse with a slight sound. These sounds repeated in rapid succession constitute the "singing" of the kettle, and are exchanged for a very much softer sound when the whole of the water reaches the boiling-point, and steam bubbles escape from the surface. Though bubbles of pure steam once produced can exist under atmospheric pressure if the temperature be above the boiling-point, yet such bubbles will not necessarily be produced in pure water as soon as it reaches that temperature. If water which has been carefully freed from air by long boiling be heated in a clean glass vessel, its temperature may be raised considerably above the boiling-point; but as soon as the continuity of the water is broken by the formation of a bubble of steam, ebullition ensues with explosive violence, and the temperature falls nearly to the boiling-point. Drops of water suspended in a mixture of linseed oil and oil of cloves of the same specific gravity have been heated by Dufour to 180° C., and generally fatty oils poured on the surface of water tend to prevent ebullition. It has been stated that the boiling of *pure* water has not yet been observed. Certain solutions, especially strong solutions of caustic alkalies, are very liable to an explosive evolution of steam at intervals, and the best way of preventing it is the introduction, when possible, of a small piece of a metal which can decompose water.

Though the temperature at which water boils depends on the impurities which it contains, and the nature of the vessel in which it is placed, yet the temperature of the steam above the water depends only on the pressure. This has been long acknowledged when the quantity of impurity dissolved in the water is small, and in order to determine the boiling-points upon thermometers they are immersed in the steam above boiling water without allowing their bulbs to touch the water. When the quantity of salt dissolved is very great, the temperature of the boiling solution is generally very much above the boiling-point of water. Thus, according to Faraday, saturated solutions of common salt, nitre, and potassic carbonate boil at 109°, 115·6°, and 140° C. respectively. The temperature of ebullition of a saline solution is sometimes employed to determine the percentage of salt present. Notwithstanding the high temperature of the solution, it seems that the temperature of the steam when first liberated from the solution is the same as that produced by water boiling at the same pressure. This conclusion is supported by Dufour, though Magnus and some others were of a different opinion. If a thermometer with a clean unprotected bulb be immersed in the steam above a concentrated saline solution boiling at ordinary pressure, its temperature will quickly rise to 100° C., then become almost stationary, and afterwards slowly rise to a temperature somewhat below that of the liquid, and depending on its nearness to the solution and the facilities which are offered for the escape of heat from the bulb. On removing the thermometer and allowing it to cool, there will generally be found a quantity of salt sticking to the bulb which has been splashed upon it from the solution. If the bulb of a thermometer be covered with cotton which has been sprinkled with some salt, and be then immersed in steam, whether above a saline solution or above boiling water, its temperature will quickly rise considerably above the boiling-point, and several thermometers whose bulbs have been covered with different salts will indicate different temperatures if suspended side by side in the same vessel of steam, leading us to suspect that the high temperature recorded by the thermometer above the saline solution may be due in part at least to salt which has been splashed upon the bulb. If the bulb be protected from splashes by a metal screen placed below it, and from condensed water trickling down the stem by a guard placed above it, the temperature will at once rise to 100° C.; but the further rise of temperature will be so slow that it may be accounted for by the radiation from the liquid and from the metal screen, which of course becomes heated in the same way as a naked thermometer placed in its position. If a test tube containing mercury be immersed in the solution, and the thermometer bulb placed in it till it reaches the same temperature, on raising it into the steam the temperature will be seen to fall considerably.

If a small quantity of a liquid be placed in a metal vessel whose temperature has been raised very much above the boiling-point of the liquid, vapour will be produced so rapidly from the under surface of the liquid that it will be supported on a cushion of its own vapour, and thus prevented from coming into contact with the metal, the separation being so complete that if the liquid be an electrolyte a current from an ordinary battery cannot be made to pass from the liquid to the metal. This condition of the liquid is called the spheroidal state, and is often referred to as Leidenfrost's phenomenon. It may frequently be noticed that the drop is in a state of rapid rotation. If by any means an indentation is made in the surface of the drop, vibrations will be set up in it, causing the horizontal section to pass into the form of a curvilinear polygon, in the same manner as the edge of a bell changes its form when struck. The surface of the drop then presents a "beaded" or corrugated appearance, formed by the superposition of the retinal images of the drop in the two extreme conditions which it assumes, and therefore always presenting an *even* number of corrugations corresponding to the vibrating segments. Surface tension of course supplies the forces necessary to produce the vibrations. When a ventral segment projects beyond the mean surface of the drop so as to form a "bead," more surface is exposed by it to the heating action of the metal than when it is in its mean position, and when it lies within the mean, or spheroidal, surface so as to form a "flute," less surface is exposed by it; but as the generation of steam cannot be instantaneous, more steam will escape from the segment while it is receding towards the centre than while it is advancing, and thus the pressure of the escaping steam upon each ventral segment will vary with the phase of vibration in such a manner as to supply the energy necessary to the continuance of the motion. If the drop be examined by ordinary daylight a fluted outline can be distinctly seen within the beaded outline, but if it be instantaneously illuminated by electric sparks, the separate vibration forms will be seen presenting half as many beads and flutes as are presented when the images are superposed through the employment of a continuous light. The lowest temperature at which the spheroidal condition can be produced varies with the nature of the heated surface, the liquid, and the temperature of the liquid when poured into the vessel. It is in virtue of this condition that Faraday found it possible to freeze mercury in a red hot vessel. When the metal is allowed to cool sufficiently, the liquid comes into contact with it, and is wholly or partially converted into vapour with explosive violence. In highly rarefied air water will assume the spheroidal condition at very low temperatures, in consequence of evaporation being accelerated by the diminution of pressure.

Previous to the introduction of the molecular theory of gases many theories were proposed to explain the diffusion of aqueous vapour through the air. Halley supposed that vapour consisted of small hollow spherules or *vesicles* filled with an *aura* considerably lighter than air, which caused them to ascend like balloons, and Atwood followed his hypothesis. Even after the similarity of vapours to air and other so-called permanent gases had been fully recognized, the *vesicular* theory was still held in a modified form to explain the suspension of cloud and fog; but in the case of very small drops the resistance of the air is sufficient to prevent the drops acquiring more than an extremely small velocity in consequence of their weight. Hooke supposed that air contains aqueous vapour in a state of chemical solution; but this theory, like the preceding, fails to explain evaporation in vacuo. De Saussure believed that water was first converted into vapour by the action of heat, and then absorbed by the air on account of a chemical affinity; while Halley, Leroy, and Franklin thought that the attraction of the air was instrumental in the first formation of vapour. The advocates of a still older theory maintained that aqueous vapour was a combination of water particles with those of fire, which caused them to ascend, and that contrary winds blowing the particles of water together loosened the fire particles from them, thus allowing them to descend as rain.

Desaguliers seems to have been the first to identify the nature of steam with that of aqueous vapour at ordinary temperatures, and to recognize the fact that steam is a transparent gas, while the cloud produced by a jet of steam is really condensed water. In a letter to the president of the Royal Society (*Phil. Trans.*, 1729, p. 6), Desaguliers maintained that the cause of vapour rising in the air is a force of repulsion between its particles, which separates them so far from each other as to render the vapour specifically lighter than air. The resistance offered by water to compression he accounts for by a similar repulsion. From some experiments with a steam engine he concluded that water in being converted into steam under ordinary atmospheric pressure expands to about 14,000 times its original volume instead of about 1650 times as it actually does. Shortly after the above-mentioned letter was written, Desaguliers, in "An Essay on the Cause of the Rise of Vapours and Exhalations in the Air" (*Natural Philosophy*, pt. ii.), attributed the repulsion between the particles of vapour to an electrical action, supposing that the particles of water were first electrified from the air and then repelled by the air and by one another.

In 1783 De Saussure published his *Essais sur l'Hygrométrie*, which give an account of many experiments executed on a great scale, and in some cases leading him to correct conclusions. By placing a known weight of dry potassic carbonate in a large glass balloon filled with air and saturated with aqueous vapour, and finding the increase in the weight of the carbonate produced by absorption, he determined the amount of vapour originally present. By filling the balloon with dry air, and suspending in it a piece of wet linen, he determined the amount of the water which evaporated from the loss of weight experienced by the linen. These experiments were repeated with the balloon filled with hydrogen and carbonic anhydride, and with mixtures of these gases, and both methods led to the same result, indicating that the amount of vapour was the same, if the temperature remained constant, whatever gas were present. The inferences he derived from his experiments at different temperatures were not, however, justifiable; nor is there any ground for his division of vapour into four classes, viz., pure elastic vapour, dissolved elastic vapour, vesicular vapour, and concrete vapour, the last of which really consists of liquid drops.

Deluc (*Phil. Trans.*, 1792) enunciated the theory that the quantity of vapour which can exist in any space depends *only on the temperature*, and is independent of the presence of any other vapour or gas with which it has no tendency to combine chemically, being always the same as if nothing but the vapour occupied the space; and this he verified by placing his hygrometer with a little water under the receiver of an air-pump, and showing that the indications of the hygrometer were independent of the pressure of the air. Deluc was the first to propose that the hygrometric state of the air should be measured by the ratio of the amount of vapour existing in it to that required to saturate it at the temperature it possesses. A more convenient measure has been proposed by Balfour Stewart, viz., the quantity of vapour associated with the unit of mass of dry air.

But it is to Dalton that we are chiefly indebted for a clear statement of the laws of evaporation. In his *Meteorological Essays* (1793, p. 134) he states that "evaporation and the condensation of vapour are not the effects of chemical affinities, but aqueous vapour always exists as a fluid *sui generis* diffused amongst the rest of the aerial fluids." Thus water at 80° Fahr. is on the point of boiling under a pressure of 1·03 inches of mercury, and from this he concludes that in the presence of dry air water at 80° Fahr. will evaporate "till the density of its vapour, considered abstractedly, becomes $\frac{1}{29}$th of what it is under a pressure of 30 inches, and its temperature 212°." This statement, though inaccurate inasmuch as it takes no account of the expansion of a given mass of steam at constant pressure when its temperature is raised from 80° Fahr. to 212° Fahr., yet shows that Dalton had discovered the true law of evaporation, and thoroughly understood its applications. If we substitute pressure for density, the statement becomes correct. Again, on page 201 of the *Essays* he states his conviction, as the result of experiments and observations,

> "That *the vapour of water (and probably of most other liquids) exists at all temperatures in the atmosphere, and is capable of bearing any known degree of cold without a total condensation, and that the vapour so existing is one and the same thing as steam or vapour of 212° or upwards.* The idea, therefore, that vapour cannot exist in the open atmosphere at a lower temperature than 212°, unless chemically combined therewith, I consider as erroneous; it has taken its rise from the supposition that *air* pressing upon *vapour* condenses the vapour equally with *vapour* pressing upon *vapour*,—a supposition we have no right to assume, and which, I apprehend, will plainly appear to be contradictory to reason and unwarranted by facts; for when a particle of vapour exists between two particles of air, let their equal and opposite pressures upon it be what they may, they cannot bring it nearer to another particle of vapour, without which no condensation can take place, all other circumstances being the same; and it has never been proved that the vapour in a receiver from which all the air has been exhausted is precipitated upon the admission of perfectly dry air. Hence, then, we conclude, till the contrary can be proved, that *the condensation of vapour exposed to the common air does not in any way depend upon the pressure of the air.*"

(The italics are Dalton's.) In these remarks Dalton manifests a clear appreciation of the true state of the case. In his experiments he aimed directly at the root of the