electrodes, it was found that the new conditions made it possible to improve on the action of a pure copper anode, and a number of changes were accordingly made. In the first place, if the arc plays for a time on pure copper, it will oxidize the surface. This oxide will fuse to a slag that becomes an insulator when cold, and on starting a cold lamp it is necessary to strike the electrodes together hard enough to break through the slag. To strike such a hard blow is undesirable, as if it is done while the lamp is burning—for example, when feeding—it is liable to spatter the fused slag out onto the glass globe. A simple remedy for this consisted in using an anode containing metals or alloys whose oxides, when fused together, would make a slag that is a good conductor when cold. The steadiness of the light largely depends on the composition of the slag, its uniformity and temperature. The anode surface is at all times covered with this slag, which slowly dissolves the metal and is itself slowly volatilized. If the arc plays on bare metal it consumes it rapidly, and it was found desirable to secure this slag cover from being knocked off. This was accomplished by providing a rough surface for it to cling to, and by running the entire anode tip very hot.

A characteristic property of the metallic arc has been a very noticeable dying-down or dimming of the light, which would occur at irregular intervals, especially after the electrodes had burned for twenty hours or more. These dim spells would last from a few seconds to two or three minutes, when the normal brilliancy would return. This is explained as follows: In the metallic arc, the brilliancy is largely due to the presence of volatilized oxide of titanium, and anything that interferes with the uniform evolution of vapors of titanium will cause the light to dim—for example, the presence of a high percentage of highly fusible oxide of chromium. This oxide of chromium is volatilized at a slower rate than the oxides of titanium and iron, and after the electrode has been burning some twenty hours the slag on the end of the cathode has become very rich in oxide of chromium,

which forms a film on the surface of the fused pool of oxides. When the film is not present there is a plentiful evolution of oxides of iron and titanium, and there is a bright arc. The oxide of chromium can be seen to gather on and finally entirely cover the surface of the pool. This stops the evaporation of titanium and iron, and the light burns to a bluish color and dies down until the chromium film is burned away again. This trouble was met by modifying the mixture in such a way that the oxide of chromium could not separate from the oxides of iron and titanium, thus doing away with the film on the surface and entirely doing away with the dim spells.

In carbon lamps there was very little done to keep the impurities volatilized from the carbons from depositing on the globe. This trouble had to be met by the carbon manufacturers, who were prodded up to produce carbons containing less than 0.2 per cent of impurities, but this means was not to be considered in the case of the metallic-arc lamp. The metallic-arc electrodes, being chiefly composed of oxides of iron, titanium, and chromium, do not burn away to an invisible gas, as does a carbon stick, but are volatilized bodily, and the vapors instantly condense, on leaving the arc, to a fluffy reddish soot that settles on everything it touches, so that a chimney is a very necessary feature in the lamp. This soot, if it comes in contact with the reflector or globe, will smudge them badly in ten minutes. As was noted before, a current of air flowing down around the electrode served admirably to keep it clean, so it was applied to the reflector and globe with gratifying results. A thin layer of air is introduced at the top of the reflector and forms a shield through which the soot-laden air cannot penetrate, so that the reflector and globe will keep clean for a long time.

As the air currents play such an important part in this lamp, it became necessary to do a large amount of experimental work on the design of an air intake and of a chimney top. The chimney could not be made long enough to cause a very powerful draft, so the wind was very apt to blow down it; but by per-

sistent effort the openings have been so designed that the wind may blow from any direction (up, down, or sidewise), and the only effect is to increase the natural draft in the lamp. Incidentally, the increasing of this draft actually centers the arc and holds it quiet.

It was found advisable to run the lamp at 4 amperes and 65 to 68 volts at the arc with a cut-out set at 85. This low cut-out was made possible by the inverted position of the electrodes and by the peculiar arrangement of the air draft, which prevented any tendency of the arc to flame or to run up the side of the electrode. Without these features, a cut-out of 100 to 110 volts would be necessary. As the power-factor at which the lamps operate depends largely on the amount of variation of voltage in the arc, this 85-volt cut-out is seen to be very desirable. In actual service the lamps, including a mercury arc rectifier, run very well at from 65 to 70 per cent power-factor.

In several places above we have described special conditions that must be obtained for getting the best results with these electrodes, and these conditions, of course, must be supplied by the lamp in which they are burned. An example of a lamp well adapted for this service is here shown. A study of its design and construction will show that it is simple and rugged, as no float feed is used; it being necessary only to strike an arc and hold the electrode in a permanent position until, due to change in voltage, the cut-out causes the restriking of the arc. The lamp consists essentially of a base and top, connected by a chimney, a set of magnets for striking the arc, a shunt cut-out for causing the lamp to feed due to rise in voltage, and a series cut-out for disconnecting the striking magnets after the arc has been formed.

The special conditions described with regard to drafts are obtained, as seen here, by the down-draft tube, which directs the current of air down around the electrode, another current of air over the reflector and circling around the globe forming a means of protection to them, and a special construction of top and case for giving proper draft conditions when under all conditions of wind.

THE GRADUAL ADVANCE OF SCIENCE.

THE RISE OF CHEMISTRY AND PHYSICS.

BY PROF. CHARLES BASKERVILLE.

AMONG the Greek philosophers, of whom Aristotle was a leader, there prevailed the opinion that a body could be hot or cold, wet or dry. A body could not be hot and cold or wet and dry at the same time. It may, however, be hot and dry (fire), hot and wet (air), cold and dry (earth), or cold and wet (water). Earth, air, fire, and water constituted the four elements of the Greeks.

The Arabs, who contributed enormously to our knowledge of chemistry, made the first systematic effort to explain the observed diversities in matter by the nature of the constituents of which it is composed. But for many centuries the development of chemistry was but an incident in the history of alchemy, or the "black art," as it was sometimes designated. The genuine alchemist sought to transmute base metals into gold.

In the eighth century the Arabian alchemist Geber (Abou-Moussah-Dschafer-al-Sofi being his full name), a true worker in seeking "perfection," considered all metals as compounds of mercury and sulphur. A metal was supposed to exhibit the sum of the properties of its constituents. The mercury or quicksilver was the vehicle of the qualities of ductility, fusibility, and luster, while the sulphur or brimstone offered the quality of combustibility. The differences between the individual metals, like gold, silver, and copper, were said to be due to the relative quantities of these constituents and to the degree of purity exhibited by them. The accomplishment of the highest purity was the "perfection" sought, but never reached, by Geber.

Five hundred years later Roger Bacon, the great philosophic alchemist, the reputed, and at least an independent discoverer of gunpowder, maintained that it was as absurd to wish to transform lead into silver, copper into gold, as to pretend to make something out of nothing. He insisted that the first necessity was to remove from the rough earthy mineral a bright metallic substance like lead, tin, or copper, as Geber before him maintained. This was only the first step toward "perfection" for Bacon. According to him, the most perfect gold is that found in the native state. It is perfect because in its nature finished her work. Therefore, the alchemist should seek to imitate nature. Nature makes no note of the cycles necessary for her work, so something was needed which would accomplish in a short time that which nature did in ages. The alchemist, therefore, should seek the "philosopher's stone," with a pinch of which it was hoped the vast changes could be made.

If we take a bone and burn it, we get fire, the ash

(earth) left behind, water given off, and a gas produced. If that ash be mixed with powdered coal and heated in a retort, as was done by the alchemist Brandt in the seventeenth century, we obtain a yellow substance known as phosphorus. This "light of Satan" was exhibited in all the courts of Europe as a new and remarkable substance because it glowed in the dark and eventually took fire when exposed to dry air, burning with a brilliant light. No other substance was known to possess these qualities, hence it was called an element. Later it was learned that if this yellow, spontaneously inflammable body be heated just below red heat in a close tube with no air present, it acquired a red color, no longer glowed in the dark, or took fire. The former substance is very poisonous, whereas this red variety is harmless. Under proper conditions the red may be changed back into the yellow phosphorus. These facts are related, as they have an important bearing upon that which immediately follows.

During the latter part of the seventeenth century, a German physician of the name of Becher explained the process of combustion as a form of destruction, a dissolution of the combustible substance into its components. According to this, what we now term an element cannot burn. His pupil, Stahl, elaborated the hypothesis by assuming that each combustible substance consists of the product of combustion united with an inflammable principle called "phlogiston"; a metal and this principle of fire combined together. From the observations made, there was good reason for accepting this hypothesis, but as Henry James has said, "we grope in the dark, carrying each our poor little taper of selfish and painful wisdom." Facts are facts, when accurately observed. Explanations are quite different. They constitute merely scaffolding for the structure of science and are to be cast away as soon as they shall have served their purpose.

It remained for Lavoisier, whom the French delight in calling the "father of chemistry," although they executed him during the revolution in the last quarter of the eighteenth century, to weigh the metals before and after the burning. He proved that nothing had been lost—in fact, there was a gain. No phlogiston or burning principle that was weighable had been given out. The principle of the conservation of mass or weight was thus established.

Just a century ago the Englishman John Dalton learned by experiment that a metal, when burned, always gained the same in weight. This he explained by stating that matter consists of very small indivisi-

ble particles, called atoms, which possess definite weights. These weights are unchangeable. These atoms, about eighty different kinds being known at present, make up all the various kinds of matter with which we are familiar. They enter in different proportions, but never in less weight than that of the atom, although many atoms may be in a substance. If these atoms are different we have a compound, just as in the bone mentioned we have our phosphorus, calcium, and oxygen. If the atoms be alike, as in our phosphorus, we have an element—an element being a substance which has not yielded anything simpler than itself.

The determination of the weight of an atom is a delicate operation, dependent upon great skill and many matters of technique familiar only to an expert. In studying the figures obtained, Prout noted that many of them approximated whole numbers. The approximation he attributed to defects in the methods or apparatus employed. If perfected, whole numbers would result. For example, oxygen, having an equivalence of 15.9, was really 16. Therefore he maintained that all the elements were actually composed of the smallest. If we could condense sixteen of hydrogen into the space of one, we should have oxygen. In short, for the transmutation of the elements it was only necessary to secure a machine which would do the work. This was in 1815. To test this, the Belgian chemist Stas determined many of the atomic values. This was a monumental labor subsequently equaled only by the classical work of Theodore Richards, of Harvard, who, as exchange professor, lectured this year in the University of Berlin.

One element—chlorine—a constituent of common table salt, always gave a value of about 35.5. In an effort to harmonize these facts a Frenchman, Dumas, said that all elements were made up of half atoms. This did not prove satisfactory, so Zangerle, in an effort to account for all the fractions obtained, said that hydrogen should be subdivided into one thousand parts. These speculations were not substantiated by the facts observed, so they constituted merely an event in the history of chemistry to be revived within the past decade apparently with experimental proof.

Just before our civil war began, two Germans, Bunsen and Kirchhoff, devised the spectroscope. With this instrument a beam of white light may be broken up into a rainbow of colors. If the light be from some element which is burned we get definite bright lines in fixed places. These lines are characteristic for the particular element experimented with. By common consent we regard a substance an element which has

definite atomic weight and spectrum. To prove the existence of a new element it has never been necessary to actually get it isolated, for the atomic weight and spectrum could be had from its compounds. In fact, up to this time no element was known which did not form compounds. Compounds are the result of the mutual attraction of the elementary constituents; therefore, each element possesses an inherent property called chemical affinity, which brings about the union in compounds.

Man has been breathing and walking through air since its existence. We have seen that once he regarded it an element. Work of numerous scientific men showed that it was essentially a mixture of one part of oxygen and four parts of nitrogen by weight. If there were one material phase of nature that men of science thought they understood, it was the air. Yet, in 1894, Lord Rayleigh and Prof. William Ramsay learned that the air contains about 1 per cent of another element—argon. This element is characterized by the absence of that usual property of the elements, namely, the ability to form compounds. So far, chemists have failed in all their efforts to make this argon combine with other bodies. It is remarkable that a man of average weight breathes about a cubic foot of this lazy gas every twenty-four hours, and the man of science, with all his refinements of investigation and research, failed to detect it through the centuries he has busied himself with observing the phenomena of nature around him. This discovery was crowned with the Hodgins prize of \$10,000 by the Smithsonian Institution in Washington.

In 1868 Jannson, and later Lockyer, independently noted an unusual line in the spectrum produced by the light given out by the chromosphere or luminous envelope of the sun. This was attributed to a new element, helium. Sir William Ramsay and his assistant, Travers, found this solar element in certain rare minerals on the earth. It is just four times as heavy and next in lightness to hydrogen. It resembles argon in its inactivity, and occurs with three other similar elements in the air, but in extremely minute amounts, so small that the ordinary methods fail absolutely in its detection. For this work Ramsay received the Nobel prize of \$40,000.

Ten years ago an intrepid Polish woman and her brilliant Parisian husband, Prof. Curie, announced a discovery that startled a world accustomed to wonders. Radium is even more remarkable to-day than phosphorus was to those seventeenth-century alchemists. It has caused such astonishment that we have so far been unable to coin an adjective sufficiently descriptive. It glows in the dark; it is always hotter than its surroundings; it charges bodies electrically when they are near; it discharges bodies already charged with electricity, and it constantly gives off a gas called an "emanation" by Rutherford, its discoverer. This emanation goes through a number of changes, eventually forming helium.

Radium is an element, according to agreement, for it has a definite atomic weight and a characteristic spectrum. So is helium. Radium is transmuted into helium and we have apparently the dream of Geber realized. This has been the attitude of belief on the part of the most generous contributors to our knowledge of these unique substances. The opposite point of view, however, has been held by Lord Kelvin in England and the writer in this country, because if radium be an element, it should not break up into anything simpler than itself. These opponents have no objection to changing their definition of an element, or even accepting radium as a "temporary element" or "meta-element," a term by which Sir William Crookes designated certain "nebulae of elemental matter."

Just as this more conservative view is securing a foothold among men of science, we are confronted with the experimental evidence indicating the transmutation of elements.

Rutherford, in his studies, learned that the "emanation" from radium during its degradation through several steps to helium gives out an enormous amount of energy, vastly greater than in any process previously known to man. A comparative idea of this is had from calculations that have been made. A pound of the purest coal when burned in pure oxygen produces enough energy to lift its weight two thousand miles, or say from New York to Venezuela. A pound of hydrogen burned under similar conditions, a most violent chemical reaction, generates heat enough to lift its weight eight thousand miles, or, say, to Honolulu. A similar amount of radium, without any burning, produces enough energy to lift itself to the orbit of Neptune, or thirty times the distance from the earth to the sun. The decomposition of the emanation produces by far a greater portion of this energy. Surely such forces operating upon matter should cause events to come to pass with which man is unfamiliar. Indeed, he can scarcely foretell them, although Tyndall once said that "most molecules—probably all—are wrecked by intense heat, or in other words, by intense vibratory motion, and many are wrecked by a

very impure heat of the proper quality." Herschel, in fact, as a result of his study of the temperature of the stars, remarked that the "atom has the stamp of a manufactured article."

When the emanation is placed in a dry vessel it breaks down into helium, as Ramsay, Soddy, and others have proved. Ramsay has just shown that when the emanation breaks down in the presence of water, neon, one of the five inert elements found by him in the air, is produced. When the emanation is allowed to break down in a solution of blue vitriol or copper sulphate, argon is the lazy gas produced. One of these is five and the other ten times as heavy as helium. We should expect the argon and neon thus produced to continue breaking down until helium is obtained. We have not been informed on this point as yet, but we do know that these elements obtained from other sources have not as yet been observed in such a temporary state.

The most remarkable part of Ramsay's observation, however, was concerned with the liquid left behind. When the copper was removed from the solution, lithium was detected in the residue by means of the spectroscope. This was not the case when copper was removed from a similar solution before treatment with the emanation. Gold, silver, copper, and lithium are members of one of the so-called chemical families. Lithium is the member with the least atomic weight, being one-ninth that of copper. Evidently, therefore, the powerful emanation had brought a degradation of the copper, and the element copper had been transmuted into the element lithium.

In justice to Ramsay it should be stated that he actually makes no real claim to what has generally been understood as transmutation. Especially does he maintain that his work has no connection with the current acceptance of the term, namely, the conversion of silver into gold. He calls it degeneration of one element into another. Now, silver is only a little more than half as heavy as gold, consequently such a conversion would be a reverse of his claims. It may be well to remind the reader that Emmens in this country made claim to this reverse process, and the claims were very widely heralded. The basis of Emmens's claims were as follows: Silver is 10.5 and gold 19.3 times as heavy as equal volumes of water. If by some mechanical device sufficient pressure could be exerted upon a definite volume of silver, so that it occupied one-half of its former volume, then we should have silver 19.3 times as heavy as an equal volume of water, the same as gold. This was called "argentaureum," a word coined from the Latin names for silver (*argentum*) and gold (*aurum*). Although it was claimed that the United States Mint accepted this "argentaureum" for gold at full price, we are not aware that it has played any part in changing the standard of values in commerce.

Can this emanation be Bacon's "philosopher's stone" reversed? If so, is there any way of taking the fairly abundant elements of comparatively low atomic weights, like calcium (from lime), aluminium (from clay), or copper even, and so saturate it with energy that it acquires properties like radium or platinum or gold?

Most writers on radium think such an accumulation of energy as shall be sufficient to build up that substance impossible, at least with our known agencies. The author, however, is not so sure of it from certain experiments not yet completed. A hundred years ago the telephone, with its present perfection, was a wild dream. Twenty-five years ago the communication of continent with continent without connecting wires was beyond comprehension. Fifteen years ago if any one had said we should soon be able to see the bony structure of the body through its fleshy covering and envelope of clothing, he would have been thought a fit and proper subject for an asylum. Yet, now we have the X-rays. Some wild dreams have come true. That, however, is no reason for assuming that all the pictures a fertile imagination may lay out are to become verities.—New York Times.

THE EARTH'S MAGNETIC AXIS.

The magnetic axis of the earth, and particularly the "magnetic north pole," appeals to the popular imagination. But the work of studying this axis is a difficult one, beset with complications. The Electrical Review sums up some recent investigations given in *Terrestrial Magnetism and Atmospheric Electricity*, by Dr. W. van Bemmelen, who deduces the position of the mean magnetic axis by means of a study of the magnetic declination alone. In the same issue, Dr. L. A. Bauer shows that if all the magnetic elements be considered, a result is obtained not in agreement with Dr. van Bemmelen's, and he then goes on to show why this is so. He first points out that Gauss's definition of the magnetic axis of the earth is the straight line about which the earth's magnetic moment would have a maximum value. If, then, the earth be uniformly magnetized, it will be possible to determine definitely the position of this imaginary line. How-

ever, not only is the magnetization heterogeneous, but it consists of two elements—internal forces and the external; and these vary independently of each other. Moreover, there is a third possible force affecting the magnetic distribution in the earth. This is magnetization caused by vertical earth-air electric current. There are therefore three elements to be considered, all of them independent, and in trying to locate the axis by means of these, different results will necessarily be obtained. In other words, the earth has three magnetic axes—one for each of the three component forces. From the surveys now being made in various countries it is to be hoped that much more will be known of the earth's magnetization than heretofore. But it is likely to be a long time before we come to any very clear understanding of the whole phenomenon.

MEXICAN BROMELIA FIBER.

Among the collections of fibers from tropical America shown at exhibitions has frequently appeared a long silky vegetable fiber of a greenish color, and showing great strength, though only an expert might particularly notice the small hanks into which the fiber is made up. When a specimen is unwrapped, however, the fineness of the fiber and its extraordinary length become apparent, for 6 feet is a common length. So strong is the fiber that it is difficult to break even a few filaments by direct strain without cutting into the hands. According to the Bureau of the American Republics, this is produced from the long narrow leaves of a "wild pine" belonging to the genus *Bromelia*. Its most common names are pita, pinuella, pinguin, and silk grass, though "pita" is meaningless, and silk grass is applied to so many other fibers that the name is worthless. The better names are pinuella and karatas. In the regions of Southern Mexico, from Oaxaca to Vera Cruz, where the plant grows in great profusion, the fiber is used largely for fine woven textures, where strength and durability are essentials, such as hunting bags and other forms of pouches. It is also used for sewing threads, and was formerly employed for sewing shoes. The fiber is cleaned by hand, and the great length of the thin narrow leaf, which is armed along its edges with sharp spines, makes it a tedious operation, hence the high price of the fiber. Efforts are being made to clean the leaves of the wild pineapple by machinery, and some fair examples of the fiber have been turned out experimentally in small quantities, so that future experiments are looked forward to with interest. The difficulty in the way of machinery extraction is largely due to the fineness and length of the leaf, a machine powerful enough to scrape off the hard epidermis inclosing the fiber layer being too harsh in its action, thus injuring the fiber. The production of well-cleaned, unbroken fiber by machinery, and in commercial quantities, would no doubt give to manufacturers a new textile which might enter into some of the present uses of flax, while the peculiar silkiness and the color of the fiber would adapt it to the manufacture of many beautiful woven articles, such as fancy bags, and even belts for summer wear. It would doubtless make superior fishing lines, and with further preparation and bleaching, it is probable that the fiber might be employed in a wide range of woven fabrics of great beauty. An Italian authority states that in Brazil and Guiana, where a similar (if not the same) plant abounds, the fine silk fiber is manufactured into many articles of *de luxe*. In an old work on Mexico a species of *Bromelia* is referred to, which is said to yield a very fine fiber 6 to 8 feet long, "and from its fineness and toughness, it is said to be commonly used in belt-making work. It also finds application in the manufacture of many articles, such as baggings, wagon sheets, carpets, etc., besides being a valuable material for making nets, hammocks, cordage, and many other articles in common use." This undoubtedly refers to the common form of *Bromelia*. A species of short-leaved *Bromelia* grows in Paraguay and Argentina, producing a somewhat similar fiber, which is known as Caraguata, the product of *Bromelia Argentina*. The filaments from this species are rarely longer than 4 feet, and while the fiber is short and strong, it does not compare with the pinuella fiber from the regions of Oaxaca, Mexico. *Bromelia* fiber is closely allied to the famous piña, or pineapple fiber of the Philippines, from which are manufactured beautiful textures, such as fabrics for ball dresses, and handkerchiefs of gossamer fineness. There is said to be little doubt that with a careful preparation, some of the wild pineapple fiber might be employed in the same manner.—Journal of the Society of Arts.

The New York Electrical Show will be open from September 30 to October 9 at Madison Square Garden, New York city. Exhibits are expected from all the prominent electric manufacturing firms of this country, and from a few foreign ones. All kinds of apparatus will be shown, from heavy generating machinery to tiny incandescent lamps.