Note in passing that this list includes almost the *entire* inorganic basis for biologic life and activity!

Most of these are topics beyond the successful grasp of children in the grades, and for their apprehension require some knowledge of several of the sciences.

Now, in answer, geology will at once suggest itself as competent to supply this lack; but consideration will show its failure in several important essentials, among which are the subordination of the biological element and almost total absence of the human.

Repeated experience in the past has, however, shown that physiography is well suited for this.

In practice, the various sciences were given about the usual degree of attention; each one being vigorously pushed to a tentative conclusion; and then, to supply omissions, revive and freshen past acquirements and at the same time gain a fresh and inspiring new view of the whole, books like Guyot or Maury were made the basis of broad and thoughtful study.

The results were such as to commend the plan to anyone feeling a similar need.

MOISSAN'S WORK WITH THE ELECTRIC FURNACE.

BY FELIX LENGFELD.

The young student who goes into a chemical library and sees the hundreds of volumes that contain accounts of experiments performed by thousands of chemists living and dead, is apt to feel that nothing more can be done along simple lines, that future work must be upon very complex substances or very rare elements. That same feeling existed a hundred years ago and probably the chemist of the twenty-first century will envy us our virgin field.

In 1800, Crell, translating an article of Proust on copper salts, takes occasion to point out that young chemists should take courage when they see what Proust has done with an old subject, and it behooves every chemist to study carefully Moissan's work to see the prizes that await the careful experimenter. When Moissan had isolated fluorine, after it had eluded other chemists for a century, it seemed to him that the well-known crystallizing power of fluorides might be used to crystallize carbon as diamond. Experiments in that direction failed. Moissan thereupon studied the occurrence of the diamond in nature and concluded that it was formed by the crystallization of carbon under pressure. This could be brought about in the laboratory by dissolving carbon in molten iron and cooling the outside rapidly. Cast iron expands in solidifying and therefore if a crust is once formed and does not crack, the pressure must increase as we approach the center. Carbon is more soluble in hot than in cold iron, and therefore the greater the difference between the melting point of the iron and the temperature at which it is saturated with carbon, the greater the quantity of carbon that separates in solidifying, and the greater the probability of obtaining diamonds. Something hotter than the oxyhydrogen flame was required, and the electric furnace was invented. Its simplicity challenges our admiration. Two blocks of lime or limestone are hollowed out so that a crucible can be placed in one cavity, the other being arched so as to reflect the heat downward. Openings are cut lengthwise to admit the carbons of the arc and the furnace is complete. In some, openings are cut horizontally at right angles to the arc carbons, so that carbon tubes may be inserted and reactions tried protecting the substance from the vapors in the arc. The blocks vary in size, depending upon the current used. In the smallest the lower block is 10 cm. by 18 cm. by 15 cm., in the largest 20 cm. by 35 cm. by 30 cm., the first figure giving the height. The covers are from 8 cm. to 15 cm. high. The carbons vary from 1 to 5 cm. in diameter and the crucibles from 4 cm. in height by 3 cm. in diameter (exterior) to 10 cm. by 9 cm. The crucibles are of graphite, but as this reduces lime they are always separated from the block by magnesia. A single experiment rarely lasts over ten minutes. With large currents the lime melts and even boils, and if the experiment be prolonged there is danger that the molten lime will cement the cover to the lower block. The substances to be heated are placed below the arc and the characteristic of the furnace is that the arc is used merely as a source of heat and that there is no electric action upon the chemicals. The temperature of the furnace has been estimated at about 3500° and there is little doubt that the boiling point of carbon has been reached, so that it is not likely that higher temperatures will be obtained with larger currents unless means be found for working under pressure. Currents of 50 volts and 35 to 1000 amperes are used. Currents of over 1000 amperes are rarely used, as the disadvantages more than counterbalance the gain. The ordinary precautions in handling large currents and intense lights must be taken, dark glasses, for instance, being absolutely essential. As the electrodes do not fit into the furnace tightly, much heat escapes through the space between carbon and lime, but, on the other hand, the outside of the furnace remains cold and one may place the bare arm on the top of the furnace though the temperature but a few inches off is almost double that of the oxyhydrogen flame, and chalk, silica, manganese boil like water in a kettle.

A mixture of sugar charcoal and iron is heated in the electric furnace and then plunged into water. There is very energetic action, great quantities of oxygen and hydrogen being formed by the dissociation of the water, but there is no explosion. When the mass is cold the iron is dissolved in boiling hydrochloric acid. The residue consists of three varieties of carbon, and other impurities. It is treated with aqua regia, then with boiling sulphuric acid and hydrofluoric acid, then put into sulphuric acid at 200° and potassium nitrate slowly added. The amorphous carbon and most of the impurities are thus destroyed. The graphite is oxidized by the mixture of nitric acid and potassium chlorate. The small residue is again treated with boiling hydrofluoric acid, then with sulphuric acid, washed and dried, and then consists of small diamonds, some black and some transparent. The latter are denser and may be separated from the others by throwing all into bromoform, collecting those that sink and repeating with methylene iodide. The diamonds thus formed resemble most of the varieties of natural diamonds. Like natural diamonds they differ in hardness, color and luster. Though small, the largest being less than a millimeter in length, they are true diamonds. The scientific problem is solved, but it will probably be many years before large artificial diamonds compete with the natural gem.

The reproduction of the diamond is but a small part of the work done with the electric furnace. At 3500°, carbon reduces most metallic oxides and it is thus possible to make in a few minutes masses of chromium, molybdenum, uranium, ziconium, titanium, etc. Metals that could be obtained only in small quantity and in fine powder with great labor can be made in masses of almost any size and their properties studied. At these high temperatures many metals combine with carbon, forming the interesting substances known as carbides. Some of these, as the carbides of calcium, barium, lithium, give, with water, acetylene; others like aluminium and beryllium carbides give methane; still others give mixtures of gaseous, or even of gaseous, liquid and solid hydrocarbons, and point to the inorganic origin of some petroleums. The carbide of silicon is so hard that it is used instead of emery under the name carborundum. Not alone carbides but silicides, borides, nitrides may be easily formed and many of them have been studied. Many minerals have been reproduced, many more will be, and we can feel certain that the électric furnace reserves many surprises for us, for the chemistry of high temperatures is still in its infancy.

THE STUDY OF BACTERIA IN THE PUBLIC SCHOOLS.

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(*Concluded from page 306.*)

The practical applications of the subject were brought out in discussion of a list of questions from which the following are selected:

1. From all your experiments state—
    a. What conditions seem to favor the growth of bacteria?
    b. What conditions seem to hinder the growth of bacteria?