prove by our preliminary hybridization work that there is need for a further genetic study of the species. On the other hand, geneticists without mycological training undertaking to study the ascomycetes should realize that the ways of these fungi are devious and beset with pitfalls. Nevertheless, it is encouraging to know that fundamentally in their reproduction and inheritance the fungi follow exactly the same laws that govern these activities in the higher plants and animals.

A GREAT PUPIL AND A GREAT DISCOVERY—BOTH SUPPORTED BY A GREAT TEACHER

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ON this February 23d, it will be exactly half a century since an Oberlin College student, young Charles Martin Hall, gave aluminum to the world as an industrial metal.

This brilliant discovery of the present industrial process of making aluminum was no accident but the result of long-continued effort and intelligent planning —in cooperation with one of the best-trained teachers of chemistry in America, Frank Fanning Jewett.

Hall at 22 succeeded where many of the greatest scientists of his century failed. It is true that Oersted, the Dane, famed for his fundamental research in electricity, was the first to isolate aluminum (1825) and that Wöhler, the German, dominant authority in chemistry, improved slightly upon Oersted's method (1827), wrongly receiving world credit for the discovery; but these pioneers saw only a little black powder instead of shining, massive aluminum. The scientific world was thrilled, but industry was not greatly benefited.

The following equation represents the method by which this metal was isolated:

$$AlCl_3 + 3K \rightarrow 3KCl + Al.$$

The eminent French chemist, Deville, complaining that aluminum was still slightly more expensive than silver, lowered the cost in 1854 by the simple substitution of the cheaper metal sodium for potassium in attack on a mixture of aluminum chloride and sodium chloride.

$$AlCl_3 + 3Na \rightarrow 3NaCl + Al.$$

Within two years, by 1856, the price of the metal dropped from $90.00 per pound to $27.00.

Sir Humphry Davy made earlier attempts than Wöhler's to reduce the oxide and failed, as did Silliman. Berzelius, the eminent Swedish chemist, almost succeeded in anticipating the success of Wöhler when he heated cryolite, the double fluoride of aluminum and sodium, with potassium. Unfortunately, he used an excess of potassium and got an alloy of aluminum with potassium. Had he used an excess of cryolite, Berzelius would now be given credit for presenting aluminum to science. Deville actually gave them all a start on the right track in another method that failed. He electrolyzed melted cryolite, a double fluoride of aluminum and sodium, but the results were unsatisfactory. Bunsen is said to have done the same thing at the same time. Half a century later these unsuccessful experiments were dragged into court in an effort to deny Charles M. Hall the fruits of his own great discovery.

Deville worked hard to cheapen the cost of the necessary sodium for his reduction process and actually founded a small industry. Heating sodium carbonate (and some calcium carbonate) with carbon he secured metallic sodium in commercial quantities.

Then came Castner, who, with admirable clearness, saw that cheaper sodium meant cheaper aluminum. With equally admirable directness he proceeded to devise a cheaper process of making sodium and at once cut the cost of aluminum to the encouraging figure of $6.00 (later, $4.00) a pound. Then, just at the moment of reasonable success, poor Castner was flattened by the news of young Hall's great discovery!

Now, in 1880, enters upon the scene a quiet, studious lad, Charles Martin Hall, son of a minister in the village of Oberlin, Ohio. Dreaming of his "schemes" to make great discoveries for humanity, actually making a real invention at 17 and finding it already patented, reading in a dog-eared old chemistry of the properties of aluminum, he was ready to enter Oberlin College in 1880.

It was most fortunate for Hall and for Oberlin College that in 1880 Frank Fanning Jewett accepted the chair of chemistry and mineralogy, bringing to the work a training equal to the best of that time. A Yale graduate, he had gone to Germany, where, in Göttingen University, he was one of the small group of American students who at that time specialized in chemical work under highly trained German teachers. Among his close friends at Göttingen were Provost Edgar F. Smith, of the University of Pennsylvania, Professor Harmon Morse, of Johns Hopkins University, and Professor Mears, Sr., of Williams College. After his return from Germany Professor Jewett served as research assistant to Wolcott Gibbs of Harvard and, later, for a period of four years as professor of chemistry at the Imperial University of Japan.

On the occasion of the fiftieth reunion of his Yale class (1920) Professor Jewett, like all his classmates, was asked to give an accounting for his 50 years of activity since leaving Yale. His remarks are worth presenting here as valuable historical material.

My great discovery has been the discovery of a man. When I went to Oberlin in 1880, on my return from four years' teaching in Japan, there was a little boy about fifteen years old who used to come to the chemical laboratory frequently to buy a few cents worth of glass tubing or test tubes or something of that sort and go off with them. He would come again after a while to get some more things to work with.

Not knowing anything about the boy I made up my mind that he would make a mark for himself some day because he didn't spend all his time playing but was already investigating. That boy was Charles M. Hall, the man who, at the age of twenty-one, discovered the method of reducing aluminum from its ores and making it the splendid metal that we now see used all over the world. Hall was an all-round student, but he did have a special liking for science.

After he had entered college and was part way through the regular course, I took him into my private laboratory and gave him a place by my side—discussing his problems with him from day to day.

Possibly a remark of mine in the laboratory one day led him to turn his especial attention to aluminum. Speaking to my students, I said that if any one should invent a process by which aluminum could be made on a commercial scale, not only would he be a benefactor to the world but would also be able to lay up for himself a great fortune. Turning to a classmate, Charles Hall said, "I'm going for that metal." And he went for it.

He tried various methods in vain, and finally turned his mind to the idea that perhaps electricity would help get the metal out of its ores. So he focused his attention on that process. I loaned him what apparatus I had to spare, what batteries we could develop. And I think that most of you who have seen an electric battery would have laughed at the one we got up—made as it was out of all sorts of cups, tumblers and so on, with pieces of carbon in them. But we finally got the current that was needed.

Soon after this he was graduated and took the apparatus to his own home; apparatus which he himself made and which I had loaned him. He arranged a little laboratory in the shed, continued his investigation and reported to me frequently.

About six months later he came over to my office one morning, and holding out his hollowed hand said: "Professor, I've got it!" There in the palm of his hand lay a dozen little globules of aluminum, the first ever made by the electrolytic process in this country. This was the 23rd of February, 1886. After that he developed his invention to its final great success.

Some further reminiscences of Professor Jewett's, written in 1914, are of great importance in throwing light on the relation of teacher to pupil and to discovery. It will be seen that Jewett inspired, advised, helped and encouraged his pupil Hall, taught him all the chemistry the boy knew and gave him the priceless privilege of a place in the master's private laboratory. Jewett did not make the discovery but he was necessary to it.

Even before he entered college, the subject of extraction of aluminum from its ores had occupied his mind. During his college course, even while engaged in regular chemical studies, he did some investigating on the subject.

At one time, he suggested that he and I should undertake to find a better material than carbon for the fiber in the incandescent lamp. He concluded that tungsten would answer. It was agreed that I should furnish the materials and that he should do the work in my private laboratory. Here he had his own desk, which he continued to use during his senior year. He worked with tungsten compounds for a season and finally found one which we thought might answer the purpose. When a fiber made of this tungsten was subjected to as strong a current as the laboratory afforded it glowed brightly for an instant or two, then snapped asunder. It was planned to take up the subject later, but circumstances would not permit. (Had they stuck to tungsten the tungsten lamp might have arrived twenty years earlier.)

Mr. Hall first tried to extract aluminum from clay by fusing it in a crucible with carbon and chlorate of potash, but nothing came of it. Later he tried to get aluminum from its oxide by fusing with different substances. Toward the end of his college course he finally abandoned altogether the idea of securing aluminum by reduction, and turned his thoughts extensively to electricity as the form of energy to be employed in separating aluminum from its compounds.

In talking the matter over he asked me at one time regarding the compound which could be most readily decomposed by the electric current, knowing that in gold and silver plating the cyanides of those metals were used. I suggested such a compound for aluminum. We soon concluded, however, that this would be impracticable on a large scale, and we next considered the fluoride. Lead dishes were now supplied in which to make these substances, and he worked assiduously for many days in preparing them. When a satisfactory compound was finally made the next step was to prepare an electric battery that would furnish a current strong enough to decompose it. All the battery cells that the laboratory could supply were pressed into service. This battery was then enlarged by additional cells made out of beakers, tumblers, jars, and everything else that ingenuity could devise, all to no purpose, however. The electric current was not strong enough to do the work.

Soon after this Mr. Hall was graduated from college, and in 1886 fitted up a laboratory in a shed at the rear of his father's house on East College Street. Thither he carried the apparatus loaned him from the laboratory, and continued his work, occasionally coming to speak of his progress, and to talk about the difficulties which arose at almost every step of his investigation. These difficulties, however, never quelled his enthusiasm nor disheartened him.

The essential features of Hall's invention may be presented briefly in his own words, spoken on the occasion of the Perkin Medal Award.[1]

I had studied something of thermo-chemistry, and gradually the idea formed itself in my mind that if I could get a solution of alumina in something which contained no water, and in a solvent which was chemically more stable than the alumina, this would probably give a bath from which aluminum could be obtained by electrolysis.

In February, 1886, I began to experiment on this plan. The first thing in which I tried to dissolve alumina for electrolysis was fluorspar, but I found that its fusing point was too high. I next made some magnesium fluoride, but found this also to have a rather high fusing point. I then took some cryolite, and found that it melted easily and in the molten condition dissolved alumina in large proportions. I rigged up a little electric battery—mostly borrowed from my professor of chemistry, Professor Jewett, of Oberlin College, where I had graduated the previous summer. I melted some cryolite in a clay crucible and dissolved alumina in it and passed an electric current through the molten mass for about two hours. When I poured out the melted mass I found no aluminum. Then it occurred to me that the operation might be interfered with by impurities, principally silica, dissolved from the clay crucible. I next made a carbon crucible, enclosed it in a clay crucible, and repeated the experiment with better success. After passing the current for about two hours I poured out the material and found a number of small globules of aluminum. I was then quite sure that I had discovered the process that I was after.

In the summer of 1888, after most discouraging efforts to secure business support of his work, Hall and his patent were taken into association with Captain Roy Hunt and other "capitalists" of extremely modest means as the "Pittsburgh Reduction Company." This name, a few years later, was changed to "The Aluminum Company of America."

Hall's commercial success brought infringement suits by the Cowles Electric Smelting and Aluminum Company of Lockport, N. Y., in 1893. It is to be noted that Hall never entered their employ until *after* his discovery and also that he gave the Cowles Company an option on his process, which they finally rejected. The Cowles people reduced aluminum oxide with carbon in the electric furnace but were forced to use copper to capture the aluminum. This was purely a high temperature reaction, not electrolytic, and produced only a copper-aluminum alloy. The temperature of reduction of aluminum oxide is close to the boiling point of the metal.

Judge Taft, later President Taft, decided in favor of Hall, in the U. S. Circuit Court of Northern Ohio. It was necessary in the trial that the date of Hall's discovery be set before the summer of 1886 and this Professor Jewett was able to do because he remembered clearly that he stood in his private laboratory in the north wing of old Cabinet Hall when the young discoverer rushed in with a few shining buttons in his hand and said "I've got it!" This north wing of Cabinet Hall was torn down in the summer of 1886 to make room for the south wing of the new Peters Hall.

It is time that the world look past the spectacular figure of every genius to find, in his shadowy background, unknown to the public, some inspiring teacher. Unfortunately, the genius may fear that tributes to the old master may detract from his own glory. On the contrary, nothing does a man more credit than gracious acknowledgment of his scholarly debts.

[1] See "The Perkin Medal Award," *J. Ind. Eng. Chem.*, 3, 143–51 (March, 1911).

SCIENTIFIC EVENTS

PROGRAM OF THE AMERICAN WILD LIFE CONFERENCE

Ira N. Gabrielson, newly appointed chief of the U. S. Biological Survey, outlined a proposal for a national program at the recent meeting of the North American Wild Life Conference. It is expected that the program to be worked out by the General Wild Life Federation, the organization formed by the conference, will be based on his suggestions. A summary of his requirements follows:

1. Land for the restoration and use of wild life. The Federal Government has a national responsibility to complete a migratory waterfowl program and, where necessary, to develop primary areas for the preservation of other wild life.

2. Closer cooperation between federal and state agencies. (a) By extending cooperative research and demonstration units now operating in nine states. (b) Federal