EDISON

Scientist and Educator

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THIS IS ONE OF THE THREE HUNDRED AND FIFTY-THREE COPIES PRINTED ESPECIALLY FOR THE CENTENNIAL DINNER HONORING THE BIRTH OF THOMAS A. EDISON

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Some thoughts on Thomas A. Edison one hundred years after his birth by one who knew him well.

EDISON—Scientist and Educator

by WILLIS R. WHITNEY

In selecting this title, I was influenced by words from the recent thoughtful report of the Harvard Committee of experts on *General Education in a Free Society*. Under Problems of Diversity, I read, "It has been said that one of the challenges of our age is to so rouse in students the sense of connection between ideas and day-to-day action that their wills be enlisted for what their minds accept, and for none has this point more importance than for those who see life primarily as action." I would repeat—*life primarily as action.*

From this I was led to reflect on Edison as Scientist and Educator. It seems to me that he somehow caught the spirit of scientific-research-for-service described by Francis Bacon over three centuries ago.

Fortunately, individual education may be largely a self-propelled device. By that oddity we are greatly assisted. Edison saw living itself as "primarily action." He worked through a long, successful life for humanity in general without distinction as to race, color, or creed, but with considerable distinction as to previous conditions of human servitude. He was exceedingly active in chemical and electrical discovery from 1863 to 1931, and his work led to more than a thousand inventions. He was so instantaneously interested and continuously productive that I have wondered if our cowardly conscience did not force us sometimes to overthinking, where native resolution is "indicated." Hamlet said, "Thus the native hue of resolution is sicklied o'er with the pale cast of thought; and enterprises of great pith and moment, with this regard, their currents turn awry, and lose the name of action."

No man has done more successful work in chemistry, physics, and electricity, nor more unsuccessful, than Edison. His failures are educative. This might help youth, though age scarcely needs it. Thus he was educator. Professor Bancroft of Cornell once suggested a publication for failed experiments. As a possible aid to science, no one was sufficiently interested in failures to stop searching for success, so that publication never was born.

Edison was kind to the press. His patents also published his histories, so that anyone who wanted to know could easily learn, even of his failures. He early told of his second chemical lab in the express car which was fired by his combustible stick-phosphorous, just before his lab was fired from the railroad. He learned about phosphorous from that. In several cases, in later years, he or others brought success to his failed plans through new knowledge; for example, his metallic wire filaments for lamps, talking movies on one film, magnetic ore concentration, poured cement houses, etc. He also once said, "The electric locomotive is the *last* word in transportation," when he meant *latest*. When asked in court, "What is Ohm's law?"—he said, "I don't know. It contains essentially the whole of electrical engineering and I'm not familiar with the whole of that subject."

Schenectady probably hears enough about Edison. I can only talk now in hopes that some youngster, or his father, may be listening.

Inventor or Scientist?

First, I want to answer a question asked me by a professor over 50 years ago, and often repeated by others since—"Wasn't Edison a mere inventor and no scientist?" The prof was perhaps a scientist and no inventor. But I have often thought about it, and I have decided that Edison was very much of both. So I ought to explain things.

Union College gave Edison the honorary degree of Doctor of Philosophy when I was ten. Princeton University made him Doctor of Science in 1915. Those things don't make him any more of a scientist than he actually was, but it is a sort of advertisement. But here's some additional data of my own. Entomologists are scientists. They study "bugs." A bug is an "heteropterous-hemipterous insect." Is it any wonder that Edison, who could coin his own words, should attribute internal electrical troubles to *bugs* for short? My dictionary says of electrical *bugs*: "A fault in the working of a multiplex telegraph or in any electrical apparatus." That telegraph was invented by Edison in 1875, and *bugs* electrical were born then. Nowadays electrical bugs are more influential than any other kind. So Edison was an *ento*mologist. But he was also an *ety*mologist (another scientist). Many friends have remarked on his powers with words. After spending 12 million dollars on iron-ore separation, he stopped suddenly, when the competitive Mesaba iron mine was discovered, saying "But I've had a hell of a good time." He once told me of trying to interest British naval experts in experiments against the terribly threatening submarines of 1916. He said, "You know how they feel? They *resent* this war." That seemed to me a fine use of a word. He was enough of an etymologist to have used billingsgate. He softened it for my ears. He was for action usually and not words. 'Tis said that he first introduced the use of *hello* in telephone conversation.

A scientist is one who appreciates creation; its apparent value to man is thereby increased or appreciated. As there is no limit to creat ion,so there are many kinds of scientists. The botanist who spends an active life collecting and classifying his herbarium is a scientist (even if we can never eat any of his studied plants). The Mendels and Morgans who devote their lives to heredity in garden-peas or in fruit-flies are well-recognized scientists. I like to call the scientist a creation-appreciator. Some of them, like Edison (besides greatly enjoying their searches among the assets of creation), may be dubbed "creators" themselves; but their work is far from pure creating. They only rearrange things already created and by principles established at the beginning.

Beyond our food-urge there is something in men called the sense of beauty: awe-at-order, etc. It is that appreciation which drives one man to study trees while another sees the beauty in rocks and rills.

Edison found his most interesting studies among new possibilities in utilities of all sorts. So I say he was an appreciator of creation, and as usual in such studies, creation itself was clarified by the process. This suggests, too, that we shall never exhaust natural possibilities because the laws and assets of creation are infinite. We can never know except in part.

He was scientist for appreciating so well matter, space and, particularly, time (but he wouldn't have a time-clock about). He was no Einstein, but our world needs both types.

"Time Is of the Essence"

He had a hunch when a boy that "time was of the essence." This may have come from his first work in telegraphy, but he was always saying it. A telegrapher, MacIntosh, whose boy Edison saved from a railroad accident, taught him telegraphy when he was 15. He never lost his interest in direct current after that. If alive now, he would probably not have attended a banquet in his honor. He would have been too busy. He watched other scientists teach, while his own ears were closed, but he educated by his actions. Here's an illustration:

Tom Robins, of the Robins Conveyor Belt Company, told me of his contacts with Edison (continuous from 1891–1931). The magnetic iron ores of New Jersey were being successfully treated in a large plant and with gigantic effort. Edison was

devoting night-and-day work to it. When too exhausted, the two took turns in work and rest. They took naps on a pile of fine, clean anthracite coal in the boiler house. Tons of ore, concentrates, and waste were being carried through the plant on belts, which were short-lived.

Robins succeeded in devising a long-life conveyor belt just as the plant was finally shut down. As soon as the discovery of the rich Mesaba iron deposit was announced, Edison immediately stopped his futile concentration work, and being told that he had spent twelve million dollars, said at once—as I have remarked before—"Well, I've had a hell of a good time."

The next day after his shutdown, Edison said to his construction expert, Batchelor: "This boy (Robins) has the making of a business in his belt-conveyor. Why don't you take him up to the people at Wilkesbarre, who have been selling us coal, and tell them about it? It's a lot better stuff than they've been using as conveyors."

Robins says that after being told by the engineer, "coal would cut his belts to pieces," it was a long time before he supplied his conveyors to coal mines. They are common now, but he adds—"I mention this incident to illustrate Mr. Edison's kindness; for within a few minutes after he had learned that his investment and years of hard work had become an almost total loss, he was friendly enough to think of my interest and to try to find for me a customer who would take the place of his own abandoned concern."

The Cement Producer

Even this great failure with iron-ores gave him the mental grounds on which he at once started building one of the largest cement plants in the world. His rock-crusher experience, air-screening, belt-conveyors, briquetting and roasting suggested to him scientific experiments for cement, and he understood the great permanency of cement as evinced in ancient structures. He, being chemist, knew about exact compositions of rock and lime-mix necessary, so he refined mixing. He also doubled the fineness of the powder of his mix, both before and after its calcination, and he insisted on new rotating kilns three times longer than usual. There are scores of things in this work which were importantly novel. He was soon the fifth largest cement producer in the country.

All this led him naturally to want to pour complete cement houses in one operation, and it seemed logical and perhaps later—as at present—quite exciting. But he was ahead of his time. Nowadays when portable rotary mixers of cement are common in our streets, and when large new buildings are poured a floor at a time, with all piping and wiring already in place, his dream does not seem so "remote."

I think that when we of this "reducing" world have been brought sufficiently close together by new methods of economical rapid transportation for men and materials; when the aims of different peoples are clarified by arts and literature, by movies, radio, and television; and when the natural actions and errors of isolated folk have been averaged and counterbalanced by more healthy mass-psychology such as we see tested in many small communities; and when at last world-peace is actually under way, then the world of Edison as world-scientist and educator will be recognized as a highly contributing factor. So I remind you that from telegraph to telephone, from movies to television, from lamps to generators and so to central power stations, with all the gadgets already being appreciated, Edison's active mind and hand performed more of the work than those of any other one person. It is a healthy sign of such science that soon the world adopts its services, because they fit the needs of all sorts of humanity.

That in turn is an education to me and a hint that the foundations of religion are a service to folks.

Using the Sixth Sense

I am anxious to analyze the case of an Edison for its educational value. Whence his powers? We were taught about man's five senses. There are more. Let's call them hearing, seeing, smelling, tasting, feeling and thinking (six). Maybe there's sense in *talking*, but think of the six.

Each one of us handles each of his senses differently. But with all of us and each of them, any one of us may increase the sensitivity of all his senses. That is clearest in case of thinking. To analyze further: assume that each of us is merely the sum of all his recorded sensations. No two of us will be alike because we've had such different sensations, multiplied by our various thinking and remembering, too. What we recall or know at the moment is exceedingly small compared with what is temporarily stored away, forgotten. Our conscious is far smaller than our subconscious. From the combination must come our instincts, imaginings, hunches, sparks, and actions. Remember that Edison could not hear. Did he make up the deficiency by more or better thinking? Sir Wm. Osler liked the words of Dryden: "Knowledge and wisdom, far from being one, have ofttimes no connection. Knowledge dwells in *heads* replete with thoughts of other men. Wisdom in *minds* attentive to their *own.*" That reminds me of Edison. Thinking must be a sense.

The fun of this analysis-game can only be gotten by playing it oneself. So think of yourself and of an Edison as being sums of all recorded sensations. Pretty complex, isn't it? But that might explain why no two of us are alike, even under identical environment, because we think differently. Our subconscious works without rest, like the circulation of blood. So anyone may waken day or night with a new hunch. I think of "hunch" as being an urge, reflex, impulse, spark, or starter. Scientists often report sudden surprises at their own unexpected problem-solution which unsolved had rattled around in their mind among old records. Their subconscious actions solved it, but they had first to possess the stored and forgotten records.

Following Hunches

In spite of centuries of world-wide work on cement-kilns, Edison felt sure he could make a better, new, continuous kiln which would have four times the capacity of any then known. His success in this case is now interesting history, and those long, rotating cement kilns are still in use. But from his beginning I can trace his natural hunches. Anyone could do this better by thinking of all his inventions. Start with the telegraph as he did. Of course, he had earlier starts galore, and he is not an average sample. But that telegraph instrument operated on a battery. So when Bell's telephone got into his mind, Edison saw that the power of the voice was the source of the feeble current Bell employed. It could only reach distances dependent on voice energy. But he had visions of amplification of the power by his telegraph-battery energy. So his "talking telegraph" was invented. The idea is still basic in our telephones. Let's call the vision or hunch "visionary," but it was a spark-plug to his actions. It isn't difficult to trace paths which he may have taken for those hunches which one by one resulted from former sense-experiences. They seem to show an exponential increase, too. He soon had more hunches than he could ever test out: multiple telegraphy, printing telegraphy, chemical telegraphs, acoustic telegraphs, telephones, speaking machines, phonographs, carbon telephones, etc. They all show the same interconnections. But all this was before 1880. Think of his "subconscious" in the next 20 years. He had an infinite stock of direct (or battery) current in his make-up. His lamps led him to making machines to supply what was

too much energy for batteries. Yet he never lost interest in batteries—primary or storage. In later years his alkali-batteries drove autos through our streets. Try this on, by, and for, yourself. I have only indicated what I mean. Time and space are always too short for "talks" but about right for "works."

When I realize that Edison was having uninterrupted fun all his long and useful life, I am at least anxious not to stand in the way of youngsters who might follow his methods. Of course, he would have denied that he was working for humanity; work seemed to be his pleasure. How did he get that way? He started at scratch as an active kid. The rest of it was natural, too.

Edison was educating himself as a boy in a laboratory in the cellar. His electrographic vote-recorder was awarded a patent the year I was born. Thereafter he always wanted to make new and useful discoveries. He did not have to seek recognition by publishing his work in scientific periodicals, though that has been a good world-wide method for spread of science for centuries. At its inception our government devised scientific encouragement by the patent method. This was intended to secure publication of novelty after the inventor had been financially rewarded. By this method, Edison published over a thousand inventions. His financial rewards encouraged him continually. It was not because he was poor or ignorant. He was never either. But he liked constructive activity. Interest in locomotives led to his getting a permit to sell papers on trains when he was 12 years old, but he soon hired boys to do this, while he installed a laboratory in the baggage car.

Here I like to reverse the order and briefly hark back in reverie from some of his latest work. I think his recent endeavors, successes, and failures are as valuable for our education as his early and less-complex life.

I came closest to him personally after he was made president of the Naval Consulting Board in 1915. Through his energetic efforts, Congress was induced in 1916 to start Naval Research by an appropriation of a million dollars for a new laboratory. While this laboratory was slow in getting under way, it was very useful and important to our Navy in the recent war. Among other things, the under-water sound reflecting and detecting device of Dr. H. C. Hayes was developed there; and more important still the original work of Dr. A. H. Taylor was started there years ago with what became "radar," a very useful reflecting radio device for the latest war. It will prove indispensable to aeronautics.

Listening for Submarines

How many other scientists, if devoid of hearing as Edison was, would insist on going to sea in a yacht, as he did on the *Sachem*, in order to study detection of submarines? No one then could hear, see, taste, smell, or feel submarines under water. Edison had that sixth sense I referred to. He thought that ears could be rented and possibly mechanically made or electrically contrived after a vigorous start. He was using his thinker, too, when he induced his wife to go along. I know that besides a submarine gun he also made 20 other recorded suggestions related to submarine problems, and he worked all the time. He even skipped board meetings.

I get a great "kick" even now in reviewing Edison's scientific method as chemist. In 1895, Roentgen had shown the X ray's photographic possibilities. Edison wanted to get a simple, cheap method of seeing the bone-shadows with his own eyes. He set to work at once. His fluoroscope was the result. He decided that the best way to find cheap, highly luminous materials was to test all possible salts. I know no better way yet. The

peculiar property of fluorescence is quite complicated and not well analyzed. One could not safely predict good experimental materials. For speed and efficiency Edison put four chemists on the job of making different substances, and soon he had 8000 salts. All were tested. Many were fluorescent, but calcium tungstate was most satisfactory. It is still used in the common fluoroscopes. And here again, he "was born too early"; or at least he left a bit undone, for later ambitious, inquisitive people. He actually stuck some of his new fluorescent salt onto the inner surface of an X-ray tube, and found that there were a few candlepower of light available. He started to make fluorescent lamps that way. He found that owing to the biological effects of the X rays the lamps would be too dangerous. Nearly a half century later quite harmless, invisible ultraviolet rays of the mercury spectrum were used to make luminescent the fluoroscopic salts in our long industrial lighting lamps. How Edison would have enjoyed that development. It was a case of using invisible rays—slightly different from X rays—which amplify themselves through "phosphors" into our most efficient illuminants.

He always acted with certainty on the principle that anything conceivable could be accomplished after thinking about it, by using properly a little electricity. That is amplification. That principle applies to all his hunches. It was merely a question of application of mental and physical effort. His only trouble lay in finding those subjects having the greatest immediate usefulness. Our long-distance telephone conversations are *amplified* by station-power—"triggered," we say—by the vibratory nature of our voice energies.

Today, in cases of world-wide radio-broadcasting, the total amplification is infinitely greater and correspondingly important. A broadcaster puts his voice energy into a microphone. If he hollered from the top of an antenna, he wouldn't get far. Amplified electrically, his energy spreads away through all space from that antenna. Still he is transmitting next to nothing with little electric ripples on it.

This radiation is dissipated and diluted down beyond conception—but not reception—by the infinitude of space it covers. Your receiving set picks out of the local space a mere sample of this invisible moonlight with its near-nothing energy. This doesn't amount to the millionth part of an imaginary flea-bite. A fly scratching his wing would do more work than all the energy-reception you get from outside into your radio in a year. But your own power circuit again amplifies successfully that part of the multiplex menagerie of waves-electrical, which by twisting a dial, you want to hear. Electrical amplification is a remarkable thing.

The "Edison Effect" in Radio

Isn't it odd that Edison disclosed the basic principle of radio amplification before 1884? This has always been called the *Edison effect.* It is as though he had put his carbon-metal phone-transmitter under some powerful electric microscope in vacuo to see how it worked. What he did was to put a metal plate into an evacuated carbon incandescent lamp. Filament and plate were connected separately to suitable current-measuring devices. Thus he learned that at high temperatures of the filament, there was a current going from the filament to the metal plate, but only in one direction and that, too, the wrong one. This experiment created great scientific interest at the time. The electronic conceptions were delayed for many years. But now we visualize a negative electron current from a heated source, a thermo-electronic, one-way current. Radio is now built on this idea.

It is important to point out that his interest in chemistry commenced in a cellar before the Civil War, set him going in the manufacture of many organic chemicals as the first war

with Germany threatened American supplies. His commercial carbolic acid plant was producing at the rate of a ton a day in about one month after its start. This led also to his successful manufacture of other chemicals such as benzol, napthalene, aniline, etc. One of his typical researches was the study of common weeds as possible sources of rubber. Who else would have done that? He was at it until he died. Everyone knew that rubber came naturally from trees and plants, but only in foreign countries. Who could tell what a research might yield? If some plant-sap held a little rubber (as many do) could they be improved, as corn and wheat were? Perhaps some of the saps would yield material which further chemistry might perfect. Rubber is rather a "state" among organic compounds than a definite chemical individual molecule. Plants with promise might be crossed with others "with power," and commercial rubber be obtained. His friend Burbank may have agreed to such a plan. Anyway it is certain that he enjoyed the chase. Perhaps a little salt of some kind could "rubberize" some plant-product, or a bit of what Teddy Roosevelt called "pep" might be put into a "near-rubber." He well knew that organic synthesis had been a hobby of German research men for years, and it was only natural that pure synthetic rubber would be first produced by them. But he knew what he himself might attempt, so he tried it with vigor and never gave up.

Doing the Impossible

I saw my first Edison lamp in a drug-store window about 1880. It operated from a battery. The only wiring then in use was a telegraph circuit. To subdivide electricity so it would operate simultaneously lights of different candlepower, and in various places, seemed impossible. The few existing arc-lamps operated in series. When one was turned off all the others of the circuit went off too. The English scientist Tyndal said he preferred "that the problem of subdividing the current should be in Edison's hands rather than his."

Scientific volumes might be written about his lamp-filament, his vacuum studies, and the sealed-off lamp. I will not start one now, but I am interested in his appreciation of contiguous, infinite creation "as-is." He merely amplified, through his hunches (and by simple work) some of the possibilities always at hand. To him, extensive research on carbon filaments seemed necessary after he had tested his earlier metallic filaments. Platinum, the best guess then available, was not good enough. His final graphite-coated carbon filament was a wonder . . . too hard to describe here. Osmium, tantalum, and tungsten wires were far in the future.

It is almost criminal to pass quickly over his enormous experimental work necessary for providing electricity under control to city buildings. This led to the first central electrical power station in New York in '82. But I want to emphasize his persistent process of mental amplification. It was natural to Edison. One step at a time he built his "subconscious" from which his countless amplifications were drawn. He grew mentally with one foot on the ground, and he kept getting taller and more powerful. Lincoln said "a man's legs should reach to the ground," but perhaps to be about the right height his head must reach up into the upper air.

So I call Edison a scientist and educator.