RESEARCH AND INDUSTRY

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Only five generations ago, the whole average family, men women and children labored fourteen hours per day for the bare necessities of life. The shelter was a hovel, scarcely comparable to a modern poultry house. The clothing was scanty and without elegance. The diet consisted of black bread and sorghum. There were vermin, squalor and poverty. There was no luxury. Now in the average family, adults only work seven hours per day for comfortable homes, beautiful clothes, nutritious food and some luxuries. Even the unskilled laborer today enjoys the luxury of the automobile, the motion picture theater and the radio concerts. How has this change been brought about? The obvious answer is by scientific research and the application of scientific knowledge gained through research.

In speakng to an audience of this kind I know it is not necessary to recite to you our sad predicament were we suddenly deprived of all our scientific inventions and machinery: no steam engine, no pump, no telephone, no cotton gin, no musical instrument. But this is not the greatest calamity that could befall us; for with our present mental attitude, with our present scientific curiosity, our desire for research, we would soon produce other inventions and other machines, possibly better than those we now have. A much greater calamity would be to have the race suddenly deprived of its scientific curiosity. Don't scold your young son when he attacks the varnish on the library table with his jack knife to see how deep it is. When he goes after the electric fan or the alarm clock with hammer and tongs to see what makes "the wheels go round." Do not reprove him in such a way as to ruthlessly kill his spirit of investigation. This scientific curiosity when nourished, cultivated and wisely guided may lead him to a great scientific discovery.

Those who are accustomed to grow eloquent in rhetorical orations on occasions like this are wont to eulogize science for the gift of the steam engine (the "iron-horse"), the reaper, the electric light, the automobile, the airplane aand radio, as if these were the greatest blessings which science has conferred upon the human race. Not so. The greatest blessing science has bestowed upon the human race is the development of our minds. We are not so credulous and gullible as our forefathers were.

We are not drifted about by every wind of doctrine. Our scientific curiosity has been aroused and this makes it, to say the least, less painful to accept new ideas and new methods.

Time was when research was not popular. Socrates was forced to drink the poison hemlock because his ideas differed from those of the economists of his day. Death alone saved Copernicus from the persecutions meted out to his followers because their ideas of astronomy did not accord with the old Ptolmaic ideas of celestial mechanics, which made our little earth the center of the universe and reduced the magnificent stars to mere lanterns, cared for by angels and hung up in the sky at night to guide the wandering footsteps of man. On the public square at Florence, Italy, now stands a beautiful monument which marks the very spot where Giordano was burned at the stake in 1600 because of his scientific investigation. Galileo was persecuted by the inquisition because he said the earth moves. Now see how times have changed. Research become so popular that even the farm club boys and girls who weigh their pigs and record the daily gain or count the bolls of cotton on a single plant are proud to be enrolled in the great and rapidly growing army of scientific investigators. The very statements for which Galileo was persecuted are now accepted by all adults and taught to all school children. When Galileo released the large and small cannon balls at the top of the leaning tower of Pisa, the antagonistic crowd seeing the balls descend with the same speed, shook its head and said, "The young fellow has bewitched us. He is a sorcerer." Nevertheless that simultaneous thud of those two cannon balls sounded the death knell of the old method of teaching science (viz: by dogma) and ushered in the new method of experimentation. The human race was then taking one of its first lessons in gaining knowledge through experiment and as stated before this ability to think for ourselves and to acquire knowledge through our own experimentation is the greatest blessings science has conferred upon the human race. Much as we enjoy luxuries, it is still true that mental development is more to be desired than material benefit.

Immediately following Galileo was Sir Isaac Newton. Newton's birth occurred almost exactly at the time of Galileo's death and it appears that Newton was to carry forward the work of Galileo. At the age of nineteen he discovered the binomial theorem with which students of algebra are still struggling. Later he invented calculus. In developing his universal law of gravitation he formulated the laws of motion known by his name. These laws are the foundation of all engineering and Newton was

encouraged to state and publish these laws only after testing them by observations made on the moon and other heavenly bodies. The average layman will have nothing to do with experiments on the moon. He wants something practical. Helium which is sufficiently practical to make the dirigible airship a success, as its name implies, was discovered on the sun.

This reminds me to say a few words concerning the very intimate relation between "theory and practice." In our present industrial system which depends entirely upon the application of science, we must hawe two groups of persons. One we may call the industrial group whose business it is to pay dividends on capital invested and the other, sometimes called the scholars, whose business it is to solve the problems of research so that we shall have a science to be applied. It is obvious that we can not have applied science until we first have science. Unfortunately these two groups are sometimes thought to be aantgonistic. We hear too much of the alleged conflict between theory and practice. I have heard an otherwise good teacher answer a student's question with the expression. "Theoretically yes, practically no." Sound theory must always agree with good practice. If practice and theory do not check it is time to examine both and revise one or both.

The correct relation between theory and practice is aptly set forth in the following story which one often hears on the campus of Johns Hopkins University and which may be found in Michael Pupin's excellent book "From Immigrant to Inventor." When the great hydro-electric plant had been erected at Niagara Falls it failed to operate. Great sums of money had been invested upon which no dividends could be paid. Engineer after engineer had tried his hand at the solution of the problem and still the great dynamos failed to function. Finally the problem was turned over to Dr. Henry A. Rowland, then a young man, head of Physics at Johns Hopkins University. After much thought and labor Rowland made his report to the board of directors. The company engineers were present and one sought to discredit Rowland's report by pompously stating that "The young man's theory sounds well but the trouble is his theory doesn't agree with practice." Rowland was instantly ready with the reply "If your practice does not agree with my theory, then shame on your practice." The board aaccepted Rowland's report, made the proposed changes and the plant has been working efficiently ever since. The rest of the story is interesting even though it is not germane to the point in question. Rowland asked one hundred thousand dollars for his services. The board refused

to pay and during the lawsuit which followed one of the defense attorneys thought to embarass Rowland by asking: "Who is the greatest authority on electricity?" Rowland answered: "I am." As he walked from the court room with his friend and colleague he was reminded that such an answer was not in keeping with his usual modesty. Rowland answered: "I thought of that but you must remember I was on the witness stand. I had to tell the truth."

Formerly all research was done by the college or university professor at such time as could be spared from his teaching schedule and often with very meager equipment. By the labors of these men discoveries were made, methods devised, principles established and laws formulated. These laws, principles and discoveries were handed down or passed on to the inventor and the manufacturer who not infrequently reaped rich rewards while the professor who made these inventions possible kept on wearing his old clothes.

During the last two decades the tendency has been to have more and more research done in the laboratories of big business and manufacturing enterprises. It is a satisfaction to note that, since the advent of researach in the laboratories of the big industries, research workers are better paid. That "teachers are poorly paid" is a statement that has become almost trite, but formerly research men were paid even less than teachers. When recearch was done on time borrowed from the teaching schedule, the research worker received no compensation except that of promotion. As soon as his work began to product results, it attracted the attention of administrators who "promoted" the research man to some executive position the duties of which greatly interfered with his research. This procedure is obviously as uneconomical as killing the goose that lays the golden egg and yet this is exactly what has happened recently in the field of physics alone in at least three of the leading universities of the United States. This process may be a financial gain to the individual but it is not good for the development of physics. We cannot censure these men for accepting promotion into executive positions with increased salary. Compensation for original investigation like that for teaching is far too meager. It is not commensurate with the results produced. The great Faraday received fifteen hundred dollars per year and he lived in a simple little cottage, a present from the queen. Even today, as a scientist, one may not hope to earn more than ten thousand per year while the large majority of scientific workers count themselves fortunate if they receive one-half to one-fifth of that amount.

Public opinion is that the labor of the scientist is not so valuable as that of the business man. It is said that the great Willard Gibbs drove the carriage for his sister when she went calling because her husband was a business man who could not spare the time. Scientific opinion is that no business man's time was more valuable than that of the illustrious Gibbs.

What does industry or business owe to science? The obvious answer is everything. What could General Motors Company or Ford Motor Company do without the laws of the expansion of gases and the laws of thermodynamics? What could General Electric Company or Westinghouse Company do without Henry's and Faraday's discoveries in induced currents? Our whole industriaal system rests upon the discoveries of scientific research. Anyone, not acquainted with this fact, who will spend a day in an oil field or a refinery such as that of the Marland plant at Ponca City will be astonished at the numerous applications of physics and chemistry. The automobile business rests upon discoveries in mechanics, and heat. The motion picture business (now one of the largest) rests upon research in mechanics and ight; the radio business upon research in radiation and so on. Each of our important industries is directly traceable to some piece of scientific research.

History seems to indicate that the more important the discovery the longer it must await to be made the basis of a big industry. Henry and Faraday were working with induced currents as early as 1830. The dynamo did not become a commercial commodity until more than a half century later. Hertz discovered electric waves in 1888; in a comparatively short time signals were sent across the Atlantic Ocean and the radio business became one of our greatest industries.

Perhaps there is no field which has attracted the attention of so many workers as the field of agriculture. Agriculture is not a science. It is a business which must make a vigorous application of all sciences—chemistry, physics and biology, including all its varied branches of botany, zoology, entomology, bacteriology and so on. Agriculture thus becomes an art. Indeed it is already one of the fine arts which includes in its possibilities the bringing into existence of new fruits and flowers, new grains and grasses which are today not dreamed of. These new varieties will have drought resisting and disease resisting tendencies. When these discoveries shall have been made, then truly will "the desert blossom as a rose."

How is all this to be accomplished? The answer is by scientific research. We must have education of the masses up to the

point where the common laborer will be intelligent enough to use the improved methods already developed by scientific investigators but we must not stop there: we must have that advanced education which is absolutely necessary in the training of research men.

In a gathering of this kind in which perhaps a majority of the members are not actively engaged in research, it may be well to point out that there are methods of making contributions to science other than through the medium of research. I refer to practicing scientific principles and disseminating the knowledge gained through research. Except for its effect upon the investigator himself, research is of little value until it is popularized, disseminated and assimilated by the people. In this task of popularizing, disseminating and assimilatng scientific discoveries so that they may be put into practice we may all find plenty to do, even though our lack of leisure and equipment may prevent zealous research.

There is much to do in combating superstition which is always an enemy of science. It is pitiable to see a college student stop his car, turn and drive around the block because a black cat ran across the road ahead of him. Did any of you ever refuse to sit at a dinner table because with you the number of diners would be thirteen? D'd you ever refuse to sleep in berth twenty-three in the pullman or occupy room twenty-three in the hotel? The great state of California is besieged with requests for automobile license numbers which do not contain the digits one, two and three so arranged as to give thirteen or twenty-three.

Scientific research carried on by the weather bureau more than a quarter of a century ago showed that the alleged gulf stream and equinoctial storms are myths, and still we hear teachers, even college teachers, describing and teaching equinoctial storms. In walking only two city blocks with the daughter of a college professor, I heard her say "If it rains on Monday is must rain three days that week." "Friday is always the fairest or the foulest" and "If it rains on Easter Sunday it must rain the seven following Sundays." We still plant the potatoes and wean the calves according to certain phases of the moon, and pay good money to the fortune teller and the longe range weather forecaster even though science has shown again and again that these practices are without foundation.

Now all these superstitious myths are diametrically opposed to science and it becomes the duty of every lover of science to do his part in eliminating them. How san a teacher teach real

science to one whose mind is already saturated with these superstitions? One can not acquire the scientific spirit until he has put aside these fallacies.

The great medical schools of our country, exemplified by the Johns Hopkins and the Harvard medical schools have accomplished almost the miraculous. Yet in the very success of these institutions lies a danger. These successes are so marvelous that all sorts of quacks are able to practice their quackeries upon a public, rendered credulous by the skill and patience of the real investigator. Did you ever swallow a pill which you purchased from a pedler at the county fair, to relieve an imaginary pain caused by an imaginary ailment? If so you were working against the interest of science. You should not do it again. It is a bad habit.

Now in conclusion let us look at the other side of the question and ask what does research owe to industry. Again the obvious answer is "everything." Research laboratories are built, equipped and supported by taxes and dividends paid by the manufacturer and the business man. Even the college professor and his family must be fed, clothed and sheltered. These funds come of course from business and industry. Again it it were not for the possibility of the application of scientific discoveries to industry a considerable portion of the interest of the investigator would be lost. Hence while it is true that industry cannot prosper without resarch, it is equally true that research cannot long continue to thrive without both the financial aid and the spiritual encouragement of industry. The time has passed to praise either science or industry to the detriment of the other. These are no longer competitors. They are partners. The age of competition has passed. This is the age of combination and cooperation. Research and industry are dove-tailed each into the other. And so it appears that science is teaching the human race, perhaps more effectively than any other agency what Dickens called the eternal dove-tailedness of things.