PRESIDENTIAL ADDRESS.

THE INNOCENCE AND GUILT OF SCIENCE.

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The Ohio Academy of Science is now gathered for its forty-third annual meeting. If we may break away from its seriousness for the moment we may facetiously doff the present dinner occasion as its forty-third birthday party. At a time when an essentially unavoidable epidemic of township, municipal, and institutional centenaries is being celebrated, a mere 43 years makes our organization seem scarcely more than adolescent. This need not make us apologetic, however; quite otherwise, for no publicist, or other megaphone-manipulator of obvious facts fails to re-announce the well-worn doctrine that the hope of civilization is in the hands of youth. We confidently assert that the 143rd annual Academy meeting will be magnificent, far more consequential than the present occasion!

Personally, I cannot avoid wondering, very sympathetically, what subject upon which to address his audience the 143rd Academy president may select. On second thought, however, it is quite possible, probably probable, that wisdom and courage will have accumulated by that time to a degree resulting in the forbidding of this recurring speech imposition! But, unhappily for you, and for me, that date is too far in the future to get any amendment into control of the present occasion. We are both "in for it," for the next several minutes: you must swallow the "bitter pill"—and bravely attempt to keep lower jaws from dropping, as you do so, or ears from drooping!

In the earlier days, as our records show, when there was only a section devoted to biological subjects, an officer could frame up something to say along the special line of that interest. Gradually, as the accretion-like growth of the Academy has proceeded, the variety of sciences now gathered under its banner has so increased that a specialized subject is practically sure to bore a majority of our total group; hence, the Academy audience, gathered for an optional dinner, but consequently in essentially compulsory attendance on the speech following,

demands discussion of a comprehensive topic, one applying to all branches of science. I do not know when such a problem has been more successfully solved than it was by your last year's president, Professor Alpheas F. Smith. My temptation was to just read his address to you, again, this evening; we all would have been the gainers.

After not a little deliberation, mostly during last summer, I decided to adopt the subject I have, "The Innocence and Guilt of Science." For a long time I had felt repeatedly peeved, when, on occasion, in reading and in conversation, the spirit and service of science was subjected to a process of mud-throwing, and other shallow-minded abuse: everyone of this audience has felt similar resentment. Then, as the autumn came on, the newly invented words, "technocracy," "technocrat" and their ilk were foisted on an unprepared public, and the noise of their machinery became so deafening and offensive that my title was abandoned—permanently— as I thought. After a while, however—and as you know—the engineering departments at Columbia, and their collaborators, engaged in a wholly worth-while and admirable "Energy-Survey," found they had been caught unawares, sucked into a vortex; in other words, were being "strung" by a strangely clever statistical legerdemainist; they escaped from his clutches by firing him; Simeon Strunsky and others came to the rescue as meditators between the "Energy-Survey" and the public—and the situation was saved, or at least relieved. In my own predicament, as the term "technocracy" became less frequent and nauseating, courage gradually returned, my partial deliberations about the "innocence of science" were pulled out of the ashes, and are now being stuffed into your ears.

Before going further, let me undeceive anyone who imagines that science really needs any defense, or that I think so. The fact is, however, that we are often so illogical and temporarily confused that a kind of misunderstanding, or misconception of things creeps into our analysis of them. The speaker does not nurse the idea that it lies within the scope of his ability to "make the crooked ways straight, and the rough places plain." Hard work or thought after a hearty banquet like this is inadvisable (I take refuge in that theory), so I only aspire to augment your gastric satisfaction by offering a sort of after-dinner mint of not too objectionable a flavor.

The actual subject matter of science was present and has

descended to us from an infinitely remote past, of course. "Before the mountains were brought forth, or ever thou hads't formed the earth and the world, even from everlasting to everlasting," the elements of force, and of substance (if there is any such thing) were pursuing a behavior, a relationship of cause and effect, en masse, and as electrons and the like, which we little men are still puzzling over and as yet do not fathom or understand except in the most fractional way.

Science, as a *body of observed fact*, has also been in existence, "on the road," as we say, a very long time. In the sense in which the term is generally used, however, it can hardly be dated back to a beginning antedating the arrival of more-or-less intelligent man; for, like sound, it does not exist save as an experience of man, to which the term is applied. Needless to say, the *facts of nature*, all its bases and laws as we call them, have existed and been in operation ever since eternity began, if we may use that paradoxical phrase; while *Science*, which etymologically implies "things known," or knowledge, presupposes a knower; and any critically recognized, and organized, and appreciated body of facts we believe to be the possession and experience of only the one genus, Homo. Perhaps so far as evidence goes, we should concede to the Neanderthalers the credit for being the earliest observers, the earliest formulators of scientific knowledge, and the earliest ones to use what we think of as "applied Science;" in other words, they were the first "technocrats." The scientists among them recognized the seasons, no doubt, correlated with differing lengths of day and night or the dropping of leaves from deciduous trees as the frosts came on; the fact of gravity as revealed by weight of rocks and limbs and the running down hill of water; they knew the cleavage qualities of flint stones; the principles of balance and symmetry in their arrows and spears; they must have known much of anatomy of the animals they killed and ate; and doubtless something of the therapeutic values of the bark and leaves of particular kinds of trees, or herbs.

From still another angle, science, as *organized knowledge*, is thought of as emerging from the limbo of a less remote past, i. e., Homo, or Homines, made deductions, or practical applications along lines which have definitely come down to us in recorded language. Approximately, astronomy dates from Thales (650 B. C.?), who determined the length of the year and studied eclipses, and Anaximander (611 B. C.) who invented

the sun-dial. Anaximander is also one of the fathers of geography, in that he made a map of the world, however erroneous it was. He also took a hand at biological philosophy and framed up a "theory" of evolution. Pythagoras, also of the 6th century, B. C., reasoned the earth to be spherical, and, as a related subject, formulated many important mathematical theorems. Xenophanes, a contemporary of Pythagoras, was one of the earliest palaeontologists. Leucippus, whose dates are obscure but probably in the fifth century B. C., practically comprehended the atomic theory. Hippocrates the 2nd (460 B. C.) was the first real pathologist. Plato (429 B. C.) was one of the earliest to see the overlap of natural science on philosophy, and his pupil, Aristotle (384 B. C.) was the father of zoology, though he should also be accorded paternal relation especially to astronomy, including meteorology. Theophrastus, Aristotle's pupil, with his description of more than 500 species of plants, merits being called the "pater noster" of botany, while Archimedes, of the third century, B. C., the great student of inclined planes and thus the inventor of the screw, is one of the earliest devotees of mechanics.

Now, I have cited the above samples from the archives of scientific history purposely. Ah, those were the "good old days," when the motive of men who dealt with nature was pure and undefiled by any thought of the practical applications, the selling values of their discoveries, the temptation to take out patents, the dreams of recognition. Yes, those men, along with their contemporaries and followers for a few centuries, were real scientists: their interest was spontaneous, they were impelled by no inferior motives; their results were accepted as interesting, and, while not unchallenged, they were respected as scholars, as contributors to the general welfare of mankind. They studied Nature for its own sake; yes, "Those were the good old days!" I remind you of these men, their work and their place in the history of science because such reference furnishes a basis for a first articulation with the subject chosen for this talk.

No field of intellectual interest and endeavor has been subjected to such a deluge of earnest opprobrium and unqualified reproach, especially during the last fifteen years, as has science. At its feet has been laid the major responsibility for most of the present misery of mankind the world over. It is blamed for the very possibility of war, in large

measure, of course, because of the instruments of war—mechanical, chemical, bacteriological, and for the consequent endless complexity of international relations, indebtedness, and the uncertain character of the centuries ahead. It is blamed for the possibility of easy and rapid production, and thus of over-production; for the consequent unemployment situation and its accompanying human misery and staggering sociological problems; for the one-time disruption of the horse-breeding, wagon, and coach industries; later for the dismantling of unnumbered thousands of miles of electric railways, and now for the actual or approaching bankruptcy of our steam-railway systems. Science is held accountable for the relative ruin of the wool industry, the silk industry—while the recent revelation of the inherent possibilities in the nettle is proclaimed as fatal to half the total textile industry of the world. Large sheaves of further verdicts have been voted by the jury of our fellow-men, who have been bamboozled into thinking that the newly-born cult of technocrats is identical with the quiet associates in scientific research. This charge such a group as the Ohio Academy of Science, and all other similar organizations, as such or as individuals, vigorously resents. In saying this the defense is made, of course, on behalf of science as such, i. e., *pure science*, and on behalf of those who work in the spirit of Thales, and Hippocrates, and Leucippus: there is not in mind the application of scientifically established facts. True scientists "do not simply handle phenomena and describe or utilize them for some practical purpose, but explain them and show their correlations." This distinction has been further well pointed out by the late Thomas Hunt Montgomery.[1] He says:

"There is an enormous mental difference between the pure technologist and the pure scientist. We do not wish to imply, for instance, that the mind of the pure mathematician is higher than the mind of the engineer, for they are rather complemental; but the former is a scientist and the latter is not, in that the former seeks interpretations and the latter applications. A physicist is scientific so long as he keeps in mind explanations, but not when he simply constructs apparatus. In the same way there are two very different kinds of men interested in the microscope: one constructs it, but he is not a

[1]T. H. Montgomery: "The Aesthetic Element in Scientific Thought." Annual address by President, Texas Academy of Science, 1905.

scientist no matter how excellent a technician he may be; the scientist is he who patiently reasons and imagines with his eye at the ocular. There is an enormous difference between the technical expert and the scientific interpreter, for the first builds apparatus, makes use of phenomena; while the second tries to relate the phenomena and bring them together into certain broad generalizations. If there is a particular group which may be sharply defined, it is the group of minds interested in mechanical constructions. But it is an egregious error to rank these and scientists together: they are rather to be considered as entirely divergent both in work and aims. Scientists need to use apparatus, they are obliged sometimes to invent it; however, this apparatus is not of primary interest to them, but simply a tool: they look ahead, far beyond the means employed."

The foregoing thesis could be supported by innumerable illustrations. Columbus was completely possessed by the then-theory that the world is spherical, and that India could be reached by sailing westward as well as eastward; he saw many evidences in support of his theory; he wanted to establish the fact; he was not at all primarily interested in buying and selling Indian goods. He blundered into America, and proved it to be a fact; but no one thinks of blaming poor old Columbus for the rise and fall of Florida real estate, or for the administration of Jimmie Walker, even if they have occurred in the field of his discovery.

Among his innumerable other accomplishments, Benjamin Franklin flew his kite and toyed with lightning; but no poor devil has yet blamed him for the electric chair. Llewenhoek is not accountable for the inhuman use of bacteria in war; it's not the responsibility of the Wright Brothers that Lowell Bayles met his death at the Detroit Flying Field; Street (1794) committed no crime because your internal combustion engine responded to your foot as you got sleepy and smashed your auto against the telephone pole. Conversely, pure scientists must forego the credit which is due the inventors and the technologists for assembling their results into the innumerable forms which bless mankind. Their turning of laboriously-won scientific facts into such combinations and machine-forms as can serve useful ends is a wholly laudable occupation in its own right, but it is nevertheless true that the bona fide scientific investigator and the inventor of commercially saleable utilities are seldom combined in the same person. Insight and brilliancy

in one of these occupations is generally associated with mediocrity, or less, in the other. Nevertheless, it is probably true that a majority of people, not a few scientists included, fail to discriminate clearly between these two mental powers, and confuse the scientific investigator with the technologist; such are numb to the shifting of their intellectual currents, e. g., as they pass from the data of the physiological chemist and chick embryologist to those of the incubator manufacturer; from the laboratory of Professor John Abel, the isolator of epinephrin, to the factory for making chocolate-covered pills; from the laboratories of Klebs and Loeffler to the bottling department of Sharp and Dohme, or Parke Davis & Co.; from the synthesis of nitroglycerin to the dynamite factories of the DuPonts. The phenomenon of a combination investigator and inventor, as has been intimated, does occasionally occur as a "rara avis." One at once cites the accomplishments of Edison, and, long before him, Watt. But they are exceptions; as a rule, a man is Dr. Jeckyl, let us say, most of the time, and only momentarily Mr. Hyde, or vice versa.

Appealing again to an authority whose words will multiply the seriousness of my contention many-fold, let me quote from one of America's one-time great mathematical sons, Simon Newcomb.[2] At the opening of the International Congress of Arts and Sciences at the Universal Exposition in St. Louis (1904), he said, in commenting on the remarkable achievements of the 19th century, "The superficial observer, who sees the oak but forgets the acorn, might feel as though the special qualities which have brought out such great results are expert scientific knowledge and rare ingenuity, directed to the application of the powers of steam and electricity. From this point of view, the great inventors and the great captains of industry were the first agents in bringing about the modern era. But the more careful inquirer will see that the work of these men was possible only through a knowledge of the laws of nature, which had been gained by men whose work took precedence of theirs in logical order, and that success in invention has been measured by completeness in such knowledge. While giving all due honor to the great inventors, let us remember that the first place is that of the great investigators whose

[2]Simon Newcomb: "The Evolution of the Scientific Investigator." Opening address, International Congress of Arts and Science Universal Exposition, St. Louis, 1904.

forceful intellects opened the way to secrets previously hidden from men. Let it be an honor and not a reproach to these men that they were not actuated by the love of gain, and did not keep utilitarian ends in view in the pursuit of their researches. If it seems that in neglecting such ends they were leaving undone the most important part of their work, let us remember that nature turns a forbidding face to those who pay her court with the hope of gain, and is responsive only to those suitors whose love for her is pure and undefiled. Not only is the special genius required in the investigator, not that generally best adapted to applying the discoveries which he makes, but the results of his having sordid ends in view would be to narrow the field of his efforts, and exercise a depressing effect upon his activities. The true man of science has no such expression in his vocabulary as 'useful knowledge.' His domain is as wide as Nature itself, and he best fulfills his mission when he leaves to others the task of applying the knowledge he gives to the world."

It seems certain that scientists for all time will find one of their great exemplars and inspirations in Louis Pasteur. Unsurpassed in his scientific methods and accomplishments, he was likewise clear-thinking and high-minded in his devotion to his calling as investigator. The anecdote is familiar: offered the post of national supervisor of the silk industry at a then-princely salary per year, he declined, remarking that "such a step would be beneath the dignity and calling of a scientist." In modern parlance, he declined the calling into technocracy!

Whatever the guilt which may attach to the devises called instruments of war, whatever the results of machine invention and machine production, whatever the credit for undreamed speeds of communication and travel, whatever the future of radio and television and air travel—pure science can deny the guilt, and must forego the credit: her dealings were and are with the fundamentals, not with devisings, or recombinations, or with any of the honorable or wicked applications of the technocrats. Her province is with the facts of nature, the facts as they are, and were, untold ages ago: the facts as they were in the proterozoic, the palaeozoic, mesozoic, and cenozoic—long before man was here to observe, and longer before he invented anything.

And here our discussion blends into the second of three of the suits often brought against science, and about which

I am venturing to say something this evening. I refer to the specific or implied injury which scientific revelations have presumably done to different theories as to the nature of things, to long-held and preciously-valued personal philosophies, to ecclesiastical tenets or creeds, and consequently to human peace-of-mind and serenity. In so far as these last have depended on unfounded tradition, on mere usage, on superficial custom and habit, on superstition, on assumed revelation or inspiration in the field of ideas and beliefs, or on childish preferences, the contentions, i. e., the truths which have been established by science, may easily have been damaging, and deep wounds have hurt. The claim is usually advanced that science has concocted new facts, created laws de novo, out of its own powers and suitable to its own whims, in part, even, mischievously: it has toyed with the holy and sacred.

Such as see the matter thus must reflect that truth never changes, that the facts of science are not new, but eternal. They should slowly read the words of that poetic thinker who, in the opening words of a sonnet, has said:

> "Fear not to go where fearless Science leads,
> Who holds the Keys of God. What reigning light
> Thine eyes discern in that surrounding night
> Whence we have come . . .
> Thy Soul shall never find that wrong is right."

Put in other words, Ecclesiasticus need not worry about true scientists when he says, "That which hath been, is that which shall be: and that which hath been done, is that which shall be done: and there is no new thing under the sun." Scientists realize those facts already: they are simply that minority of people in general who feel the universe as a whole, and the minutiae, even to the size of electrons, to be genuinely interesting, and spontaneously give their time and strength, their lives, to finding out not new things, for there are none, but rather facts and relationships which have never been noticed or formulated before.

Thus while the scientific group in the first place resents the charge that its members are identical with the inventors and technologists, they, in the second place, vigorously resent the accusation that they create new forces, either as allies of the evil one or as collaborators with Almighty God. If they pray at all, it is in these words: "Open Thou mine eyes that I may see,"—the facts and the laws of the ages.

May I comment briefly on one other of the numerous criticisms not infrequently voiced as judgments against science? Rather than attempt to define or describe its nature, let me quote:

> "Every province of human interest has been brought under scientific classification, so that nearly all thought is now cast in 'general ideas.' This mode of thinking ignores individuality and sees in men and things only units of a class. For this reason, man is content with countless repetitions of the same form because his class idea is realized if it find in each object the few characteristics common to the group."

After citing a few examples by way of illustrating the foregoing contention, the commentator continues:

> "The world has been filled with these ugly forms made in the name of art, but they only bear witness that science has subdued the earth and now holds undisputed sway."

Then he adds as a separate paragraph:

> "Not only has it driven art into the background, but it has misrepresented its character."

And further on:

> "As I have said above, science is largely responsible for the widespread misconceptions of and indifference to art."

Let me at once add that the context of the above quotation fully explains that the writer does not mean that science is anything less than invaluable in its own way. He does mean that a body of students who have been disciplined in the precision methods of science are perhaps permanently injured as to their easy grasp of the highly visionary and imaginative practices which are vital to the artist. While trying to estimate the degree to which science is thus innocent or guilty as regards the fine arts, one must not forget that they have very different goals, at least when one has in mind the ultimate ambition of each. They do not pretend to be more than supplementary to each other, or to coincide save with respect to the most elementary beginnings of each. In all their separately diagnostic features, they strive and operate in very different fields,

with different ends in view, and make very unlike contributions to the mental and spiritual life of man. Art is characterized by breadth; generally by mass effects: it feeds the spirit of man, it works through his emotions, it amplifies his vision, and enlarges his soul by bringing his imagination into play. In a degree which statistical data could never secure, art lets a person attain a depth of feeling and appreciation which he would otherwise never experience.

The method of science, on the other hand, uses the mind as a tool, and by insistence on precision, on uniformity, on endless repetition and calibration, it brings about a state of mind which demands absolute and generally tangible truth, so far as this is humanly attainable: it engenders a dislike, an intolerance of haze and fog, of crude approximations, of half truths: dreams have little place in the disciple of science. In all these ways, then it must be conceded that the precision of science not only does not contribute to imaginative art, but, in a real degree, fosters a spirit which is inimical to art.

But, so far as guilt is to be assigned, so far as responsibility in the matter goes, is it not a matter of exchange of courtesies? Each of these fields of human interest and devotion says to the other, "The same to you, my dear Madam, or Sir!" This must have always been so: for even the deference which must be given to age hardly plays any part here, so ancient are both habits of human thought. The "general, inclusive effect" which art seeks, is hardly less than an abhorrence to science, and the exactness of science stands in the way of emotional art. The artist throws himself, his very soul, into the picture or the statue—his result is an alloy of his imagination, his vision, his materials and tools, and himself: on the other hand, the product of the scientist must be unbiased, impartial, impersonal, concrete.

Fortunately, human interests are hybrid to such degree that both art and science can be understood, and tolerated, and fostered in the make-up of the single individual. This is an instance of dual-personality, and caution should be exercised lest we let either the play of imagination and vision, or the insistence on accuracy be crowded out by, or confused with the other. It is fortunate, let me say further, that, "in spite of ourselves," we constantly experience and earnestly propagate the instinct which enjoys art on the one hand and simultaneously insists on scientific accuracy.

In a not too clear-cut way, I have tried to designate three of the commoner articulations with human affairs at which science is often called into court as an offender against the material, or intellectual, or spiritual welfare of human kind. As regards the first, we insist that there is a clear distinction between the investigator and discoverer of elemental truth, the truth which resides in the nature of things, and the person who makes permutations and combinations of the facts seen first by the true research worker, facts sought and found for their own sake. The technologist depends on the research worker for the secrets on which his devises rest, but the scientist may not be held responsible for either the good or evil, or the number of machines his brother-inventor creates.

As regards perversion of man's intellectual integrity, the accusers of the scientific observer as an agent in compelling them to modify their long-established opinions, in any field whatever, must always be admonished that America was here millions of years before Columbus discovered its shores: that there is nothing new under the sun: truth is eternal. It is not changed by shutting one's eyes to it, it is not created by any man, scientists or otherwise; but the soul of no man was ever washed and saved by stubborn attendance at the shrine of ignorance.

In the third place, while man's spiritual nature is not amenable to calculation or measurement, or reducible to formula, while it does leave solid ground and fact, and finds easier expression in the unconfined methods of art, where the limits imposed by experienced truth do not hold, we should not feel that art and science are contending for the same territory in human nature. Each in its place, art giving *vision*, and science *precision*, as has been said, are each vital constituents of man's every-day needs.

Finally, while fully aware that, as in the human body many a structure besides the heart or brain is easily a vital organ, so in the material, and intellectual, and spiritual departments of our lives we needs must feed in green pastures of various sorts, and draw inspirations and satisfactions from many different fields; yet, on the present occasion we pronounce our belief in the innocence of pure science and its motives: our emphasis is on the unlimited contribution which science makes to human thought and philosophy: and we endorse the words of John Dewey, when he says, "The future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind."