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## Address to the American Scientific Association, August 20th, 1873, on American science, and modern methods of science

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# ADDRESS

TO THE

AMERICAN SCIENTIFIC ASSOCIATION,

AUGUST 20th, 1873,

ON

AMERICAN SCIENCE,

AND

MODERN METHODS OF SCIENCE.

BY

**J. LAWRENCE SMITH,**

RETIRING PRESIDENT.



# ADDRESS.

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## FELLOW-ASSOCIATES :

We meet again at a point far distant from the one where we gathered together last year, to interchange social greetings and scientific thoughts, and to form plans for future labor and usefulness. Fifteen hundred miles divides Dubuque from Portland, as the bird flies, and yet that extent of country and much more is all our own. Its living and dead treasures, with its rocks and its soil, furnish abundant study for our men of science, from which to draw rich stores of knowledge, and to direct the capital of the country to new sources of wealth.

As the American Association for the Advancement of Science hold their session for a few days only, and occupy a portion of their time in interchange of social greetings among themselves and with the inhabitants of the city where we meet, that critical examination of papers communicated to the society can not be entered upon that otherwise would be, nor can the length of the communications and discussions be easily limited. In fact, while it would be desirable to supervise these matters more fully, it is surrounded with such insurmountable difficulties that those controlling them are forced to content themselves with an imperfect discharge of their duty.

This too often gives rise to unjust criticisms on the part of the press, whose reporters visit these associations with the

same views as they would enter a learned body of scientific men, who meet at stated periods, with short intervals between them, and where both time and sound criticism are bestowed upon such investigations as are communicated.

This association, in some sense, is to be regarded as an annual scientific *fête*, where the interchange of ideas outside the audience-room suggests as much, if not more, stern matter for reflection than the communications which may be read; the minds of men that have been on the stretch during the year are relaxed, and fresh pabulum and new vigor are furnished for the coming year.

It sometimes happens that many persons who attend our associations gather erroneous impressions from them as to what the scientific men of the country are doing, and go away questioning themselves whether or not scientific societies and associations have, after all, done much for science; and conclude that the men forming them, while they have made many important investigations, and published them for the benefit of succeeding ages, that it is to practical and obscure persons that the world is indebted for her great discoveries.

I allude to this here, as it is but recently that I have seen this assertion made in an article calculated to attract the attention of the masses, and the author of that article illustrates the fact by citing Clarke, Fulton, and Morse. Now, while all honor is due to those men of skill and genius, I would ask, who gave them the fulcrums on which they placed their levers, by which they have wrought so much in practical science and the arts of life? *It was pure Science.* Without its aid Clarke's practical skill would have failed him in constructing his huge astronomical lenses; it is to the experiments on latent heat in the laboratory of Black that we owe the present steam-engine, and without which Fulton would never have ruffled the water of our rivers nor stemmed the winds of the ocean; and without the scientific thought and the grand, though inconspicuous, experiments of Galvani, Volta, Oersted, Faraday, Henry, and

others, no one would have ever dreamt of making a swift messenger of the lightning.

My thoughts on this subject have led me to reflect much upon the scientific training in this country, both for those wishing to pursue science as a profession as well as those desiring it only for general education.

There are, no doubt, serious errors in the scientific training that students undergo at our various universities and schools, which are too much in the habit of making short-cuts in going over the fields of science. We are in fact a fast people, as it is commonly expressed, and are not content to devote patient and laborious study to pursuits that can only be mastered in that way. A short time ago, a physician writing on this same error in relation to his profession, justly said that, while we have shortened distance by the railroad and the telegraph, the road to learning is the same as it was in the days of Socrates and Plato.

The student is restless to become instructor, the lecture-room enticing him from his studies before they are half mastered, and consequently his instruction to others is both meager and imperfect.

Our vast material interests draw the students from their laboratories to undertake the conducting of mines and other important works. The consequence is, bad economy reigns in most of them ; and if it were not for the patient submission of the people of this country to high prices, many an enterprise would have to suspend operations.

But it is at the door of the educational institutions themselves that the greatest blame is to be placed. First of all, our universities are too numerous (or rather I should say our so-called universities). Now-a-days a scientific school must be attached to every college, else it is not thought complete ; and the number of competent professors required to fill the scientific chairs in all these institutions could not be easily supplied in this country. Were it possible, it

would be far better to have fewer scientific schools, and to establish them on the broadest basis, with most liberal endowments, so that instruction can be imparted at some mere nominal cost to the student, and to make their examinations of such a standard that the indorsement of these several schools will be a passport to the bearer of it wherever he may seek for employment in pure science or in its applications. And furthermore, by a system of well-endowed scholarships, to retain those specially gifted with taste and talent for pure science to devote their first years to labor in that direction. Owing to these defects in our system of scientific education, American science is frequently reproached as being very deficient in pure and patient research.

Now, while admitting that our scientists have fallen short of what might have been expected of them, no one can deny that a vast amount of scientific labor has been accomplished in this country from the time of Franklin to the present day; and in the application of science to the arts we are not far behind the most advanced nation of our own time.

I know that American scientists are looked upon by their European colleagues as in some sense piratical in their nature, simply capturing the hard-earned labors of others, applying the great truths and discoveries in science others have brought to light, and not evolving them by hard and laborious study and experiment. This is to some extent true, for the labors required of our professors (who have educated and trained minds) in the countless colleges that dot the land, are so onerous that no time is given them for the exercise of original thought and investigation.

What can a physicist, a chemist, or naturalist do who has three or four classes to teach, usually in the most elementary part of their studies? The very labor unfits him for that free exercise of the mind which leads to new ideas and discoveries. He becomes an educational drudge instead of an intellectual scientist; and whatever his intrinsic merits may

be, he is commonly sustained, pecuniarily, no better than those engaged in the commonest pursuits of life, being at the same time restricted in intellectual resources—as books, scientific transactions, apparatus, etc.

I will, however, just here make one other plea for our men of science against any unjust comparison with those across the Atlantic. It is this. Our country is a new one, of most peculiar and wonderful features of surface, of soil, and of climate, and of untold and fabulous wealth within its bowels; it beckons every man to fortune; and with such ease are wealth and honors snatched from its overflowing lap that even men who love and honor science are drawn off their direct path into by-ways and other pursuits, and too often leave behind them the scientific toga that is never again assumed. In Europe it is otherwise; no temptations of this kind beset the scientist, and he delves and digs into scientific lore, acquiring great ideas and telling them to the world, exciting their wonder; and even then the honors they acquire only bind them faster to their closets, for they are not tempted as we are.

In later years the liberality of wealthy patrons of learning and science has done much to advance pure science in this country by enabling the young and enthusiastic pursuers after Nature's secrets to give full scope to their tastes, and thus have opened to them new fields of research so enticing that their entire lives may become absorbed in them.

This is increasing every day in our country, and before very long there will be such inducements to offer to her greater minds to devote their lives to pure science that America will become as prolific in new scientific ideas and discoveries as Europe.

Let us ever bear in mind that it is *abstract scientific ideas which underlie, in these modern days, all discoveries conducive to man's progress*, from the making of a pen to the construction of a telescope; or, as Herbert Spencer well expresses

it, "each machine is a theory before it becomes a concrete fact." The man of pure science paves the way, erects the mile-stones, and puts up the guide-post for the practical man. The world, long dormant to this great truth, is fast waking up to its acknowledgment; as those words *Cui bono?* (the touch-stone used by the so-called practical man) are only heard now in faint whispers, where it was formerly sounded most clamorously whenever any scientific discovery was announced.

This does not arise from any change in men; they are the same now as they were in the days of Galvani, who was doubtless regarded as a frivolous fellow, engaged in his daily experiments over the convulsions of the muscles in a frog's leg when brought in contact with two metals; but while mankind has not changed, Galvani's experiment has, and instead of a frog being convulsed by the electric force then discovered it is a world that is now convulsed, as this same electricity flashes through those nerves of metal that stretch across land and river and bury themselves deep beneath the oceans of our globe; battles are fought, victories announced, commerce controlled, and, I am sorry to say, tyranny abetted, by the same wonderful agent whose phenomena in their in-cipieny invited the ridicule of the ordinary observer.

Science at the present day commands the respect of the world; nations, looking up to it, seek its advice at all times, and move in no material enterprises without consulting its oracles; yellow-backed literature is beginning to find a rival in well-conducted popular scientific journals and popular treatises on the various branches of science.

As an association of American scientists, we are looked upon as men representing science in all its bearings upon the physical and mental world, and some even go so far as to suppose that we would arrogate its bearings equally upon the spiritual world. This being the case, it behooves us to guard well our thoughts, words, and acts, unless they may do science

and ourselves injustice, and misrepresent both Nature and Nature's God.

We are all searchers after truth ; but let us be careful that we do not mistake what truth is, and be beguiled in following some fatal error which has simply borrowed the garb of truth, and completely enveloped itself in it, so as to hide its own deformity. Error has often faint glimmer enough to dazzle the sickly eye of the enthusiast ; truth itself shines with sufficient brightness to be seen by the most jealous among scientists.

While it would not be out of place to review the activity of American science for the benefit of the general public, yet it would occupy too much time, and I will merely refer to it to show that our Government is fully alive to the value of well-directed scientific labors. The Government never hesitates to encourage the most thorough investigation by scientific men into all matters that are likely to benefit the people or advance those great scientific investigations which are of a more abstract character. Witness the care and liberality with which it encourages that corps of scientists engaged in the gigantic enterprise of the coast survey in all its various departments ; its liberal appropriation of money and means to observe those great astronomical phenomena, as solar eclipses, the transit of Venus, etc., which, while they may not be attended with any immediate material advantage to the Government, yet serve to instruct her people in those higher and nobler aspirations after great natural truths which must inevitably result in unfolding to us the riches of our land, teeming with every diversified beauty of mountain, valley, and plain, seas, lakes, and rivers, and beneath her surface with all the variety of wealth that Nature seems to have been able to produce. While the older portions of the world are making serious calculations, and even looking forward with gloomy forebodings to the time when her soil and rocks will cease to give wealth to toil, our soil and our rocks are but

just being turned up to reveal wealth tenfold greater than the world ever knew before. But in the midst of all this abundance let us feel assured of one thing, that it is so placed that no sluggard can stretch forth his hand and partake of it.

The wealth of America means toil. And perhaps in this we are even more blessed than we sometimes are disposed to think ; for the rich soil which covers such a vast proportion of our country, some of the states of which, as Illinois, with 55,000 square miles of surface, has hardly a barren acre, yet we can pluck nothing from it ; it is not like the tropical forest, from which the indolent natives may gather their food, and live a life of inertia almost akin to the beasts that wander through its rich foliage. In this country the arm must be stretched forth, the forests felled, the ground plowed, provision made against the inclemency of varying seasons, etc. ; but when this is done what a glorious return!—rich and luxurious crops, abundant harvests. Then, by the numerous navigable streams and favorable surface for roads, a ready market is afforded for the farmer's surplus. And when we go beneath the soil and mine the rock it is not only the uncertain gold and silver, but the sure coal and iron, that reward toil, and from the very nature of the labor improve those engaged in it.

As followers and patrons of science we must keep in view the wants and wishes of the people. Sometimes the people themselves, as well as their representatives, are slow to appreciate our labors ; but experience has proved that they give way at last to the patient and judicious perseverance of men of science, who in some way or other show that they are not mere abstractionists, but that what they do has practical bearings, and as such render the people more powerful both at home and abroad. Science furnishes, so to speak, the raw material out of which all the progress of modern nations is constructed. To use the words of one of our Nestors of science : " It is only in recent times that the value of scien-

tific research began to be felt ; and I hope to live, old as I am, long enough to see the community, the enlightened community which has become my second fatherland, appreciate what science is doing for the general prosperity, and then contribute to the necessities of science with that generous liberality which characterizes the acts of American people."

Thus much has been said in reference to science in America, acknowledging our short-comings and attempting to correct certain erroneous impressions, both in America and abroad, in regard to the labor of scientists in this country. It may appear an attempt on my part to urge undue excuses ; such certainly is far from my intention : it is to do simple justice to those prosecuting science under more or less disadvantageous circumstances.

I now pass to the second part of my discourse. It is in reference to the methods of modern science—the caution to be observed in pursuing it, if we do not wish to pervert its end by too confident assertions and deductions.

It is a very common attempt now-a-days for scientists to transcend the limits of their legitimate studies, and in doing this they run into speculations apparently the most unphilosophical, wild, and absurd ; quitting the true basis of inductive philosophy, and building up the most curious theories on little else than assertion ; speculating upon the merest analogy ; adopting the curious views of some metaphysicians, as Edward Von Hartmann ; striving to work out speculative results by the inductive method of natural science. To me this appears a perversion of Bacon's philosophy, and we can not wonder that one adopting such views, whatever his claim to genius may be, soon cuts loose from all physical reasoning and becomes involved in the most transcendental and to all appearances absurd opinions, which, however clear to the author, are strange and unintelligible to others ; and if at any one time we believe we have caught the conception of the author, this impression is only momentary, and we give

up in despair, realizing that we can not follow his intellectual ecstasies ; for, in the language of Tyndall, they are even "un-thinkable." Those engaged in such speculations are very commonly found in bitter conflict with each other, forcing the belief of the saying of D'Alembert, that "when absurd opinions become inveterate it sometimes becomes necessary to replace them by other errors, if nothing better can be done."

This extreme metaphysical philosophy is referred to for the reason that many scientists, ranking as sober, earnest laborers after truth, are caught dealing in such philosophy in their method of investigation, and sometimes, quite unconscious to themselves, forgetting that "science is only an accurate record of the processes of nature ; that its laws are only generalizations of its observations, and not a declaration of an inherent necessity ; and that one of its observations is the uniformity of natural sequence."

I am one of those who believe that every thing must give way to the laws of nature ; but then we must master these laws, and be sure that we have done this before either interpreting phenomena by them or venturing into the realm of speculation.

As has been already remarked, men are to-day just what they have ever been. As bright intellects and as great philosophers lived two or three thousand years ago as do now ; their minds sought out the same great truths that we are searching for in these days, and they sought for them by the lights with which they were surrounded. In those earlier ages poetry, sculpture, architecture, and even some facts belonging to natural history (things that belonged either to the imagination or to the eye), arrived to as high a degree of perfection as perhaps they ever will ; for the two senses which appreciate the ideal and the real were as perfect then as now.

But when man was called upon to labor in fields where the imagination and the eye aided them but little or not at all, then the discoveries in these fields and their interpretations

call for other means for arriving at results. In modern days we attempt to be guided by the clear light of inductive reasoning which we may think we are employing, when too often it is the very smoky torch of analogy that is being used ; and this fact serves to explain why it is that some of the most brilliant philosophers of comparatively modern days are only remembered in their name—as, for example, the great French philosopher Descartes, whom Dugald Stewart says “ is much better known to the learned of our day by the boldness of his exploded errors than by the profound and important truths contained in his works.”

And such an example as this is of great value to the reflective mind, teaching caution, and demonstrating the fact that, while the rules by which we are guided in scientific research are far in advance of those of ancient days, we must not conclude that they are perfect by any means. In our modern method of investigation how many conspicuous examples of deception we have had in pursuing even the best method of investigation! Take, for instance, the science of geology from the time of Werner to the present day. While we always thought we had the true interpretation of the structural phenomena of the globe as we progressed from year to year, yet how vastly different are our interpretations of the present day from what they were in the time of Werner! In chemistry the same thing is true. How clearly were all things explained to the chemist of the last century by Phlogiston which in the present century receive no credence, and chemical phenomena are now viewed in an-entirely different light!

Lavoisier, in the latter part of the last century, elucidated the phenomena of respiration and the production of animal heat by one of the most beautiful of theories, based, to all appearances, upon well observed facts ; yet at the present day more delicate observations, and the discovery of the want of balance between the inhaled oxygen and exhaled carbonic

acid, subverted that beautiful theory, and we are left entirely without one. It is true we have collated a number of facts in regard to respiration, molecular changes in the tissues, etc., all of which are recognized as having something to do with animal heat; still it is acknowledged that we are incapable of giving any concrete expression to the phenomena of respiration and animal heat as Lavoisier did eighty or ninety years ago.

Electricity is the same now as it has ever been, yet it was once spoken of as a fluid, then as a force, now as an energy readily convertible into caloric or mechanical energy; and in what light it will be considered fifty years hence no one can predict.

Now what I desire to enforce here is, that amid all these changes and revolutions of theories, so-called, it is simply man, the interpreter, that has erred, and not nature; her laws are the same; we simply have not been able to read them correctly, and perhaps never will be.

What, it may be asked, are we to do then? Must we cease theorizing? Not at all. The lesson to be learned from this is, to be more modest in our generalizations; to generalize as far as our carefully made out facts will permit us and no farther; check the imagination and let it not run riot and shipwreck us upon some metaphysical quicksand.

The fact is, it becomes a question whether there is such a thing as a pure theory in science. No true scientific theory deserves the name that is not based on verified hypotheses; in fact, it is but a concise interpretation of the deductions of scientific facts. Dumas has well said that theories are like crutches, the strength of them to be tested by attempting to walk with them. And I might farther add that very often scientists, who are without sure-footed facts to carry them along, take to these crutches.

It is common to speak of the theory of gravitation, when there is nothing purely hypothetical in connection with the

manner in which it is studied ; in it we only see a clear generalization of observed laws which govern the mutual attraction of bodies. If at any time Newton did assume an hypothesis, it was only for the purpose of facilitating his calculations. " Newton's passage from the falling of an apple to the falling of a moon was at the outset a leap of the imagination ;" but it was this hypothesis, verified by mathematics, which gave to the so-called theory of gravitation its present status.

In regard to light, we are in the habit of connecting with it a pure hypothesis ; viz., the impressions of light being produced by emission from luminous bodies, or by the undulation of an all-pervading, attenuated medium ; and these hypotheses are to be regarded as probable so long as the phenomena of light are explained by them, and no longer. The failure to explain one single well-observed fact is sufficient to cast doubt upon or subvert any pure hypothesis, as has been the case with the emission theory of light, and may be the fate of the undulatory theory, which, however, up to the present time serves in all cases.

A theory or scientific speculation, to possess any great weight, must receive universal assent by those minds capable of investigating the subject. Thus the undulatory theory of light is universally accepted as representing the true nature of the operation of light, so far as we are now able to interpret its phenomena.

Zoölogists equally learned will agree perfectly as regards the physical structure of an ape and a man, and thus far their results are entitled to universal acceptance ; but some of the same zoölogists, by the exercise of the imagination and ingenious analogical reasoning, deduce the man from the ape, while the others can not see or recognize any such transformation. In this way they present themselves to the curious world, and each gather around them supporters ; and, like too many cases in our courts of law, the greatest number are

convinced not so much by the law or justice of the case, but by the ingenuity and special pleading of the legal advocates.

It is not my object to criticise the speculations of any one or more of the modern scientists who have carried their investigations into the world of the imagination ; in fact, it could not be done in a discourse so limited as this, and one only intended as a prologue to our present meeting. But in order to illustrate this subject of method more fully I will refer to Darwin, whose name has become synonymous with progressive development and natural selection, which we had thought had died out with Lamarck fifty years ago.

In Darwin we have one of those philosophers whose great knowledge of animal and vegetable life is only transcended by his imagination. In fact, he is to be regarded more as a metaphysician with a highly-wrought imagination than as a scientist, although a man having a most wonderful knowledge of the facts of natural history.

In England and America we find scientific men of the profoundest intellects differing completely in regard to his logic, analogies, and deductions ; in Germany and France the same thing—in the former of these countries some speculators saying “that in Germany <sup>his theory is our common starting point</sup> ~~we commence where Darwin~~ ~~leaves off,~~” and in France many of her best scientific men not ranking the labors of Darwin with those of pure science.

Darwin takes up the law of life and runs it into progressive development. In doing this he seems to me to increase the embarrassment which surrounds us on looking into the mysteries of creation. He is not satisfied to leave the laws of life where he finds them; or to pursue their study by logical and inductive reasoning. His method of reasoning will not allow him to remain at rest; he must be moving onward in his unification of the universe. He started with the lower order of animals, and brought them through their various stages of progressive development until he supposed he had touched the confines of man ; he then seems to have

recoiled, and hesitated to pass the boundary which separated man from the lower order of animals ; but he saw that all his previous logic was bad if he stopped there, so man was made from the ape (with which no one can find fault, if the descent be legitimate). This stubborn logic pushes him still farther, and he must find some connecting link between that most remarkable property of the human face called expression ; so his ingenuity has given us a very curious and readable treatise on that subject. Yet still another step must be taken in this linking together man and the lower order of animals : it is in connection with language ; and before long it is not unreasonable to expect another production from that most wonderful and ingenious intellect on the connection between the language of man and the brute creation.

Let us see for a moment what this reasoning from analogy would lead us to, if applied to chemical science, which investigates a great variety of compounds that exhibit most curious analogies in all their properties. Take for instance soda and potash—how identical in almost all their properties, and their compounds arraying themselves in identically the same form, defying almost all the senses to detect their difference ; if they be brought into relation with other elements, they associate themselves with these elements in identically the same way. The same is true in relation to baryta and strontia, or chlorine, bromine, and iodine ; the three last elements even show most curious numerical relations in regard to their combining proportions. And then when we pass to the mineral kingdom, what a wonderful property is that isomorphism in the chemistry of Nature's operations !

The chemist, with all these facts before him, has as much right to revel in the imaginary formation of sodium from potassium, or iodine and bromine from chlorine, by a process of development, and call it science, as for the naturalist to revel in many of his wild speculations, or for the physicist who studies the stellar space to imagine it permeated by mind as

well as light—mind such as has formed the poet, the statesman, or the philosopher.

Yet any chemist who would quit his method of investigation, of marking every foot of his advance by some indelible imprint, and go back to the speculations of Albertus Magnus, Roger Bacon, and other alchemists of former ages, would soon be dropped from the list of chemists and ranked with dreamers and speculators.

To prove the truth of my assertion, that this is the legitimate result of this school of philosophy, I will quote from one of its disciples, T. W. Clarke. He says: "When one is fairly started on a line of thought it is hard to come to an end. If we assume an hypothesis to be true, a hundred others rush in upon the mind and demand consideration. We do not know but that the evolution of one element from another may be possible. The demonstrated unity of force leads us by analogy to expect a similar unity of matter. Those elements which seem to-day so diverse in character may be after all one in essence; at present it can neither be discarded as false nor accepted as true."

What is most remarkable in connection with the above opinion is that the author of it is commenting on matter in connection with the spectroscope, an instrument whose very triumphs are based on the grand distinguishing lines in the elements of matter, whether in the earth, sun, stars, or nebulae, all telling the same dissimilarity and no coalescence.

Is this to be one of the methods of modern science, I would ask? While in our ignorance and short-sightedness we should be careful in pronouncing any assumption as possible or impossible, still there is no reason why these terms should have much or any weight in the study of science; for in the abstract all things in nature are possible, not from any demonstration, but simply because no one can assert an impossibility. What a mass of confusion science would become if we studied its possibilities! for then every conceivable possibility

would be entitled to equal consideration. And we are not therefore surprised that the author last quoted should say, "So then we may proceed to theorize in the most barefaced manner, without quitting the legitimate domain of science."

Are we to introduce into science a kind of purgatory into which to place undemonstrable speculations, and keep them there in a state of probation, and say that science can not discard a theory as false when it can not be accepted as true? Science, which is pre-eminently the pursuit of truth, has but one course to pursue: it must either accept or reject what may be thrust upon it.

What I have said is, in my humble opinion, warranted by the departure Darwin and others have made from true science in their purely speculative studies; and neither he nor any other searcher after truth expects to hazard great and startling opinions without at the same time courting and desiring criticism; yet dissension from his views in no way proves him wrong—it only shows how his ideas impress the minds of other men. And just here let me contrast the daring of Darwin with the position assumed by one of the great French naturalists of the present day, Prof. Quatrefages, in a recent discourse of his on the physical character of the human race. In referring to the question of the first origin of man he says distinctly that in his opinion it is one that belongs not to science; these questions are treated by theologians and philosophers: "Neither here nor at the Museum am I, nor do I wish to be, either a theologian or a philosopher. I am simply a man of science; and it is in the name of comparative physiology, of botanical and zoölogical geography, of geology and paleontology, in the name of the laws which govern man as well as animals and plants, that I have always spoken." And studying man as a scientist, he goes on to say: "It is established that man has two grand faculties of which we find not even a *trace* among animals. *He alone* has the moral sentiment of good and evil; *he alone*

believes in a future existence succeeding this actual life; *he alone* believes in beings superior to himself, that he has never seen, and that are capable of influencing his life for good or evil; in other words, *man alone is endowed with morality and religion.*"

And it may be added that Hartmann, a philosopher of another school, says, selection explains the progress in perfection of an already existing type within its own degree of organization, but it can not explain the passage from an inferior degree of organization to a superior one.

If Prof. Quatrefages be right in regard to the moral sentiment in man, then Darwin must be wrong in asserting the development of man out of that, in which not a trace exists of what most pre-eminently constitutes a man; or he must satisfy himself in evolving the physical part of man out of the lower order of animals, then by some creative force implant within him these principles.

Our own distinguished naturalist and associate, Professor Agassiz, reverts to this theory of evolution in the same positive manner, and with such earnestness and warmth as to call forth severe editorial criticisms, by his speaking of it as a "mere mine of assertions," and "the danger of stretching inferences from a few observations to a wide field;" and he is called upon to collect "real observations to disprove the evolution hypothesis." I would here remark, in defense of my distinguished friend, that scientific investigation will assume a curious phase when its votaries are required to occupy time in looking up facts, and seriously attempting to disprove any and every hypothesis based upon proof, some of it not even rising to the dignity of circumstantial evidence.

But I have dwelt longer on this one point than I had intended to do; but the very popular manner in which it has in recent years been presented to the public mind of all classes of society and to persons of all ages warranted a full notice in speaking of the importance of avoiding as far as

possible undue speculation in connection with our method of scientific investigation.

Let me not be understood to underrate the brilliant ideas and great learning of those most distinguished men of the nineteenth century, Darwin, Huxley, and others. I am too great a respecter of both science and the pursuit of science ever to encourage by my example any thing like dogmatism among scientific men. While arraying methods of study in other branches of science to combat those employed by the followers of the evolution hypothesis, I most willingly indorse what Tyndall says concerning it, viz.: "I do not think the evolution hypothesis is to be flouted away contemptuously; I do not think it is to be denounced as wicked. Fear not the evolution hypothesis; it does not solve, it does not profess to solve, the ultimate mystery of the universe. It leaves in fact that mystery untouched." If it be grounded on truth, it will survive all attempts to overthrow it; if based on error, it will disappear, as many so-called scientific facts have done before. Science is a progressive study. It does not dogmatically pronounce itself as infallible; it is at all times ready to admit what has been once rejected, if it return clothed with truthful demonstration, which science properly calls for as a passport to admission into its domain.

I would also caution my associates to carefully avoid what may be called the pride of modern science; for so rapid have been the discoveries in science during the last century, crowding upon us especially during the past twenty-five years, that we are apt to become bewildered and dazzled, and cry out in unbounded enthusiasm: Great is the god Science! it revealeth all things to us, and we will consecrate our talent and our time to its worship. The marvelous discoveries in chemistry, geology, electricity, light, etc., have lifted the veil that concealed from us so many of Nature's secrets that we are almost baffled in our attempt to systematize them. The wonderful organic compounds; the disemboweling of

curious records of past ages; the obedient and submissive lightning that carries our messages; that wonderful light, so quiet in its operations, yet so powerful to reveal the chemistry of the universe; and the conservation of force—all these, I say, bewilder the mind so that we revel in building bright air-castles, almost losing our mental equilibrium. Of all scientists of the present day the chemists perhaps have kept a more stable equilibrium than any other class, starting out with a fixed law to govern them in regard to what are considered elements, never in any instance tolerating the development or transmutation of one element out of another, however remarkable the analogy they may exhibit in the material constitution of all known substances, and recognizing them the same whether in the earth or in the sun.

I would therefore caution against too great enthusiasm, for we are far more ignorant than we sometimes suppose. In fact, true philosophy dictates to its followers humility, and that it is the province of ignorance to believe that it knows every thing, while the philosopher is aware that he knows little or nothing.

While we are prying into space, and studying the matter, size, and movements of the heavenly bodies far beyond our own universe, we leave behind us a vast number of things that have baffled our scrutiny and defied both science and metaphysics. When we look at our bodies, without reference to the consciousness that is within, but merely studying what relates to our physical parts, how many things concerning it we have not discovered!

While occupied, the early part of this year, in reflecting upon the conservation of force and certain meteoric phenomena connected with the sun, my attention was frequently drawn to the small-pox that was then in the form of a violent epidemic around me, and seeing persons being vaccinated who had in their childhood been subjected to the same operation, and observing in the vast majority of cases the failure of the

production of any effect. And I asked myself the question, How are we to rank that mysterious agent which, when brought to bear upon the system in however minute a quantity, not only permeates every fiber and cell in every part of the body, but is never lost, for when through years every particle of the body (with perhaps the exception of the teeth and a part of the bones) has been renewed over and over again, yet, as each particle gave place to a new one, this vaccine energy (if I may so call it) was imparted to the new matter, and so on through life? Here then was the conservation of a force as mysterious in its course and operation and as hard to be understood as that of motion, light, or any other of the recognized forms of the energies of matter.

Yes! after we have studied the heavens and all contained therein that the aided eye can reach, we will yet have to descend to earth and study the every-day physical phenomena that are in and around men, finding even greater mysteries to unravel that meet our unaided senses every moment of our existence.

I come now to the last point to which I wish to call the attention of the members of the association in the pursuit of their investigations, and the speculations that these give rise to in their minds.

Reference has already been made to the tendency of quitting the physical to revel in the metaphysical, which, however, is not peculiar to this age, for it belonged as well to the times of Plato and Aristotle as it does to ours. More special reference will be made here to the proclivity of the present epoch among philosophers and theologians to be parading science and religion side by side, talking of reconciling science and religion, as if they have ever been unreconciled. Scientists and theologians may have quarreled, but never science and religion. At dinners they are toasted in the same breath, and calls made on clergymen to respond, who, for fear of giving offense, or lacking the fire and firmness of St. Paul,

utter a vast amount of platitudes about the beauty of science and the truth of religion, trembling in their shoes all the time, fearing that science falsely so-called may take away their professional calling, instead of uttering in voice of thunder, like the Boanerges of the gospel, that "the world by wisdom knew not God." And it never will. Our religion is made so plain by the light of faith that the wayfaring man, though a fool, can not err therein.

No, gentlemen ; I firmly believe that there is less connection between science and religion than there is between jurisprudence and astronomy, and the sooner this is understood the better it will be for both.

Religion is based upon revelation as given to us in a book, the contents of which are never changed, and of which there have been no revised or corrected editions since it was first given, except so far as man has interpolated ; a book more or less perfectly understood by mankind, but clear and unequivocal in all essential points concerning the relation of man to his Creator ; a book that affords practical directions, but no theory ; a book of facts, and not of arguments ; a book that has been damaged more by theologians than by all the Pantheists and Atheists that have ever lived and turned their invectives against it—and no one source of mischief on the part of theologians is greater than that of admitting the profound mystery of many parts of it, and almost in the next breath attempting some sort of explanation of these mysteries. The book is just what Richard Whately says it is, viz. : "Not the philosophy of the human mind, nor yet the philosophy of the divine nature in itself, but (that which is properly *religion*) the *relation* and connection of the two beings—what God is to us, what he has done and will do for us, and what we are to be in regard to him."

Now science on her part has her records : they are discovered truths in the relation that man bears to the animate and inanimate kingdoms around him, so far as they are discovered

by him from time to time ; but as he has to proceed in his labors with imperfect instruments and often equally imperfect senses, he has to correct himself over and over again, and his observations and theories, especially the latter, make frequent shifts, each time supposing that the true one has been reached. I will exemplify this in a marked manner by an extract from a recent discourse by Prof. Ferdinand Cohn, delivered before the Silesian Society for Natural Culture. In speaking of Humboldt and his *Cosmos* (which he styles the "Divina Commedia" of science, embracing the whole universe in its two spheres, heaven and earth) he says: "But we can not conceal from ourselves that the *Cosmos*, *published twenty-five years ago*, is in many of its parts now antiquated. Any one who to-day would attempt to recast the *Cosmos* must proceed like the Italian architect who took the pillars and blocks of the broken temples of antiquity, added new ones, and rebuilt the whole after a new plan." And I would simply ask, When is this new structure to be torn down to form material for another structure? Surely the most enthusiastic admirer of the development of the last twenty-five years does not think that we have arrived at the end of all things!

I will take yet another example. For the last fifty years or more the unity of the human race has been a most prolific subject of investigation and discussion, until it was generally conceded that there must have been more than one origin for the different races. In fact, theologians had already entered on that mischievous work called reconciling science and religion, and saying after all there was some little mistake in the biblical record on that subject, and, if the Author would only permit, it would be well to make a correction just there; but this could not be done; and there it stood—that all men were of one flesh. But science, restless, changeful, moved on; and to-day the unity of the human race is insisted on by nearly all the leading naturalists, and teach what Prof. De Quatrefages teaches, as uttered in a recent lecture of his.

He says: "In this examination of the physical man every thing leads to the conclusion which we had already reached on our earlier lecture, and *we can repeat with redoubled certainty* that the differences among human groups are characters of race, and not of species. There exists only one human species, and consequently all men are brothers; all ought to be treated as such, whatever the origin, the blood, the color, the race;" and in conclusion he further says: "I shall not regret either my time or my pains, if I am able, in the *name of science, and that alone*, to render a little more clear and precise for you the great and sacred notion of the brotherhood of man."

One other example under this head, and I have done. The book of science teaches that the sun is the source of all light and heat; yet in that post-prophetic chapter of the book of our religion it is said that the creation of the first day was light, and not until afterward was the sun created; and this was again a stumbling-block to theologians, and many wished that Moses had been a little more particular. But science in its onward march, as it grouped together the matter floating in space to form in the beginning of time this earth (our circling globe), tells us that if we can imagine one to have been placed on our globe before it had consolidated, he would have seen vast seas of vapor floating around and far above it, shutting out the very light of heaven so that darkness brooded over the waters, and that the first benign influence that smiled upon the earth was the gentle rays of light struggling through the dark mist; and the prophetic eye, either on the plain, in the valley, or on the highest mountain peak, would not behold whence it came, and might exclaim in sublime poetic ecstasy: "God said, Let there be light; and there was light." And not until ages perhaps after that did the bright orb of the sun reveal itself to the prophet as the source of this light.

So I say, Let our book of religion stand as it is—if it be

not of God, it will come to naught; and let science search for truth, and if it mistakes its results it is certain to correct them in time, for the causes of its perturbations are as surely discovered as Leverrier and Adams discovered those of Uranus.

Science and religion are both traveling to the same great point—toward the Author of all truth—yet by two very different roads; and if they be induced every now and then to turn off their routes to compare notes, they will very much retard each other's progress and waste much time in discussing the peculiar merits of their particular road, and get into a quarrel about them. The roads they travel are paved with certain principles and forces, but of a very different nature.

Science treads on certain mathematical axioms and principles, recognizing matter and certain forces or modifications of an energy innate in matter, as heat, light, electricity, etc. Religion is guided by its axioms and principles, as faith, love, and hope, and with these it is expected to work out its great end in the present and future of mankind. Science is nature revealed; religion is Nature's God revealed; and neither the one nor the other can be without its axioms, incapable of demonstration.

Some may mock at faith and say, "Faith is bankrupt, and her accounts are under strict examination, to determine what assets remain to be distributed among the impoverished souls that are her creditors;" still it is an axiom made manifest to our consciousness, as much, if not even more so, than the axiom of a mathematical point being something without length, breadth, or thickness, or a line as having length without breadth or thickness. This faith is as much an energy of the immortal as heat is one of the energies of matter. We know heat by its phenomena alone, and we know faith in the same way, its phenomena proving its existence as well to the child as to the man, to the learned and the unlearned. It led Socrates and Plato, even with their imperfect light, to the

the great God, the Creator of the heavens and the earth, and to the immortality of the soul.

What God is in his essence we know not, nor how it is that he can exist. A Being not made by himself nor any one else; without beginning of days or end of years; existing through infinite ages, but capable of past or to come; filling immensity without being in any place; every where present without displacing a single one of his myriad creatures; pervading all things without motion; being all eye, all ear, all energy, and yet not interfering in the least with the thoughts and actions of man;—this has been well styled “the greatest mystery of the universe, enveloped at once in a flood of light and an abyss of darkness—inexplicable itself, explaining every thing else, and, after displacing every other difficulty, itself remaining in inapproachable, insurmountable, incomprehensible grandeur, so that the Psalmist exclaims: ‘Clouds and darkness are around about him; righteousness and judgment are the habitation of his throne.’”

This is the God whose existence reason can not prove, while it can not disprove, and whom the religionists and scientists are looking for; that they will one day see him as he is, is my firm belief, and, as I before stated, they will see him the sooner by keeping separate roads.

That many a scientist will be swallowed up in Pantheism from want of patience is to be expected, and, I regret to acknowledge, will with Hartmann “maintain that creation is a cause, existence a misfortune, life a deepening disappointment, and that the extinction of personal consciousness is the only salvation;” but many more will enjoy the double felicity of arriving at the great end, sustained both by science and by religion, and will agree with what Socrates wrote nearly two thousand years ago, without the revealed word of God to enlighten him, or to mystify him, as some would say. Listen to that philosopher of ancient days as he says: “This great God, who has formed the universe and supported the stupen-

dous work whose every part is finished with the utmost goodness and harmony—he who preserves them perpetually in immortal vigor, and causes them to obey him with a never-failing punctuality and a rapidity not to be followed by the imagination—this God makes himself sufficiently visible by the endless wonders of which he is the author, but continues always invisible in himself. Let us not then refuse to believe even what we do not see, and let us supply the defects of our corporeal eyes by using those of the soul; but let us learn to render the just homage of respect and veneration to the divinity whose will it seems to be that we should have no other perception of him than by his benefits vouchsafed to us.”

I can not close this part of my subject without reverting to the tendency of certain men of science to make physical experiment the test of all truth; even prayer and divine providence influencing affairs in this world must become subjects for experiment; and if the results be not in accordance with these experiments, then suspicion is to be cast on faith. This has been truly explained as coming from the spirit of an age which strives to make natural science the all in all of wisdom, and begins with nature instead of beginning with God, and ends with burying man and even God within physical conditions, and assigning to the supreme Spirit the impersonality that is usually ascribed to material nature; and all this in spite of the fact that profound philosophers and earnest devotees have believed in there being a consciousness subject to influence above their sense.

If we look at nature as science has thus far penetrated into her mysteries, we discover in the innermost parts of the earth matter in a constant restless state; in the ocean or the air we behold the ever moving, never resting; above are the sun and stars speeding on through boundless space, and they in their own masses are like huge boiling caldrons casting their vapors hundreds of thousands of miles into space. And

so the toiler in science goes penetrating nearer and nearer, as he thinks, to the great cause of all things. In the same way he thinks he has discovered the cause of all motion upon this planet, both in the animate and inanimate, and he hastily concludes that the energy resident in the sun is fixed and invariable; yet while he reasons as if he has arrived at the prime cause, he admits that there is something yet unknown on which the sun depends as much as the earth does upon the sun.

While I admit most freely that the smallest event in the physical world is but the sequence of secondary causes (if I may use the expression) and effects, obedient to what appear to us fixed and invariable laws, yet it is illogical for any mind to assert that they can not be altered by the operation of some energy, that may reach beyond any cause yet discovered by the light of science.

While the *energy of the sun* travels in swift motion and in rapid undulations through the ethereal space that divides the earth from the sun, and in turn science by the spectroscope travels back from the earth to the sun over the same waves, and has revealed to her, in writing as it were, on the beautiful pages of the spectrum, the composition of that incandescent globe and the mighty power of its internal forces, so does the *energy of that great cause* that formed the sun reveal itself to the internal consciousness, reaching the eye of faith, by undulations more rapid than light; and as faith travels back, looking through its spectroscope (the revealed word of God), it beholds the constitution of that great cause as composed of infinite love and mercy, truth and justice.

As light has revealed the sun to us by penetrating an organ specially formed for its impressions, *the physical eye*, so is God revealed by faith, *the soul's eye*. As well might we say that we are acquainted with all phenomena of the rays of the sun as to arrogate to ourselves the power of limiting the operations of faith.

In these things science is both vain and modest, logical and illogical; as, for example, here is what Dr. Cohn says, in a discourse of his previously referred to: "The deeper natural science penetrates from outward phenomena to universal laws, the more she lays aside her former fear to test the latest fundamental laws of being and becoming, of space and time, of life and spirit;" and in the next breath he says: "It is not to be hoped that during the next twenty-five years all the questions of science which are at present being agitated will be solved. As one veil after another is lifted *we find ourselves behind a still thicker one*, which conceals from our longing eyes the mysterious goddess of whom we are in search."

How Dr. Cohn expects to justify his first statement by his last assertion of the increasing thickness of the impenetrable veil, is more than my logic can divine.

But in this matter of subjecting faith to physical test by what is now commonly called the "prayer-gauge," philosophers of the most advanced school differ very widely in their opinion; and that remarkable Pantheist (or Pessimist), Edward Von Hartmann, probably the most remarkable man of that school since the days of Spinoza, who believes only in nature, yet ranks with the old patriarchs in his idea of the power of faith, or something next akin to it, for he calls all mankind to "combine together in one grand act of self-abdication, and to resign the very faculty of will by a mighty concert, not of prayer, but of self-renunciation—by the help of such means as art and science may apply, and by such perfection of the magnetic telegraph as shall enable them all at once to will not to will any more, and so to bring all conscious personal life to an end by an absorption in the almighty and unconscious spirit." Not the most ascetic religious devotee could exhibit more unbounded confidence in the power of faith subverting not only the laws of nature, but nature herself, as is expressed in those views.

In fine then, gentlemen, let us stick to science, pure, unadulterated science, and leave to religion things which pertain to it; for science and religion are like two mighty rivers flowing toward the same ocean, and before reaching it they will meet and mingle their pure streams, and flow together into that vast ocean of truth which encircles the throne of the great Author of all truth, whether pertaining to science or to religion.

And I will here in defense of science assert that there is a greater proportion of its votaries who now revere and honor religion in its broadest sense, as understood by the Christian world, than that of any other of the learned secular pursuits.

In this address I may be accused of more or less dogmatism; but I can assure the association that whatever there may be of apparent dogmatism arises entirely from my reluctance to consume more time in making explanations and reasoning fully on the topics discussed. I have moreover departed from the usual character of discourses delivered by the retiring presidents of this association, and have not presented a topic that might have been of more interest to you, viz., some special scientific subject coming more immediately within the province of my research; for which departure I claim your indulgence, as well as for omitting all allusion to scientific progress during the past year.

But before concluding I can not refrain from referring to one great event in the history of American science during the past year, as it will doubtless mark an epoch in the development of science in this country. I refer to the noble gift of a noble foreigner to encourage the poor but worthy student of pure science in this country. It is needless for me to insist on the estimation in which Prof. John Tyndall is held amongst us. We know him to be a man whose heart is as large as his head, both contributing to the cause of science. We regard him as one of the ablest physicist of the time, and one of the most *level-headed* philosophers that England has

ever produced—a man whose intellect is as symmetrical as the circle, with its every point equidistant from the center.

We have been the recipient of former endowments from that land which, we thank God, was our mother country, for from it we have drawn our language, our liberty, our laws, our literature, our science, and our energy, and without whose wealth our material development would not be what it is at the present day. Count Rumford, the founder of the Royal ~~Society~~<sup>Academy</sup> of London, in earlier years endowed a scientific chair in one of our larger universities, and Smithson transferred his fortune to our shores to promote the diffusion of science.

Now, while these are noble gifts, yet Count Rumford was giving to his own countrymen—for he was an American—and they were posthumous gifts from men of large fortune.

But the one I now refer to was from a man who ranks not with the wealthy, and he laid his offering upon the altar of science in this country with his own hands; and it has been both consecrated and blest by noble words from his own lips; all of which makes the gift a rich treasure to American science; and I think we can assure him that as the same Anglo-Saxon blood flows in our veins as does in his (tempered, 't is true, with the Celtic, Teutonic, Latin, etc.), that he may expect much from the American student in pure science as the offspring of his gift and his example.

With this feeble tribute to our distinguished scientific collaborator I bid you adieu, and return to the association my most heartfelt thanks for the honor that has been conferred on me, and surrender the mantle of my office to one most worthy to wear it—Prof. Lovering, of Cambridge.