raw material of experience, should be credited with a larger measure of success in its provision of the physiological arrangements which condition reason in its endeavors to turn experience to account.

Considerations like these, unless I have compressed them beyond the limits of intelligibility, do undoubtedly suggest a certain inevitable incoherence in any general scheme of thought which is built out of materials provided by natural science alone. Extend the boundaries of knowledge as you may; draw how you will the picture of the universe; reduce its infinite variety to the modes of a single space-filling ether; retrace its history to the birth of existing atoms; show how under the pressure of gravitation they became concentrated into nebulæ, into suns, and all the host of heaven; how, at least in one small planet, they combined to form organic compounds; how organic compounds became living things; how living things, developing along many different lines, gave birth at last to one superior race; how from this race arose, after many ages, a learned handful, who looked round on the world which thus blindly brought them into being, and judged it, and knew it for what it was—perform, I say, all this, and, though you may indeed have attained to science, in nowise will you have attained to a self-sufficing system of beliefs. One thing at least will remain, of which this long-drawn sequence of causes and effects gives no satisfying explanation; and that is knowledge itself. Natural science must ever regard knowledge as the product of irrational conditions, for in the last resort it knows no others. It must always regard knowledge as rational, or else science itself disappears. In addition, therefore, to the difficulty of extracting from experience beliefs which experience contradicts, we are confronted with the difficulty of harmonizing the pedigree of our beliefs with their title to authority. The more successful we are in explaining their origin, the more doubt we cast on their validity. The more imposing seems the scheme of what we know, the more difficult it is to discover by what ultimate criteria we claim to know it.

Here, however, we touch the frontier beyond which physical science possesses no jurisdiction. If the obscure and difficult region which lies beyond is to be surveyed and made accessible, philosophy, not science, must undertake the task. It is no business of this society. We meet here to promote the cause of knowledge in one of its great divisions; we shall not help it by confusing the limits which usefully separate one division from another. It may perhaps be thought that I have disregarded my own precept—that I have wilfully overstepped the ample bounds within which the searchers into nature carry on their labors. If it be so, I can only beg your forgiveness. My first desire has been to rouse in those who, like myself, are no specialists in physics, the same absorbing interest which I feel in what is surely the most far-reaching speculation about the physical universe which has ever claimed experimental support; and if in so doing I have been tempted to hint my own personal opinion that as natural science grows it leans more, not less, upon an idealistic interpretation of the universe, even those who least agree may perhaps be prepared to pardon.

A. J. Balfour.

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*SCIENCE AND THE PEOPLE.**

Opportunities beget responsibilities. On such an occasion as this, he who has been honored with the opportunity is tempted to address you upon a specialized subject to which he has given years of thought and

* Retiring address of the president of the North Carolina Academy of Science, Wake Forest College, May 13, 1904.

interest, but the opportunity carries with it corresponding responsibilities beyond the narrow bounds of one's limited investigations. The audience is composed in part of the general public, which is more or less informed, or misinformed through no self-fault, as to the general trend of scientific thought and movement; in part of students, some enwrapt with the beauty and majesty of ancient art and philosophy, others versed in the history of science and conversant with its latest conceptions; in part, my hearers are specialists in the varied branches of science, so I feel much like Moleschott in his address at the reopening of the University of Rome, when he found himself 'in the face of an audience whom he had nothing to teach, but from whom he had much to learn.'

The groundwork of science may be thrown into three divisions: (1) laborers who work; (2) tools they must employ; and (3) that which constitutes the fields of their labors.

In the world we know there is such a thing as progress; that civilization is dependent upon something capable of increase, evidently knowledge. Although, as Schiller has said, 'Knowledge is to one a goddess, to another an excellent cow,' yet the momentum of progress is largely, if not altogether, given by science.

Variations in social conditions have caused variations in human standards of morality, but through all the ages morality has actually been a stationary thing. Different ages have known mighty things in literature and art, but each was the individual outcome of the pen or brush of the genius, who bequeathed a heritage of his own labors as a stimulus to others; but the mastership passed with him. Not so with science; for, as Whewell has said, 'It is not a collection of miscellaneous, uncorrected, unarranged knowledge that can be considered as constituting science.'

Different ages have known mighty things in science, sometimes as the outcome of a genius, but equally as often the consequence of talent building upon that which was learned before. So, never was one more mistaken than President Woodrow Wilson when he stated that science breaks with the past.

In order to appreciate the spirit of modern science, we must take a hurried glance at the motives prompting the older workers and consider their environment. We are aware, in the historical development of things, that all present knowledge arose from a chaotic state enveloping itself in mystery. This was due to the empirical means of observation, superstition attending any inquiry into the why of things, hampering circumscriptions of religions, primitive and more recent, and lack of means of communication. The wise man, exercising a little common sense, wrought cures wonderful in those dark times, many simple for the youngest practitioner of to-day. While, doubtless, some were prompted by an earnest desire to do good, many were actuated by greed of power and gain, even as to-day. Fearful of their loss once secured, they often sought to hide their own shortcomings and take advantage of the universal ignorance by their mysticism. These were not the sole motives of all workers, however. The spirit of inquiry has ever been present with mankind. For

> Ignorance is the curse of God,
> Knowledge the wings wherewith we fly to heaven.

Although, three hundred years before Christ, the living and dead were dissected at the Alexandrian School, it was not until the fifteenth century that the popes overcame popular prejudice about the sanctity of the dead body and issued edicts permitting dissection. The following century, Vesalius arose, and then Harvey discovered the circulation of the blood. Greek philos-

ophers first endeavored to place science upon a purely rational basis and they were accused of impiety. To be sure, it may be said that such impeachments have not ceased to sound for over two thousand years and cost the lives of many good and noble men. The church considered Galileo and similar workers as rank heretics. Certain scientific endeavors were tolerated, and the knowledge gained confined within monastic walls. In the hearts of some was that yearning to make known the truths they had dreamed; and monks like Roger Bacon, Basil Valentine and Berthold Schwartz put forth writings so mysterious as to be incomprehensible to many, but having hidden realities not previously made known.

Science was centuries acquiring its natural voice. In the dark ages only a small band of learned folk made itself known, yet the voice of Kepler, saying 'The scientist's highest privilege is to know the mind and to think the thoughts of God,' sounded three centuries ago, has echoed with increasing reverberations to our own time. Science, harassed by ding-dong, useless and unnecessary authority, was driven into rigid pious paths. As the very spirit of science is inquiry, it lives upon liberty and would not be bound by authoritative misconceptions. It is not strange, then, that in a democracy of thought permitting the widest range of opinions men should have been borne away to the other extreme, and such catching expressions as 'every one for himself and no god for any one' became prevalent. 'Scientific arrogance' was a pet expression of theologians who trespassed none the less than had the scientists. 'The abuse heaped upon Newton for substituting blind gravitation for an intelligible Deity' that John Fiske tells about, was nothing in comparison with the subsequent treatment of geologists by theologians for disturbing the Biblical chronology. The highest teaching of scientific verities is the absolute necessity for the existence of God. In fact, one need not go far for a chemical confirmation of the resurrection, as death is but a phase of our continual internal change; 'so when this corruptible shall have put on incorruption and this mortal shall have put on immortality,' our natural body sown in dishonor and weakness, shall be raised a spiritual body, clothed in glory and power; 'and as we have borne the image of the earthly, we shall also bear the image of the heavenly.' It is only in the most modern times that the scientific spirit, which looks to the relative and temporarily excludes the absolute, has begun to be fully applied and extended to ideas of every order.

I am by no means unmindful of the dogmatism of science at times, for it may be recalled that Daguerre was actually temporarily incarcerated in an asylum because he maintained he could transfer his likeness to a tin plate; Franklin's paper on lightning conductors was laughed at and not published by the Royal Society; and Galvani was attacked by his colleagues, designated a know-nothing, and called 'the frog's dancing master.' The Count de Gasparin even wrote in the *Journal des Débats,* 'Take care; the representations of the exact sciences are on their way to become the inquisitors of our days.'

Science does not pretend to say the last word in regard to the universe, but it builds hypotheses upon observed and unobserved facts which are altered or cast aside in the light of all new correctly obtained facts. It is ever ready to declare the increasing uncertainty of many delightful and ideal conceits, which is not to be taken as vacillation, but as evolution, growth. The late distinguished Lord Playfair at the Aberdeen meeting of the British Association said: "The changing theories which the world despises are the leaves of the tree of science drawing nutriment to the parent

stems, and enabling it to put forth new branches and to produce fruit; and, though the leaves fall and decay, the very products of decay nourish the roots of the tree and reappear in the new leaves or theories which succeed.'' With this spirit, it will not hesitate to attack any of our pet scientific, sociological or theological dogmas, which are frail as all human systems must be. These attacks are without venom, however, for ''Science * * * requires for its satisfactory prosecution the employment of our very noblest powers, and it is by them alone that we can hope to attain a knowledge of the most supreme and ultimate truths which our intellectual faculties have the power to apprehend.''—(Mivart.)

Although Gough remarked to Dalton, 'The human mind is naturally partial to its own conceptions and frequently condescends to practise a little self-delusion when obliged by the force of facts and arguments to abandon a favorite notion,' the supreme lesson in the history of science, most marked in our own time, is the pursuit of truth. Much time has been spent in defining *art* and casting that which did not fit a pet definition into a rubbish box called *science,* or 'natural knowledge' as a member of the Royal Society was pleased to term it. Many of those insisting upon such a classification are not without reason, for have not certain phylogenetics promulgated on the flimsiest excuse some *pan mixia,* as Weismann's germ-plasm theory and then easily remembering the conclusions, but forgetful of the evidence, maintained that it was a law? Or has not a Tesla over magnanimously taken the public into his confidential conversations with the inhabitants of Mars?

It has been fashionable in years gone by to say that poetry and truth were antagonistic. Coleridge and Poe, I think, insisted that science and poetry were irreconcilable. Incongruous statements, as when Shakespeare speaks of a toothache 'as humor or a worm,' doubtless gave rise to such thoughts. The Avon poet put it according to the scientific teachings of his time. Civilization and methods of interpreting the truth change and progress, but truth itself is eternal. Science will no more replace literature than can a geometric diagram be substituted for a landscape painting.

Science, to be sure, is destructive of conventions. Freedom is the breath of science, and the unshackled movement of boundless human curiosity must affect literature. Men of science look not pleasantly upon their scavenging camp followers, who, riotous in thought, indulge in a license of speech which provokes quite justly those who conscientiously differ from them, and unfortunately inculcates ideas in those unable to winnow the chaff from the grain.

Thus it may be seen that modern science makes for purity and genuineness. There is nothing more abhorrent to a man of science than the pretenses of a scientific mountebank. This elevation is dual in its effect, general and local. As an evidence of the former there have resulted ameliorated conditions of society by protecting food from harmful adulterations, improved sanitation, better and more reasonable treatment for diseases, general distribution of the products of wealth among all civilized peoples, and in many other ways too numerous to mention. A reader after Count Tolstoy and his 'recognition of the bankruptcy of experimental science,' can not but be impressed with his earnestness, and yet feel that he looks only very close at home when he writes: ''The men of science of our time think and speak and the crowd follows them, while at the same time there was never a period or a people among whom science in its complete significance stood on so low a level as our science to-day. One part of it, that which

should study what makes life of man good and happy, is occupied in justifying the existing evil conditions, while another part spends its time solving questions of idle curiosity.'' He does not apparently realize that science promotes a certain continuity of ideas, as well as the intellectual and moral education of the nations.

> There exist, indeed, and always will exist, many deplorable things, much suffering, and much wickedness in the world; but it is to the credit of science that, instead of lulling mortals with the feeling of their powerlessness into passivity of resignation, it has urged them to react against destiny, and has taught them the sure way by which they can diminish the sum of woe and injustice, and increase their happiness and that of their fellows. It has not accomplished this by means of verbal exhortations or *a priori* reasoning, but by virtue of processes and words really efficacious, because they are acquired from the study of conditions of existence and the causes of evil.

Further, as the editor of *The Popular Science Monthly* has said:

> The advance of science is evidenced in numberless ways, but our weightiest proof of it is found in the gradual acceptance of enlarged in place of narrower views of the subject. New discoveries are important; the widening of the ranges of research is important; the extension of generalization and better organization of positive knowledge are important; but more important still is the growing general recognition that science is the grand agency in modern times for reshaping the common opinions of the community.

The local elevating effect of work in pure science is the taking a man away from the sordid things of the world, and

> No life can be pure in its purpose, and strong in its strife,
> And all life not be purer and stronger thereby.

By this I would not be understood as placing him who works only in pure science on a pedestal, or intimate that he is superior to the other who makes a practical outcome of his scientific work the main object. I am well aware of the eloquent statements about this being an industrial age and the duty of young men to seek a technological education. Far be it from my purpose to exhibit the least antagonism to the general spirit of such appeals, for I endeavor to teach much of the same thing, but in it all and with it all, I would urge that the pure science be either kept ahead or abreast of commercial progress. Neither the pure nor the practical deserves to be developed alone. They are inter-dependent and have always grown together. The pure research has been utilized later in practise. Industrial demands have stimulated investigation. Illustrations abound. The destiny of nations has been changed by scientific investigations prompted either by search for research sake or by a commercial call. The history of indigo reads like a novel, for chemists have accomplished the task, not of producing artificial indigo, but the genuine indigo by artificial means. The modern spirit of pure science thus elevates man's ideals and that of the applied adds to his comfort, pleasure and happiness.

In advocating Du Bois Reymond's 'Hellenism' or the love of humanistic and scientific culture for its own sake, apart from all considerations of profit and advantage, I would not be understood as

> Nourishing a youth sublime
> With the fairy tales of science.

While I maintain that the dollar should not be the guiding star, there is no objection to dwelling upon the practical value of science; for, as Huxley has said: ''It has become obvious that the interests of science and industry are identical; that science can not make a step forward without, sooner or later, opening up new channels for industry; and, on the other hand, that every advance of industry facilitates those experimental investigations upon which the growth of science depends.''

It is well understood by those who have knowledge of the problem that the first line

of defense in industrial warfare is the educational centers. We are a great industrious and prosperous nation. Prosperity is the possession 'of enlarging opportunities to secure the gratification of our material, intellectual, social and spiritual wants.'

In the foregoing I have endeavored to show that science is an evolution. In the past, to be sure, at times it has marched with crippled steps; at present it is gripped into the vitals of nations. The modern spirit of science towards religion is sane and healthy; towards literature it leans in offering themes alive and seeking graceful modes for its expression; it fosters and grows with industry, so 'to choke the fountains of science is to dry the source of our prosperity.'

The progress of science among us very largely depends, as Draper has said, on two elements: first, our educational establishments; and second, our scientific societies.

School men within the past decade have learned that it is proper to send the whole boy to school and little by little science has come into the curriculum. There is room for much more sane science and its more widespread teaching, and it should be better taught. Let us teachers then have more to do with pushing the proper recognition of science before the attention of school boards, insisting upon adequate compensation, and let us have men and women ready-equipped for the work. Pardon a personal illustration. I use it solely because I know whereof I speak. Every year there go out from our laboratory at the university a dozen or more graduates who, with rare exceptions, and they are mainly my own assistants, are offered positions in other states. We can change this, and I take it as one of the things this academy may hold out for its accomplishment. How?

We teachers can and must get out and see the schools, confer with the boards, speak to the people, in short, see that wholesome works in science are placed in the libraries, tell of common sense hygiene, assist the great work and create like things to the farmers' institutes, popularize science. There is ' no discredit in popularizing science,' as Mendenhall has said, 'that popularizing what is not science is the thing that is to be shunned and avoided.'

This brings to our immediate attention the instructors in the various institutions that are making the teachers, making the preachers, the lawyers, the doctors, business men and the citizens. Boards of trustees must be made to clearly understand that time and equipment for these things must be had; boards of trustees must be made to understand that the best teachers are those who contribute something to that subject they would have better known and appreciated; boards of trustees must be impressed with the fact that with our present arrangements, most researchers must steal the time necessary from rest, sleep, social concernments and family pleasures and that it is not right, it is not just to make them mere teaching machines.

There is no question whatever but that many of the teachers in our institutions do the treadmill. All of this can not with justice be laid at the doors of our honorable governing bodies, however, for teachers are vain as other mortals. Some insert in catalogues a vast array of special courses, which either are solely for show, or, if they be given, of necessity, can not be with that fresh vigor which should characterize instruction. The man who does that voluntarily loves not really his science. It is far wiser to offer a few courses, give them well and contribute a bit, even a mite, to the sum of knowledge. I do not know but that the late Professor Rowland was a bit severe, yet I wish to quote from an address of his on a 'Plea for Pure Science.' Some chil-

dren may be coaxed, others require whipping.

It is useless to attempt to advance science until one has mastered the science; he must step to the front before his blows can tell in the strife. Furthermore, I do not believe anybody can be thorough in any department of science, without wishing to advance it. In the study of what is known, in the reading of the scientific journals, and the discussions therein contained of the current scientific questions, one would obtain an impulse to work, even though it did not before exist. And the same spirit which prompted him to seek what was already known, would make him wish to know the unknown. And I may say that I never met a case of thorough knowledge in my own science, except in the case of well-known investigators. I have met men who talked well, and I have sometimes asked myself why they did not do something; but further knowledge of their character has shown me the superficiality of their knowledge. I am no longer a believer in men who could do something if they would, or would do something if they had a chance. They are imposters. If the true spirit is there, it will show itself in spite of circumstances.

Your speaker wishes to plead with his southern colleagues for greater activity in research. Many have told me they had no appliances. Liebig had none at first and later bought most of that which he had from his slender stipend; Priestley utilized a lens and the sun's heat and discovered oxygen; Wöhler distilled potassium, using a bent gun barrel as a condenser in Berzelius's laboratory. Where there's a will, there's a way. There is so much unknown, so much to learn, and, as Victor Meyer has said, then there is 'the gaining of gold from rubbish.'

Yes, our equipment is meager; poorer than it ought to be for states now far richer than ever in their history; grown rich, too, as a result of the progress of industries. Science sowed the seed of the present prosperity and it is worthy of remembrance, thanks, reward. And these will come. In a measure, they have come. Every scientific man in the state takes pride in the growth of the new biological building at this institution, the beneficent generosity of a prominent trustee at Trinity College in equipping the physics department, the conduct of the soil survey under the direction of the Department of Agriculture, the Beaufort laboratory, etc.

The importance of promoting science as the duty of the states was well known to the ancients, especially to the Greeks and Arabs. The Prince Consort, in an address before the British Association in 1859, made the following statement:

We may be justified in hoping * * * that the legislature and the state will more and more recognize the claims of science to their attention; so that it may no longer require the begging-box, but speak to the state like a favored child to its parents, sure of his paternal solicitude for its welfare; that the state will recognize in science one of its elements of strength and prosperity, to foster which the clearest dictates of self-interest demand.

The endowment of any laboratory in any institution of the state but helps the others. There is no such thing as competition in doing good. The blanket of ignorance may be lifted a bit higher here than there, but each lifts and gives the fresh air of knowledge to those smothering beneath.

So, my friends, in fulfilling the responsibilities begotten of the honor, allow me in closing to give my conception of the destiny of this academy.

Man depends much for his happiness upon the sympathy of those around him; 'it is rare to find one with courage to pursue his own ideals in spite of his surroundings.' So science thrives best where societies exist for its advancement. Science speaks a universal language and knows no geographical, political or social boundaries, otherwise Humphry Davy would never have been so cordially entertained by his French colleagues when the shores of England and France bristled with bayonets in bloody antagonism. Then let us thank God for the brotherhood of science, for

true science, the spirit of modern science, is at war with war. The right spirit of science is that of patient inquiry; of longing for the truth, cost what it may in brain power, energy, money or self-denial; it is the spirit of cooperation as wide as the needs of man; of constructive effort through slow accretions by many laborers in many lands through many years. "The touch of science makes the whole world kin." CHAS. BASKERVILLE.

UNIVERSITY OF NORTH CAROLINA.

DEFLECTION OF THE MISSISSIPPI.

THE theoretical effects of the earth's rotation in deflecting the courses of streams have been discussed by several investigators, among whom are Baines, von Baer, Bertrand, Buff and Gilbert. The deflecting force being persistent and the time during which it acts practically unlimited, the sufficiency of the cause has been repeatedly maintained. So far, however, the discussion has been almost purely theoretical, few actual measurements of relative bank-cutting having been made. This note attempts to present certain qualitative and quantitative data that may have some bearing on the subject. The work was done at Harvard University under direction of Professor W. M. Davis.

The Mississippi River Commission published in 1900 a set of maps which record surveys of two different dates—that of 1883 and that of 1896. The former survey is printed in black, the latter in red. Thus the changes which have occurred in an interval of thirteen years are clearly and accurately recorded and make measurements possible of the relative amounts of right and left cutting.

The part of the river course so surveyed and mapped lies between Rosedale (below Helena, Ark.) and Bayou Goula Bend (below Natchez, La.). It may be divided into two distinct sections. The first lies between Rosedale and Vicksburg and is in that part of the river's course which here swings diagonally across the flood-plain from the bluffs of the Arkansas upland on the west to the bluffs of the eastern upland in Mississippi. The second is between Vicksburg and Bayou Goula Bend, along the eastern side of the flood-plain, where it is rather sharply limited by the bluffs against which the river impinges at ten different places. The two sections are roughly of the same length, when measured along the general course of the stream.

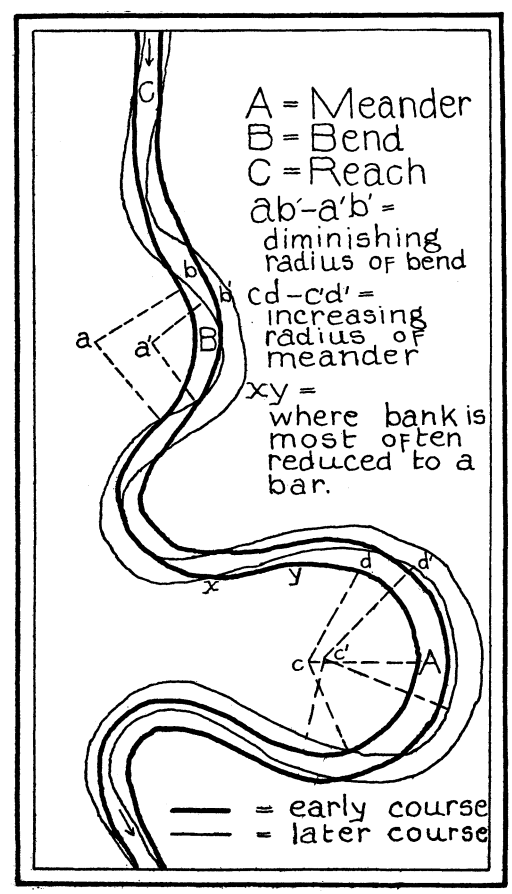

FIG. 1.

The lowermost part of the latter section —the part lying between Port Hudson and Bayou Goula Bend—has been in recent