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بسم الله الرحمن الرحيم

I commence it in the name of Allah with all His Gracious Attributes.

الحكمة ضالة المؤمن أينما وجدها فهو أحق بها

Philosophy—Science—is the lost property of a believer, where-
soever he may find it, he has a valid claim upon it.

(The Prophet.)

انا من ثناء أحبتي مقال
اذ حسنوا خلقي الذميم تعببا
اين العسود و تركه اداية
حتى يرينى من عيوبى ما اختبى

I complain of the praise of my friends who, out of love, paint my
defects as good points. Where is the searching critic who, going
out of his way, lays bare even my hidden faults?

رحم الله امرأ اهدى لى عيوبى

God bless the man who makes me a present of my faults and short-
comings.

(Caliph Omar.)



Publications of the Scientific Society, M. A.-O. College, Aligarh.

No. 1.

Inaugural Presidential Address

September, 1917.



SCIENTIFIC EDUCATION

WITH

SPECIAL REFERENCE TO THE MUSLIM UNIVERSITY, ALIGARH,
AND

INDIA'S NEGLECT OF SCIENCE.

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1ST EDITION.

Price One Rupee.

500 Copies.

PRINTED BY M. MUQTADA KILAN" SHIRWANI,
AT THE INSTITUTE PRESS ALIGARH.

December, 1917.

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FOREWORD.

No originality is claimed for the contents of this book. On the contrary, it is keenly felt by the author that the subject is, in several places, far from being well-digested or systematized and that the sequence of facts is not everywhere strictly logical. As a glance at the Analysis Table will show, the subject-matter is chosen primarily with a view to supply information to young minds about sundry Science topics. It is this informing purpose that mainly characterises my remarks. With this end in view, the last Section containing suggestions for preliminary scientific work, and a comprehensive Bibliography giving an annotated list of some of the more important popular scientific books, both English and Urdu, have been appended at the end. For the same reason, a large number of quotations from scientific literature have been freely included in the body of the book, for familiarising its readers with the ideas and writings of eminent scientists. Since the whole address was meant to be delivered in a short time, and the aim was to supply as much information as possible, it is evident that a compromise had to be effected, sacrificing fuller development and strict logical sequence to brevity and multiplicity of topics.

Although this book was originally written for the young I venture to hope that as it stands now it will afford to older persons, who will accept its limitations, interesting information concerning the scientific regeneration of India and the place of Science in a complete scheme of education. I may also add that Parts II and III and a number of paragraphs in the

other parts, as well, will perhaps appeal more to grown up persons than to the young folk or our "fresh and green" students.

I have tried to discuss some of the problems connected with scientific education and the Muslim University, Aligarh, seeking' to introduce a much neglected subject to those whom it directly concerns and who are the chief determining factors in the scientific uplifting of India. As a side-issue to this expression of my views about scientific education, I have ventured to invite attention to India's Neglect of Science as well as to the immense potentialities of the Indian mind for Research work of the highest order. The scientific development of indigenous industries and natural resources of India requires the patronage of the Government and the scientific awakening of all Indians, more especially the awakening of our leaders of thought and action. As President Thwing has aptly remarked in his monumental work—Universities of the World—the great needs of India are technical; the few technical-schools and colleges now established are insufficient in number and inadequate in force. Side by side with the broadest promulgation of scientific knowledge, India needs Captains of Industry, Technical Chemists and Discoverers of Truth.

In this connection, a recent utterance of the Right Honourable Dr. Addison, M.P., the newly appointed British Minister of Reconstruction (national reconstruction on scientific lines) is worthy of note. Speaking on October 3, at the Annual Meeting of the Library Association, he said that one of the features of the programme, which appealed to him, was the movement, apparently making considerable progress,

for the formation of commercial and technical libraries and for the setting up of research laboratories to suit the particular needs and industries of various districts...A working relationship between the higher educational authorities and the business community is absolutely essential to our industrial welfare, and public libraries can do a lot of valuable work—by placing information useful to industry at the disposal of the community.

So far, the scientific fertility of the Indian brain-power has been mostly confined to the Gangetic Delta and its vicinity : but the intellectual and industrial emancipation of the land can only be effected when we have a vast army of Discoverers and Appliers of scientific knowledge flourishing throughout the length and breadth of India. Such an ideal is not beyond our reach. Improved methods of education—diminishing the hateful dominance of examinations, (which so fatally hampers all progress and addles young minds) creating enhanced facilities for the development and exercise of scientific genius and last but not the least, using the mother tongue of the alumni for imparting scientific education—are bound to produce good results and usher in the scientific millenium for India as well.

The following pages were never meant for publication. I had jotted down my ideas—in an unfinished form—merely with a view to help me in the oral delivery of my Presidential address. My remarks were mostly addressed to the student members of the Scientific Society and it is mainly for the benefit of the Science students that I yield to the Resolution of the Society and the persistent demands of its indefatigable Honorary Secretary for the publication of this

book. To avoid unnecessary disappointment to all those in whose hands it may chance to fall, I wish to make yet another confession : that my mental inertia has well-nigh rendered it impossible for me to make adequate improvements in the address. Somehow I felt it easier to write a fresh pamphlet initially designed for publication than to recast the message that had been verbally delivered in a crude form. I hope some of my "mute, inglorious Newtons and Faradays" will determine the constants and specifications of such mental inertia, To all else, however, I apologise for the many shortcomings with which these pages are, as explained, sure to abound.

My colleagues as well as the public at large will estimate this work according to the utility, the instruction or the pleasure it affords them. But as Hermann Von Helmholtz said at the occasion of the celebration of his 70th birthday Jubilee in 1891, "an author is usually disposed to base his estimate on the labour it has cost him and it is but seldom that both kinds of judgement agree." However, I shall welcome criticism and difference of opinion, believing with the poet *اے ذوق اس جہاں کو ہے زیب اختلاف سے* that the world is better off in virtue of such differences and contrasts. I shall be fully repaid if students and other well-wishers of India take a more lively interest in scientific education and the industrial advancement of India.

In the end I thank all the members of the Society—my pupils and colleagues—gathered in the Inaugural meeting held on September 6, 1917—for the warm enthusiasm and patience with which they welcomed and heard this address for more than two hours even at the sacrifice of missing the Dining Hall

and for the keen interest which they evinced in its publication, when even after skipping through several portions, it was left unfinished. I wish particularly to thank Malik Nazir Ahmad, Alamdar Husain and Wajid Mahmud for helping me in running the Scientific Society, and Abdul Ghafoor Khan, Abbas Ali and several other Science students for helping me in the arduous * and tiresome task of correcting the proofs. It affords me pleasure to acknowledge my debt of gratitude to Khalifa Abdul Hakim M. A. (Alig.) who made a few suggestions about scientific poems while we were going to attend the meeting, and to thank Mr. H. Krall and Dr. Wali Mohammad whose unceasing interest in the affairs of the Society is a sure guarantee of its long and fruitful life, I gratefully acknowledge my indebtedness to the authors, and publishers also, from whose works and publications I have borrowed several quotations.

This address that was originally written in about three days and read out in two hours has been published with the greatest difficulty in about a month, although myself and several of my B. Sc. students were devoting practically the whole of their leisure time to the correction of proofs. I refer to this undesirable topic reluctantly ; nevertheless I believe that if the future Muslim University Press may immediately acquire "type" sufficient for the correct composition of more than twenty medium-sized pages at a time it will really be step in the right direction.

On behalf of the Scientific Society, I wish to announce that we shall be glad to exchange the publications of our Society with the publications of other institutions and to receive, with thanks, books and donations for the Scientific Society Library.

ANALYSIS OF THE ADDRESS.

SCIENTIFIC EDUCATION WITH SPECIAL REFERENCE TO THE MUSLIM UNIVERSITY, ALIGARH, AND INDIA'S NEGLECT OF SCIENCE.



N. B.—It is not unreasonable to hope that this Analysis Table coupled with the rather elaborate system of headings, margins, variety of types used in the text and other subdivisions of the subject-matter will facilitate the use of this book.

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PART I.

The Importance of Scientific Education and the Training Afforded by the Scientific Method of Investigating Truth,

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It is clear that theoretical scientific investigations must precede the applications of scientific knowledge for the good of humanity. The scientific "Researcher" should be perfectly free to work out his ideas about the discovery of Truth ; he should not be harassed with questions of utility. 38

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Tyndall's advice to American Scientists.

He said "Your most difficult problem will be, not to build institutions, but to discover men." In India there is no systematic search after genius nor are there suitable opportunities for its development. Tyndall said "Liberate genius from the hampering toils which struggle for existence often puts round it." Our motto should be men before buildings. 41

Appeal to Students of Science.

An exhortation to mute inglorious Newtons and Faradays to find out the Truth that they alone may be able to find. Patience and perseverance can overcome mountains. They should not be crestfallen or feel diffident about their latent potentialities. 4 3

Examinations are not the only test of ability: Helmholtz and Faraday had passed no high examinations. 43

Schuster's opinion about the value of laboratory training. "An intelligent student is capable of starting research work without previous, training," Solitary work should be discouraged.

There should be an intimate intellectual intercourse between students and Professors. Exaggerated impotrance is attached to full Practical Courses in Science : the student mind should be stimulated by a judicious training for early research work. 4 5

The fourfold division of scientific work.

1. The scientific research worker may bo called the Creator of Knowledge. Dr. J. C. Bose is the only Indian Discoverer of Truth. 46

2. The Applier of Knowledge, or industrial research worker whoso function is to find out a use for the facts and principles of Science. 4 6

The Science of the use of Science. 4 7

3. The Promulgator of Knowledge or the Teacher (Professor, Lecturer) of Science. 4 7

4. The Technician or engineer. 4 8

Usually these four classes of scientific workers are not clearly differentiated, especially in India and other scientifically backward countries. The advantages of this fourfold division of scientific work. The immense progress of Organic Chemistry is due to this healthy division of work. Technical chemists are employed by European firms for originating economic methods of preparing scientific products on a commercial scale 4 8

The crying need of India : the extraction of dyes from its immense vegetable wealth. The Dixon Chemical Works at Dera Dun and the successful preparation of Thymol (essence of Ajwain) by an Indian chemist, , . . . , 4 9

Applications of Science are responsible for the tremendous increase of wealth in modern times.

These applications are fruitful on account of the work of the Applier of Knowledge—the industrial research worker—whom Dr. slosson calls **the middleman between the scientist and the mechanic**, ... 50

Any -civilized society can flourish and remain healthy only if this fourfold division, of scientific work is scrupulously

observed. The harmful effects of ignoring it are illustrated by the decay of the Chinese nation. Chinese bankruptcy 'in original scientific thought and their consequent downfall establish the importance of pure scientific Research, . 52

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India's urgent needs are technical ; so that although pure scientific research may not be totally ignored, we require a larger number of industrial research-workers, technicians and scientists who should harness Science into the service of mankind. Our guides and councillors are ignorant of Science ; they are blind leaders of the blind, ... 54

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Some suggestions for imparting better Scientific Education in schools and Colleges:

1. The gulf between theoretical scientific education and practical engineering should be diminished. 60

2. Text Books should be abolished and special courses

of study should be prepared for meeting the requirements of Indian students, ... 60

3. The difficulty of a foreign language as the medium of instruction in Science should be removed by making Urdu the medium of instruction in school classes and by starting the study of English in class VII after the student has learnt to express his ideas in Urdu at least. 62

The Usmania University Scheme of making Urdu the medium of instruction and the Translation Bureau established at Hyderabad, Deccan. 61

Professor Mann's suggestions about the teaching of Physics *via* the psychological method should be substituted for the logical method at present followed. 62

Heuristic method of teaching Science.

Science and Literature. Quotation from Sir J. Fitch's book *Educational Aims and Methods*. *A copious vocabulary is a store-house of thoughts*. Indebtedness to Professor Meiklejohn for the name of the method. The Heuristic method of teaching Science is to put the student in the position of the discoverer, thus stimulating inquisitiveness and thinking more than bare acquisition and an unintelligent collection of pre-ascertained facts. Conclusion. 64

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Urdu Translation of readable books in Science.

The importance of the Urdu Section of the Scientific Society : it affords a capital opportunity for mastering such subjects which the difficulties of a foreign language may render unintelligible or hard to grasp. Scientific allegories and tales: the story of "the monkey that would not kill." 67

Scientific poems-both gay and grave. Examples of English poems by Clerk Maxwell. Scientific passages from the Masnavi M'anavi and In Memorium 6 9

*The Early Musalmans had made great progress in Science :
they taught it in their schools and colleges.*

Newton and Darwin were partly anticipated by Muslim scientists in the thirteenth century, The Masnavi Rumi proves that they knew about Gravitation, Evolution, Magnetism etc. The scientific passages of the Masnavi can not be explained away as poetic flights of imagination : cf. the scientific lines used by Tennyson in In Memorium. We are diffident about the scientific achievements of the early Muslims (1) because of Muslim degeneration in subsequent centuries and (2) because of the ruthless destruction of Muslim libraries and other stores of knowledge, so that now it is difficult to trace their scientific achievements. 7 1

Colonel Ingersoll's tribute to the scientific greatness of Musalmans during the Dark Ages of Europe. Students should try to explore this forsaken field: it is yet unexplored; no scientist has yet thrown light on the scientific achievements of the early Musalmans ; the only book available, so far, is Maulvi Habibur Rahman Khan's *ulama-i-Islam*. , 75

Through the scientific use of the imagination Urdu poetry can be enriched, ... , . 7 7

A "Register of Scientific Querries" should be kept in the Scientific Society Library. 7 8

Students should be honest workers : the precious years of life should not be wasted in idle frivolity or the summer madness of pointless excursions. 7 9

Recapitulation and apology for not economizing expression. Concluding remark: "Not as servants of Mammon do ask you to take Science to your hearts but as the strengthener **and** enlistener of the mind of man."

The Scientist's rhyme. .

SCIENTIFIC EDUCATION

WITH

SPECIAL REFERENCE TO THE MUSLIM UNIVERSITY, ALIGARH,
AND

INDIA'S NEGLECT OF SCIENCE.

INAUGURAL PRESIDENTIAL ADDRESS

DELIVERED BY

Professor Feroz Din Murad, B, A., M. SO.

*(before a meeting of the Scientific Society, M. A.-O. College, Aligarh,
held on September 0, 1917, at 11-30 a. m. in the
new Chemistry Lecture Theatre.)*

INTRODUCTORY.

WHEN the Scientific Society was revived for the first time in 1915 after a pretty long slumber of half a dozen years, I wrote a short History of it which was read to the members assembled in an inaugural meeting like the present and later on published in the Aligarh Monthly. Till the end of that Epoch, the average number of meetings held in a year was 1'7; including the years of slumber our annual average till today is 2*1—23 meetings in all having been held in the last 11 years and odd months. In my report, I had traced back the history of the Scientific Society's activities till 1906, but the latest research about the early history of the College and its dependant *learned* Societies has proved that the pedigree of this learned Society of ours can be traced back to the Sixties and Seventies of the last century—as a matter of fact this Scientific Society is the oldest Society of the College—it is as old as the defunct and memorable Scientific Society of the late **Dr. Sir Syed Ahmad Khan**. It will be pleasant, perhaps, to bear in mind, that **when we shall hold the First Anniversary meeting of our Society this year, as we hope to, we shall be virtually celebrating**

its *Fifty First Anniversary*. I mention all this to appeal to your Scientific Spirit and I earnestly hope that if you bestir yourselves you shall surely be able to show as much work in one year as has been done in the past. 11 years of the Society's recorded history by preparing Scientific papers, by arranging open-air or Strachey Hall lectures on popular Scientific subjects for the benefit of the Arts students and by giving experimental demonstrations and Optical lantern shows.

PART 1.

The Importance of Scientific education and the training afforded by the Scientific method of investigating Truth with a brief discussion of the type of the University that should be established at Aligarh.

I shall now pass on to the subject matter of my address :—
Some thoughts about Scientific Education in general.

"Knowledge is of Intrinsic, quasi-intrinsic, and Conventional worth. Truths of Science are of intrinsic worth. Study of languages is of quasi-intrinsic, and History, of conventional worth, because the mere memorising of dry dates and dead facts has no bearing upon ordinary life'

This is an emphatic utterance of Herbert Spencer and it deserves careful consideration at the hands of all students desirous to choose a suitable course of studies.

"The first experiment a man makes is a physical experiment, he is a natural philosopher (physicist) by instinct and the suction-pump is but an imitation of the first act of every new-born infant. Nor do I think it calculated to lessen that infant's reverence or to make him a worse citizen, when his ripe experience shows him that the atmosphere was his helper in extracting

the first draught from his mother's breast. The child grows but is still an experimenter : he grasps at the moon and his failure teaches him to respect distance"

(TYNDALL.)

"Whatever other reforms our educational system may demand, there is a fairly universal agreement that the mental equipment of our future citizens must include wider Scientific interests and sympathies." (Vide The Scout and Science. The School World, August, 1917.)

As the old song says :

Could a man be secure
That his day would endure
As of old, for a thousand long years,
What things might he know !
What deeds might he do !
And all without hurry or care.

But, as Herbert Spencer rightly says, we that have What knowledge but span-long lives, must ever bear in mind is of most worth. our limited time for acquisition. And remembering how narrowly this time is limited, not only by the shortage of life but also still more by the business of life, we ought to be specially solicitous to employ what time we have to the greatest advantage. Before devoting years to some subjects which fashion or fancy suggests, it is surely wise to weigh with great care the worth of the results as compared with the worth of various alternative results which the same years might bring if otherwise applied. In education thdn, this is the question of questions, which it is high time, we discussed in some methodic way.

The fundamental question in education is—**What knowledge is of most worth?**

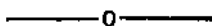
Students can not do worse than ignore this basic question of supreme vital importance. After an exhaustive survey of

the relative merits and demerits of the various subjects of study, Spencer has given a satisfactory answer to this question in his monumental work on education.* It will not do to reproduce his arguments in favour of Science here, but I will briefly indicate to you his reasons for arriving at this conclusion.

In the order of their importance, human activities can be arranged into :—(1) activities which directly or indirectly minister to self-preservation (2) activities for the preservation of the family and the race (3) social and political activities and (4) those miscellaneous activities which fill up the leisure part of life, devoted to the gratification of the tastes and the feelings.

Now for direct self-preservation or the maintenance of life and health, the all important knowledge is—Science, the Science of Physiology, Hygiene, Medicine, etc. For that indirect self preservation which we call gaining a livelihood, the knowledge of greatest value is—Science, and the *Science of the use of Science* which we will shortly explain in the sequel. For the due discharge of parental functions, the proper guidance is to be found only in—Science. And for purposes of discipline—intellectual, moral, religious—the most efficient study is once more—Science. **Hence to the question what knowledge is of most worth ?—the uniform reply is—Science,**

An all-round sound character coupled with a good scientific knowledge constitute the two chief essentials of a Perfect Life.



CHARACTERISATION OF THE MUSLIM UNIVERSITY, ALIGARH.

The Universities of the world have been classified into four characteristic types. *An important determining factor in the evolution of a University at Aligarh is the attitude of the student community.* I ask you to consider which type of the University would you like to have at Aligarh.

• Vide 1st Chapter of H. Spencer's Education, Mental Moral and Physical.

"The Universities of the world easily fall into four classes. This classification cannot be made exact, but it does serve to represent the variety and the value of the world's higher education.

One class, and perhaps the more normal, has for its purpose the discovery and the publication of Truth ; the schools of this class are devoted to learning and to scholarship; the laboratory and the library are their tools and observation represents their method. The universities which are called rather by the social than by the geographical name of German are the more conspicuous members of this class, they represent the more impressive form of the higher education of modern times.

A second class is the type which has for its primary purpose the development of character through the power of thinking. Scholarship finds its place, too, in this class, but less dominantly. The universities of this type find their best embodiment in the Scottish Universities and in those of the United States of America.

A third type has for its real, though seldom spoken of, purpose the making of the gentleman. This purpose is not the object of public proclamation. Such proclamation would be ridiculous and result in a lack of achievement, but the universities of this class do use scholarship and disciplined thinking as methods of creating men who are interpreted by the word gentlemen—in whom the intellect, the heart, the conscience, the will and the aesthetic faculty are so blended and made so harmonious that they become at home in any society. Oxford and Cambridge are the finest examples of this type.

It is a far cry to the fourth type of the University, a cry far in place and function ; this class seeks to train men of efficiency ; its members endeavour to make graduates who are able to earn their living. The universities of this class belong especially to the far East, they are found in India, China, Japan.

The characteristics of all the Universities of each of these

four classes are, of course, found in less or greater degree in every University. No precise demarkation can be made. The institution, which is primarily designed to promote scholarship, also develops the power of thinking, trains the gentleman and promotes efficiency. The University which results in training the gentleman is also scholastic, promotes thoughtfulness and should result in efficiency. Each University of each of the four types represents the characteristics of the other Universities of the other types." (Vide Universities of the World by Ch-F. Thwing, L.L. D.)

CHARACTERISTICS OF THE INDIAN STUDENT.

The following frank expression of opinion by the same eminent educational authority, gives a correct diagnosis of some of the defects obtaining in our system of education.

" The Indian student is not a student of the type in which the College officer and teacher rejoices. He lacks those virtues which are summed up in the good old word *thoroughness*. He finds it hard to concentrate his mind on a single subject. His heart seems fixed upon the prizes which the higher education may offer, rather than upon the higher education itself. He sacrifices power to honour.

Closely joined with the lack of thoroughness is the too high place given to memory in scholastic^ concerns. The Hindu has a quick power of learning. (Sic. He means the Indian student as such). This power is greater than the power of reasoning." (The Indian students are also (labelled as being more acquisitive than inquisitive, suffering from a *lack of the sense of proportion* and addicted to habits of exaggeration).

" A further difficulty under which the higher education The hateful system in India labors is the dominance of the examination. That dominance which has so long prevailed in England, and in so many respects disastrously, has tyrannized Indian education for more than half a century, the successful issue of an examination is the goal, far off or

near, on which the student fixes his heart The influence of the examination system has been and still is evil. It stimulates mere learning; it represses thinking ; it narrows the scope of training and "it robs education of its liberalizing character. It makes the student a collector of facts, and not a gentleman of culture and of intellectual, ethical and aesthetic appreciations. But be it added, in India, as in England, this system so narrowing, so devitalizing, is losing somewhat its enslaving grip and influence."

It has been said that the essential difference between a University and a College is in the way they look. The *University looks forward and the College looks backward*. The aim of the one is discovery ; the aim of the other is conservation. One gropes for the unknown ; the other holds on to the known. We hope soon to have the M. A.-O. College raised to the status of a University and it is right to expect that the University at Aligarh will be a great centre of learning and discovery.

It is not at all an extravagant wish that we would have larger numbers of students attending Science Laboratories, a host of post-graduates carrying on Research Work in the various branches of Science, chairs of Applied Chemistry Electrotechnics and last but not the least a flourishing Scientific Society, really deserving to be counted as a learned Society, with a Journal of its own publishing the original Scientific contributions of members of the Muslim University. The great desideratum is that Aligarh should be a centre of Scientific culture, with a serious Scientific atmosphere pervading its hostels and other institutions. It is gratifying to note that at Lahore a Lahore Philosophical Society has been organised, on the lines of the Cambridge Philosophical Society.

We should awaken ourselves from the nadir of educational degradation, make Aligarh a centre and spring a University. of living culture, and like the ancient Saracenic Universities try our level best to bear aloft the torch.

learning to the world at large. We should take to heart, the sound views of President Thwing about the real nature of a University. He says "A University is not a building. A University is not even a collection of books as Carlyle said it was. *A University is rather a man ; a man teaching and a student learning as Muslim practice embodies it*". The teacher, the student and teaching constitute the sacred trinity of a University.

INFLUENCE OF SOCIAL LIFE ON THE WORK OF A SEAT OF LEARNING.

We should also not ignore Max Muller's pregnant remark that the reason English scholarship is inferior to German is the 5 O'clock tea. Apart from the doubtful correctness of this remark the metaphor contains for us a significant truth, since the undue dominance of social life tends to retard the development of scholastic element in a centre of learning.

On this point, Dr. Slosson while reviewing the educational systems of the fourteen great American universities in his book of the same name remarks:—"the most vulnerable point in our collegiate system is the diversion of the interests of the student body from the true aims of the College. Social life, athletics, dissipation and the multitude of other student activities have cut down to the minimum the attention given to their studies.

Now students have never given as much attention to their books as their instructors think they should and there is no reason for expecting that they ever will. (Students are not a class, they are a race, the same all the world over, a union of contradictories, happy and serious, sober and frivolous, living for the day, thoughtful for the future, profligate and penurious, solitary and gregarious, indolent and laborious.) *But it is possible to have such an atmosphere in a University that the students will have scholarly interests, will prize scholarly honours and will cultivate scholarly diversions. Such an atmosphere has been maintained in many places and for long periods" and it*

ATMOSPHERE IN COLLEGES.

is not unreasonable to hope that it may be established in our great-University-that-is-to-be-at-Aligarh. I hope, students of Science, that the much longed-for intellectual atmosphere of AUgarh will find its practical expression and embodiment through you and in you.

Dr. Slosson also advocates inter-collegiate and inter-university contests in intellectualism as an incentive for shining in scholastic pursuits. On page 508 of his book, *Great American Universities*, he describes an animated *intellectual tournament* in which two rival universities give a public exhibition of the annual intellectual output of their respective alumni.

It is believed that great universities in great cities are usually better fitted to promote the discovery of truth than to train men, and that small colleges, placed in small towns are usually better equipped for the training of men than for the discovery of truth. Judged in this way Aligarh is favourably situated both for the advancement of learning and for the training of men since it is neither a great city nor a small town far removed from the great centres of population.

Further as students of Science, you must beware of intellectual gorging or unintelligent acquisition. Here I give another remark made by President Thwing :—

"The fundamental intellectual difference between the education of the East and the education of the West lies in the fact that the education of the East emphasizes learning, employing the memory, as its chief intellectual force, and the education of the West emphasizes thinking, employing reasoning as its chief intellectual faculty."

I hope you will free yourself from this taint, and instead of becoming collectors of facts, try to develop your reasoning faculty and power of thinking. I strongly recommend Professor Dewey's excellent book, "How to Think" to your notice.

SCIENCE AND CIVILIZATION.

Science **has** imparted a lasting stability to modern **civilization***

It has been aptly remarked that it is simply impossible for us to revert to the uncivilized condition. It will perhaps be objected to that the present European conflagration in some of its phases, at least is a reversion to barbarism but it will also be readily admitted, that what is barbarism from the moral standpoint, is drowned into insignificance when we regard the War as an unparalleled and gigantic display of scientific achievements—*an exhibition of scientific perfection*. Apart from the military preparedness of Germany it is now patent to the whole world that amongst other causes, Germany has been able to conduct the war as she has done so far, on account of the invention of the gyro-compass, so very useful in the automatic correct steering of torpedoes, the perfection of the aeroplane and airship, the fixation of atmospheric Nitrogen and scientific methods of tillage and cultivation. Science is a two-edged weapon which can be used equally well for the good of humanity or for its destruction, and certainly it is not a duty of the discoverer or inventor to pause to consider if his contribution to the advancement of learning can possibly be mal-applied.

DEFECTIVE MORALITY BATHER THAN SCIENCE, RESPONSIBLE FOR WAR.

It will be interesting to ponder over the following quotation from Nature cited by the Editor of the Scientific American in a recent issue :—

"A few days ago, a correspondent of the Daily Mail resuscitated a well-known quotation from George Gissing's "Private Papers of Henry Ryecroft" in order to associate Science with the horrors of the present war. The words are as follows, "I hate and fear Science, because of my conviction that, for a long time to come, if not for ever, it will be the remorseless enemy of mankind. I see it destroying all simplicity and gentleness of life, all the beauty of the world ; I see it restoring barbarism under the mask of civilization; I see it darkening men's minds and hardening their hearts ; I see it bringing a time of vast conflicts, which will pale into insignificance 'the thousand

years of old and as likely as not, will overwhelm all the laborious advances of mankind in blood-drenched chaos.' We have on several occasions pointed out that it is merely pandering to popular prejudice to make Science responsible for German barbarity or for the use of its discoveries in destructive warfare. Chlorine was used as a bleaching agent for much more than a century before the Germans first employed it as a poisonous gas; chloroform is a daily blessing to suffering humanity, but it is also used for criminal purposes; potassium-cyanide may be used as a poison or to extract precious metals from their ores ; and so with other scientific knowledge—it can be made a blessing or a means of debasement.

The terrible sacrifice of human life that we are now witnessing is a consequence of the fact that the teaching of moral responsibility has not kept pace with the progress of Science. Just as in medieval time all new knowledge was regarded as of diabolic origin, so even now the popular mind is ever ready to accept such views of the influence of science as are expressed in Gissing's work. The pity of it is, that the public press does nothing to dispel illusions of this kind by urging that what is wanted is not less scientific knowledge, but a higher sense of human responsibility in the use of the forces discovered."

That the European War has not come as a sudden surprise **Haeckel's diagnosis** is now clearly settled. Of late the **influence** of the malady of of Mars was felt throughout Europe ! and the Europe. alarmingly rapid progress of Science unbalanced by a commensurate advancement in morals, was feared very much. Ernest Haeckel discussing the 'Riddle of the universe at the close of the Nineteenth century' in 1899, wrote thus : "An entirely new character has been given to the whole of our modern civilisation, not only by our astounding theoretical progress in sound knowledge of Nature but also by the remarkably fertile practical applications of that knowledge in technical science, industry,, commerce, and so forth. On the other hand, however, **we have made little or no progress in moral and social life in comparison with earlier centuries at times there has been serious reaction.** And from this obvious conflict

there have arisen, not only an uneasy sense of dismemberment and falseness, but even *the danger of grave catastrophes in the political and social life*. It is, then, not merely the right, but the sacred duty of every right-minded and humanitarian thinker to devote himself conscientiously to the settlement of conflict and to warding off the dangers that it brings in its train.

SERVICES OF SCIENCE.

From this point of view, there can not be two opinions about *the utility of Science*. Lord Macaulay whom you all know as an eloquent historian, thus enumerates some of the services rendered by Science in promoting human welfare :—

"Science has lengthened life ; it has mitigated pain ; it has extinguished disease ; it has increased the fertility of the soil, it has given new securities to the mariner, it has furnished new arms to the warrior (and the hunter,) it has spanned great

As I have pointed out above, it is not Science but defective morality that is really responsible for the War. Talking of the two Ideals
The two ideals of life.

of Life and the vast progress of Science, sir J. C. Bose says:.
"Such material activities have brought in the West their fruit, in accession of power and wealth. There has been a feverish rush even in the realm of science for exploiting applications of knowledge, not so often for saving as for destruction. In the absence of some power of restraint, civilisation is trembling in an unstable poise on the brink of ruin. Some complementary ideal there must be to save man from that mad rush which must end in disaster. *«.. He forgot that far more potent than competition was mutual help and co-operation in the scheme of life. . . . The weakling who has refused the conflict, having acquired nothing, has nothing to renounce. He alone, who has striven and won, can enrich the world by giving away the fruits of his victorious experience. . . .

The ideal of giving, of enriching, in fine, of self-enunciation in response to the highest call of humanity, is the other and complementary ideal. The motive power for this is not to be found in personal ambition, but in the effacement of all littleness, and the uprooting of that ignorance which regards anything as gain which is to be purchased at others' loss Not through material acquisition, but in the general diffusion of ideas and ideals, can the true empire of humanity be established."

The supreme lesson we have got to learn is that the First Essential of a Perfect Life—both individual and national—is Character and not Science. A characterless Scientist is a devil with great powers of unbridled mischief. A scientist with character is the Beloved of God Hence follows the primary importance of Religion as a restraining code, of morals.

rivers and estuaries with bridges of form unknown to our fathers ; it has guided the thunderbolt innocuously from the heaven to earth ; it has lighted up the night with the splendour of the day, it has extended the range of the human vision, it has multiplied the power of the human muscles, it has accelerated motion, it has annihilated distance, it has facilitated intercourse, correspondence, all friendly offices, all despatch of business ; it has enabled man to descend to the depths of the sea, to soar into the air, to penetrate securely into the noxious recesses of the earth, to traverse the land in cars which whirl along without horses, to cross the ocean in ships which run ten knots an hour against the wind. These are but a part of its fruits, and of its first fruits."

Emersen, thus pays a tribute of homage to Science,

"The storm wind wove, the torrent span,
Where they were bid, the rivers ran ;
New slaves fulfilled the poet's dream,
Galvanic wire, strong-shouldered steam."

I daresay, students of Science, can, if they so desire, easily prolong these encomiums bestowed upon Science.*

In India, even the educated classes, not to speak of the Electricity man in the street, do not fully realise the as the Servant power—the immense power and usefulness—of man Science. We do not possess many opportunities of shaking off disbelief by demonstrating the serviceableness of Science in every department of life. For example, few here realise what a useful servant of mankind Electricity is, and

*Here is a pretty poetic utterance of our distinguished countryman Sir J. C. Bose. At the opening ceremony of his Research-Institute at Calcutta on the 30th of November, 1917, he said : —

"The power of physical methods implies for the establishment of that truth which can be realized directly through our senses, or through the vast expansion of the perceptive range by means of artificially created organs. We still gather the tremulous message when the note of the audible reaches the unheard. When human sight fails we continue to explore the region of the invisible, the little that we can see is as nothing compared to the vastness of that which we cannot. Out of the very imperfection of our senses, man has built himself a raft of thought by which he makes daring adventures on the great seas of the unknown "

how Chemistry helped by Electricity can supply the needs of humanity. In applied Chemistry, a revolutionary era was started by the advent of Electricity, and during the last fifty years, so many new processes involving the use of Electricity have been discovered that already " Electro-Chemistry " has been recognised as a separate branch of Chemistry and a large number of Electro-Chemical industries *e. g.*, manufacture of artificial manures, of synthetic diamonds, of calcium carbide, of organic compounds like chloroform and iodoform, fixation of atmospheric Nitrogen, electroplating, etc., have been started on big scales. With regard to the utilization of atmospheric Nitrogen, Alexander Findlay writes informingly thus,—

UTILIZATION OF ATMOSPHERIC NITROGEN.

Not only in Agriculture, but for the manufacture of dynamite, gun-cotton and all other explosives as well as for the production of dyes there is an ever-increasing demand for nitric acid and nitrates ; for the manufacture of soda, larger and larger quantities of ammonia are annually required.

In the atmosphere around us there is an inexhaustible supply of Nitrogen, and the problem of forcing this store of elementary Nitrogen has been solved and during the last 12 years, not one but several methods have been discovered whereby the atmospheric Nitrogen can, on a large scale and in a commercially successful manner be forced into useful combination with other elements.

In 1912 an announcement of the highest significance and importance was made by the Badische Anilin-und-Soda-Fabrik, to the effect that in collaboration with Professor Haber, of the Kaiser-Wilhelm Institute Berlin, their chemists and engineers had developed a process whereby the direct combination of Nitrogen and Hydrogen could be effected in a commercially successful manner. This process, the success of which is not dependent on cheap electrical power, consists in passing a mixture of Nitrogen and Hydrogen under a pressure of 150-200 atmos, and at a temperature of about 950° F. over Osmium

Uranium, or some other catalyst, that is, a substance which has the property of facilitating a reaction without itself being used up in the process. Owing to the development of this process, Germany now possesses the means of obtaining abundant supplies of cheap ammonium salts and can thus supply her agriculturists with ample amounts of the fertilizer, so necessary for intensive cultivation of the soil.

But the full significance of the synthetic production of ammonia begun on a commercial scale only in 1913, can be realised only when we recall another process, also developed in Germany, whereby ammonia can be readily oxidised or burnt to nitric acid, by passing a mixture of ammonia and Oxygen (or air) over heated Platinum. Without some means of obtaining nitric acid, no country from which the supply of Chili saltpetre was cut off, could wage a prolonged war, and it was indeed under the stimulus of apprehension (now an actuality) that such might be the fate of his own country that the German chemist, Ostwald, directed his attention to perfecting the process of burning ammonia to nitric acid, to which reference has just been made. Owing to the development of her Nitrogen industries, Germany has been rendered independent of all outside supplies of these compounds of Nitrogen, without which no country can continue to exist.

I suggest here the names of some of the books describing the services of Science for the benefit of students.

1. The Wonderful Century by Dr. Alfred Russel Wallace, an, excellent, concise, popular symposium of the scientific achievements of the 19th century as compared with the achievements of all preceeding centuries since the dawn of civilization.

2. Gresy's Discoveries and Inventions of the 20th century published by Messrs. Routledge & Co. Rs./8 as a sequel to

3. Robert Routledge's Discoveries and Inventions of the 19th Century. With the rapid advance of Science this book is a bit antiquated now, and can be read as a chapter in the history of the Science of the Use of Science.

4. A Century of Science and other Essays by J. Fiske.

5. The Progress of Physics during 33 years (1875—1908) by A. Schuster based on 4 lectures delivered to the University of Calcutta during March, 1908.

6. Whetham's Recent development of Physical Sciences.

John Fiske winds up his famous essays with these words :
 A Century of "Such is the scientific conquest achieved by science. the nineteenth century, a marvellous story without any parallel in the history of human achievement. (Students of science are probably aware that the 1st decade of the 20th century is still more rich in scientific achievement.) The swiftness of the advance has been due partly to the removal of the ancient legal and social trammels that beset free-thinking in every conceivable direction (I would like to point out here that whereas *freethinking* is a meritorious term in the English language, by a strange irony of fate, it has been degraded in its connotation in Urdu.) It is largely due also, to the use of correct methods of research. The waste of intellectual effort has been less than in former ages. Sound scientific method is a slow acquisition of the human mind and for its more rapid introduction in Priestley's time and since, we have largely to thank the example set by those giants of a former age, Galileo, Kepler, Descartes and Newton.

The lessons which may be derived from our story (viz. of the Century of Science) are many. But one that we may specially emphasize is the *dignity of man* whose persistent seeking for truth is rewarded by such fruits. We may be sure that the creature whose intelligence measures the pulsations of molecules and unravels the secret of the whirling nebula is no creature of a day, but the child of the universe, the heir of all the ages, in whose making and perfecting is to be found the consummation of God's creative work."

It has been appropriately said that Man is a tool-using animal. Weak in himself and of small stature, tool-using he stands on a basis at most, for, the flattest shod, animal" of game half square foot insecurely enough; has to straddle out his legs lest the very winds supplant him.

Feeblest of bipeds ! Nevertheless he can use tools, can devise tools; with these the granite mountain melts into light dust before him. He kneads glowing iron as if it were soft paste, seas are his smooth highway, wind and fire his unwearying steeds. Nowhere do we find him without tools ; without tools he is nothing, with tools he is everything.

SCIENTIFIC EDUCATION AS A MEANS OF INTELLECTUAL DISCIPLINE.

Now we pass on to consider another important aspect of Scientific education—*its value as a means of intellectual discipline enabling youngmen to become fit for the battle of life.*

Karl Pearson* says: "Modern science, as training the mind to an exact and impartial analysis of facts, is an education specially fitted to promote sound citizenship. Our first conclusion, then, as to the value of science for practical life turns upon the efficient training it provides in method."

I might clear a likely misunderstanding at this stage. Although the scope of science is co-extensive with the universe and although its material is endless, there being no end to the branches of systematised knowledge, yet all science, differing in its material is united in its method, and it is training in this Scientific Method of investigating Truth that is urged as the most powerful claim of Science. Further, besides the increased comfort due to Science, **the permanent gratification it yields to the aesthetic judgement is another claim of Science which is likely to be ignored or undervalued by those who are uninitiated into the beauties of Science.**

In his scholarly monograph ont "Light Waves and their uses," Michelson says : "If a poet could at the same time be a

*Grammer of Science by Karl Pearson. Vide Part I Physical, Indroductoty chapter about Science and citizenship. A charming book written in a masterly style.

One of the Decennial publications of the Chicago University (U. S. A.) issued in commemoration of the completion of the first ten years of the University's existence.

physicist, he might convey to others the pleasures, the satisfaction, almost the reverence which the subject inspires. The aesthetic side of the subject is, I confess, by no means the least attractive to me. Especially is its fascination felt in the branch which deals with light". The charms of Physical Optics—one of the most interesting branches of Physics—have also been eulogised by the late Th. Preston but we owe to Michelson the idea of a

Music colour *music analogous* to the ordinary *sound or ear music*. He ventures to predict that in the not very distant future, performances in *color music* could be given by a performer seated before a literally chromatic scale, playing the colors of the spectrum in any succession or combination, flashing on a screen all possible gradations of color,... producing, at will, the most delicate and subtle modulations of light and color or the most gorgeous and startling contrasts and color chords ! With this scientific use of the imagination, the poet's dream of rendering all the fancies, moods and emotions of human mind, seems well-nigh possible. *

To quote Karl Pearson again, "there is more real beauty in what science has to tell us of the chemistry of a distant star or in the life-history of a protozoon than in any cosmogony produced by the creative imagination of a pre-scientific age. By "more real beauty," we are to understand that the aesthetic judgement will find more satisfaction, more permanent delight, in the former than in the latter. It is this continual gratification of the aesthetic judgement which is one of the chief delights of the pursuit of pure Science.

It is an insatiable desire of the human mind to express in some brief statement, or some short formula, the facts of human experience. It is this innate desire that led the primitive

*. In the 46 th volume of the Science Progress, Dr. Houston (while discussing that Newton introduced his seventh color (indigo) partly because his own color vision was slightly abnormal, partly from a fancied analogy between the spectrum and the musical scale, influenced no doubt by Kepler's doctrine of harmonies) describes the underlying idea of color music on page 262.

man to account for all natural phenomena by supernatural agency, by deifying the wind, the shapeless stone and the flowing stream of water. And it is the same desire that leads civilized man to seek for generalisations and to express his physical and mental experience in brief formulae or the so-called Laws of Nature and Laws of Science.

After an incessant study of the planetary motions by two generations of astronomers, Kepler sums up this accumulated experience in three brief statements, known as Kepler's three Laws, but still a distinct spirit or god—a supernatural, non-physical agent—was required to guide each planet in the path it pursued. You see, this craving for accounting for the facts of observations by supernatural agency was still as strong in Kepler as it ever was in the primitive savage. Why should each planet obey Kepler's Laws or more directly how does each planet pursue its particular path was a fact calling aloud for an explanation. A cause to account for planetary motion was sought after. And even Kepler, unable to probe any further believed in gods and spirits who were constantly keeping the various planets in their respective orbits like chariots driven by men. It needed the force of a Newton's genius to displace these planetary gods and presiding angels by universal gravitation. So that ultimately it was explained that the molecular attraction between molar masses of matter is alone sufficient for explaining the peculiar motions of the various planets.

The above episode in the history of astronomy illustrates an important law in the theory of causation. Hamilton appropriately calls it the *Law of the Parsimony of causes*. It means that wherever smaller causes can sufficiently account for certain phenomena, bigger causes should not be applied there. (Beautiful illustrations of this law are afforded by the history of Evolution and General Biology.) It is evidently childish to rush into a supernatural explanation wherever a natural explanation is found sufficient to account for the facts. Once

admit the glaringly illogical principle that we may assume the operation of higher causes where the operation of lower ones is sufficient to explain the observed phenomena, and all our science and all our philosophy are scattered to the winds. **The law of parsimony constitutes the only logical barrier, between Science and superstition. For it is manifest that it** is always possible to give a hypothetical explanation of any phenomena whatever, by referring it immediately to the intelligence of some supernatural agent ; so that the only difference between the logic of science and the logic of superstition consists in Science recognising a validity in the law of parsimony which superstition disregards.

The aim of Science is to know Nature and to know it for the sake of knowing. The Latin word *scientia*
Aim of Science. signifies, broadly speaking, learning or knowledge. What then is the difference between Science and knowledge ? It is easier to give expression to the general conception of Science, as distinguished from knowledge, in metaphor than in reasoned definition. However, in general usage, the modern term Science has come to mean an ordered knowledge of the phenomena or appearances of Nature, and of the connection or relations which have been discovered between them. I mention here a few comparisons which illustrate the difference between Science and knowledge still more prominently. If knowledge be compared to a pile of bricks, Science is masonry. If knowledge is a shower of separate raindrops, Science is the mountain torrent to which they give birth. In short, knowledge is discrete, inco-ordinate, unsatisfying ; Science is concrete, co-ordinate, effective. With observation as the starting point, the mind amasses knowledge, and knowledge by provoking thought leads to the acquisition of fresh knowledge, out of which a wider thoughtfulness, builds, a scientific system,

CLASSIFICATION OF SCIENCES.

The classification of the sciences is in detail a very compli-

cated matter, and it would be too lengthy for the scope of this address to attempt even a brief survey of the various systems of classification, proposed by Bacon, Bain, Pearson, Spencer, Comte and a host of other scientists. Students of Science should study some of these systems. I mention here the names of some books which will help them much.

- 1, J. A. Thomson's Introduction to Science or Alex. Hill's Introduction to Science. Both are small shilling books and are really nice. They should be in the hands of every student of Science. Each contains a chapter on classification.
- 2, Comte's Positive Philosophy, First two chapters, published in a 6d. volume by the Rationalistic Press Association. I would like to remark, in passing, that the publications of this Association known as the R. P. A. cheap reprints obtainable at 6d. or 1s. cloth bound, should find a place in the library of every earnest student. For the full course of Comte's philosophy, students are referred to Miss Martineau's translation published in 3 volumes in the Bohn Library at 1/ each.
3. Flint's History of the classification of knowledge.
4. H. Spencer's classification of sciences.

Says Bacon : "The divisions of the sciences are not like different lines that meet in one angle but rather like the branches of trees that join in one trunk."

However, since it is of great practical importance to have in the mind some clear map of knowledge, I will mention here two fundamental points. W. C. D. Whetham* says "Custom and convenience have divided Science into 3 main sections: physical science, biological science and psychological science. Although the Greek word *physis* is perhaps equivalent to the Latin word *natura*, the name physical is confined, by general agreement, to that part of Science which deals with matter and energy without reference to life. Biological science, on

The Foundation of Science by W. C. 1). Whetham, F; R. S.

the other hand, treats of living thing and of those special problems of matter and energy to which their life gives rise. Psychological science is concerned with the phenomena of mind and the influences affecting it—primarily of course with the mind of man, but not exclusively so, since comparative psychology is investigating also the minds of animals."

PSYCHICAL RESEARCH.

I think the time is come when Psychical Research or the Spiritual Science should be classed as a distinct and definite branch of human knowledge. The realm of spirits is no longer *the* vague ghostland of old. Ghosts and spirits have now been experimented upon in a systematic and thoroughgoing manner that reflects credit upon human mind. The adherence of eminent scientists—physicists and philosophers—to the programme of the Society for Psychical Research and their public declaration of belief into life after death—the existence of the spirit or soul as a definite distinct entity—arrived at after a searching inquiry into the details of the problem, warrants this brief reference to a branch of scientific knowledge which here in India is relegated either to blind faith or to superstition. The proceedings, of the Psychical Research Society published in about 30 bulky volumes are a monument of human patience and inquisitiveness. If practicable, these should be studied, otherwise a shilling book entitled "Psychical Research" published by Messrs. Williams Norgate & Co., in the Home University Library will amply repay an intelligent reader. It is an excellent summary of the lines on which Psychical Research has proceeded so far. Meyer's Human Personality, (a standard Philosophical treatise in 2 volumes, of which some chapters have also been included in the Cambridge Mental Science Tripos Examination) and Sir Oliver Lodge's 'Survival of Man' are excellent and highly illuminating reading matter.

The relations between the various sciences are discussed in a separate science called the Science of knowledge or Epistemology, vide Mivart's Groundwork of Science.

THE TWO STAGES OF SCIENTIFIC KNOWLDGE.

The second point worth remembering is concerning the two stages of Science as defined by Lord Kelvin in his introductory lecture on the Scope and Methods of Physical Science. This lecture which he delivered in 1846 as Professor of Natural Philosophy in Glasgow University was repeated for over fifty years from the same manuscript. In the words of Lord Kelvin* :—

"In the progressive study of natural phenomena, that is, the phenomena of the external world, the first work is to observe and classify facts ; the process of inductive generalization follows, in which the laws of nature are the objects of research. These two stages are successively designated by the expressions of natural history and natural philosophy. In other words, there is an observational and descriptive stage, in which the discoverer or narrator is busied with observing facts, cataloguing and classifying them and filling up the gaps revealed in his natural classification. The latter stage is the stage of generalization and formulation, in which the facts being already gathered together, the in vestigator is concerned with discovering their mutual relations, and strives to bring them within the sweep of general laws or causes."

A quotation from Professor Tait will not bo out of place here. "Descriptive botany, natural history, volumes of astronomical observations etc. are collections of statements, often facts, from which scientific truth may ultimately be extracted, but they are not Science. Science begins to dawn, but only to dawn when a Copernicus and after him a Kepler or a Galileo sots to work on these raw materials, and sifts from them their essence. She bursts into full daylight only when a Newton extracts the quintessence. There has been as yet but one Newton." *"God mid let Newton be, and there was*

* Vide Appendix to chapter V, Life of Lord Kelvin by S. P. Thompson in 2 volumes. An interesting study and a mine of useful information.

light". This startling quotation simply refers to Newton's unifying discovery of the universal Law of Gravitation.

CHARACTERISTICS OF SCIENTISTS.

Ignorant people often betray themselves by calling men of Science impious and irreligious. Now in the first place, these two terms are not synonymous and on the other hand, my belief is that scientists lead godly lives, as a statistic study of the lives of eminent scientists of all ages can adequately prove. There is no real conflict between Religion and Science. The motive power of the actions of scientist may not be the same as that of a formally religious man but cognisant as they are, of the immensity of Nature and their own littleness, in so far as they are true votaries of Science, they dare not waste their lives in arrogant conceit or pointless actions. On this point, you should carefully attend to the words of Sir John Herschel. In his eloquent language, he says * "The character of the true philosopher is to hope all things not impossible, and to believe all things not unreasonable. He who has seen obscurities which appeared impenetrable in physical and mathematical Science suddenly dispelled and the most barren and unpromising fields of inquiry 'suddenly converted, as if by inspiration, into rich and inexhaustible springs of knowledge and power on a simple change of our point of view or by merely bringing to bear upon them some principle which it had never occurred before to try, will surely be the very last to acquiesce in any dispiriting prospects of either the present or future destinies of mankind ; while on the other hand, the boundless view of intellectual and moral as well as material relations which open on him on all sides in the course of these pursuits, the knowledge of the trivial place he occupies in the scale of creation, and the sense continually pressed upon him of his own weakness and incapacity to suspend or modify even the slightest movement of the vast machinery, he sees in

* vide Discourse on the study of Natural Philosophy by Sir John Herschel, one of the best treatises on Scientific Method ever written.

action around him, must effectually convince him that **humility of pretension, no less than confidence of hope, is what best becomes his character as a scientist.**

Life's waters run to waste when they are not controlled and employed by some intelligent agent. The hidden potentialities for good vested within every running passion and throbbing pulse of life, are not brought into play and made use of for better purposes until the magic eye of intelligence after meek years of patient research or with the sudden insight and flash of genius reads into the heart and mystery of things and lays bare the beauty, delicacy and immensity of God's creative work.

A scientist is alive to the beauties of Nature. The German poet Schiller says : "O wunder schon ist Gottes Erde, und schon auf ihr ein Mensch zu sein" which means: *O wonderful beautiful is God's earth and good it is to be a man upon it.* You will agree with me, when I say that the man who can really enjoy the beauties of God's earth and be thankful for the same, is one who devotes his life to the study of natural phenomena, trying to find out their hidden mysteries and beauties.

The characteristics of scientists are very tersely summarised in the following quotation from Charles Kingsley. He describes scientists thus: "Good men, honest men, accurate men, righteous men, patient men, self-restraining men, **fair** men, modest men. Men who are aware of their own vast ignorance compared with the vast amount that there is to be learnt in such a universe as this. Men who are accustomed to look at both sides of a question ; who instead of making up their minds in haste like bigots and fanatics, wait like wise men, for more facts, and more thoughts about the facts. In one word, men who have acquired just the habit of mind which the study of Natural Science can give and must give ; for, without it, there is no use studying Natural Science and the man who has not got that habit of mind, if he meddles with Science will merely become a quack and a charlatan,

only fit to get his bread as a spirit-rapper, or an inventor of infallible pills.

It is not claimed for science that it can provide a complete code of ethics, but science certainly does teach that every action must be rewarded and is rewarded according to its merits and that every deed carries with it a consequence—"not in another world but in this"—to be felt either by ourselves or by others, in our own time or the generations to come.

PATIENT INDUSTRY IS AN ESSENTIAL OF SUCCESS IN SCIENCE.

Let us now cast a glance at the lives and utterances of some of the most eminent scientists of modern times, and thereby gather the true method of doing scientific, work and turning our education to the best possible use.

Darwin writes* : "My success as a man of science whatever this may have amounted to, has been determined, as far as I can judge, by complex and diversified mental qualities and conditions. Of these, the most important have been—the love of Science, unbounded patience in long reflection over any **subject**, industry in observing and collecting facts, and a fair share of invention as well as of common sense."

"It is true to understand that no man can be considered to have received a liberal education unless he has some acquaintance with the principles of Science ; and that **the works of Darwin and Faraday are as worthy of national honour** as those of Tennyson and Scott. The training that ends in literary culture without Science is just as incomplete as one which promotes scientific knowledge without the power of clear expression." †

"That man I think has had a liberal education who has been so trained in youth that his body acts as the ready servant

* *vide* Darwin's Autobiography.

† *vide* Discovery or the Spirit and Service of Science by R. A. Gregory. An excellent book.

of his will, and does, with ease and pleasure, all the work that as a mechanism, it is capable of; whose intellect is a clear cold logic engine with all its parts of equal strength and in smooth working order, ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forgo the anchors of the mind; whose knowledge is stored with a knowledge of the great and fundamental truths of Nature and of the laws of her operations; and who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heal by a vigorous will; the servant of a tender conscience; who has learnt to love all beauty, whether of Nature, or of art, to hate all vileness, and to respect others as himself."

Huxley.

THE SECRET OF SUCCESS IN LIFE.

In his Inaugural Address delivered on November 30th 1917, Dr. J. C. Bose said, "The personal, yet general, truth and faith whose establishment this Institute commemorates is this: that when **one dedicates himself wholly for a great object, the closed doors shall open and the seemingly impossible will become possible for him.**

This day, 23 years ago, I resolved that as far as the whole-hearted devotion and faith of one man counted, that would not be wanting and within six months it came about that some of the most difficult problems connected with electric waves found their solution in my laboratory. That day the closed gates suddenly opened."

No other example culled from contemporary history can illustrate better the fruitful results of concentrating all our energies for the attainment of a single supreme object of life than the life-story of the great Indian scientist, Professor J. C. Bose. Many men gifted **with high brain powers pass ordinary mediocre lives, simply because they fritter away their limited stock of energy in too many pursuits.**

Even the hottest fire is dulled by the introduction of too many
 The Law of the poker in it, whereas a single poker will neither dull
 Conservation of the glow nor itself remain, unheated, in fare in
 human energy. our analogy is the stock of human energy and the poker represent

the diversified interests and pursuits of man. With one supreme object of life as the focus of all activity, marvellous success can be achieved, but ramified butterfly tastes end in nothing.

The great cosmic Law of the Conservation of Energy governs human activities as well. The sum total of a man's energy is constant; energy spent in one direction means its diversion from some other channel, and energy spent in empty talking lessens the amount available for action. To derive maximum effect, therefore, the main stream of human energy should flow in channels of utility, accompanied by its minimum possible waste in aimless pursuits, desultory talk or pointless action.

THE IMPORTANCE OF THE SCIENTIFIC METHOD AS A MEANS OF TRAINING YOUNG MINDS-

A serious defect in the scientific education imparted in The Scientific Indian Colleges is the little or no attention method is not taught to our bestow upon the teaching of the Scientific young men. Method. This course of action is as preposterous as building a lofty superstructure on flimsy foundations. The minds of the students are no doubt stocked with facts and some of them can talk in a learned manner about scientific subjects, but the majority of them gain no insight in the basic principles of Science, and the particular method of scientific investigation and rational inquiry remains, for them, a sealed letter. The importance of a thorough grounding in scientific method for giving an efficient scientific training can not be emphasised too much. Suffice it to say that the barrenness of scientific education in India can, in part, be certainly removed if a preliminary course of lectures, on "method" be regarded as an indispensable introduction to all Science teaching, since the method of scientific inquiry is perfectly general in its application to Physics, Chemistry, Biology, Geology etc, etc. A student ignorant of this can, at best, grope his way, as if, in the dark, without making any steady or well-directed progress. In the brief delineation of the scientific method appended here, I have concisely elucidated its main features, More than this

could not be done in an address meant to be read in a short time. But my object will be attained, if students of Science would grasp the educational importance of mastering the Scientific Method in full detail. The educative element in the study of the method can be best seen by going through all or any of the following excellent books about the method of Science:

1. Discourse on Method written, as a pioneer, by Rene Descartes.
2. Westaway's Scientific Method.
3. Armstrong's collection of papers on the "Teaching of the Scientific Method."
4. The Principles of Science by Jevons.

The last book is rather diffusely written, starting from the very elements of reasoning. At any rate, it used to be a Text Book prescribed by the Punjab University for the M. A. Examinations in Physics and Chemistry till 1907. There was a separate paper assigned to it and although I do not regard it as the best book on the subject, I deplore the removal of that paper on Principles of Science, since I think that questions in Science should not be set from particular text books, but that they should be based on the general principles of the subject, common to all good books.

And now without any further introduction, I will try to explain to you, in its barest outline, the salient features of the Method of Science.

The very first step in the application of the Scientific Method is the *collection of facts*—facts con-

A brief outline

¹of the Scientific concerning the prob

Nature. Now so long as man gathered his facts by *observation* alone, his stock of facts was very limited indeed; but when *experimentation* was once known, his progress became more rapid. In performing an experiment, it is possible to alter the attendant circumstances in such a way as to gather facts bearing on a certain point. The vast difference between the scientific achievements of the ancients and the modern man is primarily due to the ignorance of the ancients concerning experimentation. Aristotle's false statement that heavy bodies fall more quickly to the ground than light bodies was

meekly obeyed without anybody caring to verify whether this was actually so or not. For more than fifteen hundred years the darkness of blind homage to wrong authority prevailed, ultimately Galileo came, who on ascending the leaning Tower of Pisa performed *the first experiment* and dropping two stones of different sizes established, beyond doubt, the falsity of Aristotle's statement. This simple but bold experiment ushered in an age of experimentation. The next stage is the classification of the facts thus gathered.

But since the whole fabric of Science depends upon the basic facts, one must first make sure that **Caution about the collection of facts.** fact are correctly recorded. Even with

regard to simple problems, it is often difficult to get a grip of the facts of the case and even with regard to simple occurrences it is often difficult to give a quite accurate account of what takes place. It is often due to the untrained eye, which sees only what it has the power of seeing—sometimes little indeed and in the opposite direction—to preconceptions which often enable a man to see what is not to be seen. It is also due to lack of mental discipline ; as for example, nothing is commoner than a narration that mingles observations with unconscious inferences from observations. This is one of the common elementary fallacies.

When facts have been properly grouped together, and a sound classification has been arrived at, the *inductive step* is taken. Before proceeding further, I may briefly explain what *induction* means. Induction is a sort of generalization in which we go beyond our facts of experience. Fowler * defines Induction as the legitimate inference of the general from the particular or of the more general from the less general. This definition can be nicely illustrated by considering the well-known ^'Guinea and Feather" experiment. A guinea and a feather are

* *vide* Inductive Logic by Fowler. Jevons' Primer of Logic is an excellent elementary book for beginners. Welton's Manual of Logio published by the Tutorial Press in two volumes is also a nice standard Book of reference.

placed at the same height under the exhausted receiver of an air-pump.' When released, they are observed to reach the bottom of the vessel at the same instant of time. The inference drawn from the experiment is that but for the resistance of the atmosphere and other impeding circumstances, all bodies, whatever their weights, would fall through equal vertical spaces in equal times. There are two assumptions in our argument viz., the **Law of Universal causation** and the **Law of the Uniformity of Nature**. These two assumptions are based on the highest degree of probability—all the accumulated experience of mankind points to their truth, but such is the habit of scientific men, that they **differentiate certainly from even the highest degree of probability**, and although there can not be any two opinions about the uniform course of Nature, they will still not call it dead certainty. They leave their minds always open for correction and guide their opinions and verdicts by the sifted facts of experience alone.

When facts have been properly classified, the result of induction is the enunciation of a brief tentative statement pointing out the relationship between the facts and paving the way for future generalization and expansion. This brief statement is called a *Working Hypothesis*. The subject of the validity of an hypothesis forms a much-disputed part of Inductive Logic, but we are not concerned here with any controversial points. Suffice it, to say, when a valid working hypothesis has been framed, the next step is to deduce certain consequences from this hypothesis. The final test of the validity of an hypothesis is the confirmation of these theoretical deductions (consequences) by experimental means. This is called *verification* of the hypothesis. When there are two or more rival hypotheses, their relative claims are settled by performing **a crucial or test experiment**.

An hypothesis is verified completely in two ways :—

First, when the theoretically derived and calculated results, are found to agree with the practically observed **and** experimentally obtained results; secondly when fresh **cases**

having arisen and fresh facts bearing on the hypothesis having been obtained, they can be accounted for by our hypothesis. *When an hypothesis has been tested thus, it is exalted to the stage of a theory or law*, and the final statement of the modified and verified hypothesis is taken as the representation in words, of a Law of Nature as discovered by man.

Sometimes, laymen in Science object that since the theories of Science are ever changing, Science is not trustworthy. They should remember what Professor Poynting says on this point. "The hypotheses of Science are continually changing. Old hypotheses break down and new ones take their place. But the classification of known phenomena which an hypothesis has suggested and the new discoveries of phenomena to which it has led, remain as positive and permanent additions to natural knowledge when the hypothesis itself has vanished from thought"

But, as explained above, no final sanction is given even to such a theory or law. The scientifically trained mind is ever open to receive fresh impressions, no matter if they go against an old belief. If future facts belie a theory or any part of it, that theory or that part is renounced without **any** cant or dogmatism.

SCIENTIFIC DOUBT IS HONEST DOUBT.

From **all** this, it will be clearly seen that an important characteristic of the scientific mood is cautiousness. A scientist is one who habituates himself to withhold judgement when the data are obviously incomplete; who doubts conclusions that have been quickly reached or are based on scanty observations, and who hesitates in accepting what is particularly attractive whether in its simplicity or its symmetry. "The hardest of intellectual virtues is philosophical doubt and **the mental vice to which we are most prone is our tendency to believe that lack of evidence for an opinion is a reason for believing something else**. Suspended judgement is one of **the greatest triumphs of intellectual discipline**." The scientific

cautious desire to test everything is charmingly hit off in the following German definition of a Professor. "*Ein Professor ist ein Mensch der anderer Meinung ist*". A Professor is a man who is of a different opinion. Huxley's definition of Science as organised common sense and of men of Science as common men drilled in the ways of common sense is also worthy of note.

Having said so much about the scientific Method, let us now attend to Faraday's opinion about men of Science and their patient industry. He says : "The philosopher should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biassed by appearances ; have no favourite hypothesis, be of no school, -and in doctrine have no master. . . . Truth should be his primary object. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of Nature."

Talking of his own work, Faraday says in another place :

"The world little knows how many of the thoughts and theories which have passed through the mind of a scientific investigator have been crushed in silence and secrecy by his own severe criticism and adverse examination; that in the most successful instances, not a tenth of the suggestions, the hopes, the wishes, and the preliminary conclusions have been realised."

Huxley has written a famous paragraph in his autobiography, in which he expresses his aims in life thus: "If I may speak of the objects, I have had in view since I began the ascent of my hillock, they are briefly these : **To promote the increase of natural knowledge, and to forward the application of scientific methods of investigation to all the problems of life to the best of my ability, in the conviction which** has grown with my growth, and strengthened with my strength, that there is no alleviation for the sufferings of mankind except veracity of thought and action, and the resolute facing of the world as it is." The last words remind me of a

beautiful Persian adage, which the late Major Syed Hasan Bilgrami used to repeat to us in the M. A.-O. College Club :—

" Truthfulness is the concordance of deeds'with words and words with thoughts and from these three strings one tune is produced that none of them clashes with the rest."

HABITS OF ACCURACY ARE DEVELOPED By PRECISE MEASUREMENTS.

, Now let us turn our attention to another aspect of scientific education—the habit of accuracy and precision. All Science is measurement: as a matter of fact, *Science begins with measurement*. You all know the story of the discovery of Argon in atmospheric Nitrogen. This valuable addition to our knowledge which has proved itself to be the harbinger of other discoveries, was simply made because Lord Rayleigh and Sir William Ramsay possessed the scientific habit of accurate measurement.

It has been said * **"Future discovery lies in the sixth place of decimal."** Clerk Maxwell, f one of the greatest Physicists of the last century says : " This characteristic of modern Science—that it consists principally of measurements—is so prominent that the opinion seems to have got abroad that in a few years all the great physical constants will have been approximately estimated and that the only occupation which will then be left to men of Science will be to carry on these measurements to another place of decimal." Further he says: "Our principal work, however, in the laboratory must be to acquaint ourselves with all kinds of scientific methods, to

* *vide* Miehelson's Light waves and their uses.

† *vide* Introductory Lecture on Experimental Physics in Clerk Maxwell's collected works.

compare them and to estimate their value. It will, I think, be a result worthy of our University, if by the free and full discussion of the relative value of different scientific procedures, we succeed in forming a school of scientific criticism and in assisting the development of the doctrine of Method."

In his Presidential address at the meeting of the British Association at Dover in 1889, Sir Michael Foster* said :

"Man, unscientific man, is often content with "the nearly" and "the almost." Nature never is. It is not her way to call any two things which differ, the same, though the difference may be measured by less than the thousandth of a milligram or of a millimetre or by any other like standard of minuteness. And the man, who carrying the ways of the world into the domain of Science, thinks that he may treat Nature's differences in any other way than she treats them herself, will find that she resents his conduct; if he in carelessness or in disdain overlooks the minute differences which she holds out to him as a signal to guide him in his search, the projected tip, as it were, of some buried treasure, he is bound to go astray and the more strenuously he struggles on, the farther will he find himself from his true goal."

As scientific workers, I believe, you are all well aware that in measurements and observations the degree of accuracy attainable is not always the highest, and* that the degree of approximation varies with the individual. Some persons are **born measurers and experimentalists; there are others who** cannot be good measurers and just as we distinguished carpenters who can work to this or that fraction of an inch of **accuracy, so we must distinguish ourselves and our acquaintances as able to measure and record to this or that degree** of truthfulness. Thus it is that the work with the sextant,

**vide* Report of the British Association for the Advancement of Science (1889).

micrometer, or the chemical balance serves as an **apprenticeship in precision**—As Agassiz has put it: "A training in natural Science is one of the best preparations, a man can have, for work in any department of life where accurate carefulness and adherence to the facts of the case are of indispensable importance."

From all this, it will be clear that the value of Science as a factor in developing habits of precision, truthfulness and attention to details is no less important than its many other advantages referred to above.

A scientist never feels ashamed of getting a wrong result, provided it has been obtained honestly and by fair means. Students of Science should take this important lesson to heart—whatever work they may do in the laboratory, they must do it honestly. Fabricated observations and cooked-up correct results are worse than discordant observations and cent per cent wrong results.

In the forcible language of the Great Wizard,
This above all: to thine own self be true,
And it must follow as the night, the day,
Thou can'st not then be false to any man.

Furthermore, the following lines of Shakespeare should be compared with Faraday's words,* betokening the attitude of scientific workers, given on page 33 supra.

Give thy (immature) thought no tongue,
Nor any unproportioned thought, its act.
Give every man thy ear, but few, thy voice;
Take each man's censure but reserve thy judgement.

A scientist lacking in the **triple concordance of deeds, words and thoughts** is sure to cut a sorry figure in the battle of life.

PART II.

Scientific Research in India, with special reference to the development of her industries and natural resources.

Now I wish to devote a few minutes to a very important phase of our subject viz. the place of pure Science in a scheme of education. In this connection, I shall try to explain to you the real significance of Scientific Research and its importance as a source of inspiration for fostering useful industries.

In a letter addressed to Thomas Young, Fresnel says:

The spirit of for a long timethat sensibility or that Scientific Research. vanity which people call love of glory, has been much blunted in me. I labour much less to catch the suffrages of the public than to obtain that inward approval which has always been the sweetest reward of my efforts. Without doubt, in moments of doubt and discouragement, I have often needed the spur of vanity to excite me to pursue my researches. But all the compliments I have received from Arago, La Place and Biot never gave me so much pleasure as the discovery of a theoretic truth or the confirmation of a calculation by experiment." These words of Fresnel embody the fundamental truth about science viz. that it should be cultivated for its own sake, for the pure love of truth, for knowing more about Nature,—the work of God—rather than for the applause or lucre that it brings. Lives of eminent scientists who have left their mark behind, tell us that the motive which spurs them on "to forsake pleasure and live laborious ways"V nay even "to divorce that last infirmity of

man"—love of fame—is nothing but an all-absorbing interest in the investigation of natural phenomena, and an insatiable thirst for knowledge.

Tyndall has written a short but very interesting biography of Faraday. In this biography, an inspiring episode is told, viz. that at a certain stage of his career, Faraday was forced to ask himself and decide whether he would make wealth or Science the pursuit of his life. He could not serve two masters and he chose Science. In Tyndall's emphatic words. "Taking the duration of his (Faraday's) life into account, this son of a blacksmith and apprentice to a book binder, had to decide between a fortune of £150,000 on one side and his undowered Science on the other. He chose the latter and died a poor man. But his was the glory of holding aloft, among the nations, the scientific name of England for a period of forty years."

PURE SCIENCE VERSUS APPLIED SCIENCE.

Pasteur, whose illustrious name must be quite familiar to all of you, once said "I could never work for money, but I would always work for Science."

Here, then, is an apparent antagonism between the interests of pure scientific research and the so-called applied sciences. But I believe there is no real conflict between the two. Both are useful but you must credit superiority and priority to scientific research—the study of Science for the sake of Science ; and also, as the sequel will amply establish, you must keep in view that pure scientific education is the fountain-head from which* the stream of technical education flows and gains sustenance. It is clear even on a superficial view that the applications of Science must follow the pure investigation of knowledge. If the source dries up, the outflowing stream is sure to suffer and ultimately vanish. Thus it is obvious that the interests of pure scientific research and the applied sciences are not opposed to one another.

The only other question left is this : whether research in •Scientific Research Science should, from the very outset, keep a and utility material end in view or should the scientist be given a *carte blanche* to explore the vast domains of Nature at his pleasure. The history of scientific progress proves that all the great discoveries were made by men who had no practical end in view. The vast magneto-electric machinery and the huge electric installations which supply Electric Energy for doing a thousand and one things cheaply, profitably and conveniently are the result of an absolutely pure search after Truth.

Mr. R.A. Gregory has described an incident,-connected with the early stages of Faraday's discovery of electro-magnetic induction, in such an interesting way, that I feel tempted to quote him here. He writes : "The most original experimenter, the world has ever seen is lecturing before a distinguished audience at the Royal Institution in London. He shows that when a magnet is brought suddenly near a coil of wire, a slight current of electricity is produced in the wire. The experiment is not very impressive ; and a lady probably voiced the feelings of most of the audience when she asked afterwards, **But, Professor Faraday, even if the effect you explained is obtained, what is the use of it?"** The memorable reply was **"Madam, will you tell me the use of a new born child"?** And certainly the potentialities of a newly made discovery are far more certain than the chances of a newly born babe who may turn out a rogue and produce negative results seriously detrimental to the well-being of the society.

On another occasion, Gladstone put the same silly question viz. "What is the use of it" to Faraday about his discoveries, to which Faraday replied "Why Sir, there is every probability that you will soon be able to tax it!" and in this case, this reply was, as subsequent events prove, wonderfully correct and prophetic.

Scientists do not propose to themselves money as an end and knowledge as a means of obtaining it.

Thscience.for the most part they nobly reverse the process; they make knowledge their end, and such money as they possess, the means of obtaining it. At the same time, the scientific man as such, does not care whether his discovery puts a penny into the pocket of any human being. The history of Science, however, amply proves that scientific discovery may not only fill the coffers of individuals but may put millions into the exchequers of nations; but the hope of doing so, never was and never can be the motive power of the true investigator.

Writing upon this theme, Cuvier states "These grand practical innovations are the mere applications of truths of a higher order, not sought with a practical intention, but pursued for their own sake and solely through an ardour for knowledge. Those who applied them, could not have discovered them, but those who discovered them had no inclination to pursue them to a practical end. These rising workshops, these peopled colonies, these ships which furrow the seas,—this abundance, this luxury, this tumult—all this comes from discoveries in Science and it all remains strange to them. At the point where Science merges into practice, they abandon it; it concerns them no more."

I believe a great part of the misunderstanding may be removed if the terms useful and practical were

- rightly understood. Tyndall makes this knotty point clear in these words: "Surely, no two terms were ever so distorted and misapplied with reference to man, as these terms useful and practical. Let us expand our definitions until they embrace all the needs of man, his highest intellectual needs inclusive. It is especially on this ground of its administering to the higher needs of the intellect, it is mainly because I believe it to be wholesome, not only as a source of knowledge but as a means of discipline, that I urge the claims of science upon your attention."

We thus get the final answer to the question, which must surely have puzzled some of you. What then are the motives of scientific work, if the praise and reward of the world have no meaning? The answer is **Joy of discovery and love of truth and knowledge**,

TYNDALL'S ADVICE TO AMERICAN SCIENTISTS.

In a paper published in the Hindustan Review, September, 1913, I wrote, at some length, about the problem of Scientific Research in India.* I crave your indulgence for reading out a rather lengthy passage therefrom bearing upon the problem of Scientific education, which we are, at present, considering.

Tyndall delivered a series of scientific lectures in 1872-73 before a large scientific audience in New York. He had been invited there by all the American Scientists of note, who had raised a large fund, by way of remuneration, for Tyndall. But Tyndall, as a true votary of science, refused to accept any remuneration for the scientific services he had rendered them and advised them to use their money without stint for the promulgation of science. He wound up his course of lectures with the following pregnant words of advice from which the Americans have derived immense benefit and which, *mutatis mutandis*, can well be taken into serious consideration by all well-wishers of India. (And now that the Muslim University Scheme is in full swing, I will add that these words of advice should be duly appreciated by the Aligarh authorities: the Americans earned them after so much ado, now that they are in black and white they can be had gratis by all of us whose duty it is to make the Muslim University a successful venture.) Tyndall expressed himself in these words:—

"Your most difficult problem will be not to build institutions but **to discover men**. You may erect laboratories and endow them; you may furnish them with all the appliances needed for

**vide* Scientific Research in India by Prof. Feroz Din Murad, M.Sc. The Hindustan Review September 1913, pp, 709-716.

inquiry; in so doing you are but creating opportunity **for the** exercise of **powers** which come **from** sources entirely **beyond your** reach. **You can not** create genius by bidding for it. It is *the* gift of God, and the most you could do, were your wealth, and your willingness to apply it a million-fold what they are, would be to make sure that this glorious plant (*viz* scientific genius) shall have freedom, light and warmth, necessary for its development. We see from time to time a noble tree dragged down by parasitic creepers. These the gardener can remove, though the vital force of the tree itself may be beyond him, and so, in many a case, you men of wealth can liberate genius from the hampering toils which the struggle for existence often puts round it. Drawn by your kindness, I have come here to deliver these lectures. No lecturer was ever rewarded as I have been. From this vantage-ground, however, let me remind you that the work of the lecturer is not the highest work, that in science, the lecturer is usually the distributor of intellectual wealth amassed by better men. And though lecturing and teaching, in moderation will, in general, promote their mental health, it is not solely or even chiefly as lecturers (teachers of science, also called Professors in India and England) but as investigators that your highest men ought to be employed. You have scientific genius amongst you, not sown broadcast, believe me, it is sown thus nowhere but still scattered here and there. Take all unnecessary impediments out of its way. Keep your sympathetic eye upon the originator of knowledge. Give him freedom necessary for his researches, not overloading him with the duties of tuition nor demanding from him the so called practical results—above all things, avoid that question which ignorance so often addresses to genius, "What is the use of your work"? Let him make truth his object, however impractical for the time being, it may appear. If you cast your bread thus upon the waters, be assured it will return to you, though it may be after many days."

If we compare the United States of the time of Tyndall's Lectures, 1872-73, with the America of to-day, the contrast is astounding. But what has our own benighted unscientific country done during all these years? However, as we are, if the spirit of

Tyndall were to visit India at the present day, he would still repeat his old advice to us and I assure you, acting upon his advice, we would improve in no time.

AN EXHORTATION AND APPEAL TO STUDENTS.

Members of the Scientific Society, you are the flower of your college; its scientific hopes are embodied in your work. Most of you are yet upon the threshold of your scientific careers; believe me, your budding genius may bring honour to your country and to your *alma mater*; do not waste your opportunities; who knows **many a mute, inglorious Newton and Faraday may be sitting there** in the front rows; the college and its laboratories provide you with every facility and remember also, the world is no sluggard's paradise; be energetic and pushing, be not crestfallen and dejected; any spark of genius that you may have in you, make the most of it, fan it, till it glows and illuminates the world, at any rate preserve it till you have got a preliminary training in the method of Science—a necessary drilling which you should welcome and when you are able to prosecute post-graduate studies in Science, do not hanker after the loaves and fishes, be true to yourself and **with patient industry find out the truth that you alone may be able to find.**

Research work is a big term, but do not be frightened by names. You may not be able to shine in examinations but still you may become investigators of knowledge, if only you apply yourself strenuously in its pursuit. With **intelligent industry**, at your command you can say "open sesame" to the buried treasures of Nature, and exploring them, extend the bounds of scientific knowledge. Faraday, Joule, Newton and Helmholtz had not passed any advanced examinations in Science but still their work is an everlasting honour not only for them alone but for human intellect as well.

Even at the risk of lengthening out my discourse, I **may**

mention to you the story of the rise of Johns Hopkins University, U.S.A. It is not one of the biggest American universities, but it is (or rather was) famous as a seat of learning and teaching—the two things for which all universities should exist. One of its early Presidents took as his motto, "**men before building**" and it was due to this policy that this university shone out like a star. The President found some difficulty in the actual application of his motto. Hence he consulted an eminent physicist about it and asked him,

"we can not have a great university without great professors. We cannot have great professors till we have a great university. Help us from this dilemma."

The sound reply of the scientist was :—

"Your difficulty applies only to old men who are great. These you can rarely move. But the young men of genius, talent, learning, and promise you can draw; these should be your strength."

If it was because its President had the ability to discover **plants** before they were grown up, that Johns Hopkins became at once the leading American university. I hope and believe that the Aligarh authorities will man their university with similar intellectual giants in the making, and that some of you will grow up to be its eminent scientists and educationists. The gift of choosing the proper men is rare in our age, but believe me, your talents can not long remain unrewarded.

THE VALUE OF LABORATORY TRAINING.

Talking about the value of systematic laboratory training, A. Schuster says : * "Though, its educational value can not be, called into question, it is doubtful whether the systematic training in practical work, which has grown up during the last twenty five years, has had a material influence upon the

*Vide Progress of Science by A. Schuster, by A. Schuster,.

progress of Science The cardinal fact to bear in mind is, that previops tol870, when laboratory instruction, if given at all, was sporadic, the experimental skill of investigators was as great as it is now. We need only mention the names of Faraday, Joule, Helmholtz and Regnault, in support of that contention. The conclusion is irresistible that an intelligent student, possessing a sufficient amount of theoretical knowledge, is capable of Starting research work without previous special training. It is not for him that complicated laboratory courses have been designed, but for the ordinary student, who requires a certain amount of theoretical knowledge, which is acquired far more easily, if the principal phenomena are brought to his notice by practical work. The future investigator will, no doubt, ultimately save time, if at an early stage he acquires a certain amount of technical skill and becomes acquainted with physical methods, but otherwise the efforts of the teacher should be directed to stimulating his scientific!activity rather than sending him through all manipulations which he might possibly have to perform. If we place this stimulation of the mind in the foreground we must, all the more, insist on the necessity of securing an intimate intellectual intercourse between students and Professors. Accepting this,as the correct view, nothing can be more antagonistic to the true interests of a student than his condemnation to solitary confinement in a cell, while he is performing his first research. This tendency of laboratory designers to favour solitary work may be partly responsible for the small number of experimental discoveries which can be traced to the direct influence of laboratory teaching."

THE FOURFOLD DIVISION OF SCIENTIFIC WORK.

Now that we have discussed, at some length, the relations existing between pure scientific research, the diffusion of seientific knowledge and the application of scientific results to practical ends, we can sum up by saying that a scheme for the proper and useful distribution of scientific work should encourage the following four classes of workers:

First, the investigator of natural truth, the discoverer,
1. The Creator of knowledge. and originator of scientific lore; in one word, "the Creator of knowledge." His vocation should be to extend the field of discovery for truth's own sake, without reference to practical ends. All his energy must be focussed upon the pursuit of Truth, irrespective of its bearings upon industry, manufacture or utility. This pioneer work will be the mainspring and the storehouse from which the other three classes of workers will draw their material. But for him, their energies will bear no fruit.

Here in India, with the solitary exception of Dr. J. C. Bose, there is no other creator of knowledge, in the realms of Science. He alone commands the esteem of scientists all over Europe and America. The Aligarh University awaits this honour at your hands. Through your glorious work and discoveries, Aligarh can become the cynosure of the scientific eyes of the world.

Secondly, the Applier of natural truth, the practical investigator of the use of Science, the
2. The Applier of knowledge. practical research-worker and inventor whose vocation it is to show how scientific knowledge can be rendered available for the needs, comforts, and luxuries of civil life. He is not the ordinary Engineer; he is much above your Mechanical or Electrical Engineer. He is indeed the link that binds the discoverer of truth with the Engineer. Mr. W. F. Durand, Professor of Mechanical Engineering, recently delivered an address on the "Application of Science." To make my point clear, I will insert here a few extracts from his address.

"There are two fundamental motives determining interest in Science,

(1) a desire to know the universe, its constitution, phenomena and the laws of evolution, and

(2) a desire that the facts disclosed may be applied to the service of humanity.

Now all the facts of Science are not equally susceptible of useful application. Some possibly may have no such application. It is impossible to foresee the future. However, it is not unreasonable to assume that, in a large way, all facts of Science contain the potentiality of some useful application at some stage in the evolution of humanity on the earth.

SCIENCE OF THE USE OF SCIENCE.

The problem of the application of the facts of Science is that of bridging the gap between the observed facts and the correlated demand presented by the needs of civilization. This problem divides under two types :

1. Given a fact of Science, what is its application ?
2. Given a need of civilization, what is the foundation in Science for meeting the need ?

There is, thus, a specific need for the development of a new branch of Science; the Science of the use of Science. Hence, something should be done towards the development of a more orderly method for the establishment of a correspondence between the needs of humanity and the facts of Science, and we should look forward to this effort as one of the distinctive marks of progress in the 20th century—the beginning, at least, of the development of a Science of the use of Science."

I specially recommend the name of the new Science thus coined : the Science of the use of Science. The name clearly illustrates my point and shows the dependence of the useful work upon the absolute search after truth.

Thirdly, the Promulgator of natural truth, your Professor, 3. The Promulgator Lecturer, and Teacher of Science who gives of knowledge, public diffusion to the knowledge already won by the discoverer and inventor. He is the medium through which knowledge passes to the public mind ; without him, the layman in Science will be at a loss to understand the symbolism and shorthand technical expressions of the research worker. He is the popularizer of scientific lore.

Fourthly, we have the Engineer and Technical Expert, whose vocation it is to give practical expression to the suggestions made by the Applier—the Industrial Research worker—about the use of Science, Engineers, Captains of Industry, big Manufacturers employing the services of complicated machinery, etc. all come under this heading.

Generally speaking, the work of these last two classes of workers is mere routine work, void of any intellectual inspiration—one teaches old knowledge and lectures on known facts, the other uses machinery or makes machinery according to the directions of the technical specialist, the expert in the Science of the use of Science. But the teacher of Science, as such, may introduce original methods of teaching and impart knowledge by ways hitherto unknown, and the engineer may devise better and more efficiently working machines and therein lies the glory of their work.

Usually these four classes of scientific workers are not definitely differentiated. The discoverer and the teacher, and the practical research worker and engineer oftentimes merge into one another. If the discoverer stoops to teaching, the teaching may be exalted but the search after truth suffers. On the other hand, if the teacher has peeped behind the veil—has done some original research work—his teaching in that branch of Science, at least, is surely more inspiring and energising than ordinary routine teaching.

The distinction between the practical research worker and engineer is still less observed, but in the scientifically advanced countries, this distinction is responsible for a lot of good work. An example

An illustration of the four-fold division of Scientific work from Organic Chemistry.

would illustrate my point more clearly. Wohler first showed the possibility of organic synthesis in 1828. His discovery was the starting point of a new branch of Chemistry. Before his day, it was believed that compounds met with in animals and vegetables can only be made within a living system through the intervention of the life-process. Such compounds

were called organic compounds to distinguish them from the ordinary mineral or inorganic compounds which could be artificially prepared in the Laboratory. Wohler was the first to falsify this wrong belief by his artificial synthesis of Urea or Ammonium cyanate. Subsequent discoveries have developed the now Science of Organic Chemistry until to-day it is one of the most useful and important factors of modern civilization. But the name of Organic Chemistry would have remained shut up within the laboratory of the discoverer and the lecture theatre of the Professor, had not the applier and the expert technical chemist found out a use for this new Science. The artificial preparation of a large number of organic substances, like Indigo and Sachcharino, has demonstrated, beyond a shadow of doubt, the utility of Organic Chemistry. But the work of the technical chemist as an Applier of Science ends when he has shown that a given substance can be artificially prepared cheaply and abundantly on a commercial scale. The actual preparation, synthesis and refinement is the work of the chemically trained engineer. Rich firms in European countries employ such technical chemists, and laying huge funds at their disposal ask them to work in thoroughly equipped laboratories with the sole object of devising cheap processes or synthesising something new. Here in India, we have got an utter lack of such technical chemists—neither the Indian Government nor the Indian public has yet bestowed any attention to this question. No doubt, funds are wanted for encouraging well-trained chemists to take up technical research. But I assure you, there is no end to the problems yet awaiting solution. For example, India would most certainly be better off if somebody could devise some suitable process for the extraction of dyes from its immense vegetable wealth. All that we want to do is to encourage some of our expert chemists to take up this problem.

Again, there is Thymol (or the essence of **اَجَوَایْن** Ajwain) awaiting commercially cheap preparation. Before the war, Germany supplied Thymol to the markets of the world. In the

early days of the war, attempts were made to put Thymol prepared in India and England on the market, but the result was staggering ; it was found that the actual cost of preparing a pound of Thymol was about five times more than the price charged by German firms before the war. So, you see from this, that there is ample scope for the expert Technical Chemist—his research in this case will be to originate economical methods, but whenonce he has perfected those methods, the chemically trained engineer will step in and turn out the commodity in bulk.

It is a happy sign of the times that a Thymol manufacturing company with English capital has been organised, with its chemical works at Dehra Dun and it is further gratifying to note that an eminent Indian chemist has, with his intelligent and patient industry, nearly solved the problem of Thymol preparation,* so that when the war ends, German Thymol may be ousted from the markets of India, because the bulk of Ajwain used by Germany went from India.

I will just give one more illustration of my fourfold division of Scientific work. Faraday unravelled the laws of electromagnetic induction in 1833. His was an absolute discovery and he did not care whether it could be usefully employed or not.† Later on, technical electricians found out a use for it by showing that Dynamo-electric machines could supply electric energy in abundance. The electrical engineer now-a-days supervises the working of Dynamos and all this is popularly explained and promulgated by a teacher of science.

APPLICATIONS OF SCIENCE ABE RESPONSIBLE FOR THE TREMENDOUS INCREASE OF WORLD'S WEALTH IN MODERN TIMES.

In continuation of the foregoing remarks, I append here a condensed version of Dr. Slosson's views about the part

* Dixon Chemical Works. Dr. Ch. Khuda Dad Khan, B. A. Ph.D.

† In this connection, the two anecdotes told about Faraday, on page 39 should be read again.

played by Science in the advancement of the world. He begins by remarking that the present age is sharply distinguished from all that have preceded it in the history of the human race by the amazing increase in wealth. In every civilized country the value of property per capita is far greater than ever before, notwithstanding the unprecedented increase in population during the last century, and the higher standards of living among all classes. (Alas I that semi-civilized India, despite its fabulous wealth, is a very poor country by contrast.) Luxuries, longed for, or undreamt of by our parents, are our common household convenience. Our tenements are better than medieval palaces. Bricklayers now get more than Professors used to, and still they are not satisfied, and there is no reason why they should be, so long as they can get still more.

This sudden increase in the wealth of the world can be traced to one cause. There is a new factor in civilization. This new wealth is the gift of modern applied Science. All the other wealth-producing factors have remained substantially unaltered. The natural resources of the earth are no greater ; in fact they are less, for our soil is less fertile, and our ore lies deeper. It is not because men of ability are any more common than they used to be. There has been no sudden eruption of genius on this planet.

Now, what we have and our ancestors had not is more knowledge of the laws of Nature and more willingness to apply them. There are some who complain that Science is becoming commercialized. That may be, but a commercialized Science makes greater progress than a philosophized Science ; greater progress, even in its most abstract branches. The shop is pushing the Study. (The present war-time is responsible for far more inventions than a corresponding period of peace. India sorely lacks this blessed commercialization of Science.)

The mathematician works, as he always has, for the pure joy of seeing what the human mind can do with lines and numbers and quantities, but now the engineer (our Applies of

knowledge) waits impatiently besides his desk, like the office boy on the editor, to snatch his formulas from him before the ink is dry to construct a new dynamo with them. The chemist, working with the electric furnace, out of pure curiosity and the desire to read a paper before the Academy, makes some new Carbides ; within a few years the waterfalls of Europe and America are turning them out by the ton, and our automobiles are lighted by Acetylene and polished with Carborundum. A new element is discovered, good for nothing, apparently except to fill a gap in Mendeleef's table, but it speedily appears in our gas burners and cuts down our bills.

It is **this middleman between the scientist and the mechanic**, who is the new force which is accelerating the wheels of progress. It is the engineer, **the technician; his profession is so recent that it has no proper name.**"

In the above remarks, I believe the paramount importance of the industrial applications of Science in India has been adequately emphasised, and if it may not be hoping against hope, I may here give public expression to my heart-felt yearning, that Aligarh, too, may put her shoulder to the wheel of Science and help itself and India by **devising suitable means for spending more on scientific pursuits calculated to enrich and to extend the bounds of knowledge.**

At present, the diminishing number of students in the First Year Science class is seriously alarming and proves nothing but retrogression in scientific affairs at Aligarh.

THE IMPORTANCE OF THIS FOURFOLD DIVISION OF SCIENTIFIC WORK.

Any civilised society can remain healthy only, if all the four classes of workers are duly encouraged and this fourfold distribution of scientific work, scrupulously observed. It may be that in accordance with the varying needs of a society or a particular period, one aspect of the work might be intensified at the expense of others, but my point is that none of them should be totally forgotten or unheeded.

Here, in India, our need, at the present time, is **to encourage** the useful application of Science **on an unprecedented** scale;

my belief is that the scientific progress of India shall commence only when we have from amongst ourselves **captains of industry and manufacturers of machinery** besides the prosaic and uningenious teachers of science and engineers that we have, at present. But we can not absolutely ignore the claims of pure research ; we must have a few men employed at it, so that although the main current of our attention may be directed to the diffusion and application of scientific knowledge, the lamp of research may keep on burning slowly and, ultimately when we may have finished our preliminary programme of scientific regeneration, kindle the torch of learning, otherwise our fate would be akin to that of the Chinese.

The ancient Chinese were once a scientifically advanced nation. They encouraged the investigation of truth and thus the mainsprings and fountain-heads of their scientific knowledge were continuously replenished. A scientific spirit permeated the whole Chinese society. The technical applications were intelligently understood by the Appliers of natural truth. But when the ago of true investigators who drew their inspiration direct from Nature was over, fresh supply being cut off, the stream of (Chinese) technical education was eventually dried and in the words of De Tocqueville, the Chinese having forgotten the scientific origin of what they did, were at length compelled to copy, without variation, the inventions of an ancestry wiser than themselves who had drawn their inspiration direct from Nature.

You should remember, students of Science, that you have got duties and obligations and it is obligatory upon you to devote your lives to the scientific service of your country and to induce others to study Science even as amateur scientists. The present is an age of Science, and India has certainly passed through the Theological and Metaphysical states of mental development; but the Positive (or Scientific) stage is yet to come. We are still, even with the most liberal allowance, about a century behind the other civilized nations of the world. Inactivity would simply widen the gap. The present is the time for making a good start.

PART III.

India's Neglect of Science and the right sort of Scientific Education.

Several years ago, John Perry wrote a number of essays, which can now be seen published together under the name, "England's Neglect of Science." Indians and other well-wishers of India should note that if England is to be blamed for neglecting Science even when we see so much done there, the case of India is poor indeed. It is high time now that serious attention of our leaders of thought and action should be focussed on the scientific regeneration of India. But alas ! "Our guides and counsellors are, in the majority of cases, unaware of the most obvious facts and phenomena of Nature, and have no acquaintance with the most elementary vocabulary of Science. In every thing that relates to the material world around them, they are **blind leaders of the blind** ; and they call their darkness light. They are indifferent to the wonderful growth and extent of scientific knowledge, and live in a paradise in which rounded phrases and curious fancies are of more importance than actual facts. In such a world, a one-eyed man can be a king." A more enlightened view will only be taken when it is realised by our leaders and others who hold the reins of our destiny in their hands that an educated man must know something of Science as well as of Literature.

The future uplifting of India can only be effected by a liberal policy of scientific grants and diffusion of scientific knowledge. England has now realised—the grim war is to be thanked for this late though happy realisation—that **scientifically she is backward and the German preparedness is**

largely due to Germany's more liberal development of Science.

In the leading article in *Nature*, dated October 18, 1917, we have the following important remarks, under the heading **Research and the State**:—

"It was remarked by Professor .W. J. Pope, in an address to which we referred last week, that if suitable provision had been made by the State for the pursuit of scientific research twenty years ago we should have been saved from the horrors of the present conflict. He asked why the Government did not then make the experiment which it has now undertaken by the establishment of a Department of Scientific and Industrial Research with an endowment of £1,000,000. The answer to the question is that our statesmen have never had sufficient knowledge of science to understand its relation to national advancement or sufficient faith in scientific discovery to believe that provision for it would ultimately benefit the community both industrially and politically. The public mind has been awakened to the essential value of research in all progressive industries, and every manifesto recently issued by organisations concerned with the future development of British trade insists upon its importance".

England and America also are keenly alive to this paramount need and the deficiency is being fast made up. A number of Cambridge graduates have written forcible essays and the Master of Downing College has edited them in book form with the title **Science and the Nation**.* Besides, this Scientific Research Committees have ere now been organised and now they are clamouring for a share in the Government—a **Ministry of Science** is demanded and National Reconstruction on a scientific basis is the topic of the day. I give here three quotations from recent scientific publications in support of my contention.

Professor D. Fraser Harris, M. D., D. Sc. etc. in his Presidential address to the Nova Scotian Institute of Science,

* *Science and the Nation*—published by the Cambridge University Press.

delivered on November 13, 1916, said : "Science, in short, must have a Department, a Government office, before the public will accord it its place of honour. We may regret that this sort of thing has to be, but our regret will not change public opinion; and it appears to be a part of the British Constitution that nothing can be done or should be done without a large body of public opinion behind it. But the official recognition of Science cannot wait until the public has seen fit to render Science the homage it deserves. To begin at the top let there be a **Minister of Science and a Ministry of Science**, and with just as much prestige accorded to it as the war office, the foreign office or the Home office. The duties of the **Minister** of Science would be primarily to foster Science in every way possible, to foster its interests, to administer its affairs somewhat after the manner in which the Board of Trade looks after trade, the Department of Agriculture and Fisheries, agriculture and fisheries."

The eleventh Annual Meeting of the British Science Guild, was held on April 30, 1917 under the presidency of the Lord Mayor of London. Lord Sydenham, the new President of the Guild, delivered an address on **National Reconstruction** in which he referred to the lack of appreciation of the importance of Science and scientific research which lay at the root of so many difficulties ; and urged the application of Science in its broadest sense to national affairs in the future.

Sir Ronald Ross writes † "The whole world, like a sinner that repenteth, is talking of **Reconstruction** after the war, but we hope that it will not imitate the personage who, when he was sick, determined to be a saint."

Here is a resolution of the American Association for the Advancement of Science, passed in their last meeting in April, 1917, "That in view of the present conditions, it is the duty of American men of Science to exert themselves to the utmost

† *vide* Science Progress July, 1917—A quarterly journal of Science edited with **great** ability by Sir Ronald Ross M.D., D.Sc, F.R.A.S. etc.

to secure due recognition and participation of Science in the gigantic problems of natural and inter natural re-adjustments by which the world will soon be confronted."

Gentlemen, my object in laying before you this evidence about the keen interest taken in scientific affairs by all the civilized nations of the world, is to urge upon you to apply yourself heart and soul to the acquisition of a true scientific culture, so that in the fullness of time our hearts may be gladdened by seeing here, as well as in other colleges of India, a large number of Indians prosecuting post-graduate studies and doing research work in Science with the Indian public and the Government encouraging the industrial development of India by munificent grants and liberal endowments.

At this stage, you should listen with attention, what Professor Armstrong says in his admirable paper "Research in Education": * The success of Germany is, in no way primarily the outcome of technical education in the sense in which the term is understood in this country, but is mainly due to the fact that the universities have done their duty and that the nation is educated. Their Universities have always been (and are still) schools of research and inquiry; and unless and until ours become such and our youths are trained to advance, there can be no hope for us. God help us to make the change, before it is too late !" The following quotation from a special article, published in a recent issue of Nature sheds further light on the same point:

"ORGANIZATION OF CHEMICAL INDUSTRY AFTER THE WAR. "

" Among the problems comprehended under that somewhat elastic term "Reconstruction" none is more important to the economic future of the nation than the organization of its chemical industry. The position in which we stood

* *Vide* page 152, The Teaching of Scientific Method by Professor Armstrong.

immediately after the outbreak of hostilities revealed only too plainly with what foresight and craft Germany had organized her trade and linked up her manufactures in view of the world-wide conflict upon which she deliberately and of "*malice prepense*" embarked after forty years of sedulous preparation. So intimate a union as is there made manifest between the governing powers and the leaders of industry, and of chemical industry in particular, in the common effort to secure the domination of the world, is without a parallel in history."

THE DISTINGUISHING FEATURES OF SCIENTIFIC EDUCATION.

I would now add a few remarks on the right sort of scientific education. To my mind, the distinguishing feature of the study of Science is to discipline the mind and prepare it for grappling with the problems of the world, to shake off prejudices and to keep the mind always open to receive new impressions. A mind properly disciplined is a scientifically developed mind. It is not at all claimed that a scientific mind can solve all problems. Far from it. What is really claimed is this, that scientific education coupled with an intimate working knowledge of the methods of scientific investigation enables the students to attack any problem with confidence when sufficient data are given. To be scientific is not merely to know, but to have the power of using the knowledge properly.

Says Professor Armstrong: "To teach smatterings of Science is mere waste of time—to teach scientific method is to move towards salvation : because you cannot be scientific unless you are exact and honest, observant and thoughtful—**the parrot has no place in Science.**"

It is one of the primary requisites of **a liberal education**

What is in the modern and correct sense of the term liberal education? that besides knowing everything of something (*viz* specializing) one should also know something of every thing (*i. e.*, be well-informed,) so that the mental outlook may not be cramped. Judged from this

viewpoint, the average Indian student of Science is not at all liberally educated. No doubt, it is an age of specialization, and we do not want butterfly students of Science, but what I mean is that students of (Physical) Science,* (although they may not (and they should not) try to march through the vast Kingdom of Science from one end to the other,) should not grovel in hateful ignorance concerning the highly illuminating and interesting sciences of General Biology, Evolution, Astronomy, Geology, Sociology, Experimental Psychology, Physiology, Palæontology etc. etc.

That depth of view and expanse of the intellectual horizon, which alone entitle a man to be called by the exalted title of an educated citizen, necessitate a rudimentary acquaintance with the great group of the modern evolutionary Biological Sciences besides Physics, Chemistry Astronomy and Mathematics.

Talking of liberal education, here are Dr. Slosson's suggestions about imparting a complete education to youngmen passing degree-examinations. He is deploring the cheapening of the Doctor's degree in America and remarks that in order to raise the status and value of the Ph.D. degree, a long and informal conference should be held, attended by representatives of all the principal Departments, to test the candidate's personal fitness for the honour, his range of ideas and his command over them. "If the Professors of Political Economy and Philosophy find that the candidate for Ph. D. in Botany cannot converse intelligently with them on their own ground,

* I feel tempted here to point out to you a beautiful illustration of the subject-matter of Physics given by Tyndall in one of his lectures before the Royal Institution in 1854. He defines the field of Physics as that portion of natural Science which lies midway between Astronomy and Chemistry. The former indeed is Physics applied to masses of enormous weights while the latter is Physics applied to atoms and molecules. The subjects of Physics proper are, therefore, the light and heat of the Sun, colour, sound, motion, the load-stone, electrical attractions and repulsions, thunder and lightning, rain, snow, dew and so forth,

they should exercise their veto power. If on the other hand, they find that they cannot converse intelligently with him on botanical subjects, they should resign and go into the insurance business. Now-a-days when the Civil Service examiners expect mail carriers to know the distance from the earth to the sun, and policemen, the Capital of Sweden, it is not too much to require of Doctors—and of Professors—a corresponding extent of information. The University authorities may believe that they are certifying only to a man's knowledge of "The Intra-cellular Enzymes of *Penicillium Camemberti*" but the outside world interprets the degree differently, and in five years the specialist in mouldy cheese may be arbitrating a strike or quite unconsciously, teaching pragmatism."

I admit that Dr, Slosson's suggestions are radical but there is no denying the fact that the underlying idea of liberalizing education is thoroughly laudable and worthy of adoption in the projected Muslim University, Aligarh.

SUGGESTIONS FOR IMPARTING BETTER SCIENTIFIC EDUCATION.

In an article* recently published in the Educational Review, Madras, I have discussed at some length the possible lines of improvement in the scientific education imparted to Indian students. I have made the following suggestions there,

(1) that the gulf separating theoretical training given in Science Colleges and the practical training given in Engineering Colleges and Poyltechnic Institutes should be diminished as much as possible and

(2) that the syllabus of studies for students of Science should be got up and taught in such a way as to make them efficient scientists, well-versed in the method of Science and able to grasp fresh problems with confidence.

* "Some suggestions for imparting better and more useful scientific training to our youngmen in schools and colleges" by Professor F. D. Murad(vide Educational Review, Madras, June, 1917.)

With regard to my first suggestion, I would point out the modern Universities of Birmingham, Manchester, Sheffield etc. as its exemplars. In them the courses of study in Pure Science and Engineering are the same in the First year class.

With regard to my second suggestion, I may add that unless a student thoroughly grasps and assimilates scientific ideas, he cannot make any use of them. Now lack of mastery over the English language is a great impediment. But for scientific instruction being imparted in a foreign language, which the majority of First year students in Colleges do not fully understand, better results will accrue even from the work done under a faulty syllabus of studies. In this connection, I should like to draw your attention to the Urdu section of the Scientific Society. The Urdu meetings are specially welcome because they afford a means of thoroughly assimilating knotty points, bristling with difficulties, which may not be adequately removed through a half-understood foreign language.

I am not in a position to make any authoritative statement Usmania University concerning the Hyderabad (Deccan) Usmania Hyderabad. University scheme. But judging from the meagre information that has leaked out so far, it is pleasant to learn that the medium of instruction therein will be Urdu throughout—Professors will lecture in Urdu and students will write their answer papers in Urdu also—that English will be taught as a compulsory subject throughout, and that a Translation Bureau for the compilation of books in Urdu, on all subjects, has already been organised. It is a welcome laudable scheme for a harmonious blending of the East and the West, and reminds one of the palmy days of Islam when the great Abbaside Caliph, Harun-ur-Rashid had established a similar Bureau of Translation at Bagdad and camel-loads of scientific works were annually secured from Greece, by way of tribute.

In British India, such a radical though necessary reform in our defective educational system can not be introduced at once. But a compromise can be made, as shown below:

(1) by making Urdu (and other vernaculars, where necessary) **the medium of instruction in schools,**

(2) by limiting the study in English in the last four School Classes only. At present our boys neither know English nor Urdu nor the Sciences, because English is taught from the 2nd or 3rd Primary class, with this disastrous result that the majority of our poor boys, who are the helpless victims of this highly objectionable system, are, for life, incapacitated to give expression to their thoughts and ideas, either in English or even in Urdu.

(3) by keeping English as the medium of instruction for the College and University studies only. Ultimately the Usmania University scheme can be safely introduced in British India, also, when this initial step has been taken.

MISUSE OF THE TEXT BOOKS OF SCIENCE.

I give here another' quotation from my paper referred to above. "Text books should be discouraged. . . . It is the spirit which underlies these texts that is to be denounced. 'It is meet and proper for a clergyman preaching to a mob to dogmatise and lay down a general statement or a text as an appropriate introduction for a Sunday sermon.'* But it does not behove a votary of Science to lay down texts or hard and fast rules before young minds which it is our aim and object to train into scientific and rational methods of thinking

Granting the entire elimination of the Text Books of Science, I would very much like to see suitable courses of study in Physics, Chemistry etc, especially written by experienced teachers of these subjects, keeping in view the special requirements of Indian students and copiously illustrated with examples and actual problems borrowed from the affairs of

* *vide* Teaching of Physics by Professor Mann. He suggests that instead of teaching Physics in the present order, viz. "principle, demonstration, exemplification in the laboratory, application," it should be taught thus: "application, problem, solution in the laboratory, principle."

everyday life. I would strongly advocate the introduction of only those methods of measurements in Practical courses which besides supplementing the instruction given in theoretical courses, should be practically useful in all walks of life." In connection with these words I would ask you to take to heart the following advice of a great mind. "Our work is scientific in spirit only when it springs from the desire to know of our own knowledge some definite thing concerning which our curiosity has been moved."

There is no surer way to arouse the boy's interest in the principles of Natural Science than by acquainting him with their manifestations in everyday experience whilst the most complete practical efficiency is based on an intelligent understanding of the principles involved.

HEURISTIC METHOD OF TEACHING SCIENCE.

I would like also to make a passing reference to the **Heuristic method** of teaching science, so strongly advocated by Professor Armstrong. Those desirous of gaining full information about the Heuristic method should study Professor Armstrong's Teaching of Scientific Method, a valuable collection of papers containing a lot of information useful for students of science. Courses of study for elementary Science classes drawn up in accordance with the Heuristic method are also given in this book. But before proceeding further I would point out to you an instance of scientific open-mindedness. Professor Armstrong frankly acknowledges that he owes this term—Heuristic—to Mr. Meiklejohn, Professor of English Literature. He says : "I first came across it in an eminently suggestive paper by Professor Meiklejohn." In the words of Professor Meiklejohn, the Heuristic method is the only method to be applied in the pure sciences ; it is the best method in the teaching of the applied sciences and he goes on to show that it is applicable to literature also.

"Heuristic methods of teaching are methods which involve the placing of students as far as possible in the attitude of

discoverers—methods which involve their **finding out** instead of being merely told about things. Few realize that neither is discovery limited to those who explore dark continents or Polar regions nor to those who seek to unravel the wonders of Nature; that invention is not confined to those who take out patents for new devices, but that on the contrary, discovery and invention are divine prerogatives, in some degree granted to all, meet for daily usage: consequently it is of importance that **students should be taught the rules of the game of discovery and learn to play it skilfully,"**

It is sometimes complained that Professors of Science decry the study of Literature but I would venture to say that this is untrue. As I have elsewhere stated in this Address, education is incomplete without a harmonious combination of Literature and Science. And I perfectly agree with Sir J. Fitch when he says that **each word that a student learns supplies him with an idea** and thus an important purpose is served by a vast comprehensive vocabulary; it stores the mind with ideas of all kinds. Here is a quotation from Sir Joshua Fitch's excellent book "Educational Aims and Methods" p. 58.

"And I am sure that we, as teachers have a special interest in that part of the Socratic teaching which bore upon the exact connotations and the right use of words. Grammar, verbal and logical analysis, rhetoric, style—all these things will still, notwithstanding the occasional satire and remonstrances of the modern Professors of Science, hold their own as among the chief instruments in the training of a human being for an active and a thoughtful life. And why? Because **a copious vocabulary is a storehouse of thoughts.** Because, whatever we are hereafter to learn, whether about History, Politics, Astronomy or Physics, must, to a large extent, be learned from books; and because whatever gives us greater command of the language of books and more exact conception of the significance of that language, enlarges our resources as thinking beings."

Spoon-feeding should not be encouraged in imparting scientific education, and if a student works on the lines of the Heuristic method, he should seek to arrive at the solution of a definitely stated problem, exactly as if he were going to solve an original, unsolved problem.

Further "we should encourage Juvenile Research and before we can reach the zenith of our hopes and efforts, Physical Science should be introduced as a leading element in the curricula of all secondary schools, and I would say even in the primary schools, in which the children of the poor are Expected to turn to the best account, the little time they can snatch before the worries of life besiege them."

To recapitulate, the prime essential of scientific education is not simply to stock the mind with facts but to digest and assimilate the great scientific ideas of the day, to be thoroughly conversant with the scientific method of investigating truth, to develop the reasoning faculties and last but not the least to foster a spirit of wider toleration for all kinds of opinions. It is thus, and thus alone that the grand principle of evolution coupled with the inductive method of teaching Science, can be harnessed into service for efficiently training young minds into scientific methods of thinking and enabling them to become better citizens.

The aim of scientific education should be to develop rationalistic tendencies, to uproot superstition, sentimentalism and an uncritical regard for authority, and last though not the least to build an upright manly character, alive to all the exquisite beauties of Nature and athirst for Truth, with that youthful enthusiasm which springs from a healthy appreciation **of life.**

Part IV.

*Some suggestions for scientific work by students with
a passing reference to the scientific progress
of the early Musalmans.*

And now before I resume my seat, I want to make a few suggestions about the work that you can do for the Scientific Society in particular and for the service of Science in general,

I would very strongly recommend to you to read scientific Value of scientific biographies. Lives of Faraday, Maxwell, biographies. Lord kelvin pasteur Ch. Darwin, Ch. Lyell the Herschels, (father and son) etc. are all worth reading in full. They are a perennial source of inspiration and stimulus for work. They are living examples for all serious workers and lovers of knowledge. A diligent study of such eminent scientific careers cannot fail to impress any body with the truth, so nicely sung by the poet :—

Lives of Scientists all remind us
We can make our lives sublime,
And departing leave behind us
Footprints on the sands of time.

The study of biography should invariably be preferred to fiction by juvenile readers. The latter introduces to their immature minds unreal and unrealizable scenes which serve as a stumbling block in their programme of life by engendering false hopes and presenting wrong ideals before them. Lives of great men (scientists) however, will familiarize them with actualities and a **knowledge of the circumstances under which high brain powers can be developed.** A word of caution about studying the lives of eminent scientists might be mentioned here, viz, that these prodigies are exceptions rather than the **rule,**

hence the little that we may be able to do should not be looked down upon in comparison with their gigantic achievements.

These books would suggest to you several topics for essay Scientific Essays writing. I dare say you differentiate between a scientific essay and a scientific paper or article. These terms are not rigorously confined to their respective senses and generally they are treated as synonyms. But strictly speaking, in scientific literature the term paper or article is applied to a writing in which detailed information about a subject is given in an exhaustive and masterly manner, whereas an essay is a general term for any sort of writing, in which an attempt is made to discuss any subject. The idea of originality is also attached to a paper or an article. Some of you may be able to write good papers and articles after making an exhaustive study of the subject by giving a critical exposition of the same in your own words. But the majority of you can, with a little effort, easily write scientific essays on sundry topics. I shall always be delighted to help you, and suggest suitable subjects and books of reference which might be used in preparation.

I will specially recommend you all to do two things in Essay Reviews of connection with your work for the Scion-notable books. tific society if you feel interested in any book of Science and you think that it would be useful for others also, do write an essay review on this book, in which besides giving a lucid summary of the various points treated in the book you should give your own criticism of it along with supplementary information gathered from other books bearing on the same subject.

Secondly, try to translate such useful books into Urdu: translate ten lines every day and do it regularly, books in Science. You will find that at the end of a year, you will have got a decent book in Urdu. By thus translating popular scientific books, you will not only enrich Urdu in no time, but you will also enrich your minds as well. At present there is only one prize for the translation of scientific books

but if many of you show me that you have started this work, I think we can easily award decent prizes for the three best translations of the year.

In the course of my address, I have already referred to the Urdu Section of Urdu section of the Society; what I wish to say the Society. here in connection with **Urdu papers** is that there is no dearth of suitable subjects for them. Everything is yet new for Urdu and anything that you write in Urdu will be welcome. Above all, remember that before starting to write, you must have clear and definite ideas, otherwise, you will agree with me that it is useless to inflict your confused and confusing ideas upon others. Your essay should be a sort of message in which you should try to convey some definite information to those whom you address.

Some of you might do well in writing scientific allegories—Scientific scientific stories calculated to teach certain ideas allegoric. in a popular garb. A very nice book known as **برہماتہ نامہ (تراث)** or the Story of the Solar system was written, a few years ago, by Mr. Kanwar Sen (Principal, Law College Lahore). In this book, the author expounds astronomical ideas in a very interesting manner. In Houston's Wonder Book of Light you will find a nice parable about the dispersive action of the prism. A little girl is asked by her step mother to separate a number of coloured feathers contained in a big box. The poor little girl is at a loss to do this difficult task, but her friend, Prince Percinot, helps her with his magic wand and thus the analogy of the prismatic separation of colours from one another is brought home in the guise of a fairy tale.

I will here tell you, at some length, the story of **"the monkey that would not kill"** as told by Henry Drummond, in the hope that we will have still better stories illustrating scientific principles from you. It is the story of an irrepressible monkey, whoso doings led his successive masters to seek to put an end to him. Once he was thrown into the sea, tied to a stone which he could not lift, but **while under water**, he was able to

lift the stone and walk to the shore, because the stone **was** lighter in water than in air. This simple story illustrates in a striking manner the principle of Archimedes and might be utilised for teaching young boys and girls how the purity of different specimens of water can be tested. Ask them to weigh the same stone in air, pure water, salt water, sugar solution and finally to convince them directly about the loss of weight suffered by objects when immersed in water give them a stone which they cannot lift in air but can lift when carried under water.

There is yet another way in which you can make use of scientific your talents for popularizing Science. Write poems. scientific poems, both grave and gay. You may not be able to write very good English verse yet I do hope some of you can render certain scientific ideas in excellent Urdu verse.

I give here a few specimens of Scientific poems. Professor Armstrong gives a long poem on the Conservation of Matter in his book "The teaching of Scientific Method." Here are a few lines :—

"You have learnt a lot of symbols, long equations and the rest,
And of these, just like a parrot you can chatter,
But have you thought on your own account to test
The Indestructibility of Matter"?

James Clerk Maxwell's name is well-known to all of you. All his writings are rigorously scientific but still at times, he indulged in versification. In 1874 the British Association met at Belfast, under the presidency of Tyndall. Maxwell has published an amusing paraphrase of Tyndall's famous Belfast Address.

Maxwell's poems have been collected by Professor Campbell in his "Life of Maxwell." Here are a few Specimen lines :—

British Association 1874.

Notes on the President's Address.

In the very beginning of Science, the parsons who managed things then,

Being handy with hammer and chisel, made gods in the likeness of men ;

Till commerce rose and some men of exceptional power

Supplanted both demons and gods by the atoms, which last to this hour.

Yet they did not abolish the gods, but they sent them well out of the way,

With the rarest of nectar to drink, and "blue fields of nothing" to sway.

I believe, you will readily agree with me in saying that the expression "blue fields of nothing" is an excellent scientific paraphrase for the firmament and its blue colour and is a remarkable addition to literature.

Molecular Evolution (Maxwell).

At quite uncertain times and places,

The atoms left their heavenly path,

And by fortuitous embraces,

Engendered all that being hath.

Hail Nonsense ! dry nurse of Red Lions *

From thee the wise their wisdom learn ;

From thee, they cull those truths of Science,

Which into thee, again they turn.

What combinations of ideas

Nonsense alone can wisely form !

What sage has half the power that she has

To take the towers of Truth by storm ?

SCIENTIFIC PASSAGES FROM THE MASNAVI M'aNAVI.

And now after citing examples of gay scientific poetry, I will mention here a few specimens of serious scientific verses.

Most of you have heard the august name of Maulvi Jalal-ud-

* The Red LiONS was a Club formed by members of the Royal Association to meet for relaxation after the graver labours of the day.

Din Rumi, the author of the world-renowned mystic poem, Masnavi M'anavi. This mystic philosopher, somehow or other, gives a few scientific passages in his colossal work, which throw an interesting sidelight on the **scientific culture of the Muslims** of his age. I have picked out three passages, which, interpreted literally and non-metaphorically, afford indubitable proofs of a partial anticipation of Darwin and Newton's work upon Evolution and Gravitation. At the same time, these passages show also an intimate scientific knowledge of Magnetism—Maulvi Rumi talks of a piece of iron situated at the centre of a hollow magnetic globe—the rotundity of the earth, molecular attraction, certain acoustic phenomena, the electrification of the amber etc. etc.

The first passage I wish to quote shows a knowledge of gravitation and magnetic attraction. The lines in the Masnavi run thus:

- ۱ — جملہ اجزائے جہاں زان حکم پیش
جفت جفت و عاشقان جفت خویش
- ۲ — هست ہر جزوے عالم جفت خواہ
راست ہمچوں کہرباؤ برگ کاہ
- ۳ — آسماں گوید زمین را مرحبا
باتو ام چوں آہن و آہن ربا
- ۴ — گفت سائل چوں بماند این خاکداں
در میان این محیط آسماں
- ۵ — ہم چو قندیلے معلق در ہوا
نے بر اسفل می رود نے بر علا
- ۶ — آن حکیمش گفت کز جذب سا
از جہات شش بماند اندر ہوا
- ۷ — چوں زمقنا طیس تہ ریختہ
در میان ماند آہنے آویختہ

These lines may be freely translated thus : (It should be understood, however, that the term love (Ishq) is used here in a mystic sense instead of attraction.)

1. It is owing to a law that all the components of the world are in pairs and each one loves and attracts the other.

2. Every material body (or particle) in the universe attracts every other body exactly as amber attracts a piece of Straw,

3. The heavenly bodies (or literally the sky) greet the earth saying 'we are related to you as the magnet is to a piece of iron'.

4. Somebody asked how is it that the earth remains suspended in the circumscribing heavens,

5. Like a round lantern suspended in the air, it neither falls down nor goes upwards.

6. The philosopher replied to him that it is because of the celestial attraction (what we now-a-days call universal gravitation) that the earth is equipoised in the air from all (six) directions.

7. Exactly like the suspension of a piece of iron at the centre of a hollow magnetic globe.

The other passages dealing with the doctrine of evolution and development are much better known and it is a pity that instead of being interpreted physically they are metaphorically understood in terms of spiritualism. I am sure none of you will believe that the passage quoted above refers to spiritual gravitation rather than material and physical gravitation as I have explained it.

از جمادی مردم و ناسی شدم * وز نما مردم بھویاں سرزدم
مردم از حیوانی و آدم شدم * پس چہ تو س کے زمردن کم شدم
..... * پس بر آدم از ملائک بال و پر
پس عدم - گردم عدم چوں ارعنوں . * گو یدم کانا اایہ را چہوں

In these lines, the poet traces the **evolution of man** from dead matter, and he even hints at the idea of the **superman**. But I admit that the whole passage is rather vague.

آمده اول به اقلیم جماد
 وز جمادی در نباتی او قتاد
 سالها اندر نباتی عمر کرد * وز جمادی یاد نارد از نبوی
 وز نباتی چوں بکویاں او قتاد * نامدش حال نباتی هیچ یاد
 جز همنامی که داند سوئے آن * خاصه در وقت بهار ضمیراں
 همچنیں اقلیم تا اقلیم رفت
 تا شد افکوں عاقل و دانا و زفت

Like the preceding passage, these lines also refer to the development hypothesis. They are, however, sometimes interpreted as a statement of the old doctrine of transmigration.

همچو سبزه بارها روئیده ام * هفتصد هفتاد قالب دیدہ ام

This line and the others following it are of doubtful origin, although they are attributed by some to Maulvi Kami. Their subject matter is sufficiently clear and the same remarks, as have been made above, apply here.

میل هر جزئی به جزئی می نهد * ز اتحادے هر دو تولیدے جهد
 دور گردوں را ز موج عشق دان * گر نبودے عشق بغیردے جهان

If, as explained in the introductory remarks, the word *ishq* (love) is taken to denote attraction, the second line may refer to the orbital revolution of the earth, just as the first line clearly refers to gravitative attraction between particles of matter i. e. molecular attraction.

THE EARLY MUSALMANS HAD MADE GREAT PROGRESS IN SCIENCE.

Now the Masnavi was written more than six hundred years ago in the thirteenth century of the Christian era when Europe was steeped in the darkness of perverse ignorance and the Inquisition was stifling Science and burning alive men of scientific genius. Add to this, the deplorable fact that the Musalmans of later centuries have not shone in Science and not to speak of improving upon and adding to

the scientific achievements of their illustrious ancestors, they have allowed them to sink in oblivion, so that to-day it is very difficult to believe that the early Musalmans could have made so much progress in the Physical and Biological Sciences.

Since I do not want to enter into the controversial aspects of the problem, I will state my unbiassed opinion briefly and reserve a thorough discussion for my thesis :— " Scientific Achievements of the early Musalmans"—which I hope to publish as soon as certain references to the original sources are completed.

After the sack of Bagdad by the heathen barbarians and the burning of vast collections of books amassed by the Muslim love of learning, on the one hand, and the fanatic expulsion of Moors from Spain on the other, most of the scientific treatises of the early Musalmans were lost. Very few books were left safe after that deluge of barbarism in Asia and this eruption of fanaticism in Europe. During this stormy period of sack, plunder, spoliation, library-bonfires and the wholesale slaughter of Muslims, only the most cherished books on religion, Sufiism and Theology, with a few scattered books on other subjects were taken care of. The result of this massacre of books is that to-day we come across references to scholarly scientific treatises written by early Musalmans but those books are not available. Most of them are extinct now—only the names of a few remain in catalogues and certain books of reference.

After these introductory remarks, you can easily see that the Masnavi, which is not a book expounding scientific laws and theories, uses the scientific remarks contained in the passages quoted above, as illustration material for bringing home conviction about certain points or for elucidating other remarks with the help of these. It shows that these scientific theories were universally believed by the Musalmans of that period to such an extent that Maulvi Rumi thought it fit to give them a place in his religious poem which has been called the commentary of the Qoran—nay the very Qoran itself—in Pahlvi (pure Persian). **A poet only uses such scientific**

ASCENDENCY.

facts in his poems as can be readily understood by the
A Scientific common people of his age. For example,
 Tennyson's Tennyson, while, bemoaning the death of his
 In Memorium. bosom friend, wants to state emphatically that
 the soul of his friend is immortal and immutable, Instead of
 saying this directly, he illustrates it by borrowing the imagery
 of Geological Evolution thus :—

There rolls the deep, where grew the tree,
 O Earth ! what changes hast thou seen.
 There, where the long street roars, hath been
 The stillness of the central sea.
 The hills are shadows, and they flow
 From form to form, and nothing stands ;
 They melt like mists, the solid lands,
 Like clouds they shape themselves and go.
 But in my spirit will I dwell,
 And dream my dream, and hold it true.
 For tho' my lips may bid adieu,
 I can not think the thing farewell.

(In Memorium).

Because Science is still going strong in our day, we unhesitatingly give credit to Tennyson for this scientific illustration and believe that he has truly portrayed the scientific beliefs of his age. We do not explain away the scientific substratum by calling these lines a poet's fantasy, metaphor or a freak of imagination. Similarly Maulvi Rumi's lines also denote an advanced scientific age at his time but unfortunately no trustworthy or reassuring records of that bygone scientific age are easily available. Hence our reluctance in believing that Newton and Darwin were anticipated, even partially, by the Musalmans in the palmy days of the Caliphate at Bagdad.

Just to show you what others say about this theme of mine,
 Ingersoll's I quote one statement, out of a large number
 tribute to the Of similar statements, about Muslim scientific greatness
 of early tific ascendancy. This is an unprejudiced
 Musalmans. and frank expression of opinion by It. G.
 Ingersoll, the great American Freethinker. He says "In the

tenth century after Christ, the Saracens, governors of a **vast** empire,' established colleges in Mongolia, Tartary, Persia, Mesopotamia, Syria, Egypt, North Africa, Morocco, Fez, and in Spain. The region owned by the Saracens was greater than the Roman Empire. They **had not only Colleges but** Observatories. **The** Sciences were taught. They introduced the ten numerals, taught Algebra, and Trigonometry, understood cubic equations and knew the art of surveying.

They made catalogues and maps of the stars, gave the great stars the names they still bear ; they ascertained the size of the earth, determined the obliquity of the ecliptic, and fixed the length of the year. They calculated the eclipses, equinoxes, solstices, conjunctions of planets and occultations of stars. They constructed astronomical instruments. They made clocks of various kinds and were the inventors of the pendulum.

They originated Chemistry, discovered sulphuric acid, nitric acid and alcohol.

They were the first to publish pharmacopoeias and dispensaries.

In Mechanics they determined the laws of falling bodies. They understood the mechanical powers and the attraction of gravitation.

They taught Hydrostatics and determined the specific gravities of different bodies.

In Optics they discovered that a ray of light did not proceed from the eye to an object but from the object to the eye.

They were the manufacturers of cotton, leather, paper and steel. They gave us the game of chess.

In their schools **they taught the modern doctrines of evolution and development. They anticipated Darwin and Spencer.** ••• ••• ••• • •••

And yet while the true Christians were tearing out the tongues of heretics, these wretches were irreverently tracing the orbits of stars. While the true believers were flaying philosophers and extinguishing the eyes of thinkers, these godless (sic. **godly**) followers of Muhammad were founding colleges.

collecting manuscripts, investigating the facts of Nature, and giving their attention to Science. But it is well to know that **we are indebted to the Moors, to the followers of Muhammad, for having laid the foundations of modern Science"**

Gentlemen, I believe Ingersoll's emphatic pronouncement will serve as an eye-opener for many of you and that you will now think it worth while to investigate the past scientific achievements of Musalmans which were made long before the advent of modern Science, for which I am the first to acknowledge my indebtedness to Europe. Here is research awaiting your labours. So far no scientist has made any systematic exploration of this field. I know only one book in Urdu—Ulama-i-Islam by Maulana Habibur Rahman Khan Shirwani—that deals with this subject. It is an excellent little book so far as it goes but then it is only an introductory small brochure about a vast and extensive subject. As I have said before, I am collecting materials for a thesis on this subject and if ample progress is made, my monograph on the "Scientific Achievements of the early Musalmans" will, insha-allah, see the light of the day. But in the meantime, I shall be only too glad to help any of you desirous to take up this subject. Further I will strongly advise those of you knowing Arabic and Persian (if you do not know these beautiful languages, you must try to have a smattering of them) to study from original sources the story of Muslim advancement and slumber, before and after the downfall of Bagdad, Cordova and Granada.

This is a definite scientific task which has suggested itself to me while'-talking to you about the scientific Urdu Scientific poems will popularize Science. implied inferences. But we were talking of scientific poems in general. I wish to point out to you that whereas the abstract scientific works of the early Musalmans have practically vanished from our sight, a passing notice of them taken in a mystic poem has immortalised them. The conditions are now utterly changed and although I can not promise such imperishable glory awaiting your scientific poems,

yet I dare say, they will popularize Science immesnely. There is no dearth of suitable scientific subjects for such poems.

Science has very much extended the bounds of poetry and Science and Urdu the scientificuse of imagination can work poetry. wonders. Some of the facts of Science are perhaps more wonderful and fertile than the wildest flights of unscientific poetic imagination. Some of the stock phrases of the oriental poet are now stale through over-use and it is time that the infusion of fresh ideas should enliven our poetry. If you can sing about the restless electron, the imponderable ether, the doctrine of energy, Darwinism, the Earth as an excellent horse, the beauties of Nature etc. etc. I assure you that such singing will form an integral portion of your scientific-education.

Register of scientific queries.

We hope soon to have a Library belonging to the Scientific Society. I would recommend that on the table of the Library,. a Register of Scientific Querries be placed and that members should freely note down questions and queries in that register. For example, I would ask you to explain intelligently, why does the wet portion of a towel appear darker than before when it is wetted with water or to explain why da hillmen, living at high altitudes, scatter handfuls of dust on the accumulated beds of snow covering their fields or the roofs of their houses ? They treasure basketfulls of dust as a valuable commodity to be spent at the advent of summer. You? might also succinctly jot down, on the reverse side of the register, items of valuable scientific intormation for the benefit of others.

And now before closing my list of suggestions, I advise you again to work whole-heartedly and with a will. Gird up your loins for scientific service and acting upon the wise saying—charity begins at home—try first of all to complete your scientific education, with zeal and zest.

Waste not the precious years of life in idle frivolity, laziness, or the summer madness of pointless excursions. Above all, be honest workers, mindful of your duties and rights alike.

And now gentlemen, I have said my say, in a somewhat lengthy Address, and for this reason I owe you

Recapitulation

an apology, because, as Michelson says : "Scientific men are necessarily educated to economize expression so as to condense whole sentences into a single word and a whole chapter into a single sentence". I have purposely dilated upon certain points in order to thrash them fully for the benefit of the student members of the Scientific Society.

I have tried to discuss, at some length, the scope and purpose of Scientific Education. I have pointed out some of the defects obtaining in our system of Scientific Education and I have read out to you the opinions of eminent scientists and educationists about the removal of these defects. I have also explained to you the true relationship between Scientific Research and the applications of Science. While discussing the typo of the University that should be established at Aligarh, I have suggested that we should have chairs of Technical Chemistry and Electrotechnics and that great importance should be attached to post-graduate studies and the development of Indian industries. I have further tried to convey to you some idea of India's Neglect of Science and I have also appealed to you for the proper completion of your education, always keeping in view the scientific service and regeneration of the motherland. I have all along wanted to impress upon you that **glory** lies in the attempt more than in the success. We should try our level best and leave the rest to God. I hope the suggestions for scientific work will not be lost upon you and as far as in you lies, you will try to revive the scientific glory of early Musalmans and to enrich **Urdu, the lingua franca and real Esperanto** of India, with scientific* works of merit.

In the eloquent words of Tyndall, let me remind you in conclusion that the claims of that Science, which finds in me to-day its unripened advocate, **are the claims of God's**

workmanship upon the attention of His creatures, and that its exercises, as an agent of culture are based upon the natural relations subsisting: between man and the world in which he dwells. Here on the one hand, we have apparently lawless shifting of phenomena; on the other side, mind, which requires law for its equilibrium, and in obedience to its own indestructible instincts, believes that these phenomena are reducible to law. To chasten this apparent chaos is a problem which man's Creator has set before him.

Not as servants of Mammon do I ask you to take Science to your hearts, hut as the strengthener and enlightener of the mind of man.



THE SCIENTIST'S RHYME.

We scatter the mists that enclose us,
Till the seas are ours and the lands,
Till the quivering ether knows us,
And carries our quick commands.
From the blaze of the sun's bright glory
We sift each ray of light;
We steal from the stars their story
Across the dark spaces of night.

But beyond the bright searchlights of Science
Out of sight of the windows of sense,
Old riddles still bid us defiance,
Old questions of Why and of Whence.
There fail all sure means of trial,
There end all the pathways we've trod,
Where man by belief or denial,
Is weaving the purpose of God.

BIBLIOGRAPHY.

Nearly all the scientific works mentioned below can be seen by students in my private collection of books. Some of them can also be had from the Physics Department Reference Library. I shall always be glad to lend my books to those desirous of studying them. But in the case of the cheap sixpenny and shilling books I will advise students to purchase them as cheap as possible. Certainly the claims of their intellectual food should not be totally ignored and I am confident several of them can afford to purchase a few books without pinching their stomachs or baring their backs.

I POPULAR SCIENTIFIC BOOKS (ENGLISH.)

1. With the men who do things by R. Bond. (Messrs Mun & Co., U. S. A.)

An excellent book about great engineering enterprises in U. S. A.

2. Scientific Ideas of to-day by Ch. R. Gibson. (Seeley, Service & Co.)

A popular exposition of modern Scientific thoughts and theories; an account of the nature of Matter, Electricity, Heat, Light etc., in non-technical language. I have commenced writing a similar book **جدید علمی خیالات** in Urdu, but the progress of this book as well as that of my other scientific works is inevitably slow on account of the pressure of College duties.

3. Discovery or the spirit and Service of Science by R. A. Gregory. (Macmillan & Co.)

Enough has been said about the merits of this nice book in the body of the Address.

4. , Physics of the Household by Lynde. (Macmillan & Co.)

A valuable introduction to some of the applications of Physics in the Household.

5. The teaching of Physics and Chemistry by Smith and Hall. American teacher's library. (Longman & Co.)

6. The teaching of Physics by C. R. Munn. Teacher's professional library. (Macmillan & Co.)

7. Special Method in the teaching of Elementary Science by Murray. (Macmillan & Co.)

8. Introduction to Science by J. A. Thomson. Home University library 1/- (Williams & Norgate.)

A valuable book admirably suited for the study of students.

9. Introduction to Science by Alex Hill. (Temple Primers 1/-)

A brief introduction to some of the important problems of the day.

10. Foundations of Science by W. C. D. Whetham People's Books. (T. C. & C. E. Jack 6d. only.)

11. Principles of Science by Stanley Jevons. (Macmillan, & Co.)

A treatise on Logic and Scientific Method.

12. Scientific Method by Westaway. (Blackie & Sons.)

An admirable symposium of the methods of work pursued by eminent scientists.

13. Logic Primer by Stanley Jevons. (Macmillan & Co., 1/-)

Every student of Science should study it to acquire the minimum amount of Logic indispensable for the elementary study of Science.

14. An easy outline of Evolution by D. Hird. (Rationalist Press Association 6d. paper cover 1/- bound in cloth.;

The Publications of the Rationalist Press Association are admirable in all respects. Lovers of knowledge cannot adequately pay off their debt to this excellent Association.

15. Riddle of the Universe by E. Haeckel. (R.P.A. cheap reprint 6d.)

This is an epoch-making book translated from the German book *Die Weltrathsel* by J. McCabo with the full title "The Riddle of the Universe at the close of the Nineteenth Century." **More than fourteen hundred thousand copies of the Riddle have been sold.** In English alone over two hundred thousand copies have been sold. It has been translated into 14 languages. Urdu is so far poor since it does not possess such a rich treasure. Haeckel calls it his philosophical testament. I have translated a portion of it into Urdu under **معنی کائنات** but I fear it can not be published soon. Even if my translation **معنی کائنات** were published, I fear, it for a long time to come, remain unappreciated waiting for a greater diffusion of scientific knowledge.

16. Mechanical Inventions of today; an interesting description of mechanical inventions in non-technical language by T.W. Corbin. (Seeley, Service & Co.)

Vide other books also in this 'The science of today' series, *e.g.* Engineering of

17. Use and limit of the Imagination in Science by Tyndall. (Longman, Green & Co.)

A lecture delivered before the British Association for the Advancement of Science at Liverpool in 1870.

18. The Scientific Evidences of organic Evolution by G.J. Romanes. (Macmillan & Co., in the Nature Series.)

19. The Ascent of Man by Drummond..

For lucidity of diction this book cannot be praised **too much** **Compare** with it Darwin's *Descent of Man*.

20. Physiography by T. H. Huxley. (MacMillan & Co.)

Revised and partly rewritten by E. A. Gregory. A valuable introduction to the study of Nature. An extremely lucid and illuminating First Book of Science. Portions of it have been translated into Urdu. *Vide infra* مقدمة الطبقات in the list of Urdu books on Science.

21. Aids to Reflection in the formation of a manly character by S. T. Coleridge. (Routledge & Sons) 1/-

One of "the best 100 books of the world."

22. Discourse on Method and Metaphysical Meditations by Rene Descartes (The Walter Scott Publishing (Jo.)

This book gives, besides the Discourse, some autobiographical reminiscences of Descartes the pioneer of Scientific Method.

23. A Picture Book of Evolution by D. Hird. (Watts & Co. in two parts 2/6 each.) Part I contains lessons from Astronomy, Geology, Zoology.

Part II contains lessons from comparative Anatomy and Embryology and also gives the Pedigree of Man.

An excellent book for beginners in Science.

24. Elementary Biology : Plant, Animal and Human by J. E. PeaBody and A. E. Hunt.. (The MacMillan Company,, New York.)

25. The Elementary Principles of General Biology by J. F.. Abbott. (The MacMillan Company.)

Both these books are written for the general information of junior Science students about the great problems of Biology.

26. A short history of Natural Science by A. B. Buckley.. (MacMillan & Co.;

A comprehensive elementary book—should be studied by all First year students.

27. A short History of Physics by Dr. Cajore with an interesting appendix on the Evolution of Physical Laboratories

28. Starland by Sir Robert Ball. (Cassel & Co.) Talks With young people about the wonders of the heavens : six lectures delivered before a juvenile audience at the Royal Institution in 1881 and 1887.

An excellent and matchless introduction to popular Astronomy. Every Science student must at least know as much about the nocturnal visitors peopling the grand laboratory of the firmament, as this book tells. I have translated portions of this book into Urdu and if there is evidence of genuine scientific taste in the public, I may publish my translation **مناظر فلک** in book form.

29. A Primer of Astronomy by S. R. Ball 1/6.

A valuable easy introduction to elementary mathematical Astronomy.

30. The story of the Heavens by Sir R. Ball (Besides these, other books of Sir R. Ball and Proctor may profitably be studied by young students.)

31. Astronomy for Amateurs by Camille Flammarion. (Th. Nelson and Sons.)

The style of the book is quite poetic at some places. It was originally written in French for women.

32. Practical Physics by H. Black and H. N. Davis (MacMillan & Co.)

An admirable introduction to Physics giving Fundamental Principles and Applications to Daily life.

33. History of Anthropology by B. C. Haddon (Watt & Co.)

Vide other books also of this series 'History of the Sciences' e. g. Chemistry, Astronomy, Geology, Biology etc, each at the phenomenally low price (for a work of original research) of 1/, net bound in cloth.

34. Childhood of the World by E. Clodd (MacMillan & Co.)

A simple account of Man's origin and Early History. This book has enjoyed an ever-increasing popularity for over

40 years now. I have translated it into simple Urdu with suitable explanatory notes and hope to publish it soon under the title **دنیا کا عہد طفلی**

35. Achievements of Chemical Science by J. O. Philip (MacMillan & Co.)

36. Wonders of Physical Science by E.E., Founder (MacMillan & Co.)

Both these books are excellent and are really "Readable Books in Natural Knowledge." The other books in this series of Readable Books are also worth studying. Each can be had for 1/6.

I intend writing a small book in Urdu on these lines under the title **کمالات سائنس**

'37. Science of Common Life by A. T. Simmons and Stenhouse (MacMillan & Co.) This book was formerly called Experimental Hygiene and should be taught to young boys and girls.

38. The New Knowledge by R. K. Duncan. (Hodder and Stoughton, 1907.)

A Populr account of the New Physiscs and the New chemistry in their relation to the New Theory of Matter.

39. Charles Darvviir and the Theory of Natural Selection by F. B. Poulton (Cassel & Co.)

This book is published in the Century Science series. The following biographies published in this series via. Dalton, Herschells, Charles Lyell, J. C. Maxwell, H. Davy, Michael Faraday, Pasteur and Hermann von Helmholtz are excellent introductions to the life-work of these eminent scientists as well as to the fundamental principles of the sciences of which they were the chief exponents.

40. Geology Primer by Sir A. Geiko F. R. S. (MacMillan & Co.) MacMillan's series of Science Primers so ably edited by Professors Huxley, Roscoe and Balfour Stewart are a model of clear exposition and simple but masterly treatment of scientific subjects. The first three primers of the series have already been translated into Urdu and published by Messrs. Gulab Singh & Co, Lahore. *Vide infra* Urdu Books- of Science

The following (Nos, 41 to 49) People's Books, 6d each bound in cloth, are all worth studying.

41. The Experimental Psychology of Beauty by G. W. Valentine.

42. Dietetics by Alex Bryce M. D.

43. Nature of Mathematics by E. B. Jourdain.

44. Embryology, the beginning of life by Dr.

Leighton,

45. The structure of the Earth by T.G Bonnoy

46. -Radiation by P. Phillips. (Simply nice.)

47. Lord Kelvin by A. Russel.

48. Huxley by Dr. Leighton.

49. The Science of the stars Astronomy without the Telescope by E. W. Maunder.

50. Life of Lord Kelvin by S. P. Thompson in 2 volumes.

An exhaustive scientific Biography, and a mine of information about the progress of Physical Science in the 19th century.

51. Psychical Research by W. F. Barrett.

A concise introduction to this new realm of experimental investigation.

52. Human Personality in 2 volumes by F., W. H. Myers. (Longmans & Co.)

This *magnum opus* contains the substance of the Psychical Research Society's investigations down to the dawn of the 20th century and is a standard book on Psychical Research.

53. The Survival of Man by Sir Oliver Lodge. (Methuen & Co.)

An outline of the authors' investigations on psychical research more especially with regard to automatic writing and contemporary records which have convinced him that trustworthy evidence exists on behalf of the human survival of bodily death.

54 On the threshold of a New World of thought by W. F. Barrett. (Kegan Paul, Trench & Co.)

In this book, the author discusses the question of spiritualism from a scientific and religious point of view.

55. Modern Man and his Forerunners, by H., G. F. Spurrell. (G. Bell & Sons 1917 7/6 net.)

A short study of the Human Species, Living and extinct.

56. Science and Industry, by A. P. M. Fleming. (Published for the department of Scientific and Industrial Research by his Majesty's Stationary office, 1917 2/6 net.)

A series of papers bearing on Industrial Research.

No. I Industrial Research in U. S. A.

57. science and Industry, by Sir R. T. Glazebrook. (Cambridge: At the University Press 1917, 1/6 net.)

The book is a reprint of the Rede Lecture for 1917, and indicates briefly the place of Cambridge in any Scheme for the amalgamation of Science and Industry.

58. The Principles of Rational Education by Dr. C. A. Mercier. (The Mental Culture Enterprise, London 1917, 2/6 net.)

"This book should take the place so long occupied by Herbert Spencer's Education, which was translated into every language in Europe, and was disseminated throughout the world. It has done its work and the time is now ripe for an advance. The way to this advance is shown in this new book by Dr. Mercier.

59. Education, Intellectual, Moral and Physical by Herbert Spencer. (Can be had for 1/- bound in cloth or 6 d. paper cover from Watts & Co., in R. P. A., cheap Reprints.)

Spencer's Education is *the book* for students to study and digest. It will open a new world of thought and action before their minds. It has also been translated into Urdu as **فلسفۂ تعلیم**.

As a companion volume students might profitably study **Blackie's Self-Culture as well.**

60. Higher Education and the War by J. Burnet (Mac Millan & Co., 1917, 4/6 net.)

61. The Organisation of Thought, Educational and Scientific by A. N. Whitehead (Williams & Co., Norgate, 1917, 6/- net.)

62. Genetics and Engenics by W. E. Castle (Oxford University Press 1916, 8/6 net.)

The conclusions, arrived at by the author with regard to the improvement of the human race, will probably meet with fairly general acceptance. The Study of Eugenics will introduce to students the scientific application of Biology, Heredity etc., with reference to race regeneration.

63. The Borderlands of Science by A. T. Schofield (Cassel & Co., 1917 6/- net.)

64. Waves and Ripples in Water, air and Ether by Fleming. For lucidity of expression and illustration, this book is unrivalled, and forms a nice introduction to Kumatology or the Science of waves.

65. A Laboratory Manual of Dietetics by Mary S. Rose Ph. D. Asstt. Professor in the Departments of Nutrition. (The MacMillan Company, 7/6)

Investigations into the quantitative requirements of the human body have progressed so far as to make dietetics to a certain extent an exact science and to emphasise the importance of a quantitative study of food materials. The number of calories or the amount of heat which different foods can supply to the human body is an important problem.

66. Elementary Household Chemistry by J. F. Snell (The Mac Millan Compay 5/-).

The principles of chemistry are developed and their everyday applications are studied simultaneously.

67. The Idea of God as affected by Modern Knowledge by J. Fiske.

68. The Destiny of Man, based on his origin by J. Fiske.

The following R. P. A. 6d publications are one and all excellent and well worth studying (Watts & Co.)

89. Huxley's Lectures and Essays.

70. , Tyndall's Lecture and Essays.

71. Clodd's Story of Creation.

72. Three Essays on Religion by J. S. Mill.

73. Haeckel's Evolution of Man in 2 vols.

74. Man's Place in Nature by T. H. Huxley.

75. Twelve Lectures and Essays by T. H. Huxley.

76. Haeckel, his life and Work by W. Bolsche.

77. The Fundamental Principles of Positive Philosophy by Auguste Comte.

78. J. S. Mill's Autobiography (Unabridged.)

79. Ingersoll's Lectures and Essay. Three series.

N.B.—Other books published by the Rationalist Press Association have already been mentioned on previous pages.

80. Pioneers of Science by Sir O. Lodge.

81. Fragments of Science by Tyndall, 2 vols.

82. Popular Lectures and Addresses by Lord Kelvin, 3 vols. (MacMillan & Co.)

Popular lectures and addresses of other scientists viz. Helmholtz, Faraday, etc., should also be studied. Senior students should study their Collected Papers giving first-hand information about the original scientific investigations of various scientists.

83. Science and Education (Price 1/- net. (London: William Heiremann.) Edited with an Introduction by Sir Ray Lenkeshor, K. C. B.

This volume contains seven lectures which were delivered by Whewell, Faraday, Latham, Duubeny, Tyndall, Paget and

Hodgson before the Royal Institution in 1854. For clarify of expression and a true grasp of the highest educational ideal they have never been surpassed and they should prove a valuable contribution to the theory that should give educational reconstruction.

84. Principles of Physics by W. A. Magie. (Bell & Sons.)

85. The New Physics by Poincare. (K. P. Trench Tubner.)

86. Mechanical Production of cold by Ewing. (Cambridge University Press.)

87. Theory of Heat by Th. Preston. (MacMillan & Co.)

88. Light waves and their uses by Micholson. MacMillan & Co.)

89. Accoustics of Public Buildings by T.R. Smith. (Crosby Lockwood & Co.)

90. How Telegraphs and Telephones work. (Seeley, Service & Co.)

91. Forecasting Weather by Shaw (Constable & Co.)

92. Wireless Telegraphy, popularly explained by I I . Kerr (Seeley and Co.) A short lucidly written primer.

93. Origin of Species by Ch Darwin, 6d or 1/-

94. Darwinism by A. Wallace (MacMillan & Co.) An admirable book.

95. Wonder Book of Light by E. J, Houston Ph. D. (Chambers & Co.)

Vide 3 other books in this "Wonder Book of Science" Series on Magnetism, Atmosphere, and Volcanoes and Earthquakes.

96. How we think by Dewey (Harrap & Co. U. S. A.)

An extremely interesting and lucid analysis of the fundamental process of reflective thinking.

97. A History of the Cavendish Laboratory 1871—1910.
(Cambridge University Press.)

Written by the colleagues of Sir J. J. Thomson to celebrate the completion (in 1909) of the 25th year of J. J. Thomson's Cavendish Professorship of Experimental Physics in the University of Cambridge. This mode of celebrating such occasions is much in vogue on the continent of Europe. It contains besides other articles a survey of the last 25 years by Sir J. J. Thomson and the Development of the Teaching of Physics by L. R. Wilborforce.

98. Notes on observation by Lupton. (MacMillan & Co.)

An excellent book for students of Science : a valuable introduction to the Mathematical Theory of Errors and Probability.

99. Interpretation of Radium by Fred. Soddy. Independent Professor of Physical Chemistry and Radio activity in the University of Glasgow.

100. Matter and Energy by Professor F. Soddy. (Home University Library.)

Gives the Physical History of man's progress and discusses the vitally important problem of man's future stock of Heat energy when the present coal beds are exhausted.

101. Chemistry and Chemical Magic by V. E. Johnson
(Hodder & Stoughton.)

102. Discoveries and Inventions of the 20th Century by Cressy (Routledge & Co.)

N. B.—In this connection see the other books mentioned on pp. 15, 16 in Part I of the Address,

103. Radium and Radio-activity by A. T. Cameron. (Romance of Science Series published by the Society for Promoting Christian (?) knowledge.)

104. Autobiography of an Electron by C. R. Gibson.

105. Elements and Electrons by Sir Woi. Ramsay.

106. Radio-activitiy and Geology by Joly.

107. Age of the Earth by Sollas.

108. Electricity and Matter by J. J. Thomson.

An account of the Electronic constitution of the Atom.

109. ^Discharge of Electricity through Gases by J. J. Thomson.

110. Radio-active Substances and their Radiations by Rutherford. (1913)

Both these books are standard text books of the New Physics,

111. Modern Electrical Theory by Campbell (Camb. Univ. Press.)

112. Progress of Physics 1875-1908 by A. Schuster. (Camb, Univ. Press.)

Four lectures delivered before the Calcutta University.

113. Recent Development of Physical Science by W. C. D. Whatham.

114. Electrons by Sir Oliver Lodge.

115. The Electron Theory by Fournier (an attempt to explain all electrostatic and electrical phenomena in terms of the electron,)

116. Modern Views of Electricity by Sir Oliver Lodge (Macmillan & Co.)

These views are now somewhat antiquated.

II Pupolar Scientific books (Urdu) .

۴ — لکھنے سائنس یعنی مجموعہ سائنٹیفک مضامین
حصہ اول مصنفہ پروفیسر فیروز الدین مراد ایم ایس
سی بی اے (علی گڑھ) *

انشاء اللہ القوی یہ کتاب جنوری سنہ ۱۹۱۸ء میں شائع ہو جائے گی۔
طالب علمان سائنس کے لیئے بالخصوص مفید ہوگی۔ اس میں ہر ایک
قسم کے علمی مضامین عام فہم اردو میں بیان کئے گئے ہیں۔ اس کا مطالعہ
معلومات عامہ اور سائنٹیفک واقفیت کے لیئے ازبس ضروری ہے۔ مضامین
کی تعداد ۳۰ کے قریب ہوگی اس کے بعض عنوانات حسب ذیل ہونگے۔
اعجاز سائنس - فلسفہ فطرت - زمین کی پیدائش اور اندرونی حرارت
زمین کا وزن - ہماری بے غدر خدمت برق - ریڈیم گھڑیاں اور ریڈیم کلاک
حیرت انگیز جدید علمی انکشافات - چاند تک کی سفر - نہ دیکھائی دینے
والی روشنائی - باسی روٹی اور سائنس - ہندوستان میں تحقیقات سائنس -
قانون تجاذب مادی اور کشش ثقل - ارتقائے حیوانی اور انسان کی
طبعی تاریخ - انتہائے سائنس - حرکت کا پہلا قانون - ہوا کا دباؤ اور اُس
کے علمی فوائد وغیرہ *

انشاء اللہ العزیز اس کتاب کی اشاعت کے بعد جو اب قریب الاختتام
مفصلہ ذیل مدرسہ کتب سائنس بسرعت ممکنہ شایع کرنے کی کوشش کی جائے گی
و الامر بید اللہ - دنیا کا عہد طفلی - جدید علمی خیالات
حوائج زندگانی کی سائنس *

۵ — برہمانڈ ٹانگ یعنی نظام شمسی کی دلچسپ کہانی بطرز
ڈراما - لالہ کنز سین صاحب ایم اے (مفید عام پریس لاہور) *

اگر اس کتاب میں ہندی الفاظ کی بیجا کثرت نہ ہوتی تو میں اسے
نہایت ہی دلچسپ اور نادر علمی کتاب کہتا - لیکن جو اصحاب ہندی
الفاظ سمجھ سکتے ہیں اُن کے لیئے اس کی زبان سلیس اور شیریں
بدرجہ اند ہے *

۶ — عجیب و غریب صدی - پنجاب رلیجس بک سوسائٹی
لاہور - ۶ آٹہ

یہ لحاظ قیمت یہ کتاب عجائبات عالم میں شمار کئے جانے کے
قابل ہے *

۷ — مقدمات الطبیعات ، مولفہ مرزا مہدی خاں
صاحب کوکب *

(سلسلہ انجمن ترقی اردو نمبر ۹ - قیمت ۱ روپیہ ۸ آنے، الناظر بک ایجنسی چوک لکھنؤ سے دستیاب ہوسکتی ہے) *

توضیح مطالب ، وسعت مضامین اور سلاست زبان کے لحاظ سے یہ کتاب اردو کی بہترین سائنٹیفک تصانیف میں شمار کیئے جانے کے قابل ہے ۔ بلکہ یہ کہنا بجا ہے کہ اس وقت تک زبان اردو میں اس کے سوا اور کوئی قابل ذکر عمدہ سائنٹیفک کتاب موجود نہیں ہے ۔ علمی اصطلاحات کے لحاظ سے یہ کتاب نمونہ کہلانے کی مستحق ہے ۔ جس خوبی سے حضرت کوکب نے مناسب اور دلنشین اصطلاحات وضع کئے ہیں وہ انہیں کا حصہ ہے ۔ صرف بعض مقامات پر عربی مصطلحات کے استعمال میں غلو محسوس ہوتا ہے ۔ لیکن بحیثیت مجموعی ہم مولوی عبدالحق صاحب (سکریٹری انجمن ترقی اردو) اور حضرت مصنف صاحب کو ان کی اس عظیم المثال کامیابی پر تہ دل سے مبارکباد پیش کرتے ہیں اور اس قلبی مسرت و انبساط کے لیئے جو ان کی اس اولین تصنیف کے مطالعہ سے ہمیں حاصل ہوئی ہے شکر گزاری کا اظہار اپنا اعلیٰ علمی فرض سمجھتے ہیں ۔ اس کتاب کا ماخذ فزیوگرافی (مصنفہ ہکسلے) ہے *

۸ — طبقات الارض - مولفہ مرزا مہدی خاں صاحب کوکب (سلسلہ انجمن ترقی اردو نمبر ۱۵) *

۹ — مبادی ساگنس - ترجمہ مولوی معشوق حسین صاحب بی اے علیک (سلسلہ انجمن ترقی اردو) *

موخر الذکر ہر دو کتب عام مطالعہ کے لیئے از بس غیر موزوں ہیں، اور نہ صرف عام فہم نہیں ہیں بلکہ پیچیدہ عربی اصطلاحات کے استعمال کے باعث (جو بلا شریح درج کتاب کردی گئی ہیں) ایک بڑی حد تک نکمی ہو گئی ہیں ۔ نہایت اور چبھائی بھی ناقص ہے *

۱۰ — القہر - یعنی چاند کے حالات - بموجب تحقیقات جدید مولفہ مولوی راحت حسین صاحب بی اے (سلسلہ مطبوعات انجمن ترقی اردو قیمت ۸ آنے) *

۱۱ — سورج ، چاند ، ستارے (پنجاب ریلیجس بک سوسائٹی ۸ آنے) *

۱۲ — علم طبعہ کی تاریخ حصہ اول اور دوم (پنجاب ریلیجس بک سوسائٹی ۱ روپیہ) *

- ۱۳ — مقام الفنون و رسالہ حرارت (انجمن صالح و الفنون
 الہ آباد نے ہندی میں لکھوا کر ترجمہ کرایا) *
- ۱۴ — فلسفہ جذبات مصنفہ عبدالماجد صاحب بی اے الہ آباد
 (انجمن ترقی اردو) *
- ۱۵ — فلسفہ اجتماع - مصنفہ عبدالماجد صاحب بی اے (انجمن
 ترقی اردو)

ہردو کتب نفسیات (علم النفس یا سائیکا لوجی) کے متعلق بہت
 ہی دلچسپ اور عمدہ معلومات کا ذخیرہ ہیں۔ کتابت اور چھپائی
 اعلیٰ ہی — موخر الذکر کتاب کے جستہ جستہ اجزا بعنوان
 (Psychology of Leadership) کتاب کی شکل میں نشرائون کمپنی
 کے یہاں سے انگریزی میں شایع ہو کر مقبول ہو چکے ہیں *

I I I . Popular Science Journals.

1. Scientific American without Supplement (weekly 4 dollars p. a.)

A weekly Journal of practical information. The supplement contains original and advanced articles on scientific and technical topics.

2. Science—(weekly, Annual Subscription 3 dollars.)

It is the official organ of the American Association for the Advancement of Science.

3. Popular Science Sitings (weekly, 10/- p. a.)

It is a cheap popular paper, somewhat garrulous and sensation-monger even in the realms of Science.

4. The Scientific Monthly (3 dollars p. a.)

An illustrated magazine devoted to the diffusion of Science, publishes articles by leading authorities in all departments of pure and applied Science including the applications of Science to Education and Society.

ESSAYS READ BEFORE THE SCIENTIFIC SOCIETY FROM 1907-1917.

1. The General Scope of Science. 2. Surface Tension.
3. The Solar System. 4. Inorganic Evolution. 5. Astronomy, old and new. 6. Astronomy and kindred Phenomena. 7. The sun and his eclipses. 8. The Salt in aqueous solution. 9. The Constitution of the atom. 10. Halley's comet and its collision with the Earth (an open-air lecture.) 11. Immunity from disease. 12. What should be the precise definition of an acid ? (a lecture illustrated with experiments.) 13. History of Thermo*metry. 14. The Construction of Motor Cars. 15. The Induction Coil. 16. The Dynamical Theory of Heat. 17. The origin and structure of the crust of the Earth. 18. مصنوعي جواهرات ترکیبی
19. The Composition of the atmosphere. 20. The Fixation of Nitrogen. 21. A brief History of the Scientific Society. 22. Are the stars infinite in number ? 23. The Spectroscope. 24. Is ether matter ? 25. The Arabs and Science. 26. The development of Science from ancient Greek civilization to the dawn of 20th century. 27. Scientific Education and India's Neglect of Science (Presidential Address.) 28. Theories about the constitution of Matter. 29. معمل طبیعیاتی کا ارتقاء Evolution of Physical Laboratories. 30. The Pursuit of Scientific of knowledge. 31. Evolution of Metrology and Principles of Physics. 32. Meteorological and Physical Phenomena: a Strachey Hall Lecture (illustrated with Lantern slides). 33. The Conquest of air. 34. Living Matter. 35. جاپانی کوا آتش نشان
36. Imitation of Life in the Laboratory. 37. The Household Fly as a Carrier of Disease. 38. روشنی- ارتقاء اور ماحیئت
39. Manufacture of Brassware in Moradabad (a lecture in Urdu, illustrated with actual modeds.) 40. Chemistry is more useful than Physics (a debate),

ABSTRACT OF RULES AND REGULATIONS OF THE SCIENTIFIC SOCIETY.

The object of the Society is to develop Scientific taste
among the students reading Science and to
Aims and objects provide popular lefutures on Scientific topics
tor students in general

Members of the Cabinet and other office-bearers are elected annually in a general meeting of the Society by a simple majority of votes : The President and two Vice-Presidents, from amongst the members of the Staff of the Prince of Wales School of Science ; the Honorary Secretary and Assistant Secretary are usually IV and II year class students and the two joint Librarians, III and I year class students respectively. Besides these four student-members of the Managing Committee, one more representative from each of the Science classes is also annually elected for helping the office-bearers in running the Society and officiating for them during their absence from Aligarh.

Ordinary meetings are held every week, and students are "Weekly Meetings, expected to read essays in them.

SIX PRIZES FOR ENGLISH AND URDU ESSAYS.

One prize for the best essay in English written by B. Sc. students. One prize for the best essay in English written by Intermediate Science students. One prize for writing the largest number of essays in English, open to all Science students.

Similar 3 prizes for essays written in Urdu.

One Medal will be annually awarded to the student who Summer-Vacation does the best scientific work during the three Gold Medal. months of Summer Vacation. If- the work shown is highly satisfactory a gold medal may be awarded. The number of medals awarded in any one year may be suitably increased if more than one student does excellent work. Besides making original scientific observations about natural phenomena or performing experiments, a working idea of the scientific work expected from students is sketched in Part IV of the Address.

NOTE.—This year the medal will be awarded to the student doing excellent scientific work till the end of January, 1918.

The Scientific Society **Cup** has been specially sanctioned Science Trophy, with a view to develop *esprit de corps* among A Class Prize, students in the pursuit of scholarly glory. It **will** be annually awarded to the class evincing best scientific

taste, both by preparing meritorious essays and by regular attendance at the meetings of the Society.

This Purse shall be open for competition to all the students Scientific Society of the College and shall be awarded to the Translation Purse. author of the best urdu translation of some useful work on iScience.

The underlying idea of these multifarious inducements for scientific work is to develop scientific taste among students, to enrich Urdu and to popularize Science as much as possible.

Besides giving other necessary information about the yearly work of the Society, the Annual Report will * publish the four Prize-Essays and the best Urdu translations of the year.

Publications of the Scientific Society will be distributed to all members either gratis or at a nominal price*

SUCCESSION LIST,

PRESIDENTS.

Dr. E. P. Harrison, Professor of Physics.	1907-08.
Dr. Zia Uddin Ahmad, Professor of Mathematics.	1908-08.
Mr. H.B. Dunncliff, Professor of Chemistry.	1908-12.
Dr. Wali Mohammad, Professor of Physics.	1915-16.
Mr. H. Krall, Professor of Chemistry.	1916-17.
Mr. Feroz Din Murad, Professor of Physics.	1917-

„ SECKErAKIES.

Dr. Sir Syed Ahmad Khan, Founder of the Scientific Society, Aligarh.	1866-
Mr. Khuda Bakhsh.	1907-08.
Mr. Khair-ud Din.	1909-10.
Mr. Mohammad Haidar Khan.	1910-12.
Mr. Md. Zumair taqvi.	} . . 1912-12.
Mr. Omar Hayat Malik,	
Mr. Zahur Hussain.	
	1915-16.

Mr. Zahur Ahmad.	1916-17.
Mr. Malik Nazir Ahmad.	1917-

SHORT HISTORY OF THE SCIENTIFIC SOCIETY, ALIGARH.

The Scientific Society has a chequered history extending over half a century. The story of its life can be fitly divided into the following three ueriods :—

Stage I.	Genesis and Infancy	, t	1866-1907.
„ II.	Preparation period	.	1907-1917.
„ III.	Period of action	.	1917-

The Scientific Society was first formed by the late Dr. Sir
 1 Syed Ahmed Khan, in 1866 with the ob
 ject of "spreading western Science among the
 Mohammadans of India." Standard English books were translated
 into Urdu, and important lectures illustrated by experiments
 were delivered from time to time. "In 1896, the Society was
 revived by Mr. It. B. Qadri and transferred from the Society
 Gardens to the M.A.-O. College." The Society then possessed
 a Reference Library, which has till now remained an uncared-
 for, uncatalogued part of the Lytton Library. At the suggest-
 ion of Professor F. D. Murad, the Society is trying to amal-
 gamate it with the newly created Scientific Society Library.

After the opening of the B. Sc, classes, Professor

II E. P. Harrison revived it again in 1907.

1907-17. But after his departure in summer 1908, the
 Society had a long nap again, until Professor H. B. Dunni-
 cliff re-organised it in November 1911. After holding a
 few meetings the iSociety again slumbered until it was
 revived by Dr. Wali Mohammad and Professor Feroz Dir
 Murad in March 1915, when a new constitution was draftee
 by Professor Murad. Henceforth every Science studem
 had to pay a monthly subscription of annas four. Aboul
 half a dozen meetings were successfully held, but with the
 change of ministry in 1916, another period of inactivity for
 lowed and the Society hold no meetings for more than a year.

Continued.

SHORT HISTORY OF THE SCIENTIFIC SOCIETY, ALIGARH.

Under the Presidentship of Prof. Feroz Din Murad, the Scientific Society has turned a new leaf in its **September 1917** and After. chequered history. Regular weekly meetings are now held in which Science students and Professors read papers and deliver lectures on scientific subjects: against 23 meetings held in the last 11 years, 14 meetings have been held so far during the last three months and a half.

The Urdu Section of the Society has also held three meetings in this short interval.

The Inaugural Address is a new departure and if this desirable precedent is followed by future Presidents of the Society, Science students will certainly gain much in this way.

A new series of lectures (illustrated with models) about local district industries has also been started.

Besides the six prizes for writing meritorious essays on scientific subjects, a class prize (in the form of: the Scientific Society Cup) to be awarded to the class evincing best scientific taste, a gold Medal for scientific work done during Summer Vacation and another prize in the form of a Purse for encouraging the Urdu translation of useful scientific books have been sanctioned in December 11)17.

A Library has also been started in connection with the Society and it is hoped that in conjunction with the other inducements for scientific work, it will considerably help the 'development of Scientific taste.'

Efforts are being made to hold the first—or correctly speaking the fifty-first—anniversary meeting on a grand scale in September 1918, in which eminent scientists, both external and internal, will be requested to deliver a number of lectures on important scientific subjects.

SCIENTIFIC WORKS

PROFESSOR E. D. MURAD b, A., M.SC.



1. **Scientific Education and India's Neglect of Science**, with a comprehensive Bibliography and suggestions for scientific work, pp. 100 + xiv Price one Rupee.

2. **Water in the Economy of Nature.** Price annas eight.

A popular exposition of the part played by Water, Ice and Steam in the economy of Nature, complete in three parts, pp. (JO). The three parts can also be had separately.

Part 1. Water in the liquid state. Price annas four.

Part II. Ice and Steam. (In the Press.)

Part III. Solution and the study of Water as a Solvent.

(In the Press.)

3. **The Electron Theory Of Matter** : an essay. It is a condensed summary of our knowledge of the electrical origin of Matter as revealed by a study of the Radio-active Transformations.

4. **Scientific achievements of the early Musalmans.**

(In preparation.)

5. قیمت ایک روپیہ اٹھ اے تحفہ سائنس

یعنی مجموعہ سائنسیک مضامین حصہ اول ۳۰۰ صفحات

Tuhfa-i-Science or Vol. I of a Collection of Scientific Papers in Urdu, with a comprehensive glossary of Urdu scientific terms and their English equivalents, pp. 300. Price Rs. 1/8/-

6. جدید علمی خیالات (In preparation.)

یعنی زمانہ حال کے سائنسیک قیاسات کی عام فہم تشریح

7. حوائج زندگی کی سائنس

Science of daily life with applications of Physics and Chemistry in the household.

8. دنیا کا عہد سنائی (In preparation.)

اس دلچسپ اور نصیحت آموز کتاب میں انسان کی ابتداء اور زمانہ ماقبل از تاریخ میں اس کی ترقی کے حالات عام فہم اور سلیس اردو میں بیان کیئے گئے ہیں اور دارونیت اور فلسفہ ارتقاء سے بھی ضمناً بحث کی گئی ہے *

9. مقدمہ سائنس (In preparation.)

An easy introduction to the Scientific Method, the principles or Science, and some of the great problems of the day.