CHAPTER 1

INTRODUCTION

Science in the modern world.

"The civilization of a race is simply the sum total of its achievements in adjusting itself to its environment". The nature and method of adjustment have been different at different times. We are living in a much more complicated and chaotic world than our ancestors. Science has revolutionized the material world in which we live. According to Whitehead "it has practically recoloured our mentality". Thus every thing about us has been influenced by science. Our dress, our food, our home, transportation and communication have all undergone remarkable changes depending upon scientific discoveries and inventions. Due to the benefits of science the world seems highly shrunk. Man to-day regards this universe too narrow for his activities. He has been probing into the other planets for greater comfort. The successful trip of Gagarin of Russia and Shephard of America in the outer space is ample proof of man's aspirations and abilities in understanding and overcoming the forces of nature with the help of science. Society must take advantage of such adventures and discoveries for the progress of the human race. "Science discoveries affect the every day lives of every one. Society must see how science must

1. Ruh Shih, "The Civilization of the East and the West", in Whither Mankind, page 27.
be used for the satisfaction of human wants".¹

Pandit Nehru has aptly observed 'Science is now a new dimensional thinking for the solution of national and international problems. The future of the world lies not in the hands of the politicians but in the hands of Scientists and technologists'. Independent India wants men to outgrow their superstitious structure and develop a modern progressive scientific outlook to face the changing conditions of the universe due to atomic fission, radio activity and the sort in keeping with the advancements the Western countries have been making in the field of science. It is not enough if there is a Raman for the whole country. Every Indian child must develop the reasoning pattern of Raman, imagination of Bose and the inquisitive nature of Ray, if India has to survive the struggle for knowledge and progress. Hence it is incumbent on the part of educators to see that children develop scientific interest and attitude right from the very beginning and do not waste their time in cramming some scientific information.

"In our schools and colleges, students think with a few test tubes and measurements, visualising of science as a laboratory issue. They are ignorant of wider implication in everyday life and conduct. They are not being given scientific education at all, they are only

Meaning and scope of science.

We had so far a glimpse of the influence of science on the modern world. But then what is Science?

"Science is an inter-connected series of concepts and conceptual schemes that have developed as a result of experimentation and observation and are fruitful of further experimentation and observation. In this definition the emphasis is on the word 'fruitful'; Science is a speculative enterprise. The validity of a new idea and the significance of a new experimental finding are to be measured by the consequences - consequences in terms of other ideas and other experiments. Thus concerned, science is not a quest for certainty. It is rather a quest which is successful to the degree it is continuous."  

Twiss summarizes the meaning of science as "knowledge so classified and organized that it may be used in acquiring other knowledges; that it implies not only content or subject matter classified and organized, but also a method of investigation or problem solving including observation and measurement, observation and logical inference - both inductive and deductive by means of which subject matter is organized and used in prediction, discovery and invention; that its subject matter is constantly growing

1. Saiyidin K.G., "Education, Culture and Social Order".  
in volume and being brought under simpler and more comprehensive forms of description; that all human material is legitimate material for its investigation; that it grows out of the problems related to human needs, physical, industrial, social, emotional and intellectual; and that it is so intimately connected with industrial development that neither can go on without the other. Thus we see that science is a continuous quest for systematized and organized knowledge. Science is not a collection of facts. According to Poincare, Science is no more a collection of facts than a building is a collection of bricks. Science is man's relentless search for the understanding of the environment. It is a search by man by exploring, enquiring, seeking accurate description and explanation. The answers are tentative, inquiry continuous, always something more to be learnt. It is a search for classified understanding or interpretation of the environment. These interpretations become the body of science knowledge. They are the concepts, principles, generalizations which state our best present interpretation of our environment. The product of a scientific enquiry is a body of classified concepts.)

Scientific Method.

The content and method of science have certain charac-

teristics. The content of science consists, as mentioned above, of a continuously expanding body of systematized knowledge based upon scientific method. The method of arriving at knowledge in science is based upon certain principles. John Dewey opines "that the heart of science lies not in conclusions reached but in the methods of observation, experimentation and mathematical reasoning by which conclusions are reached." Thus we may say that the conclusions reached must be according to a particular method which includes observation, experimentation and proper reasoning. That is to say, the student of science takes more pains than the man in the street does to get at the facts. He is not content with sporadic knowledge, but will have as large a body of facts as he can get; he summarizes the data, draws his inferences from them and sums up in a generalization or a formula. According to Bertrand Russell, the essence of scientific method is the discovery of general laws through the study of particular facts. There are three stages in arriving at a scientific law (a) observation of scientific facts, (b) arriving at the hypothesis and (c) deducting generalizations which can be tested by observation or verification. In short scientific method is "induction for deduction with a view to construction".

Branches of Science.

Science has two major branches, pure science and applied

pure science aims at understanding nature whereas applied science deals with predicting and controlling it. Pure science has many branches—physical sciences, biological sciences, and earth sciences. This division is purely intellectual. Science does not exist in nature on this compartmental basis. The division of sciences are not like the different lines that meet in an angle but rather like the branches of trees that join in one trunk.1 Science teaching on a compartmental basis is justified only for specialization in a subject or for technology. On the other hand, a basic knowledge of science, as it exists in nature in the natural surroundings of children, is essential for all. This is possible only in an integrated course of study wherein all branches of science are included under the name of general science. Moreover in the early stages children see things as unanalysed wholes rather than the components.

Place of General Science.

The Committee2 on the Reorganization of science in Secondary Schools in America issued a report as far back as 1920 stating that steps should be taken to prevent the increase in specialization from diminishing the value of instruction from the standpoint of the general needs of the pupils and the needs of society. "It further stated that general science should provide a basis for discovery of interest in special sciences". It should prove to be the best training for any pupil who can take only one

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course in science. The subject matter should be selected from the environment and hence should vary from place to place and should deal with problems of social reconstruction. The science of common use should be the Science of the class room. The decision of the All India Committee on Secondary Education to adopt the concentric method of teaching general science is quite in consonance with the above mentioned report. The Science Masters' Association of America clearly defines general science in the following manner. "General science therefore should be a course of scientific study and investigation which has its roots in the common experience of children and does not exclude any of the fundamental sciences. It should seek to elucidate the general principles observable in nature without emphasising the traditional divisions into specialised subjects until such time as is warranted by the increasing complexity of the field of investigation, by the developing unity of the separate parts of that field and by the intellectual progress of the pupils".

The conditions obtainable in our State are not quite conducive to the teaching of general science at the present stage. The department should have introduced the scheme of science teaching on the topical method after training teachers in the art of teaching an integrated course of science. Most of the teachers do not have the

2. Science Masters' Association of America.
academic qualifications for teaching the integrated course. Hence lack of complete knowledge on the part of the teacher results in lack of suitable interest in the pupils leading to an irregular patched type of knowledge unrealistic in its nature. It is a welcome sign that the department has thought of conducting a content course in science to eradicate the above mentioned flaw. General science is introduced as a course of study in the University. The prevailing defect would be permanently overcome when graduates with these optionals handle general science in high schools.

Objectives of Science Teaching.

Science ever since the times of Arabs has had two functions; first to enable us to know things and second to enable us to do things, says Bertrand Russell. Science as has already been stated is systematized knowledge. This definition of science is giving way to science as a power for manipulating nature to the advantage of man. Learning or doing of any thing must have some objectives. Evidently teaching of science must also have some clear cut objectives. The Seminar on teaching of general science held in New Delhi in the year 1956 has proposed the following objectives for Science teaching (1) to familiarise the pupil with the world in which he lives and make him understand the impact of science on society so as to enable him to adjust himself to his environment and (2) to acquaint him with scientific me-

2. The First All India Science Seminar on Teaching of Science in India", page 35.
thod and enable him to develop a scientific attitude. In 1924 Watkins¹ investigated the objectives for general science and his findings were to insure that the pupil acquires (1) an understanding and control of environment; (2) a fund of information concerning nature and science; (3) a preparation for later science courses; (4) a training in the scientific method; (5) development of power of interpretation, and application; (6) development of interest in science and (7) culture.

In 1927 Cureton² found the following to be the most important objectives of general science: (1) Appreciation of the values and importance of science as it affects his daily life, so that he may acquire the proper attitude towards those civic scientific issues which he will later be called upon to lend his voice in solving; (2) to develop in the child these general attitudes and habits of broad-mindedness, fidelity to truth, careful inquiry and evaluation of evidence in connection with problems and logical analysis of data which will tend to mould his character and temperament in the best manner; (3) to develop in the child interest in the value, worth and beauty of science, so that he may have opened before him a great number of interesting avocations and he may be stimulated to go further into one of the many fields of scientific endeavours, (4) to

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2. Cureton, Edward E., "The Aim and Content of the Course of Study in General Science".
develop in the child those particular habits and attitudes and to present to him those particular facts and principles most likely to be of definite use to him both as a child and as an adult, (5) to give the child and as an adult a general preview of science to the end that he may have a better basis for the selection of further science work in school and perhaps in life. A study of high school curriculum in America from 1860-1918, reveals that the values of science teaching could be conveniently classified under the following heads (1) the religious aim (2) knowledge aim, (a) knowledge to the end that the learner may be regarded an intelligent person, (b) knowledge for its practical utility, (c) knowledge for mental discipline. These aims found recognition in educational literature and prefaces of text books. Writing about science study in his book "Natural History" for the use of schools and families Hooker states "This study has a practical learning on many of the most valuable and extensive occupations of man". "The practical benefit is - the discipline which it gives the mental powers".

Boyer F.R.A. in his book "Laboratory Manual in Biology" writes, "The aim of science teaching is to develop rather than to inform. Hence the laboratory method is more important than the information involved. Accuracy in observation is a pre-requisite for accuracy in description as well as to logical inference" In his book "Elements of Chemistry" Ira Remson said, that the course was not to make chemists

but to help to develop sound minds and awaken interest in important natural phenomenon. Smith in his discussion on teaching of Chemistry gives the following reasons for the study of Science. "Our first reason", he says, "rests on the training in observation for which it furnishes the opportunity. The second reason is that it trains the pupil in the organization of his observation by comparison and induction. A third is that of exercise and control of the imagination. He further states that science gives training in self elimination (which may be defined as unbiased judgement). He recognized the value of information the study of science imparts. S.Ralph Powers writing in "The plan of public schools and the programme of Science Teaching" states that "science must be viewed from two specific points - for the immediate educational values for high school pupils; and for the background of preparation they afford for the more intensive and specialized study of the sciences by those who continue in colleges later. Educational values of real significance will be attained if pupils as a result of such instruction acquire (1) the ability to use the scientific findings that apply in their experience, (2) the ability to interpret natural phenomenon in their environment and (3) an appreciation of scientific attitude through the understanding of, and ability to use, some of the methods of study that have been employed by scientists". From the multitudes of

the objectives mentioned above the aims of Science teaching can be grouped under four broad heads.

1. Utilitarian aim,
2. Disciplinary aim,
3. Cultural aim,
4. Social aim.

**Utilitarian aim.**

Children must be given such knowledge of science as has direct contact with the affairs of their daily life. Great importance must be given to scientific principles of wide generality so that their understanding may lead to useful application in solving the problems of life. Science must also be used to harness the forces of nature to the advantage of man.

**The disciplinary aim.**

Teaching of science must thrill the students and sharpen their minds. It must inculcate in them the habits of accurate observation, separating the relevant from the irrelevant in a purely objective manner, uninfluenced by bias or prejudice. It must develop openmindedness and unyielding attitude to authority and superstition. Teaching of science must develop the spirit of inquiry. The methodical procedure in experimentation and observation and the scientific outlook they develop in a course of scientific study—should go a long way to help them tackle life problems on a scientific basis.
Cultural Aim.

The culture of a race is the sum total of the modifications and adjustments it has undergone to suit the changing conditions. The social heritage shows us the way our fore-fathers have reacted to certain environmental conditions to suit their interest and the interest of their descendants in similar conditions. Our children should also have something to hand over to the future generation. Teaching of science must arouse their interest in mysterious happenings in their environment and they must quench their inquisitive thirst by self effort. We have inherited the knowledge of aeroplane from our predecessors and we hand over the knowledge of jet planes, atomic fission, atomic energy and inter-continental missiles to the future generation. Knowledge is a legacy from the past and a gift to the future.

Social aim.

Science has and has been changing our social life. Our ways of transportation, communication, agriculture, trade and commerce have all been influenced by science. The world of to-day is too small, when advantages of science are made use of. One may break-fast at Bombay, lunch in London and dine in New York. The child must be enabled to adjust itself to this sort of social progress and the ever-changing ways of life. The child must develop healthy habits, scientific attitude and a corporate way of life.
Measurable outcomes of Science teaching.

In the fore-going paragraph the objectives and aims of science teaching have been dealt with at length. Here mention is made of the measurable outcomes of science. There are five types of major measurable qualities in science - knowledge, skills, concepts and understanding, application and interests and attitudes.

Knowledge.

Information and knowledge are emphasised in science teaching. Knowledge is a necessary criterion for satisfactory adjustment to life, though it cannot be said that mere possession of knowledge would lead to proper reaction. Hence measurement of the knowledge of scientific information is essential.

Skills.

Skill in handling scientific instruments, apparatus and tools and performing experiments is as essential as knowledge. For example the pupil should have the skill to use a cycle pump and should be able to set it right should it go out of order; or he should know how to replace a fuse in case it is burnt out.

Concepts and understandings.

As facts are the vehicles of thought, the relation between facts and generalizations is the vehicle of understanding. Attainment of generalized ideas in science is indispensable. Tests on this aspect of learning cannot be lost
sight of.

Application.

Application of scientific knowledge is the most important objective of science teaching. Test items that involve understanding of new situations demand the ability to use scientific knowledge, reasoning and judgement. Test items of this kind must find a place in any testing programme of science.

Interests and Attitudes.

Tests on interests and attitudes are as important as any other outcome of science. They are the signals which indicated the future professions, occupations and hobbies of the pupils. Constructing tests on this aspect of the outcomes is not easy. All the same all possible efforts should be made to test this outcome.

Measurement of Educational outcomes.

In the previous paragraphs enough light is thrown on the broad aims of science teaching and its measurable outcomes. The outcomes of science teaching, as any other subject, have to be subjected to measurement in order that we may reap the full benefit of the programme of science teaching in our schools. "Measurement is the principle implement of science changing that field of human endeavour from medieval gropings into modern exactitude". 1

Sir Galton is of opinion that until the phenomena of any branch of knowledge have been subjected to measurement and number, it cannot assume the status and dignity of science.¹ What are the different types of measurement available? There are two major types of measurement, the essay type and the new type or objective type. Time and again the defects of the old type or essay type of examinations have been pointed out. It is subjective, unreliable, invalid, time consuming both on the part of the pupil and the examiner and suffers from lack of wide sampling and definiteness of questions. It is needless here to go into the details of studies made by Staroh and Elliot, Ballard, Falls, Ellis, Rulton and others regarding the alarming short comings of the essay type. In a study made in the University of West Virginia, Ashburn² came to the conclusion that 40 per cent of the passes or failures depended not on what they knew but on who read the papers and the passing or failure of 10 per cent depended upon when the papers were read. In contrast to those the new type of examinations are more objective, highly reliable and much more valid. They enjoy wide sampling, dependability and clarity. They are easy to administer less time consuming and more thought provoking.

George Fisher³ an English School Master, realising the subjective nature of the essay type of examinations

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¹ Sir Francis Galton, quoted by L.W. Howerth page 1 of "Measurement of Mental Phenomena".
proposed a "scale book" made up of various standard specimens of handwriting arranged in order of merit. But this did not produce a lasting effect. Ayres feels that this is due to the fact that the people in those days did not believe that human behaviour was susceptible to quantitative study. The real inventor of the comparative test in America was J.M. Rice. In 1894 he constructed tests in spelling, arithmetic and language to discover the minimum time required to teach these subjects. It took ten years for his attempts to get the approval of educators. In 1904 Thorndike gave the world his memorable book "Mental and Educational Measurements". Thorndike is rightly regarded as "the father of the objective test movement". Stone, a student of Thorndike, published the first standardized test in Arithmetic in 1908. This was followed by Thorndike's "scale for handwriting for children" in 1909. Thus came into use the objective tests in America. Though educators were first opposed to these, the defective nature of the other type of examinations and the objective nature of the new type compelled them adopt the latter.

Even in India educationists have not been blind to the evil effects of the present system of examination. A thorough re-orientation of examinations has been a long felt need. As far back as 1938 the Zakir Hussain Committee

2. Leonard P. Ayres, page 11
stated⁴ "The system of examinations prevailing in our country has proved a curse to our education. A bad system of education has, if possible, been made worse by awarding examinations a place out of all proportion to their utility. Examinations are neither valid nor complete, they are inadequate and unreliable, capricious and arbitrary". The same Committee suggests the administration of objective tests constructed in consultation with the experts in curriculum making. Dr. Radha Krishnan in his report has clearly indicated the common profound dissatisfaction with the existing system of examination and its down-right condemnation in no unmistakable terms. The report says, "Examination, as they have been functioning, have been recognised as one of the worst features of Indian education, with its pernicious domination over education .... they kill all initiative in the teacher and the student .... have made it almost impossible to provide true education and to develop wider interests and have created temptation of cheating and corruption". In his opinion "The obsession to secure as it were a ticket in the lottery of job-securing has overshadowed the educational purposes which a good examination can serve".² The Commission feels convinced that "If we are to suggest one single reform in education, it should be that of examinations." The Commission suggest, however is not in favour of abolishing the examinations. On the other hand it recommends the improvement of the existing system

1. Menzel, "The Use of New Type Tests in India" - preface.
by the introduction of "valid, reliable, adequate objective examinations".

The Mudaliar Commission on Secondary Education declares "Examinations have so pervaded the entire atmosphere of school life that they have become the main motivating force for all efforts on the part of the pupils as well as teachers. If any school activity is not related directly or indirectly to the examination it fails to evoke or enlist the students' enthusiasm - they have come to exercise a restricting influence on the entire field of Indian education to such an extent as almost to nullify its real purpose". All the above reports indicate their disgust only with the existing type of examination in our country. This does not mean to advocate the abolition of examinations as such but only a change over to the new objective type of examinations.

Dr. Benjamin S. Bloom, the American expert on evaluation who conducted a number of evaluation workshops in India has revolutionized our conception of examinations by introducing objectivised tests in the field of education. This has given a new fillip to the evaluation technique in India and many efforts are being made in this direction. The present investigation is a humble venture to standardize an achievement test in general science for High School First Year as per the syllabus of the Old Mysore State. The test was administered to a sample of 20423 students representing the various parts of the Mysore State under various managements and under different socio-economic strata of
society - Urban, rural and industrial. Mysore and Bangalore are taken as urban areas, Mysore, K.G.F. and Bhadravathi as industrial and the other parts as rural areas.

The test is a battery of nine sub-tests. Instructions and samples are given at the beginning of each sub-test.