Great Scientists

Writer and Publisher
Dharam Pal Kapoor
B.A. (Hons.) M.A.

Kothi No. 1135, Sector 11
Panchkula-134112 (Hry.)
Phone : 0172-2567845
Mobile : 9356301618

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PERFACE

Not gold but men can make a nation great and strong

–Emerson

I beseech (pray) you to spare a few minutes of your valuable time and go through the book “Great Scientists” witch I have penned for you after a lot of labour and profound thinking. Do not just glance through it cursorily, but savour it with your heart. Your time will not be wasted rather gain fully utilized. A deep study of it will compel every reader to put the precept (commad) into daily practice and the same will definitely bestow on the seeker great peace and prosperity, health and happiness in the modern age of tension and stress.

It is really a valuable and excellent anthology (collection) of prose containing 25 different Scientists provided for the readers. It offers comfort and consultation, elightenment and elucidation (explanation) in such a manner as to make a direct apeal to the modern young and old alike. Optimism is the key note of this book. Its pages abound in constructive suggestions for a fuller and happier life. I hope it may inspire many thirsting and aspiring souls in humble and sincere prayer.

It is our hope that 25 "Great Scientists" will be read with enjoyment and satisfaction by those who wish to use it for leisure reading and by those who are more specifically motivated to seek authoritative information about selected "Great Scientists".

I am very thankful for Sharvshri Sardari Lal ‘Kamal’, Naresh Bansalji and Jai Kishanji etc. for their help in publication of this book. Perhaps I would have not able to do so without their valuable co-operation. I am also indebted to God who inspired me to do it.

I have tried my level best to write this book correctly according to my capacity and ability. But no body on the earth is perfect except God. Actually man is a mannequin of mistakes to error is human. I, therefore, am not an exception. If, there, is any mistake, I beg pardon from the readers. Any suitable suggestions from the readers are keenly awaited and welcome from the very core of my heart.

In the end, I am very grateful to all those authors whose books have inspired me to write this book and whose thoughts have quoted in this book.

D. P. Kapoor

(D.P. Kapoor)
B.A. (Hons.) M.A.
Kothi No. 1135, Sector-11,
Panchkula (Hary.)
Ph. : 0172-2567845
Mob. : 9356301618

Reviewer's Views

Shri Dharam Pal Kapoor is a born bachelor having a sacred soul, pious pen and roams in religions realms. If God has been benevolent upon him, he is equally charitable towards the poor, be they relatives or strangers. That is why he spends a lot on writing, publishing and free distribution of his instructive/religious books for the benefit of society and humanity. Whatever he preaches, he practices; he does not simply deliver precepts (Maxims) and sermons (Discourses). This book entitled "Great Scientists" is a speaking example.

The views, ideas and ideals have been backed profusely by quotations of well known writers/poets, thinkers and philosophers so as to make them acceptable. At some places, the writer's views may be at variance with the readers but that shows his individual personality and free thinking and should be welcome.

I can only wish the writer's mission of teaching and preaching of great ideals a sure success.

Sardari Lal Dhawan 'Kamal'
1433, Sector 11, Panchkula
Phone : 0172-2563659
Mob. : 9417838090

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(D.P. Kapoor)
B.A. (Hons.) M.A.
Kothi No. 1135, Sector-11,
Panchkula (Hary.)
Ph. : 0172-2567845
Mob. : 9356301618

CONTENTS

1. HIPPOCRATES

In Greek, Mythology, Asclepius was the son of Apollo, the god of medicine. Eventually, he acquired the reputation of being so proficient in his father's art of healing that he became the chief patron of physicians. Staff of Asclepius, became the symbol of the medical profession. In ancient Greece, temples were erected in his honour where the sick would come to sacrifice a pig or a ram (male sheep) and to pray for good health. Ministers attached to these temples formed a powerful guild of (association) physician-priests called Asclepiad. Medical knowledge was veiled in superstition and guarded as sacred secrets to be transmitted only from father to son.

The fifth and fourth centuries B.C, were the Golden Age of Enlightenment in Greece, and such great searchers for wisdom as Socrates, Sophocles, and Plato speculated on the nature of man and of the universe. The time was ripe for a great scientific mind like that of Hippocrates to free medical practice from its mythical and superstitious bonds.

Hippocrates, the father of medicine, was a man, not a god. He was born in the year 400 B.C. on the island of Cos in the Aegean Sea. Very little is actually known about his life. Apparently, his father was a member of the physicians guild in the magnificent temple at Cos. According to custom, the boy was initiated into the secrets of the healing art by his father. He showed such brilliant perception (experience) in his studies that his father sought out the wisest teachers in order to give his son the best education possible. One of his masters is believed to have been Democritus, who had traveled throughout the world to gain a vast knowledge of the natural sciences, mathematics, philosophy, and the fine arts. Hippocrates received an excellent foundation for his future intellectual growth.

Like his master, the young Hippocrats visited the great centres of learning in the ancient world. Hewent to Athens, and remained there for several years to teach and to practice medicine. He may well have met Plato, the pupil of Socrates, and the most distinguished teacher of the era. Plato, in his writings, referred to Hippocrats as an eminent medical teacher said that-

One cannot understand the nature of the body's parts without understanding the nature of the whole organism.

Hippocrates insisted that the physician should study the patient, not just his illness. To make a correct diagnosis, he must learn everything possible about the patient's condition, his daily routine and occupation, his family background, and the environment in which he lives. In treating his patient, he should do everything to assist nature, the great healer, to effect cure. His final prognosis (forecast of a disease) should follow from his careful observations. With a remarkably modern approach, Hippocrates fought to eliminate (expel) guesswork and haphazard (random) remedies from medical practice.

While Hippocrates rejected most of the speculative theories proposed by the philosophers to account for human behaviour and well-being, he accepted the homour doctrine of his time. According to this teaching, men were phlegmatic or spirited, choleric or melancholic, depending upon the blending of cold, hot, dry and moist humours (fluid) in the body. A serious excess or deficiency of any of the body humours might result in abnormal behaviour, ill health, or even death. The physician's duty was to restore and maintain a proper balance in the body humours.

The humoural theory became a basic tenet of Galen's medica teaching in the second century A.C., and it continued to be taught and accepted for many years. In the sixteenth century, Paracelsus insisted that each disease had a specific cause and a specific remedy, and showed his contempt for the humoural theory by a public burning of the writings of Galen. Yet three hundred years later, the great French physiologist, Claude Bernard, stressed the role of body fluids in preserving a constant internal environment. An established dynamic equilibrium (balance) of chemicals in the blood, lymph, and tissue fluid is now deemed essential to normal body functioning and good health. Without any knowledge of chemistry, the thinking of Hippocrates contained a seed of truth that required over two thousand years to germinate.

Since dissection (critical analysis) of the body after death was strictly forbidden by the ancient Greeks, knowledge of human anatomy, physiology, and pathology was primitive. In spite of this, the treatise attributed to Hippocrates on Fractures and Dislocations reveals a remarkably advanced acquaintence with the structure and the function of bones and ligaments (tissues), and of muscles and tendons. Since physical fitness was greatly stressed by the Greeks, treatment of physical injuries incurred in strenuous exercises became a routine phase of medical practice. His directions for the diagnosis and treatment of dislocation and fractures, which included methods for bandaging and splinting, are surprisingly modern.

Physicians accompanied Greek armies into battlefields to care for the sick and to provide surgery for the wounded. Did Hippocrates ever serve (an army surgeon). Every sentence of the Hippocratic treatises on surgery suggests an author who acquired his knowledge , technique and skill through actual experience. His writings contain sound and practical directions for the treatment and care of wounds.

Long before Lister, the need of asepsis was recognized, though not understood. Hippocrates had instructions for the preparation of the operating room and surgical instruments. Wounds were to be scrupulously cleaned before the edges of the cut were closed by bandaging. Healing herbs were to be applied and covered by a clean pad. A great deal of stress was placed upon diet, care, and nursing of the patient while nature healed his wounds. Hippocrates would have been at home in any twentieth-century hospital.

A milestone in medicine was the assembling of the medical writings of Hippocrates and his disciples for the great library of Alexandria during the third century B.C. This great work, called the "Hppocratic Collection", was the physician's bible for almost five hundred years. It consists of 87 medical treatises (compositions) that cover almost every phase of medical practice. Its greatest value was the insistence on the need for correct principles in approaching problems of health and disease. Above all, the collection emphasized the nobility of medicine and the training the prospective physician must receive. Some of the treatises find a ready place in present-day medical thinking.

The Hippocratic treatise on the Sacred Disease presents an enlightened opinion on epilepsy a sickness characterized by convulsions (viailent an voluntary contraction of muscles) and loss of consciousness. Many ignorant doctors, who regarded this violent disease as the visitation of a displeased god or demon, attempted to exercise the patient with incantations (magics), charms or amulets (taviz), The ire of Hippocrates is evident as he pointed out that such doctors regard the disease as sacred only because of their inability to learn its real cause. He insisted that every disease, no matter how frightful, must have a natural cause. This was a prodigious step for scientific medicine because it stripped medical practice of its last vestige of myth and superstition.

Even in the days of Hippocrates good doctors were often overworked. A series of pithy precepts are contained in Aphorisms which encourage he busy practitioner to think correctly at all times. The tone of th book is set by its oft-quoted opening sentence :–

> **Life is short and the art of healing long the opportunity to provide healing is fleeting:experiment is dangerous, and decision difficult.**

Some of the aphorisms (sayings), such as the saying that one man’s meat is another’s poison,” have become a part of our everyday speech. Suggested procedures, such as the induction (introduclion) of sneezing to stop hiccups, are still popular household remedies.

To Hippocrates medicine was an art as well as a science. Fundamental to this art was his insistence that the physician develop the skill to apply what he has learned through observation and experience. Hippocrates wrote :

> **Medicine of all the arts is the most noble, but owing to the ignorance of those who practice it, it is far behind the other arts. His pupils were bound to their master by a private contract that was later expressed as the Hippocratic Oath. Down through the ages each new doctor, as he receives his medical degree, publicly professes this oath to keep pure and holy both his life and his art.**

2. Euclid

Euclid alone has looked on Beauty bare...

Let all who prate of Beauty hold their peace....

The Great American Poet, Edna St. Vincent Millay, who had the entire universe and limitless ages from which to choose the essence of beauty, paid tribute in her poem to the beauty, paid tribute in her poem to the beauty of logic and the splendour (great brightness) of a flash of vision transformed by clear thinking into logical sequence. Classical Greek civilization was renowned for its creation and appreciation of beauty, both in art, such as sculpture, and in the clarity of ideas of its great philosophers and scientists. Euclid was one of those who developed the art of arranging ideas through deductive reasoning to its highest form.

Very little is known about the personal life of Euclid. He was probably born and educated in Athens and, thereafter went to Alexandria in Egypt, which was then a great centre of learning. Here he founded a school in which he taught the principles of geometry that have come down to us today. (One of his pupils, Canon, was the teacher of Archimedes.) Ancient writers who refer to Euclid describe him as a **gentle and kindly old man.**

His students revered him for his patience and kindness. Yet he could be firm even with a king. King Ptolemy I of Egypt, who was having difficulty in studying geometry from Euclid's text, the Elements, asked him whether there was not an easier way for a monarch to learn the subject. To this Euclid responded :

Sir, there is no royal road to geometry.

The Egyptians used geometry for surveying and measuring a man's land after the annual floods of the Nile had washed away many of the landmarks of property–the very word, geometry, means the measurement of the earth. The Greeks, on the other hand, were not interested in practical applications of geometry but rather in its theorems and proofs as exercises in logic and deductive reasoning. On one occasion, when a pupil of Euclid's complained because he saw no practical advantages in learning geometry, Euclid turned to one of the servants and said wryly : (in a distorted manner)

Give this pupil a piece of money since he must have profit from what he learns.

Euclid's great contribution to mathematics was to revise and reorganize geometry as an orderly study, to simplify and rearrange the separate works of his predecessors, to establish logical sequences of theorems and proofs, to revise older proofs, and to devise new geometric proofs where gaps existed. Some of the earlier geometricians whose work Euclid improved were Hippocrates of Chios, Thales and Pythagoras.

The most famous of these was Pythagoras who, in the sixth century B.C., helped to establish mathematics as an independent and important subject of study. He and his followers, known as Pythagoreans, formulated definitions of some fundamental geometric elements, such as point, line and surface. They proved and utilized the Pythagorean Theorem, which states that the sum of the squares on the two sides of a right triangle is equivalent to the square on the hypotenuse. In arithmetic the Pythagoreans gave a new meaning to numbers. They used numbers and numerical relationships to clarify distances in nature and relationships of objets of different shapes.

They even explained music in numerical terms by demonstrating that different sounds were produced by plucking strings of different numerical lengths. Moreover, numbers were given a mystical quality by the Pythagoreans. The number “one” was associated with reason because it was a consistent whole. “Five” was associated with marriage because it represented the first union of an even number (two) with an odd number (three); one, which represents unity, was not considered as either an odd or even number.

Euclid’s work, the Elements, which has been translated into all languages, has remained in use as a basic geometry textbooks for more than two thousand years; the first English translation was made in 1570 by Sir. Henry Billingsley. The Elements was written in thirteen books, of which only six are usually included in school editions. Some parts of the

Elements were prepared by pupils of Euclid, but the direction, planning, and the major portions were his.

Euclid began with definitions of essential terms, such as a “straight line” (that which lies evenly between its ends), a “point”, a “triangle,” etc. He then sought to establish absolute truths or axioms (principles) regarding these concepts, which would be accepted by every rational man without proof. Thus he devised such axioms as : “The whole is greater than any of its parts”; “it is possible to draw a straight lin joining any two points.” The axioms were set forth in his Elements, and building upon these, Euclid proceeded, by a system of logical, deductive reasoning, to prove a multitude of theorems describing the properties of geometric figures which can be constructed by ruler and compass.

The first four books of the Elements deal with the simpler geometric figures : the triangle, the circle, polygons, parallel lines, and applications of the Pythagorean Theorem. Book V presents a theory of proportion, using various forms of the equation $\frac{a}{b} = \frac{c}{d}$ Book VI, using the ideas of Book V, treats similar figures; Books VII to IX deal with proporties of whole numbers’ Book X deals with complicated irrational numbers. Books XI to XIII deal with solid geometry; i.e. such figures as the pyramid, cylinder, cone, and sphere.

Century after century passed, and the geometry and axioms of Euclid continued to be accepted almost without challenge. Although none dared openly to controvert Euclid, one axiom (the parallel postulate) troubled some mathematicians. It stated that through a point P, not on a line X, only one line L can be drawn which would not meet X, no matter how far the line are extended. (principles)

Some intrepid geometricians reasoned that no one had had any experience in extending lines indefinitely into space ; therefore, perhaps the statement was not true. Hundreds of mathematicians unsuccessfully sought to prove the parallel postulate (self-evident proposition) by using other axioms. Then a great German mathematician of the eighteenth century, Karl Gauss, developed a non-Euclidean geometry which did not accept the parallel postulate. However, Gauss' work was not published until after his death. In the nineteenth century, a Russian mathematician, Lobachevsky, and a Hungarian, Bolyai, assumed that through point P it was possible for an infinite number of lines to be parallel to X. They had the courage to proclaim and publish their findings and to create a "non-Euclidean" geometry which, however, utilized many of the axioms and the methods of proof employed by Euclid. The German, Riemann, later contributed much to the development of "non-Euclidean" geometry.

Euclid wrote other books besides the Elements. Many of these have been lost, but among those which have survived are the Optics; a work entitled

Phenomena, which dealt with spheres ; and a book entitled Data, which contained ninety four propositions to prove that, if certain designated elements in a figure are given, other elements can be determined.

Euclid's work had an influence far beyond geometry. It gave scientists and philosophers guiding principles and a method (deductive reasoning) for the logic formulation and solution of problems. Although modern science has advanced our knowledge far beyond the ken of the ancient greeks a few of these ancients stand out as men whose scientific contributions have successfully withstood the test of the centuries. One of these few, in his field of mathematics, was Euclid.

In the late nineteenth century some minor defeats in Euclid's Elements, faulty definitions and incompleteness in axioms, were noted and these defects were eliminated by revised versions. However, the substance of the Elements was not changed.

3. Roger Bacon

Roger Bacon, who lived in the thirteenth century, is credited with inspiring Columbus to make his voyage of discovery in the fifteenth century. In the mathematics section of the Opus majus, Bacon indicated the possibility that the Indies could be reached by sailing westward from Spain. This passage so impressed Columbus that he quoted it in a letter to Ferdinand and Isabella. Perhaps it even helped to persuade the two monarchs to support the Italian navigator in the voyage which led to the discovery of America. It is remarkable that this man, who had little influence on the thinking of his own time, is today considered the first modern man of science. In the thirteenth century he wrote of machines which navigated without rowers, wagons which moved with unbelievable rapidity without animals, and flying machines with a man in he midst revolving some engine by which artificial wings were made to beat the air like a flying bird!

Although records are not in complete agreement, it is said that Bacon was born in the year 1214, in Ilchester in Somerset, England. When he was twelve years old he entered Oxford where studies were conducted in Latin. The course of study consisted of the trivium) grammar, rhetoric, and logic) and the quadrivium (arithmetic, music, geometry, and stronomy). Trivium and quadrivium together were known as the ”seven Liberal Arts.” Becon received his degree at Oxford and remained there to lecture and study.

Medieval scientists sometimes showed a strange indifference to precise measurements, and often repeated errors based on unverified experiments copied from earlier writers. It was against such evils in scholasticism that Roger Bacon raised his voice, criticizing his contemporaries for their ignorance and their willingness to perpetuate (commit) error when the simplest observations would have been sufficient to show them the truth. Unlike others of his time, Bacon seemed aware of the vast amount of information still to be unearthed, and although he respected the work of the ancients, he could not believe that they had made the final contributions to knowledge.

One result of the Fourth Crusade was that many Greek manuscripts became available to scholars who had previously read the scientific works of the ancients only in Arabic translation. Bacon was wel-versed in Latin, Greek, Hebrew and possibly Arabic, so he was able to make use of these manuscripts.

By 1245, Becon was lecturing on Aristotle at the University of Paris, where he had been invited because few in Paris were as well prepared for this task. Eight series of lectures on Aristotle have been printed from this period. Those available are in the form of Question-and-Answer (Quaestiones), a technique Bacon employed which permitted a greater degree of free interchange of ideas between teacher and student.

Sometime before 1250, he returned to England, filled with the idea of the unity of knowledge in which all sciences are interconnected and mutually helped. Anxious to acquire as much learning as possible, he spent large sums of money on books, instruments, and documents in order to become an authority, a wish he was unable to fulfill in his own time.

The exact date that Bacon became a monk in the Franciscan order is unknown, as is his reason for taking such a step. There is no doubt that he considered the ultimate goal of science to be in service to the Church and believed that Christendom would be protected through its power over nature. Although, as a member of a religious order, he was permitted to pursue his investigations, he was not encouraged to publish and was often reprimanded (rebuked for fault) when his work bordered on what was then considered magic, or evil.

Having incurred the antagonism of his Order by his constant criticisms of their methods and his dabbling in forbidden experiments, he was transferred by his superiors to Paris in 1257, where more careful supervision and restriction could be practiced. There is some evidence that he appealed to Pope Clement IV for assistance, hoping to persuade him to change the teaching in Christian schools so that there would be more emphasis on observation and experimentation. In a letter dated 1266, the Pope asked Bacon to send him his work that you may declare to us through your writing what remedies seem to you fitting for dealing with those matters which you recently intimated to be of such moment; and do this secretly as far as you are able and with as little delay as possible. Despite the difficulties that such an injunction caused, his Opus majus and Opus minor were on their way within a year. The Opus majus was a major piece of work which established Bacon as one of the most profound and original thinkers of his time, although he also held some of the prejudices of his age.

The Opus majus was divided into seven parts: (1) Causes of Error; (2) Philosophy vs. Theology; (3) Study of Languages; (4) Importance or Mathematics; (5) Optics; (6) Experimental Science; and (7) Moral Philosophy. The Opus minor, which was sent along with the major treatise, was a digest of the Opus majus in case the Pope was too busy to read the larger work.

In Bacon's time the rejection of authority for all belief was a major step and a courageous one, especially for a member of an Order."It meant complete rebellion against the whole spirit of scholasticism; it was the assertion of freedom of thought, of the claim of science to push forward to its conclusions.....

Roger Bacon has been described as a "progressive schoolman" who criticized his contemporaries for their undue regard for authority and who forecast inventions unknown to man in his day. He seems to have foreseen fundamental discoveries, such as the possibility of circum-navigating the globe, of propelling boats by mechanical means, of flying, of utilizing the explosive property of gunpowder, and of improving human sight by proper use of lenses. Any one of these might not be considered remarkable, but the combination of so many was most unusual.

Hi greatest claim to fame was his belief in the experimental method. Although he did little original experimentation himself and was not well versed in higher mathematics, he saw better than anyone else in his time that mathematics was the key to all sciences, but he felt that experimentation was needed to carry out the researches which mathematical deduction suggested. His letter to the Pope in favour of the correction of the calendar, although unsuccessful in his own day, is credited with influencing the adoption of the Gregorian correction in 1582.

Bacon lived five hundred years before chemistry as we know it today was developed. Alchemy (art which transmutes base material into gold) was chemistry in its pre-scientific period and, as such, was often confused with magic. To Bacon, it was a means of studying the transition of matter to its final form and, if he dealt with magic, it was to expose “the mad acts of the magician” through the true tests of experimental science. He was one of the first to emphasize that medicine should make use of the remedies provided by chemistry.

The fact that he borrowed from the works of others is true, yet Bacon was able to add his own contribution to the work of each. There is evidence that he worked with gunpowder which was previously used for fireworks; he suggested that the explosive power of the powder would be increased if it were enclosed in an instrument of solid material. He continued to study the rainbow, experimenting with the sun in different positions in relation to the raindrops and the observer, and he pointed out that a rainbow is produced by the differential refraction of sunlight passing through discontinuous drops of water.

In the field of optics, Bacon knew that the use of parabolic mirrors caused all the reflected rays to be concentrated in a single focus. His major contribution lay in his efforts to turn what was known to practical use. He had a perfectly clear conception of the simple microscope, and his scientifically-trained mind led him to suggest the possibilities of bringing distant objects near and of magnifying minute ones. A convenient method of isolating stars by observing them through a tube had already been introduced by the Arabs; however, credit is given to Roger Bacon for his inspired suggestions which led to the invention of the telescope in 1571.

The use of practical geometry in such areas as the fabrication of astronomical instruments, musical instruments, optical instruments, medical and surgical appliances, and chemical apparatus is described by Bacon. It is obvious that his interest lay in applied rather than abstract mathematics.

Bacon was deeply interested in astrology. He believed that the stars and planets exercised a powerful influence on everything and everyone. He felt that a careful observation of the position of the stars at the moment of birth would be useful in forecasting the future of development of the individual. In these beliefs he was no different from other learned men in medieval times. He made a clear distinction between astrology and magic, but much of what he believed is today considered error and superstition.

Returning to Oxford, Bacon planned to write an encyclopaedic work on all the sciences, but it is doubtful if he was ever able complete it. A fragment of the Communia Mathematicae Naturallum (Principles of Physics) and of De Coelesibus (Concerning the Heavenly Spheres) exist. Copies of these manuscripts are scattered throughout various libraries in Europe.

In 1277, Jerome of Ascoli, Minister-General of the Friars Minor, "condemned and reprobated the teaching of Friar Roger Bacon, as containing some suspected novelties, on account of which the same Roger was condemned to prison." Since the "novelties " were never explained, it is possible that his condemnation was based on the animosity generated by his criticisms of and general reactions to authority. His imprisonment probably lasted until 1292, when Jerome, who had become Pope Nicholas IV, died.

Bacon's earliest biographer, John Rous, set the date of his death as 1292, indicating that "the noble doctor was buried at the Grey Friars in Oxford on the feast of St. Barnabas the Apostle." Half-seer, half scientist during his life time bacon was a noteworthy encyclopedist, who brought together a wealth of knowledge in his desire to show its unity and its relation to divine revelation. In the history of science, he has gained increasing stature as a result of the depth, diversity and creativity of his thinking.

4. Nicolaus Copernicus

The youthful professor of astronomy at the University of Rome in 1502 paused for a moment in his lecture on the design of the universe. From all the civilized countries of the world his students had come to hear Copernicus lecture on the stars and planets. He continued with his exposition of the Ptolemaic system :

> **The earth is the centre of the universe: the sum, the moon, and the five planets are satellites that revolve daily around our majestic earth in a perfect circle. Beyond all these are the all-encompassing fixed stars. These are basic truths which were described by the great Claudius Ptolemy more than fifteen hundred years ago and which are evident to the senses.**

A bright-eyed young man had a question. "Learned professor," the youth spoke timidly, "did not the ancient Geek philosopher Pythagoras dispute this, saying that it is not the earth that is the centre of the universe but the sun?"

Copernicus was about to respond, as he had many times before–that the great Aristotle had positively refuted Pythagoras and that man, being a greatest work of God, the earth which he inhabited must be the centre of the universe. This time, however, Copernicus has such little faith in his usual anwer that he dismissed the class and abruptly left the room. After three years of teaching, he had made up his mind to resign. No longer willing to teach what he himself doubted, he decided to return to his home in Frauenburg, then a part of Poland, to devote himself to proving to his own satisfaction whether Ptolemy and the learned professors of the sixteenth century were right or wrong.

Nicolaus Copernicus was born at Thorn, a small port town in Poland on the Vistula River near the Baltic Sea.His father, a merchant, died when Nicolaus was ten years old; and his uncle, a leading figure in Poland. Bishop Lucas Watzerlrode, became responsible for his guidance. As a youngster, Nicolaus was influenced by the realistic and practical outlook of his merchant father and his church-administrator uncle. On the other hand, his imagination was stimulated (excited) by the stories of seamen and merchants who came through the port of thorn from Asia, Italy, Russia, and other far-off places.

In 1942, when Columbus was discovering America and opening up a new geographic world, Copernicus was enrolled as a student in the University of Cracow in Poland, one of the most distinguished centres of learning at that time. Here he came under the tutelage of Albert Brudzewski, an outstanding mathematician and astronomer, who cultivated Nicolaus' deep interest in these subjects. However, on the advice of his uncle, the Bishop, Nicolaus obtined his degree in medicine so that he might be of more direct help to his countrymen in

Poland.

Nicolaus work at Cracow opened the portals of learning to him. He asked his uncle whether he might continue his studies in Italy, the centre of learning and the hub (central part) of the Renaissance (period of Revival of Arts or letters). His uncle wisely consented and arranged for him to attend the famous University at Bologna where he studied law and furthered his knowledge of mathematics and astronomy. He also learned Greek in order that he might be able to read the original texts of the Greek astronomers as well as their translations of the ancient Arabian mathematicians. In keeping with the Renaissance concept of the well rounded education, Copernicus also developed skill as a painter and poet.

At this time he became a professor of astronomy at the niversity of Rome. Although he taught the traditional Ptolemaic astronomy, his own readings of original statements by Pythagoras and some of the other ancients and his paragmatic background led him to doubt the accuracy of the Ptolemaic theory of the geocentric structure of the universe, which had been accepted for fifteen hundred years, He asked himself such questions as these : If the sun rotates around the earth in the fixed orbit of a perfect circle, how does one account for the change of seasons? How is it that some stars and planets vary in their positions from year to year? Of course, the learned savants (man of learning) of his time explained these variations by calling them aberrations (warding from right path) capricious migrations, or mystic movements of the inner souls of the planets. To the keen, inquiring young mind of Copernicus these answers were a travesty (rediculous); therefore, he decided to leave Rome and seek the solutions that would content him in the quiet of his homeland. But it was to be a long time before he would find these solutions. In 1504, he resigned his professorship and returned to Frauenburg to be made a canon of the church.

Thereafter, he spent several years as physician and assistant to his uncle, bishop Watzelrode. In this capacity he won the esteem and affection of all those with whom he came in contact. His training in law enabled him to be fair and just in administering the church lands. He became known far and wide as a skillful physician and he gave freely of his medical knowledge to heal the poor and needy. When help was needed by the towns people, whether in easing a water drought by building a dam or in storing food against a famine, his advice was sought and sagely given.

At the request of the Pope, he suggested some practical reforms of make the calendar more accurate. Clavius, who studied the development of our modern calendar, wrote: Copernicus was the first to discover the exact duration of the year. Subsequent authorities found that his calculation of the length of a year was in error by only twenty-eight seconds.

When the rulers of Poland, in time of financial crisis, called upon Copernicus to reform their monetary system, he advocated central coinage for all of Poland and restored confidence in Polish money by bringing about the abolition of indiscriminate minting of new coins without proper backing of silver and gold. For a time, in 1520, he served as governor of Allenstein Castle and successfully defended in against a siege by the Teutonic Knights.

Although he devoted himself to the welfare of his church and his countrymen during these busy years, Copernicus did not forget his desire to solve the riddle of the structure of the universe. Nights would find him in the tower of his mountain-top home observing the stars and planets, making notations (comments) about their positions, and reading all the available manuscripts of earlier astronomers. His research was especially difficult because the telescope had not yet been invented and, for much of the year in this vicinity (nabourhood), the climate obscured visibility of the heavens. Progress was slow. He studied the eclipses that occurred in 1509 and 1511. Using mathematical formulas and his own theory of the movement of the planets, he predicated the positions of the planets Mars, Saturn, Jupiter and Venus. Then, anxiously scanning the heavens as the years went by to see whether his calculations were correct, he found to his joy that they were.

At last he had evidence to show that the Ptolemaic theory, with its unrealistic explanations of variations and its web of confusion and inconsistencies which had stultified astronomy, was false. The theory that Copernicus had verified placed the sun at the centres of the universe, with the earth and other planets revolving around it, and the stars in the vast limitless heavens surrounding them all. He knew that the earth also revolves on its own axis, which accounted for day and night. These motions follow the unerring mathematical laws of nature. The location of any planet along the highway of the heavens at any given time, and even eclipses, can be predicted by mathematical formulas.

Copernicus had found the truth, but getting the world to accept the truth was a slow and dangerous business, for he was dealing with long-established beliefs that were tied to superstition and religious dogma. Although the Renaissance was a time of wild inquiry and considerable freedom of discussion in enlightened circles, suspected contradiction of religious dogma was regarded as heresy. Copernicus, therefore, decided not to publish his findings but to try to win followers among the learned by conversation and discussion. This he did with limited success, but even this road was fraught with danger. martin Luther denounced him as a fool who wanted "to turn the whole art of astronomy upside down". Calvin quoted Psalm 93 against him : "The world also is established that it cannot be moved."

Toward the end of his life when Copernicus was persuaded to publish his ideas, the wrote De revolutionibus orbium coelestium (Concerning the Revolutions of the Heavenly Spheres), dedicating the book to Pope Paul III to win ecclesiastical approbation. Ironically, the printer in Nuremberg was so frightened by the revolutionary nature of the text that he engaged someone to write a preface that claimed the book was not a scientific treatise but a "playful fancy," Copernicus would have been chagrined indeed to have read this description of his life's work, but he never actually read the printed book which was placed in his hands while he was on his death bed on May 21, 1543.

Copernicus work formed the foundation upon which Galileo, Brahe, Kepler, newton, Einstein, and others built modern astronomy, but he did more that this. Other intrepid souls in later times were encouraged by his example to challenge further the mystical beliefs based upon superstitions which shackled the mind of mankind. In addition, he established a model of sound scientific research based upon careful, patient observation, analysis, and experimentation. Nicolaus Copernicus was one of the truly great figures of the Renaissance.

5. Galileo Galilei

He was a sixty nine years old, and his hair and beared were as white as hoar frost (frozendew). His eyes, which had looked at the heavens through his telescopes and had seen more than any other human being since the beginning of time, were now dimmed by age. His reputation as one of the greatest scientists of his time had led kings, queens, princes, and dukes to vie (long for supriority) for his services. Now he knelt before the dreaded tribunal of the Inquisition (search), compelled to make public confession of an error that was no error:

> **I Galileo Galilei, ... abandon the false opinion.... that the Sun is the centre of the universe and immovable....I abjure (take oath), curse and detest (dislike) the said errors.**

Some said that when the old man rose he muttered inaudibly, "E pur si muove." (Nevertheless the earth does move [around the Sun]).

Whether he dared to whisper this recantation (withdrawal) or not, his mind was free to range through the years. He thought of his father's admonition (advice) to him as a boy :

> **.....freely to question and freely to answer....as well becomes those who are sincerely in search of truth."**

Indeed he had followed his father's advice. At first he had been cautious, as he was when he refused young Kepler who had urged him to support publicly the Copernican theory. Then Galileo remembered the thrill of satisfaction he had felt when, years later, his book, Siderius mnuncius, reported to the world the proofs of the Copernican theory that he had seen through his telescopes. The die had been cast then, and he had fought for truth against superstitious ignorance and relentless authority. The struggle had been a long one, against heavy odds; and he wondered now whether it had been in vain, for the inexorable voice of the Insquisition decreed that Galileo's books be banned and that he be placed in confinement. Thus, in 1633, the old scientist. in his hour of agony, looked back upon the years.

He was born in Pisa, Italy one of a family of seven children, to a father who was a talented musician and a man of considerable education. At an early age Galileo showed great promise both mentally and manually. When he was seventeen he entered the University, of Pisa where he majored in medicine and also studied mathematics and physical science.

Once, while still a student at Pisa. he observed the regularity of a swinging lamp in the cathedral. He could hardly wait until he returned home to experiment with leaden pellets (pills) attached to strings of different lengths. Wonder of wonders! He discovered that, regardless of the size of the swing, or the size of his leaden weight, the swinging pellet took the same amount of time to complete a forward and backward trip. Only a change in length affected the time of swing (the Period of Vibration). This observation let to the invention of the pendulum used to clocks and other instruments for precise measurement of time. He read avidly the works of Archimedes and used mathematics to prove some of the latter's experiments with liquids and alloys. As a student he had an inquiring mind and a reputation of being disputations.

At the age twenty-five, with the assistance of the Grand Duke of Tuescany, to whose attention he had come as a result of his scientific work as a student, Galileo was engaged as a professor of mathematics at the University of Pisa at a salary of about sixty-five dollars a year. (At this time, mathematics professors were paid much less than all others because mathematics was considered of little importance.) As a professor, Galileo continued his quest for truth, analyzing the scientific Galileo continued his quest for truth, analyzing the scientific theories of Aristotle by application of mathematics and experimental observations. or example, Aristotle had claimed that the speed of falling objects was proportionate to their weight.

Galileo, who was aware of experiments by a Dutch scientist which refuted this theory, announced that he would publicity disprove Aristotle's theory. Before a multitude (lot) of observers that included many of his skeptical colleages from the University, he proceeded to drop a one-pound and a ten-pound leadon ball from the top of the Tower of Pisa. Lo and behold, the two leaden balls struck th earth at about the same time! Seeing a basic similarity between the free fall of objects and objects rolling down an inclined plane. Galileo followed up this experiment by making an inclined plane out of a twenty-foot length of wood, with the idea that it would be easier to study the motion of objects on the inclined plane. By cutting notches (cuts) to mark distances along the side of the board and timing the rolling of round leaden balls down the plane, he developed theories concerning the relationship between speed, time, and distance.

Thus he developed the concept of acceleration that is used in modern physics: namely, acceleration is the rate of change of velocity per unit time; and the modern concept of friction and inertia (laziness small) with respect to objects in motion. He analyzed the components of force, showing, for example, that the forces affecting the flight of a bullet are downward and forward in such fashion as to be mathematically measurable. These experiments, begun before 1590, were further developed and were published in 1638 in his book. Dialogues concerning Two New Sciences (motion and machines). Galileo's pioneering in developing basic understanding in these fields led to Newton's more precise formulation of his laws of motion and subsequent refinements of these laws by others.

Of great significance for the future of science was Galileo's dictum that one should learn about nature by observing and experimenting rather than by seeking answers in the works of Aristotle and the ancient savants (man of learning). In his own lectures at the University of Pisa, Galileo presented his own experimental observations and vigorouly criticized the orthodox works of the ancients when he found them to be false. In thus fighting for new truths against the proponents of the status quo, he made powerful enemies.

Galileo was a nonconformist in other ways as well. For example, he refused to wear the academic robes worn by his colleagues, saying that they restricted his movements unnecessarily. For failing to wear the robes, he was forced to pay several fines out of his meager (increased of speed) salary. At length his enemies prevailed, and Galileo was dismissed from the faculty at Pisa.

Despite his own stringent circumstances at this time, Galileo was quite generous to his family. He assumed responsibility for a large dowry on the marriage of his sister. An extravagant younger brother constantly drained money from him so that he might live in elegant (graceful) style.

Galileo's departure from the University of Pisa turned out to be fortunate, for he obtained a better-paying position (at about two hundred dollars per year) at the university of Padua, where he also found greater freedom of discussion. His life here was happy and productive for many years.

One of his early inventions at Padua was a calculating instrument called a sector, consisting of two straight rulers hinged together at one end, which could be used for drawing all sorts of many-sided figures according to scale. By varying the angle of the sector and moving it over a quadrant centered on the hinge, it could also be used for many computations; e.g., extracting square roots or ascertaining interest charges.

Galileo set up a workshop to manufacture these instruments (magnetic compasses) and, later on, to manufacture thermometers and telescopes. He also became an expert on the construction of military fortifications. His reputation was so great that students from all ranks and places now came to attend his classes. At one time as many as two dozen of his students were actually living with him, as was the custom of the time, and he enjoyed the social life immensely.

Early in the 1600's. Galileo heard that a Dutch optician had put together a concave (hallow) and convex (curued) lens in such a way as to make distant objects seem nearer. Using this idea, he constructed a telescope that magnified objects thirty times and, in 1609, gave a public demonstration of its use, the ambassador of the Grand Duke of Florence, who was one of those attending the demonstration, reported his amazement to the Duke. Looking out to sea through the telescope, he had been able to discern ships that would not be visible to the unaided eye for some three hours. Galileo presented the telescope to the Duke and, in gratitude, the latter made him a lifetime professor at the University of Padua at a salary of about five thousand dollars a year.

When Galileo turned his telescope toward the heavens at night, he opened up new vistas of knowledge which he described in his book, Sidereus nuncius (Messenger of the Stars). In it he says;

> **"I give thanks to God, who has been pleased to make me the first observer of marvelous things unrevealed to bygone ages. I have ascertained that the moon is a body similar to the earth..... I have beheld a multitude of fixed stars never before seen..... But the greatest marvel of all is the discovery of four new planets (four satellites of Jupiter)....**

I have observed that they move around the sun. He ascertained that the Milky. Way consisted of a myriad of stars; that the planets were not self-luminous but reflected the light of the sun; that the universe was not, as his contemporaries believed, fixed and unchangeable, for new stars appeared in his view and then disappeared; that the planets Venus and mercury also moved around the sun; and that the un itself revolved on an axis.

Galileo, who had been eager to return to the land of his birth, at this time sought and received an appointment to the University of Pisa. This was a tragic blunder, as it turned out, for Pisa was subject to the Inquisition, whereas Padua, in Venetian territory, had much greater independence.

In Pisa, his book, instead of being claimed as indisputably establishing the truth of the Copernican theory, stirred the deep animosity of the reactionary groups in power. In 1616, when Galileo wrote a letter criticizing the ruling hierarchy by stating that approval of the traditional geocentric theory of the universe was not due to errors in Scripture but to errors of those who were interpreting the Scriptures, he was summoned by the Inquisition. However, the friendship of Pope Paul V and the influence of other highly placed friends enabled him to get off with a warning, on his agreement not to "hold, teach, or defend" the Copernican theory.

For a number of years thereafter Galileo devoted himself to meditation and research in astronomy, and further research in physics on his theories of motion and mechanics. He took a small home near the convent where his two daughters, born of a brief common-law marriage, were unns. He enjoyed visiting and chatting with hi daughters at the convent. However, his one son, also a product of this relationship, turned out to be an extravagant ne'er-do-well.

In 1632, Galileo borke the silence that had been imposed upon him by publishing another book, "Dialogue concerning the Two Principal Systems of the World", a brilliant satire showing, by means of dialogue, the flaws in the geocentric system.

Once more he was called before the Inquisition, but now his predicament was more gave because he had broken his agreement of 1616 in which he had promised to conform and to desist from heresy. Finally, the decision was rendered that Galileo must publicly swear that his beliefs were false, must abandon further work in science, and must suffer confinement. Because he was in poor health and was aged, he was permitted to remain under guard in a small house he had secured near his daughters convent.

Even now the great scientist was not fully silenced. He prepared his last book: Dialogues concerning Two New Sciences, summarizing all his research in the field of motion and mechanics and smuggled it to Holland where it was published in 1638. Regrettably; Galileo never saw this work in print for, in 1638, at the age of seventy-four, he became blind. When he died in 1642, venerated by the citizenry and many civic and Church leaders, the Inquisition refused to permit a public funeral for him.

Galileo needed not have feared that his efforts were in vain, for the world soon recognized his achievements in astronomy and physics. In addition, his methods of relying upon experimentation and firsthand observation, rather than upon prior authority, was one of the cornerstones of modern science. Perhaps of paramount importance is the lesson that should have been learned from his experience by future generations: uman progress requires that the minds of men be kept free to challenge ideas and seek for truth without fear of repression (check) or reprisal (retaliation).

6. Robert Hooke

In 1669, a lecturer at Oxford University described the members of the newly-founded Royal Society of London as individuals who “admire nothing but fleas (kinds of small jiming insects) lice, and themselves.” this vicious attack was aimed chiefly at Robert Hooke, the society’s Curator of Experiments, who had a short time previously published his Micrographia. In this book, Hooke described the minute structure of familiar plants and animals which he had observed with a microscope he himself had constructed and perfected.

There is no record whether Hooke ever answered this sarcastic jibe: but his still popular book, containing accurate and detailed drawings of the microscopic structure of many living things, including the flea and the louse, aroused the interest and the curiosity of many young scientists and foreshadowed the significant role the microscope was to have in the future development of biology. Although the identity of his critic is all but forgotten, Hooke’s name has been immortalized among scientists for having named and described for the first time in this classic work the tiny boxlike components of thin slices of cork tissue. These he called cells–a term now universally used for the unit structures which make up the tissues of all organisms.

Every biology student is familiar with Hooke's frequently-reprinted drawings showing the "cells" of cork and the primitive microscope used to observe them. The physics student has memorized Hooke's Law, which states that "mechanical strain is proportional to stress." But few persons know the strange genius and paradoxical personality of the man, who rubbed elbows with many of the great men of science, and who had such a profound influence on the rapid scientific advancement made in England during the latter half of the seventeenth century.

Robert Hooke was born in 1635 on the Isle of Weigh off the southern coast of England. The desolation of the rocky shore where he was born reflected the loneliness of his childhood. Robert was a sensitive, sickly child who was unable to run and play with other children. Confined to his home, he developed his inventive mind by making all kinds of mechanical toys. such as sundials, clocks, water mills, and ships. His father, a kindly country curate, was then too poor to send his child to school. He taught the quick-witted Robert the "Three R's" and the classics. The sudden death of his father when Robert was only thirteen years old was a tragic blow. With his only close friend gone, he was now completely on his own.

Hooke went to London and became an artist's apprentice. Finally, he was able to use his small savings to attend college at Westminster School, where he proved to be a brilliant student. His aptitude in mathematics was such that he mastered the first six books of geometry in a single week. His proficiency in his studies gained him ready admission to Oxford University.

Hooke was eighteen years old when he entered Oxford, and his poverty became a blessing in disguise. The time utilized by other collegians in frivolous (silly) pursuits was used to earn the necessities of life. His serious application and budding scientific genius soon attracted the attention of one of his teachers, Robert Boyle, the influential chemist who had already initiated experiments on the nature of gases in his own laboratory near the university. Hooke considered himself the most fortunate young man in the world when Boyle hired him as a laboratory assistant to help him with his experiments. A warm lifelong friendship was formed the two scientists.

Hooke's first assignment in Boyle's laboratory was the design and creation of a pump to compress air and produce a vacuum. Boyle used the air pump that Hooke had ingeniously constructed to complete the experiments that resulted in the formulation of his gas law, which states that the volume of a gas is inversely proportional to its pressure. Boyle soon demonstrated his esteem for Hooke by recommending him for the post of first Curator of Experiments for the Royal Society. Hooke was invited to become a member of the Royal Society, not only because of Boyle's recommendation, but also on the basis of an excellent paper reporting his original work on surface tension and capillary (hair-like) action phenomena. As Curator of Experiments Hooke's responsibilities were great: he was expected to determine the lines along which the Society's research was to be conducted, to serve as general research consultant for members of the Society, and to present three or four significant experiments for public consideration and discussion at each weekly meeting. The rapid early growth of the Royal Society can be attributed almost solely to Hooke's genius, to his unquenchable enthusiasm, and to his capacity for a phenomenal amount of work.

In 1665 Hooke was appointed Professor of Geometry at Gresham College. Here, in a small turret over his rooms, were the telescopes he constructed to observe the movements of stars. Hooke was content to live in this peaceful centre learning for the rest of his life.

In 1667 he became city surveyor of London, steady income enabled him to continue his work with the Royal Society. In fact, Hooke's whole existence was closely entwined with the activities of the Royal Society for forty years. During this period, he made many significant contributions, which have earned him the right to be classed among the great scientists ofall times; yet, many historians of science have not given Hooke the recognition he deserves. Usually, he or his work was criticized for one of three purported reasons : (1) he was only a technician with some skill in presenting demonstrations based entirely upon the ideas of others; (2) he was a dabbler (devoted) in many fields of knowledge and posed many scientific problemised but solved none; and, (3) he was a "quarrelsome eccentric." Recent evaluation of his work shows that these criticisms were unjustified.

During Hooke's time, England's prowess, and even her survival, depended upon her control of the seas, and dominance in navigation in the days of sailing vessels depended on the ability to forecast weather changes accurately. Hooke was the founder of scientific meteorology, because he devised the instruments used to record changes in weather conditions and perfected methods for recording weather information systematically. A listing of the instruments he invented includes the wheel barometer, a sealed alcohol-thermometer, an improved chronometer, the first hygrometer, a wind gauge, and a weather "clock" to register automatically the readings of his various weather instruments. The supremacy over the seas that England was to retain in future generations owed much to Hooke's inventive genius.

The perfection of his vacuum pump made it possible for Hooke to conduct several experiments on the nature of combustion. His observation that objects would not burn in a vacuum prompted him to light wood in a sealed containing with a limited amount of air. Burning proceeded for a brief period and then ceased until the supply of air was renewed.

Hooke surmised that some substance in the air, which we now know to be oxygen, was consumed during the burning process. He proved this when he determined that the volume of air was diminished after combustion had ceased. His intuition led him to ask what would happen if plans or animals were placed in a chamber from which the air had been exhausted. He noted that all activity ceased in the living organisms and that death followed in a short time. He then concluded that respiration (act of breathing) must be a form of combustion (destruction by fire) requiring some essential substance in the air.

Although Hooke's experiments on combustion were carried out in 1668, some two decades later, Stahl prposed his erroneous phlogiston theory which started that substances furn because they lose something to the air. Not until 1780 did Lavoisier and Laplace publish their memoir refuting the phlogiston theory. One of the great mysteries of science is that Hooke's experiments on combustion were completely forgotten for more than a century, and that he never received credit for priority of discovery which he deserved.

One of Hooke's remarkable glimpses into the future is shown by his prediction that artificial substitutes for silk would someday be made. After observing with his microscope that special glands of the silkworm produce a sticky secretion from which fibers are formed to spin its cocoon, he proposed that synthetic glutinous substances might be produced and drawn into fibers which could be used to weave new kinds of cloth. How prophetic were his words! in 1945, Du Pont chemists culminated their extended research which led to nylon, orlon, dacron and other remarkable synthetic fibers that have revolutionized the clothing industry.

Foreseeing the possibility that future man might want to adapt to altered atmospheric pressure, he confined himself for a period of time in a chamber with reduced pressure and carefully recorded the effects of such an environmental change on his body. He even designed and tested a diving suit which enabled a man to tolerate deep submersion (State of being submerged) in the sea for four minutes.

Along Hooke's many contributions are thee ; he was the first to formulate the theory of planetary movements as a mechanical problem; he glimpsed universal gravitation; he devised practicable system of telegraphy; he invented the spiral spring in watches and the first screw-divided quadrant; and he constructed the first arithmetical machine and the Gregorian telescope. Without a doubt, Hooke was the greatest mechanic of his age.

Hooke has, however, in the past often been pitured as a selfish morose, and irritable recluse with none of the human qualities that endear a scientist to his fellow man. Nature had not been kind to him. He had a lean, crooked body with tangled hair hanging down over a haggard, ugly countenance. However, he had a host of friends during the golden years when his most significant scientific work was accomplished. Nevertheless, the last years of Hooke's life were not happy. He had a disagreement with Sir Isaac newton, who charged him with being a usurper (one who takes possession of another property). Newton said that Hooke sought to rob him of full credit for his work on gravitation. But Newton's opinion of Hooke was not shared by other scientists. The Royal Society attended his funeral as a body, in respect for his extraordinary merit as a scientist whose universal genius, diverse discoveries, and ingenious insights had a profound influence on the development of science in the seventeenth century.

7. Sir Isaac Newton

Sir Isaac Newton was an English Physicist and mathematician. He made major contributions in mathematics, and theoretical and experimental physics and achieved a remarkable synthesis of the work of his predecessors, on the laws of motion, especially the law of Universal Gravitation.

Isaac Newton was born on December 25, 1642, at Woolsthorpe, a hamlet in south western Lincolnshire, England. Newton was the only son of the local yeoman, also Isaac Newton and Hannah Ayscough. He was born after the death of his father. A tiny and weak baby. Newton was not expected to survive his first day of life. Deprived of his father before birth, he soon lost hi mother as well, for within two years she married a second time, and left young Issac at Woolshorpe, in the care of his grandmother. For nine years, until the death of his stepfather in 1653. Isaac was effectively separated from his mother, and his pronounced psychotic tendencies have been ascribed to this traumatic (portaing to wounds) event. The acute sense of insecurity, that rendered him obsessively anxious, when his work was published and irrationally violent when he defended it, accompanied Newton throughout his life and can reasonably be traced to his early years.

After a rudimentary education in local school, h was sent at the age of 12, to the King's School in Grantham, where he lived in the home of an apothecary named Clark. In 1661, at the age of 19, he entered Trinity College, Cambridge. After receiving his bachelor's degree in 1665, apparently without special distinction, Newtonstayed on for his master's: but an epidemic of plague caused the university to close. Newton was back at Woolsthorpe for18 months in 1666 and 1667. During this brief period, he performed the basic experiments and apparently did the fundamental thinking for all his subsequent work on gravitation and optics, and developed for his own use, his system of calculus.

Returning to Cambridge in 1667, Newton quickly completed the requirements for his master's degree and then entered upon a period of elaboration, of the work begun at Woolsthorpe. His mathematics professor, Isaac Barrow, was the first to recognize Newton's unusual ability, and when, in 1669, Barrow resigned to devote himself to theology, he recommended Newton as his successor. Newton became Lucasian Professor of mathematics at 27 and stayed at Trinity in that capacity for 27 years.

Newton was much inspired by the Italian scientist Galileo. Galileo had died the year Newton was born. Newton picked up his idea of a mathematical science of motion and brought his work to full fruition. Newton carried forward Galileo's task of lying the foundation of modern science, based on experimental proofs. In fact, Galileo's results were the starting point for Newton's investigations. Newton gave many a new and original ideas, and made a number of scientific discoveries of fundamental importance.

Isaac Newton, enunciated (proclaimed) the basic Laws of Motion; extended the concept of force from terrestrial to celestial phenomena; discovered the Universal Law of gravitation and explained Kepler's laws of Planetary Motion. Newton also invented a Reflector Telescope, which made it easier to study the heavenly bodies. He also invented the prism.

One of the founding fathers of physics, Newton is best known for his work on gravitation and mechanics. The theory of gravitational pull of the Earth was a matter of chance. How he came across the idea of gravity when, he saw an apple fall from a tree, is one of the most famous legends of science. He proposed that, all bodies attract each other with a force, that is directly proportioned to the product of their masses and inversely proportional to the square of the distance between them. He called this force gravity and applied his theory to explain the motion of the moon around the earth. He proposed three Laws of Motion, which from the basis of the science of Mechanics. His first Law of Motion is a reformulation of Galileo's Law of Inertia (sluggishness). These laws and the scientific concept of force were explained for the first time in his book, Philosophiae Naturalis Principia Mathematica- commonly known as the "Principia".

Newton also made basic contributions to the study of light. He explained the nature of light and showed that, ordinary white light was a combination of different colours. He proposed the Corpuscular Theory of Light which assumes that, light rays consist of moving particles. Newton and the German mathematician, Gottfried Leibnitz, independently discovered differential Calculus. Newton was conferred the title of 'Sir', and thus became the first scientist to get this honour. The Royal Society of London, first elected him its fellow and then made him its life President.

Isaac Newton was the culminating figure of the scientific revolution of the 17th century. In optics, his discovery of the composition of white light, integrated the phenomena of colours into the science of light and laid the foundation for modern physical optics. In mechanics, his three laws of motion, the basic principles of modern physics, resulted in the formulation of the law of universal gravitation. In mathematics, he was the original discoverer of the infinitesimal calculus. Newton's Philosophiae Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy), 1687, was one of the most important works in the history of modern science.

Two other area to which Newton devoted much attention, were chronology and theology. A shortened form of his chronology of Ancient Kingdoms, appeared without his consent in 1725, inducing him to prepare the longer work for publication. In it, Newton attempted to correlate Egyptian, Greek and Hebrew history and mythology and for the first time made use of astronomical references in ancient tests, to establish dates of historical events. In his Observations upon the Prophecies of Daniel and the Apocalypse of St. John, published posthumously, his aim was to show that the prophecies of the Old and New Testament had so far been fulfilled.

Newton also evinced keen interest in the field of alchemy which was evolving into chemistry. Among the vast body of hi manuscripts, are notes indicating that his Chronology and Prophecy and also, his alchemical work, were parts of a larger design that would embrace cosmology, history, and theology in a single synthesis.

The mass of Newton's papers manuscripts, and correspondence which survives, reveals a person with qualities of mind, physique, and personality, extraordinarily favourable for the making of a great scientist : tremendous powers of concentration, ability o stand long periods of intense mental exertion, and objectivity. The uniqueness of Newton's achievement, could be said to lie in his exploitation of the unusual circumstances. He alone, among his gifted contemporaries, fully recognized the implications of the scientific discoveries. In shifting the emphasis from quality to quantity, from pursuit of answers to the question "Why?", to focus upon "What?" and "How?", he effecively prepared the way for the age of technology. He died on March 20, 1727, at the age of 84 in London. Sir Isaac Newton said –

I donot know what I may appear to the world, but to myself I seem to have been only a boy playing on the seashore and deversing myself in now and than finding a

smoother pebble on a prettier sell ordinary. Whist the great ocean of truth lay all undiscovered before me.

What was the secret of Newton's ability? There is no doubt of his genius, but he also had a tremendous and tenacious (Retantive) power of concentration. When his mind seized upon a problem, he had the power of stripping away irrelevancies, focusing upon basic considerations, and organizing his approach in ways that led, step by step, to solutions. So intense was his power of concentration that, when he was preparing the draft of the Principia, he often worked until two or three o'clock in the morning, ate sparingly, and sometimes forgot to eat at all.

What is Newton's place in science? Because of the magnitude and importance of his work, some-regard him as the greatest scientist who ever lived. Although Einstein amplified, clarified, and even modified some of Newton's findings, the basic substance of his discoveries stands firmly as the bedrock of modern scientific concepts of the Nature of the universe. The famous poet Alexander Pope said to him :

Nature and Nature's laws lay hid in night;
God said, 'Let newton bel' and all was light.

8. Joseph Priestley

Benjamin Franklin had just finished a lecture on electricity in a small auditorium in London, and his listeners were crowding around him with questions and congratulations. From the fringe (border) of the throng (crowd), a young man dressed in the black cloth of a clergyman moved forward and addressed him :

Mr. Franklin, I am deeply interested in your experiments with electricity. How can I find out more about this wonderful force?

Observing his lean and determined face, Franklin turned toward him and asked his name. "Joseph Priestley, Sir." Franklin extended his hand in greeting : "Very well, tomorrow, visit me at my lodgings."

When the young minister had gone, Franklin asked about him. "Oh," said one of his hosts, "he is a poor clergyman, a Dissenter (one who thinks in diffently) from Leeds, who has shown an interest in chemistry. He has had no university training, however, and is not likely to amount to much."

Franklin smiled inwardly; he had no University training either. The young man's look of quiet determination came back to his mind. He would talk with Reverend Priestley and give him whatever help he could.

Thus it was that Joseph Priestley, a poor Presbyterian minister from Leeds, struggling to support his family on a meager church allowance which he supplemented by part-time tutoring, was encouraged to make his first written contribution to science, a treatise entitled History of Electricity. Publication of this work led to his election to the Royal Society in London.

Joseph Priestley, the son of a poor textile worker, was born on March 13, 1733 in a small town. Fieldhead, in England. When his parents died before he was seven years of age, he went to live with an aunt who was an active member of a Protestant group called Dissenters. This sect had high ideals of learning and a strict, simple code of life. Young Priestley did not indulge in the usual games of children but, instead, found his recreation in books and in listening to the religious discussions of his elders. He had a natural ability in languages, and he mastered Greek, Latin, French, German, and even Arabic.

In 1752, he entered the small Nonconformist academy at Daventry in preparaton for the ministry. Upon his graduation, there was little opportunity for him. Dissenter congregations were generally poor, and he was handicapped a preacher by a stuttering impediment (difficulty). For twelve years, he eked out a bare existence in several tiny pastorates, doing part-time tutoring in languages and English grammar. By the age of thirty-four, when he became pastor (elegyman) of the Mill Hill Chapel at leeds, he already had a small family. It was at this time that he met Benjamin Franklin, and it was here that he developed an abiding interest in science, particularly chemistry, as a hobby.

Joseph Priestley had read many books on chemistry and was performing experiments with gases. Near his home in Leeds was a public brewery which attracted his interest. The huge vats (square vessels), filled with fermenting liquids that gave off all sorts of malodorous gases, seemed to offer opportunities for experimentation. During spare hours, the black-coated young minister could be seen bending over the vats, in which he suspended lighted chips of wood or sought to trap some of the gases in an assortment of containers. It was not wonder that some of his parishioners, after a while, began to question whether he was a disciple of the divinity or a follower of evil spirits.

When Priestley observed that the colourless gas that was entitled from the fermenting vats extinguished the burning chips that he held over them, he suspected that this might be the same "fixed air" which had been obtained from heating limestone by Joseph Black some years earlier. Working at home, he was able to prepare a quantity of this same gas, and bubbling it through water, he found that some of it apparently dissolved in the liquid making "a glass of exceedingly pleasant speakling water." The gas was carbon dioxide, although Priestley did not give it that name, and the "sparkling water" has become known as soda water. This achievement brought him to the attention of the Royal Society of London.

Now Joseph Priestley, the minister who was an amateur scientist, began to give more and more time to his homemade laboratory and his experiments in chemistry. Heating ordinary salt with vitriolic acid and collecting the resultant gas over a mercury trough, he obtained hydrogen chloride gas. When this gas was dissolved in water, hydrochloric acid was formed. Each discovery increased his enthusiasm and his zeal for new experiments. Heating spirits of hartshorn ammonia water) over his mercury trough, he discovered a punt eye-searing gas which he called "alkaline air." This was, in fact, ammonia gas, used today in refrigerators and fertilizers. His next experiment was to send electric sparks through this gas, to separate it into its components of nitrogen and hydrogen.

Priestley's success in isolating and discovering gases was due, in part, to his invention of the pneumatic trough for collecting gases over mercury rather than over water. Moreover, he used glass flasks and jars for collecting gases rather than the elastic bladders of the time, which were cumbersome to handle. Priestley would fill a flask with mercury, insert a tube in the flask, and then invert it in a trough of mercury. When the gas entered the flask hrough the tube, it would displace the mercury in the flask and remain trapped. In the order method, where water was used instead of mercury, the gas would enter the bottle or bladder and, often being soluble in water, would enter the solution rather than displace the water. Thus, if Priestley had used the older method, he never would have been able to isolate ammonia or other soluble gases.

Although Priestley's time in Leeds seemed fully occupied by his church duties and his passion for research in chemistry, he was able active in the fight for the political and intellectual freedom that his early life had led him to cherish. He wrote pamphlets and letters criticizing the British government for its latter's struggle for independence.

In 1772, Priestley left his post at Leeds to accept the position of librarian and literary companion to Lord Shelburne. After staying with Lord Shelburne for eight years, he was able retire on a small pension. These were productive years in chemistry for Joseph Priestley, for he now had a fairly well equipped laboratory and was able to give more time to his experiments.

Priestley's greatest discovery was made in 1774. He had been using a large magnifying glass, which was one foot n diameter, to utilize the sun's rayes for heating various solids in a bell jar. One day he heated a powder, red oxide of mercury in the bell jar and collected the resultant colourless gas in a flask. A candle was burning near at hand, and Priestley, possibly recalling his experiments in the brewery with lighted chips of wood, decided to see what would happen to the burning candle when it was inserted in to see readily their way home after spending the night discussing science, politics, and literature.

During the French Revolution, the Dissenter Priestley supported the revolutionists in their fight for 'liberty, equality and fraternity.' In doing this, he come into further disagreement with the government authorities and other conservative leaders of Great Britan. As the French Revolution went from high ideals to the excesses of the guillotine more and more Britons withdrew their support. On July 14, 1791, the anniversary of the fall of the Bastille, a mob was incited against the dissenters, who were alleged to be plotting the overthrow of the established Church of England in the style of the French Revolution. Priestley's chapel and home were burned and his possessions, including valuable records of his experiments, were destroyed.

Conditions were such that he had to leave Birmingham and take up residence in London. Here he was snubbed (humiliated) by members of the Royal Society, because they disagreed with his political views. Unhappy in this situation, he finally decided to emigrate to A in 1794.

He was warmly welcomed in Philadelphia by his old friend Benjamin Franklin, who offered him a professorship at the University of Pennsylvania, the leadership of a Unitarian Church, and other distinguished positions. However, Priestley, now past sixty, preferred to make his home with his three sons in Northumberland, Pennsylvania, where he could devote himself fully to his research and writing. He visited with Thomas Jefferson, George Washington, and other outstanding American leaders. Hi adopted country now became the scene of some new discoveries in chemistry. In 1797, he discovered carbon monoxide by passing steam over white-hot charcoal, and subsequently he discovered nitrous oxide, later known as "laughing gas."

After Priestley' death in 1803, his home and laboratory became a national museum in which visitors might see the jars, pneumatic troughs, flasks, corks, and other apparatus actually used in his experiments. Joseph Priestley, a minister who was a self-taught chemist, made a permanent mark on the roll of great scientists. His discoveries of gases paved the way to an understanding of the atmosphere in which we live and of the very air we breathe.

9. James Watt

Jamie, I've never seen such a queer boy as you. Aren't you ashamed to be spending your time on that silly stuff/ Why don't you runoff and play like other boys?

This was the admonition (advance) that had been directed at James Watt one day, when he was having tea at the home of his aunt. Young Watt was a confirmed daydreamer who, on this occasion, seemed to be completely "out of this world" as he spent more than an hour in first removing and then replacing the lid from a tea kettle. He then held a spoon over the condensing steam, watched it rise from the spout, and caught it as it gathered into tiny drops of water. To the uninformed observer, James was aimlessly playing with the steam kettle.

James Watt was born on January 19, 1736, into a poor but respectable family in the little Scottish village of Greenock, near Glasgow. Young Jamie was taught to read and write by his mother, because he was too sickly to be sent to school. When he was in his teens, he was finally permitted to go to formal classes, where his great interest and aptitude in chemistry, physics and geometry were soon recognized despite his frequent and lengthy absences. However, his formal schooling was much too brief, since Jamie was compelled to go to work following the death of his mother.

Young Watt's "clever fingers" came to his aid when he entered the service of an optician in Glassgow. This optician was truly a jack-of-all-trades who not only ground eyeglass lenses, but was also able to upholster furniture, make fishing rods, tune spinets, and repair violins. Nonetheless, Watt's first employer was amazed at the versatility and skill of his young apprentice, who quickly mastered a variety of trades.

However, Watt desired to do even more specialized mechanical work, such as the construction of scientific and mathematical instruments. Therefore, he left for London, where he was apprenticed to an instrument maker. In those days, instrument-makers were required to join a strong guild, which insisted on a seven years' apprenticeship for all of its prospective members. In spite of this regulation. James Watt left London after completing only one year of a very strenuous (earnest) and long-houred service, during which ill health continued to bother him.

When Watt applied for membership in the Glasgow Guild, he was summarily refused, as it was inconceivable (that cannot be imagined) that any young man could have learned his trade in only one year. He was also refused permission merely to rent a shop for performing scientific experiments, rather than for business. At this low point in his career, some friends of the family intervened by getting the University of Glasgow to offer Watt a workroom in one of the college buildings. Here he would be free of the guild's restrictions, owing to a special provision in the university's charter.

Watt quickly made his business successful by diversifying his work. He was able to repair almost any kind of mechanical device, including a variety of musical instruments. However, before attempting to build or repair a new instrument, before attempting to build or repair a new instrument, Watt would do a thorough research job on both its theory and operation. This informal education led Watt to master a variety of foreign languages just so that he could read about subjects on interest in the other language. By the time Watt had completed the construction of his first organ, he had already acquired a more complete knowledge and understanding of the laws of musical tones and harmony than that of the science and music professors. For this reason, it was no accident that the workship of this self-educated craftsman was soon visited by the leading university professors and scholars. Two of these distinguished visitors were John Robinson, and his teacher, joseph Black, who became Watt's most intimate and lifelong friends.

Professor Black was already the most distinguished philosopher and scientist at the University of Glasgow. Black was so highly impressed by Watt that he soon sought Watt's help and skill in preparing scientific apparatus for his own experiments and lectures. However, this intimate relationship was to be of even greater benefit to James Watt, because Black's pioneering researches in the field of heat physics had already prepared the way for Watt's great engineering discoveries in the area of steam power by making heat a mathematical famous Carron Iron Works. Roebuck agreed to bear all costs in ex-change for a two-thirds share of the profits.

In 1769, Watt finally applied for and received his first steam engine patents for the discoveries which were to completely revolutionize British and world industry. Yet every engine, which he built according to plan and which was theoretically sound, refused to come up to specifications when put into practical use. It was now obvious that Watt's brilliant ideas could only be carried out, if at all, by means of much more precisely-constructed cylinders, pistons, and metal parts. As neither the precision tools nor the expert machanics existed in all of Scotland, it was a most fortunate stroke of luck that Matthew Boulton, the owner of the largest hardware factory in the world, at Soho, near Birmingham, England, bought out John Roebuck in 1774.

Since Boulton had the best mechanics in Europ working at Soho, it is not surprising that in less than a few months Watt's original engine had become a complete success. Additional patents were obtained for improvements, including the centrifugal governor which automatically limits the speed of the engine when too much steam is produced. By 1783, all but one of the Newcomen engines had been replaced by Watt's designs.

From this successful business partnership a most ardent friendship developed as well. Boulton was both an expert businessman and a philanthropist. He only employed orphans and parish wards as apprentices. whom he fed properly, sheltered, and educated, Watt, who had no head for business, was a perfectionist who personally planned and installed every one of their clients' machines. The cost of the engines was paid for by the immense fuel savings which the mine-owners for mills and factories. Before the patents expired in 1800, both Boulton and Watt turned over their intervests in their thriving business to their son.

In spite of the incessant (continual) work needed to perfect his steam engine, James Watt devised many other inventions in his leiure hours; e.g., a copying-press for manuscripts, a surveying quadrant, a drawing machine, and an instrument for measuring distances between the planets and stars. He also independently discovered that water is a compound of two gases–oxygen and hydrogen. After her retirement form business in 1800, James Watt was free to devote the rest of his life to his mechanical and social pursuits. His persistent headaches had disappeared, and he was able to enjoy fully his stimulating contacts with Birmingham's famous Lunar Society, which included many scientific and intellectual luminaries. The friendship of this intimate group was broken only by death, and James Watt, the last surviging member, died at the age of eighty-four, in 1819.

10. Edward Jenner

One of the most frightening stories in all literature is Daniel Defoe's A Journal of the Plague Year, which was published in 1722. Although somewhat fictionalized, it is extensively documented and is a realistic picture of the terror which can grip a city attacked by plague. Some of Defoe's vigenttes (titles) are striking :

> **.....the voice of mourning was truly heard in the streets. The shrieks of the women and children at the windows and doors of their houses, where their dearest relations were perhaps dying, or just dead, were so frequently to be heard that it was enough to pierce the stoutest hearts in the world to hear them......And that which was still worse, those that did break out (from quarantine) spread the infection farther by their wandering about with the distemper upon the, ...and perished in the streets or fields for mere them, ...and perished in the streets or fields for mere want, or dropped down by the raging violence of the fever upon them... they perished by the roadside, none daring to come to them or relieve them.....**

All the world knew the fury of smallpox plagues. A Persian physician distinguished smallpox from measles in 900 A.D., and its ravages were recorded many centuries earlier. Asia and Africa had repeated bouts of smallpox; Europe's population was decimated (destroyed a tenth part) by the killer in 1614; and England's great epidemic, Iron 1666 to 1675, left a frightful toll in its wake. The New World did not escape–in fact, some historians feel that the smallpox epidemics decimated the Indians and made them vulnerable (liable to be injury) to the white man's conquest.

As early as 1717, the Chinese technique of inoculation (injuction) against smallpox had been introduced in England. Lady Montagu learned about the Eastern practice of scartching a patient's arm and drawing through it a thread soaked in the fluid of a smallpox pustule. Although the principle was sound, the procedure was so dangerous, due to the possibility of infection, that only a hardy few submitted to it.

The man who was to conquer smallpox so effectively that only a few doctors in our time ever see a case firsthand was Edward Jenner. He was born in Barkeley, England, on May 17, 1749. After his early schooling he began to study medicine as an apprentice to a local surgeon. He did so well that his mentor sent him to London to work under the direction of England's famous Dr. John Hunter, the founder of surgical pathology. Because Hunter's interests were broad, Jenner studied subjects as varied as geology, the plumage of birds, the life history of eels, and the temperature of hedgehogs. While he was working in London, Jenner had a part-time job preparing zoological specimens for Sir Joseph Banks, who had collected them during Captain Cook's first voyage in 1771. Jenner toyed with the idea of accompanying Cook on his second expedition but, fortunately for us, he returned to Berkle to practice medicine.

One of the mild diseases which the young doctor was called upon to treat occasionally was cowpox, an infection which is transmitted from a cow's udders to the hands of milkers. Many dairymaids developed widespread pustular rash, but they were quickly well again. There are many superstitions involving disease and some, strangely enough, have scientific merit lurking beneath the mystical mumbo-jumbo, Jenner had often heard dairymaids tell him that they could not get smallpox, because they had already had cowpox. For some reason, this bit of folklore stuck in his mind and, from 1775 on, he investigated the connection between the two diseases with mounting interest.

As he probed the mystery of smallpox, his conviction grew that the daily people were not to be ridiculed. Cowpox did seem to bring immunity against the dangerous smallpox–the smooth-skinned dairymaids stood out in sharp contrast from their pock-marked fellow citizens who had been lucky enough to survive a smallpox attack. Jenner's training in science was invaluable, for instead of rushing off to trumpet his findings, he continued to probe. His supposition was questionable, because his research showed that some people who recovered from cowpox did eventually contact smallpox. Perseverance paid off who Jenner learned that there were two types of cowpox, only one of which gave immunity to smallpox, and only if it were transmitted at a specific stage of the cow disease.

In 1796, he vaccinated an eight year old boy with pus from the sore of a dairymaid suffering form cowpox. Two months later, the boy was inoculated with pus from a virulent case of smallpox. During the incubation (hatching) period of two weeks, Jenner (and the boy's mother) endured the torments which Pasteur was to undergo as he waited for the results of his first rabies vaccination. The boy remained well, as did the twenty-three subsequent patients he inoculated.

After Jenner had told his momentous story to the medical world in an article, inquiry into the Cause and Effects of Variolae Vaccinae, which was published in 1798, many clamored for the vaccine. Each day's mail brought an assortment of reactions to Jenner's claims : some asked for the serum (eccentric ideas), some congratulated him upon his discovery, and others requested additional information. Jenner had to hire several secretaries to help with the correspondence, and he complained to his friends that he had become "vaccine clerk to the world". There were other letters to Jenner, however, in which he was attacked as a charlatan and a threat to mankind's survival. Although most of those letters came from clanks, some were written by doctors who feared that Jenner's vaccine might spread smallpox, rather than check it. They felt that the vaccine had not yet been tested sufficiently.

The excellent early results of the vaccine allayed (polluted) the fears of the doctors. Just as the public was beginning to accept Jenner as a hero, however, the news of a smallpox epidemic all but wiped out their faith in him. A few hundred people had contracted smallpox after having been vaccinated. Jenner rushed in to prove that the serum had been calmed contaminated (calmed) because of faulty preparation ; when his prescribed methods for preparation were observed, he showed the vaccine was pocen and safe.

Slowly the principle and practice of preventive vaccination gained acceptance. During an eighteen-month period of trial, twelve thousand people were vaccinated in England, and the annual death rate from smallpox fell from 2,018 to 622. The precious vaccine was sent to other countries in Europe, the Near East, China, India, South America, and the Caribbean countries, Havana, which had had the highest smallpox death rate in the world, reported no deaths after two years of widespread vaccination. In 1803, the Royal Jennerian Society was established in London with universal vaccination as its lofty goal. Another of mankind' worst scourges (lashing of chastising) had bowed to the efforts and genius of scientists!

11. John Dalton

The beautiful valvet (small value) knee breeches (lower part of body), the glossy buckled shoes, and the gleaming sword had been laid out for John Dalton to wear. he was to be presented to King George IV in a traditional ceremony whereing the King honoured his distinguished subjects. But the courtiers had not reckoned with Dalton; he was a quaker (a member of the society of friends who advocated peace), and his beliefs forbade him to wear such garments or to carry a sword. What to do? in the throne room, George was becoming restless. The Lord Chamberlain was nearly out of his mind with fury at Dalton's stubbornness, but to no avail. Dalton would not allow court protocol to interfere with the tenets of his religion.

A bright young groom saved the day! Dalton was told that he could cover himself with a robe that he had recently worn while being granted an honorary degree from Oxford. The flaming red cloth was draped over Dalton's frail shoulders, and he was finally ushered into the impatient King's presence. A number of Quakers in the audience gasped when they saw Dalton bedecked in scarlet, a colour which no genuine Quaker was pemited to wear. Dalton, however, was colour blind and unaware of th faux pas which was committing. (Subsequently, Dalton became one of the first men to do serious studies of colour blindness, and to this day the phenomenon is often referred to as Daltonism.)

For John Dalton, the son of an impoverished (poor) English weaver, the presentation at court was a memorable occasion. Most of the boys with whom h had grown up in the tiny village of Eaglesfield had never left the town, and had continued to scartch their meager living from its soil. But John Dalton, born in 1766, had achieved eminence by dint of perseverance and brain power, commodities which he had in abundance.

Young John was an “egghead” in days when it was fashionable to be one. For miles around, the boy was referred to as a genius, and when he opened his own school in an empty barn at the age of twelve, people took it in their stride. They had come to expect much from a lad who mastered Latin and Greek during his evenings, after he had helped in the fields all day. They knew of John’s fascination with numbers, of his ability to solve the most difficult mathematical problems with lightning skill, of his homemade instruments for performing experiments, and of the pile of notebooks in which he recorded daily weather observations. Great things, they were sure, lay ahead for John Dalton.

Slowly, however, John began to sink into the quicksand of Eaglesfield. The proigy’s light was in danger of being extinguished by the provincial aspects of his environment. Luckily, Dalton escaped in time. In his mid-twenties, he took a position as a university teacher of science and mathematics in industrial Manchester, a lively city which was able to boast of science discussion groups and a Literary and Philosophical Society, Upon his first visit to that prominent club, he was awed by the membership and the quality of the papers which experimenters read to the Society. In succeeding years, Dalton was to become its most famous member and was to read dozens of his own papers at their meetings.

One of the first problems upon which he reported, in 1800, involved the expansion of gases. Dalton collected several quarts of nitrogen by talking the oxygen out of air and bottling the residue. The nitrogen, which is almost completely insoluble in water, was then bubbled into water, where it displaced its own volume. Dalton measured the displaced volume, and he next repeated the experiment, using oxygen only. Then he collected both oxygen and nitrogen, nothing that the amount of water which they displaced jointly was equal to the amounts displaced separately by the two gases. This showed that each gas acted independently, completely free from interaction with the other. The result of this simple experiment which stated that the total pressure exerted by mixture of gases is equal to the sum of the individual pressures of the different gases. Dalton's work formed the basis for the understanding of the physical behaviour of gases under changing conditions of temperature and pressure.

This early interest in air and air pressure led ohn Dalton to greater achievements. It seemed obvious to him that air must be porous (full of pores), otherwise how could his familiar gases–nitrogen and oxygen–mix so thoroughly and easily. The explanation must be that each gas I made up of particles which are separated from each other by relatively great distances. Thus, when a gas is released in a space occupied by another gas, the two mix with each other quite easily; e.g. the perfume from a bottle opened at one end of the room will soon diffuse so that its oduor can be detected in all parts of the room.

Dalton spent the next few months collecting air samples from every part of England; trips to rural areas, the mountains, and Manchester's sooty streets helped provide Dalton with hundreds of air-filled test tubes. Analysis revealed that the samples had approximately the same composition, which is surprising, because one might have expected the heavy carbon dioxide to settle to the bottom. Further experiments on gas mixtures enabled Dalton to assume that a gas was composed of tiny particles, separated from each other by considerable distances. However, the word "particle" did not satisfy Dalton. Newton had written about God's primitive particles, which were incapable of wearing out, but Dalton preferred the term "atom" after a Greek word. In reading Greek, he had discovered that the ancient mathematician, Democritus, had called the smallest possible particle an atom, from the Greek atomos, meaning uncut or indivisible.

Continued studies culminated in Dalton's major achievement–the formation of an atomic theory. Some of its highlights are as follows : (1) All materials are composed of infinitesimal, indivisible particles called atoms; and there are as many kinds of atoms as there are kinds of elements; (2) Atoms of the same element are exactly the same: (3) Atoms are rearranged, but not changed, as they enter into chemical compounds; the whole atom takes part in the chemical changes: and (4) Atoms cannot be created or destroyed.

In order to make his theory clearer Dalton fashioned little symbols for the atoms of each element. Black balls stood for the carbon atom; white balls indicated the oxygen atom; one black and one white symbolized a carbon-monoxide molecule, and so on. At the same time that Dalton promulgated his theory, he published a fairly accurate table of atomic weights which he had painstakingly developed. He assigned the weight "I" to the hydrogen particle, which is the lightest atom of all. The practical values of his theory have become enormous. Dalton realized that an intelligent standardization for chemists and for pharmaceutical companies could become a reality, if the scientists were able to arrive at an exact system for weighing components of compounds. No longer need drugs very in potency; no longer need chemists make unscientific approximations in their preparation.

Dalton's pioneer work with atomic weights influenced men such as Berzelius, who improved upon Dalton's estimates; Mendeleer, who developed the Periodic Table of the Elements by atomic weights; and Moseley, who prepared the Periodic Table of the Elements by atomic number. Then, too, Dalton's work was basic to the discoveries of atomic scientists such as Einstein, Fermi, and Meitner. Dalton's findings contained a number of errors, although they were remarkably accurate, considering his crude laboratory equipment. For one thing, he did not know that it took two hydrogen atoms combined with oxygen to form one molecule of water–hence he erred in the computation of the weights. Today we assign the atomic weight of "16" to oxygen, because we know that the oxygen atom weights sixteen times as much as the hydrogen atom, not eight times as much.

In addition to the atomic theory, Dalton gained a reputation for numerous other scientific achievements. He was the first to measure the rise in the temperature of are due to its compression; he suggested in 1811 that all gases could be liquefied by high pressure and low temperature; and he discovered the electrical natural of the aurora borealis.

Dalton, unlike some others among the scientific greats, lived to enjoy the plaudits (applause) of his countrymen. He had an audience with the king, and he was given the medal of the Royal Society of England in 1826.His colleagues in France elected him to their exclusive Academic des Sciences, and they presented him with the key to the city of Paris upon hi visit there. When John Dalton died in 1844, more than forty thousand people filed by his coffin as he lay in state. It was a beautiful tribute to one of England's most distinguished sons.

Interstingly enough, Dalton's notebooks on weather observation were up-to-date when he died, reflecting his "universal assiduity," a phrase he used himself. On the day of his death, in fact, he did not neglect to make his final notation, one of over two hundred thousand distinct entries.

12. Michael Faradya

Michael Faraday was one of the great scientists of the 19th century who made pioneering contributions in the field of electricity and magnetism. He provided the theoretical foundation for the electromagnetic field theory and was the first person to produce electric current from a magnetic field.

Faraday was born on September 22, 1791, in Newington in Great Britain. His father was a blacksmith who was sick most of the time. Faraday, therefore, had a very poor and unhappy childhood. His mother however, provided him with emotional support. Faraday also found spiritual sustenance (power to keep alive) from the Christian sect, Sandemanians, in which he believed. this was reportedly the most important influence of his later life. Due to his circumstances Faraday could not afford formal education and at the age of 14, he became an apprentice to a book binder. Here he tried to read as much books as possible, brought to the binder. Interested by certain articles on electricity, he started conducting some very crude experiments.

Later on he got a chance to attend the chemical lectures by Sir Humphrey Davy. Finally, he became Davy's laboratory assistant in 1812 and it is often said that Faraday was Davy's greatest discovery. In 1821, Faraday discovered the basic principle of motor and built a primitive model. In this endeavour (effect) he was inspired by the experiments conducted by Hans Christian Orestead and Andre-Marie Ampere. Faraday's motor demonstrated that there is a circular field of magnetic force around a current-carrying conductor.

In 1823, Faraday discovered the phenomenon of electromagnetic induction. He observed that whenever a magnetic field about an electromagnet was made to grow and collapse by closing and opening the electric circuit of which it is a part an electric current could be detected in a separate conductor nearby. Faraday also discovered the law determining the production of electric current by magnets : the magnitude of the current was dependent upon the number of lines fo force cut by the conductor in unit time.

Further studying the nature and properties of static and electromagnetic electricity. Faraday developed the laws of electrolysis, Known as Faraday's laws of electrolysis, it says that the amount of chemical change produced by current, at an electrode-electrolyte boundary is directly proportioned to the quantity of electricity passed through the cell. The law also says that the amount of chemical changes produced by the same quantity of electricity in different substances are proportional to their equivalent weights. Faraday also identified that all materials have specific inductive capacities. In 1839, Faraday discovered physical and chemical nature of conductors and insulators.

Farday's honesty and lack of guile (cunning) were both his greatest glory and his severest handicap. His frankness made many enemies for him, including his mentor, sir Humphry Davy. When a governmental committee investigated the hazards encountered in British coal mines. Faraday testified that Davy's "miner's safety lamp" was not always safe. For this Davy carried a resentment that led him, years later, to oppose Faraday's election as a fellow of the Royal Society. In spite of this undeserved opposition from Sir Himphry, who was then the President of the Society. Faraday was elected in 1824. Yet Faraday never bore any resentment against his former master and teacher. Years afterwards, when Sir Humphry was dead, he publicly defended Davy as his great friend and benefactor.

Practical electrical motors were not to be developed immediately after Faraday's original discoveries for a number of important reasons. Faradays, like his American counterpart, Joseph Henry, had no desire whatsoever to profit personally from any of his discoveries. Thus, as soon as a discovery seemed to be developing into a commercial possibility, Faraday invariably went on to something else. In this instance, however, William Wollaston and Davy accused him of stealing there ideas. Although Faraday was able to convince other scientists, and eventually even Wollaston, that his work was original, he refused to return to his electrical researches again until 1831, after more than seven years had elapsed.

Due to strenuous (earnest) hard work and research Faraday’s health really suffered. In 1839 he suffered a breakdown of his health which severly curtailed his activities for the next six years. Once he regained his health, he restarted his research. He then discovered the properties of paramagnetism and diamagnetism. The paramagnetic objects conducted magnetic lines of force much better than the surrounding medium while the diamagnetic objects conducted them less well.

Faraday evolved a new concept of space and force when he was almost 60 years old. Faraday believed that the space was a medium capable of supporting the strains of electric and magnetic forces. Giving a basic framework to field theory, Faraday suggested that the energies of the world were not localized in the particles from which these forces arose but rather were to be found in the space surrounding them.

The persisting ill health badly affected the hyperactive brain of Faraday. His mental faculties began to fail from 1855 even though he carried on with his experiments. He at this point of time was focused on gravitation force, which he thought could be converted to electricity. He failed in the endeavour. For his outstanding contributions to the field of science. Queen Victoria gifted him a house at Hampton Court. He was also offered Knighthood which he politely refused. Faraday's health continued to fail and he died on August 25, 1867. Faraday was an example of true scientific genius which developed and blossomed without formal education.

Although his extreme modesty prevented Faraday from accepting the Presidency of the Royal Society and knighthood, this hy genius was immortalized by the naming of the "farad" as the practical unit of electrical capacitance. One can truly say that today's entire electrical industry owes most of its existence to his pioneering discoveries.

13. Charles Lyell

A half dozen excited young men were sprawled around the table in a London pub (bar), roaring with (triumph exultation) and singing themselves hoarse (harsh sound). This was an occasion for celebration because earlier in the day they had learned that their applications for the right to practice law had been approved. Several of them had spent as many as six years of postgraduate study before becoming eligible for accreditation (approval) as full-fledged lawyers. Off in a corner, however, silently starting into his tankard of ale, sat Charles Lyell. His mood was in distinct contrast to that of his classmates. Instead of taking pleasure in his accomplishment, Charles was miserable. He had allowed his parents to push him into the study of law, to chain him to the massive legal reference books whose tiny print aggravated his already weak eyesight, and to shut him away from the world of nature where his instincts told him that he truly belonged.

Ever since he had been a youngster, toddling around the various estates to which his family moved, Charles had shown an interest in insects, birds, trees, and flowers. Several years after Charles birth in 1797, his parents settled in Southampton. England, and it was there that the young boy had the opportunity to cultivate his love for the natural world around him. The elder Lyell was a Scotch aristocrat whose income allowed him to live the life of a country gentlemen. The grounds which surrounded his large Southampton home provided his son with many opportunities to study the local flora and fauna (laid in careless manner).

Since Mr. Lyell was an amature botanist, Charles had an early introduction to science, and he displayed an uncommon interest in his father's extensive collection. Because of his poor health, Charles went to school only intermittenly. When he was well enough to attend private school, he was depressed by the antics (odds) of the other students. Charles had a sense of humour, but he could see nothing funny in nailing a boy's shoes to the floor, putting mice in his blanket, or pelting unfortunate victims with rotten eggs. As a result, Charles almost looked forward to his illnesses because they took him back to the quiet of Southampton–to the woods, streams, butterflies, and contentment.

In 1816, at the age of nineteen, Charles Lyell went to Oxford to study mathematics and the classics. A roommate frequently talked in flowing terms about his geology professor, William Buckland, and dragged Charles off to sit in on one of his lectures. This fascinating teacher, one of Oxford's great attractions, had a great influence on Lyell's life. Buckland had investigated hundreds of British caves, dug into ancient ruins, explored Europe's mountains and valleys, and pondered creatures. He was able to imbue (dye) others with the drama of geology, and

Charles quickly fell under his spell.

Charles plugged (fitted) away at Oxford's traditional curriculum, but his real interest lay with Buckland whose detective work with rocks and relics made Lyell's law books seem tame indeed. When vacation-time came, Buckland encouraged Charlees to go off to Scotland volcanic rock formations. It turned out to be the most exciting month that Charles had ever sent. He roamed over the lava cliffs of Edinburgh and saw the awesome splintered pillars in Fingal's Cave. This trip set the pattern for Lyell's future vacations. The entire world became his laboratory as he explored various continuents in his search for knowledge about the history of the earth.

Charles father agreed that geology was a promising science, but he still favoured the law for his son. In order to persuade his parents. Charles urged them to go to Europe with him for three months of mountain climbing, in 1818, as he traced the Alpine flood. It was a great holiday for the young man, but he was unable to convince his foot-weary parents that geology was an adequate substitute for a law career.

Dutifully, Charles returned to his books, but rock and fossile (dugs) were never far from his mind as he engaged in mock trials with other aspiring barristers, his thoughts constantly strayed to the greener fields of geology. Charles joined the Geological Society of London and attended their meetings regularly in order to keep up with the latest discoveries in the field.

A combination of Charles falling vision and his powers of persuasion finally won his parents over to his side. He gave up the law in 1827, and became a full-time geologist. The following summer found him in France, exploring in active volcanoes, digging up fossils, and examining ancient lake deposits. Lyell's health improved rapidly as he pursued this outdoor regimen (described course of diet). He was up before dawn and tramped (rolled) over the countryside until darkness called a halt to his work.

The notes with which Lyell filled several trunks were distilled into his masterpiece, Principles of Geology, the first volume of which appeared in 1830. The book's subtitle is a significant one: "An Attempt to Explain the Former Changes of the Earth's Surface by References to Causes Now in Operation." Prior to Lyell's work, leading scientists believed that geological changes could be attributed to the occasional catastrophes (ruins) which our earth had undergone.

They argued that Noah's Flood and other global catastrophes (ruins) had wiped out civilizations and reshaped the earth. In between the periodic cataclysms the distinctive plants and animals flourished and then vanished to be replaced by new species which characterized the new age. Lyell, however, contended that erosion sandstorms, glaciers, and other natural forces still at work were responsible for the earth's changing face. To learn about what had happened in the past, he reasoned, we must study the present, wherein we may see the process of change which the earth has encountered. The story of the past may be read in the fossils that may be found currently.

Principles of Geology describes the relatively rapid pace with which erosion may proceed. Lyell recorded statistics about the coast of Yorkshire, which lost from sever to fifteen feet each year; and he referred to the oyster beds of Ghile which rose four feet a day to become level with the land. The book tells of the rock startification and deposits in which extinct and living molluscan shell reveal the record of the past. When all the processes had been analyzed, Lyell could point to the continuum of activity and change which has persisted from ancient to modern times. Lyell was laying the foundation for modern geology.

Another significant contribution which Lyell made in Principles was the division of the Tertiary geological period (modern) into epochs called Eocee (”dawn of recent”), Miocene (”less of recent”), and Pliocene (”more of recent”). He outlined the geological characteristics of these periods and the evidence for his conclusions.

Lyell’s book had a great influence among contemporary scientists, including Charles Darwin, and was a runaway best seller. His publishers kept him busy with demands for new editions. By 1833, two more volumes had been issued, for the book had grown from an essay on earth's changes to an encyclopedia of man's knowledge of prehistoric times. On the strength of the book's reception, Lyell was appointed professor of geology at London's King's College, and shortly thereafter he married Mary Horner, the daughter of a colleague. Mary, who was to travel widely with Charles for the next forty years, delighted her husband by suggesting a geological walking tour as part of their honeymoon.

The young geology professor was lionized upon his return to England. His lectures at King's College were jammed with laymen whose interest had been captured by the new science. When the galleries were thronged regularly with society girls, the college administrators took steps to restrict their attendance. In a huff, Lyell quit and went off to America on a successful lecture tour. He found new treasures in the Mississippi Delta, in Virginia's Dismal Swamp, and at Niagara Falls.

With Travels in North America (1845), Lyell added to his stature by detailing the geological wonders of the United States and Canada, Further exporations were charted in A Second Visit to the United States (1849). Although Lyell was always interested in shells, fossils and dinosaur prints, he was also a careful observer of current social conditions. His books tell of the starving children of Europe, of the dirt and disease which he found everywhere, of political oppression and tyranny. America's progress, however, made a deep impression upon Lyell. He wrote approvingly of the social reforms, the satisfactory working conditions, liberalized education, decent houing, and the excellent wages which he noted in this country.

One of the reasons that Lyell's books were warmly received by experts and amateurs alike was his literary style, Lyell grew poetic over geology, and he was able to impart to his readers the majestic qualities of the science. These lines from Principles typify Lyell's romance with his subject :

> **Thus, although we are mere sojourners on the surface of the planet, chained to a mere point in space, enduring but for a moment of time, the human mind is not only enabled to number worlds beyond the unassisted ken of mortal eye, but to trace the events of indefinite ages before the creation of our race, and is not even withheld from penetrating into the dark secrets of the ocean or the interior of the solid globe.**

When Darwing's Origin of Species appeared (1859), Lyell was one of the first to evaluate correctly the book's greatness, supporting the new theory, and devoting fifteen chapters of a new edition of Principles to it. In 1863, he published The Geological Evidences of the Antiquity of Man, an examination of the arguments concerning man's appearance on earth, in which he lent further support to Darwin's theory of evolution. Lyell had collected so many specimens in preparation for this new book that he and his wife were forced to move to a larger house in order to store the implements, fossils, and rocks which they had accumulated on their European travels.

Prince Albert, noting Lyell's interest in social reform, appointed him to many committees. Lyell became involved in welfare groups which handled the problems of London's aged and homeless, and he toiled diligently to introduce progessive techniques to Britain's hidebound universities. For his contributions as a scientist and humanitarian, he was knighted in 1848, and made a baronet (title) in 1864. Upon his death, his country honoured Lyell by having him buried in Westminister Abbey, where he wa eulogized (paraised) as "the most philosphical and influential geologist that even lived, and one of the best of men.

14. Joseph Henry

The world famous English scientist, Michael Faraday, had just clapped his hands with glee and said: “Hurrah for the Yankee experiment! What in the world did you do?” If Joseph Henry had been anyone else but a modest scientific investigator, he might have exploded with : “If you would only read what I publish and understand what you read, you’d know what you just saw!” Instead, the Princeton science professor patiently explained the phenomenon of self-induction in the man whom the world had already credited with the discovery of induction (introduction).

This little incident which tells so much about Joseph Henry, America’s greatest experimental investigator of the nineteenth century, occurred in the spring of 1837 in an English laboratory, where Charles Wheatstone and Michael Faraday were vainly trying to draw sparks by closing and opening an electric circuit which was capable of carrying only a very weak current. While Faraday and Wheatstone argued back and forth over the probable cause of failure to produce a spark, Joseph Henry absent-mindedly wound a small length of wire about one of his fingers in the form of a corkscrew-shaped coil. Before the world-famous electrical scientists could stop him, Henry had opened their circuit, added his tiny coil to one of the leads, closed the circuit and then drawn some clearly visible sparks on opening the circuit again.

There was nothing in Joseph Henry's background to predict either the direction of his interest in science or the extent of his ability and practical scientific insight. His life was truly a story of a rise from poverty and relative ignorance to one of fame (and riches, if he had but chosen to patent any of his discoveries). Henry did not receive proper credit for his most significant scientific discoveries until after his death, when the scientists of the world first recognized him as an intellectual giant by granting him scientific immortality with the naming of the unit of electrical inductance as the "henry." The "henry" has joined the "volt," the "ampere," the "ohm," and the "fared"–all of which are lower-case names for our basic electrical units.

Henry was born, in 1797, in a small farm town near Albany, New York, where his childhood was spent in abject poverty. Henry barely knew how to read by the time he was thirteen years of age. He worked as a farm had and as a watchmaker's apprentice during his early years. Two accidental and unrelated occurrences undoubtedly were responsible for shaping his later career in science. One day, while playing with his pet rabbit. Henry chased it into the library of a church which happened to contain a number of romantic novels. The dreamy lad forgot the rabbit and began to read the books. He was so inspired by the books that he decided to become an actor. The two years which this hard-working and talented apprentice actor spent in learning this trade stood him in excellent stead in later years, because this training taught him that every good scientific demonstration must be convincing, dramatic, and foolproof.

Henry’s second accidental discovery occurred when he was sixteen years old, and he happened to pick up a book that had been left in his room by a fellow-boarder. It was a book of science which asked questions: e.g., “Why does a stone or arrow return to earth after being sent skyward, while smoke from a fire seems always to go upward without any force appearing to push it?” Thus, his stage career came to an abrupt close, and be immediately decided to become a natural philosopher. The fact that the other boys were years younger and came from wealthy families did not stop Joseph Henry from enrolling as a student at the Albany Academy.

After only seven intensive months of night classes and special tutoring, Henry had learned enough to get an appointment as a country schoolmaster. Now he could afford to continue his studies and to follow his new dream, even though teaching and learning took more than sixteen hours a day. Later he was made an assistant to his professor of chemistry, and he helped to set up experiments for the professor’s public lectures.

After completing his own course at the Albany Academy, Henry took a job as an engineer and surveyor on the Erie Canal. It seemed as though his days of want were over, because a person with this training could then make a good salary anywhere he chose to work. Yet, after only a few month, he decided to return to Albany Academy as a professor of mathematics and natural philosophy, for he believed that the country needed advanced teachers more desperately than they needed engineers.

In spite of a tremendously heavy teaching schedule which restricted his research to summer vacations, he was able to perform some of his greatest experimental work in the consecutive summers of 1827 through 1831. Because of his innate modesty and thoroughness, Henry was reluctant to publish anything until he had an overwhelming amount of experimental data. Thus, his first written accounts of his researches did not appear until 1832.

Henry’s first great discovery was different from most of his subsequent work in that, in this instance, he did not actually discover something that was new, but rather he greatly improved on the invention of another. In 1823, William Sturgeon had invented an electromagnet which was little more than a laboratory curiosity because it could lift only a few ounces of magnetic material. Sturgeon’s device consisted of a loosely-wound, single layer of bare copper wire, wound on an iron core which was insulated with a coating of varnish. In 1825, this device could still lift no more than twenty times its own weight, Henry's improvement, in 1827, seems very simple today, for he merely insulated the wires instead of the iron core. By 1831, he was able to support a load of 750 pounds. Not only did Henry have to wind his many miles of wire tightly into many-layered coils which were placed one on top of the next, but h also had to spend interminable hours in hand-winding the insulation onto the wire from strips of silk cloth which were allegedly obtained from his wife's old petticoats. The insulated wire that is used today was still unknown in 1837. Henry's discovery is so fundamental that today's electromagnets are virtually the same as his devices.

Henry also continued to experiment with his electro magnets by varying the voltage of his battery supply and varying the electrical resistance of his windings to obtain maximum magnetic effects. He was able to establish the proper relationships between voltage and resistance and to rediscover Ohm's Law before either he or America had heard of Ohm. (Ohm finally received proper recognition from the scientific world in 1837). This basic research led Joseph Henry to devise two types of electromagnets: one was for producing a large electrical current in order to produce a maximum lifting effect, while the other type produced a week current which, by means of a long continuous coil, could be sent over great distances.

Thus in 1831, he invented and demonstrated the first practical electromagnetic telegraph which could operate a bell at a distance of one mile. Henry never chose to patent this discovery, for he felt that his knowledge should be shared and used for the benefit of all mankind. He freely discussed his discoveries with Wheatstone, the “English inventor” of the telegraph, who received his patent in 1837; and Morse, the “American inventor” of the telegraph, who received his patent in 1840, before either had perfected his device. Although both men gained wealth and acclaim from their devices, they never bothered to give henry any of the credit he deserved for solving the problems of transmission over a long distance; yet Joseph Henry was not the type of man to carry a grudge.

As part of his first telegraph, Henry invented the electric relay.” This device enables many electrical appliances to be operated at a great distance. Transcontinetal radious and telegraphs use this principle of amplifying (enlarging) feeble electric currents which actually control the local electrical circuit of a more powerful magnet.

Henry’s most controversial discovery greatly paralleled the independent work of Michael Faraday. By a process now known as electromagnetic induction, Henry was able to produce electricity from magnetism. Most of the earlier investigators had tried to duplicate Oersted's procedure of producing steady magnetic effects from the steady flow of electricity through a wire in reverse, by using a uniform magnetic field to produce a steady flow of electricity. However, Henry discovered that electrical could be produced only when the magnetic field is made to vary, or when the wire carrying this newly-created or induced current is made to move through the magnetic field (space between the poles of a magnet in which magnetic effects are noticeable).

Joseph Henry's fatal delay in publishing an account of this discovery might also have been due to his belief that he was years ahead in this research, as well as to his thoroughness and modesty. After Faraday had published his own discovery of electromagnetic induction in 1832, which was based on research done in the fall of 1831, which Henry was prevailed on to publish the results of his own research, too. This included the material on self-induction which was still unfamiliar to Faraday as late as 1837, when these two great electrical wizards (enchanters) first met.

In 1832, Henry was appointed to the faculty of Princeton University, where he was provided with both the time and materials for his research work. The next fourteen years were the happiest ears of Henry's life. He was able to elucidate the laws which govern the operation of the electric transformer. He demonstrated that a low voltage will induce a high voltage by the proper arrangement of the coils of wire (step-up principle) and that the induced electrical current could also be increased when the induced voltage has been decreased by a different arrangement of the coils (step-down principle). What is so remarkable is that Henry did not have meters (voltmeters and ammeter) to measure his voltages and currents, but he had to rely on electrical shocks and chemical effects instead. Henry did not even have the use of alternating current, for it had not a yet been discovered. Therefore, his alternating current consisted of the opening and closing of a direct current circuit–a very poor substitute. Thus, his correct theory and conclusions are most remarkable.

In 1842, Henry also produced wireless radio or ‘Hertzian Waves,” which traveled through thirty feet of air and more than two feet of wood flouring. This was more than forty years before Hertz produced the same phenomenon and many years before James Clerk Maxwell mathematically predicted their existence. Yet Henry was so far ahead of his time that none of his contemporaries understood what so far ahead of his time that none of his contemporaries understood what he had accomplished. It took almost half a century before the scientists had learned enough to appreciate his work.

In 1846, Joseph Henry again heeded (attended) the call of duty, when he ended his brilliant career as America's foremost research physicist. He was chosen as the first secretary of the newly formed Smithsonian Institution, where he became America's first national administrator of science. He was a great administrator whose contemporaries knew him as a person who helped encourage young inventors and scientists, such as Bell and Morse. Joseph Henry gave American science its first great agency for the free publication of scientific research, and he inaugurated the distribution of these publications to the world's libraries and scientific organizations.

He was also responsible for the creation o the United States Weather Bureau through the pioneer efforts of the Smithsonian Institution, whose corps of volunteer observers east of the Mississippi River would telegraph their weather reports to Washington, D.C., where the information would be collated and published. The success of this operation directly led to the creation of this governmental bureau. In 1848, he was the first man to project an image of the sun on a white screen where, by means of a sensitive thermopile, he was able to show that the temperature of the sunspots on the sun's surface was cooler than that of the other areas of the sun.

Henry was an organizer of the National Academy of Science and of the American Association for the Advancement of Science, as well as the director of our science effort during the Civil War. In fact, the Civil War might have ended much earlier if the United States Navy had followed his minority recommendations for the construction of an ironclad gunboat. The South later adopted this rejected design in the building of the Merrimac.

Joseph Henry, the man whose life began with such limited promise, was to die in 1878, after having had not one, but two highly successful careers. Yet, this same modest man regarded wealth with indifference. He was satisfied with an annual salary of three thousand dollars from the Smithsonian Institution, and he repeatedly turned down both increases in salary and better-paying jobs. His life was truly devoted to science where his only reward was the Advancement of man's knowledge.

15. Charles Robert Darwin

Charles Darwin came from a distinguished family. His grandfather, Erasmus Darwin, was a eminent physician, an inventor, and a competent author with liberal views. In one of his works, he had suggested the idea of evolution, but he incorrectly assumed that it was accomplished through the transmutation (change into another form) of living forms. Charles grandfather on his mother's side was Josiah Wedgwood, the industrialist who established the world famous pottery works. Because his father wished him to follow the family profession of medicine, he sent Charles to a classical secondary school and then to medical school at Edinburgh University.

Charles did poorly at both places, because he was less interested in these studies than in several hobbies that he had cultivated. He joined a club of young zoologists and made several expeditions along the shores of England to study marine life. He perused books on travel, natural philosophy, and geology. The beginning of his thinking on evolution may possibly b traced to his reading of Lamarck and to his grandfather's journal which suggested this idea.

The English naturalist Charles Robert Darwin discovered that natural selection was the agent for the transmutation of organisms during evolution, as did Alfred Russel Wallace independently. Darwin presented his theory on origin of Species. The concept of evolution by descent dates at least from classical Greek philosophers. In the 18th century, Carl Linnaeus postulated limited mutability of species by descent and hybridization Charles Darwin's grandfather, Erasmus Darwin, and the Chevalier de Lamarck were the chief proponents of evolution in about 1800.

Darwin was born on February 12, 1908 at Shrewsbury, Shropshire (England), the fifth child of Robert and Susannah Darwin. His mother, who was the daughter of the famous potter Josiah Wedgwood, died when Charles was 8, and he was reared by his sisters. At the age of 9, Charles entered Shrewsbury School. His record was not outstanding, but he did learn to use English with precision and to delight in Shakespeare and Milton.

Darwin was a naturalist. He is renowned for his Theory of Evolution and for a theory of its operation, known as Darwinism. His father Robert Waring Darwin was a distinguished physician. Darwin after an early life that showed little promise of his later prominence, developed an interest in natural history. He got his education in medicine at the University of Edinburgh. Subsequently, he shifted to Cambridge University, where, he obtained his degree in medicine in 1831 with no special distinction.

Charles Darwin propounded the theory of evolution which revolutionized the biological, environmental and earth sciences. His theory of evaluation involved commitment to common organic descent, gradualism and multiplication of species. He explained how multitude of living things in our world are so finely adapted to their environment. Regarding the origin of human species. Darwin maintained that man descended from the age.

Darwin reached these conclusions after years of hard and patient research. In 1831, Darwin sailed on an expedition as a naturalist to South America and the Pacific Islands. The objective of his travel was to survey the wildlife of the west coast of South America. On the recommendation of John Stevens Henslow, a leading Cambridge botanist. Darwin was offered the position of naturalist for the second voyage of the H.M.S. Beagle to survey the coast of Patagonia and Tierra del Fuego and complete observations of longitude by circumnavigation with a formidable array of chronometers. The Beagle left on December 27, 1831 and returned on October 2, 1836. During the voyage, Darwin spent 535 days at sea and roughly 1200 days on land. Enough identification of data could be done on the spot, but sufficiently accurate identification of living organisms required systematists accessible only in London and Paris.

Darwin kept his field observations in notebooks with the specimens listed serially and their place and time of collection documented. On July 24, 1834, he wrote :

My notes are becoming bulky. I have about 600 small quarto pages full; about half of

this is Geology the other, imperfect descriptions of animals.

During the trip, Darwin discovered the relevance of Lyell's uniformitation views to the structure of St. Jago (Cape Verde Islands).

Upon his return to England, he worked for 20 years refining his ideas before he started to write a definitive account of evolution in 1856 which he published in 1859 as "The Origin of Species". The book was so popular that all the published copies were sold out the very first day. His second book "Descent of Man" was published twelve years latter. In this book Darwin proved that man, like other animals had evolved over millions of years from the same prehistoric ancestors. His later days were spent in much physical discomfort as he suffered from 'Chages' disease, which he had contracted while in South America.

Darwin married Emma Wedgwood, his first cousin, in 1839. They lived in London until 1842, when ill health drove him to Down House, where he passed the rest of his life in seclusion. Four of their sons became prominent scientists : George was an astronomer and methamatician. Francis a botanist, Leonard an eugenist, and Horace a civil engineer.

There were few visitors at Down House, because Charles health was poor. He was restless and slept poorly; stress gave him fits of shivering and nausea. But despite his seclusion and illness, he never lost his humanitarianism or his gentle disposition with his visitors or children. His sincere modesty was Darwin was reportd to have said : “Mr. Gladstone is a great man and yet he talked to me as if he wee an ordinary person like me.” When Gladstone was told of this, he remarked: “My feelings toward Mr. Darwin are exactly the same as his toward me.”

In 1859, when Darwin published “the Origin of Species”, in which he set forth his theory of evolution through natural selection, a storm of discussion arose. Although Charles avoided mentioning man in his book, the implication was clear. His theory of evolution was regarded by many as a denial of the Biblical account of the special creation of mankind. The debate raged furiously, but Darwin himself kept aloof. Partly because of his ill health, he was content to present his theory with its substantial supporting evidence without fighting for its acceptance. Thomas H. Huxley, a contemporary scientist and a capable writer and debater, waged the battle for acceptance of the theory.

Twelve years later Darwin published the “Descent of Man”, in which he applied the same rules of natural selection to anthropology; and a later work, The Expression of the Emotions in Man and Animals, applied the theory of evolution to psychology. In writing Variation of Animals and Plants under Domestication, he became a pioneer in genetics by trying to answer the question: “How does the variation in species come about?” It was a question he never fully answered.

Darwin explained his theory of evolution or natural selection as nature’s selection of those features of a species which enable it to survive in a given environment and elimination of those which are not necessary. A most common example of such an elimination in man is the appendix, which once served a useful bodily function as a part of the digestive system. Modifications in species may take hundreds or thousands of years. Darwin's theory meant different things to different groups. Many scientists hailed his work as being on a par with Isaac Newton's. Newton had discovered unity and coherence in the physical structure of the universe. Similarly, Darwin discovered the unity and coherence of living things as evolving, according to understandable scientific laws, from the simple to the more complex.

To the unscrupulous industrialists of Darwin's time and to ruthless dictators (like Hitler in more recent times) the "survival of the fittest" justified exploitation and even elimination of the weak to foster their own selfish interests. Darwin never proposed any such concept. By the "fittest" Darwin meant, not the strongest," But the most "adaptable." He saw progress for mankind, not in strife and extinction of the weak, but in enlightened co-operation and development of the total culture. In pointing out the unity and interrelationships of all living things, he set the stage for the humanitarian social philosophy that was espoused by many great authors of the nineteenth century, such as Dickens, Ruskin, and Tennyson. Darwin said :

> **Selfish and contenious people will not cohere, and without coherence nothing**

can be effected..... and....the moral faculties are generally and justly esteemed (disliked) as if higher value than the intellectual powers.

It is ironical that a man like Charles Darwin, who was gentle and philanthropic by nature and who detested controversy, was the focal point of one of the greatest controversies of his century and was accused, by those who did not understand his work, of seeking to debase (daltrate) mankind.

Darwin's theory had influenced the thinking of physical geographers. In fact, it was after Darwin's work that apart from biology, geology and geomorphology became the most ambitious branches of natural sciences. Darwin's theory thus closely influenced the growth and development of geomorphology, human geography, political geography and cultural geography, and led to the development of enormous new philosophical concepts and methodologies in geography. Darwin's theory gave a new direction to the discipline of geography and it became more socially and environmentally relevant. He died on April 19, 1882, at Down House, Downe, Kent (England). At the time of Darwin's death there was no longer any controversy over his greatness and he was buried in Westminister Abbey, London.

16. Louis Pasteur

In 1888, when Louis Pasteur was sixty-six years old, he spoke at the dedication of a new research institute, named in his honor:

> **Two contrary laws seem to be wrestling with each other nowadays. The one, a law of blood and of death, ever imagining new means of destruction and forcing nations to be constantly ready for the battlefield–the other, a law of peace, work, and health, ever evolving new means for delivering man from the scourges which beset him.**

Few men in our world's history have ever devoted themselves to the latter law with as great success than did Louis Pasteur. In Pasteur's century, the skills of many scientists were turned toward perfecting instruments of war, but Pasteur's contributions were completely constructive and beneficial.

The French chemist and biologist, Louis Pasteur is famous for his Germ Theory and for the development of vaccines. He became, a great benefactor of mankind for his discoveries in the fields of medicine and chemistry.

Louis Pasteur, the son of a tanner (mochi) was born on December 27, 1822, in the small town of Dole in France. Since his childhood, he was full of patriotic thoughts. By nature, Louis was shy but he had a special liking for nature, painting and science.

He studied in the college of Arbosis and at Besancon, where he graduated in Arts in 1840. As a student preparing for the prestigious (respected) Ecole Normale Superiure of Paris, he did not doubt his ability. When he gained admittance by passing fourteenth on the list, he refused to take admission. Taking the examination again, he got the third position and accepted admission. For his doctorate his attention was directed to the obscure science of crystallography. This was to have a decisive influence on his career.

Pasteur, under special dispensation (action of distributing) from the Ministry of Education, received a leave of absence from his duties as professor of physics at the Lycee of Tournon to pursue research on the optical properties of crystals of the salts of tartrates and paratartrate, which had the capacity to rotate the plane of polarized light. He prepared 19 different salts, examined these under a microscope and determined that they possessed hemihedral facets. Pasteur was elated; he repeated his experiment under the exacting eyes of Jacques Biot, the French Academy's authority on polarized (restricted) light who had brought Eilhardt Mitscherlich's work to pasteur's attention. The confirmation was complete to the last excating detail, and Pasteur, than 26 became famou. The French Government made his a member of the Legion of Honour, and Britain's Royal Society presented him with the Copley Modal.

In 1854, though only 31 years old, Pasteur became Professor of Chemistry and Dean of Sciences at the new University of Lille. The course of his activities is displayed in the publications which he gave to the world in the next decades : "Studies on Wine" (1866), "Studies on Vinegar" (1868), "Studies on the Diseases of Silkworm" (1870), and "Studies on Beer" (1876). In 1888 the Pasteur Institute was established, which was destined to become one of the most productive centres of biological study in the world.

Pasteur had propounded the Germ Theory of Disease. By a series of elaborate experiments he demonstrated that micro-organisms do not grow in filtered, heated air, proving beyond doubt that there is no such thing as spontaneous generation. He was the first scientist to demonstrate experimentally that is caused no by chemical decay, as had been previously believed, but by the action of certain micro-organisms.

Pasteur discovered and identified several disease causing micro-organisms and developed vaccines against some of them including chickenpox, and also discovered an inoculation (protective measures) against the dreadful disease of anthrax. Pasteur was also the first man to identify different optical isomers of tartaric acid, founding the field of stereochemistry.

Pasteur also discovered that milk becomes sour because of the presence of bacteria in it. He also showed that many of these bacteria could be destroyed by the application of a certain amount of heat (65^0C for 30 minutes or 72^0C for 15 minutes). Thus milk and milk products like butter, etc., could be preserved for longer periods. By this special method, even those germs which are responsible for causing tuberculosis could be eliminated. Thus, by discovering the method of elimination and checking the growth of germs, Pasteur besides finding cure for various diseases also helped in preserving food items. The method of making milk safe for drinking by killing off any disease causing organisms present in it, that Pasteur discovered is known a Pasteurization method and it is practised everywhere in the world.

Pasteur was elected a member of the French Academy in 1882 and thereafter he undertook what was perhaps his most significant research effort. By a series of experiments he successfully developed a vaccine for rabies which was hitherto incurable and this led to the foundation of the Pasteur Institute in Paris in 1888.

Pasteur' seventieth birthday was the occasion of a national holiday. At the celebration held at the Sorbonne, Pasteur was too weak to speak to the delegates who had gathered from all over the world. His address, read by his son, concluded :

> **Gentleman, you bring me the greatest happiness that can be experienced by a man whose invincible belief is that, science and peace will triumph over ignorance and war....Have faith that in the long run.....the future will belong not to the conquerors but to the saviours of mankind.**

Louis had also made his contribution in the

French Revolution of 1789. For the French people he was an angel who lessened the sufferings and miseries of mankind by his scientific discoveries.

On September 28, 1895, honoured by the world but unspoiled and overflowing with affection, Pasteur died near Saint-Cloud. His last words were.

> **One must work; one must work. I have done what I could.**

He was buried in a crypt in the Pasteur Institute. There is a strange postscirpt to thisstory. In 1940 the conquering German came again to Paris. A German officer demanded to see the tomb of Pasteur, but the old French guard refused to open the gate. When the German insisted, the Frenchman killed himself.

The theme which underlay Pasteur's efforts throughout his lifetime is evident in his remarks to the youth of France in 1895 :

> **Say to yourself first : What have I done for my instruction? and, as you gradually advance, What have I done for my country? until the time comes when you may have the immense happiness of thinking that you have contributed in some way to the progress and good of humanity.**

17. Alfred Nobel

Alfred Bernhard Nobel was a Swedish chemist, engineer, innovator, and an industrialist. He invented dynamite. He was born on October 21,1833 in Stockholm, Sweden. He was the third son of Immanuel Nobel and Andriette Ahlsell Nobel. In 1842 he went with his family to Saint Petersburg, where his father started a 'torpedo' works. Alfred studied chemistry with Professor Nikolay Nikolaevich Zinin. When Alfred was 18, he went to the United States to study chemistry for four years and worked for a short period under John Ericsson. In 1859 he left his father's business completely and devoted himself to the study of explosives.

Alfred Nobel emphasised the peaceful uses of dynamite. His invention of dynamite was a matter of chance only. One day, he was preparing some nitroglycerine' in his laboratory. This explosive could explode at the slightest jerk. Suddenly, a small fraction of this fluid fell out of the flask into a box of fine earth power below. Nobel observed that the fluid did not explode. It turned into a paste like form on getting soaked (made wet) into the earth powder. He picked up a little of this paste and carefully shaped it into a tiny ball. He moved out of the laboratory with it. When he set if off, it made a powerful explosion. Thus, Nobel found out a safe way to handle nitroglycerine. He named it dynamite.

Nobel carried various other experiments in the same field. He invented gelignite, a mixture of nitrocellulose and nitroglycerine. It was more of a powerful explosive then dynamite. Then he invented ballistite, similar to gelignite. It was produced in response to the military demand for a smokeless, slow burning projectile propellant (kind of Gas).

Throughout his life. Nobel made improvements in all his inventions. He patented them and left them to his companies. He had very little formal contact with the companies. With Nobel's invention, a worldwide industry was established. Nobel's view of manking and nations was pessimistic. He was well aware of the misuse of dynamite for destructive purposes. But he never thought that the destructive powers of his inventions would encourage was.

Nobel had great interest in literature. In his youth, he had written poetry in English. He gained proficiency in six languages, namely Swedish. French, Russian, English German and Italian. He was reserved and shy by nature. He hated personal publicity. He loved traveling. He traveled ceaselessly to many countries.

The dynamite found many uses all over te world.

He accumulated (collected) a huge amount of money from the royalty income of his inventions. In 1890, he presented his will, whereby he left $9,000,000, the interest earned on which was to be distributed yearly among those who had benefitted mankind the most. The benefits could be in different fields like science, literature and work for peace. Alfred Nobel established a trust which promoted the cause of peace, science and literature. It also promoted research in various branches of science. The trust gives international awards called 'Nobel Prizes', for excellent work done in different areas.

The foundations of the Nobel Prize were laid in 1895 when Alfred Nobel wrote his last will, leaving much of his wealth for its establishments in five disciplines namely physics, chemistry, medicine or physiology, literature and peace. In 1969, the sixth Nobel Prize, known as the 'Alfred Nobel Memorial Prize in Economic Science' was instituted by the Swedish National Bank. It is awarded by the Royal Swedish Academy of Sciences.

The award of the prizes in chemistry and physics is decided by the Royal Swedish Academy of Sciences. The Royal Caroline Institute in Sweden decides the award of prizes in physiology or medicine. The prize in literature is decided by the Swedish Academy and the prize in peace by the

Nobel Committee of the Norwegian Parliament. The value of each prize is about 100,000 US dollars. Today the Nobel Prize is considered as the most highly regarded international award.

Nobel lived in Hamburg from 1865 to 1873. Then he lived in Paris till 1891. He remained a bachelor throughout his life. He spent the last years of his life in San Remo, Italy. He died on December 10, 1896 at the age of 63. He was burried in Stockholm.

18. Thomas Alva Edison

The Wizard of Menlo Park', as Thomas Alva Edison came to be known, was the greatest American inventor of the 19th century and perhaps of all times. He was also a scientist of a very high calibre and is called the 'King' among the scientists of the world. The quantity and quality of his work make us awestruck at his talent. He had 1093 patents signly or jointly and has played a critical role in ushering in the age of electricity. The most notable inventions which have proved of lasting service to mankind are the gramophone or phonograph (1876) that filled the world's atmosphere with music, the movie projector and the incandescent bulb.

Thomas Edison was born in Milan, Ohio on February 11, 1847, in a poor American family. His father did different kinds of odd jobs and his mother was a teacher. He spent three months in school and then was taught at home by his mother. But he had a questioning mind and as a young boy he was busy doing experiments, though he may not have succeeded in all of them. At the age of 12, Edison saved the life of the child of the station master while he sold fruit, candy and papers on the train. In return of which he got the opportunity to learn telegraph operation. Exempt from military service because of deafness, he was a tramp telegrapher until he joined Western Union Telegraph Company in Boston in 1868.

Probably Edison's first invention was an automatic telegraph repeater (1864) and his first patent was for an electric vote recorder. In 1869, as partner in a New York electrical firm, he perfected the stock ticker and sold it. This money, in addition to that from his share of the partnership provided funds for his factory at New York.he hired technicians and experts in physics, chemistry and mathematics. From 1870 to 1875, Edison made many telegraphic improvements, and also worked on the typewriter. In 1876 Edison's carbon telegraph transmitter for Western Union marked a real advance towards making the Bell telephone practical. With the money received from Western Union for his transmitter, he established a factory at Menlo Park. Here also within 6 years he had patented more than 300 inventions.

Edison's most original and lucrative invention, the phonograph was patented in 1877. To research incandescence, Edison and others, including J.P. Morgan organised the Edison Electric Light Company in 1878 (Later it became the General Electric Company). Edison also opened the first commercial electric station in London in 1882. In 1883, Edison made a significant discovery in pure science, the Edison Effect-electrons flowed from incandescent filaments. In 1885, Edison patented a method to transmit telegraphic 'aerial' signals, which worked over short distances and later sold this to Marconi.

Edison's factory at West Orange, New Jersey was the world's most complete research laboratory, an antecedent of modern research and developmental laboratories, with teams of workers systematically investigating problems. Another invention was the motion picture camera, the kinetograph which could photograph action on 50 feet strips of film, 16 images per foot.

The Edison Company product over 1,700

movies. Synchronizing movies with the phonograph in 1904, Edison laid the basis for talking pictures. In 1908 his cinema phone appeared, adjusting film speed to phonograph speed. In 1913, his kinetophone projected talking pictures, thus giving birth to ‘talkies’. Edison produced several ‘talkies’. This was perhaps his second greatest contribution to the modern world of the entertainment industry.

Meanwhile, among his other inventions are the universal motor (1907), electric safety lantern, the telescribe (combining) features of the telephone and dictating phonograph), storage battery and mimegraph duplicating machine. He had made over 1000 experiments before he succeeded in inventing the electric bulb. It proves his irrepressible urge for invention and determination to achieve his aim.

During World War I, Edison headed he U.S. Navy consulting Board and contributed 45 inventions, including substitutes for previously imported chemicals (especially carbolic acid, or phenol), defensive instruments against U-boats, a ship-telephone system, an underwater searchlight, smoke screen machines, antitorpedo nets, turbine projectile heads, collision mats, navigating equipments, and methods of aiming and firing naval guns. After the war, he established the Naval Research Laboratory, the only American institution for organised weapons research until Wrold War II. In 1927 Edison was elected a member of the National Academy of Sciences.

With Henry Ford and the firestone Company, Edison organised the Edison Botanic Research Company in 1827 to discover or develop a domestic source of rubber. Some 17,000 different botanial specimens were examined over 4 years an indication of Edison's tenaciousness (quality of being adhesive). In 1930 he produced a cross breed which contained 12 percent late x. This was his last patent he received.

Edison married twice. First in 1871 and when he became a widower with three young children in 1886 he married again. He had difficulty in socialising and neglected his family. Edison died in West Ornage in October, 1931. The laboratory buildings and equipments associated with his career were presented in Greenfield Village. Detroit.

Edison's career was the embodiment of the American rags-to-riches story through hard work and intelligence. In temperament he was an uninhibited egoist, at once a tyrant to his employees and their most entertaining companion. By the time he was in his middle thirties he was said to be the best-known American in the world. When he died he was venerated (infected with poison) and mourned as the man who, more than any other, had laid the basis for the technological and social revolution of the modern electric world. He has written –

Genius (great natural ability) is 1% inspiration (divine) and 99% parspiration (sweat) invention is not discovery.)

19. Jagdish Chander Bose

The momentous (important) discovery that plants, like other living being also throb (beat) with life was made by the renowned Indian scientist, Sir Jagdish Chandra Bose. The world was greatly surprised to hear about this new and wholly unexpected discovery of Bose. With the help of various scientific instruments. invented by Bose himself, he demonstrated that plants too live, drink, sleep and breathe as all other living beings.

Jagdish Chandra Bose was born on November 30, 1858 in a village in East Bengal (now Bangladesh). His father was a doctor. After completing his early education Jagdish Chandra Bose was sent to Calcutta. There he was admitted to St. Xavier's College from where he went on to gain a degree from the University of Cambridge in 1884. Bose was Professor of Physical Science at Presidency College (1885)-1915). He left it to establish and direct the Bose Research Institute, Calcutta from 1917 until his death.

Bose, as plant physiologist and physicist invented highly sensitive instruments for the detection of minute responses by living organisms to external stimuli (effect of exciting), which enabled him to anticipate the parallelism between animal and plant tissues. To facilitate his research, he constructed automatic recorders capable of registering extremely slight movements and these instruments produced some striking results. One of them was Bose's demonstration of an apparent power of feeling in plants, exemplified by the quivering of injured plants. Bose also invented the device, cryocograph which is used to measure the development of a plant.

Though Bose's fame rests mainly on his discovery of life in plants, he also made another very important discovery–the discovery of Wireless Telegraphy. True, that around the same time the Italian scientist. Marconi was also conducting experiments of transmission of radio signals. But for this purpose Marconi used 'long electric waves' while Bose used 'short waves'. The 'short waves' came to be used in Radar and Television etc. Thus Bose's experiments on the quasi-optical properties of very short radio waves (1895) led him to make improvements on the coherer, an early form of radio detector, which has contributed to the development of solid-state physics. Bose conducted experiment on electric energy too. Once the created waves with the help of wires that made a telephone ring. The phone was kept at a distance of 75 feet. In 1900, Bose was nominated to represent India at the International Science Congress held in Paris. At the Congress, Bose expanded his scientific theories and the world scientists were astonished at his amazing talent.

The University of Calcutta conferred Dsc. on

Bose in 1917. The British Government of India honoured Bose by conferring, on him the title of 'Sir'. In 1920 he was elected a Fellow of the Royal Society of London. He also wrote some books about his experiments. Notable among them are "Response in the Living and Non-living" (1902) and "The Nervous Mechanism of Plants" (1926). The life of this illustrious scientist came to an end in 1937.

Jagdish Chandra Bose will always be remembered for his quest for the truth and his talent in science-both physiological and physical. He remains yet another symbol of the triumph of science by an Indian in British ruled India.

20. Marie Curie

Marie Curie was born in Warsaw on November 7, 1867, the youngest of the five children of Wladislaw and Bronislava Boguska Sklodowska. From childhood she was remarkable for her prodigious (marvellous) memory, and at the age of 16 she won a gold medal on completion of her secondary education at the Russian lycee (state of secondary school) in 1883. As girls could not attend universities in Russian-dominated Poland, Marie at her father's suggestion spent a year in the country with friends. On returning to her father's house in Warsaw the next summer, she had to take up teaching because her father, a teacher of mathematics and physics, lost his savings through bad investment. At the age of 18, she took up the post of a governess.

In 1891, Marie Sklodowska went to Paris and began to follow the lectures of Paul Appeal. Gabriel Lippman, and Edmond Bouty at the sorbonne. There she met renowned physicists jean Perrin, charles Maurain, and Aime Cotton. Marie worked far into the night in her students' quarter garret and virtually lived on bread, butter and tea. She came first in the licence of physical sciences in 1893. She began to work in Lippmann's research laboratory and in 1894 was placed second in the licence of mathematical sciences. It was in the spring of this year that the she met Pierre Curie.

Marie's marriage with Pierre Curie in 1895 marked the beginning of a partnership that achieved results of world significance. In the summer of 1898, her attention was drawn to pitchblende, a mineral whose activity, superior to that of pure uranium, could only be explained by the presence in the ore of small quantities of an unknown substance of high activity. Pierre Curie joined her in that work and it led to the discovery of new elements, polonium and radium. Polonium was so named by Marie in honour of her native land. Later Pierre Curie diverted from this path but Madam Curie struggled and obtained pure radium in the metallic state.

From 1898 to 1902, the Curies also published, jointly or separately, a total of 32 scientific papers. Among them was the one which announced that diseased, tumor-forming cells were destroyed fater than healthy cells when exposed to radium. On the results of her research Marie Curie received the Davy Medal of the Royal Society, London.

The birth of her two daughters, Irene and Eve in 1897 and 1904 did not interrupt Marie's intensive scientific work. She was appointed lecturer in Physics at the Ecole Normale Superieure for girls in Sevres and introduced a method of teaching based on experimental demonstrations. In December 1904 she was appointed chief assistant in the laboratory directed by Pierre Curie. Though the sudden death of Pierre Curie in April 1906 was a bittern blow, it was also a decisive turning point in her career. In May

1906 she was appointed to the professorship that had been left vacant on her husband's death. She was the first woman to teach in Sorbonne. In 1908 she became titular (held by virtue of title) professor, and in 1910 hr fundamental treatise on radioactivity, Traite de radioactivite was published. In 1911, she was elected as permanent member of the Solvay Conferences in physics. She was also offered the directorship of the Institute of Radioactivity in Warsaw. In 1914 she saw the complation of the building of the laboratories of the Radium Institute at the University of Paris.

The Curies had invented a new science of radioactivity, and they gave their process of extracting radium to the world as a gift. In refusing to take out valuable patients (radium sold for one hundred and fifty thousand dollars a gram), Marie said :–

> **Radium is an instrument of mercy and it belongs to the world.**

Throughout World War I, Marie Curie, with the help of her daughter Irene, devoted herself to the ue of X-radiography. She devoted much of her time during the 4 years of World War I to equipping automobiles in her own laboratory with X-ray apparatus to assist the sick. It was these cars that became known in the war zone as 'little Curies'. The year 1919, witnessed her installation at the Radium "Institute and 2 years later her book la Radiologie et La guerre" was published.

In 1921, accompanied by her two daughters. Marie Curie made a triumphant journey to the United States, where President Warren G. Harding presented her with a gram of radium bought as the result of a collection among American women. She gave lectures, especially in Balgium, Brazil, Spain and Czechoslovakia. She was made a member of the International Commission on Intellectual Co-operation by the Council of the League of Nations. In addition, she had the satisfaction of seeing the Curie Foundation in Paris develop and the inauguration in 1932 in Warsaw of the Radium Institute of which her sister Bronia became director. One of Marie Curie's outstanding achievements was to have understood the need to accumulate intense radioactive sources, not only for the treatment of illness but also to maintain an abundant supply for research in nuclear physics: the resultant stockpile was an unrivaled instrument until the appearance after 1930 of particle accelerators (increase of speed).

Madam Curie had the rare honour of receiving two Nobel Prizes and that too for different disciplines. In 1903 she shared the Nobel Prize in Physics with Pierre Curie and henri Becquerel for the discovery of radioactivity. In 1911 she was awarded the Nobel Prize for Chemistry, for the isolation of pure radium. She pioneered some of the earliest medical applications of X-rays and radium. Till date, radium therapy remains one of the major treatments of cancer. Madam Curie worked almost to the very end and succeeded in completing the manuscript of her last book, Radioactivite. Ironically, she died of blood cancer as a result of exposure to radiation on July 4, 1934. Madam Curie's contribution to physics had been immense, not only in her own work, the importance of which had been demonstrated by the awarding to her of two Nobel Prizes, but because of her influence on subsequent generations of nuclear physicists and chemists.

Albert Einstein, who knew Marie Curie personally, rendered a fitting tribute to her memory :

> **Her strength, her purity of will, her austerity toward herself, her objectivity, her incorruptible judgement– all these were of a kind seldom found joined in a single individual....her profound modesty never left and room for complacency.... Each of Dr. Einstein's carefully chosen words portrayed a significant aspect of Marie Curie's character and work.**

21. Albert Einstein

The German-born, American physicist, Albert Einstein, revolutionized the science of physics. In the history of exact sciences, only a handful of men–like Nicolaus Copernicus and Isaac Newton–share the honour with Albert Einstein for initiating a revolution in scientific thought. When describing the achievements of other physicists, the tendency is to enumerate their major discoveries; when describing the achievements of Einstein, it is possible to say, simply, that he revolutionized physics.

Einstein, in the first 15 years of the 20th century, advanced a series of theories that for the first time asserted the equivalence of mass and energy and proposed entirely new ways of thinking about space, time and gravitation. He developed special and general theories of relativity, the equivalence of mass and energy, and the photon theory of light.

Albert Einstein was born on March 14, 1879 at Ulm, Wurttemberg in Germany, in a jewish family and obtained his early education inMunich. In 1894, he became a naturalized civizen of Switzerland. He was not a child prodigy (wonderful example) in fact, he was unable to speak fluently even at age 9. Finding profound joy, liberation, and security in contemplating the laws of Nature, already at age 5 he had experienced a deep feeling of wonder when puzzling over the invisible, yet definite, force directing the needle of a compass. Seven years later, he experienced a different kind of wonder : the deep emotional stirring that accompanied his discovery of Euclidean geometry, with its lucid and certain proofs. Einstein mastered differential and integral calculus by the age of 16.

Einstein's formal secondary education was abruptly terminated at 16. He found life in school intolerable. His teacher expelled him for the negative effects his rebellious attitude, was having on the morale of his classmates. Einstein tried to enter the Federal Institute of Techonology (FIT) in Zurich. Switzerland, but his knowledge of non mathematical disciplines, was not equal to that of mathematics and he failed the entrance examination. On the advice of the principal, the thereupon first obtained his diploma at the Cantonal School in Araru, and in 1896, he was automatically admitted into the FIT. There he came to realize that, his deepest interest lay in physics, both experimental and theoretical, rather than in mathematics.

Einstein passed his diploma examination at the FIT in 1900. He earned a doctorate at the Polytechnic Academy in Zurich in 1905, and in the same year he published four research papers, each containing a great discovered in physics. These papers made Einstein famous, and universities soon began competing for his services. In 1909, after serving as a lecturer at the University of Bern, Einstein was invited as an associate professor to the University of Zurich. Two years later he was appointed a full profesor at the German University in Prague. In 1920, Einstein was appointed to a lifelong honorary visiting professorship at the University of Leiden.

Albert Einstein, one of the most illustrious scientists of the 20th century, had provided concepts that revolutionized modern physics. His major contribution is the Theory of Relativity and the interconversion of mass and energy embodied in the formula $E=mc^2$ (where E is energy, m is mass and c is a constant, equal to velocity of light). Einstein promulgated his Theory of Relativity in 1905. When his scientific research papers were published International fame came to Einstein in 1919, with the announcement that, a prediction of his General Theory of Relativity was verified. This theory established his reputation among the physicists of Europe. According to the concepts of the Theory of Relativity, the speed of light appears to be the same, whether an object is moving rapidly to meet it or going away from it.

Einstein's Theories of Relativity were a profound advance over Newtonian physics and revolutionized science. Einstein also developed a theory of Brownian Motion. He advanced the idea that light is composed of individual particles like quanta (later called photons) ; stimulated by the work of the

Indian physicist S.N. Bose. Thus, Einstein's theory predicts many other remarkable phenomena like gravitational waves, black holes and so on. Moreover, on a cosmic scale the theory is indispensable (absolutely necessary) for a proper description of the universe as a whole.

When Hitler, who had a profound (deep) hatred for Jews, came to power in Germany in 1933, Einstein left Germany. During the winder of 1933. Einstein then accepted a research position and said –

> **I will stay in a country only liberty, toleration and equality of all citizens before the law are rule. Such condition donot exist in Germans after present time.**

Thus, despite his great scientific achievements the shy. sympathetic, straight forward, earnest boy, Albert Einstein, had not changed as an adult. He abhorred (hatred) ostentation (display) and material riches, saying :

> **I am absolutely convinced that no wealth in the world can help humanity forward... The world needs permanent peace and lasting good will.**

Einstein joined the Institute for Advanced Study in Princeton, U.S.A., and became a U.S. citizen in 1940. At the institute, Einstein continued his work on general relativity, the unified field theories, and the critical discussion of the interpretation of the quantum theory. He also co-operated with charitable and social organisations, to help the large number of refugees who were arriving in the United States from Nazi Germany.

In 1921, Einstein was awarded the Nobel Prize for Physics for hi photoelectric law and work in theoretical physics. The next three years he spent in touring the world and explaining his scientific theories to the people. Fellow physicists were always struck with Einstein's uncanny ability to penetrate to the heart of a complex problem, to instantly see the physical significance of a complex mathematical result. Einstein's belief in strict causality was closely related to his profound belief in the harmony of nature. The frequent use of God's name in his speeches and writings, provides us with a feeling of his religious convictions. He believed in God, who reveals himself in the harmony of all beings. Since Einstein's God manifested himself in the harmony of the universe, there could be no conflict between religion and science for Einstein. In 1945, Einstein retired from his position at the institute, but continued to work there till his death. He died on April 18, 1955, at the age of 76 in Princeton, U.S.A.

22. Srinivasa Ramanujan

Srinivas Ramanujan was the greatest prodgy (wonderful example) of mathematics that our country produced. In 33 years of his life he left a permanent mark on the intellectual horizen of our country.

Srinivas Ramanujan, born into a poor Brahmin family at Erode on December 22, 1887, attended school in nearby Kumbakonam. By the time he was 13, he could solve, unaided every problem in Loney's Trigonnometry, and at 14 he obtained the theorems for the sine and the cosine that had been anticipated by L. Euler. In 1903, he came upon George Shoobridge Carr's Synopsis of Elementary Results in Pure and Applied Mathematics. This collection of some 6,000 theorem (non of the material was newer than 1860), aroused his genius. Having verified the results in Carr's book, Ramanujan went beyond it, developing his own theorems and ideas. In 1903, he secured a scholarship to the University of Madras but lost it the following year because he neglected all other studies in pursuit of mathematics. Despite two later attempts, he never qualified for the first degree in arts.

Ramanujan continued his work without employment and living in the poor circumstances. After his marriage in 1909, he began a search for permanent employment that culminated (reached highest point) in an interview with a government official, is Ramchandra Rao. Impressed by Ramanujan's mathematical prowess (outstanding skill) Rao supported his research for a time, but Ramanujan, unwilling to lie on charity, obtained a clerical post with the Madras Port Trust.

While working at Madras Port Trust Ramanujan came in contact with V. Ramaswami Aiyar, the founder of the Indian Mathematical Society. He grabbed (catched) the opportunity of contributing articles. In 1911 Ramanujan published the first of his papers in the Journal of the Indian Mathematical Society. His long article on 'Some properties of Bernoulli's Numbers' was noticed by Prof. G.H. Hardy, the greatest mathematician of his age. His genius slowly gained recognition, and in 1913 he began a correspondence with Godfrey H. Hardy that led to a special scholarship from the University of Madras and a grant from Trinity College, Cambridge. Overcoming his religious objections. Ramanujan travelled to England in 1914, where Hardy tutored him privately and collaborated with him in some research.

Ramanujan's knowledge of mathematics was startling (remarkable). Althought almost completely ignorant of what had been developed, his mastery of continued fractions was unequalled by any living mathematician. He worked out the Riemann series, the elliptic integrals, hypergeometric series, the functional equations of the zeta function, and his own theory of divergent series. On the other hand, the gaps in his knowledge were equally startling. He knew nothing of doubly periodic functions, the classical theory of quadratic forms, or Cauchy's theoram, and had only the most nebulous (formless) idea of what constitutes a mathematical proof. Though brilliant, many of his theorems on the theory of prime numbers were completely wrong.

In England, Ramanujan made further advances, especially in the partition of numbers. His papers were published in English and European journals, and in 1918 he became the first Indian to be elected to the Roayl Society of London. In 1917, Ramanujan contracted tuberculosis, but his condition improved sufficiently for him to return to India in 1919. He died on April 26, 1920, generally unknown to the world at large, but, recognised by mathematicians as a phenomental genius without peer since leonhard Euler (1707-83) and Karl Jacobi (1804-51).

One who is equal to rank in the short life of 33 years, Ramanujan brought pride to India. In 1927 G.H. Hardy brought out the collected works of Ramanujan. In the history of all those who did India proud in foreign lands the name of Ramanujan shines like a polestar. The Government of India issued a commemorative stamp in his honour. The Indian National Science Academy and many other scientific institutions in India have established various medals and awards in the memory of this great genius.

When he returned to India, Dr. g.H. hardy, the head of the Department of Mathematics, Trinity, College, remarked :

> **Ramanujan is returning to India as the greatest Mathematician India has ever produced. I hope his country will give him a befitting reception.**

23. C.V. Raman

C.V. Raman is a glowing (shining heat) example of the fact that even a scientifically backward, British-ruled India could make a fundamental contribution to the realm of modern science. It was a milestone in the history of India because his discovery of 'The Raman Effect' fetched the Nobel Prize for him. It was equally a milestone in the march of science and influential in the growth of science in India.

Born in Tiruchiarapally in November 7, 1888, Chandrashekhara Venkata Raman studied at Vishakhapatnam and Madras and was a distinguished student. His father's name was Chandra Shekhar Aiyer who had special interest in science and mathematics. His mother Parvati was a cultured lady. Raman was very intelligent since his early childhood. He passed his matriculation when he was only 12 years old. In 1904, when he was only 16, he passed his M.Sc. from the Presidency College, Madras, and he was the only student to get a first class. He did his M.A. in Physics from the same college and came out with flying colours. He grew up in an atmosphere of books and reading as his father was a teacher in a college. The scientific talent of Raman appeared at a very young age. As an undergraduate he took up original investigations in acoustics (concerned with eyes) and optics (relating to sound). On the advice of this teacher Professor Jones, he sent his research papers and they were

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related to light phenomena,
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researches in light and sound
now called Raman-frequenci

is termed ‘Raman Effect’. This discovery and other notable contributions brought him the coveted Nobel Prize in 1930. C.V. Raman was the first Asian and non-White to receive the Noble Prize for science. It was a moment of great pride for every Indian. It proved that Indians were in no way inferior to Europeans in the field of science, which in those days was believed to be their exclusive domain.

C.V. Raman knighted in 1924. He was appointed Director of the Indian institute of Science, Bangalore, one of the country’s premier scientific orgnisations. In due course, he also founded the Indian Journal of Physics and the Indian Academy of Sciences, to encourage the scientific talent in the country. How a science movement could be started in India was always uppermost in Raman’s mind. During the nazi occupation of Germany, Raman wished to provide asylum to top physicists lke Max Born, Erwin Schrodinger and others. But the management of the Indian Institute of Science could not appreciate Raman’s vision. As a result, he gave up the Directorship and also refused Directorship of a prestigious science institute in Holland. In 1948 he realised his dream of building his own institute, now known as Raman Research Institute in Bangalore. He gathered his own savings, asked forr donations and started some industries to ensure a regular supply of funds.

After Indian attained independence in 1947, he felt disappointed as no effort was being made to evolve science in the country itself. He declined the offer for Vice Presidentship without a second thought. As he wished to dedicate himself only to the cause of science. He was the recipient of the Bharat Ratna in 1954 and was the first scientist to be conferred this award. He was also awarded Lenin Peace Prize in 1958. A lover of Nature and flowers, Raman devoted a large part of his time during his later years, on original experiments, on colour of flowers and their origin and on the physiology of vision. He had once remarked.

> **Science is my religion and I intend to pursue it till the end'.**

He was true to his words till his death in 1970.

Raman was the first to put India on the consciousness of the modern scientific world. C.V. Raman picked up a lost thread, and the principles he proclimed illumined the path, as it were, for a free Indian to take for its growth and strength. The fillip (thing that encourages) Raman gave to India's recovery and upsurege of science I immeasurable. As a matter of fact he was the greatest scientists of India and his massage is give under–

> **I would like to tell the young man and women not to lose hope and courage. Success can only come by courageous devotion to the task and there is nothing worth in the world that can come was without that the sweat of our brow.**

24. Satyendra Nath Bose

Satyendra Nath Bose was an Indian mathematician and physicist noted for his collaboration (working together) with Albert Einstein in developing a theory regarding the gas-like qualities of electromagnetic radiation. He was a veteran teacher revered by his students for his affection, discipline and methodical work.

Satyendra Nath Bose was born on January 1, 1894 in Calcutta. His father Surendra Nath Bose, was employed in the Engineering Separtment of East India Railway. Satyendra Nath's mother amodini died at an early age. It is said that when Satvendra Nath was hardly three years old, a Bengali astrologer made this prediction : This child will face many obstacles (difficulties) all through his life: nevertheless he will overcome them with his exceptional intelligence and attain great fame. His father, naturally, took a special interest in his progress. Satyendra Nath by his own efforts stood first throughout his academic career. Because of his deep interest in science he did much research and earned a name both home and abroad.

During hi school days, Bose was recognized as an intelligent student. His teachers had predicted that Bose will one day become as great a mathematician as Laplace or Cauchy. When in the fourth standard in Hindu High School, Calcutta, Bose solved some problems in mathematics by more than one method. Teacher was so much impressed by this that he gave him more marks than the maximum. Thus he established a new record scoring 110 marks for a maximum of 100 in mathematics. For higher studies Bose joined the Presidency College of Calcutta. At the age of 19 Bose became a graduate. On May 5, 1914 at the age of 20, he married Ushadevi. The next year he completed his post-graduation getting the M.Sc. degree. In all the examinations –Intermediate, B.Sc. and M.Sc. he got the first rank.

Bose started his career in 1916 as a Lecturer in Physics in Calcutta University. He served this University for five years i.e., from 1916 to 1921. In 1921 he joined Dacca University as a Reader in Physics. In 1924 came Satyendra Nath's major theoretical work on Physics known as the Bose-Einstein or simply as Bose statistics. It formed an important amendment to earlier research by Maxwell and Boltzmann on the behaviour of crowds and molecules, known as Maxwell-Boltzmann statistics. Bose detected flaws, which were responsible for a discrepancy in the result of experiments based on them. Bose's Planck's Law and the Hypothesis of Light Quanta was published in 1924. Einstein translated the paper into German and elaborated it.

He also sent it for publication to a famous periodical in Germany, Zeitschrift fur Physik. The paper also led Einstein to seek him our for collaboration.

In 1924 Bose went to Europe. Inb Paris he got permission from Madam Curie to work in her laboratory. There he took certain difficult measurements of the piezo-electric effect, a property exhibited by suitably shaped pieces of quartz under the influence of an alternating current field. During 1925-26, Dr. Bose, worked with Einstein in Germany.

After his return, he became professor and Head of the Department of Physics at Dacca University. Bose served in Dacca University from 1921 to 1945.His students and colleagues held him in high esteem. He was very friendly and helpful to them. In 1944 Bose was chosen as the General President of the thrity-first session of the Science Congress. In 1945, he was again appointed in Calcutta University as the professor of Physics. He retired from Calcutta University in 1956. The university honoured him on his retirement by appointing him as 'Emeritus Professor' (having tired, but keeping his title as an honour). Bose was Chairman of the National Institute of Science in India from 1948 to 1950. From 1956 to 1958, he was the Vice-Chancellor of Viswabharati University. In 1958, he was made a Fellow of the Royal Society, London. In the same year he was also awarded Padma Vibhushan and made a National

Professor. He represented India on many International committees.

Satyendra Nath's scope of research was vast and varied. His numerous Scientific papers, published from 1918 to 1956, contributed to statistical mechanics, the electromagnetic properties of the ionosphere, the theories of X-ray crystallography and thermoluminescence, and unified field theory. Bose regarded Albert Einsein as his 'Guru' (the teacher). Every time Bose took a problem to him, Einstein would help him solve it as a teacher solves his student's problem. The able guidance of this celebrated scientist enabled Bose to explore fresh fields of research. Bose successfully carried on research in Physics and discovered boson and Bose Gas.

Dr. Bose was a passionate believer in the propagation of scientific knowledge among the people. A science association named 'Bangiya Vigyan Parishad' was founded by him in 1948 in Bengal. All its correspondence was carried out in Bengali. It also used to bring out a periodical Jnan O' Bijnan. Bangiya Vigyan Parishad took up the task of propagating science among people in the mother tongue, Bengali. Bose spared no pains in developing this institution. He was one of those champions who fought for the introduction of mother tongue as the medium of instruction.

In 1952 Dr. Bose became a member of the Rajya

Sabha. He utilized this opportunity to work for benefit of both science and society. His devotion to duty was exceptional. He never allowed his personal in convenience and difficulties to interfere with his duty. Bose authored Light Quanta Satatistics and Affine Connection Coefficients and many other works on science. He wrote Albert Einstein in Bengali. He with Meghnad Saha translated from German into English book on Einstein's Theory of Relativity. He also wrote many books on science in Bengali. With all his greatness, he was always modest and courteous. Dr. Bose passed away on February 4, 1974 at his residence in Calcutta.

25. Har Gobind Khorana

Har Gobind Khorana was an Indian chemist and co-winner of the 1968 Nobel Prize for physiology or medicine. His research in chemical genetics, vastly extended our understanding of how the chemicals of a cell nucleus transmit information to succeeding generations of cells.

Har Gobind Khorana was born in Raipur, Punjab on January 9, 1922. He studied at D.A.V. School in Multan (now in Pakistan) and later at the Panjab University, Lahore. His father was a taxation clerk, but spite of being poor he was dedicated to educating the family. After obtaining a doctorate in chemistry from the University of Livepool, Khorana worked with V. Prelog at the Federal Institute of Technology in Zurich and with Sir Alexander Todd at Cambridge University. From 1952 to 1960, he was head of the Organic Chemistry Group of the British commonwealth Research Councilin Vancouver, and for part of this period, he was visiting research professor at the Rockefeller University in New York City. He moved to the University of Wisconsin. Madison in 1960, and in 1964 was named as the Conrad A. Elvetyem Chair in Life Science at the Institute of Enzyme Research.

Khorana's research embraced many fields : peptides and proteins; chemistery of phophate esters, nucleic acids, and viruses; and chemical genetics. it was his work in chemical genetics that secured for him three coverted prizes : the Merck Award of the Chemical Institute of Canada in 1958, the Louisa Gross Horwitz Prize of Columbia University in 1968, and the Nobel Prize in the same year. He also received the Gairdner Foundation International Award.

Khorana's work supplements the research of Marshall Nirenberg and Robert Holley. In 1961, while experimenting with the intestinal bacterium Escherichia coli. Nirenberg had deciphered the coded messages that DNA (deoxyribonucleic acid) sends to RNA (ribonucleic acid), which in turn prescribes the synthesis of new proteins. Further experiments revealed codes for most of the known amino acids normally present in proteins.

With his co-workers, Khorana resolved this gap by synthesizing all of the 64 possible trinucleotides. He used synthetic polydeoxyribo - nucleotides of known sequence to direct the synthesis of long complementary, polyribonucleotides in reaction catalyzied by the enzyme RNA polymerase. By preparing RNA-like polymer directs the synthesis of a polypeptide with alternating amino acids - leucine and serine.

After testing a large number of such polymers, Khorana afforded a clear proof of codon assignments and confirmed that the genetic language is linear and consecutive and that three nucleotides specify an amino acid. In addition, he proved the direction in which the information of the messenger RNA is read and that the code words cannot overlap. The manner in which polyribonucleotides are manufactured afforded the clearest proof that the sequence of nucleotides in DNA specifies the sequence of amino acids in proteins through the intermediary of an RNA. In 1970, he synthesised the first artificial copy of the yeast gene.

In 1970, Khorana left the University of Wisconsin for the Masachusetts Institute of Technology, becoming the Alfred P. Sloan Professor. He was associated with Cornell University from 1974 to 1980 as well. Also in 1970, Khorana made a major breakthrough when he announced the synthesis of the first artificial gene. Six years later, Khorana and his team created a second artificial gene, this one capable of functioning in a living cell. This valuable work laid the foundation for a future in which scientists could use artificial gene to synthesize important proteins or to cure hereditary diseases in humans. Khorana had also synthesized the gene for bovine rhodopsin, the retinal pigment that converts light energy into electrical energy.

Khorana, who became an American citizen in 1966, had developed a reputation as a tireless worker who once went 12 years without a vacation. He enjoyed hiking, listening to music, and often took his scientific inspiration from long daily walks. In 1952, he got married to Elizabeth Sibrer of Swiss origin and with his wife, he raised two daughters, Julia Elizabeth and Emily Anne, and one son, Dave Roy.

Dr. Khorana visited India in 1969 and was awarded 'Padama Bhushan' by the Government of India, and also conferred with honorary degree of D.Sc. by Panjab University, Chandigarh. He died on November 12, 2011 at the age of 89 years.

लेखक द्वारा प्रकाशित एवं निःशुल्क वितरित पुस्तकों की सूची :–

1. रामचरितमानससार
2. गीतासार
3. उपनिषद्सार
4. सत्यार्थप्रकाशसार
5. भक्ति
6. सुखीजीवन
7. आत्मबोध
8. वेदवाणी
9. वैदिकसाहित्य
10. अमृतवाणी
11. महर्षि दयानंद
12. स्वामी विवेकानंद
13. शरणागति
14. वैदिक रामायण
15. क्या आप जानते हैं ?
16. शेर-ओ-शायरी
17. ओ३म्
18. गायत्री रहस्य

लेखक द्वारा अप्रकाशित पुस्तकों की सूची :–

1. वैदिक मनुस्मृति
2. वैदिक उपनिषद्वाणी
3. वैदिक दर्शनवाणी
4. वैदिक महाभारत
5. वैदिक गीता
6. अमर धर्मग्रंथ
7. अमर नीतिग्रंथ
8. पुराणपरिचय
9. ईश्वरसिद्धि
10. राष्ट्रभाषा हिन्दी
11. मर्यादा पुरुषोत्तम श्रीराम
12. महावीर हनुमान
13. योगिराज श्रीकृष्ण
14. आदिशंकराचार्य
15. आचार्य चाणक्य
16. दस गुरु
17. आर्यसमाज के महामानव
18. स्वामी रामतीर्थ
19. संस्कार
20. गीतांजलि
21. आर्यसमाज
22. ज्ञानामृत
23. यज्ञ
24. संत
25. संतवाणी
26. आत्मकथा
27. भतृहरिशतक
28. ब्रह्मचर्य
29. गृहस्थ
30. सामान्य हिन्दी (भाग I-II) (सब कक्षाओं के लिये)
31. धर्म
32. कर्म
33. मन
34. सुखी कौन?
35. भारत के क्रांतिकारी
36. भारत के भक्त
37. Great Thoughts
38. Great Indians
39. Great Thinkers
40. Great Scientists
41. General English (Part I to V) (For All Classes)

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2. आर्यसमाज
3. आर्यसमाज के महामानव
4. आदिशंकराचार्य
5. आचार्य चाणक्य
6. अमर नीतिग्रंथ
7. अमर धर्मग्रंथ
8. दस गुरु
9. ईश्वरसिद्धि
10. गायत्रीरहस्य
11. ज्ञानामृत
12. गीतांजलि
13. क्या आप जानते हैं ?
14. मर्यादा पुरुषोत्तम श्रीराम
15. महावीर हनुमान
16. महर्षि दयानंद
17. ओ३म्
18. पुराणपरिचय
19. राष्ट्रभाषा हिन्दी
20. संस्कार
21. संत
22. संतवाणी
23. स्वामी विवेकानंद
24. स्वामी रामतीर्थ
25. शरणागति
26. शेंर-ओ-शायरी
27. सामान्य हिन्दी (भाग **I-II**)
(सब कक्षाओं के लिये)
28. वैदिकसाहित्य
29. वैदिक उपनिषद्वाणी
30. वैदिक दर्शनवाणी
31. वैदिक रामायण
32. वैदिक महाभारत
33. वैदिक गीता
34. योगिराज श्रीकृष्ण
35. यज्ञ
36. आत्मकथा
37. भर्तृहरिशतक
38. ब्रह्मचर्य
39. गृहस्थ
40. वैदिक मनुस्मृति
41. धर्म
42. कर्म
43. मन
44. सुखी कौन?
45. भारत के क्रांतिकारी
46. भारत के भक्त
47. **Great Thoughts**
48. **Great Indians**
49. **Great Thinkers**
50. **Great Scientists**
51. **General English**
(Part I to V)
(For All Classes)