INTRODUCTION

Science is one of the most important aspects of human life. It is a broad field which studies various subjects from nature to machines. Science has led to better understanding of the world and is making human life much better. As man’s curiosity and needs grew, his knowledge also grew. Science thus began from simple inventions and later developed into complex theories.

NATURE AND CHARACTERISTICS OF SCIENCE

Science has given solutions of many problems of man. It is a process to understand natural phenomena. Scientific knowledge is continuously increasing. To know what qualifies a certain study as a science we need to understand the meaning and characteristics of science.

1) Meaning

The word science is derived from the word scientia meaning knowledge. Thus any body of knowledge can be termed as science. It is a systematic study of knowledge based on reasoning, observation and experimentation. It can be defined as, an organized knowledge especially when obtained by observation and testing of facts about the physical world, natural laws and society.

Science is a way of discovering what is in the universe and how those things work today, how they worked in the past, and how they are likely to work in the future. The above definition states that science aims at acquiring factual information and presenting it in structural form. Thus the smallest atom, the universe, anatomies of living beings and even their social lives become a part of scientific study.

2) Principles and characteristics
There are certain basic principles that make science unique. Following are some of the essential characteristics of science.

*Scientific method*

Science studies various phenomena using the scientific method. This method is systematic process of finding relevant data, forming hypothesis, analyzing its validity and conducting experiments. It is a gradual process. At the end scientists end up with new facts, theories and inventions. Answers to questions are found based on reasoning and accurate data.

*Observation and inference.*

Scientific data is gathered through observation and studied through inferences. Observations are made through five senses often supported by technology. Based on the observations logical interpretations are derived. For example the earliest model of planetary systems was prepared on the basis of continuous observation of the sky over a long period using simple tools.

*Objectivity*

Science is based on facts. It depends upon observation and logic. It is not concerned with the personal beliefs, opinions and prejudices of the people conducting the study. The facts of science and results of its are therefore objective. They do not change from person to person. It is unbiased and factual.

*Universal basic ideas*

Science assumes that the universe is a system in which basic rules apply everywhere. Laws developed by science are thus universally applicable such as the law of motion or magnetism. Scientific experiments can be thus inducted in any one part of the universe to understand the working of the entire system.

*Tentative*

New hypotheses sometimes challenge well established facts. Even with strong evidence it is not possible to prove that a certain law will be true in every condition. Sometimes new
experiments improve earlier facts and theories. Thus scientific knowledge is tentative. For example, the earlier theory that earth is the centre of the system was later proved wrong by Copernicus who showed that sun is the centre and earth revolves around it. Science is thus improvising continuously.

*Precise and durable knowledge*

Since scientific knowledge is based on rigorous experiment it is precise and reliable. Scientific knowledge is expressed in clear language to avoid ambiguity. Once scientific ideas are established as facts they remain unchanged for a long time. Several ideas are consistent facts such as gravitational force and facts relating to energy and matter.

*Creative thinking*

Creativity and imagination are the roots of scientific ideas. Scientists use creative, never-before-used methods to conduct their experiments. They are inspired to stretch the limits of their imagination and bring it to reality.

*Laws and theories are different*

Scientific laws and theories are related to each other However they are not the same. Both are based on hypotheses and supported by empirical data. Laws are established facts that explain the relationship between various factors and explain patterns of systems under particular conditions. They are descriptive and mathematical.

Theories on the other hand provide explanation to established facts. They are non mathematical and give answers to how a certain system works. Theories are interpretations of laws. A few theories become laws while some theories lead to discovery of new facts. For e.g. Ptolemy’s theory on planetary systems led to almost accurate prediction of position of planets.

*Science has limitations*

Science predicts and explains phenomena. However it cannot solve all problems with complete accuracy. For example there are a few diseases which are not curable today.
Thus, Science is a subject that describes, finds solutions, prepares models and provides explanations to natural phenomena. It is based on empirical data.

3) Science as knowledge

As a body of knowledge science has the following aims:

Empirical

Empirical knowledge means knowledge gathered through sensory experience, i.e. through touch, sight, sound, taste or smell. In science, all hypotheses and theories are tested against observations of the natural world. Along with reasoning experience is given importance. Evidence derived from experiments become basis for knowledge. For example, Aristotle one of the earliest philosophers said that knowledge of the natural world is based on its perception and thoughts based on what is experienced.

The empirical data can be subjected to bias of the scientists. Verification of scientific data can help to avoid bias of the investigator. Thus scientific knowledge is validated.

Theoretical

Construction of useful theories is a major goal of science. A scientist formulates a hypothesis means a calculated conclusion which he wants to prove right. To do this he conducts experiments and observes facts. The result of this process is a theory. A scientific theory can be proved wrong by testing it under various conditions. As new ideas develop and new evidences are found, theories improve accordingly. No theory is at any time completely proven, except in mathematics. Wrong theories are modified or completely discarded. For e.g. the planetary theory of Ptolemy remained true for around 1000 years till Copernicus gave his heliocentric theory. However, Newton’s theory of gravitation, Darwin’s theory of evolution is self consistent. Scientists conduct research to verify theories, check their validity or sometimes to improve them.

The theories should be able to predict. On the basis of existing theories new discoveries and experiments should be made.

Practical
Practical knowledge of science refers to the application of scientific knowledge. Basic theoretical research is required for further technical research. Through application of scientific knowledge man has found solutions to several problems, increased efficiency of human life and has made many useful thing. The application of studies in molecular biology, genetics and anatomical research has opened many new areas in medicine. Knowledge of space and astronomy has encouraged man to dream of exploiting resources from other planets for use on earth. Sciences such as psychology and neuroscience aim at understanding human thinking but there are practical motives such as treatment of mental illness.

3 DEVELOPMENT OF SCIENCE

Science as a body of knowledge developed along with man's understanding of nature. All things that man did for survival are a part of the story of growth of science. Development of science can be studied in the following stages:

1-. Development of Science in the Ancient cultures:

Ancient period of history of man dates back to more than one million years ago. The ancient man was completely dependent on nature for survival. He observed nature and devised simple ways to explain it. He made several attempts at experimenting on the basis of his observation.

a) Stone age

During the early Stone Age, man was completely dependent on what was available in nature. He experimented with resources for food, shelter and clothing. Simple tools of stone, the discovery of fire, clothes of animal skin are some of the discoveries he made using his knowledge of nature. He also formed simple social and religious institutions. Though writing was not known to him, the various cave paintings belonging to this period discovered all over the world show his inclination towards culture. These painting might have also been means of communication.

When man experimented with creating his own resources by manipulating nature, the New Stone Age began. This shows that by this time he had accumulated lots of knowledge of nature. In the absence of writing, this knowledge was communicated orally through generations. By understanding season cycle and use of water he invented agriculture around 9000 years ago. He
also domesticated animals. During this stage man’s relationship with nature changed. He became less dependent on nature.

b) Civilization stage

In around 3500 BC, man developed civilization. A new urban society in which agriculture was developed, writing was invented, trade and commerce flourished. Development of writing is one of the biggest milestones of human kind history. It enabled man to store knowledge. Early form of writing was in symbols. Several inscriptions from the Egyptian and Mesopotamian (ancient Iraq) civilizations give us knowledge about life during that period. Arts and science was developing during these civilizations.

The Sumerians of Iraq have contributed to modern science with their numerical data. For e. g. the number system based on 60 is basis for 360 degree circle. Astronomical periods identified by them are still widely used in lunar calendars. Babylonian astronomy was the first attempt at refined mathematical description of astronomical phenomena. Ancient Egypt made significant developments in astronomy, medicine and mathematics.

2 -Development of Science in the classical age:

The Classical age is a period spanning over 1000 years from the 8th century BC to around 6th Century AD. It is the age of cultural advancement of the Greek and Roman civilizations. Philosophers during this period developed such knowledge in science that became basic foundations for later scientific study. The art of Classical Greece began the trend towards a more naturalistic depiction of the world, thus reflecting a shift in philosophy from the abstract and supernatural to more immediate earthly concerns. Philosophers stopped merely ―suggesting‖ the human form and began ―describing‖ it with accuracy.

Thales (7th c BC) is considered as the Father of Science. He was the first to state that movement of earth and earthquake were geological phenomena and not works of gods. Pythagoras (6th C BC) founded school of mathematics, while Euclid (3rd C BC) devised axioms, theorems and proofs in mathematics. Mathematical devices of both are still considered basics foundations in geometry. Aristarchus (2nd C BC) was the first to propose a heliocentric model of
solar system, i.e. the sun was at the centre and the earth revolved around it. Eratosthenes calculated approximate accurate circumference of the earth.

Hippocrates, the father of Medicine, and his associates were the first to describe many diseases and medical conditions. Herophilos described the nervous system.

Leucippus and his student Democritus introduced the theory that all matter is made of indivisible units called atoms.

Plato and Aristotle gave philosophical explanations to natural phenomena. They also made important contributions to biological sciences. With the spread of the Greek empire, scientific knowledge also spread in Egypt. Greek became the primary language of Science. Schools of science were established in Alexandria in Egypt. Later German works were translated into Latin by Roman philosophers. Many scientists during this period were pioneers in their field. It was such path breaking knowledge that made this period—classical—for later generations.

3- Development of Science in the Middle Ages:

The period between the classical ages and European Renaissance is referred to as the Middle Ages. It marked both the decline of scientific advancement and also later its revival. The middle ages are studied in three parts; early, high and later. Early Middle ages (476-1000 AD)

Following the decline of Roman Empire, economic and cultural deterioration began in Europe. The knowledge of Greek declined, and scholars had limited original work to study from. By the early 5th century Christianity had spread in Europe on a large scale.

There was rise of monasticism. Surviving manuscripts of Roman classics were copied in monasteries. These served as sources for study to philosophers. However, very less original work was produced. By the 6th century monasteries became centers of teaching and learning. Bible became the centre of study; even if nature was studied it was for practical purposes for e.g. study of astronomy to calculate the day of Easter. It was not done for theoretical study.

Under the rule of Charlemagne in Italy, sciences were encouraged. He introduced several educational reforms and brought about Cultural Revolution. Due to the transformations he brought about, his rule is known as the period of Carolingian Renaissance. He set up new schools
throughout his empire. Some experts believe that the scientific study during Charlemagne’s rule was not original, but based on researches on ancient Roman texts. Because of lack of original scientific contribution and also loss of several ancient works, this period is called the Dark Ages. During the dark ages many arts were lost and science suffered major decline.

High Middle Ages (1000-1300 A.D.)

From the 11th century onwards, innovation again got impetus. There were new scientific discoveries. The European scholars during this period were influenced not only by classic Greek works but also by Arabic texts. They translated these ancient classics into Latin and started improving the knowledge base. Inventions such as the windmills and magnetic compass advanced agriculture and trade. The introduction of papermaking by the Chinese transformed the way knowledge was stored and circulated.

During this period many new universities were established. This gave institutional support and encouragement to scientific studies. Eminent scholars like Albertus Magnus, Roger Bacon researched old theories of empiricism and developed it to a new level. They proposed the study of nature based on reason and logic.

The period witnessed the development of new form of art. The Gothic style of architecture was introduced and used on a large scale for churches.

Late middle ages (1300-1450 A.D.)

The most important development during this period was the separation of science from theology and philosophy. Scientific works of the Byzantine and Islamic empire influenced the Europeans during this period. Science was no more joined with religious understanding. The most lasting and strong foundation theories were given by William Occam (14th century). Today it is known as Occam’s razor. Its simple explanation means “when you have two competing theories that make exactly the same predictions, the simpler one is the better”. It was later on utilized by Newton and Einstein.
Thus the middle ages were not dark throughout. There were several scientific advances. However by the end of the 15th century, Europe was affected by the Black Plague. It not only led to huge loss of population but also a setback to the interest in science. During this period science was largely associated with religion.

4- Development in the Renaissance (1450-1650)

The modern period in European history was ushered in the 15th century by the Renaissance. The term renaissance means rebirth in Italian. It was a cultural movement that brought new thought and discoveries. After the rise of the Ottoman Empire in the mid 15th century, scholars from Turkey moved to Europe with ancient and medieval classics. The rediscovery of classics by the Europeans led to the reintroduction of reason and emphasis on human emotions and ideas. The invention of printing press by Johan Gutenberg in 1436, ideas spread rapidly. With its centre in Italy, Renaissance gradually spread towards north Europe by the 16th century.

The scholars and philosophers during this period rejected medieval idea of god being the central idea for nature and art. They developed new theories which rejected the classical theories.

Nicolas Copernicus developed a more detailed and accurate heliocentric theory of the planetary system. His explaining the revolution of earth and other heavenly bodies revolving around the sun was banned by the church, since it believed in the geocentric theory. He also made theoretical studies in mathematics.

Johan Kepler was a strong follower of Copernicus’s theory. He studied it and added the fact that planets revolve around the sun in ellipse and not complete circles. His contribution is the famous Three Laws of planetary motion.

Galileo Galilee was the man of true renaissance spirit. He was not only an astronomer, but also a physicist, mathematician and philosopher. His first scientific discovery was the law of pendulum. He later successfully developed several devices like magnet, compass, thermometer, microscope etc. His breakthrough discovery was however, the use of telescope for observation of space. He is known as the father of Modern physics as he developed the law of falling bodies.
Francis Bacon argued that truth required evidence from the real world. He devised the inductive method for study of nature. He stated that scientist’s should frame axioms or simple statement and prove them through the process of experimentation and analysis.

Apart from astronomy and mathematics, study of human anatomy was also developing very differently from the classics. While Andreas Vesalius laid the foundations of modern medicine and anatomical studies, William Harvey described blood circulation.

Leonardo da Vinci is known as the Renaissance man. He was a scientist, mathematician, philosopher, architect and painter. He wrote and drew on subjects including geology, anatomy, flight, gravity and optics, often flitting from subject to subject on a single page, and writing in left-handed mirror script. He made proto types of the bicycle, airplane, helicopter, and parachute. Renaissance was thus a period of new ideas and growth of scientific knowledge.

5- The Age of reason and enlightenment (1650-1800)

The new ideas of reason and independent understanding of nature were carried forward strongly in the late 17th century. Scholars emphasized the right of individuals to think and express themselves freely. During Renaissance the church opposed scientific theories of Copernicus and Galileo. Such opposition of church and domination of the monarchy was rejected during this period. This led to the scientific revolution.

The Age of Enlightenment succeeding the Age of Reason was the period of further scientific advancement. Reason was to be the basis of authority and belief. Science was looked as a study of nature with the aim of developing humanity and achieving advanced progress. Intellectuals or Philosophers based their arguments against any authority on the basis of logic. Thus in social and political field also there was rejection of tyranny and tradition.

John Locke is considered as the father of Classical Liberalism. Locke argued that human nature was changeable and that knowledge was gained through accumulated experience rather than by accessing some sort of outside truth. His thoughts greatly influenced political philosophy all over the world.
Issac Newton is considered the greatest figure of scientific revolution. He was a physicist, astronomer, mathematician and also a theologian. He gave the theory of gravitation. He made significant contributions to the fields of optics and mechanics.

Several universities and institutes of scientific studies were set up all over the world during the scientific age. This encouraged scientific research.

In the 19th century further advances were made in astronomy, new planets were discovered and phenomenon like dark stars and star creation were studied. Medicine progressed with better understanding of human body and diseases. Cure to several medicines started being discovered, the very earliest being the discovery of vaccination for small pox by Louis Pasteur. One of the milestones of scientific theories of the 19th century was Charles Darwin’s Theory of Evolution which described the evolution of life on earth and led to the foundation of modern biology.