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08141710097
SUMMARY OF GST105 WITH PAST QUESTIONS

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Module 1 Unit 1: The nature of science

The objectives below specify what you are expected to learn after going through this unit.

[...]

Outline the three ways of defining science. Identify carefully the areas of knowledge which qualify to be science.

Definitions of Science

The word 'science' is derived from the Latin word, 'scientia' which means 'Knowledge' . On the simplest level, science has been defined as the knowledge of the world of nature . The above definition however does not exhaust the full meaning of science. So it is difficult to define it.

Science as a body of knowledge

You will study about these differences in a subsequent section. Science as a method for acquiring knowledge Science has well-known procedures for obtaining knowledge. The two branches of science, which are empirical and formal sciences, use what is called the scientific method. Anybody that uses the scientific method or the method of formal sciences to obtain knowledge is said to be involved in science.

Science as an institution Science can be viewed as an institution which comprises millions of experts.

Fill in the blanks by choosing the correct word or phrase

List the three main ways in which science is viewed. In the last section you learnt the various meanings of the word 'science'. In this section, you will be exposed to the two ways of grouping scientific disciplines or bodies of knowledge. This will enable you to identify, any time, the areas kofn o wledge which qualify to be called science.

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These can be observed with the senses or measured with instruments because they are material things. For instance, we can see a cow walking on the road, perceive the odour of its droppings, touch its hairy body or taste its flesh . Thus, empirical scientists observe and experiment in order to find out how things originate, grow or develop, function and relate to each other. They also try to find out the laws which govern their behaviour.

They are interested in trhege u larities or laws, which enable them to understand or explain the objects or phenomena under study. The knowledge derived in empirical sciences includes inductive generalisations, laws and theories. You will study about these concepts in units 2 to 4. The concepts are formulated in clearly defined statements, propositions or in statistical equations or formulae.

Objects which cannot be perceived by the senses include values such as the goodness or badness of a thing, rightness, virtue, beauty, holiness and truth. It is not possible, and so the study of 'goodness' is outside empir ical science. The second way of grouping scientific disciplines is according to the class of objects or phenomena they deal with . These deal with living bodies such as human beings, animals, insects and plants.

These disciplines are concerned with drugs and drug contents of plants and other objects.

[...]

In spite of all these classifications of science, there is a point that is worth noting. The figure shows how the theme 'light and shadow' is viewed or studied by disciplines such as art, physics and botany.

Weather All of the above

Match the items in 'A' with those in 'B' by filling in the correct letter in the space provided. Right from the dawn of history, man has tried to understand himself and the nature tshuartr o unds him. He has seen the world around him, which evidently has remained the same world, and yet is full of change, motion and of variety. Such knowledge is usually summar ised using concepts, laws and theories.

These help us to express and systematise our understanding of objects apnhde n omena. Science also equips us with practical knowledge in terms of the various ways, mechanisms and instruments which enable us to control objects and phenomena. You may be able to identify areas of non-science if you have understood sections and 3.2. Consequently, knowledge based on them does not enable us to explain, predict and control phenomena in the way scientific knowledge can.

Science, on the other hand, is not dogmatic. It is based on reason and does not accept any idea or belief on faith. It does not accept anything as sacred and unquestionable. Science seeks knowledge that is objective, certain, systematic, provable and supported by evidence.

This is done through a systematic method of ionbqsueirrvya,t i on, formulation of hypothesis, experimentation, organised theory construction, etc. It further overcomes the limitations of the senses through the use of instruments, diagrams, equations and formal symbols . However, some have argued that science differs from non-science only in degree. It is pointed out, for example, that common sense has a certain scientific character. You will discover this when you study the next unit, which is unit 2.

In general, science is said to be objective, systematic, reliable, etc. Being objective means that all those who adopt the same method or procedure can prove or verify the claims or statements, which the body of scientific knowledge contains. Being systematic means that all the various elements in a body of skcnioewntliefidcg e are locally related and each can be inferred from the other. For instance, go to the library, and get hold of any science textbook. If you turn to the table of contents, you will observe that topics are arranged sequentially.

So you need to understand what the cell is before you can understand the structure of the kidney or the liver. Science being reliable means that it can enable us to adequately and correctly, explain, predict and control any phenomenon in question.

[...]

In this unit, you have learnt what the nature of science is. The definitions, branches, and aims of science were discussed. From these discussions you would now be able to tell which disciplines qualify to be sciences and what the overall purposes of sciences are.

Creative and critical thinking

In this unit, that method of acquiring scientific knowledge called the scientific method will be discussed in detail. The emphasis will be on how it works in real life and how it has worked in science. This Unit promises to be very exciting because you will learn the method of effective thinking. It will be of great value to you if you apply it to solving life problems.

Thus after studying this unit certain things will be required of you. They are listed in the objectives below.

[...]

Explain vividly with one example how the method can be used to solve a named life problem. Explain briefly with one example how the method can be used to solve a hypothetical scientific problem. Assess clearly the use of the steps of creative and critical thinking when given a hypothetical case story.

Scientific Method of Acquiring Knowledge

Although these facts are interesting – even fascinating – they are not the essence of science. Rather, the excitement of science lies in the intriguing observation and the carefully designed experiments that scientists have devised to help us learn about nature. The process is characterised by a sequence of steps, which enable scientists to approach objective truth as closely as possible .

Observation Knowledge comes from noticing resemblances and recurrences in the events that happen around us — Wilfred Trotter

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Direct observations are made with the aid of the senses just as our hypothetical student observed the maize grains with his eyes. Indirect observations are performed with the aid of instruments. Atomic nuclei and magnetism, for example, cannot be perceived directly through our sense organs, but their effects can be observed with instruments. What other things do you think can be observed indirectly?.

Spontaneous or passive observations which are unexpected

The thing noticed will only have meaning if the mind of the observer either consciously or unconsciously relates it to some relevant knowledge or past experience. It can also be important if the observer in the process of thinking over it arrives at some hypothesis. From our hypothetical example, the student noticed that the pale yellow colour of the leaves of the maize grains was different from the normal green colour of maize grains. He thus related what he observed with his previous knowledge.

This is the reason why a scientific observation must be repeatable. Science does not take any observation at face value. After an observation has been made, the second step of the scientific method is to define the problem.

Problem definition

In this step, questions are asked about the observation. If our hypothetical student in above shows further curiosity, he will decide to find out why those seedlings had pale yellow leaves instead of green. He asks himself, 'Why are the leaves pale yellow instead of green?' This is the kind of causal question that the scientific method deals with. Science is fundamentally about finding answers to questions.

It took a genius to ask, 'How come?, and few questions have ever contributed more to science as this. Good questioning, like good observing, is a high art.

Hypothesis formulation

One guesses what the answer to the question might be. Scientists call this assumed answer ah y pothesis. The main function of a hypothesis is to predict new experiments or new observations. Thus our hypothetical student in above will try to state all the possible explanations of his observation, or all the possible solutions to the problem he defined.

One possible explanation he might give is that the pale yellow colour referred to is the characteristic of the particular variety of maize that was germinating in the dark cupboard. Another explanation he might give is that the pale yellow colouration resulted from the exclusion of light. If experimentation shows that the first guess was wrong, tshceie n tist then must formulate a new hypothesis and once more test for validity by performing new experiments. Obviously, much faster progress would be made if the number of hypotheses were few.

The amount of previous knowledge or experience a scientist has enables him to achieve this. If

you may recall from section 3.4 of unit 1, it is while hypothesising that common sense, intuitions and lucky accidents help science enormously. The story has it that in one famous case, the German chemist, Kekulé went to bed one night after a fairly alcoholic party . In his sleep, he dreamt of six monkeys chasing one another in a circle, the tail of one held in the teeth of the other.

Practically, our whole chemical industry is based on that dream because it told the sleeping scientist what the structure of benzene was. Scientists at that time had been trying to figure out the structure of benzene. Kekulé then concluded that benzene has six carbon atoms 'chasing' one another in a circle, and that's exactly the present structure of benzene. And it is good to know that benzene is the fundamental parent substance for thousands cohf e mical products.

Since it is the function of every experiment to test the validity of a scientific guess, the fourth step of the scientific method is experimentation.

Experimentation

You might be aware by now that answers without evidence are really unsupported opinions. Experimentation can provide the necessary evidence and anyone who experiments after guessing at answers becomes truly 'scientific' in his approach. Let us examine the two hypotheses regarding the young man's observation of pale yellowing leaves of maize seedlings. The first hypothesis to explain the observation was that the yellowing was due to the variety of maize germinating.

A simple way to test that hypothesis is to collect various varieties of maize, put them in the dark cupboard and observe the results. All the varieties will be found to have produced the same pale yellow leaves. The other hypothesis, which states that the exclusion of light produced the pale yellow leaves effect, can also be easily tested. This is done by germinating a batch of seeds in the dark and another batch in a well-lit condition.

What do you think gives the green colour in plants?.

Conclusion

We shall again illustrate this step with our hypothetical example above. The test of the first hypothesis leads us to reject that hypothesis while our test of the second hypothesis leads us to accept the second hypothesis. Exclusion of light caused the yellowing of the leaves. Scientific conclusions can be redefined, modified and clarified when the situation arises.

Some other conclusions may even be overthrown and discarded. This will lead him to modify his original conclusion. He may add that 'other factors besides lack of light may cause yellowing of leaves'.

Theory formulation

This evidence must be obtainable in many different laboratories and by many independent

researchers. Theories are open to tests, revisions, and tentative acceptance or rejection. As soon as new information is observed in the course of applying the theory, such existing or established theory is revised. Thus, a new theory emerges to replace the existing one.

The figure below illustrates the process of the scientific method

There is something very important which you have to know concerning figure 1.2. In practice, you may go back to an earlier step or work on several steps simultaneously. But for you to be sure that your final conclusion is right, all steps must be completed.

When does a new theory emerge to replace an existing one?

We have just gone through the process of the scientific method. Let's suppose that you wake up one night with a skin rash . You want to know what caused this rash . You first try to figure out how this situation is similar to other known situations.

Perhaps a classmate of yours had a similar rash that was caused by an allergy to the grass at a close by football field. You realise that your rash has appeared after all the football games that you have played on that field. The similarity between your friend's allergy and your rash leads to the explanation that your rash is caused by an allergy to the grass, too. If your hypothesis is correct, you would not expect to get a rash from other kinds of grass .

Your results match the prediction of the grass–allergy hypothesis from which you decide that your rash is caused by the grass at a nearby football field . However, if this was your only hypothesis, you have not actually identified the cause. Perhaps your rash was caused by fertilizers, pesticides, bacteria, fungi or other agents associated with the grass or soil at one football field and not another. By testing a single hypothesis, you have not ruled out any of these other possibilities.

Either way, you make progress by testing several hypotheses, not just one. If you can reject all with the exception of the grass–allergy hypothesis, you can more confidently conclude that the grass caused your rash. You may agree with me that all of this seems like common sense, which it is. The use of the scientific method is not restricted to scientists.

For example in 1820 at New Jersey, U.S.A. a colonel named Robert Johnson used the scientific method to disprove the belief that tomatoes were poisonous . He bravely climbed the steps of a city courthouse and ate a basketful of tomatoes. This action greatly amazed the 2000 townspeople who thought that tomatoes were poisonous. His bold experiment and its result proved the townspeople wrong.

There is always something more to study, something new to learn. Tr y using the scientific method to solve a hypothetical life problem. You have seen in section 3.2 how the scientific method works in a real life situation. In this section, one example will be used to illustrate how a real scientist made an important discovery by using the method.

In the, it was reported that in certain parts of Great Britain and Western Australia there used to

occur a nervous disease of sheep known as ‘swayback’ . The cause of this disease baffled investigators for years . Bennetts for certain reasons suspected that the cause of the disease might be lead poisoning . This suggested to Bennetts that the cause of the disease might be defitchiee n cy of some mineral which was present in small quantities in the first batch of ammonium chloride .

Bennetts went ahead to find out the constituents of the ammonium chloride . He found out that ‘copper’ was present in the ammonium chloride in small amounts as an impurity. When afflicted sheep were given pure copper mineral they recovered from the disease. He then concluded that the disease was due to deficiency of copper .

A deficiency of copper was never previously known to produce disease in any animal. So by using the scientific method, Bennetts contributed to science the information that a deficiency of copper can cause disease in an animal. In the next section, creative and critical thinking will be discussed briefly.

We live in a complex but rapidly changing society, in which we have to make simple or difficult decisions every minute of our lives. Such decisions might be vital to both our own and other people’s health, success and happiness. How well the decisions turn out to be will depend in part on the procedures tohfi n king we use . The importance of the scientific method of thinking is richly illustrated by the history of science.

You will learn about this in units 5–8. Until tsheev e nteenth century, science progressed quite slowly. In the last three centuries, procedures of thinking, the scientific method which we have just discussed, evolved. Its use has been responsible to a large extent for the impressive success of modern science in discovering the secrets of the universe, as well as in developing solutions to technological problems.

Many of our most serious problems can be lessened or even solved by the application of these techniques. Progress in solving most human problems has lagged far behind progress in science. Most human problems cannot, of course, be taken to the laboratory to be worked on, and some aspects of the scientific method may not apply to these problems. However, a large body of evidence confirms that effective methods of thinking can be of great value in solving everyday human problems .

TChriintikcianlg , on the other hand is the testing and evaluation of these proposed solutions. In diagnosing an illness for example, a physician first develops possible diagnoses that seem to fit the symptoms. The final diagnoses cannot be right unless the possible diagnoses include the right one. If you have understood the scientific method discussed in section 3.1, you would agree that it is both creative and critical.

Outside the laboratory, however, both scientists and laypersons tend to be careless about both creative and critical aspects of thinking. When our feelings are aroused, we are likely to act first and think only after it is too late. This cycle should not be treated as a rigid procedure in which each phase must be completed before the next is begun. In practice, you may go back to an earlier phase or work on several phases at the same time.

But if you are to have any real assurance that your final decision is sound, all phases must be completed.

[...]

You should know that every phase of decision-making is strongly affected by the fact that each one of us sees both the world and ourselves from our own personal point of view. This can interfere with objectivity, which is ivmerpyo r tant to effective thinking. How effective our thinking is depends partly on how objective we are in viewing ourselves and the world without bias. However, absolute objectivity is impossible because we observe the world only through the lens of our own point of view.

You should keep in mind two essential things for objectivity. The second element in objectivity is to be open to your feelings. Exclude them when they are not relevant and include them when they are, and you must be able to discern the difference. It should now be clear to you that perfection in thinking cannot be attained.

Effectiveness is the important thing. Also a satisfactory solution to every problem is too much to expect. The person who expects to solve every problem and make the right decisions every time is unrealistic. Effective thinking, like laying a musical instrument, requires practice.

This is important both for understanding the techniques fully and for developing skill in applying them.

This unit has introduced you to the scientific method of acquiring knowledge. You must have also learnt how it can be applied to solve real life problems and scientific problems.

The steps of the scientific method are

It can be direct or indirect, spontaneous or induced. Scientific observation must be repeatable. This involves question asking about the observation made. Scientific questions must be relevant and testable.

It can be redefined, modified and clarified when the situation arises.

Evolution after Darwin

The material in this unit will explain to you in detail what a scientific theor y means and also list some of the basic scientific theories. Emphasis in this unit will be on the theories of evolution.

Identify three events that led to the revival of discussion on evolution

Explain concisely how other fields of inquiry have led to a better understanding of the mechanism of evolution.

What is a scientif ic theory?

As was stated in that unit, a scientific theory is an explanation about the cause or causes of a broad range of related phenomena . A theor y explains how things are related or their common properties. As the facts accumulate, organizing them into higher knowledge becomes imperative. This is because our minds require a rationalised, logically consistent body of knowledge to help retain and use information .

To help in the organisation, a working hypothesis is usually required. Thus, theories start as hypotheses or tentative formulations meant to explain the phenomenon under investigation. It says, 'given such and such conditions', any phenomena, which satisfy those conditions, are subject to the theory under reference. Let's take for instance that a new drug called 'Relief tablets' against bacterial disease 'X' is manuf actur ed in Nigeria .

Additionally, the experiment is carried out under specified hospital conditions with proper allowance for unspotted errors and with different doses of the drug. At the end of the experiment the drug might be found to have an effectiveness of 60% against the bacteria. If this result is confirmed by many independent researchers in different localities, a theory may be proposed. The theory might state that 'in bacterial disease X, «Relief tablets» are effective in 60 per cent of the cases'.

This statement is very much broader than the experiment on which it is based, and theories are always like that. You will learn about these in unit 4. Laws also do not pronounce certainties. In conclusion, theories enable us to explain, predict and control phenomena.

They also provide us with a new way of looking at a familiar object or phenomenon. The theory of optics, for instance, provides us with a new way of looking at the phenomenon of light . With the theory of optics, people's way of looking at light changed. Since the advent of modern science in the sixteenth and seventeenth centuries AD, many scientific theories have been proposed.

These include the theory of universal gravitation, the theory of evolution by natural selection, atomic theor y, genetic theory, relativity theory, quantum theory, etc. The theories of evolution will be discussed in the next section.

Test yourself with the following questions

It was only in 1862 that Louis Pasteur disproved, once and for all, the theory of spontaneous generation . The search for explanations has proved to be challenging. The idea of evolution was not originated by Darwin in the nineteenth century as some people think . Some ancient philosophers observed that organisms ranged from very simple to relatively complex ones.

Each group of organisms, according to them, was created by God. Modern individuals of each group trace their ancestry to the individual created by God. The Judeo–Christian culture also promoted such thinking. Most early scientists believed fully that each kind of organism with all of its individual adaptations was created by God.

They studied these organisms, their structures, and the relationships between them as a way of learning more about the creator. In the seventeenth century, for example, the English scientist–clergyman, John Ray clearly declared his belief that each kind of animal and plant had remained unchanged from the day it was created . All these views are collectively known as the doctrine of fixed species or creationism. It was never convincingly challenged before Darwin .

During Darwin's time, biology was dominated by natural theology. The natural theologians believed that the variations and adaptations of organisms proved that each species was fashioned by God for a particular purpose. Besides they believed that the earth was only a few thousand years old. For them, this was not long enough for significant evolutionary change.

Gradually, some discoveries led to the revival of discussions on evolution.

These include

The study of fossils which was begun in the eighteenth century by Georges Cuvier . Fossils as you might be aware are remains or body impressions of dead organisms that lived in the past. To him, these observations seemed to be boundaries for dramatic change in ancient environments. His attempt to explain these changes came to be known as catastrophism.

a French biologist named Georges-Louis Comte de

In 1795, a geologist, James Hutton argued that the earth was older than a few t housand years . This idea is known as gradualism. His explanation indicated that the earth was millions rather than thousands of years old. They were convinced of an ancient earthbut they found it difficult to explain the appearance and disappearance of species in the fossil record.

In 1809, the year Charles Darwin was born, Jean Baptiste de Lamarck proposed that all species, including human beings were descended from other species . He believed that life changed progressively from the simple to the more complex. He was the first naturalist to present a unified theory that attempted to explain the changes in organisms from one generation to the next. Lamarck's explanations were based on the theory of inheritance of acquired characteristics, which he propounded.

The theory states that 'changes acquired during an individual's life are brought about by environmental pressure and internal «desires» and that offspring inherit the desired changes' . These offspring in turn stretched their necks to reach higher leaves. Thus generations of animals desiring to reach higher leaves led to the modern giraffe. Using similar reasoning, he also proposed that the use and disuse of a feature governed the fate of that feature in successive generations .

[...]

Match the following individuals and ideas by filling in the correct letter in the space provided.

**Individuals Ideas——————————Judeo–Christians Gradualism——————————
Cuvier All mammals have common features——————————— Lamarck Catastrophism———————————— Buffon Doctrine of fixed species——————————— Hutton Inheritance of acquired traits**

In this section, you will learn about Darwin's ideas on evolution. His ideas have had a great impact on a wide array of human endeavours than any socthieenrt i f ic advancement of the past 150 years . His research work on evolution provided the first scientific explanation for the diversity of life. His explanation of how evolution works has attracted more controversy than most scientific ideas.

This is because it has affected not only science but also philosophy, religion and human attitudes. At the age of eight, his interest in observing the natural world was manifested. At ten, his interest shifted to the habits of insects and birds . At the university, he could not complete his study of medicine, because that was not his area of interest.

He later graduated from Cambridge University as a clergyman but was still interested in natural history. The aim was to gather more knowledge of nature to add to the store of human knowledge . The ship they boarded was called H.M.S. Beagle. While on the expedition, Darwin had chances to study many diverse forms of life on the islands where they stopped, near mountain ranges and along rivers.

He returned to England in 1836, after nearly five years at sea and he began a long life of study and contemplation.

[...]

Let's continue from where we stopped. First, while the coast of Argentina was being mapped, he repeatedly got off the ship for exploratory trips inland. On these trips, he made detailed field observations and collected fossils. He saw for the first time many unusual species, including an armadillo.

Glyptodonts were very large animals that closely resembled the living armadillos. This is shown in figure 1.3.

[...]

Nothing else in the world resembled either animal. Although nobody including Darwin had ever seen one species evolve into another, he later wondered whether armadillos were descendants of glyptodonts. Second, he had observed that populations of similar kinds of organisms that lived in different geographic regions often showed remarkable differences in some of their traits . Darwin again wondered how such modification could occur.

This statement struck Darwin and he thought about all the populations he had observed during his voyage.

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In what year was it published?

As we were discussing, Darwin got a clue of how modifications could occur from Thomas Malthus's 'Essay on the principles of population'.

He described the process of natural selection as follows Starr and Taggart

If there were struggles for existence within a population, then individuals that possess superior physical, behavioural or other attributes might have an edge in surviving and reproducing. Favoured individuals would pass on the useful traits to offspring, their offspring would do the sa me and so on. Gradually, descendants of the favoured individuals would make up most of the population, and less favoured individuals might have no descendants at all. Darwin published his work in 1859 and it caused an immediate sensation.

Many people were very disturbed because the theor y implied that humans probably evolved from apes, monkeys, etc, since all share similar characteristics. Surprisingly, in 1858, Darwin received an essay from a young English naturalist named Alfred Russel Wallace . Both of them had independently reached the same conclusion about evolution. However, Darwin was given the credit of propounding the theory because of the amount of evidence he marshalled out.

Thus, Darwin's theory of evolution is one of the main unifying themes of the biological sciences. The likeness could be anatomical or molecular. The fossil record that shows a sequence in the kinds of organisms that have lived on earth over billions of years. It did not explain the mechanism of heredity – that is the way desirable traits or characteristics were transmitted to offspring.

You will read about the solution to this problem in the next section. Two keen observers of nature who outlined the theory of evolution by natural selection were Cuvier and Lamarck. Natural selection may occur when there are heritable traits. You will learn about the contributions of the first three fields in this section.

Darwin before his death predicted that the fossil record should yield intermediate links between the great groups of organisms. Paleontologists confirmed this prediction two years after Darwin's book was published. In 1861, an early bird-reptile called archaeopteryx was discovered. It resembled reptiles and birds.

This is shown in figure 1.4. Like fossils of small two legged reptiles, it had teeth and a long bony tail. Like modern birds, its body was covered with feathers . The discovery of other fossils has shed light on the ways in which organisms have evolved from the simple to the complex over the course of this enormous time span.

The evolution of the major groups of vertebrates and their relationships to aonnoe th er have become reasonably well understood since their bones and teeth are often seen in the fossil record . In the early part of the tcwenetnutriyet,h Gregor Mendel's laws of inheritance were rediscovered. Scientists found that those laws accounted for the origin of new variations in organisms and how these variations were passed on from parents to their offspring. Biochemistry

is the science that examines the chemical processes and substances that occur in living things.

Its techniques are being used tuon d erstand evolution better . Samples of the same kind of protein are obtained from different organisms. Then biochemical tools are used to determine the sequences aomf i no acids in those protein samples. When tsheeqsuee n ces are compared for, let's say, 10 different species, their degree of relationship can be specified precisely.

The following information might interest you very much The Guardian

Natural selection is leading women to have the first child earlier in life. This tendency is partly inherited. As a result, evolution is leading to an increasing biological pressure on women to start families earlier than later.

In the study, Roman Catholic women are found to have a 20% higher

University educated women, on the other hand, had 35% lower fitness than those who left school early. The study, however, found that such cultural influences could not explain all reproductive differences between women. Genes were found to explain about 43% of the differences in age of first child within the female population. Their next step according to Dr Owens is to try to discover what these genes are.

Fields of inquiry which have contributed to a better understanding of the mechanism of evolution include:——————————————————————————— ——
——————————————————————————— and ————————

In this unit you have learnt what a scientific theory really means and its various characteristics. You have also been introduced to the various ideas on evolution before Darwin proposed his own theory. It is good to be aware that Darwin's theory of evolution by natural selection is one of the most comprehensive themes in biology. This is because it explains how life began and how idti v ersified into the organisms of today.

Events that led to the revival of discussions on evolution include

The study of fossils which showed that layers of sedimentary rocks held different kinds of fossils. Comte de Buffon's observation that all mammals he studied had common features. The proposition of de Lamarck's theory of inheritance of acquired characteristics.

Some of Darwin's pieces of evidence that evolution occurs include

Layers of sedimentary rock held different kinds of fossils and they appeared in chronological order. Populations of similar kinds of organisms that lived in different geographic regions often showed noticeable differences in some of their characteristics. Darwin got a clue as to how those modifications could occur from Thomas Malthus's 'Essay on the principles of population'.

[...]

‘Any population tends to outgrow its resources and its members must compete for what is available.

Law of gravitation

Think about when you wake up in the morning, you would first of all meet the dawn, that is when night is gradually giving way to daytime. Nighttime is always associated with some difficulties such as not seeing clearly the mater ial things of nature, while daytime gives us light which enables us to see things very well. When the earth turns its face towards the sun, that region of the earth will have daylight, when it turns its back, the region will have nighttime. And you know that this is a continuous event which man has observed right from ancient times.

This daily motion of the sun is simple to observe while the annual motions are far more difficult to observe. Both motions are also related to other important events that occur on earth such as the seasons. In Nigeria, there are both the dry seasons and the rainy seasons while in European and American countries, they have winter, spring, summer, and autumn. These seasons as you know occur regularly, one changing into the other.

Thus there are many regularities in nature which mankind has had to recognize for survival since human beings emerged as a species. These include births and deaths, storms and calms, the solid earth and the ever-restless seas, etc. The pattern and regularity of these changes can be expressed as rules or laws. These laws are called natural laws because they are derived from the natural properties of objects and phenomena. You can see that it’s going to be an interesting unit.

If you study it very well, it will help you to understand a lot of natural events. And whenever such events are being discussed you would not be a novice there.

[...]

The discussion in this section will help you. Some people believe that some regularities are figments of human imagination. They say that the human mind leaps to conclusions because it cannot tolerate disorder or chaos. That means that not all theories are laws and laws also do not pronounce certainties.

Our ability to predict events and apply the fundamental laws of the sciences depends on this law of uniformity. That is why J.S. Mill cited in Nwala defined laws of nature as ‘nothing but the uniformities, which exist among natural phenomena’.

[...]

In traditional thought, these laws are believed to have a spiritual and teleological character. That means that the scientist reasons through and tries to find the causes by means of some activity. We cannot cklnaoimw le dge of anything unless we are able to show why and how it occurs. This knowledge is expressed in terms of general rules or laws.

Scientific laws are objective, factual and can be expressed in quantifiable form. You know that

the steps include observation, problem definition, hypothesis formulation, experimentation, conclusion and, finally, an appropriate theory is formulated which embodies the law. The entire universe is said to show uniform patterns and to form a united system. This view is called the law of the uniformity of nature.

You will learn more about this in the next section.

Theories that have proved to be so universally valid and have such a high degree of probability are called ——————————

This natural sequence, regularity and pattern of behaviour of things is evidence that there is a causal order. Hence, men believe that every event has a cause, and that for anything that happens there must be a cause for it. It is said that like events behave alike and also have similar causes. Belief in the uniformity of nature enables us to explain, predict and reproduce these events, where we can .

Induction , according to some scientists, is based on the general law of the uniformity of nature. You will learn more about induction in a subsequent unit. Since there is orderand regularity in the occurrence of events, if we observe certain characteristics in a certain number of members of a class, we can assume or conclude that all members of that class must have the same characteristics. For example, if we know from observation that all the men we have come across are mortal , we then conclude that 'All men are mortal'.

This generalisation covers all men who have died, all those who are alive and all those who will be born in future. From the point of view of logic , the law of the uniformity of nature claims that nature is a system composed of many parts. Within this system, everything happens according to rule. The law assumes that the universe does not change and, therefore, the laws of the uniformity of nature governing its behaviour remains constant .

David Hume cited in Nwala has criticised our concept of causation. He attributes the use of the idea 'cause' to the habit of anticipating one event after another because they have been associated in the past. His view is that we cannot demonstrate the idea of causation. And also that the necessary thing which links two events that are often associated together may not be there.

What is there is the habit of seeing one following the other and thereby expecting that this will always be the case. For example, red and green lights may succeed each other without causing the other.

The law of gravitation

In section 3.3 you were introduced to the law of uniformity of nature, which is one of the natural laws. The next natural law you will learn is the law of gravitation. The law of gravitation first started as a theor y of universal gravitation. The theory was first postulated by Sir Isaac Newton an English mathematician and physicist.

He tried to explain the behaviour of falling objects. Before this theory, mysterious interpretations had been given as the reason why objects do fall downwards when suspended in space. The theory was the first scientific explanation of the behaviour of falling oNbejwectotsn. Since the earth has a centre of gravity, all objects in the universe are attracted towards this centre.

It was also noted that as objects move away from the earth, the gravitational force decreases, and their weight also decreases. It did this by explaining theoretically and empirically why objects behave the way they do. Albert Einstein's theory of relativity, which was formulated in 1905, explained the Newtonian theory properly by asserting that gravitation is a property of space. The presence of any physical substance within space causes it to curve in such a manner that a field of gravitational force is created .

Newton realized that gravitational attraction applies not only to bodies on the earth but is also responsible for holding the moon in its orbit round the sun.

Test your understanding of the two laws discussed here with the following

Other topics discussed here include the law of uniformity of nature and the law of universal gravitation.

Ancient Western science Science in the Roman period

In this unit you are going to learn how Western science originated in ancient times. If you can recall from unit 1, science can be defined in terms of the method of acquiring knowledge of nature. From the time of recorded history to the early sixteenth century AD, Western science progressed very slowly. It was the emergence of this method of science in the seventeenth centur y that enabled the science to achieve the impressive success it has achieved today.

This topic is important because it will help you to appreciate how logical thinking is of indispensable value to man. It is also important because it will expose the mistakes of the past and enable us to learn from them.

The histor y of Western science is going to be discussed in four phases namely

Rather, one period merged into the next. As was mentioned earlier, this unit will only treat the origin of science in the ancient times. The other phases will be discussed in subsequent units. The objectives below specify what you are expected to have learnt after studying this unit.

[...]

Discuss vividly how Thales of Miletus, Anaximander and Pythagoras explained the fundamental component of matter. It has been possible to infer what the content of science in these areas was from archaeological remains. There was nothing like a botanist, zoologist, an astronomer, etc. It was in Alexandrian Academy in Egypt that specialisations started. You will read about this subsequently.

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This is because the Greeks believed that whoever tried to study and understand nature was trying to be wise.

The kingdom of Egypt was divided into three religious centres, which were

These centres were administered by priest–scholars. They were called scholars because they were the intellectual class of the ancient Egyptians. Their power twreams e ndous and even the kings were subject to it . The schools were a kind of university where every known discipline was taught by the priests.

So they counted 12 moons or months and figured out when the Nile would rise again. Their accuracy in these predictions led to their invention of the lunar calendar.

They divided the year into 12 'moons' or 'months' of 30 days each and added a space of 5 days to each year, thus bringing each year to a total of

It contained arithmetical problems and solutions involving the use of fractions and decimals. They are said to have performed caesarean operations and removed cataracts from the eyes. Evidence for these is contained in the Edwin Papyrus, which was excavated. He was called 'the god of medicine' by the Greeks and he lived 2000 years before the Greek doctor, Hippocrates, who in modern times is called the father of medicine .

The Egyptians also invented writing called Hieroglyphics and paper on which they recorded their ideas and culture. The sciences of mathematics, astronomy and engineering also developed in Babylonia about 1800–1600 BC. The Babylonians believed that the heavens were the abode of their gods. They also believed that terrestrial disasters such as floods, insect attacks and storms were caused by these gods.

Thus, they studied heavenly events carefully in order to know when their gods were angry so as to pacify them. Out of these practices grew a descriptive astronomy that was the most sophisticated of the ancient world until the Greeks took it over and perfected it. The first accurate astronomical observation they recorded was the rising and setting of the planet Venus . The Babylonians also realised the importance of fixed units of physical measurement.

Mathematics thrived under these conditions. For instance, they needed to calculate the volume of dirt to be removed from canals and the provision necessary for work parties. You will agree that the Egyptians and the Babylonians were obsegrovoedr s of nature and they gave precise descriptions. What was missing was scientific explanations.

To them, all knowledge was attributed to the revelations of their gods. They believed that it was the function of religion and magic to understand nature but that man could describe it and use it.

The first physician of the ancient world was ——————————

The influence of colonial education has made it difficult for many to appreciate Africa's contribution to world civilisation.

[...]

Henry Breasted, we learn the fact that Egypt is said to have colonised Greece and dominated its culture. The ancient Greeks also acknowledge the Egyptian origins of their language, identity, science, philosophy, names of their gods, their rituals, etc. the fact that many of the leading Greek intellectuals lived and studied in Egypt.

Aristarchus, the great astronomer and 'Copernicus of

Archimedes, the great mathematician who laid the foundation for the science of mechanics. He founded the Archimedean screw for raising water and is attributed with the doctrine of levers. Eratosthenes, the librarian at Alexandria who was called 'the most learned man of antiquity'. He also advanced the knowledge of prime numbers.

It showed the paths in which the planets appear to move in the heavens, a detailed star catalogues and, extensive description of astronomical instruments.

[...]

These people were known as natural philosophers because they engaged themselves with the study of nature and the origin of the world. They were ten in number and they included, Thales of Miletus, A Phoenician who migrated to Miletus in Ionia, Anaximander, Pythagoras, Heraclitus, Democritus, etc, who were Ionian philosophers. These men are usually called early Greek philosophers by some historians while some others are consistent in noting their non-Greek origin. They studied in Egypt eolrs e where under the same curriculum.

After their studies, they went back to their respective countries to expand the teachings of the Egyptian Myster y System School . They were more concerned with the phenomenon of change. They observed that physical substances change into one another but their main concern was to find out the original stuff from which all tohriingginsa t ed and to which they return. They attempted to answer this question and named the 'world-stuff'.

Thales of Miletus

He is usually referred to as the father of Western philosophy. He taught that water was the source of all things in the universe. According to Aristotle, Thales got this idea from seeing that the nutriment of all things is moisture and that water is the origin of the nature of moist things.

Anaximander

He was quick to argue that water could not be the basic substance, because water is essentially wet and nothing can be its own contradiction. According to him, if Thales were correct, the opposite of wet could not exist in a substance and that would preclude all the dry things in the world. Therefore Thales was wrong . On his own part, he called the 'world-stuff ' the 'infinite

something'.

This expresses the idea that the original stuff had no beginning, was imperishable, inexhaustible and indestructible. He was also the first among the Greeks to represent the earth on a map, though the science of map making was known in Egypt and Babylonia. He spent 22 years in Egypt and received instruction in mathematics, physics, theology, music, philosophy and ethics from the priest–scholars of the Mystery System schools .

Heraclitus

He was the first Greek to advance the principle of change as a universal law. Change, he said is the only reality and that there is nothing permanent in the world.

Democritus

He was a disciple of Leucippus who is credited with the founding of the atomic theory or the doctrine of matter. He became the ablest and bestknown interpreter of the atomic theory . He proposed that matter is made up of atoms and they are infinite in number and too small to be perceived by the senses. He said that atoms differ in size, some bigger, some smaller and that there is empty space between them.

According to him, everything new is produced from a combination of atoms and that death or cessation takes place when atoms separate. So you can see that even the atomic theory was known in the ancient times. This effort of the Greeks to explain the basic components of matter is important in the histor y of scientific thought. This is because they tried to reason and to explain it in seemingly simpler terms.

The Socratics

They included Socrates, Plato and Aristotle. Plato studied in Egypt, but histor y is silent on whether Socrates and Aristotle also studied in Egypt.

Socrates

He was the teacher of Plato and was born in Athens. He was a moral teacher and sought truth by asking questions. He enriched science with the tools of universal definitions and inductive reasoning. You will learn about inductive reasoning in a subsequent unit.

Plato

He taught that it was more noble and dignified to seek answers by reasoning rather than by experiments. He loved mathematics and he formulated the idea of negative numbers. His Academy also produced philosopher–scientists such as Heracleides of Pontus . Heracleides suggested that the earth rotates on its own axis once in every 24 hours and that Mercury and Venus circle round the sun like satellites .

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He was the most accomplished of Plato's pupils.

Aristotle

He wrote books on almost all the areas of knowledge –
biology, botany, anatomy, physics, metaphysics, astronomy, mathematics, logic, economics, politics, law, psychology, etc. His influence on subsequent development of science and philosophy was enormous. In particular, his views on physics and astronomy controlled the view most men had of the universe for two thousand years. In the next section, you will learn about the contributions of Rome to science. In the meantime, answer the following questions to check your understanding of the topic so far.

Match the items in 'A' with those in 'B' by filling in the correct letter in the space provided:——————— Imhotep Wrote the book called 'Al magest'——————— Hypathia The first to dissect the human body——————— Euclid The first physician in the world——————— Herophilus The first woman philosopher——————— Archimedes Synthesised geometry as a science——————— Ptolemy Laid the foundation for the science of mechanics

The following are what they named. The Roman Empire, however, did not have much influence in the development of science. It was more interested in conquests and maintenance of power through political and military administration. The spirit of independent research was quite foreign to the Roman mind, so scientific innovation was interrupted for awhile .

However, some scientific works were produced during this period, but none of them was revolutionar y in nature. They were mainly a detailed explanation of scientific conceptions already developed in Alexandria or Greece. In this calendar, the length of the year is fixed at 365 days and at 366 days at every fourth year. The month of July is also named after Julius Caesar.

Additionally, Pope Gregory III made a slight innovation to the Julian calendar. He made the leap year occur in any year whose number is exactly divisible by 4. The revised calendar is called the Gregorian calendar. Medical education and health care The Romans of this period also established hospitals and paid physicians who worked there.

They also promoted public health, hygiene and sanitation.

Pliny's natural History

Pliny promoted the development of natural history. He wrote a book on natural history and the topics of discussion in it were on animals and plants, especially medicinal plants and their uses. The advances they made were more of a practical nature. This unit has introduced you to how science originated in Egypt aBnadb y lonia and how the sciences were advanced further in Greece and in the Roman Empire.

You have also been informed that Western philosophy and science owe their origins to Egypt. Science originated in Egypt and Babylonia . Babylonians developed the most descriptive

astronomy of the ancient world. They were the first to divide the day into hours, minutes and seconds and also divided the circle into 360 degrees.

Evidence can be found in the writings of ancient Greeks themselves such as Homer and Pythagoras, and from modern historians such as William Stace and James Henr y Breasted. Pre-socratics named the original stuff from which all things originated and to which they return.

Plato formulated the idea of negative numbers

Scientific innovation began to decline in the Roman Empire. The calendar invented by the Egyptians was modified further by Julius Caesar and Pope Gregory III.

[...]

Arkady, L. Tell Me Why, The Hamlyn Publishing Group Ltd, London.

Reference and further reading

Here, we shall learn about how tshcaiet n ce progressed in the Middle Ages of Europe. Middle Ages as we learnt in unit 5, is a period in European history between about 476 and 1400.

[...]

The period was dominated by Christian Theology and characterised by initial decline of science and its rise again much later .

The Renaissance

Development in learning, architecture, science and art slowed down or stopped altogether. Life also became unsafe as a result of the many wars among the petty kingdoms within the Empire. A kind of ‘darkness’ covered life in Europe. For this reason, the period from about AD 450 to 800 is sometimes called the ‘Dark Ages’.

It became a symbol of unity, such that the united Christian world was called ‘Christendom’. During the Dark Ages, the fathers of the church showed little interest in knowledge of nature for its own sake. They believed that holding discussion on the nature and position of the earth would not help them in their hope of life to come . Therefore, the desire and the power to study nature with an open mind gradually passed away.

From the Christian perspective knowledge of nature was valued only as a means of edification, or as an illustration of the passage of scripture. People soon lost the ability to criticise and believe anything particular ly if it was in accordance with the scriptures. EFxoarm ple, a dictum of Aristotle, says, ‘everything that moves is moved by something else’. Thomas Aquinas, one of the fathers of the church, used the statement as evidence that God must exist since he is an unmoved mover.

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These included the inventions of the rigid horse collar and the iron horse shoe. In addition, the monks in monasteries ensured that some amount of learning was kept alive. During that period, they translated ancient knowledge and works of the Egyptians, Babylonians and Greeks into Latin. They also kept alive some knowledge of the art of agriculture, since they were practical farmers.

While Europe was in the Dark Ages, Islamic learning started to flourish in the East. You may recall from unit 2 that critical thinking was defined as the testing and evaluation of proposed solutions to a problem. In unit 5 also, it was mentioned that 'critical tradition is fundamental to the advance of science'. You might be aware that some of the foreign-made goods don't function properly in Africa because of the weather, even though they help to solve some of our problems.

As we already mentioned in the foregoing, the Arabs criticised and innovated. They constructed great astronomical observatories, which they used in checking Ptolemaic predictions. The Arabs further made many improvements in medicine. In their hands, the primitive chemistry of the Greeks known as alchemy developed into modern chemistry.

Islamic thinkers were fascinated with numbers. This fascination thus served as the motivation for the creation of algebra and the study of algebraic functions . They also borrowed the idea of zero from the Hindu mathematicians and invented the Arabic numerals. Towards the end of the medieval period, it was widely recognised that the East held the secret of ancient wisdom in learning and science.

Europeans developed interest in Arabic language and commenced translations of books from Arabic to Latin. You can observe the influence of Arabic learning of this period from several basic scientific terms that have their origins in Arabic or Persian language .

[...]

By the close of 11th century, the decline of Arabic learning had set in, and from then, science was chiefly a European activity.

Science in the Renaissance Period

This period is the second half of the Middle Ages of Western Europe and it started from the 9th to 15th century. During this period, men began to be dissatisfied with a way of life, which made progress very slow. The learned men of this period saw that the ancient scholars had a lot to offer them. But they were not satisfied to learn simply what those before them had written or taught.

They tried to find out new things for themselves. You would observe that this attitude of renaissance men was different from that of the men of the Dark ages. Men of the Dark Ages were often satisfied with whatever they learnt, without any form of questioning. This spirit of questioning old beliefs and forming new opinions generally came to be described as the 'Renaissance', which means rebirth or revival of learning.

Both of them taught at the University of Paris. They were the first to accept the idea of a

distinction between knowledge of nature and revealed knowledge. But they also pointed out that God was the author of both. This rationalistic approach separating large segments of human knowledge from theology, prepared the way for a relatively independent development of science.

...

Some scientists of this period with experimental and practical bent of mind include the following

He determined the main direction of the physical science in the 13th and 14th centuries. He had knowledge of the workings of mirrors and of the nature of lenses . He was the first man in Europe, during the renaissance period, tahpaptr o ached in scientific spirit, the great Arabians who preceded him. This was because of his clear understanding that experimental methods alone give certainty in science.

He read all the authors he could reach. This included those of the Arabic and Greek authors. Instead of accepting the facts and inferences of natural knowledge from the scriptures, the fathers, the Arabians or Aristotle, he told the world that the only way to verify their statements was to observe and experiment. But in spite of his writing, he did not appear to have done much experimenting himself, except in optics.

In addition, for all his comparatively advanced outlook, ahcec e pted most of the medieval attitude of mind. This was with regards to the fact that the end of science and philosophy was to explain and adorn their queen – theology. He was an Italian and he could stand as the incarnation of the true spirit of scientific thought of the renaissance. Vespucci gave him a book on geometry.

[...]

They truly founded modern science. They emphasised observation, hypothesizing and experimentation, which are the core elements of the scientific method. In spite of the above statement, science at the Renaissance period was still a branch of philosophy. This is because renaissance men were still philosophers in spite of their advanced scientific outlook.

Africans, especially Nigerians of all works of life should cultivate the habit of using the scientific method of reasoning. It was the emergence of this method and its use that led to the advancement of countries of Western Europe and other advanced countries.

Where did it start and who started it?

Mention the two people who started the Renaissance in science. In this unit, we have discussed how Western science, which originated in the ancient times, progressed through the Dark Ages and Renaissance period. As you are now aware, the Dark Ages and Renaissance period constitute the two parts of the time called the Middle Ages of Europe. Within these periods, Western science was still tr ying not only to find its feet, but also to free itself from the clutches of philosophy and religion.

The next unit will focus on how science finally found its feet.

The main points in this unit are as follows

In the Dark Ages, knowledge of nature was valued only as a means of edification or as an illustration of the passages of scripture. In that period also, people lost the ability to criticise and believed anything that was in accordance with the scriptures. Thus, science and earning declined rapidly. In that same period, the monks in monasteries translated ancient works into Latin and thus kept alive some amount of learning.

While Europe was in the Dark Ages, Islamic learning started to flourish. They treasured ancient science. The Arabs did not stop with assimilation. They also criticised and innovated.

They also borrowed the idea of zero from the Hindu mathematicians and

The Renaissance period was characterised by an increasing desire for knowledge such that critical power resurfaced. They also pointed out that God was the author of both. This attitude of theirs prepared the way for a relatively independent development of science.

[...]

During the Dark Ages of Western Europe, the desire and the power to study nature with an open mind gradually passed away.

Scientific revolution The classic ages of science

The last unit described the state of science in the Middle Ages of Europe. This unit will introduce you to how that science finally became independent.

The scientific revolution

The first great change in scientific outlook after the renaissance was made by a polish mathematician and an astronomer called Nicolaus Copernicus . You will recall that in unit 5 of module 1, we came across a man called Ptolemy of Alexandria. He wrote a book called Al Magest. In that book, he showed how the heavenly bodies such as the moon, the stars, the sun and all the planets move.

According to him, the earth is located at the centre of the universe, and all other heavenly bodies move round it in circles. This view of his, can be called the Ptolemaic system or Geocentric system or Geocentric Theory.

[...]

Ptolemaic system was the view which people of that time had of tmhoe v ement of heavenly

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bodies, until Copernicus came along and challenged it. To Copernicus, the sun is at the centre of the universe while the earth and other heavenly bodies move round it in a uniform, circular motion. This view is known as Copernican world system or Heliocentric theory . So he set out to justify it observationally and mathematically.

As a result, he had a lot of conflicts with the church authorities. Galileo , an Italian, provided a most beautiful evidence, to justify that ancient authorities should no longer be accepted without criticisms. This is because he combined experimental and inductive methods with mathematical deductions to obtain his results.

You will recall that it was said in unit 2 of module I, that whosoever

With the aid of this telescope, he saw countless stars, whose existence no one had suspected. At the same time Galileo was searching the heavens with his telescope, in Germany, Johannes Kepler was searching them with his mind . He was the first to apply mathematics as an empirical instrument in searching for the laws of heavenly motions. The year 1660 seems to be the most important time in early development of modern science.

It was in that year that Isaac Newton achieved one of the greatest successes of all times. In other words, through his work, he confirmed the results of Copernicus, Kepler and Galileo. Thus all the results formed the first great synthesis of physical knowledge, which is the primary aim of science. The accuracy of Newton's theory or law proved to be amazing.

With the help of this theory, generations of astronomers have been able to explain and predict astronomical events. As we mentioned in unit 2 of module I, 'every good theory has a predictive value'. At the time of the scientific revolution, scientific advances were restricted largely to physics, Astronomy and Chemistry .

The classic ages of science

The person that can be called the 'Newton of Chemistry' was a man named Antoine Laurent L avoisier . He discovered that it was a gas, which he named oxygen that enables combustion and respiration to take place . As you might be aware, people of nowadays now take it for granted that we need 'air' in order to breathe well. They were not able to explain why burning takes place in certain situations and not others.

So you can appreciate the beauty of discoveries and inventions. This involves paying particular attention to the weight of the ingredients involved in chemical reactions and of the products that result. His discovery became known as the law of the conservation of mass . The 19th century has been regarded as the beginning of the scientific age because of many reasons.

There was very rapid growth of knowledge of nature during the period. Again, within this century, people started carrying out scientific investigations, with the sole objective of gaining more knowledge. It was understood that such investigators were moved by their insatiable curiosity concerning the unknown. Clerk Maxwell, a British Physicist conducted research to determine the relationship between heat and other forms of energy.

He expressed his findings in mathematical formulas to design cars and even rocket engine that use fuel more efficiently. Thus within this period, scientific research and industrial development went hand in hand. This was unlike in former ages when the need to solve a problem led to inventions unless those inventions were produced by accident. You may have observed that the study of living things had lagged far behind chemistry and physics.

This was because people at that time believed that organisms were too complex for them to study. However, in the 19th century, researchers interest shifted from astronomy to geology and from physics to biology. The understanding that atoms and molecules are the basic building blocks of matter. If it does, it means you have been understanding the materials presented for the previous units.

In module I, unit 5, we learnt that, the early Greeks tried to find out what matter was made of. Various answers were given such as water, divine fire and atoms. It was Democritus that mentioned atoms. It was only in the 19th century that John Dalton confirmed that Democritus was right.

Let's use water to illustrate. It is now known that water can be produced by combining hydrogen atoms and oxygen atoms. The understanding that cells are the basic building blocks of living things. Although in 1665, R obert Hooke used his primitive microscope to observe that plant materials have a cellular structure .

Living things are built with cells. In human beings also, the cells which aid reproduction are called gametes. The gametes from fathers are called sperms, while those from mothers are called eggs or ova. The combination of the sperm of a man and the egg from his wife brings pregnancy, which ultimately results in bringing baby or babies into the world after nine months of pregnancy.

This is what happens in all living things – whether plants or animals. That is why it is said that 'cells are the building blocks of living things'. 4 The statement that 'cells are the building blocks of living things' is called the cell theory. In unit 2 of module 1, it was defined as an phenomena.

Scientists observed from experiments that all living things were composed of cells. In this unit, you have learnt how there was a complete revolution isnc ie ntific outlook from the late 15th century onwards. Experimental science became independent of philosophy and religion. You have also learnt that the 18th and 19th centuries are called the classic ages of science because of the explosion in knowledge of nature that occurred at that time.

The first great change in scientific outlook was made by Nicolaus Copernicus . He disproved the Ptolemaic system or Geocentric theor y, which stated that 'the earth was the centre of the universe and all other heavenly bodies move round it in circles'. To Copernicus, the sun was the centre of the universe while the earth and other heavenly bodies move round it, in a uniform circular motion. This view is called the Copernican world system or Heliocentric theory.

Copernicus got into trouble with the church authorities who believed the Geocentric theory. But

it did not make him give up his theory. 4 The next person that brought this change in scientific outlook was Galileo . While Copernicus obtained his result by using simple observations and mathematics, Galileo added experiments to those two.

He invented a scientific instrument of observation called the telescope. This instrument enabled him to extend his sense of sight and he saw clearly that the sun was at the centre of the universe. Johannes Kepler discovered the laws that govern movements of the heavenly bodies. He was the first person to apply mathematics as an empirical instrument to discover these laws.

However, in spite of their results, Galileo and Kepler could not answer why objects do not fly off the earth, considering their submissions that the earth revolves or moves round the sun. Another question they couldn't answer was how it was possible for the earth, which was suspended in empty space to go round the sun without anything pushing it.

It was in the year 1660 that these questions were answered by Isaac Newton 1642 –

Francis Bacon was the first person who attempted to arrange the steps of the scientific method in a logical manner. An explosion in growth of knowledge of nature occurred at this time, especially in the 19th century.

Why is the 19th century regarded as the beginning of the scientific age?

In unit 2, we discussed how Western science became independent of Philosophy and Religion, and thus progressed to an unprecedented degree. 20th century scientific revolution will be discussed in this unit. It is in this century that science reached its zenith.

Here, you will read about the ingenuity of man – modern Homo sapiens – in using scientific knowledge to produce products that are both useful and harmful to him. After studying this unit, you are expected to have achieved the objectives listed below.

[...]

Since the end of the 19th century, great advances have been made in our knowledge of life and its manifestations. But the chief ideas by which those advances have been guided were formulated before 1901. Mathematics and Physics of the 20th century were characterised by a true revolution in thought. While 20th century biology still followed the main lines laid down before the century began .

Sir Francis Bacon expressed his belief that with the increase in knowledge of nature, man would soon be a master to nature. You will read about this in the next section. Some discoveries in physics, which really led to a true revolution are worthy considering here. In December 1895, the German Physicist, Wilhelm Röntgen discovered the xrays.

The discover y of x-rays and radioactivity revealed to the physicists that the structure of the atom was not as simple as they thought . If you are sitting in a moving train and look out through the

window, you will see things moving by quickly. The second basic part of his theory said that the only absolute unchanging quantity in the universe was the speed of light . Because of this theory, the very foundations of physics threatened to crumble.

In spite of all these, it may interest you to know that science in the 20th century worked wonders. The new physics – relativity, quantum mechanics, particle physics – may insult our common sense but it enables physicists to examine closely the minutest part of matter . This led to their production of many new compounds. They also developed a variety of plastics, synthetic fibres such as nylon and polyesters and synthetic rubber.

It is good for you to know that all the plastic cups, plates basins, slippers etc which were use in our homes, were aplrlo d uced by using the new information about atoms. Polyester nylon stockings, shirts and dresses are practical things made from the new information about atoms. The chemists also developed drugs, food preservatives and synthetic chemicals for use in agriculture. It may also interest you to know that astronomy and cosmology have been transformed almost beyond recognition.

This is because of the invention of new instruments like radio telescopes, orbiting laboratories, a lunar and planetary probe. In 1969, men walked on the moon and unmanned landings have been made on the planets – Mars and Venus, in the 1970s.

Albert Einstein formulated ———————————— theory in the year————————————

This means that many disciplines are involved in any biotechnological activity. They include microbiology, biochemistry, genetics, plant and animal biology, chemical and process engineering. The aim of using these techniques is to increase the production of goods and services for the benefit of mankind.

[...]

Our emphasis in this section will be on genetic engineering. All these products have already been made by genetic engineering. Does this remind you of anything? You would recall that in unit 3 of module 1, we discussed Darwin's theory of evolution by natural selection. Darwin was worried that his theor y could not explain how favourable characteristics are passed on to the offspring from the parents.

You might want to know the exact function of a gene. Genes are responsible for all the characteristics of living things. This means that there are genes responsible for the colour of the skin, the shape of the nose, height, flower colour in plants and so on. So when it is said that genes are the basic units of heredity, it means that the genes for different character istics are what are transferred from parents to offspring.

If I tell you that I resemble my mother in height and if my mother is tall, it means that my mother transferred her gene for tallness to me through her gamete called the egg or ova. The male gamete in the father is called sperm. Every human being is built up through the fusion of a sperm

and an egg. Whatever characteristics parents pass on to their children are contained in the genes found in both the sperm and the eggs.

Find a chicken that lays big eggs, collect the gene responsible for those big eggs and transfer them into your own chicken. Your chicken will start laying big eggs. An interesting fact here is that no matter where you put a gene, it will still perform that function assigned to it. Genetic engineering was born in the 1980's.

Since then, the technique has been applied in pharmacy, medicine, agriculture, industry, etc. In the examples that began this section, the potato plant has bacterial genes that make polymers, which can be used to make biodegradable plastics. In other words, there are some bacteria that are difficult to grow but they make small amounts of polymers . We were discussing the application of genetic engineering technique to solving practical human problems.

[...]

In traditional agriculture, weeding of the farm is done at intervals, and it is a tiresome activity. The disadvantage is that some times both the plant you are trying to protect and the weeds destroyed. So herbicides can now be sprayed on fields harbouring such crops without any fears. Through genetic engineering, the gene responsible for producing that toxin was extracted from the bacterium.

This resulted in the production of the toxin by the plants. Thus, whenever any insect larvae eat, for instance, the leaves of any of the plants, the digestive process of the insect is interrupted and the insect dies . There are other applications of genetic engineering. An example is in human cloning.

This means producing offspring that are genetically identical to the individual from whom a cell nucleus has been obtained. There are various reasons people give for wanting to do this. The cell is manipulated in certain ways in the laboratory. After some time, an embryo will start developing from that cell.

The embryo is transferred back into, let's say 'Mr John's wife'. After nine months, another 'Mr John', but now in a baby form of him will be born. This is because the adult Mr John and the baby Mr John will have the same genes in their bodies. It is important that you take note of one fact in this process.

The new baby originated from a body cell of Mr John and not from the fusion of the sperm from Mr John and the egg from his wife. Presently, there are laws, in the United Kingdom and some other countries, against human cloning. Bills have been passed in the US congress to protect the cloning of humans. Match the items in 'A' with those in 'B' by filling in the blank space provided.

Imagine how people who lived before that century coped without this fastest means of transportation. It was in 1903, that two American bicycle makers called Orville and Wilbur Wright built the first petrol-engine aeroplane . It became the first aeroplane not only to lift a

person into the air, but also to fly successfully. Since some other people before these Wright brothers had tried to build a flight machine but they were not successful, the two brothers got the credit for building the first aeroplane.

Aeroplanes with jet engines were built during the late 1930's by German engineers. The first supersonic passenger airliner, called the Concorde, began flight services between Europe and the United States in 1976. These are called supersonic jets because they travel at about 2,400kph, which means that they exceed the speed of sound. Normal aeroplanes, on the other hand, travel at 800 to 1000 kilometre per hour.

Although men of the previous centuries studied the planets and other heavenly bodies from the earth with the aid of instruments, it is the men of the 20th century that actually decided to go to some of those planets and heavenly bodies to see what they looked like. Gagarin was the first person to be in space. He was called the Columbus of the interplanetary age. The first American in space is called Allan Shepard.

These days, men and women enter the space and return to earth like any normal journey. It will not be out of place to also call the 20th century the age of communication. The traditional electronic means of communication such as the fax, the telephone, the radio, and television are now commonplace devices, despite the improvements made in some of them. For instance, cellular telephones were introduced in 1979.

They have made it possible for people to communicate without the restriction of telephone lines and geographical locations. It is one of the additional developments of the 20th centur y that made it possible to use single telephone lines for several simultaneous transmissions. This line, for example, may transmit cable TV broadcasts and phone calls simultaneously. The single telephone line can also serve as a picture phone or video conferencing device .

It was first introduced in 1964. The first communication satellite called Echo I, was launched by the United States in 1960. They can relay several television programmes or many thousands of telephone calls at once. Thus, if you install the necessary equipments, you can turn your TV on and watch programmes from any TV station of your choice.

You can watch programmes from BBC, CNN, Hallmark, etc, by just sitting in your house. The TV stations are changed with the aid of a remote control. There is hardly any sector of human endeavour that is unaffected by computer technology –
homes, schools, universities, military, police, banks, medicine, agriculture, etc. Indeed, the computer revolution is total and has completely replaced the industrial revolution of the last 150 years or so . The first electronic digital computer was built in.

[...]

When someone talks about being 'on' the Internet, it means that his/her computer is connected to one of the interconnected networks that make up the Internet .

[...]

Your email address provides all of the information required to get an electronic message to you from anywhere in the world. The first obvious advantage is speed. Instead of several days or even weeks, your message can reach the other side of the world in hours or even minutes. The other advantage is that you can use your e-mail address to access databases and file libraries.

By using this, one can copy a file from a computer in New York to one in South Africa at a very fast speed. In Nigeria, as you might be aware, oil companies, banks, tertiary institutions of learning, many government bodies, have acquired mainframe computers. Satellite dishes can be found in a number of homes, hotels, offices, etc for the reception of broadcasts from foreign states. NITEL in conjunction with SIEMENS, the German contracting firm to NITEL is trying tdoi g italise many of the telephone exchanges in Nigeria.

Mobile telephone services have been established in major cities in the country. You can see that some building blocks that will enable Nigeria join the information super highway are already in place. The nuclear weapons of destruction such as the atomic, hydrogen and neutron bombs have been stockpiled by both developed and developing nations. Nuclear weapons are real, and could put the human race out of existence within a twinkle of an eye.our own.

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GST105 List of Questions

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Q1 There are ___ chromosones within the nucleus of a productive cell

- 20
- 39
- 46
- 40

Q2 All living beings are said to compose of ___

- nose
- cells
- legs
- DNA

Q3 ___ distinguishes him from other living things

- Capacty create
- Ability to stand on two legs
- ability to breathe

- ability to walk

Q4 The first known hominids were the ___

- Brirtish gorrillas
- Southern apes
- African Cicygus
- Asian blaba

Q5 The use of language first evolved among ___

- homo habilis
- homo erectus
- homo sapiens
- homo incredata

Q6 The evolutionists believe that man evolved directly from ___

- woman
- apes
- God
- fishes

Q7 Current evolutionists put forward the belief that man and primates originated from ____

- Europe
- Australia
- Africa
- Asia Minor

Q8 Scientists who try to prove the theory of evolution rely heavily on ___

- fossils
- gene mutation
- DNA
- Racial variation

Q9 The belief that God created the universe is called ___

- miracle
- divine intervention

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- genesis
- creationism

Q10 ___ type of logic is also regarded as Baconian logic

- deductive
- syllogism
- inductive
- categorical imperative

Q11 Branches of philosophy do not include ___

- ethics
- metaphysics
- logic
- science

Q12 The beleief in a existence of external reality independent of our belief or knowledge of it is called ___

- universality
- systematic
- relativity
- objectivity

Q13 Whch of these is not a characteristic of scientific knowledge?

- universality
- systematic
- relativity
- objectivity

Q14 ___ is not among the similarities between science and philosophy

- both are critical
- both employ empirical method of investigation
- both are in search of systematic knowledge
- both exhibit curiousity to know

Q15 Which of these is not among the commitment of British Society for Social Responsibility in Science?

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- make scientists aware of social significance of science
- make them aware of their social responsibility
- make them aware of the need to bridge scince gap among countries
- help create an informed public that can exercise a choice in scientific matters

Q16 Scientists and Engineers for Social and Political Action was formed in __

- 1969
- 1949
- 1959
- 1979

Q17 Technological progress is not responsible for ___

- increase in population
- purification of air
- water polution
- povert

Q18 We owe the discovery of electricity to ___

- Faraday
- Newton
- Bacon
- Copernicus

Q19 ___ is not method of technology acquisition

- poached technology
- technology transfer
- adaptation technology
- apprenticed technology

Q20 The discovery of ___ is the most important discovery of stone age

- stone
- fire
- cloth
- numbers

Q21 Man's technical progress is governed by __ and ___

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- demand and supply
- science and technology
- trade and industry
- discovery and invention

Q22 ___ drives scientific inventions

- wealth
- patent
- copyright
- curiousity

Q23 The advantage of email over regular mail is ___

- speed
- international reach
- legibility of message
- computer literacy

Q24 ___ was the first person to fly into the space

- Albert Einstein
- Yuri Gagarin
- Joseph Shevchenko
- Abraham Alimatheia

Q25 The aeroplane is an example of invention of the __ century

- 20th
- 30th
- 21st
- 19th

Q26 Genetic engineering emerged in the ___

- 1970s
- 1980s
- 1990s
- 1960s

Q27 The basic unit of heredity is called ___

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- family tree
- chromosones
- gene
- embryo

Q28 The first man to walk on the moon with his partner was ___

- Armstrong
- Einstein
- Neibur
- Gagalin

Q29 ___ was the number of scientists able to understand the relativity theory of Albert Einstein

- 10
- 5
- 12
- 7

Q30 Wilhelm Röntgen discovered the ___

- bomb
- xrays
- cells
- photography

Q31 ___ confirmed that atoms and molecules were the building blocs of matter

- Newton
- Gabriel
- Dalton
- Da Vinci

Q32 We credit the invention of telescope to ___

- Ptolemy
- Albert the Great
- Galileo
- Copernicus

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Q33 The idea that the sun is the centre of the universe was first held by ___

- Ptolemy
- Albert the Great
- Galileo
- Copernicus

Q34 The author of "Al Magest" is ___

- Aquinas
- Euclid
- Anselm
- Ptolemy

Q35 Leonardo da Vinci held that true knowledge must begin with ___

- God
- ancient positions
- observation
- speculation

Q36 Renaissance means___

- rebirth
- protestant
- discovery
- imagination

Q37 The ___ were responsible for te development of primitive alchemy into modern Chemistry

- Greeks
- Arabs
- Romans
- Africans

Q38 The dark age of history was marked by ____

- halt in the advancement of knowledge
- cannibalism
- idolatry
- primitive colonialism

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Q39 The fixing of leap year to any year whose number is exactly divisible by four is attributed to ___

- Karl Marx
- Hegelianism
- Julius Caeser
- Pope Gregory III

Q40 Greek science was more __ and ___

- secular and atheistic
- speculative and theoretical
- experimental and practical
- observational and practical

Q41 __ is regarded as the most accomplished of Plato's pupils

- Socrates
- Anaximenes
- Aristotle
- Pericle

Q42 __ formulated the idea of negative numbers

- Socrates
- Aristotle
- Plato
- Engel

Q43 The practice of definition in scientific discourse is owed to ___

- Socrates
- Aristotle
- Plato
- Engel

Q44 According to Democritus, separation of atoms leads to __

- growth
- death
- suffering

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- diseases

Q45 ___ first advanced the principle of change as a universal law

- Heraclitus
- Pythagoras
- Aristotle
- Euclid

Q46 __ believed that the universe is composed of numbers

- Heraclitus
- Pythagoras
- Aristotle
- Euclid

Q47 Thales regrded __ as the source of all things

- gods
- science
- religion and atheism
- water

Q48 The world's first woman philosopher is ___

- Hypathia
- Victoria
- Euclid
- Hannah Arendt

Q49 God of medicine is the name given by the Greeks to ___

- Ptah-Hotep
- Hippocrates
- Ipuwar
- Imhotep

Q50 Ptah-Hotep is reputed the world's first ___

- scientist
- musician
- philosopher

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- physician

Q51 The Egyptians and the Babylonians regrded all knowledge as __

- fruit of study
- product of consistency and hard work
- revelation from the gods
- workable solutions to human problems

Q52 The Babylonians divided the circle into___ degrees

- 360
- 180
- 90
- 45

Q53 The two great rivers of the ancient Babylonians were __ and __

- Tigris and Nile
- Missisipi and Euphrates
- Nile and Niger
- Tigris and Euphrates

Q54 In Babylonian system of measurement one cubit consisted of ___

- 50 fingers
- 40 fingers
- 30 fingers
- 20 fingers

Q55 The Babylonians engaged in astronomy in order to ___

- control natural forces
- subdue the earth
- pacify the gods
- have bountiful harvests

Q56 The greatest physician of the ancient time is an Egyptian known as ___

- Imhotep
- Lycugus
- Midas

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- Hipocrates

Q57 Astronomy has its origin in ___

- Greece
- Egypt
- Babylon
- Mesopotamia

Q58 ___ is not among the religious centres of ancient kingdom of Egypt

- Miletus
- Memphis
- Thebes
- Heliopolis

Q59 Love of wisdom is etymological meaning of ___

- education
- history
- science
- philosophy

Q60 Philos, the Greek word that is a component of the term philosophy means ___

- knowledge
- love
- wisdom
- prudence

Q61 Science is said to have its origin in the __ age

- Paleonthic
- Communalistic
- Neolithic
- Greco-Roman

Q62 We trace the origin of science to __ and __

- Athenians and Romans
- Americans and British
- Russians and Ethiopians

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- Egyptians and Babylonians

Q63 The theory of relativity was formulated by ___

- Einstein
- Newton
- Marx
- Quinne

Q64 The theory of universal gravitation was intended to explain the phenomenon of ___

- steam engines
- falling objects
- industrial revolution
- magnetism

Q65 ___ does not capture the character of scientific explanation of realities

- meditation
- material
- causal
- rational

Q66 The view that developments occur because of the purpose or design they serve is known as ___

- divine plan
- teleology
- adaptism
- developmentalism

Q67 Theories that have proved to be so universally valid or true, that is, they are true anywhere in the world and have such a high degree of probability, are called ___

- general theories
- hypothesis
- natural laws
- universal theories

Q68 The science that examines the chemical processes and substances that occur in living things is called __

- Biochemistry

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- Biology
- Paleontology
- dialectical communism

Q69 The observation that any population tends to outgrow its resources and its members must compete for what is available was first made by ___

- Machiavelli
- Darwin
- Newton
- Malthus

Q70 The ship whose expedition to America that Charles Darwin was a member is known as ___

- G.D.P. Hope
- Q.V.T. Shakespeare
- H.M.S. Beagle
- M.V.T. Elizabeth

Q71 An explanation about the cause or causes of a broad range of related phenomena is known as ___

- observation
- conclusion
- theory
- problem definition

Q72 The second step in scientific method is known as __

- observation
- formulation of hypothesis
- conclusion
- definition of problem

Q73 When observations are unexpected we regard it as ___

- excellent
- passive
- active
- indirect

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Q74 Scientific observation can be __ and ___

- ancient and modern
- empirical and formal
- informal and physical
- direct and indirect

Q75 Characters of science does not include___

- objectivity
- systmatic
- speculative
- reliability

Q76 ___ is not anexample of empirical science

- mathematics
- physics
- biology
- chemistry

Q77 A branch of science whose contents, arguments and procedures obey certain rules is known as ___

- formal science
- deductive science
- inductive science
- empirical science

Q78 ___ cannot be attributed to formal science

- rules
- prophecy
- concepts
- theories

Q79 Science regarded as a body of knowledge does not include ___

- Chemistry
- Sophistry
- Biology

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- physics

Q80 The term, science, was derived from a Latin word, namely___

- scintilla
- sciencia
- sciensia
- scientia

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