UNIT 1 FUNDAMENTALS OF SCIENTIFIC RESEARCH

Contents

Learning Outcomes

After reading this unit, the student will learn to:

- Explain what science is and how it is distinguished from common sense;
- Describe the classical modes of understanding science; and
- Identify the transformations that have occurred with respect to the definition of science and its methods, in recent times.

1.0 INTRODUCTION

Before we enter into an understanding of what the nuances of research methods in anthropology entail, we need to begin at the beginning. This lesson therefore will deal with the basics of what research is and how does it justify itself as scientific.

We are all habituated to referring to anything we consider as true and logical, as being scientific. The word 'science' or scientific conjures up a feeling of respect and also of belief. When told something is backed by 'scientific' research, the usual reaction is that it must be true. This link between science and truth is however the product of a history, that of colonisation, since most of what we understand today as science and the scientific method is a particular form of knowledge that originated in the West, in specific North European countries that were at the same time the mother countries of the colonised south. The spread of so called scientific knowledge was a result of an imposed power hierarchy. Therefore, the belief that only western science was science and all other forms of knowledge were not also became widespread. If we accept that science is the pursuit of truth as well as a tool to solve the problems of human existence, then science began the day an earlyman or woman in the Pleistocene picked up a stone and used it as a tool. From the earliest times of their evolution as a human species, humans have been endowed with the capacity to both make and use tool, to modify their

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environment and to create things for their use. They have also been inquisitive about what was happening around them? They had questions and they sought answers to them. Thus the beginning of science as the pursuit of knowledge and its application towards fulfillment of human requirements is as old as human kind. What happened later was the systemisation of this knowledge and its classification into different classes depending upon the kind of questions that were to be answered and the area into which knowledge was applied. For example astronomy is one of the oldest of sciences. Ancient humans looked up at the sky to answer many questions regarding their environment and they learnt the science of reading stars and heavenly bodies to predict weather and to find directions and to navigate the seas. In this Unit, let us begin by discussing the difference between science and common sense.

1.1 SCIENCE AND COMMON SENSE

Although it is recognised that much of what we call science today, originated from commonsensical activities used to solve day to day problems. In fact many pre-literate societies, like for example the Australian Aborigines, had deep knowledge of say, aerodynamics that had enabled them to make a tool like the returning boomerang. But the difference between science and what we now understand as indigenous knowledge is that science goes beyond the achievement of a practical goal, to seek explanations for the phenomenon. The establishment of a causal relationship between the variables is to look for explanations of why things happen, and not stopping at making them happen. Thus science will try to explain how and why the boomerang returns, just as it will go beyond the use of a plant for medicinal purposes and try to establish the exact chemical component of the plant and its relation to the disease.

Science tries to systematise and organise knowledge so that by comparing and classifying a large number of processes and factual data it is able to deductively, that is through the power of reasoning as well as intuitive insight, establish regularities that at time become generalised principles or laws. For example, had the Australian Aborigines been aware of the actual principles of aerodynamics that informs the making of their boomerangs, they would have extended it to make other tools as well, and could have advanced to making aircrafts.

The value of systematisation and classification of knowledge as a part of the scientific endeavour has the effect of bringing together a large range of phenomena under one key explanatory framework; as for example the laws of gravitation can be used to explain a huge range of events and actions, from the falling of apples to the movement of planets.

Another significant difference between common sense and science is that the former is derived from experience and observation and thus works fine as long as the conditions of its application are the same; but they are not able to deal with changing circumstances and also how to diversify the range of application of their knowledge as they are not aware of the basic principle or causal relationship underlying a particular application.

Further, the language of common sense observations is not precise. For example people may say that if water is heated, it boils after some time, but they will not know the exact temperature at which it boils. In fact concepts such as exact

temperature and exact time are not known outside of the scientific terminology. When ordinary people talk about such matters they use a language of approximation, and science uses a language of being exact, even up to a very high degree of precision. Thus precision and exactness separates scientific language from commonsense.

Another aspect of science is its predictability, based on the knowledge of the exact causal relationship that causes a phenomenon; like science knows exactly how water can be made in the laboratory, but common sense knowledge, lacking the precise causative relationship may have to depend upon a hit and trial method.

Scientific observations are also of a more abstract nature and offered at a higher level of generalisations than common sense observations that are also directly related to human needs. Much of science in spite of their possible application to real life is carried out for purely esoteric reasons that are for the pure abstracted pursuit of knowledge. Thus those who were engrossed in discovering the structure of the atom, for example, were not thinking about making an atom bomb! Science has so far distanced itself from the consequences of the knowledge that it produces whereas common sense knowledge is grounded in human society and everyday lives.

Let us now examine what is meant by a scientific method and modes of explanation.

Check Your Progress

1) How does scientific thinking differ from commonsense?

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2) What are the most salient characters of scientific thought?

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1.2 THE SCIENTIFIC METHOD

The scientific method comprises of several types of explanations that is the various ways in which one arrives at the explanation or conclusion with respect to any phenomenon.

Deductive method is the most highly regarded and respected of all types of scientific methods. It involves a purely logical process of analysis and is most

applicable to mathematics and related subjects. In the social sciences it is usually associated with some degree of observation and contextual reference. But the deductive explanation must contain at least one premise of a universal truth. For example the deductive reasoning of the law of gravitational pull is supported by the universal premise that everything on earth will fall to the ground; if things were flying away and even if only one object flew instead of falling then one has to look for a sufficient reason for it to do so and a reason that is still explainable within the law of gravitation. If no reason is found then one has to abandon the basic premise and it ceases to be universal. It is possible and it is always possible to happen that some basic premises that were taken to be true have to be abandoned. Then the law built upon that premise has to be abandoned as well.

Racism for example was a deductive theory based upon the premise that human beings are graded into superior and inferior, but Darwin's theory proved that Homo Sapiens is one species and all members are identical, thus the Race theory was rejected as *a scientific theory* even though it may continue in a social form.

Deductive logic is attributed to Aristotle, who considered it a definitional aspect of scientific explanation. The deductive process is essential in the formulation of general laws that is the ultimate goal of science. Formulation of laws means that a large number of even apparently disparate phenomena can be explained with one generalised statement; like for example Newton's Laws of Motion. The ultimate goal of the scientific method is organisation and classification of phenomena in a way that it advances our understanding of what is happening. Therefore a large number of events can be explained with Newton's laws and more importantly there is explanation for those that cannot be explained.

The theories that are formulated with help of the scientific methods link two or more phenomena in a definitive way, like the Theory of Evolution that describes the descent of the species with modification. Basically the theory tells us that species undergo modifications in their progeny in very minute ways, or that a progeny is never identical to its parent and these minute changes accumulate over a very long period of time, in the scale of thousands of years to produce a modified version of the species. The important aspect of any theory is that it can never be proved directly. The very general nature of a theory makes it invisible or non-observable. No one can for example *see* evolution. But the existence of evolution can be demonstrated by illustrative cases and also by the universality of its application.

All laws are also based upon some associated premises, for example the biological law of evolution is based upon the universal premise of reproduction, that all creatures are offsprings of their parents. This is a universal or what is known as a law of nature. Such a law is not derived but is taken as a given condition. All deductive reasoning must contain at least one such universal or natural premise in its explanatory conditions.

Aristotle had also given what is known as the epistemic or cognitive aspect of an explanation. In other words what we know or perceive about an explanatory premise. An explanatory premise must be known to be true and in a scientific explanation the truth must also be demonstrable or knowable. But as pointed out by Nagel (1979: 43) if pursued too far, it may block scientific explanations that are often derived from intuition or hunches. "Were it adopted, few if any of the explanations given by modern science could be adopted as satisfactory". However

it is necessary that the explanatory premises should be at least commensurate with known or existing facts or should not be negated by known observations. For example the explanatory premise should not be based on a statement like "The storm was caused by a winged horse", for there is no evidence that such a horse exists or has even been seen anywhere.

Another kind of explanation that is weak is one that is known as a circular or tautological explanation. That is where the explanation contains the conditions of the explanation already; for example it is raining so the sky must be cloudy.

A satisfactory explanation however need not be based on what is widely known, like the sun rises every day, but may contain things that are not known or familiar to most people. Yet one goal of science is to make things intelligible to as many people as possible, like today most people know the explanation of rainfall through the water cycle and do not think rains are tears of a heavenly bird or any other such thing. The goal of science is thus to make the unknown known and that too within a logical frame of reference.

Check your Progress

3) What is deductive logic? How does it define science?

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4) Discuss the contribution of Aristotle to the construction of modern science.

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5) What are the different kinds of explanations possible in science?

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1.3 LAWS

A law is a statement of universal conditionality. It is characterised as infallible and mostly unchangeable. The first kind of law, based on common sense as well

as systemic observation is what is known as Laws of Nature or Universal Laws.

The definition of universal laws is vague and often it is based on observation without explanation, like horses do not fly. At one level it is based on the universal observation that no horse has ever been known that flies, or will be known in the future. But this is not a fully satisfactory or scientific law. A scientific law must have a stronger connection between the antecedent and consequent conditions than a mere statement based on recorded observation. For if we make the above statement it does not cover for the possibility that a horse may one day be found that flies. But if we frame an explanation in known and proven premises other than mere observation, then we can say that some creatures can fly because they have the biological and anatomical pre-requisites for flying. As far as a horse is defined as a horse, it does not have the anatomical features of a flying species, and therefore it does not and will never fly. Thus to our physical observation we must add the scientifically determined premise of how any living thing flies. If ever a horse like creature that flies is discovered then it will be scientifically put into a category that is neither a horse nor a bird, but we will say a new species has been discovered.

There is a difference between what is accidental universality and nomic universality. The fact that all tigers have stripes is an accidental universality but a nomic universality would depend on a logical and necessary relationship between the antecedent and consequent conditions. However these definitions are often debated and refer to deeper philosophical issues and will not be discussed here.

More often in science we deal with causal laws where the consequent is an effect of the antecedent. For any causality to assume the status of a law, it must satisfy four conditions. Thus if A and B are the antecedent and consequent conditions, then the first is that whenever A occurs B will follow, Secondly A is a necessary condition for B to happen, further A constitutes both a necessary and sufficient condition for B to occur and finally while B is the effect of A, the opposite is not true, that is B is not necessary for A. These again are open to criticism, for example not all causal relationship are asymmetrical (the last condition); clouds and thunder have a symmetrical relationship for example.

Not all laws are based on observation, some are also based on pure logic and they are known as theoretical laws. They are most likely to be found in a pure science (purely logical) like mathematics. Thus evaporation of water, when based upon observation can be called an experimental law and when based upon the properties of molecules, can be called a theoretical law. The latter are mostly not observable or beyond observation, like the law that parallel line meet at infinity. The methods based on observation are called as inductive.

However most theories are related to observations, although the theoretical laws are expressed at a higher level of generalisation and are usually not observable in the generalised form. Thus when we observe the progeny of a couple as resembling the parents in essential features like colour of hair and eyes and skin colour, then we may call it an experimental law but when it is explained on the basis of genetics and the composition and structure of chromosomes, we call it a theoretical law as chromosomes and their transmission cannot be observed but only inferred from observations. A theory in itself can be neither proved nor disproved except by the proving of secondary statements and hypothesis that is

derived from it. If any observation is contrary to the law then one has to look for additional information as to the reason for the discrepancy that may itself be another theory. Like for example, if a child is born not resembling its parents then an additional theory of genetic mutation is referred to for explanation.

Experimental laws can also be proved by setting up artificial conditions or laboratory conditions for proof. For example, if we want to prove that water is nothing but a combination of two molecules of Hydrogen and one molecule of Oxygen then this process can be recreated in the laboratory and water created under these artificial conditions, will be exactly like natural water. Unlike theoretical laws where all components can be abstract, in the case of experimental laws at least one component is observable.

A critical difference between an experimental law and a theory is that the latter has a much broader range of explanation than the former. A general theory can explain many divergent kinds of phenomena and subsume several experimental laws under it. An example of a general law is Archimedes' principle of buoyant force of liquids that can explain a wide range of phenomena.

The theory is also only a premise, and it is something that can be referred to in order to demonstrate, prove or disprove some hypothetical statements. It is not in itself a demonstrated truth. The value of a theory lies in its application and the extent to which it can explain a wide range of phenomena.

This process called experimentation is an integral part of scientific method and setting up of an experiment by creating artificial conditions in the laboratory also allows greater control over the different parts of the process. One can manipulate them for different variations and new products. In fact experimentation is the key to scientific creativity and growth of scientific knowledge. However there are limits to experimentation mainly because of reasons of ethics and humanity. It is not ethical to experiment on human beings except on volunteers, especially if such experimentation is likely to have adverse effects on a human. Medical experiments have been done on animals but in recent times, there has been great resistance and criticism of such experiments. Yet experiments are still being done on animals and covertly on human beings as well. Nuclear experiments in the name of science have caused much damage to the environment as well as to human and animal populations.

Check Your Progress

6) What are the characters of a scientific law?

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7) What do you understand by accidental and nomic universals?

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8) What is a theoretical law?

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9) What is an experimental law?

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1.4 CHANGING PERCEPTIONS OF SCIENCE

In the period of the European Renaissance, which also marks the consolidation of western system of scientific thinking; science was defined largely in terms of the validity of sensual perceptions and the faith that was reposed in human faculty of reasoning. The possibility of pure reason existing is attributed to the existence of a thinking being, namely the human. The human being has a consciousness that expresses itself through doubt. Doubt was viewed by him as the foundation of the scientific method that basically means that one should not accept anything without reason. For example he established that God exists by the process of reason and not by faith. Thus reason is the basis of science and the basis of science is doubt, not taking anything for granted.

Renee Descartes is credited with making a separation between the mental and physical world; in other words the abstract world that humans have the power to create and imagine and what is the material and the objective world that is available to the senses. This has come to be known as Cartesian duality where only the object or phenomenon that is located on the axis of space and time as described by the four dimensions of height, width, depth and time; have any material existence. He also imposed a duality between humans and animals by positing that animals have no subjective consciousness and therefore are to be treated as mechanistic object and not as beings.

Much of what he said is discredited today, both the duality of mind and matter and the division of human and non-human have been proven to be wrong. His description of the material world and in fact the entire concept of what constitutes matter has been disproved by modern physics, which shows that matter can turn into energy only by speed. Although the doubt as the basis for science is still acceptable, the question of proof through reason alone is no longer acceptable as physicists are delving into Black Holes and Dark Matter. Today as science is going further and further with knowledge production, the distinction between

material and non-material is getting blurred. Yet Descartes's contribution in establishing what we understand as the philosophy of modern science lies in his recognition of the human subject as a doubting and thinking being and in his positing of human reason as the path to true knowledge. No matter what direction the concept of science may take, the notion of proof of evidence as the basis for acceptance in science will always remain.

1.5 THE SOCIAL SCIENCES

The prefix, science was added to social or the study of society, when it was believed that societies are like natural beings or that social behaviour is subject to rules that are organised, systematic and capable of being classified and generalised as laws, for example, the Principles of Kinship as postulated by A.R. Radcliffe-Brown and Structuralism as advocated by Levi-Strauss which attempts to be viewed as a universal theory. The period of modernism in anthropology was marked by the application of the scientific method to the collection and analysis of data on society. Anthropology thus has the basics of science like theory and methods. It also had the scientific perspective of objectivity based on the duality of mind and matter, like the attempt of classical anthropologists to develop an objective attitude towards the subjects of their study. This period was marked by the application of the comparative method borrowed from the natural sciences in order to overcome the limitations posed by the impossibility of conducting laboratory experiments on human subjects and society.

The comparative method takes either a temporal perspective or a spatial perspective for the sake of establishing relationship between two variables. For example if we wish to study the effect of the introduction of television on family life, one way would be to study a family before and after they buy a television. However if this is not feasible then one can study a family that has a television and one that does not. Again such a comparison will be somewhat successful if all other variables are held constant. Although some commendable works have been done by the comparative method including Raymond Firth's method of dual synchronic study to document the changes that took place in Tikopia society over a period of twenty years, it remains an awkward method especially in today's world when there is a need for quick documentation. The comparative method however remains an inherent part of anthropological research even when a particular research is compared to others through reference to existing and ongoing works.

The modernist period also focused on the generation of what was regarded as 'factual data', emphasising on collection of quantitative and substantive data such as field census, household budgets, genealogies, demographic and geographical data and so on. The basic philosophy of the scientific method, namely that of evidence based truth and of applying reason was and is still being followed in most anthropological research.

Let us take a look at what Alan Barnard (2000: 5) has to say about the theory in anthropology as compared to theory in pure sciences.

Barnard considers four aspects of theory: Questions, Assumptions, Methods and Evidence. He summarises his opinion about these four aspects as follows:

The most pertinent questions are regarding what one is trying to find and how

this knowledge is useful. The first question relates directly to the nature of the discipline. In anthropology the questions pertain to the nature of culture and of society, they look for explanations to behaviour, to the material products of culture, they are directed towards finding both causes and effects of change and any number of questions with respect to why humans behave as they do. The second aspect can be of either esoteric or instrumental and more frequently a combination of both. Scientific inquiry was ideally supposed to have been 'pure' or what is known as 'knowledge for the sake of knowledge'. However the knowledge so gained, like about the properties of matter or about the nature of heredity were applied for numerous instrumental ends like making of machines and treatment of cancer. Yet one can distinguish the initial query as being directly in the applied field like if someone is looking for cure to a particular ailment or driven by pure inquisitiveness like looking for a new species.

Assumptions refer to what we have already discussed as basic premises or the presumed laws of nature. At this point it may be mentioned that assumptions play a very significant role in a discipline like anthropology, where the various schools of thought go their different ways. For example while all anthropologists believe that societies are the creation of human beings and not of any divine being, they differ in thinking of societies as harmonious and integrated or as driven by inner contradictions. Some may assume that all social institutions are functional and some others may not agree.

A third aspect of any theory is method. Method refers to the operational aspect of doing research but it is closely related to theory. Some theories are associated with a synchronic method where the data needs to be collected mostly for things as they are, but some others that emphasise upon change or social transformation, need to refer to history. Even the understanding of change differs, for example in the classical structural functional method, change was seen as external to the system and studied that way but in the Marxist perspective change is internal to the system and therefore the study will focus on the process of history. The method of study is thus closely linked to the basic assumptions that any scholar or school of thought holds with respect to how they view what society is or what culture is, and what is the relationship between individual and society and whether a sociological perspective should include psychological aspects also or not.

The last aspect of Evidence, again depends to a large extent on the theoretical perspective; some anthropologists who have a positivist approach may think that evidence can only be collected by an objective and impartial method from the outside while those who think more subjectively might derive evidence from the narratives of the informants and from the beliefs and values held by the members of society rather than by those held by the researcher. Thus some may believe in the comparative method and some may believe in holistic ethnographic method for comprehensive evidence of any social phenomenon.

Check Your Progress

10) How can social sciences use the experimental method?

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11) What are the components of a theory?

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12) How is theory in anthropology different from that in the pure sciences?

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1.6 IS ANTHROPOLOGY A SCIENCE?

Lastly let us come to the final and important question of whether anthropology is a science? There has been considerable debate on this point, as some scholars are of the opinion that anthropology, since it deals with human behaviour, cannot be considered as a science. Human beings are conscious beings with a will, and therefore their behaviour cannot be understood within a restrictive framework. One character of a scientific law is predictability and the second is generalisation. Although some structural laws have been postulated for human societies, there is always the possibility that individuals may change their behavior or already existing institutions may transform according to changes in times.

Thus while the laws of mechanics apply to inert bodies, laws of society apply to sentient, living beings with a volition of their own. Although societies have their norms and all social actions are bound by certain rules, there is always the possibility of individual dissent. According to some scholars and certain perspectives, like that of Levi-Strauss, the regularities of human behaviour are at a deeper layer than what is apparent on the surface and therefore ethnographic differences mask regularities that can be discovered by the analyst. This view confirms to the positivist view of science that things that may look very disparate may be confirming to an underlying principle, not apparent to the lay person and to common sense. It also contributes to the belief that science is purely objective and transcends all cultural and subjective bias.

However in the post-colonial era when the field of science was critiqued on these very premises, namely that science as it developed in the West was not as purely objective as it was purported to be but was both Eurocentric and Androcentric; that is the white male was taken as the standard for rational and logical thinking; and non-whites, women and even people from the fringes of the European countries were seen at various levels of primitiveness, ignorance and intellectual disability. A significant contribution in this direction was made by Feminist scholars. Sandra Harding (1993:4) points out that androcentricism can be found in even such areas like physics and logic, mathematics, abstract

thinking, standards of objectivity and good method by the very assumption that these qualities or capabilities are possible only in certain kinds of humans, namely white and male persons.

The criticism of scientific objectivity and the fallacies committed by western science such as racism and environmental destruction are increasingly being accepted even by the scientific community in the west. According to Harding (1993:6) the National Academy of Sciences of the United States now advocates that the meaning of scientific method should be broadened beyond the accepted and well known parameters of random selection, double blind trials and properly administered controls to include the subjective judgements that scientists make while assessing the reliability of the data and also in analysis. The decisions that are made to prioritise or choose problems for study as well as decisions to end a particular research are also important aspects of research where the political and economic considerations play a critical role, for example US president Ronald Reagan's refusal to further research to aid HIV and AIDs infected patients and George W. Bush Jr's stopping of stem cell research. Method also includes the manner in which knowledge is exchanged or made available to others and in the public domain. In other words the embeddedness of science in economic and political as well as cultural contexts is now well recognised.

In the context of the changing perspective about science not only can we recognise anthropology as a science but also the contribution that anthropology can make to the construction of an effective scientific methodology that will move it further towards what Harding has called 'hard objectivity'. The removal of subjective bias is possible only by its recognition.

Check Your Progress

13) Discuss the criticisms leveled against western science.

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14) What are the changing perspectives with respect to scientific methodology?

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1.7 SUMMARY

In this Unit the students have learnt about the basics of what is conventionally understood as science as well as the historical and political context of this understanding. They have been exposed to the key debates with respect to

scientific methods and the cultural, political and economic influences that shape both the definition of science as well as its methodology.

1.8 REFERENCES

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1.9 ANSWERS TO CHECK YOUR PROGRESS

1. See section 1.1
2. Same as above
3. Refer to 3rd paragraph of section 1.2
4. Refer to the 3rd, 4th, 5th and 6th paragraphs of section 1.2
5. Refer to section 1.2
6. Refer to 1st paragraph of section 1.3
7. Refer to 1st paragraph of section 1.3
8. Refer to 5th, 6th and 7th paragraphs of section 1.3
9. Refer to 5th, 6th, 7th and 8th paragraphs of section 1.3
10. Refer to sections 1.3 and 1.5
11. Refer to 3rd and 4th paragraphs of section 1.2; 6th and 8th paragraphs of section 1.3 and 1st, 3rd and 6th paragraphs of section 1.5
12. Refer to section 1.5
13. Refer to the 4th paragraph of section 1.6
14. Refer to sections 1.4 and 1.6