## 2 scientific method

**2.1 TYPES - SCIENTIFIC METHODS:** The **scientific method** is a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge.[1] To be termed scientific, a method of inquiry must be based on empirical and measurable evidence subject to specific principles of reasoning.[2] The *Oxford English Dictionary* defines the scientific method as "a method or procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses."[3]

The chief characteristic which distinguishes the scientific method from other methods of acquiring knowledge is that scientists seek to let realityspeak for itself, supporting a theory when a theory's predictions are confirmed and challenging a theory when its predictions prove false. Although procedures vary from one field of inquiry to another, identifiable features distinguish scientific inquiry from other methods of obtaining knowledge. Scientific researchers propose hypotheses as explanations of phenomena and design experimental studies to test these hypotheses via predictions which can be derived from them. These steps must be repeatable to guard against mistake or confusion in any particular experimenter. Theoriesthat encompass wider domains of inquiry may bind many independently derived hypotheses together in a coherent, supportive structure. Theories, in turn, may help form new hypotheses or place groups of hypotheses into context.

Scientific inquiry is intended to be as objective as possible in order to minimize bias. Another basic expectation is the documentation, archiving andsharing of all data collected or produced and of the methodologies used so they may be available for careful scrutiny and attempts by other scientists to reproduce and verify them. This practice, known as full disclosure, also means that statistical measures of their reliability may be made.

**2.2 HISTORY:** The development of the scientific method is inseparable from the history of science itself. Ancient Egyptian documents describe empirical methods inastronomy,[108] mathematics,[109] and medicine.[110] In the 7th century BCE, Daniel, a Jewish captive of the Babylonian king Nebuchadnezzar, conducted a scientific experiment complete with a hypothesis, a control group, a treatment group, and a conclusion. The control group partook of the king's delicacies and wine, whereas Daniel's test group limited themselves to vegetables and water.[111] At the end of the test, Daniel's hypothesis was proven true.

The ancient Greek philosopher Thales in the 6th century BCE refused to accept supernatural, religious or mythological explanations for natural phenomena, proclaiming that every event had a natural cause. The development of deductive reasoning by Plato was an important step towards the scientific method.Empiricism seems to have been formalized by Aristotle, who believed that universal truths could be reached via induction.

For the beginnings of scientific method: Karl Popper writes of Parmenides (*fl.* 5th century BCE): "So what was really new in Parmenides was his axiomatic-deductive method, which Leucippus and Democritus turned into a hypothetical-deductive method, and thus made part of scientific methodology."[112]

According to David Lindberg, Aristotle (4th century BCE) wrote about the scientific method even if he and his followers did not actually follow what he said. Lindberg also notes that Ptolemy (2nd century CE) and Ibn al-Haytham (11th century CE) are among the early examples of people who carried out scientific experiments. [113] Also, John Losee writes that "the *Physics* and the *Metaphysics* contain discussions of certain aspects of scientific method", of which, he says "Aristotle viewed scientific inquiry as a progression from observations to general principles and back to observations."[114]

However in order for true scientific method to develop, Aristotle could not be taken at face value. Errors in his "On the Heavens" and "Physics" had to be realized and corrected. Moreover, the pagan view common in the world during that era followed two concepts that prevented them from progressing toward a functional scientific method:

1. Organismic view of nature – nature and created objects are divine or are themselves without beginning or end
2. Circular reasoning as opposed to linear reasoning.[*discuss*]

According to Haffner, cultures that were thus debilitated included Chinese, Hindu, Meso-American, Egyptian, Babylonian, Greek and Arabic.[115]

**2.2.1 EMPIRICAL METHOD: Empirical research** is a way of gaining knowledge by means of direct and indirect observation or experience. Empirical evidence (the record of one's direct observations or experiences) can be analyzed quantitatively or qualitatively. Through quantifying the evidence or making sense of it in qualitative form, a researcher can answer empirical questions, which should be clearly defined and answerable with the evidence collected (usually called data). Research design varies by field and by the question being investigated. Many researchers combine qualitative and quantitative forms of

analysis to better answer questions which cannot be studied in laboratory settings, particularly in the social sciences and in education.

In some fields, quantitative research may begin with a research question (e.g., "Does listening to vocal music during the learning of a word list have an effect on later memory for these words?") which is tested through experimentation in a lab. Usually, a researcher has a certain theory regarding the topic under investigation. Based on this theory some statements, orhypotheses, will be proposed (e.g., "Listening to vocal music has a negative effect on learning a word list."). From these hypotheses predictions about specific events are derived (e.g., "People who study a word list while listening to vocal music will remember fewer words on a later memory test than people who study a word list in silence."). These predictions can then be tested with a suitable experiment. Depending on the outcomes of the experiment, the theory on which the hypotheses and predictions were based will be supported or not.

**2.2.2 EXPERIMENTAL METHOD:** The experimental method involves manipulating one variable to determine if changes in one variable cause changes in another variable. This method relies on controlled methods, random assignment and the manipulation of variables to test a hypothesis.

**2.2.3 HYPOTHETICAL DEDUCTIVE METHOD:** The **hypothetico-deductive model** or **method** is a proposed description of scientific method. According to it, scientific inquiry proceeds by formulating a hypothesis in a form that could conceivably be falsified by a test on observable data. A test that could and does run contrary to predictions of the hypothesis is taken as a falsification of the hypothesis. A test that could but does not run contrary to the hypothesis corroborates the theory. It is then proposed to compare the explanatory value of competing hypotheses by testing how stringently they are corroborated by their predictions.

Concisely, the method involves the traditional steps of observing the subject, in order to elaborate upon an area of study. This allows the researcher to generate atestable and realistic hypothesis.
The hypothesis must be falsifiable by recognized scientific methods but can never be fully confirmed, because refined research methods may disprove it at a later date.
From the hypothesis, the researcher must generate some initial predictions, which can be proved, or disproved, by the experimental process. These predictions must be inherently testable for the hypothetico-deductive method to be a valid process.

**2.2.4 METHOD OF SCIENTIFIC OBSERVATION:** Scientific observation is the central element of scientific method or process. The core skill of scientist is to make observation. Observation consists of receiving knowledge of the outside world through our senses, or recording information using scientific tools and instruments. Any data recorded during an experiment can be called an observation.

**2.2.5. METHOD OF MEASUREMENT:** The technique or process used to obtain data describing the factors of a process or the quality of the output of the process. Measurement methods must be documented as part of a Six Sigma project or other process improvement initiative, in order to ensure that measurements of improvements to a process are accurate.

**2.2.6. DIALECTIC METHOD: Dialectic** (also *dialectics* and *the dialectical method*) is a method of argument for resolving disagreement that has been central to European and Indian philosophy since antiquity. The word *dialectic* originated in ancient Greece, and was made popular by Plato in the Socratic dialogues. The dialectical method is discourse between two or more people holding different points of view about a subject, who wish to establish the truth of the matter guided by reasoned arguments.[1]

The term dialectics is not synonymous with the term debate. While in theory debaters are not necessarily emotionally invested in their point of view, in practice debaters frequently display an emotional commitment that may cloud rational judgement. Debates are won through a combination of persuading the opponent; proving one's argument correct; or proving the opponent's argument incorrect. Debates do not necessarily require promptly identifying a clear winner or loser; however clear winners are frequently determined by either a judge, jury, or by group consensus. The term dialectics is also not synonymous with the term rhetoric, a method or art of discourse that seeks to persuade, inform, or motivate an audience.[2] Concepts, like *"logos"*or rational appeal, *"pathos"* or emotional appeal, and *"ethos"* or ethical appeal, are intentionally used by rhetoricians to persuade an audience.[3]

The Sophists taught *aretē* (Greek: ἀρετή, *quality, excellence*) as the highest value, and the determinant of one's actions in life. The Sophists taught artistic quality in oratory (motivation via speech) as a manner of demonstrating one's *aretē*. Oratory was taught as an art form, used to please and to influence other people via excellent speech; nonetheless, the Sophists taught the pupil to seek *aretē* in all endeavours, not solely in oratory.[*citation needed*]

Socrates favoured *truth* as the highest value, proposing that it could be discovered through reason and logic in discussion: ergo, *dialectic*. Socrates valued rationality (appealing to logic, not emotion) as the proper means for persuasion, the discovery of truth, and the determinant for one's actions. To Socrates, *truth*, not *aretē*, was the greater good, and each person should, above all else, seek truth to guide one's life. Therefore, Socrates opposed the Sophists and their teaching of rhetoric as art and as emotional oratory requiring neither logic nor proof.[4]Different forms of dialectical reasoning have emerged throughout history from the Indosphere (Greater India) and the West (Europe). These forms include the Socratic method, Hindu,Buddhist, Medieval, Hegelian dialectics, Marxist, Talmudic, and Neo-orthodoxy.

## 2.2.7 PHENOMENOLOGICAL METHOD:

**Phenomenology** (from Greek: *phainómenon* "that which appears" and *lógos* "study") is the philosophical study of the structures of experience and consciousness. As a philosophical movement it was founded in the early years of the 20th century by Edmund Husserl and was later expanded upon by a circle of his followers at the universities of Göttingen and Munich inGermany. It then spread to France, the United States, and elsewhere, often in contexts far removed from Husserl's early work.[1]

Phenomenology, in Husserl's conception, is primarily concerned with the systematic reflection on and study of the structures of consciousness and the phenomena that appear in acts of consciousness. This ontology (study of reality) can be clearly differentiated from the Cartesian method of analysis which sees the world as objects, sets of objects, and objects acting and reacting upon one another.

Husserl's conception of phenomenology has been criticized and developed not only by himself but also by students, such as Edith Stein, by hermeneutic philosophers, such as Martin Heidegger, by existentialists, such as Max Scheler, Nicolai Hartmann, Maurice Merleau-Ponty, Jean-Paul Sartre, and by other philosophers, such as Paul Ricoeur, Jean-Luc Marion, Emmanuel Lévinas, and sociologists Alfred Schütz and Eric Voegelin.

The object of phenomenological research is to draw from other people's experiences. Phenomenological researchers figuratively live through their subjects so they can better understand the meaning of their experiences. Phenomenological research poses inherent challenges, as lived experience descriptions are never identical to lived experience itself. Thus, even if lived experience is captured right

at the moment, it is already transformed. For their part, researchers employ a variety of qualitative research methods to best preserve life meanings.

**2.2.8. HISTORICAL METHOD: Historical method** comprises the techniques and guidelines by which historians use primary sources and other evidence, including the evidence of archaeology, to research and then to write histories in the form of accounts of the past. The question of the nature, and even the possibility, of a sound historical method is raised in the philosophy of history as a question of epistemology. The study of historical method and of different ways of writing history is known as historiography.

**2.2.9 Inductive logical method**: An inductive logic is a system of evidential support that extends deductive logic to less-than-certain inferences. For valid deductive arguments the premises *logically entail* the conclusion, where the entailment means that the truth of the premises provides a *guarantee* of the truth of the conclusion. Similarly, in a good inductive argument the premises should provide some *degree of support* for the conclusion, where such support means that the truth of the premises indicates with some *degree of strength* that the conclusion is true. Presumably, if the logic of good inductive arguments is to be of any real value, the measure of support it articulates should meet the following condition:

**Criterion of Adequacy (CoA)**:
As evidence accumulates, the *degree* to which the collection of true evidence statements comes to *support* a hypothesis, as measured by the logic, should tend to indicate that false hypotheses are probably false and that true hypotheses are probably true