CHAPTER 1: SCIENTIFIC INQUIRY 1

The different branches of science

Science is used to describe a huge group of subjects that deal with the search for knowledge about the universe and all that is in it. Each of these subjects is also separately referred to as a science–for example, the science of chemistry, physics or biology.

Chemistry is the study of matter and the chemical reactions between substances. It is also the study of matter's composition, structure and properties.

Physics is the study of matter and its motion and behaviour through space and time, along with related concepts such as energy and force.

Biology is the scientific study of living things and their vital processes.

Safety in the laboratory and in the field

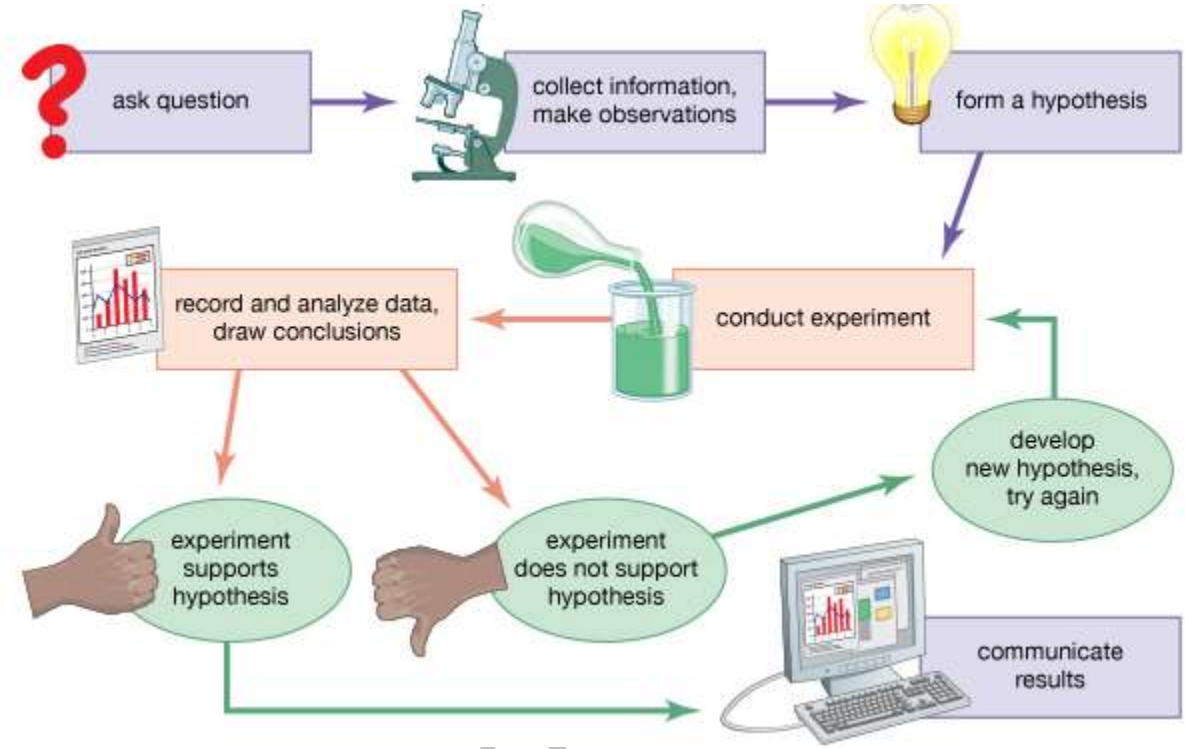
Safety is freedom from danger, injury, or damage. Being safe requires actions by you and by others.

Basic safety rules for chemistry students:

1. Follow instructor (teacher or laboratory attendant) and laboratory instruction directions carefully.
2. Wear proper eye protection for use around chemicals at all times.
3. Wear clothing that protects against exposure and provides protection from spills. Wear chemically resistant gloves when prudent to do so.
4. Do not eat, drink, smoke or use smokeless tobacco products, chew gum, apply cosmetics or take medications in the laboratory.
5. Use the chemical hood when working with volatile chemicals, flammable liquids or gases, or odorous chemicals, or when there is a possibility of the release of toxic chemical vapours, powders or dusts.
6. There should be no boisterous conduct, excessive noise or practical jokes in the laboratory.
7. Never taste any laboratory chemical. When smelling a chemical (if you are instructed to do so), gently waft the vapours toward your nose. Do not directly inhale the vapours.
8. If any chemical spills on your skin or in your eyes, immediately flush the affected area with water and notify the instructor.
9. Do not work alone in the laboratory.
10. Read the entire experiment before entering the lab. The teacher must approve experiments manual beforehand.
11. Notify the instructor immediately of all breakages, accidents, incidents, injuries, spills, or hazardous situations; a hazard is a potential source of danger or harm.
12. Dispose of waste chemicals in the containers provided.
13. Do not heat flammable liquids with a Bunsen burner or other open flame.
14. Label containers with their names if they contain chemicals or solutions.
15. Return all equipment, clean and in good condition, to the designated location at the end of the lab period.

The scientific method

Scientists believe there is a natural explanation for most things. For any problem they see, they try to understand the cause so that they can come up with a solution. By learning what causes a disease, for example, scientists can work to control its spread. The process that scientists use to solve problems is called the scientific method.



Scientists start by finding out as much as possible about a problem. Then they make a hypothesis. A hypothesis is an attempt to explain the problem. They test the hypothesis with an experiment. If the experiment does not support the hypothesis, the scientists think about the problem again and develop a new hypothesis. They then test that hypothesis with a new experiment. If the experiment supports the hypothesis, other scientists repeat the experiment to make sure that they get the same results. If they do get the same results, the hypothesis will be accepted as true until it can be proven false.

Asking meaningful questions about phenomena

Phenomena refers to a fact or event in nature, which is not fully understood. Science begins with a question about a phenomenon about which we are curious or one that makes us wonder. For example, “Why is the sky blue?” or “What causes cancer?” Science then seeks to develop theories that can provide explanatory answers to such questions. A basic practice of the scientist is formulating empirically answerable questions about phenomena, establishing what is already known, and determining what questions have yet to be satisfactorily answered.

A scientific question is a testable question. A testable question asks something that can be measured and observed through experimentation. In other words, a testable question can only be answered by gathering evidence. If your question does not require collecting data (qualitative and quantitative observations), then your question is not testable.

Conducting simple investigations from instructions

Conducting simple investigations from instructions (cookbook science) usually involves a set of procedural steps for which only one solution to the problem exists. It is useful for learning science only if it is followed by reflection on the processes afterward. Just as we must learn the alphabets before we can read, cookbook science helps us develop the necessary skills before we can investigate on phenomena.

Making observations and collecting data

First, there is the scientist's observation of the world as it leads to hypothetical theory.

Second, in the collection of data in an experiment using the scientific method, there are two types of observations namely, qualitative and quantitative.

When a scientist performs an experiment that requires observations concerning the quality of what has happened in an experiment, it is considered a qualitative observation or data, for example, how the colour of a chemical substance changed during a chemistry experiment. Thus, if you are asked what is observed, answer by writing down:

1. what is seen (colour change, solid disappearing, effervescence with evolution of gas, etc.),
2. what is heard (for example, squeaky pop sound),
3. what is smelled (for example, a pungent gas is evolved),
4. what is felt (for example, the contents in the flask become warm).

Quantitative observation during an experiment employs mathematical models and relies on the scientist to collect information based on numbers, for example, how many grams of a chemical substance were produced during a chemistry experiment.

Representing data in different forms

Data is initially collected from a given source, whether they are observation or experiment. It is then represented in different forms, for example, by using tables, diagrams, charts or graphs.

A table consists of a list of facts or numbers arranged in a special order, usually in rows and columns.

A diagram is a simple drawing using lines to explain how something works or how to set up an apparatus. In science, we use a pencil to draw and label a diagram.

A chart is a graphical representation of data, in which the data is represented by symbols, such as bars in a bar chart or slices in a pie chart.

A graph is a planned drawing, consisting of a line or lines showing how two sets of numbers are related to each other.

Making inferences from recorded data

An inference is a logical conclusion based on observations and prior knowledge. Inferences are commonly drawn:

1. by deduction, which, by analysing valid argument forms, draws out the conclusions implicit in their premises,
2. by induction, which argues from many instances to a general statement,

3. by probability, which passes from frequencies within a known domain to conclusions of stated likelihood, and
4. by statistical reasoning, which concludes that, on the average, a certain percentage of a set of entities will satisfy the stated conditions.

Writing a logical conclusion from analysed data

After making inferences from recorded data, scientists are now in a position to analyse the data in order to confirm or refute a hypothesis. If the hypothesis is confirmed, the scientist will usually communicate the results of his findings.

Scientists use the information they learn from testing many hypotheses to develop a scientific theory. A theory is a much broader explanation than a hypothesis. Scientists consider theories to be the best explanations for why some things happen in the natural world. A theory may later need to be revised if scientists discover new information about the subject.

Using ICT for acquiring information and presenting results

Information and Communication Technology has revolutionised the way we learn science. For acquiring information, data loggers are now used by many scientists. A data logger is an electronic device, with a built-in instrument or sensor that records data over time or in relation to location. They are based on a digital processor or computer.

For presenting results in the form of tables, diagrams, charts and graphs appropriate software may be generated and shared through printing or via the internet. Computer applications like spreadsheets, word processors, internet browsers, diagramming and vector graphics applications are used for such purpose.

By using Virtual Reality (VR) and Augmented Reality (AR) hardware and software, scientists can now simulate an experiment in three dimensions without putting his life in danger. This also reduces the costs of laboratory equipment and chemicals.