7.1.1 THE WORLD OF SCIENCE[M1]

Science is both

- a body of knowledge
- a method of enquiry

7.1.1.1 Scientific Method

1. Make observations (Ask questions)
2. Form hypothesis (Guess answers)
3. Experiment to test hypothesis

An experiment needs

i) Careful planning
ii) A control
iii) Care in drawing conclusions

Hypotheses that have the consistent support of much experimentation become Theories.

A Theory that has been shown, through extensive observation and experiment, to be without contradiction becomes a Law [of Science].

7.1.1.2 Frames of Reference

We can make scientific observations at many different levels. Man will probably first have noticed the things that had an immediate impact on his life: the weather, the growth of edible plants, the behaviour of edible animals and certainly that of predators. In the evening, the 'lights' in the sky would have attracted the attention of the more inquisitive.

With the passing of time, and the development of different technologies, Man has developed tools to allow him to look more closely at the world around him. He invented the telescope to allow him to explore the heavens, and the microscope with which he could explore his more immediate surroundings. More recently, he has developed radio telescopes and different kinds of instruments that allow him to observe and measure things that he could never before see, hear, touch taste or smell.

7.1.1.2.1 The Universe[1]

The Universe is a term generally used to define the bounds of our current scientific endeavours. It appears to stretch out indefinitely from our galaxy in all directions. The Universe comprises all those things that we have observed to date, and many things that we have not and are yet to discover.

7.1.1.2.2 Our Galaxy[2]

Our galaxy, known as the Milky Way, is the collection of stars, including our own Sun, which we see in the sky at night. There are many millions of stars in our galaxy, many of which we can see with the naked eye, many of which we can only see with the aid of special telescopes, and probably many more we are yet to discover. The Milky Way is

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1 http://www.nasa.gov

2 http://www.seds.org/messier/more/mw.html (Students for the Exploration and Development of Space)

what is known as a spiral galaxy, about 100,000 light years in diameter. The nearest dwarf galaxies are only a few hundred thousand light years away, while our nearest giant neighbour, the Andromeda Galaxy, also a spiral, is about 2-3 million light years away.

7.1.1.2.3 Our Solar System[3]

Our solar system comprises the nine planets (that we currently know) and their moons, other bodies such as comets, asteroids and meteors, and maybe other entities that have not yet been discovered that revolve in orbits around the Sun. It is quite likely that many of the suns in our galaxy, and indeed in the Universe, comprise similar collections of orbiting bodies, leading scientists to contemplate the existence of life forms on planets other than Earth.

Planet	Distance from the Sun (km)	Diameter (km)	Orbital Period	Rotational Period	Surface Temp Range (°C)
Mercury	58,000,000	4,878	88 days	58.65 days	-184°C–427°C
Venus	108,000,000	12,104	225 days	243 days	457°C ave.
Earth	150,000,000	12,753	365 days	24 hours	-89°C–58°C
Mars	228,000,000	6,785	687 days	24.6 hours	-129°C–0°C
Jupiter	778,000,000	142,800	12 years	9.8 hours	-150°C ave.
Saturn	1,426,000,000	119,871	29.5 years	10.67 hours	-170°C ave.
Uranus	2,877,000,000	51,488	84 years	17.24 hours	-200°C ave.
Neptune	4,508,000,000	49,493	165 years	16 hours	-210°C ave.
Pluto	5,955,000,000	2,390	248 year	6.387 days	-233°C–-223°C

Table 1: The Planets of our Solar System

7.1.1.2.4 The Earth

The Earth is the planet on which we live. It is the only planet in our solar system known to support life as we know it. There are several more obvious reasons for this observation: the temperature on the surface of the Earth, largely related to the distance from the Sun, its oxygen-bearing atmosphere, and the existence of water.

7.1.1.2.5 Animal, Vegetable, Mineral

On Earth, we generally notice that objects fall into one of three general categories: the plant and animal life forms, and the non-life forms. Life forms (mainly plants and animals, but also bacteria, viruses and fungi) are differentiated from non-life forms by the fact that they are capable of reproducing themselves.

7.1.1.2.6 Atoms

All matter that we have been able to observe in the Universe to date is made up of combinations of a small number (about 100) of entities known as atoms. In most cases atoms do not exist in isolation, but as collections of specific combinations of atoms known as molecules. Furthermore, atoms themselves are made up of combinations of individual atomic particles: electrons, protons and neutrons.

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[3] http://www.windows.ucar.edu/tour/link=/our_solar_system/solar_system.html
http://www.shatters.net/celestia

The number of protons in an atom defines its fundamental nature (*i.e.* what 'element' it is), the number of electrons its oxidation state, and the number neutrons the isotopic variant of an individual element.

More recent observations and theories suggest that some of these sub-atomic particles (protons & neutrons) are themselves made up of smaller entities (quarks, mesons *etc.*) generally referred to as sub-nuclear particles.

7.1.1.3 Forces at Play

The behaviour of bodies, of all sizes, within our universe is governed by many factors, but fundamental to these are the different forces that influence behaviour at the different observation levels identified above. The primary forces involved, gravitational, electromagnetic and nuclear, are described briefly below. There are, of course, many other forces, such as various frictional, elastic, hydrostatic and aerodynamic forces that come into play in specific environments, but they are all simply manifestations of the primary forces.

7.1.1.3.1 Gravitational Forces

Gravitational forces exist between any two bodies in the Universe. The gravitational influence exerted by one body on another is in proportion to both its mass and the distance between the two bodies.

The most obvious illustration of gravitational force is the fact that objects effectively remain on the surface of the earth. Objects of greater mass are more difficult to move away from the Earth because the gravitational force acting on them is greater—the gravitational force acting on an object is directly proportional to the mass of the object. As an object is moved further away from the Earth its weight, the common measure of gravitation attraction, decreases—the gravitational force between two objects is inversely proportional to the distance between them. The fact that objects remain in orbit around the Earth, even though they appear to be 'weightless' is an indication that the Earth is still exerting some gravitational influence on them.

Note also that gravitational forces are not just forces imposed by a larger body on a smaller body. The smaller body will also have an impact on the larger body. It is the gravitational influence of the Moon on the Earth, for example, that causes the movement of water in the oceans that gives rise to tides.

7.1.1.3.2 Electromagnetic Forces

Electromagnetic forces are forces that exist between charged particles, or charges. The electromagnetic forces between objects at rest are called electric forces, and the science that deals with them is called electrostatics. A moving charge is known as a current, and the force exerted by one current on another is called a magnetic force.

An electromagnetic force, therefore, can be thought of as the sum of two forces: the electrostatic force, which depends only on the charges and their separation, and the magnetic force, which depends also on their velocities.

7.1.1.3.3 Nuclear Forces

Nuclear forces are the forces that hold together the particles, known as nucleons, in the nucleus of an atom. They are not as well understood as gravitational and electromagnetic forces. Nuclear forces do not depend on either the mass (*cf.* gravity) or the charge (*cf.* electromagnetism) of a nucleon, although they do depend on the distance between nucleons, and their magnitude can be defined using Einstein's famous equation $E=mc^2$.

7.1.1.3.4 The Unified Field Theory

The relationship between gravitational, electromagnetic and nuclear forces, if any, is one of the major unsolved problems of physics. The proposition that such a relationship exists, that there is an underlying unity between all the forces observed within our Universe, is known as the Unified Field Theory. Albert Einstein believed that such a relationship must exist, but was unable to prove his belief. His conviction is poetically expressed in his popular quote: "God casts the die, not the dice".