Concept and Definition of Genetics

The word "GENETICS" is derived from 'genesis' meaning creation, to become, or the way in which something is formed; and it was coined by Bateson in 1906. Genetics may be defined as the science of heredity and variation which deals with resemblances and differences among individuals related by descent. Heredity means the similarity which progeny shows to its parents, and provides for the genetic continuity between generations while variation deals with the differences and similarities exhibited by individuals in the progeny. In other words, heredity constitutes a way of biological preservation whereby parental characteristics continue from generation to generation. The resemblance expressed by a new-born baby places a confidence in the heredity of that family. Wheat grains will produce wheat seedlings and puppies grow into dogs and never into cats. The general growth and development pattern of the off-spring in the living organisms, resembles that of their parents so closely that the inheritance of characters becomes a matter of fact. Heredity is, therefore, the genetic continuity between the parents and the offsprings, and thus preserves a race by developing progeny in the parental image.

Variation

There are billions of peoples living on this earth; no two of them are exactly alike. Members of the same family and, in some instances, even the identical twins are different from one another for many characters such as complexion, body size, intelligence, voice etc. They show differences although they share common parentage. This is deviation from the *heredity* and is called *variation*. The variation present in the various characteristics of the members of the same race or a group of closely related individuals may arise due to change in the gene structure, new combination of genetic factors or change in the environment. Heredity and variation are common attributes of all biological organisms, and the science of genetics deals with the study of these two phenomena.

Preservation of ancestral characters generation after generation

Heredity and environment

Heredity—the force of preservation of the ancestral characters generation after generation—determines fundamental biological patterns and the ultimate development of a character is the product of its heredity and environment. Some of the traits are influenced more by the environment than others. A change in environment, therefore, may change the expression of a trait but such a change will only persist for the life-time of that individual and should not be expected to be transmitted to its off-spring.

Environment is of two types, i.e. internal and external. The internal environment includes the cell contents within which lies the heredity material (chromosomes), while the external environment comprises extracellular conditions, e.g. soil, climate and similar other factors. As we have said before, environment exerts vital influence, on the development of a character. For instance, if the white body hair of a Himalayan rabbit (white body except the tips of feet, nose and ears) are removed and new hair allowed to grow under cool temperature, it will be black. On the other hand, if the hair from the black part (i.e. ear tips) is removed and that part is kept warm, the new hair that grows will be white. This shows that hereditary factors responsible for the production of black pigments in the Himalayan rabbit produce their effect only in cool temperatures.

To cite another instance, there is a maize variety Sunred, in which the outer husk of the cob develops red colour in the presence of sunlight. The portion of husk emerging at night or in the dark is green and the one growing in the sunlight is red.

HISTORY OF GENETICS

Genetics has been developing as a vigorous science since the beginning of the twentieth century. We find in the literature on the history of biology that speculations on the nature of heredity are as old as the history of mankind. An old Babylonian tablet dating back to 6,000 BC shows the pedigree of a large number of successive generations of horses. Stone carvings of the same period illustrate cross pollination

of the date palm. The early Chinese are known to have made considerable improvements in the varieties of rice. It is believed that most of the common domestic animals and plants were brought in the service of man before the beginning of the recorded history.

Sexual reproduction and hybridization

Camerarius (1764), a German Professor, was the first to describe sexual reproduction in plants. He is also credited with the production of the first hybrid plant artificially. Later, Kolreuter performed experiments on artificial hybridization on tobacco varieties and studied their hybrids. Schleiden and Schwann (1838) first recognised the cell as a unit of structure and function and propounded the theory that the new cells arise only from the pre-existing cells. Strasburger and Hertwig (1875—1885) found that only a single sperm is required to fertilise an egg. They suspected that the nucleus of the cell was the basis of heredity and that male and female gametes took equal part in the transmission of heredity.

Before Mendel, various scientists tried to solve the mystery of heredity; views of some of them are summarised below :

Preformation and epigenesis

In 1679, Swammerdam claimed that he was able to see in the human sperm under his crude microscope a miniature figure of man which he named "homunculus". He believed that man's body was preformed in the sperm and that during the embryonic stage, only the growth of different organs to a full-size baby occurred. Bonnet who believed more in egg cell than sperm differed with this theory only slightly. He advanced his own theory called "egg encapsulation or box theory" which held that the female contains all the germ cells of her immediate and remote progeny, and that Mother Eve in her ovary had the germ cells of all the men to be born. With some improvement in the microscope, Wolff (1733—1794) and Von Baer (1792—1876) studied the structure of sex cells carefully and discovered nothing like homunculus or the little man but observed that cells were composed of structureless fluid. They replaced the idea of preformation with *epigenesis*. According to this idea, the

process of development involved both male and female sex cells and that a vital force was responsible for the formation of organs in the embryonic stages.

Inheritance of acquired characters

The Greek philosophers thought that the inherited characters of the individuals were acquired through direct contact with the environment. This idea first materialised into a theory advanced by a French biologist, Lamarck (1744—1829), who emphasized an animal's desire to determine its needs. The desire, in turn, would determine the use or disuse of the body parts and this selective use and disuse would bring about modification of that organ. The modification so induced in the parents by the environment was believed to be imprinted upon the germinal material (egg and sperm) and was thus transmitted to the offspring. According to Lamarck, variations are induced in the organism in response to urgent needs of the individual and ultimately are impressed upon germinal material. To support this idea he cited instances of the long neck of giraffes to secure food from tall trees, absence of eyes of fish living in dark caves under the sea, webbed feet of frogs, etc. The present knowledge of the germinal material and the developmental processes in plants and animals, however, do not support Lamarckism.

Darwin's hypothesis of Pangenesis

In the mid-nineteenth century Charles Darwin tried to figure out the pathway of heredity in a very interesting manner. He proposed that each body cell produced its rudimentary copy, which he called pangene or a gemmule. These gemmules were supposed to be delivered in the animal's blood stream ultimately to reach the germinal tissues (ovary and testicle), where the gemmules obtained from all body cells form gametes. A gamete so synthesised had all the cells of an organism in rudimentary form which would develop into a full-fledged new individual; thus heredity was supposed to be due to the gemmules representing blueprints of different body organs.

This hypothesis was rejected by Galton (1822—1911) during the lifetime of Darwin. He transfused blood of a black rabbit into the body

of a white rabbit and expected a progeny of black and white from it, in accordance with Darwin's theory. But he did not obtain the expected results.

Germplasm theory

Weismann, a German biologist (1834—1914), conducted his famous experiment on mice to show the difference in body tissue and germplasm. He cut the tails of mice for 22 generations and observed that the progeny in the 23rd generation still had normal tails. He believed that the reproductive tissue (germplasm) is quite separate and distinct from the body tissue (somatoplasm). He emphasised the remarkable stability of germplasm which is transmitted unchanged from generation to generation. Somatoplasm is a product of germplasm and, therefore, any change induced by the environment on the body cells cannot be transmitted to the germinal tissue. Acquired characters are not inherited because germplasm is the only channel through which heredity is carried to the offspring. Of all the theories discussed heretofore, this theory comes closest to the Mendelian concept of heredity.

PROBLEMS

1. Define heredity and explain its basis in detail.
2. List some human characters which are easily influenced by the environment and those which are not.
3. Make a list of some of the characters of domestic animals which you think are controlled by heredity.
4. How will it help the geneticist to improve a race, assuming that the acquired characters are (a) inherited (b) not inherited?
5. What were the factual bases of the theories of inheritance of acquired characters, epigenesis, preformation, pangenesis and continuity of germplasm?
6. A boy refuses to marry a girl whose father, grandfather and great grandfather all died of tuberculosis. Comment on his thinking.
7. If a character is transmitted only through mother, which part of the female gamete (cytoplasm, nucleus) do you think will carry the factor