The Chemistry of Controlled Mutations

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Mutations may be produced in plants and animals in three ways. In a few cases a reasonably accurate prediction of mutation that will occur under carefully controlled conditions can be made. We have recently become much more interested in the study of the causes of cancer. We know that a tendency to acquire cancer may be inherited. Studies of cancer in animals have shown that some strains of laboratory animals are much more susceptible to cancer than are other strains. Since cancer itself is not inherited it is not considered to be a mutation. Natural mutations do occur, but hybridization and selection somewhat increase their frequency of occurrence. This method of producing mutations has given mankind many of the plants and animals that now exist. The Concord grape and the Starking apple are good examples of mutations produced by this method. The seedless orange and the seedless grape are also mutations of more or less accidental origin. There is safety in numbers. Only by producing a large number of plants is there very much chance of a mutation occurring. Mutations are not always improvements. They may be of less value than the parent type in many instances. Those types of little worth are seldom propagated while the more valuable types are very commonly grown.

The second method of producing mutations is by the use of radiations. The X-ray is probably the most valuable of all radiations in producing new varieties of plants. Radioactive elements and compounds may give us many kinds of mutations in plants and animals. Their present use is largely confined to studies in growth and nutrition. The chemical changes occurring in plant and animal life can be traced by means of radioactivity.

The third way of producing mutations is by chemical treatment. When a chemical compound or mixture partially dissolves a cell wall and acts within the cell it is very effective in the production of mutations. It is well known that it is difficult to determine whether some kinds of living cells are plant or animal. There are many instances of chemically induced mutations in plants but it is more difficult to determine how mutations may be produced in animal life. From the similarity in cell structure it would seem that any chemical that proved to be particularly effective in making cellular changes in plants might be expected to perform a similar function in changing the cell structure in animals. The first mutation that commonly occurs when certain forms of animal life are given proper doses of certain chemical mixtures is the increased rate of reaction to stimuli. The response may be more easily produced with a comparatively weak stimulus with a decrease in reaction time. Bees and other insects show an ability to assimilate the chemicals quite rapidly and show a decrease in reaction time by moving the wings more rapidly and producing a tone of higher pitch than the controls that were not given the chemicals. Pigeons show a more rapid response to a stimulus applied to either of their feet. Their increased ability to quickly find their way through a maze shows that there may be a corresponding increase in intelligence when they are fed these chemicals. There seems to be some increase in flying ability. As it has been impossible for accurate measurements to be made because of the lack of adequate equipment these observations cannot be regarded as scientific evidence but are merely my own opinion on this matter. Cuprammonium hydroxide, ethyl nitrate, and partially nitrated cellulose may be used to make up a chemical mixture for this purpose. It is probable that glutamic acid could be given immediately after the cuprammonium hydroxide solution to obtain similar results. These chemicals must be given in very small amounts which can be determined only by experimentation.

Hyperglycemia may be expected to be a symptom of a slight overdose of a mixture of these chemicals. An amount must be given that is sufficient to produce a physiological reaction. The chemicals tend to have an accumulative action when several doses are given. As cases of fusion occur in plants in quite a few instances it seems reasonable to assume that a similar fusion of axones of neurones may be the cause of a lessened reaction time in animals. There are two theories of impulse conduction; the contact theory and the continuity theory (1). It has been shown that an axone could be excited by placing it very near another axone of the same type which received an electrical stimulus (2). It has been suggested that life originated by chemical combinations of nonliving matter (3, 4). This opinion does not imply that life was not created.

The chemical treatment of plants is not difficult, but no result may occur if the solution is too dilute. Serious burning of the foliage and other undesirable results are apt to occur when too strong a solution is used. A strong solution usually produces an undesirable mutation. To make a solution, ammonium hydroxide is mixed with copper sulfate until all the mixture is of a purple color, then a mixture of napthalene and carbon disulfide is added to it. One ounce of cuprammonium hydroxide shaken well with an ounce of a saturated solution of napthalene in carbon disulfide should be put in from five to ten gallons of water for best results. The solution should then be sprayed on the plants to be treated. The concentrated mixture shows the Brownian movement very well under the microscope. It is probable that this bombardment effect changes the arrangement of the genes in the chromosomes. Polyploid forms are common. The somatic chromosome number can be changed by such treatment. The accompanying photographs show some of the results obtained.

With dogwood the change was from a simple leaf to a compound leaf. In potato, variegated leaves were obtained. Peanuts produced four peanuts per pod instead of the usual number.

Pansies produced ruffled flowers instead of the normal type. Tomatoes were produced with part of the carpels seedless when the plants were treated lightly. Plants given excessive treatment produced small, seedy fruit and the stems of the plants were greatly thickened. Carrots produced additional divisions of the leaf at the midrib of the leaf. In gourd, two types of gourd were produced from the same vine. Parts of the vine assumed various polyploid forms as shown by a fusion of parts in the stems and flowers. In crab apple double flowers were produced by pruning and chemical treatment, but the effect was not repeated the following year when the flowers were normal. With asparagus a height of nine feet was reached while the stems were sometimes flattened and the number of branches were sometimes doubled. Phlox produced several kinds of dwarf plants of the perennial phlox, while the phlox, Drummondi, produced stems several feet in length and bloomed freely. Jerusalem artichoke produced seed and grew to a height of from eight to ten feet. Russian sunflower was dwarfted to several feet in height and produced no seed when excessive treatment was given. Catnip produced stems of about twice normal width. Fuller's tease produced dwarf growth. Tulips produced branched stems. *Aristolochia serpentaria* showed an increase in height.

Bibliography

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