Sports or Mutations in Fruits

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Higher plants develop from seed as a result of the multiplication of a single cell—the fertilized egg. Growth is largely a process of cell division repeated thousands or millions of times, as the single cell from which the plant originated grows into a tree or other large plant.

Each living cell is a complicated structure. It includes a cell wall within which are the cytoplasm and the nucleus. The nucleus contains a number of bodies called chromosomes, which are so small that they can be seen under a microscope only after special staining. These chromosomes are the carriers of the hereditary factors, or genes.

The process of ordinary cell division is also highly complex. Each chromosome in the nucleus divides lengthwise. Then the split chromosomes orient themselves in a plate in the middle of the cell. One half of each original chromosome then moves to one side of the cell and the other half moves to the opposite side. Next, a cell wall forms and divides the mother cell into two daughter cells, each with a nucleus, and each with a chromosome number like that of the mother cell. In this process the genetic qualities of the chromosomes remain the same in the two new cells. Thus, when cell division is normal, each progeny cell is genetically identical with every other cell.

However, division of the chromosome and genes occasionally fails to occur or is imperfect. After the chromosomes have split, the cell may fail to divide, so that the number of chromosomes may become doubled. Apparently this sometimes occurs in nature, and frequently under the influence of the drug colchicine when it is applied experimentally.

Also, a particular gene carrying a certain factor such as fruit skin color or time of fruit ripening may be changed, perhaps by imperfect division of the gene when the chromosome which carries it divides. Color of fruit, flower, or time of ripening of the fruit may therefore be modified in tissues produced from the cell carrying the changed gene. Only if the mutation occurs in the original fertilized egg of a flower is it likely that an entire plant will be affected. Presumably mutations may occur at any time that cell division occurs in tissues in any part of the plant. If the mutation happens to occur in a cell in a growing point, the changed characteristics of the cell may be expressed in the structures arising from that growing point. Unquestionably, however, many mutant cells in plants never give rise to structures that show the mutant characteristics.

It is now apparent why some mutations do not remain fixed under vegetative propagation. In many cases the mutant branch is made up of two regions; in one the mutation is present and in the other the tissue is normal. Some mutants are chimeras, which may produce both normal appearing plant structures such as fruits as well as some that show the mutation.

Certain treatments are known to increase the tendency of cells to mutate. The drug colchicine, applied to plant tissues in which cells are ac-

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tively dividing, tends to prevent the division of some of the cells after the chromosomes have divided. As a result, the number of chromosomes contained in such cells is doubled. Exposure of cells to X-rays and to radioactive radiations may also bring about mutations; but rarely have beneficial mutations been produced by radiation. Often the mutation induced by these means involves the loss of some essential character for plant development, and is more likely to be detrimental than beneficial. Exposure of dividing cells to extremely high or low temperatures may also induce mutations.

Our knowledge of how various parts of the plant develop has been greatly increased through studies of chromosome doubling (polyploidy) in various tissues resulting from colchicine treatments. Cells that contain double the chromosome number of normal cells are larger and have larger nuclei. They can readily be identified under the microscope in many plant tissues. When the chromosomes of a cell in the growing point of a bud or shoot are doubled, it is possible to determine what tissues or areas in a plant part —leaf, stem or fruit—are developed from the mutant cell. All such tissues will be made up of cells with a double chromosome number. Microscopic examination has shown that often, following the colchicine treatment, only the epidermal cells are polyploid, the internal tissue remaining normal. The reverse may also occur, the internal tissue being polyploid and the epidermis normal. In some cases only a part of the internal tissue consists of chromosome-doubled cells.

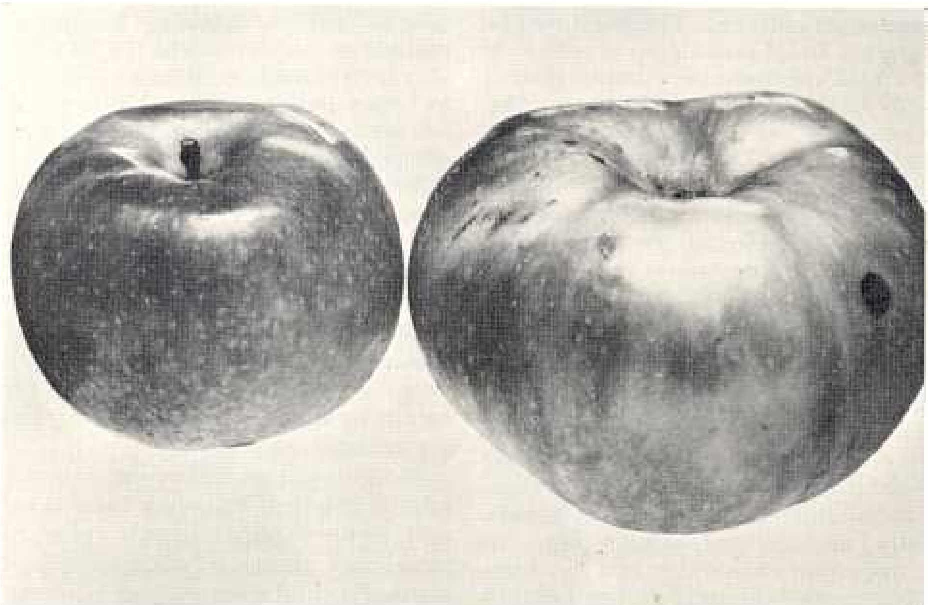

FIG. 1. A normal fruit (left) and colchicine induced tetraploid of the McIntosh apple.

Under the microscope, the cells in the terminal portion of the growing shoot-tip of fruit plants appear in layers. The outermost layer, designated L–I, gives rise to the epidermis. The inner layers, designated L–II and L–III, give rise to the internal tissues of the shoots, leaves, flowers and fruits. Critical study of leaves and fruits indicates that the relative amounts of tissue derived from L–II and L–III cells may vary considerably.

The pigments of the skin of fruits such as apple, peach and pear, are in the cells below the epidermis, cells normally derived from L–II. Tissue derived from L–II also normally gives rise to the egg and pollen grain cells. Thus a fruit skin color mutation occuring in L–II would normally be expected to show up in breeding. As far as has been studied, this has always been the case.

Fruits in which either the L–II or L–III cells have the chromosome number doubled will generally be larger than normal since the cells in such tissues are enlarged. The fruits will be larger if L–III is made up of cells with doubled chromosome number than if only L–II is polyploid. Fruits of maximum size would be obtained when both L–II and L–III have the chromosome number doubled.

In fruits such as apple, definite segments of the skin that are more highly colored, or more poorly colored than normal, or russeted, are seen fairly frequently. These sectors may be either quite narrow or broad. Such chimeras undoubtedly represent mutations that occur at some later stage of flower bud differentiation, specifically at a time when a terminal growing point differentiates into a flower.

A method by which shoots genetically uniform throughout may be grown from chimeral plants has been developed. This method has been to induce the development of adventitious (endogenous) buds. Such buds develop from a single cell or a group of cells of L–II or L–III tissue. All normal buds are removed from well-rooted vigorous young plants, which have been cut back to single stems. When this is done, adventitious buds sometimes form in an internodal region of the shoot. The tendency to such formation apparently differs with variety and kind of fruit. A number of such buds have been obtained on some apple varieties. So far we have failed to obtain them on peach. When true adventitious buds are formed, shoots derived from them consist entirely of cells like those of the tissue from which the bud was developed. If that tissue is polyploid, then the entire new shoot is polyploid; or if that tissue carries a color sport (mutation), then the adventitious shoot derived from it will be pure for the sport character.

From this description we can better understand how mutations occur in nature and how certain forms of mutations may be induced by special treatments such as colchicine. We can also better understand how mutations are often chimeral and why they may not always come true under vegetative propagation.

The valuable mutations that have been discovered in fruits have consisted mainly of earlier and more intensive coloring, and earlier or later maturing fruit. These are readily detected. Yet, many other types of mutations such as sweeter or more acid fruit undoubtedly occur. These would only rarely be detected, since whole trees are seldom involved.

Most mutations that occur naturally modify the fruit to only a limited extent, as for example, its skin color. In most cases, therefore, such mutations are similar to the parent variety except for the one character noted.