temporal (seasonal or long-term cycles) or functional (*e.g.*, males and females of species) i nature. In each 'ecological niche' a different 'phenotypic optima' is selected for so that t population ultimately consists of two or more recognizable forms; such a selection is calle ***disruptive selection***. The consequences of such a selection depend mainly on the followi two factors : (1) whether the different optimal phenotypes are independent of or depende on, each other for their maintenance or function, and (2) the rate of gene flow between the For example, the male and female forms of a single species are completely interdependent i function, *i.e.*, reproduction, and show 100% gene exchange. At the other extreme, a specie may occupy a habitat that is fragmented into two or more independent niches. In each niche different phenotypic optima is selected for. In such cases, if the selection pressure is hig enough and continued long enough, genetic barriers to crossing may arise leading to the genetic separation of these forms, and eventually to their evolution as distinct species.

Disruptive selection maintains polymorphism in a population. Further, it shows such features as frequency-dependence (*e.g.*, less frequent alleles being more favoured), density-dependence, cyclical nature, etc.; a discussion of these aspects is beyond the scope of this book. *Since disruptive selection is 'directional' in nature within each 'ecological niche' of the habitat, it favours dominance and epistasis. In addition, it often leads to the establishment of integrated 'supergenes', e.g., in case of male and female forms of a species.* A ***'supergene'*** is a set of closely linked genes that together lead to the development of a specific optimal phenotype, *e.g.*, a male or female form.

2.1.3. Changes in Plant Species under Domestication

The precise sequence of events during the evolution of crop plants under domestication is not known. Presumably in the initial stages, considerable genetic variability existed in each domesticated species. This variability was acted upon by both natural and artificial selections. It may be expected that man always tried to pick out the plant types, which better suited his needs. He would obviously have selected for larger fruits and seeds. Our record of planned and systematic selection goes only as far back as middle of the nineteenth century. Before this period, selection efforts were obviously unfocussed and primitive. But judging from the results, *i.e.*, the differentiation of crops from their wild prototypes, the then completely unscientific man was not a bad plant breeder at all. The domesticated species have undergone several important changes as a consequence of his efforts.

Domestication of crops is believed to have occurred independently in the following at least six regions : (*i*) Mesoamerica, (*ii*) the Southern Andes (including the eastern piedmonts), (*iii*) the Near East, (*iv*) Africa (probably the Sahel and the Ethiopian highlands), (*v*) South East Asia, and (*vi*) China. In spite of the geographical diversity of these centres, a remarkably similar set of traits seems to have been selected in widely different crops; these traits are called ***domestication syndrome traits*** (Table 2.1). The changes in crop traits under domestication have resulted from selection of spontaneous mutations. Almost all the characteristics of plant species have been affected under domestication. The characters that show more distinct changes are those that have been objects of selection and are still plant breeding objectives in many cultivated species. Some of the important changes that have occurred under domestication are briefly listed below.

TABLE 2.1
The different traits comprising domestication syndrome

Selection at growth stage	*Selected trait*		*Example crop(s)*
	General feature	*Specific trait*	
Seedling	Increased seedling vigour	Loss of seed dormancy	Many crops, *e.g.*, mungbean
Reproductive system	Increased rate of selfing	—	Tomato, sunflower, *B. juncea*
	Adoption of vegetative reproduction	—	Sugarcane, cassava, etc.
Harvest or after harvest	Increase in seed yield	Loss of seed dispersal	Legumes
		More compact growth habit	Legumes
		Increased number or size of inflorescence	Maize, wheat
		Increased number of grains/inflorescence	Maize
		Changed photoperiod sensitivity	Legumes, rice
		Colour, size, taste, texture	Many crops
		Reduction in toxic substances	Cassava, lima bean, cucurbits

1. ***Elimination of or reduction in shattering*** of pods, spikes, etc. has taken place in most of the cultivated species.
2. ***Elimination of dormancy*** has taken place in several crop species. Lack of dormancy has become a problem in crops like barley (*Hordeum vulgare*), wheat (*Triticum aestivum*), mung (*Vigna radiata*), etc.
3. ***Decrease in toxins*** or other undesirable substances has occurred in many crops. The bitter principle of cucurbitaceous plants provides an example of this type.
4. ***Plant type*** has been extensively modified. The cultivated plants show altered tillering, branching, leaf characters, etc.
5. In several crop species, there has been a ***decrease in plant height***, *e.g.*, cereals, millets, etc. This is often associated with a change from indeterminate to determinate habit.
6. In some species, on the other hand, there has been an ***increase in plant height*** under domestication, *e.g.*, jute (*Corchorus* sp.), sugarcane (*Saccharum officinarum*), forage grasses, etc.
7. ***Life cycle has become shorter*** in case of some crop species. This is particularly so in case of crops like cotton (*Gossypium* sp.), arhar (*Cajanus cajan*), etc.
8. Most of the crop plants show an ***increase in size of their grains or fruits.***

9. ***Increase in economic yield*** is the most noticeable as well as desirable change und domestication. This is self-evident in every crop species.
10. In many crop species, ***asexual reproduction has been promoted*** under domesticatio *e.g.*, sugarcane, potato (*Solanum tuberosum*), sweet potato (*Ipomoea batatas*), etc.
11. There has been a ***preference for polyploidy*** under domestication. Many of th domesticated plant species are polyploids, *e.g.*, potato, wheat, sweet potato, tobacc (*Nicotiana* sp.), etc., while diploid counterparts are present in nature.
12. In many species, there has been a ***shift in the sex form*** of the species. In man dioecious fruit trees, bisexual forms have developed under domestication. Sel incompatibility has also been eliminated in many crop species.
13. ***Variability within a variety has drastically decreased*** under domestication. Th extreme case is represented by pureline varieties, which are completely homozygou and homogeneous genotypically.

2.2. PATTERNS OF EVOLUTION IN CROP PLANTS

It is apparent that selection by nature and man has been responsible for the evolution of cro plants. However, selection is effective in altering a species only when genetic variabilit exists in the populations of that species. There are three major ways in which geneti variability has arisen in various crop species, *viz.*, (1) Mendelian variation (generated mainl by gene mutation), (2) interspecific hybridization, and (3) polyploidy. The patterns o evolution of various crops may, therefore, be broadly classified according to the mode o origin of genetic variation crucial for evolution of that species.

2.2.1. Mendelian Variation

Many crops have evolved through variation generated by gene mutation, and b hybridization between different genotypes within the same species, followed b recombination. Ultimately, all the variability in any species originates from gene mutations Most of the gene mutations are harmful and are eventually eliminated. But some mutation are beneficial and are retained in the population. The mutations may be grouped into tw categories: (1) macromutation and (2) micromutation. *A **macromutation** produces a large an distinct morphological effect, and often affects several characters of the plant.* A singl macromutation is believed to have led to the differentiation of modern maize (*Zea mays*) plan from the grassy pod corn. This mutation has affected the positions of male and femal inflorescences, the habit of the plant and several other characters. Similarly, cabbag (*Brassica oleracea*), cauliflower (*B. oleracea*), broccoli (*B. oleracea*), and Brussel's sprout (*B. oleracea*) have originated from a common wild species and they differ from each othe with respect to a few major genes.

The greater part of variation, however, has resulted from *mutations with small and les drastic effects, i.e., **micromutations***. Since micromutations have only small effects, they ten to be accumulated in a population. Natural selection would accumulate and select for mor favourable gene combinations. Man would have selected from the populations desirable plan