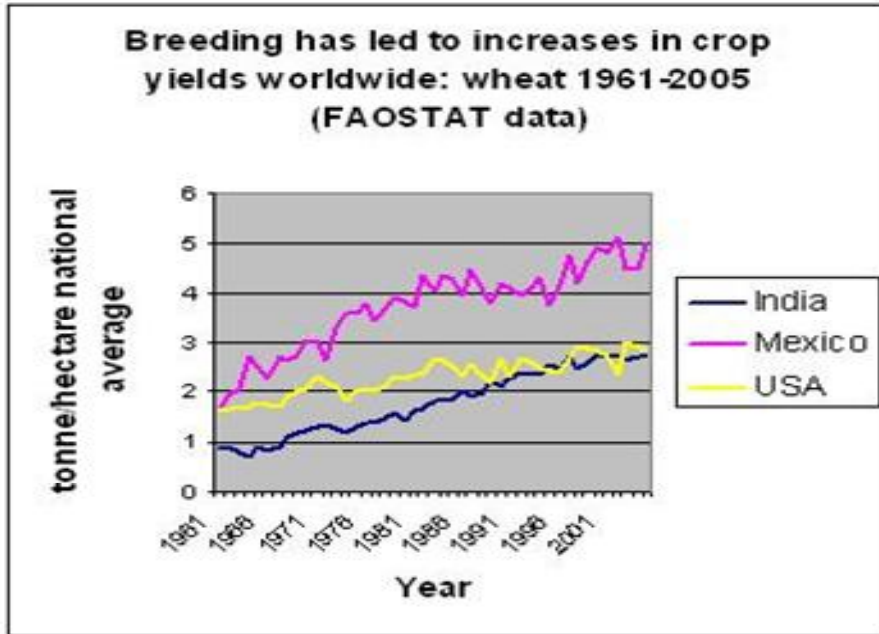


Plant breeding

Plant breeding is the purposeful manipulation of plant species in order to create desired [genotypes](#) and [phenotypes](#) for particular purposes, such as food production, [forestry](#), and [horticulture](#). Breeders have tried to introduce, into crop plants, traits that will increase the quality and yield of the crop; enhance their ability to tolerate harsh environmental conditions including salinity, high temperatures, and water shortage; enhance their ability to resist infection by viruses, fungi and bacteria, and enhance their ability to withstand insect pests and to tolerate herbicides.

Plant breeding is an artificial version of natural [evolution](#), involving artificial selection of desired plant characteristics and artificial generation of [genetic variation](#); it complements other farming innovations (such as introduction of new crops, [grafting](#), changed [crop rotations](#) and tillage practices, [irrigation](#), and [integrated pest management](#)) for improving crop productivity and land stewardship. Since 1930, crop breeding, in concert with these other innovations, has led to spectacular increases in crop yields especially with cereal grains. Plant breeding has been practiced since the beginning of human civilization, but rapid advances since 1900 have been driven by concepts and techniques developed in the science of [genetics](#). This scientific plant breeding has contributed about 50% of the improvement in crop yield seen in the major cereal crops since 1930 http://en.citizendium.org/wiki/Plant_breeding.

Plant breeding is practised by both [government](#) institutions and commercial enterprises. International development agencies believe that breeding new crops is important for ensuring [food security](#) and for developing [sustainable agriculture](#) by developing crops that minimize agriculture's impact on the environment.



FAOSTAT data December 2006

[Domestication](#) of plants is an [artificial selection](#) process conducted by farmers to produce plants with fewer undesirable traits than wild plants, and which makes them dependent on artificial (usually enhanced) environments for their continued existence. Many crops in present-day cultivation are the result of domestication in ancient times, about 5,000 years ago in the [Old World](#) and 3,000 years ago in the [New World](#). In the [Neolithic](#) period, domestication took at least 1,000 years and possibly as much as 7,000 years. Today, all of our principal food crops come from domesticated varieties.



A bowl of indica (white, long grains) and japonica (brown, short grains) rice. [From: 'Rice genome approaches completion'](#)

A cultivated crop [species](#) that has evolved from wild populations due to selective pressures from traditional [farmers](#) is called a [landrace](#). Landraces, which can be the result of natural forces or domestication, are plants (or animals) that are ideally suited to a particular region or environment. An example are the landraces of [rice](#), *Oryza sativa* [subspecies](#) *indica*, which was developed in [South Asia](#), and *Oryza sativa* subspecies *japonica*, which was developed in [China](#).

Genetics and crop breeding intertwined

Plant breeders created the earliest artificial hybrids between different species (such as the feed cereal [Triticale](#)) in the 19th century, and progress in the science of [genetics](#) has been intertwined with crop breeding ever since. In 1903, W. L. Johannsen defined the heritable component of biological variability in experiments with a self-pollinated bean. In 1908, US plant breeder G. H. Scull discovered substantial crop yield improvements in interspecies hybrids of maize (now called 'hybrid vigor' or [heterosis](#)) with dramatic consequences for the development of a successful commercial corn-seed breeding industry, first in the USA and later elsewhere. Plant geneticists subsequently realized that hybridization can allow fuller exploitation of genetic diversity available in a plant population, and developed widely used interspecies hybrids for [pearl millet](#), [sorghum](#), [rice](#) and [rapeseed](#) (canola) crops.

[Barbara McClintock](#) developed fundamental concepts about [chromosome](#) behavior and [cytogenetics](#) with [maize](#) in the 1930s. Chromosome and genome relationships both within and between crops species have been the conceptual keystones to much successful crop breeding. It is now realized that most crops have undergone duplication of the minimal [diploid](#) set of chromosome at some stage, either as ancient duplications (as in the case of [maize](#)), or by hybridization between different species (as in [allopolyploids](#) such as [wheat](#))

Protecting major crops against disease has rested on alien gene transfer into the crop variety using chromosomal engineering. This technique relies on manipulation of chromosome pairing at [meiosis](#). In 1956, chromosomal engineering enabled Ernest Sears to translocate a segment of goatgrass (*Agilops umbellulata* Zhuk) chromosome that conferred resistance to [leaf rust](#) onto wheat chromosome 6B, and this achievement

was followed by numerous successes in transfers of alien genes to crop plants by chromosome manipulation (the so-called wide-crosses)

Chromosomal engineering is facilitated by using X-ray radiation to promote chromosome breakage, plant tissue culture, and mutants such as *Ph-1* of wheat that relax normal strict pairing of homologous chromosomes in meiosis. It can be valuable to artificially promote doubling of chromosome number using [colchicine](#) in inter-species and inter-generic cross hybrid lines as a step to enable transfer of alien chromosome segments into crop germplasm.

The expansion of biotechnology after 1980 led to many advances in genetics which are accelerating the usually slow process of plant breeding and leading to important discoveries that improve plant breeding, such as [molecular markers](#), plant [genomics](#), [RNA interference](#), and numerous gene characterizations such as the genes affecting [abiotic stress](#) responses and pest and pathogen tolerance.

Strategies for scientific plant breeding

The starting point for plant breeding is the identification of novel, useful traits in [populations](#) of parental organisms. The use of chemically or radiation induced [mutation](#) can also be exploited to increase the range of useful genetic variability, and plant breeding exploits [genetic recombination](#) to generate novel combinations of traits. The end-result of lengthy selective breeding programs using these methods is "elite" varieties of high performing [germplasm](#) for major crops that are used widely in broad-acre farming.

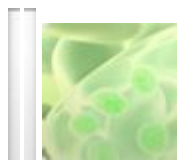
Plant breeding strategies used by the International Maize and Wheat Improvement Center (CIMMYT) encapsulate the way in which modern plant breeding should be pursued. CIMMYT wheat breeding strategies aim to achieve an optimal combination of the best genotypes, in the right environments, under appropriate crop management, and appropriate to the needs of the people who must implement and manage them.

Useful traits

Techniques for increasing the available heritable variation in the initial population include introduction of new germplasm from distant geographical regions or from seed-bank collections, cross-pollination, either within the species, or between related species and genera - including

wide-crosses using wild relatives of domesticated plants to introduce pest resistant traits needed in domesticated varieties, and creation of [mutations](#) by irradiation or chemical treatment.

Variation: differences between parents and their offspring or among individuals in a population. It is an important aspect of breeding, for if all organism look alike there will be no bases for breeding work. Variation in a population or among a group of individual therefore is important to the breeder.



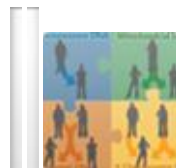
CELLS



DNA TO PROTEIN



PROTEIN



HEREDITY & TRAITS (pass from one generation to the next)

SYNTHESIS,
generation to the next)



South Asian Wolf, *Canis Lupus*
the ancestor of the domestic d

VARIATION DOES EXIST EVEN IN ANIMAL OF THE SAME SPECIES.

Genetic variability is a measure of the tendency of individual [genotypes](#) in a [population](#) to vary from one another. Variability is different from [genetic diversity](#), which is the amount of variation seen in a particular population. The variability of a trait describes how much that trait tends to vary in response to environmental and [genetic](#) influences.^[1] Genetic variability in a population is important for [biodiversity](#), because without variability, it becomes difficult for a population to adapt to environmental changes and therefore makes it more prone to [extinction](#).

Variability is an important factor in [evolution](#) as it affects an individual's response to environmental stress and thus can lead to differential survival of organisms within a population

due to [natural selection](#) of the most fit variants. Genetic variability also underlies the differential susceptibility of organisms to diseases and sensitivity to toxins or drugs — a fact that has driven increased interest in [personalized medicine](#) given the rise of the [human genome project](#) and efforts to map the extent of [human genetic variation](#) such as the [HapMap project](#).

Causes

There are many sources of genetic variability in a population:

- [Homologous recombination](#) is a significant source of variability. During [meiosis](#) in sexual organisms, two [homologous chromosomes](#) from the male and female parents cross over one another and exchange genetic material. The chromosomes then split apart and are ready to form an offspring. [Chromosomal crossover](#) is random and is governed by its own set of genes that code for where crossovers can occur (in cis) and for the mechanism behind the exchange of [DNA](#) chunks (in trans). Being controlled by genes means that recombination is also variable in frequency, location, thus it can be selected to increase [fitness](#) by nature, because the more recombination the more variability and the more variability the easier it is for the population to handle changes
- [Immigration](#), [emigration](#), and [translocation](#) – each of these is the movement of an individual into or out of a population. When an individual comes from a previously genetically isolated population into a new one it will increase the genetic variability of the next generation if it reproduces.
- [Polyploidy](#) – having more than two homologous chromosomes allows for even more recombination during meiosis allowing for even more genetic variability in one's offspring.
- Diffuse centromeres – in [asexual](#) organisms where the offspring is an exact genetic copy of the parent, there are limited sources of genetic variability. One thing that increased variability, however, is having diffused instead of localized [centromeres](#). Being diffused allows the [chromatids](#) to split apart in many different ways allowing for chromosome fragmentation and polyploidy creating more variability.
- Genetic [mutations](#) – contribute to the genetic variability within a population and can have positive, negative, or neutral effects on a fitness. This variability can be easily propagated throughout a population by [natural selection](#) if the mutation increases the affected individual's fitness and its effects will be minimized/ hidden if the mutation is deleterious. However, the

smaller a population and its genetic variability are, the more likely the recessive/hidden deleterious mutations will show up causing genetic drift.

Sources of Variability/ Variation.

- Immigration of genes
- Mutation

Mutation—natural or spontaneous mutation

- induced mutation

Induced mutation: (a) use of chemicals e.g EMS, mustard gas, ethyldiumbromide (b) Radiation e.g X-ray, UV, infrared ray.

Virtually every organism show individual differences in nature, these differences could be continuous or discontinuous.

i. Qualitative or discontinuous characteristics: possess only a few distinct phenotypes and can be grouped into distinct phenotypic classes. They are usually inherited in a Mendelian ratio e.g flower, pod and seed coat colour, seed coat texture- plant.

ii. Qualitative or continuous characteristics: these arise from 2 phenomena

(b) Many are polygenic i.e they are influenced by genes at many loci, and therefore many genotype are possible each producing a slightly different phenotype.

(c) When environmental factors affect the phenotype because environmental differences result in a single genotype producing a range of phenotype.

Examples of qualitative traits; height, yield, days to flowering or maturity, pod length etc (agronomic traits).

- Recombination
- Crossing Over