Humans choose the parents

Artificial selection, or selective breeding, changes populations by controlling which individuals reproduce. Progress depends on heritable variation in the desired traits.

1. DEFINE A BREEDING OBJECTIVE

Choose measurable traits, such as disease resistance or milk yield. A desirable trait is useful to people; it is not necessarily advantageous in the wild.

2. SELECT AND CROSS PARENTS

Identify individuals likely to pass on useful alleles, then breed them. Selection uses existing genetic variation; choosing parents does not create the mutations they need.

3. ASSESS AND SELECT OFFSPRING

Offspring differ because alleles segregate and recombine. Retain suitable offspring as parents, considering inherited potential as well as their observed performance.

4. REPEAT OVER GENERATIONS

Repeated breeding and selection can increase the frequency of alleles contributing to the desired trait. Improvement is not guaranteed in every offspring or indefinitely.

5. DISTINGUISH THE PROCESSES

Natural selection: environmental conditions influence relative reproductive success.
Artificial selection: breeders decide which parents contribute.
Genetic engineering: DNA is directly altered; ordinary selective breeding does not require this.

Principles and distinctions: Wellcome Connecting Science, YourGenome.
Required breeding examples: Cambridge 9700, section 17.2.

Scope: Cambridge Biology 9700, section 17.2, outcomes 6-7, p. 43.

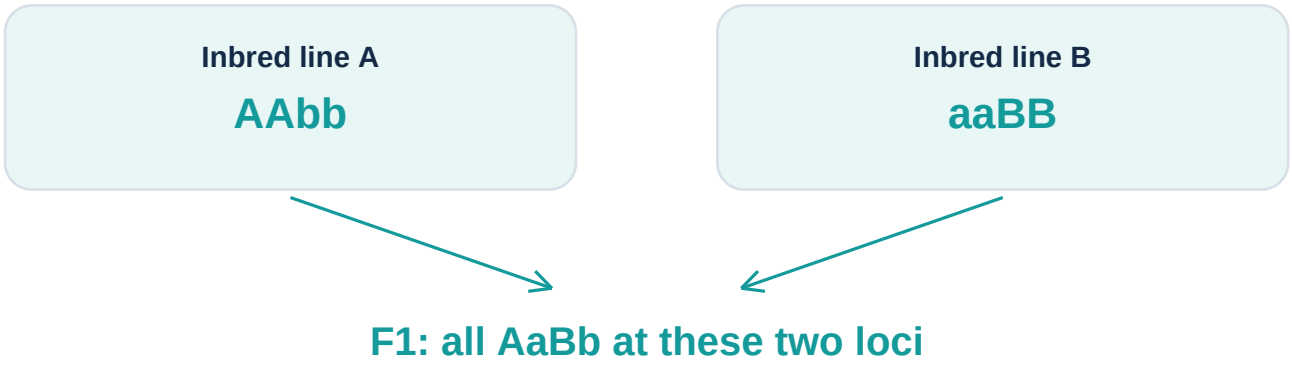
Breed resistance and hybrid vigour

Crop breeding combines useful alleles and tests their effects. Disease-resistant cereals and uniform maize hybrids illustrate two different breeding strategies.

1. DISEASE RESISTANCE IN WHEAT OR RICE

Cross a high-yielding variety with a compatible resistant donor. Select descendants that retain resistance and useful crop characteristics. Backcrossing to the high-yielding parent, with selection for resistance, can recover much of its genetic background. Field testing checks performance before release.

2. MAIZE: INBREED FIRST, THEN CROSS



Repeated self-pollination increases homozygosity within each line. Crossing two selected, genetically different inbred lines produces an F1 that is uniform between plants yet heterozygous at loci where its parents differ.

The genotypes illustrate inheritance only, not real maize yield genes. Uniformity between individuals does not mean homozygosity within each individual.

3. WHY PRODUCE F1 SEED AGAIN?

Suitable crosses can show hybrid vigour (heterosis): improved growth or yield compared with their inbred parents. In the F2, segregation and recombination break up combinations, reducing uniformity and often performance. Breeders maintain the parental lines and repeat the cross for new F1 seed.

Resistance breeding: International Rice Research Institute, Rice Today.
Maize hybrids and saved seed: Cornell University, Crop Adviser Resources.
Inbred lines and F1 production: University of Florida IFAS.

Scope: Cambridge Biology 9700, section 17.2, outcomes 6-7, p. 43.

Improve yield without losing resilience

Milk production reflects both genotype and environment. A breeding programme aims to improve inherited potential while maintaining health, fertility and useful genetic variation.

1. MEASURE INHERITED POTENTIAL

Record milk yield and compare animals while accounting for factors such as feed, age and stage of lactation. A well-fed cow is not automatically genetically superior. Breeding values use performance, relatives and, increasingly, DNA information to estimate genetic merit.

2. SELECT BOTH SIDES OF THE PEDIGREE

COWS

Choose females with suitable records and genetic merit.

BULLS

Use genetic evaluations, including information from relatives and daughters.

Breed, assess offspring, select again

A bull does not produce milk, but can transmit alleles affecting his daughters' milk yield.

3. BALANCE BENEFITS AND COSTS

Selecting only for yield can overlook fertility, disease resistance and welfare. Modern breeding objectives combine production with health and management traits. Retain multiple breeding lines and avoid overusing closely related parents.

4. INBREEDING IS NOT THE SAME AS SELECTION

Inbreeding increases homozygosity, making harmful recessive alleles more likely to be expressed. Using a narrow parent pool can also reduce diversity, leaving fewer variants for future breeding or changing conditions.

Milk traits and genetic evaluations: AHDB, Traits and Indexes.
Balanced selection: AHDB, UK Breeding Objectives.

Scope: Cambridge Biology 9700, section 17.2, outcomes 6-7, p. 43.