



*Joshua Lederberg*

# Crossbreeding Is Nature's Device to Speed Evolution

REPRODUCTION and sex are closely associated in the biology of the animal world. Many plants show more options, reproducing either sexually, from pollen to seeds, or vegetatively, by cuttings, runners or bulbs. And within any organism, the proliferation of cells is a reproductive process, likewise vegetative or asexual.

From an evolutionary point of view, sex is a secondary superstructure built over the more primitive processes of asexual reproduction. It is nevertheless a very ancient one. Sexual processes are now known to occur in the most primitive forms of life, the unicellular bacteria, molds and algae.

In these organisms, vegetative reproduction is the usual mode but it is occasionally punctuated by the merging and reshuffling of genetic information from two distinct lines of cells. This kind of "genetic recombination" can also be demonstrated for the simplest viruses. Most recently, there have been exciting indications of a successful reconstruction of the enzyme system for the combination of DNA molecules in the test tube.

IT IS UNIVERSALLY accepted that the fundamental use of the sexual process throughout the living world is to serve evolutionary variation, to ensure that as many recombinations as possible of the existing genetic types will be generated. The fittest among these diverse progeny will then be sieved by natural selection for a preferential part in further generations.

We know many examples of genes which may have a neutral or even detrimental

effect when present alone. These need to be favorably recombined to show their utility. An efficient eye would be useless without a corresponding region in the brain to process its signals and another one to control the muscles that aim and focus it.

Evolutionary progress of life is therefore firmly dependent on the frequent occurrence of gene recombinations via sexual reproduction. In this light, we are not surprised to see so many elaborate mechanisms by which crossbreeding is encouraged. These may be contrary to easy reproduction, especially for plants lacking active means of travel and spreading only by their own growth.

With these life habits, finding a compatible mate may be so difficult that dividing the population equally into two sexes would penalize the species: half of the random encounters would be useless. So this problem is sometimes solved, as it is in the mushrooms, by evolving not just two but a large number of mating types, of which any pair can unite unless the two individuals are exactly the same.

Then if they are, say, ten mating types, 90 per cent of random encounters will be fruitful. At the same time, cells from the same colony will still be excluded from a

sexual process that could give no useful recombinations.

MOBILE LIFE, as in the animal world, has evolved another solution: the active pursuit of the opposite sex. This entails not only limbs for the chase but all the behavioral drives and cultural milieu in which higher sexuality is embedded.

In the higher mammals and man, these drives have become deeply intertwined with all of the other highly evolved functions. How deeply the brain is involved hardly needs to be elaborated except to remark how important the correct assortment of sex roles is for every aspect of human performance.

This efficient biological and behavioral apparatus to support crossbreeding in the reproduction of mammals is associated with a commitment to sex in the maintenance of the species. The possibility of vegetative reproduction has virtually disappeared in the natural history of the vertebrates and perhaps altogether in the mammals. Nevertheless, some exceptions show that whatever has been de-evolved that was needed for vegetative reproduction may be relatively easy to restore either by chance evolution or by intelligent design.