Student 3: Low Merit

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Selective breeding of corn was originally done by ancient farmers by choosing kernels with specific traits such as the ability to grow
1 well in various climates, soil types and produced the largest number of kernels. A kernel is a seed that has resulted from a female egg fertilised by a male pollen grain. This means only the best or most suitable kernels will grow and reproduce. Over time, the quality of the crop will increase as the favoured offspring reproduce repeatedly.

However, planting a kernel from a corn plant that appears to have one or more desirable 2
traits is not always reliable. The outcome of selective breeding is not always guaranteed, because of hidden genes and mutations that can happen. Even though its phenotype may seem to be suitable, the genotype (and therefore phenotype) of its offspring may not be suitable. If the original plant had a recessive gene in its genotype that was not expressed in its phenotype, and its egg was fertilised with a male pollen grain that also had a recessive
1 gene, there would be a chance of the kernel being homozygous recessive. This would mean that the particular phenotype expressed in the original corn plant would not be expressed in the new plant.

Selective breeding has become easier with time. The offspring of selectively bred corn plants will inherit similar genes, traits and DNA from its selectively bred parents .Farmers can now deliberately cross two members of the same species that both possess either homozygous dominant or homozygous recessive genes and almost guarantee a purebred offspring. The first way was by using a test cross. By crossing one organism that is showing the dominant
1 form of a trait with another of the same species that is homozygous recessive for the same trait; it is possible to determine the other organism's genotype from the traits expressed in the offspring. Other more efficient methods like marker assisted selection (MAS) are now used for indirect selection of desirable traits. MAS can be useful for traits that are difficult to measure or are expressed late in development. The process for MAS includes mapping and then using this information for marker assisted selection.

Since humans have begun selectively breeding a number of crop plants, including corn, the genetic diversity of these plants has decreased. A biological implication is that the outcome may not be completely successful because of linked genes. Linked genes are those that are 2
found on the same chromosome and tend to be transmitted together. The negative consequences of using and/or reproducing that plant would probably outweigh the positive features. Similarity within species also means that if the species comes into contact with a disease, there is a high chance of the whole species being wiped out. Its scarcity will have implications on other things. For instance, it could have detrimental effects on ecosystems if one species is removed from a food chain.

Genetic cloning of whole corn plants is another way to produce crops with desirable traits.
3 The techniques used allow scientists to introduce certain genes into a plant without having to go through the risky trial-and-error process of selective breeding, as biologists have more control throughout the process. It is relatively easily to add certain genes one species may not naturally possess. Genetically modified corn crops include Bt corn. These crops have been modified for specific beneficial traits to assist with pest resistance and herbicide tolerance. The technique used for cloning of Bt corn is a form of transgenesis, which is when genes from one organism are transferred to another organism of a different species.
Bt corn came about to try to prevent corn crops being destroyed by pests such as insects. 'Bt' stands for the soil bacterium *Bacillus thuringiensis*. This pathogen produces toxins that act as insecticides and kill insects. Scientists insert a gene from the bacterium into corn cells
3 in order to reduce the damage done by pests like the European corn borer (ECB) that eats corn stems.
To make Bt corn, biologists start with a plasmid in *Agrobacterium tumefaciens*. Plasmids are genetic structures that can replicate independently of chromosomes, and this particular type

3 of plasmid is used often as a means to transfer genetic information from one organism to another. *Agrobacterium tumefaciens* is used as the vector because it has a large plasmid. The plasmids that have the Bt gene inserted can be used to add the gene to target cells in corn. Cells are taken from the corn and the cell walls removed. They are grown on a nutrient and treated with recombinant *Agrobacterium*. These cells form a callus which is further treated with hormones and then grown into transgenic corn plants. The large plasmids become incorporated in the host corn cell's DNA. By cloning corn plants, the rate of crop yield can be improved. This technique is used because *Agrobacterium* is a naturally occurring soil bacterium that infects some plants and causes crown gall disease.

A biological implication of pest resistant Bt corn is that there will be less genetic diversity within the population, as the plants have been cloned and reproduced from the same one plant, meaning all their genes will be identical. In the same way that little genetic variation affects selectively bred plants, it will affect genetically modified plants. If all the corn plants have identical DNA they will all be susceptible to the same things, such as; particular diseases, drought, floods, bad soil quality and herbicides/pesticides, etc. 4
Another biological implication of Bt corn is the possible negative effects it can have on populations other than those intended. A study done in 1999 found that Bt corn is also toxic for Monarch butterfly larvae. They suffered a significant decrease in fitness when their normal diet was dusted with Bt corn pollen.

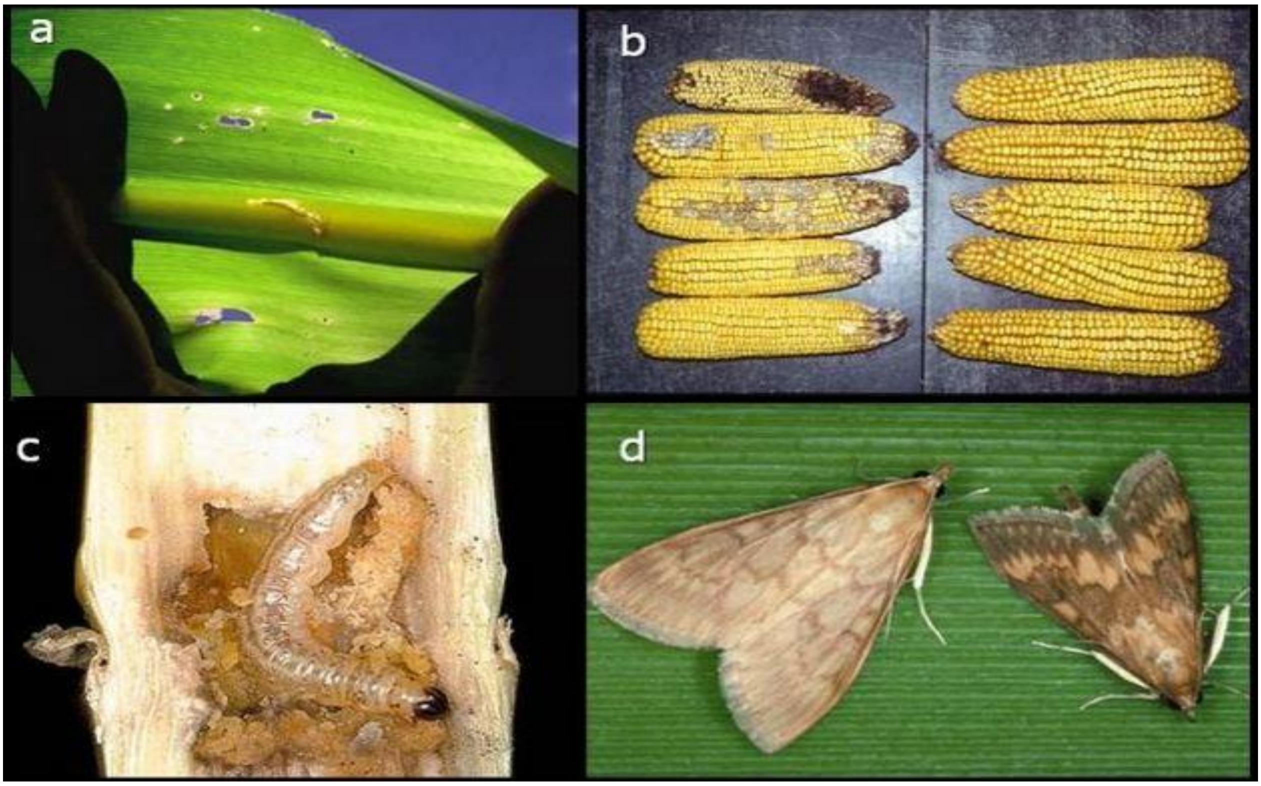

Figure 1
European corn borer: shotholes and tunnel in leaf midrib (a), damage and fungal infection in non-Bt maize (left) and Bt maize (b), stalk tunneling (c), and adult female (left) and male (d). [a, c, d photos courtesy of Marlin Rice, b photo courtesy of Gary Munkvold]

2 As there is little genetic variation in selective breeding, if a species is wiped it will have effects on other organisms as part of an ecosystem and food chains and food webs. The aim of plant breeders is to assemble a collection of genes in a crop like corn to make it useful and as productive as possible. The world population has topped seven billion people and is expected to double in the next 50 years. Ensuring an adequate food supply is a major challenge in years to come to ensure the survival of the human species. 2