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Thinking Matters Symposium

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## Genetically Modified Organisms are Important but Also Controversial

Masen Pelletier

*Southern Maine Community College*, [masengpelletier@smccme.edu](mailto:masengpelletier@smccme.edu)

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# Genetically Modified Organisms Are Important But Also Controversial

–Masen Pelletier, Southern Maine Community College, South Portland, Maine–



Figure adapted from Oliver M

Abstract : Genetically modified organisms (GMOs) are organisms containing a set or multiple sets of genes that have been introduced into the organism using laboratory techniques. In the instance of agriculture, the genes introduced provide advantages for the farmer and consumer by yielding plants that produce greater yields, longer growing seasons, longer shelf lives, greater concentrations of vitamins or add additional vitamins that are novel to the plant. There are two general ways that GM (genetically modified) crops are produced: the addition or removal of genes. This review will focus on an example of each strategy. an example of the latter is GM *A. bisporus* fungi in which genes are removed. Production of polyphenol oxidase has been disabled by knocking out one of the polyphenol oxidase (PPO) genes, and the reduced PPO activity allows the mushrooms to have a longer shelf life. An example of the former is golden rice, in which genes for 4 additional enzymes are introduced into *Oryza sativa* using *Agrobacterium* allowing production of  $\beta$  carotene the precursor of vitamin A. The controversy around GMOs stems from the idea of novel proteins being introduced into plants. Some are concerned about genetic drift of the novel genes. Organisms with a gene removed may be less controversial as an agricultural product. Greater controversy surrounds a transgenic GMO such as golden rice.

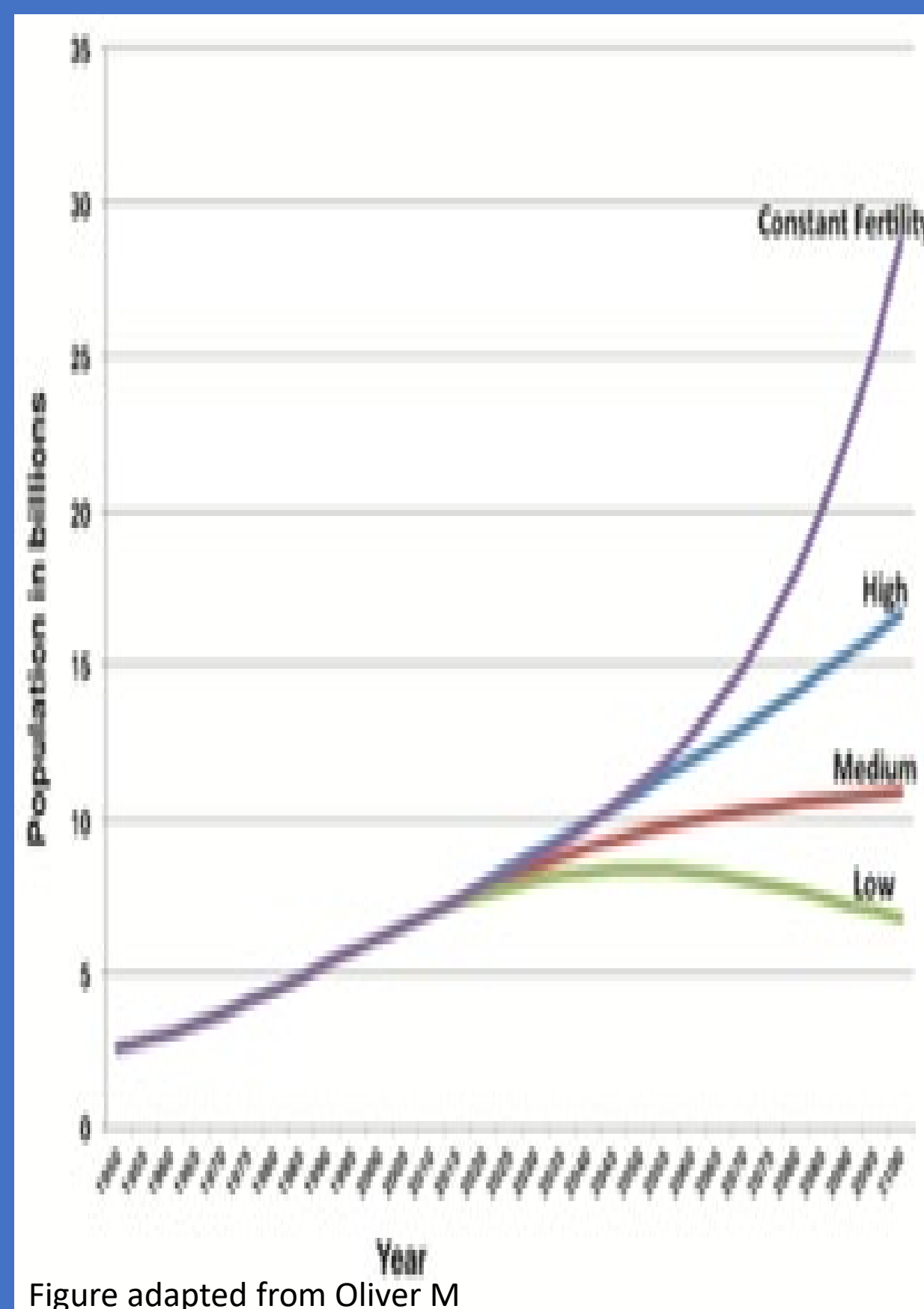


Figure adapted from Oliver M

## The Importance Of GMOs

- ◆ The current population is 7.8 billion.
- ◆ By 2050 the estimated population ranges from 8.3 to 10.9 Billion people.
- ◆ In 2012 868 million people were suffering from hunger and malnutrition.
- ◆ In order to provide sufficient food for the global demand agricultural production will have to double by 2050.
- ◆ Climate change and water resource issues make such efforts more challenging.
- ◆ GM's such as the wheat produced by Rothamsted Research can increase yields 20%.

## The Controversy Of GMOs

- ◆ GMOs are often seen as unnatural and pushing the boundaries of nature, because modifying genomes gives rise to a completely novel organism, that would have never existed without genetic intervention.
- ◆ Perhaps if they knew of systems such as CRE-LOX or CRISPR-Cas9 that can selectively remove genes that may be harmful to the environment, these worries would be relaxed.
- ◆ Other concerns stem from how GM foods were introduced into the market. Unlike GM medicines, consumers of the GM foods were not sat down and counseled on the pros and cons of the technology.
- ◆ People often only support things they can see direct benefits from. Focus groups consisting of people from the general public, expressed skepticism towards the research being used for the purposes of helping third world countries. However, golden rice was a community backed project, that was a non-commercial venture, who aimed to make golden rice as cheap as possible and easy to distribute.

## Golden Rice

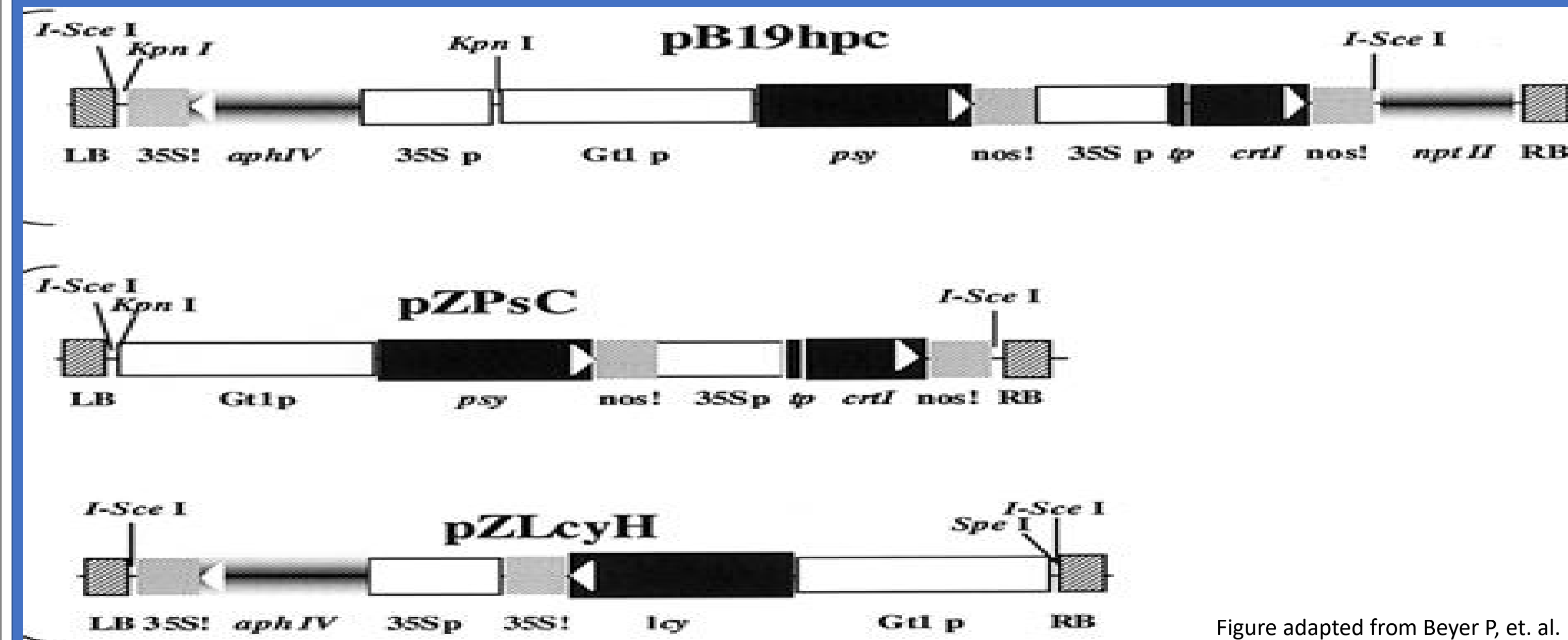


Figure adapted from Beyer P, et. al.

- ◆ The lack of vitamin A in rice causes countries using it as a staple to suffer from vitamin A deficiency.
- ◆ Rice endosperm produces geranylgeranyl diphosphate, an early intermediate in the production of  $\beta$ -Carotene.
- ◆ 3 proteins are required for the completion of the  $\beta$ -Carotene biosynthetic pathway, phytoene synthase, lycopene  $\beta$ -cyclase and phytoene desaturase.
- ◆ In order introduce these 3 proteins into *Oryza sativa*, agrobacterium-mediated transformation methods were employed in order to deliver the plasmids depicted in figure 3.
- ◆ The pB19hpc plasmid carries sequences for plant phytoene synthase that originates from daffodils and bacterial phytoene desaturase. Both sequences were fused with their own transit peptide in order bring them to the endosperm plastids, the site of the biosynthetic pathway.
- ◆ The pZPsC plasmid carries sequences for plant phytoene synthase and bacterial phytoene desaturase like pB19hpc, however it lacks the set of sequences for the aphIV marker.
- ◆ The PZLeyH plasmid carries sequences for the enzyme lycopene  $\beta$ -cyclase, originating from *N. pseudonarcissus*. The sequence for  $\beta$ -cyclase is also attached to a sequence that codes for a transit peptide in order to bring the protein into the plastids of the endosperm. Thus, completing the  $\beta$ -Carotene biosynthetic pathway.

## The CRE-LOX System

- ◆ Markers are often used in order to detect for the presence of transformation.
- ◆ The most used markers are those that code for antibiotic and herbicidal tolerance.
- ◆ The inclusion of these markers in the final product is thought to pose unacceptable environmental risk.
- ◆ In order to remove these markers enzymes called site specific recombinases are used.
- ◆ In order to remove the gene of interest Lox is coded with recognition sites for the target gene in tandem direction. Thus, allowing LOX to recognize the sequence, and CRE to act upon the it and remove it.

## PPO Knockout Mushrooms

- ◆ The rapid browning of white button mushrooms leads to major economic loss.
- ◆ In order to combat this problem CRISPR-cas9 based knockout was used to reduce oxidation of phenols, such as tyrosine, by performing a knockout on a polyphenol oxidase gene (PPO).
- ◆ By performing a knockout on a single PPO gene in specific bases, the total PPO activity is taken down by 30% leading to a reduction of browning and an increased shelf life.
- ◆ By encoding the synthetic guide RNA with the sequence for the PPO gene of interest, the Cas endonuclease can make a double strand break and repair the broken ends by fusing the free ends together.

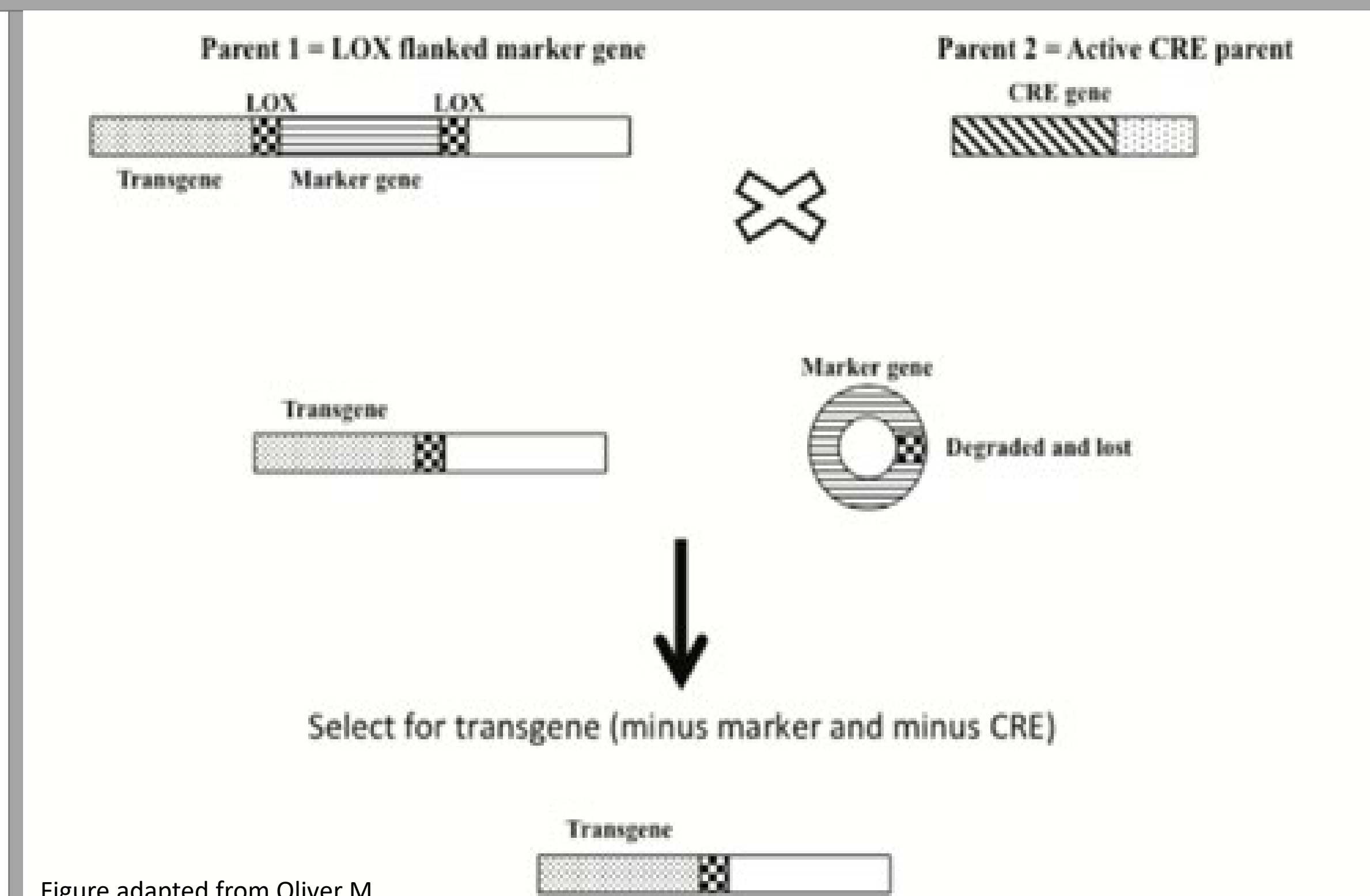


Figure adapted from Oliver M

**Acknowledgements: 2021 genetics class, Daniel Moore, SMCC.**

## Citations

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