Transgenic Plants: Friend or Foe of Sustainable Agriculture

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What is a transgenic plant?

1. A plant whose genetic make-up has been changed from the “wild” version.
2. A plant that has had gene(s) transferred into its genome from another species
3. A genetically modified organism
4. A plant that has had gene(s) inserted into its genome using recombinant DNA technologies
What techniques are used to make transgenic plants?

1. “convince” plant cells to accept new DNA using bribes of gold or other precious metals.

2. Plant cells are subjected to torturous electric shock treatments to force them to alter their genetic material.

3. Plants are held at gun point and forced to change their genetic identity.

4. Plants are subject to treatment with infectious bacteria that alter their genetic make-up.
How sure are you of the answers you just gave?

1. I am so sure that I would be willing to give a lecture on it during Dr. Puthoff’s Plant Physiology class.

2. I do not know about a lecture, but I would be confident enough to explain it to a friend.

3. I would only explain it if I was sure the person to whom I was explaining it did not know anything about transgenic plants.

4. I just guessed.
GMO vs. transgenic plant

Regeneration of Haploid Plants After Distant Pollination of Wheat Via Zygote Rescue

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Haploid wheat plants have been produced by a new method of zygote rescue carried out after distant pollination. Wheat stigmas were pollinated with maize pollen and subsequently the activated egg cells from the elongated ovaries were rescued for in vitro plant development in single cell culture. As the control, 2-week-old embryos were also dissected and then cultured. The efficiency of both techniques was comparable. Wheat was also pollinated with rice, and the further development of rescued zygotes into multicellular structures is reported here for the first time. Because the lack of a normal endosperm hampers embryo development even in the early stages, early zygote rescue (two days after distant pollination) may represent a more efficient way of producing double haploid (DH) plants in cultivars that are recalcitrant in androgenic cultures, after further optimization of in vitro culture of isolated single cells.
GMO vs. transgenic plant

Credit: Nicolle Rager Fuller, National Science Foundation
Musa acuminata crossed with Musa balbisiana gives us bananas.

Triticum aestivum crossed with Secale cereale gives us triticale
One thing is clear – we will need more food.
Ways to increase the amount of food:
    Eat less
    Waste less
    Grow more
    produce more with what we have
    get more land into production
Let’s talk genes

Humans have about 20,000 genes
other animals about the same
Plants have about 25,000 genes
Fungi have about 20,000 genes
Bacteria have about 4,400 genes (E. coli)

They all have the same basic structure

Promoter | Coding sequence | Terminator
They all have the same basic structure

Kim and Triplett 2001
They all have the same basic structure.

Promoter

Coding sequence

 Terminator

The image shows a diagram of a coding sequence with Promoter and Terminator regions. The sequence provided is a string of nucleotides typical of a coding sequence in a gene. The diagram is labeled with the regions and the sequence is shown below.
They all have the same basic structure

They all have the same basic structure
The cool thing is you can mix and match them...
**glo fish**

http://www.agripinoy.net/cultivation-of-tobacco.html
How to make a transgenic plant:

Agrobacterium tumefaciens
Agro inserts DNA into plant cells for its own benefit
Tissue culture process

http://generalhorticulture.tamu.edu/YouthAdventureProgram/TissueCulture/TissueCulture.html
Other ways to get gene into plants

Electroporation

http://artsci.wustl.edu/~anthro/blurb/Backgrounder.html
Most common transgenic plants

- **Corn**
  - Bt and herbicide resistance
- **Soybeans**
  - Bt and herbicide resistance
- **Canola**
  - herbicide resistance
- **Cotton**
  - Bt and herbicide resistance
- **Sugar beet**
  - HR
- **Papaya**
  - virus resistance
- **Squash (summer)**
  - Multi-virus resistance
- **Flax / linseed**
  - HR
- **Tomato**
  - Delayed ripening
  - Bt
- **Tobacco** - reduced nicotine
- **Rice** - HR
- **Plum** – plum pox virus
- **Potato** – colorado potato beetle; PVY
- **American chestnut** - sort of
Sustainable Agriculture -
What does that mean?

Environmental responsibility
Economics
Practicallity
What transgenic crops do for us?

Theoretically, anything
Practically, if given enough time, anything

Golden Rice
Added genes from daffodils and bacteria to increase B-carotene
Need to eat a lot
Next generation added iron accumulation
All patents on genes and technologies were waived
Drought tolerance

Additional antioxidant
First generation transgenic crops
simple traits – 1 or 2 genes
herbicide resistance
insect resistance
virus resistance

Next generation transgenic crops
complicated traits – 3 – 10 genes
nutrition
drought / WUE

By Andrew Davis, John Innes Centre
Environmental effects

– CONS

• Gene escape / transfer to close relatives
  – Could give them edge
    • depends on the trait

• Increase in resistance to
  – Insecticides
  – Herbicides (super weeds?)

• Non-target species
Environmental effects

- **PROS**
  - Less toxic herbicides and insecticides can be used
    - Glyphosate
    - Bt
  - Could save water / pesticide / fertilizer applications
    - cotton
  - Other

<table>
<thead>
<tr>
<th>Insecticide class</th>
<th>Sprays per field</th>
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<tbody>
<tr>
<td></td>
<td>Bt cotton</td>
</tr>
<tr>
<td>Organophosphate</td>
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<tr>
<td>Pyrethroid</td>
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<tr>
<td>Carbamate</td>
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<tr>
<td>Neonicotinoid</td>
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<tr>
<td>Pyrethroid + Organophosphate</td>
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<tr>
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<td>Pyrethroid + Oxadiazine</td>
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<td>Organophosphate + Neonicotinoid</td>
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<tr>
<td>Total</td>
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Effects of transgenic Bt cotton on insecticide use and abundance of two generalist predators
Other issues relating to sustainable food production
social aspects
    seed saving
economic aspects
    who is it really benefitting?
Are transgenic crops friends or foes of sustainable food production?

they have some benefits

they have some drawbacks

In the end, they are just another tool to reach the goals
If I take a tomato gene and put it back into tomato using recombinant DNA technologies with no other DNA sequences, is the plant transgenic?

1. Yes
2. No
What if the tomato gene is from a “wild” relative of tomato and the two tomatoes are able to cross with each other. Is it a transgenic plant?

1. Yes
2. No
What if the gene is from a close relative of tomato (potato, eggplant), same genus. Is it a transgenic plant?

1. Yes
2. No
What if the gene is from a not-as-close relative of tomato (pepper, tobacco), different genus. Is it a transgenic plant?

1. Yes
2. No
If a gene was transferred from pigs to tomatoes, would the tomato be vegetarian?

1. Yes
2. No
Questions?