The Case of the "Tainted" Taco Shells: General Edition

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Part I – Taco Night

"Hi Dad, I'm home! Can Chris join us for supper?" Mark asked as he walked into the kitchen. "Practice ran over and he's got to go straight to the fields and help his dad, but there's always time for taco night, right?"

Dad lifted his head up from the newspaper. "Only if he likes tacos without the shells. Hi, Chris. Got a date for the prom yet?"

"Nope. Still looking, Mr. Schumer."

Dad continued, "I went to Kroger today, and all of the Taco Bell shells were gone. The cashier said there was some sort of recall. And you know your sister can't have the flour ones because of her wheat allergy."

"Well, we've got some hot dog buns, so let's imp-ro-vise!" Mark said with a flourish. "What's up with the recall? I thought that only happened with bad hamburger?"

Dad folded the paper over and pointed to a headline. "It's all in the genes. This article says the shells accidentally contained some genetically modified corn called StarLink. StarLink is a feed corn, but it isn't approved for human consumption."

"So the cows can eat it, but we can't? That doesn't make sense," said Mark.

Chris jumped in. "StarLink hasn't been proven to be safe for humans to eat—you know, not toxic or allergenic. That's important, especially to your sister."

"What's important to me?" asked Michelle as she walked in and sat at the table. "Hi, Chris."

"Oh… Hey, Michelle." Chris was blushing. "We were just talking about, um, taco shells."

Mark rolled his eyes.

Dad turned to Chris. "Chris, your family farms corn, right?"

"Right."

"Well, why would your dad want to grow genetically modified corn?"

"Well, do you remember the year Mark helped us detassle?" Chris asked.

Mark winced. "That was the worst job ever. My hands felt like they were at a paper-cut convention!"

"That was the easy part." Chris said. "What if you had to walk the fields twice a year and pull all the weeds? That's what my dad had to do when he was a kid. Now he uses Roundup spray and Roundup Ready seeds. He sprays the field once and all the weeds die. But the crop is okay because the seeds have been genetically modified so the plants won't be affected. The only bad thing is that the seeds are a little more expensive and you have to buy the spray, but it is still a lot cheaper than weeding by hand."

"And my hands thank you," Mark said, waving his hands and bowing.

Chris ignored Mark and continued. "My dad uses another seed that is resistant to insects. When I was ten years old, we almost lost the entire crop to corn borers, so Dad was pretty happy when this seed came out."

"So how does it work?" Michelle asked, smiling.

"Well," said Chris, his face still a little pink. "All I know is from talking to the seed salesman. He said the corn produces a bacterial protein that is toxic to insects. So when a bug chews on the plant, it dies."

Michelle frowned. "Bacteria? You mean they're loading up my food with extra chemicals and toxic proteins just to make life easier for farmers?"

"Wait a minute. Farming isn't easy, Michelle. My dad had to get a second job just to keep the farm that's been in our family for three generations!"

"Well, what about the butterflies?" Michelle asked, setting her jaw. "They're related to corn borers. Are they killing them, too?"

"I don't know, Michelle." Chris was getting defensive. "Besides, what does that matter? Butterflies don't eat corn!"

"But I do!" Michelle sputtered. "And I'm not gonna eat any of this Franken-Food if I can help it!"

Mark stuck his arms out forward and wobbled around. "Igor, it's alive! ALIVE!!"

Dad looked up again. "Mark, grow up. Michelle, calm down. This could be a good thing. There's another article in here about a company that is genetically modifying rice to include vitamin A. They think it will greatly reduce childhood blindness in developing countries."

"That's great," Mark said, "but with all this modification and insect resistance I wonder what happens if the weeds become resistant to the Roundup?"

"Good question," said Dad. "Let's continue this over dinner. Mark, sit over here. Chris, why don't you sit next to Michelle."

Questions

1. Is genetically modified corn safe?
2. Can farmers make a living without it?
3. Will Chris ask Michelle to the prom?

Part II – Project Design

To understand the science behind the use of genetically modified foods, Chris, Michelle, and Mark ask our class to help them. Since there is a lot of material to understand, we will divide into three "interest groups." The three interest groups are:

- Entomologists
- Farmers
- Immunologists

Each student in the class will be assigned to an interest group. Each group will read several primary literature papers to understand how transgenic plants are made and the biochemical issues of interests to their constituents and then hand in written answers to the common questions and their group questions.

Each group also will prepare a 15-minute oral presentation. Your written work will be due at the time of your oral presentation. Following the presentation, there will be an opportunity for questions from the other groups, and a general discussion after all the presentations are complete. Your grade will be 50% for the group written work, 40% for the group presentation, and 10% for your participation in the discussions of the other interest groups.

Common Questions (all groups answer these in their written answers)

Read the following:

- "Are You Ready for [a] Roundup?" by Bert Popping, *Journal of Chemical Education*, June 2001, 78: 752–756.
- *What Are Transgenic Plants?*
  http://cls.casa.colostate.edu/transgeniccrops/what.html (Last accessed: 9/30/11)
- *How Do You Make Transgenic Plants?*
  http://cls.casa.colostate.edu/transgeniccrops/how.html—watch the animations on this page (Last accessed: 9/30/11)

Then, answer the following questions:

1. Besides the gene of interest, what other DNA sequences must be inserted into the plant to make it transgenic?
2. Describe two different methods that can be used to generate a transgenic plant.
3. Explain the three most common genetic modifications of plants and why each modification has been made.
4. Compare and contrast the general ELISA and PCR methods for detecting genetically modified foods. Which method is most commonly used, and why?

Interest Group Questions (only answer the questions for your group)

Entomologists

Read:

- "Transgenic Pollen Harms Monarch Larvae" by John E. Losey, *Nature*, May 20, 1999; 399: 214.
- "Monarch Larvae Sensitivity to *Bacillus thuringiensis*-Purified Proteins and Pollen" by Richard L. Hellmich, et al., *Proceedings of the National Academy of Sciences*, October 9, 2001; 98 (21): 11925–11930.
- "Impact of *Bt* Corn Pollen on Monarch Butterfly Populations: A Risk Assessment" by Mark K. Sears, et al., *Proceedings of the National Academy of Sciences*, October 9, 2001; 98 (21):11937–11942.

Then, answer the following questions:

1. Describe and compare the experimental procedures used in the *Nature* paper and the first *PNAS* paper.
2. What effect did exposure to *Bt* corn pollen have upon larval survival, leaf consumption, and larval weight?
3. An insect is called an instar when it is between two molts. A newly-hatched insect is called a first-instar or larva. An adult is a final instar. Most caterpillars (butterfly and moth larva) have five or six instars (to see the different instar stages, go to http://www.gpnc.org/monarch.htm). Does pollen from *Bt* corn affect all instars equally?

4. In addition to the effects of *Bt* corn pollen on monarchs, what other factors should be considered in evaluating the risk of such transgenic crops?

Farmers

Read:

- "Farm-Level Effects of Adopting Genetically Engineered Crops," *Economic Issues in Agricultural Biotechnology*, Economic Research Service/USDA, Bulletin AIB-762: 10–15.
- "Widely Used Crop Herbicide is Losing Weed Resistance" by Andrew Pollack, *New York Times*, January 14, 2003; vol. 152, issue 52363, page C1.
- *The abstract only* for the paper "Glyphosate-Resistant Goosegrass: Identification of a Mutation in the Target Enzyme 5-enolpyruvylshikimate-3-phosphate synthase" by Scott R. Baerson, et al., *Plant Physiology*, July 2002; 129(3): 1265–1275.

Then, answer the following questions:

1. What factors have encouraged farmers to use genetically modified plants?
2. Under what conditions do farmers reap an economic benefit from using GM crops?
3. The enzyme affected by Roundup (glyphosate) is 5-enolpyruvylshikimate-3-phosphate synthase or EPSPS for short. EPSPS is involved in the synthesis of aromatic amino acids, such as phenylalanine and tyrosine. Why is this pathway crucial for plants but not for animals?
4. Describe how the sequence of the resistant goosegrass EPSPS enzyme differs from the wildtype (normal) goosegrass EPSPS enzyme.
5. What can farmers do to prevent resistance in weeds?

Immunologists

Read:

- "What's Hiding in Transgenic Foods?" by Bette Hileman, *Chemistry & Engineering News,* January 7, 2002; 20–22.
- "Digestibility of Food Allergens and Nonallergenic Proteins in a Simulated Gastric Fluid and Simulated Intestinal Fluid—A Comparative Study" by Tong-Jen Fu, et al., *Journal of Agricultural & Food Chemistry,* November 20, 2002; 50(24): 7154–7160.
- "Screening of Transgenic Proteins Expressed in Transgenic Food Crops for the Presence of Short Amino Acid Sequences Identical to Potential, IgE-Binding Linear Epitopes of Allergens" by Gijs A. Kleter, et al., *BMC Structural Biology*, December 12, 2002; 2(1): 8 (http://www.biomedcentral.com/1472-6807/2/8).

Then, answer the following questions:

1. What methods are used to predict whether a protein may be an allergen? What are the advantages and disadvantages of each of these models?
2. Describe in detail the conditions used to test the digestibility of proteins and how digestion was evaluated. What criterion should be used in "establishing a globally used standardized assay condition"? Based on the results of this study, what should those criteria be?
3. Computational methods also may help screen for potential allergens. Describe the possible algorithms that could be used for such a screening.
4. What is the probability that a protein would contain a given six amino acid sequence? Seven amino acid sequence? Eight amino acid sequence? What are the advantages and disadvantages of a long and a short reference frame?
5. What would be the advantage of discontinuous epitope searches, and why aren't they currently used?