Maize is an old crop!
- Genetic modification of maize has been occurring for thousands of years.
  - Center of origin = Mexico, Central America
  - Earliest plant breeders = women
  - Important source of human and animal sustenance
- The miracle of maize is manifested in the thousands of ways that the grain has been used for years.

Many uses of maize...
- Alcoholic beverages
- Animal feed
- Baking, snack foods
- Other beverages
- Building materials
- Canners/packers
- Cereals
- Chemicals
- Condiments
- Confectionary
- Fats & oils
- Formulated dairy products
- Fuel alcohol
- Household needs
- Ice cream/frozen desserts
- Jams, jellies, preserves
- Meat products
- Mining/metallurgy
- Misc. foods
- Misc. industrial
- Prepared mixes
- Paper & related products
- Paste, adhesives
- Syrups, sweeteners
- Textile
- Tobacco

U.S. maize use...

<table>
<thead>
<tr>
<th></th>
<th>2001/2002</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food, alcohol, industrial</td>
<td>2025</td>
<td>548</td>
</tr>
<tr>
<td>Seed</td>
<td>20</td>
<td>220</td>
</tr>
<tr>
<td>Food &amp; Residual</td>
<td>5825</td>
<td>250</td>
</tr>
<tr>
<td>Exports</td>
<td>1925</td>
<td>690</td>
</tr>
<tr>
<td>Soys</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Corn Refiners Association

U.S. food & industrial use...

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFCS</td>
<td>131</td>
</tr>
<tr>
<td>Glucose &amp; sucrose</td>
<td>186</td>
</tr>
<tr>
<td>Starch</td>
<td>250</td>
</tr>
<tr>
<td>Fuel alcohol</td>
<td>690</td>
</tr>
<tr>
<td>Beverage alcohol</td>
<td>548</td>
</tr>
<tr>
<td>Cereals, etc.</td>
<td>220</td>
</tr>
</tbody>
</table>

Source: Corn Refiners Association
Maize: New Uses For An Old Crop

Specialty grain traits...
- Characteristics that add value to end-user...
  - Blue
  - Hard Endosperm/Food Grade
  - High Amylose
  - High Lysine/Opaque
  - High Oil
  - High Oil/High Oleic
  - High Starch
  - Low Phytate
- Low Stress Cracks
- Low-Temperature Dried
- Non-GMO Corn
- Nutritionally Dense
- Nutritionally Enhanced (sometimes called High Protein)
- Organic
- Post-Harvest Pesticide Free
- Waxy
- White

New uses in their infancy...
- Tires (BioTred™)
  "...micro-droplets of corn starch as a tire ingredient to reduce tire weight and rolling resistance."
  "...less energy to produce and their lower rolling resistance is expected to reduce fuel consumption and noise."

- HarvestForm™, a polymer composite manufactured from maize and soybean polymers.
  Deere® claims that all combines manufactured in 2002 would include panels made from this new composite.

- Compostable plastics...
  Compostable plastics, packaging films, fast food serving utensils manufactured with maize-based polylactic acid (PLA).
  "...takes less fuel to produce and breaks down into natural components – water and carbon dioxide – when composted."

- Plastic foam...
  Loosefill packaging material also manufactured from maize PLA.
  Non-static (great for electronics)

- Clothing, carpeting, textiles, bedding...
  "Corn-based PLA can be blended with cotton, wool and silk to make exercise clothing, suits, even a 100% corn-fiber wedding dress."

http://www.vegrains.org
http://www.iowacorn.org/newuses.htm
http://www.iowacorn.org/newuses.htm
http://www.goodyear.com/media/pr/22251ti.html
http://www.iowacorn.org/newuses.htm
http://agproducts.unl.edu/plastic.htm
http://agproducts.unl.edu/plastic.htm
NatureWorks™ at http://cargilldow.com
NatureWorks™ at http://cargilldow.com
Cargill Dow partnership...

- NatureWorks™ production facility in eastern Nebraska.
- Targeted production of 140,000 metric tons of PLA per year.
- Targeted maize usage of 1,000 metric ton of maize processed per day.

New uses in their infancy...

- Antifreeze from maize...
  - "Levulinic acid.....has proven to be an effective ingredient in antifreeze. This chemical could replace the toxic, petroleum-based ingredients now in use."

New uses on the horizon...

- Plant-based manufacture of pharmaceuticals & therapeutics
- Crops as an oral delivery system for vaccines and other health-related products

Examples:
- Prodigene
- Epicyte
- Monsanto
- Meristem
- Therapeutic

Epicyte

- Plant-based manufacture of human monoclonal antibodies (Plantibody™)
- Partners w/ Dow Chemical & Dow AgroScience
- Rice and maize = targeted crops
- Oral, topical, inhaled modes of delivery
  - Herpes simplex virus (clinical trials 2002)
  - Respiratory Syncytial Virus
  - Clostridium difficile-associated diarrhea

Prodigene...

- Maize-based manufacture of...
  - Oral vaccines
  - Hepatitis B
  - Lt-B (E. coli toxin assoc. w/ traveler's diarrhea)
  - Transmissible gastroenteritis virus (swine)
  - Therapeutics (e.g., aprotinin)
- A human therapeutic protein that is commonly used to control blood loss during surgery.
- Industrial enzymes (e.g., laccase, trypsin)
- Proteins used in applications such as laundry detergents, paper bleaching and food processing.

Long term goal: Oral delivery system for an AIDS vaccine

Monsanto Protein Technologies

- Maize-based manufacture of therapeutic proteins.
  - "Monsanto’s experience and technology in corn (maize) has enabled the development of a manufacturing process compatible with the stringency of pharmaceutical and regulatory standards."
  - "Additionally, pharmaceutical proteins are stable in corn (maize) and can be expressed in large quantities of protein, while potentially lowering the costs of goods."

http://agproducts.unl.edu/antifrez.html

http://www.epicyte.com

http://www.prodigene.com

http://www.mpt.monsanto.com

http://cargilldow.com

http://www.mpl.monsanto.com
**Meristem Therapeutics...**
- Plant-based manufacture of therapeutic recombinant proteins.
  - Mammalian gastric lipase (maize) for treatment of exocrine pancreatic insufficiency common to cystic fibrosis and pancreatitis patients.
  - Clinical trials at the moment.
- Human lactoferrin (maize), a natural defense protein against infections.
- Collagen (tobacco), for skin and tissue repairs.
- Human serum-albumin (tobacco), to expand blood volume in critical situations (surgery).

**New uses via transgenics...**
- The use of transgenic technology to develop crops with desirable, but heretofore unachievable, output trait characteristics is accompanied by several challenges.
  - Public acceptance of transgenics to date.
  - Uncertainty about the agronomic acceptability of the resulting varieties.
  - Increased need for I-P segregation at both the farm and grain handler levels.

**Public acceptance...**
- Most, if not all, of the transgenic agronomic crops commercialized to date have no clear benefit to the consumer.
  - Insect resistant and herbicide tolerant crops benefit primarily the producer.
  - Indirect benefits to the environment.
- The next generation of human health transgenics may lessen public concern.

**Agronomic adaptability...**
- Can be an issue with any specialty grain if the genetic background is “old” or simply deficient in agronomically important traits.
  - May not be an issue if value of grain is great enough to compensate for lower yield per acre.
  - May not be an issue if grain production is simply a component of a larger vertically integrated manufacturing system (from seed to pill) owned by a single biotechnology firm.

**Containment & I-P needs...**
- Containment of maize pollen is challenging to say the least.
  - Production in isolation among best options.
  - Genetic pollen incompatibility may be an option.
- Segregation of grain after harvest is achievable, but requires...
  - Additional expense (labor & equipment)
  - Diligence to detail
- May not be an issue with vertically integrated systems

**Philosophicating on new uses**
- Profits associated with new uses will accrue to those who play the "game".
  - The seed developer
  - The producer
  - The grain buyer
  - The manufacturer
  - The wholesaler or retailer
- Unfortunately, the profits are not often distributed equally to all of the players.
The challenge for producers...

- Figuring out how to participate meaningfully in the profit stream generated from the introduction of a new product or process that uses an enhanced maize trait as an input.

Producers can...

- Produce & sell the enhanced maize trait for a significant premium, and/or
- Participate as an investor or partner in the new venture itself.

Producing for a premium...

- The track record to date for significant price premiums paid to producers for specialty grain production is not particularly encouraging.

  - Buyers and/or end users will always pay the least they possibly can for raw input.
  - Especially if the grain production is part of an overall larger vertically integrated system.

Typical niche markets...

- By definition, fill up quickly.

  - When the demand for the raw input is reasonably low, requiring reasonably few acres to produce, the market can become saturated quickly.

  - Requires producers to wisely identify opportunity early, be the first to participate in contract production, and know when to move to new opportunity before market drops.

  - High oil corn, white corn, waxy starch corn in the U.S.

Participate in profit stream...

- Opportunities exist for producers to cooperatively form new ventures.

  - Corn masa production facility in SW Indiana
    - Targeted at tortilla mfgr thousands of miles away in Georgia.

  - Ethanol production facility in NW Indiana
    - Proximity of nearby “mega” dairies offer sales outlet for distillers’ grain by-product high protein or energy grain feed.

“A final disclaimer...

“An expert is one who knows more and more about less and less until he knows absolutely everything about nothing.”

-- Nicholas Murray Butler