FACT: SCIENTISTS ARE DEVELOPING NEW KINDS OF CORN WITH TRADITIONAL GENETICS AND WITH BIOTECHNOLOGY

LESSON 1:	Rate that Trait	(Math)*
LESSON 2:	Genes-R-Us	(Science)*
LESSON 3:	Wonder Corn	(Multidisciplinary)*
LESSON 4:	Farm or Pharmacy?	(Science, Social Studies, Current Events) Jr. & Sr. High Students

** All Lesson Plans are adaptable for ALL ages!*

ELIZABETH LEARNS WHY SHE HAS BLUE EYES

The day Elizabeth turned 16 she took a hard look at herself in the mirror. "It'll do," she thought, and smiled.

Her eyes were very blue, like her mom's, unless she was wearing her green contacts. Everyone said she looked like her mom. But her hair was thicker, and she was taller. Her teeth were straighter too.

"You're a hybrid," her mom always said. "You have the best characteristics from both your dad and me. You have the worst too. But in most respects you're an improved version. That's what hybrids are. Corn breeders choose parents with desirable qualities, then improve them in the next generation."

Elizabeth didn't like being compared to a corn plant. She was tired of her mother using agricultural examples for everything. She was going to become a pediatrician and help save the lives of sick children. Corn was not her thing.

Well, on second thought, maybe she'd become an archaeologist. When she was 13, a group from the university had been studying the site where Native Americans had lived on her farm 1,000 years ago. She'd joined them for a few days, sifting dirt for arrowheads and pieces of pottery, and she'd been there when they'd found a grindstone. Standing there that day, touching that rock, she had seen, heard, and felt the women and children of that ancient village grinding corn between two stones. Grinding corn so they could eat! It still gave her goosebumps.

So, her plan was to become either a doctor or an archeologist, and it had been her plan for two years. That's why, in eighth grade when her teacher said she had to do a science fair project, she'd decided to do it in one of those areas.

The archaeology professor had helped her out. He'd offered to provide her with corn seeds like the kind that had been planted by those native people. He said they were the first farmers in the area, and he'd collected five kinds of the seed they'd used. He thought it would be interesting for Elizabeth to compare old varieties of corn to new ones.

Corn again. It wasn't like she'd wanted to please her mom or anything. It was like she couldn't think of anything better to do.

But she'd done a great experiment, and even won a trip to the state science fair. She'd learned something too. She'd learned the Native Americans had saved corn seed from one year, then planted it the next, and they'd used sticks to plant it, poking it into the soil as evenly as they could. The seed they planted did well in those conditions. Modern seed wasn't saved from year to year, and it was adapted to machines that could plant evenly across a field. It didn't grow when she planted it too deep.

Oh, this was ridiculous. Help! Here she was, sweet sixteen, looking in the mirror, thinking about corn. She needed a psychologist.

No. She needed to pay attention to her thoughts. Maybe she wasn't being fair. Maybe corn was cooler than she thought. *She* was cool—look at that smile. Her brain was just making some mysterious connection between herself and corn; a connection she didn't understand yet.

She loved it when her mind came up with these things.

Maybe it had to do with becoming a doctor. Her mom had managed to slip in comments about corn being used to make medicine. Man, her mom drove her nuts. She said they'd discovered ways to create corn that was higher in certain nutrients, so whoever ate it would be healthier. And they could make it higher in protein, or in oil, or in starch, depending on what people wanted. They could even make corn into operating gowns for surgeons.

Scientists could do that by studying the genes of the corn plant. If they could identify every single gene in the corn plant, they could use that information to improve corn.

Improved corn. Hey, not bad. They could make it sweeter or taller. More nutritious. Easier to make into plastic, or ethanol. She thought her mom had even talked about corn that could protect itself from insects. Cool—armored corn.

So, what did this have to do with her?

Well, maybe someday she'd be a great doctor who discovered a cure for a terrible disease. Maybe she'd figure out how to insert that cure into a corn plant. So farmers could raise that cure in their fields. So there'd be enough of that cure for everyone. So it wouldn't be too expensive for poor people.

Elizabeth, the great, famous doctor who saved the world using corn. Yes. She could see her name in the headlines, imagine her speech as she accepted the Nobel Prize. She could feel the gratitude of generations to come. Yes, this could be it. It was a sign!

Maybe she could get kids to take their vitamins by hiding them in corn. Hey, what if it was purple corn? That was it! If she, the greatest doctor of all time, could figure out a way to put kids vitamins in corn that was so purple they wanted it, really wanted it, she could probably make a million dollars.

Well, she'd save the world at the same time.

She wondered if she should try to patent the idea before someone else thought of it. Maybe there actually was some potential in this corn genetics stuff. Potential for her. Well, for the world too.

She looked at herself again in the mirror. Good eyes. Nice earrings. Neat jeans. Jeans? Designer jeans?

Designer GENES!

Wow! What a mind! It never ceased to amaze her.

Now was that from her mom, or her dad?

LESSON 1: RATE THAT TRAIT

SUBJECT: Math
OBJECTIVE: Students will learn some of the criteria used by farmers to select corn hybrids, and will use numerical ratings to guide their selections, just as farmers do.
MEASUREMENT: Students will be able to use numerical ratings to compare traits of different corn hybrids.

BACKGROUND FOR TEACHERS:

In the 1930s an important advance in corn production was made, called hybrid development. Hybrids can be bred for specific characteristics such as yield, stalk or root strength, resistance to insects or disease, tolerance to particular soil or climatic conditions, and much more. Today, there are thousands of hybrids to choose from, and those numbers continue to grow.

Proper hybrid selection is a challenge for farmers. There are few decisions as crucial in determining the health and yield of a cornfield, but it is an increasingly complicated and difficult decision. To aid in this selection, seed companies rate their hybrids, and pass that information on to farmers. Rating systems vary from company to company, but all attempt to list the traits a farmer looks for, and then rank each hybrid according to its performance for that specific trait.

STUDENT ACTIVITIES:

1. Ask students to read the story Elizabeth Learns Why She Has Blue Eyes, and ask them to think about some of the traits she described in corn—taller, sweeter, more nutritious, resistant to insects, etc. Ask them to imagine other traits that could affect corn plants.

2. Use Worksheet 1 to complete the following exercises:
   - Younger students can be asked questions which can be answered by looking at which numbers are the highest or lowest. For example: Which corn hybrid has the strongest roots? Which plant is the tallest? Which one is most resistant to Northern corn leaf blight, or European corn borer? Which one has the highest Relative Maturity rating (in other words, which one needs the longest season to mature)?
   - Younger students could also be asked to graph the values from one or more columns on graph paper, and color it.
   - They could also be asked to pick a particular hybrid and draw a picture of it, based on the traits that are most significant.
   - Older students can be split into teams of two; one student is the "farmer" and the other is the "seed salesperson." Ask the farmer to place an order, asking questions about specific hybrid traits. The salesman should be able to answer the questions using the numeric ratings given.

- Older students can also be asked to average the values for one or more of the traits. They could also enter this information into a computer spreadsheet from which they could create charts and graphs.
- Older students can also be asked to calculate percentages; for example, what percentage of these hybrids has a Relative Maturity over 95 days?

Pioneer® brand corn hybrid ratings

CHARACTERISTICS RATINGS

	Specialty Segment[1]	Base Genetics[2]	CRM[3]	Silk CRM	Physiological CRM[4]	GDUs to Silk	GDUs to[5] Physiological Maturity	Yield for Maturity[6]	Adaptability to[7] High Population	Adaptability to[8] Low Population	Grain Drydown[9]	Stalk Strength	Root Strength	Staygreen	Drought Tolerance	Test Weight[10]	Early Growth[11]	Plant Height[12]	Ear Height[13]	Ear Retention	Mid-Season[14] Brittle Stalk
39K72			75	77	76	970	1760	8	7	8	6	5	6	4	6	7	7	5	5	5	7
3979			76	76	75	950	1740	7	8	7	6	5	4	5	7	4	5	6	6	5	6
39K73'	Bt	39K72	77	77	76	970	1760	9	9	9	6	7	6	5	6	7	7	5	4	6	7
39J69'	Bt	3970	79	80	79	1000	1840	9	9	9	5	6	5	5	4	6	4	6	6	6	7
3963			79	80	82	1000	1920	7	7	6	7	5	6	4	5	4	5	5	4	6	7
39A26'			80	82	81	1030	1900	9	9	9	7	7	5	6	5	6	4	6	8	5	6
39Y85'			82	78	81	980	1900	7			8	7	6	8		5	6	5	5	6	6
3941			82	81	83	1020	1950	8	8	8	6	7	4	8	5	5	4	5	5	6	6
39D81'			85	87	82	1090	1920	9	9	9	6	5	7	5	7	5	6	5	5	5	5
3914			86	87	86	1090	2030	7	7	7	6	5	6	6	7	5	4	6	6	6	7
39F06'	Bt	3905	88	88	88	1100	2080	9	9	9	6	8	6	8	7	5	7	5	8	6	5
3893			89	90	90	1130	2130	8	9	8	6	4	6	5	7	5	7	5	6	6	5
3878			89	93	92	1160	2180	7	7	7	6	5	6	4	6	5	3	7	6	5	7
3845			91	94	93	1180	2210	7	7	7	8	5	6	7	5	5	9	8	7	4	6
38R21			92	91	91	1140	2160	7	7	7	6	5	3	3	8	5	8	6	8	6	6
38K06'			92	93	94	1160	2240	9			6	5	5	6	7	4	7	5	8	6	5
38W36	Bt	3893	93	92	91	1150	2160	9	9	8	6	6	5	6	7	5	7	6	7	7	5
38P05			94	94	94	1180	2240	9	9	9	6	5	5	6	7	6	5	5	5	5	6
38P06'	Bt	38P05	95	96	94	1200	2240	9	9	9	6	6	5	7	7	6	5	5	5	6	6
37J99	CL	37M81	97	98	99	1230	2370	9	9	8	7	4	4	6	7	4	6	6	6	5	4
3751			97	98	98	1230	2340	8	8	8	7	4	4	5	7	4	4	5	4	5	6
37R71	Bt	37M81	98	97	98	1210	2340	9	9	8	7	6	5	7	7	4	5	6	6	7	4
3730			99	99	99	1240	2370	9	9	7	6	6	5	5	7	5	8	6	4	6	4
36F30	Bt	3751	99	100	100	1250	2390	9	8	9	7	6	4	6	7	4	4	6	6	5	6
36H36			100	99	101	1240	2420	9	9	9	6	6	6	7	7	5	7	5	5	6	5
36R10'			101	100	100	1250	2390	9			6	6	5	7	7	5	4	6	5	5	6
36R11'	Bt	36R10	101	101	101	1260	2420	9				7	5	7	7	5	4	6	4	6	6
36B08'			102	100	100	1250	2390	9			5	6	7	7	7	6	7	4	4	5	5
36Y96'	Bt, YFC	36Y95	103	101	103	1260	2470	9	9	8	6	7	4	7	6	7	5	4	5	5	6
36D14'	CL		103	102	103	1270	2470	9			6	6	4	6	6	4	5	5	5	4	6
3563			103	105	106	1310	2530	8	8	8	7	6	7	6	7	8	4	7	4	7	4
35P12'			104	103	105	1290	2530	9			7	5	6	7	7	4	7	5	5	6	6
35R57			104	104	105	1300	2530	9	9	8	7	7	5	5	8	6	4	5	4	5	4
35R58'	Bt	35R57	105	105	106	1310	2550	9	9	8	7	7	5	5	8	6	4	6	5	5	4
3522			105	103	104	1290	2500	8	8	8	6	7	4	5	7	5	5	4	6	5	4
35N05	Bt	3563	105	107	107	1340	2580	9	9	9	8	6	7	7	7	7	5	7	5	7	4
34G81			106	106	106	1320	2550	9	9	8	8	7	3	6	8	6	5	5	5	5	5
34G82'	Bt	34G81	106	107	107	1340	2580	9	9	8	8	7	4	7	8	6	5	5	5	6	5
34R07'	Bt	3489	110	110	109	1370	2630	9	9	9	7	5	6	7	8	6	4	6	5	6	3
High Oil Products																					
38F48'	HOSX, Bt		95	95	93	1190	2210	7	8	6	6	5	6	5	7	5	6	4	4	6	7
37H97	HOTC	37M81	98	97	98	1210	2340	8	8	7	7	4	4	6	6	4	6	6	7	5	4
Waxy Hybrids																					
37B04'	WX	3752	99	96	97	1200	2320	8	8	8	6	4	4	5	7	7	4	5	4		7
35G41'	WX	3522	106	104	103	1300	2470	8	8	8	5	7	3	5	7	5	5	4	6	5	4
34H98	WX	34K77	108	108	110	1350	2660	8	8	8	7	5	5	7	7	6	6	5	6	5	6

DISEASE AND PEST RESISTANCE RATINGS

	Gray Leaf Spot[15]	Northern Leaf Blight[16]	Head Smut	Gibberella Ear Rot[17]	Eyespot[18]	ECB, 1st Brood[19]	ECB, 2nd Brood[19]
39K72		2	7	6		5	4
3979		4	7	6	6	7	4
39K73'			7	6		9	9
39J69'			8		6	9	9
3963		2	7	5		4	5
39A26'		7	7	5		3	
39Y85'			7	7	3		
3941		5	7	5	6	3	6
39D81'		6	4	4	4	3	
3914	2	3	8	5	4	3	5
39F06'		6	7	4	5	9	9
3893		5	6	5	4	3	4
3878		4	9	5	3	4	5
3845		6	9	5	7	5	6
38R21		5	8	6	4	3	5
38K06'		7	8	4	6	3	
38W36		5	6	5	5	9	9
38P05		7	8	5	5	4	5
38P06'		7	8	5	4	9	9
37J99	4	5	7	5	5	4	3
3751	3	5	8	5	7	5	3
37R71	4	5	7	5	6	9	9
3730	3	5	8	5	6	5	4
36F30	3	5	8	5	7	9	9
36H36	4	6	9	5			4
36R10'	5	6	9	7		6	3
36R11'	5	6	9	7		9	9
36B08'	5	7	9	6		6	5
36Y96'	3	6	8	4		9	9
36D14'	5	6				5	3
3563	3	5	8	5	6	4	5
35P12'	4	5	9	6		5	5
35R57	3	6	7	4	5	4	4
35R58'	3	6	6	4	5	9	9
3522	3	6	6	5	6	3	5
35N05	4	5	7	5		9	9
34G81	4	7	9	4	6	4	4
34G82'	4	7	9	4	6	9	9
34R07'	4	4	8	5	6	9	9
High Oil Products							
38F48'	3	5	3	4	6	9	9
37H97	4	5	8	5	5	3	3
Waxy Hybrids							
37B04'			9	6	4		
35G41'	3	6		5		4	4
34H98	4	5	8	6		4	3

Trait ratings provide key information useful in selection and management of Pioneer® brand products in your area. Scores based on period-of-years testing through 1998 harvest and were the latest available at time of printing. Some ratings may change after 1999 harvest. Contact your Pioneer sales professional before planting for the latest trait rating information.

***NEW** for 2000

† This information reflects preliminary ratings and positioning. Contact your Pioneer sales professional to confirm ratings prior to planting. Many ratings based upon the non-converted version of this hybrid.

For Pioneer® hybrids 36R11, 35R58, 34G82 and 37H97: Many ratings are based on the base genetics of these hybrids. For HOTC products, ratings are for the female grain parent only.

RATINGS: 9 = Outstanding; 1 = Poor; **Blank** = Insufficient Data.

IMPORTANT: Ratings based on comparison with other Pioneer hybrids, not competitive hybrids. Ratings are assigned from research and data over a wide range of both climate and soil types, based on average performance across area of adaptation under normal conditions. Extreme conditions may adversely affect performance. Consult your local Pioneer sales professional for specific product information in your area.

SPECIALTY CORN RATINGS: Based on comparison with other Pioneer hybrids, not competitive hybrids. Yield and other trait ratings for white and waxy hybrids reflect comparison with non-modified yellow hybrids of a similar maturity. Specialty ratings based on average performance across area of adaptation under normal conditions. Extreme conditions may adversely affect performance.

1 **SPECIALTY SEGMENT: Bt** – The YieldGard[a] gene offers a high level of resistance to European corn borer, southwestern corn borer and southern cornstalk borer. The gene also offers a moderate level of resistance to corn earworm and common stalk borer; strong resistance to Fall armyworm. **CL**[b] (formerly IMI T) – Contains gene for imidazolinone herbicide resistance. (No protection from sulfonylurea [SU] herbicide carryover or from SU herbicide-insecticide interactions.) **WX** – Waxy. **YFC** – Suitable also for yellow food corn use. **HOSX** – High oil single-cross. **HOTC** – High oil TC Blend[c].

a Registered trademark of, and used under license from, Monsanto Company.
b Trademark of American Cyanamid Company.
c Registered trademark of Optimum Quality Grains, L.L.C.

2 **BASE GENETICS:** Identifies the non-converted hybrid which is modified to include new technologies. Manage similarly to the base genetic hybrid.

3 **CRM (COMPARATIVE RELATIVE MATURITY):** With no industry standard for maturity ratings, comparing hybrid maturity and harvest moisture ratings between companies is usually difficult. Use the CRM rating to compare Pioneer hybrids with competitive hybrids of a similar maturity and harvest moisture. Individual company ratings may show variation from this average comparative rating. CRM ratings for relative harvest moisture of ECB-resistant hybrids are calculated across all levels of corn borer infestation. Under heavy corn borer pressure, the relative harvest CRM between ECB-resistant hybrids and similar CRM non-ECB resistant hybrids may differ by as many as 2-3 CRM units.

4 **PHYSIOLOGICAL CRM:** Physiological maturity/zero milk line. To help decide if a new hybrid fits your area s growing season, compare its physiological maturity to a hybrid that you plant or one that is successfully used in your area.

5 **GDUS TO PHYSIOLOGICAL MATURITY:** Physiological maturity/zero milk line. To help decide if a new hybrid fits your area s growing season, compare its physiological maturity to a hybrid that you plant or one that is successfully used in your area.

6 **YIELD FOR MATURITY** ratings for ECB-resistant hybrids are scored relative to only other ECB-resistant hybrids. Yield for maturity ratings for non-ECB resistant hybrids are scored relative to only other non-ECB resistant hybrids.

7 **ADAPTABILITY TO HIGH POPULATION:** Reflects adaptability to yield at high plant density and maintain harvest dependability.

8 **ADAPTABILITY TO LOW POPULATION:** Reflects adaptability to yield at low plant density; ability to yield at reduced stands.

9 **GRAIN DRYDOWN:** Compares hybrids of similar maturity for rate of moisture loss during grain drydown. A higher score indicates faster drydown. A lower score indicates slower drydown, or a wider opportunity for silage and high-moisture corn harvest.

10 **TEST WEIGHT:** Higher score indicates heavier test weight.

11 **EARLY GROWTH:** Ratings taken when two leaf collars are visible.

12 **PLANT HEIGHT:** 9 = Very Tall; 1 = Short.

13 **EAR HEIGHT:** 9 = High; 1 = Low.

14 **MID-SEASON BRITTLE STALK:** Ratings determined by frequency and severity of stalk breakage at lower to middle stalk internodes from conditions usually favored by rapid or optimum growth. Relative response of hybrids can be affected by planting date, stage of growth, rate of growth, wind severity and other variables. Scores derived from both natural observations and artificial push test evaluation just prior to tasseling.

NOTE: Scores do not reflect breakage enhanced by or due to herbicide interaction. The use of growth regulator herbicides such as 2,4-D and dicamba can increase the brittle stalk potential of corn hybrids. Hybrids with lower brittle stalk ratings will require more caution and have a higher risk associated with the use of growth regulator herbicides. Early application, proper rates and application methods, along with both hybrid and herbicide selection can help reduce this risk.

BRITTLE STALK PRECAUTION: In areas with higher potential for brittle stalk breakage, growers must balance the risk of planting hybrids with brittle stalk ratings of 1 to 4 against the overall performance of more resistant hybrids with higher ratings. All hybrids have a period of susceptibility to brittle stalk. Hybrids with low ratings may have a longer period of susceptibility, or they may experience more severe breakage relative to hybrids with higher scores in their period of susceptibility.

DISEASE PRECAUTION: Grower should balance hybrid yield potential, hybrid maturity and cultural practice selection against their anticipated risk of a specific disease and need for resistance. In high disease risk conditions, consider planting hybrids with at least moderate resistance ratings of 4 or higher to help reduce risk. When susceptible hybrids with disease ratings of 1 to 3 are planted in conditions of high disease pressure, the grower assumes a higher level of risk. If conditions are severe, even hybrids rated as resistant can be adversely affected. Independent of yield reduction, diseases can predispose plants to secondary diseases such as stalk rots. This requires individual field and hybrid monitoring for stalk stability and timely harvest when warranted.

DISEASE AND PEST RATINGS: 8-9 = Highly Resistant; **6-7** = Resistant; **4-5** = Moderately Resistant; **1-3** = Susceptible; **Blank** = Insufficient Data.

15 **GRAY LEAF SPOT PRECAUTION:** Avoid planting hybrids with a lower gray leaf spot (GLS) rating in continuous corn fields that have a history of GLS infection unless tillage operations that bury significant amounts of corn residue and inoculum are practiced.

16 **NORTHERN LEAF BLIGHT CAUTION:** In conditions where northern leaf blight (NLB) risk is high, growers should consider planting only hybrids with at least moderate NLB resistance ratings of 4 or higher.

17 **GIBBERELLA EAR MOLD CAUTION:** Growing hybrids with a score of 6 or less north of a line formed by the Nebraska/South Dakota border, to the Illinois/Wisconsin border, curving south of the Great Lakes to the Pennsylvania/New York border, may increase the risk of Gibberella ear mold infection and the associated mycotoxins, including deoxynivalenol (DON or vomitoxin) and zearalenone.

18 **EYESPOT:** Degree of resistance to the disease under natural infestation. Data is limited by the number of observations, but it should give a general ranking of resistance.

19 **ECB, 1ST BROOD:** European corn borer – 1st Brood leaf feeding visual score; not based on yield reduction data.

20 **ECB, 2ND BROOD:** European corn borer – 2nd Brood post tassel visual score; not based on yield reduction data.

HERBICIDE FAMILIES

	AMIDE[1]	GROWTH REGULATOR[2]	PIGMENT INHIBITOR[3]	SU[4]
39K72				
3979				
39K73*				
39J69*				
3963				
39A26*				
39Y85*				
3941				
39D81*				
3914				
39F06*				
3893				
3878				
3845				
38R21				
38K06*				
38W36				
38P05				
38P06*				
37J99				
3751				
37R71				
3730				
36F30				
36H36				
36R10*				
36R11*†				
36B08*				
36Y96*				
36D14*				
3563				
35P12*				
35R57				
35R58*				
3522				
35N05				
34G81				
34G82*				
34R07*				
High Oil Products				
38F48*				
37H97				
Waxy Hybrids				
37B04*				
35G41*				
34H98				

Under certain environmental conditions any hybrid can be injured by any herbicide. This guide can assist in selecting and managing herbicide programs. It is based on replicated research trials and field observations. See your Pioneer or herbicide representative regarding herbicide-hybrid combinations that require careful management.

ADEQUATE TOLERANCE: This herbicide-hybrid combination has acceptable tolerance. Available research and field observations suggest injury is unlikely to occur in normal growing conditions when label recommendations are followed.

REQUIRES CAREFUL MANAGEMENT: This herbicide-hybrid combination may require careful management in challenging environments such as sandy soils, soils low in organic matter, high pH soils, cool wet conditions, or hot and humid growing conditions. For growth regulator herbicides, these hybrids may exhibit greater early season stalk breakage when applied prior to a significant windstorm.

NOT RECOMMENDED: Based on field observations and research results, this herbicide-hybrid combination should not be used.

INSUFFICIENT DATA: Additional testing is needed to evaluate crop response and grain yield.

1 **Amide** (chloroacetamide) tested was Harness. This family includes Axiom, Dual, Dual II, Frontier, Harness, Lasso, Surpass, Topnotch, and others in pre-packaged mixes.

2 **Growth Regulator** tested was Banvel. This family includes 2,4-D, Banvel, Clarity, Stinger, in pre-packaged mixes. Hybrids may exhibit greater early season stalk breakage when growth regulator herbicides are applied prior to a significant windstorm.

3 **Isoxazole (pigment inhibitor)** tested was Balance. The herbicide prevents the biosynthesis of a photosynthetic pigment (carotenoid). The carotenoid pigment prevents the degradation of chlorophyll. Susceptible plant will turn white and chlorotic.

4 **SU** (sulfonylureas) tested were Accent, Basis and Basis Gold. This family also includes Accent, Accent Gold, Basis, Basis Gold, Beacon, Permit, Exceed, Ultim, Exceed and others in pre-package mixes. A similar family called Sulfonanilides includes Python, Broadstrike + Dual, and Hornet.

CAUTION: Some sulfonylurea products have label restrictions on hybrids with maturity shorter than 88 CRM. Review the herbicide label before applying any sulfonylurea product to hybrids less than 88 CRM.

All herbicides are trademarks of their manufacturers.

LESSON 2: GENES-R-US

SUBJECT: Science
OBJECTIVE: Students will learn that genes they inherited from their parents determined some of ***their*** traits.
MEASUREMENT: Students will know that genes determined some of their traits.

BACKGROUND FOR TEACHERS:

During the 1860s, an Austrian monk and botanist named Gregor Mendel discovered that “factors” determine inheritance in pea plants. He observed that many traits, from height to flower color, seemed to be controlled by these factors. In 1903, researcher William Sutton made the connection between Mendel’s factors and chromosomes—microscopic structures in the cell nucleus that carry genetic material. The genetic material itself, known as deoxyribonucleic acid (DNA), was discovered by Johann Miescher in Switzerland in 1869. Yet it wasn’t until two researchers, Francis Crick and James Watson, proposed a double-helix structure for the molecule that we began to understand how this material carries the genetic code of life.

A gene is a unit of information that can be passed on to offspring. It is a segment of DNA. Genes help determine whether your hair is straight, whether your eyes are brown, and whether you can curl your tongue. They also may help determine whether you’ll get a certain disease, have a learning disability, or be a gymnastics champion. Genes are powerful influences on physical and mental characteristics. Yet genes don’t exist only in people. Genes make hens white or speckled, give frogs smooth skin and let roses smell sweet.

They influence all the traits of corn covered in Unit 4, Lesson 1. Genes are found in all living things!

As mighty as genes are, however, it’s important to remember that environment also helps shape organisms. A person might have a genetic predisposition to be tall, yet be short because of poor childhood diet. A plant might inherit a tendency to produce bright red blooms, but be unable to flower because of lack of nutrients. (Nutrients needed for corn are discussed in Unit 2, Lesson 2.) The interactions between a living thing and its environment affect how it will turn out.

Domineering Genes

With some exceptions, every organism has two of each kind of gene. An offspring gets one of each type from each parent. Genes are usually either dominant or recessive. A dominant gene is expressed in the offspring no matter what gene the other parent contributes. A recessive gene is expressed in the offspring only if both parents contribute recessive genes. If you have blue eyes, both of your parents contributed a recessive blue gene. And yes, it is possible for two brown-eye parents to have blue-eyed children, if both contribute the recessive blue-eyed gene.

Mutations Rule

Over the billions of years the earth has been around, plants, animals and other living things, have evolved through the changing of genes. Genes have been transferred, deleted and mutated between generations. These changes led to life as we know it today.

Mutation produced the countless variations of living things we see around us. Most mutations place a living thing at a disadvantage—for example, a mutation might produce a white caterpillar that is easily spied by predators. Some mutations, however, give an individual a better chance of survival. Individuals with such mutations are more likely to survive to have offspring, so over time, this mutant gene will likely become established in the gene pool (the genes of a breeding population).

Genes Across the Ages

In nature, genes generally are transferred between members of the same species. Some new studies, however, suggest that genes also move between unrelated organisms. For the most part, such "horizontal" gene transfer takes place between bacteria and viruses.

Today, horizontal gene transfer also can occur through genetic engineering (See Unit 4, Lesson 4), tools of the new biotechnology that came into existence during the 1970s. DNA can be transferred via direct injection or by inserting the DNA into bacteria or viruses that carry it into the cells they infect. This means that traits determined by single genes can conceivably be transferred from one living thing to another.

Characteristics coded for by more than one gene are much harder to transfer, since the contributing genes must all first be identified, found, and isolated. The idea of moving genetic material from one living thing to another will continue to challenge researchers well into the 21^{st} century.

STUDENT ACTIVITIES:

1. Ask students to read the story Elizabeth Learns Why She Has Blue Eyes, paying close attention to the features she inherited from her mom and dad—blue eyes, height, hair, teeth, brains!

2. Complete the activity described on the following worksheet. (Worksheet 1) In this activity, pipe cleaners will represent genes that control certain traits. The traits were chosen as examples because these traits are coded as single genes in people. Many human characteristics such as height or weight are coded by multiple genes. (Example 1, 2)

   There will be 10 bags, 5 representing "Mom's genes" and 5 representing "Dad's genes." The number of pipe cleaners in each bag should equal or exceed the number of participants.

Acknowledgements:

The material in this section was derived from the book Field of Dreams: Making Sense of Biotechnology in Agriculture, published by the National 4-H Council. (Found on the Internet at http://www.fourhcouncil.edu).

Brown eyes

Inherited Traits

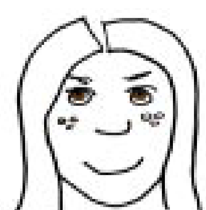

Free ear lobe


Attached ear lobe


Ability to roll the tongue

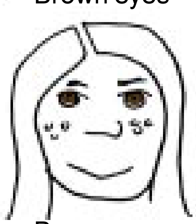

Brown eyes

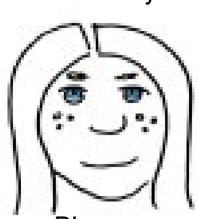
		B (BROWN)	b (blue)
Dad	b (blue)	Bb (BROWN)	Bb (BROWN)
Mom	b (blue)	Bb (BROWN)	bb (blue)


Brown eyes


Brown eyes


Blue eyes


Brown eyes


Blue eyes

GENES-R-US ACTIVITY WORKSHEET

1. Discuss how parents and children are alike. Why are they alike? *(because of genes)*

2. Explain that cells contain information that determines how children look, and that genes are the messengers that carry the information, just as a child would carry a note to a teacher. Stress that we can't see genes with our eyes—they are very, very small.

3. Poll how many participants have blue eyes, brown eyes, how many have attached ear lobes, how many can roll their tongues. (Show them the drawings of earlobes and rolled tongues! - Example 1) Ask them to count the number of girls and boys in their family.

4. Explain that the information for some traits is dominant over that of others.

   Ask, can two brown eyed parents have a blue eyed child? The answer (yes, if both have a recessive blue-eyed gene) can be demonstrated by placing four brown pipe cleaners, two short and two long, into a bag. This would be represented by the following punnet square:

	B (BROWN)	b (blue)
B (BROWN)	BB (BROWN)	Bb (BROWN)
b (blue)	Bb (BROWN)	bb (blue)

   The odds of having a blue-eyed child (rr) are one in four. But will this probability match what actually happens?

   Take turns drawing two pipe cleaners at a time from the bag (replace after each turn). Tally the number of blue and brown eyed people made. Does it work out to the 3:1 ratio predicted by the punnet square?

5. Write the following on a board: *(Suggestion: Limit this exercise to only two or three traits for younger students.)*
   - Brown = Eye Color (long = dominant = brown) (short = recessive = blue)
   - Red = Tongue Rolling (long = dominant = can roll) (short = recessive = can't roll)
   - Green = Number of Fingers (long = dominant = five fingers) (short = mut
   - White = Earlobe Structure (long = dominant = attached) (short = recessive = not attached)
   - Yellow = Sex (two longs = girl) (one long and one short = boy)

6. Help the students prepare 10 bags, 5 are "Mom" and 5 and "Dad".

   - Bag Mom 1 (Mom's eye color genes): Mom has blue eyes (recessive). Fill bag with 100% short brown pipe cleaners.

- Bag Dad 1 (Dad's eye color genes): Dad has brown eyes because he received a dominant "brown gene" from his mother and a recessive "blue" gene from his father. Fill bag with 50% short brown pipe cleaners and 50% long brown pipe cleaners.

- Bag Mom 2 (Mom's tongue rolling ability gene): Mom can roll her tongue because she received a dominant tongue rolling gene from her mother, while receiving a recessive tongue rolling gene from her father. Fill the bag with 50% long red and 50% short red pipe cleaners.

- Bag Dad 2 (Dad's tongue rolling ability gene): Dad can also roll his tongue because he received a dominant tongue rolling gene from his mother, while receiving a recessive tongue rolling gene from his father. Fill the bag with 50% long red and 50% short red pipe cleaners.

- Bag Mom 3 (Mom's earlobe attachment genes): Mom has attached earlobes and received dominant genes from both of her parents. Fill bag with 100% long white pipe cleaners.

- Bag Dad 3 (Dad's earlobe attachment genes): Dad also has attached earlobes and also received dominant genes from both of his parents. Fill bag with 100% long white pipe cleaners.

- Bag Mom 4 (Mom's gender genes): All females have 2 "X" chromosomes. Fill the bag with 100% short yellow pipe cleaners.

- Bag Dad 4 (Dad's gender genes): All males have 1 "X" and one "Y" chromosome. Fill the bag with 50% short and 50% long yellow pipe cleaners.

- Bag Mom 5 (Mom's finger genes): Mom has five fingers and no mutant finger genes. Fill the bag with 100% long green pipe cleaners.

- Bag Dad 5 (Dad's finger genes): Dad has six fingers due to his possession of two mutant finger genes inherited from his parents. Fill the bag with 100% short green pipe cleaners.

7. Line the 10 bags up on a table, appropriately labeled "Mom eye genes, Dad's eye genes, Mom's tongue rolling genes, etc. Split students into teams of two, then have each student pick one pipe cleaner from each bag.

8. After all are finished, ask each team to decide, and then describe or draw, what their "person" will look like (male or female, blue eyes or brown, tongue rolling ability or not, five or six fingers, attached earlobes or not). Share these results with the classroom.

   - Eyes: Offspring of these two parents should be 50% blue eyed and 50% brown eyed. Mom always contributes a recessive blue gene, while dad contributes a blue gene half the time and brown gene the other half.
   - Tongue rolling ability: Offspring should be 75% tongue rollers and 25% non-tongue rollers. This

result can be predicted from the punnet square given the genes of the parents. In reverse, the genetics of the parents could have been deciphered from the ratio of tongue rollers to non-tongue rollers among the offspring.

- Earlobes: 100% of the offspring have attached earlobes, since both parents possessed only dominant genes for this trait.
- Gender: Just like real life, 50% of the offspring will be females, and 50% will be males. Females always have two X chromosomes and males always have one X and one Y chromosome.
- Fingers: All offspring have 5 fingers. This is an opportunity to point out how dominant normal genes can cover up a "defect" caused by recessive genes. The offspring, while having five fingers (normal), are "carriers" of the "recessive-mutant" gene.

LESSON 3: WONDER CORN

SUBJECT: Multidisciplinary

OBJECTIVE: Students will define the word "biotechnology" and will use their creativity to invent new kinds of plants that offer benefits to the world.

MEASUREMENT: Students will be able to define biotechnology as "using a living thing to make something useful" and will have stretched their minds, imagining ways that this technology might change the world.

BACKGROUND FOR TEACHERS:

Biotechnology is simply using biological processes to make things for humans. Bread, for example, is made using biotechnology. The biological activity of the yeast helps dough rise, creating a low-tech product with the help of active microorganisms.

Since humans have been making bread for thousands of years, we could say that biotechnology is an old process. But today when people talk about biotechnology, they are discussing high-tech applications involving transferring genetic material between organisms. This process uses the tools of genetic engineering, or recombinant DNA technology.

STUDENT ACTIVITIES:

1. Ask students to read <u>Elizabeth Learns Why She Has Blue Eyes</u>, paying close attention to her insights into new and better kinds of corn, particularly the "armored corn," that is resistant to insects.

2. Older students can be given this "biotech quiz" without any introduction. (Worksheet 1) When they're finished, review the correct responses, then continue with the rest of the lesson.

3. (*Younger students can begin with this yeast/bread example of biotechnology, even baking bread if you want*!):

   Talk about bread making. Explain that using living things (yeast) to make things we use (bread) is very old. The yeast is alive and as it grows in the warm water and sugar, it gives off carbon dioxide that causes the bread to rise.

   - Define biotechnology on the board, or in your own words for younger students.
     Biotechnology uses biological processes to make products. It has been used for centuries to make things, including beer and bread using yeast. It's a process in which living things are used to make other things.

4. Explain that today scientists use other living things, such as bacteria and plants, to make new products too. This is the new biotechnology, or genetic engineering. It is not quite the same thing as adding yeast to bread. It involves moving genes between living things. It changes the traits of the organism that receives the genes.
   - Define genetic engineering for older students:
     Genetic engineering is a new biotechnology. It uses molecular tools to move genes from one organism to another, changing one or more traits of the recipient organism.

5. Explain the process of genetic engineering using this film analogy. If you have an old movie or video film, use a scissors to "cut" some frames out and "splice" or "paste" them in different sections. (Example 1)

   "Let's say you and your friends are making a videotape to send into a television show. You're taping segments of people skiing down "Suicide Hill." Many people fall. Others swoosh gracefully to the bottom. You'd like to put together a tape of people falling, one right after the other. How could you do this?

   Well, you could cut and splice…

   Now, suppose you want to raise a lot of corn in a field. The only problem is that corn plants are often attacked by corn borer insects. If there were a way to keep the insects from eating the corn, you could grow more.

   A friend of yours suggests you take a gene (See Unit 4, Lesson 2 for more information on genes) from a bacterium that kills corn borers, place it in the genetic material of the corn plant, then cross this plant with other altered plants. The genetic material from the bacterium is "cut" with an enzyme, just like the scissors, then "pasted" into the corn genetic material. Wow! You'd have a corn borer resistant plant!

   Well, it's not that simple, but is it science fiction? No, it's recombinant DNA (genetic engineering)."

6. The picture on this handout illustrates this "cut" and "paste" biotechnology. Older students could be quizzed on the eight steps. (Example 2)

7. Now for the creative part! Ask students to brainstorm a list of ways to improve corn and corn plants. (Unit 1 has information about corn plants). Do not limit their imagination. Tell them anything is possible for this exercise! They might want to work in small groups, or teams of two.

   - For example: Corn plants would be better if they could protect themselves from insects that hurt them (Elizabeth's "armored corn"). Corn plants would be better if they did not freeze in cold weather, so farmers could grow them all year. Corn plants would be better if they could grow without much rain or sunlight. Corn would be better if it had medicine in it for people (Elizabeth's idea for purple corn with vitamins for kids.) Corn would be better if were easier to turn into clothes we could wear. (See Units 8 and 9 for more uses of corn.) Corn would be better if it were easier to pick. Corn would be better if it would stay fresh longer. ETC!!

8. Now, ask students to think of something in nature that already has the good thing they want to see in corn.

   - For example: Is there a plant or other organism not bothered by freezing temperatures? Is there a plant or other organism that can grow without much rain or sunlight? Is there a plant or other organism that is easy to pick?

9. Finally, ask students (or teams) to combine the solution they thought of in #8 with a corn plant, to make a "Wonder Corn" that can solve the problem they thought of in #7.

   - For example, since a pine tree does not freeze, a student could imagine a Wonder Corn that can grow all winter growing in pine trees…

   The purpose of this exercise is to allow students to imagine what might be possible, NOT what is practical. (Older students in the math or social studies choices can discuss feasibility and ethical issues!)

   Then ask students to complete one or more of the following:

   - **Art**: Draw their "Wonder Corn." (Or build it from any material they choose.)
   - **Language Arts**: Write an essay about their "Wonder Corn" describing how important this new corn will be for the world.
   - **Math**: Develop a business plan, complete with financial budgets, for getting this corn to market, and then selling it.
   - **Social Studies**: Act out a debate between two political candidates discussing the ethics, or the pros and cons, of their "Wonder Corn" creation.
   - **Music**: Write a tune with words, to be used as a radio commercial for their "Wonder Corn."

Acknowledgements:
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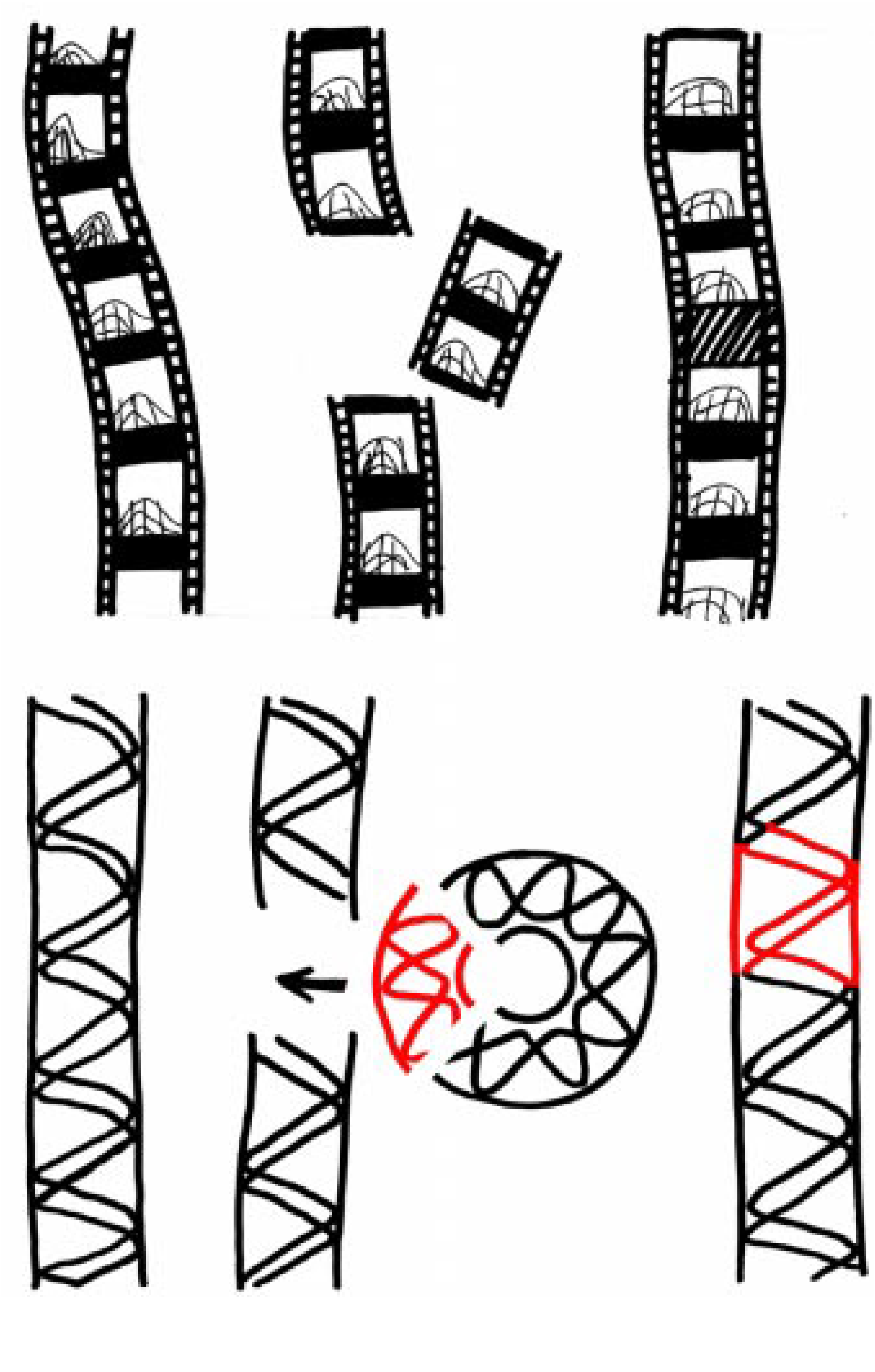
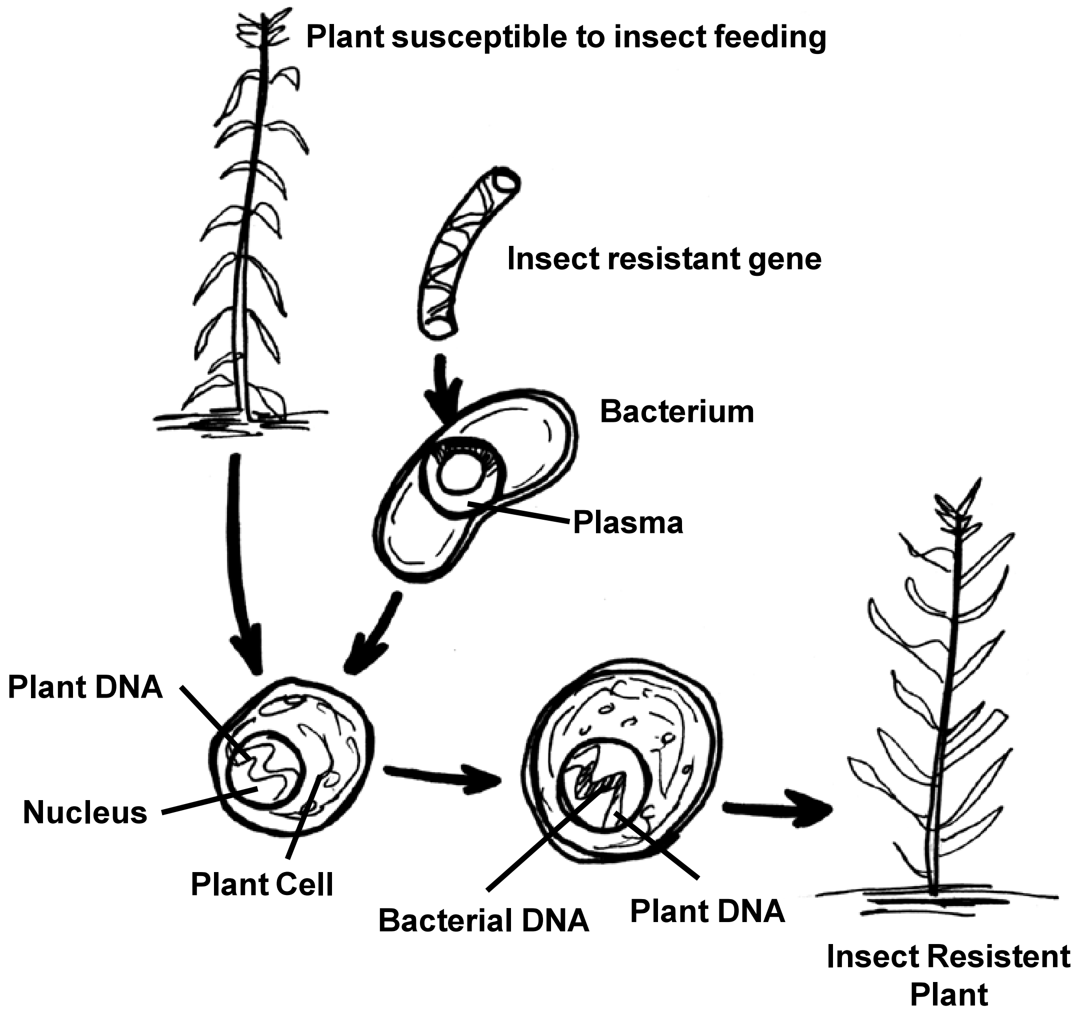
Genetic Engineering





8 Steps to Creating New Plants

1. Identify the trait you want.
2. Identify the source of the gene
3. Isolate the gene from that source
4. Adjust the gene to confer the desired trait.
5. Transfer the gene to plant
6. Test to see if the trait you wanted is there.
7. If it is, go to step 8. If it isn't, go back to step 5.
8. Run field trials to:
   a) make sure there are no detrimental effects of the gene
   b) the gene works the way you want it to

Biotech Quiz

1. Biotechnology (say bye'-o-tek-nawl'-o-jee) is (circle one):

   a.) using nuclear power to make life from nonliving things such as rocks and soil
   b.) using microorganisms, plant cells, or other living things to make things
   c.) a rare species of owl
   d.) a technique that uses lightning bolts to create new life

2. Circle all the things below made using biotechnology:

   a.) bread
   b.) cheese
   c.) penicillin
   d.) delayed-ripening tomatoes

3. Genetic engineering is (circle all that apply):

   a.) changing living things by changing their genes
   b.) the deliberate transfer of genes between and among species by humans.
   c.) changing stones into living things
   d.) dependent on finding and moving DNA

4. To make a pea plant that produces more peas, we could (circle all that apply):

   a.) selectively breed pea plants that produce a lot of peas with each other
   b.) use glue to stick many pea pods option a plant
   c.) feed a plant lots of fertilizer and hope it will produce lots of peas
   d.) assuming we could locate and isolate the genes that could make more peas, transfer them to our plant

5. Biotechnology began:

   a.) about five years ago
   b.) about 35 years ago
   c.) about 135 years ago
   d.) more than 10,000 years ago

6. Genetic engineering techniques have been used to selectively move genes between living organisms:

   a.) for about 5,000 years
   b.) for about 100 years
   c.) for about 25 years
   d.) haven't been developed yet

LESSON 4: FARM OR PHARMACY?

SUBJECT: Social Studies, Current Events
OBJECTIVE: Students will become aware of the fact that cornfields could become factories for medicines and vitamins, and they will begin to notice the media coverage.
MEASUREMENT: Students will be aware that the potential exists for medicines and nutrient supplements to be produced in cornfields.

BACKGROUND FOR TEACHERS:

"Nutraceuticals" are health supplements or vitamins delivered through food. The potential benefits for the world's populations are awesome, especially in malnourished regions where daily diets are often low in adequate vitamins or proteins. Supplementing needed nutrients through common grains such as corn, wheat, or rice could greatly improve the health and stability of entire nations.

If antibodies or vaccines could also be inserted into plant-based products they could be produced more cheaply, and also administered more attractively. Who wouldn't rather take medicine in a bowl of corn flakes than by an injection?

Large companies are investing billions of dollars into research. Farmers are watching closely to see if they will be able to benefit economically. They also wonder if regulating agencies such as the Food and Drug Administration will restrict on-farm production of these products.

STUDENT ACTIVITIES:

1. Ask students to read the story Elizabeth Learns Why She Has Blue Eyes, paying close attention to her dreams of saving the world by creating corn supplemented with vitamins, and her idea of getting a "patent" on the improved corn plants. Ask students if they think her ideas are realistic, ethical, or if they're only science fiction.

2. Ask students to discuss a comment by Bill Gates in which he calls the genetic code the "software of life." (See Unit 4, Lessons 2 and 3 for more information on the genetic code.) Do they agree? Should private companies be able to develop, and then get a patent, on "software of life"?

3. Encourage students to keep their eyes and ears open for articles in the newspaper, or reports on the television, about these issues, and to bring them to the classroom.

4. Ask students to read those articles to the class. Discuss how biotechnology could make their lives better.