PLANT BIOTECHNOLOGY

A Resource Guide for Biotechnology Club Sponsors

NSF Award
0401988

This chapter contains background information, experiment ideas and contact suggestions. Topics covered include:

- **Plant Propagation**
  - **Plant tissue culture**
  - **Genetic engineering**
- **Plants for Fuel**
- **Plants for Fiber**

Lone Star College Montgomery
Biotechnology Department

Plant Biotechnology

Field of Dreams

The field of plant biotechnology is concerned with developing ways to improve the production of plants in order to supply the world's needs for food, fiber and fuel. In addition, plants provide us with many pharmaceuticals and industrial compounds. As our population grows, our needs also grow. To increase the quantity of crop production as well as to produce specific characteristics in plants, biotechnologists are using selective gene techniques. The two major methods of propagation are:

- Plant tissue culture*
- Genetic engineering*

In addition to food for consumption, food products are also being produced for

- Fuel*
- Fiber*
- Pharmaceuticals

*These items will be explored in this manual for possible club/classroom focus.

Plant Tissue Culture (PTC):

Plant tissue culture is the sterile, *in vitro* cultivation of plant parts. Plants have the ability for differentiated cells revert to an undifferentiated state called callus. These cells will then divide and then differentiate back to somatic embryo cells that will regenerate the entire plant.

Plants cultured *in vitro* yield thousands of genetically identical plants (clones) from a single plant. This process is called micropropagation and is used to commercially propagate plants asexually. The rapid multiplication allows breeders and growers to introduce new cultivars much earlier than they could by using conventional propagation techniques, such as cuttings.

Through the use of biotechnology, desirable genetic traits can be transferred from one organism to another by transfer of DNA. Many more plants with the desirable DNA can be regenerated from small pieces of the transformed plant tissue. Examples of plants produced using tissue culture include the large variety of ornamental plants; agricultural crops such as strawberry, banana, potato, and tomato; and a variety of medicinal plants.

Commercial tissue culture involves exposing plant tissue to a specific regimen of nutrients, hormones, and light under sterile conditions to produce many new plants over a very short period of time.

There are three main steps to the tissue culture process:

STAGE I: initiation phase. A piece of plant tissue is cut from the plant, disinfested, and placed on a medium. A medium typically contains mineral salts, sucrose, and a solidifying agent such as agar. The objective is to achieve an aseptic culture (one without contaminating bacteria or fungi).

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STAGE II: multiplication phase. The plant material is re-divided and placed in a medium with plant growth regulators that induce the growth of multiple shoots. This process is repeated many times until the number of plants desired is reached.

STAGE III is: root formation phase. Hormones are used to induce rooting and the formation of complete plantlets.

The plants are then moved from the laboratory to greenhouses and placed in soil for further development.

Internet background:

TAMU in College Station, TX
http://aggie-horticulture.tamu.edu/tisscult/tcintro.html

Plant tissue culture links
http://www.home.turbonet.com/kitchenculture/tcinfo.htm

Plant tissue culture kit order information
http://www.kitchenculturekit.com/index.htm

Short description of history and uses of plant tissue culture along with nice graphic.
http://edugreen.teri.res.in/explore/bio/tissue.htm

Lab activities:

Plant tissue culture: Web site provides guidelines for preparation and the laboratory protocol for micropropagation. (Click for web snapshot) Page 15
http://www.accessexcellence.org/LC/ST/st2bgplant.html

Affordable plant tissue culture for the classroom: Site has directions and pictures for plant tissue culture that can be done with home supplies. (Click for web snapshot) Page 16
http://www.kitchenculturekit.com/sivbposter.htm

Plant tissue culture for home gardeners: Directions for home gardeners and hobbyists (Click for web snapshot) Page 17
http://www.une.edu.au/~agronomy/AgSSrHortTCinfo.html

Plant Micropropagation Using African Violet Leaves
http://www.biotech.iastate.edu/publications/lab_protocols/AV_Micropropagation.html --

A complete lesson on tissue culture. Very nice pictures and support material.
http://croptechnology.unl.edu/viewLesson.cgi?LessonID=957885612 --

Local Contacts:

April Herring: Tissue Culture Production Manager at Magnolia Gardens Nursery (a wholesale dealer only)
aprher@magnoliagardens.com

Dan Lineberger: Creator of Aggie Horticulture web site which includes a section on cell culture information exchange
Dan-lineberger@neo.tamu.edu

Dr. Larry Loomis-Price: Director of Montgomery College Biotech Institute. The college can support experiments in the biotech lab on campus.

Genetically Engineered Plants

Our ancestors have been improving crops and livestock for thousands of years through selective breeding or crossbreeding to produce desired traits. Biotechnology is just an extension of this process. Genes are added, deleted or temporarily silenced to produce desired results.

Genetic engineering involves cutting and moving snippets of DNA from one plant to another. Permanently integrating new DNA into a plant's original DNA forms what's known as a transgenic plant or genetically modified organism (GMO).

Major goals of genetic engineering of plants:

- Produce crops with less impact on environment
- Reduce expense of food production
- Produce crops less vulnerable to insects, diseases, weeds and harsh environments
- Develop crops with more nutrients
- Develop crops for production of medicines and vaccines

Major genetically engineered traits in plants:

- Insect resistance
- Herbicide resistance
- Virus resistance
- Delayed fruit ripening
- Altered oil content
- Pollen control

Genetically engineered foods: More than 60% of processed foods in the US contain ingredients that come from genetically engineered plants (mostly corn and soybeans). Although 12 different genetically engineered plants have been approved in the US, not all are on the market.

Nutritionally enhanced plants – golden rice. There is an international effort to engineer rice to accumulate b-carotene, which is converted to vitamin A in the body. Incorporation of the trait and widespread distribution could prevent blindness and eventual death in ½ million children each year due to vitamin A deficiency.

Molecular farming: plants being genetically engineered to produce pharmaceuticals and vaccines.

Health and environmental concerns:

- Farm worker and consumer safety
- Environmental effects on plants, animals and water systems
- Genes moving from genetically engineered crops into wild plants
- Pests eventually developing resistance to pest-resistant crops
- Introduction of allergy-causing compounds in foods

Safety regulators in the US

US Department of Agriculture (USDA) -- determines if it is safe to grow
US Food and Drug Administration (FDA) – determines if it is safe to eat
Environmental Protection Agency (EPA) – determines if it is safe for the environment

Internet background:

Wonderful slide show on Plant Biotechnology
http://www.whybiotech.com/html/assets/Biotech%20Overview_12_04_02_files/frame.htm

An introduction and resource guide for transgenic crops: History of plant breeding, how to make transgenic plants (animation), regulation, current products and other resources for teachers with links to printable articles, slide presentations, lessons and other links. (Click for web snapshot) Page 24
http://www.colostate.edu/programs/lifesciences/TransgenicCrops/index.html

Library of crop technology lesson plans
http://croptechnology.unl.edu/listLessons.cgi

Facts and fiction about plant and animal biotech. (Click for web snapshot) Page 18
http://www.bio.org/foodag/facts.asp#1

Biotech products on the market
http://www.bio.org/speeches/pubs/er/agri_products.asp?p=yes

GE Foods in the Market. A series of articles from Cornell Cooperative Extension's Public Issues Project
http://www.geo-pie.cornell.edu/crops/eating.html --

Dining on DNA: A complete book about food biotechnology for high school students and teachers. Each unit contains background information, objectives, materials needed, teacher preparation necessary, procedures and follow-up activities. (Click here for table of contents) Page 19
http://www.accessexcellence.org/RC/AB/BA/DODpub/

Teaching aids, curriculum and student activities
http://ucbiotech.org/ --

Resources for teachers
http://www.colostate.edu/programs/lifesciences/TransgenicCrops/teachers.html

Web simulations:

How to make Transgenic Plants: Animation Demo
http://www.colostate.edu/programs/lifesciences/TransgenicCrops/animation.html --

Engineer A Crop and ***Selective Breeding:*** Students work through a transgenic manipulation activity and compare their results. (Click for web link) Page 20
http://www.pbs.org/wgbh/harvest/engineer

Teen scene contains interactive information and quizzes on agriculture/biotech topics. Check out the Pizza Explorer under the Entertainment heading.
http://www.agclassroom.org/teen/enter1.htm

How DNA sequencing provides for crop trait selection. Maize or corn genome is explored with sound and animations. (Click for web snapshot) Page 21
http://www.koshlandscience.org/exhibitdna/crops01.jsp# --

Lab activities:

Finding plant genes in public databases (teacher version) (Click for snapshot) Page 22
http://www.geospiza.com/outreach/biolabs/instplant.pdf

Finding plant genes in public databases (student version)
http://www.geospiza.com/outreach/biolabs/studplant.pdf

Where in the World is the Food? (Click for web snapshot) Page 23
http://www3.iptv.org/exploremore/ge/teacher_resources/teaching_materials/soc9_where.cfm --

Feed the World and Fill a Basket Activity (Click for web snapshot) Page 25
http://www.pioneer.com/education/lesson_plans/module_1/feed_the_world/activity_feed_the_world.doc

Explores the concepts of resistance and susceptibility and how populations are impacted by a stressor. Other lessons can be found on this site. (Click for web snapshot) Page 26
http://agbiosafety.unl.edu/res_suscep.shtml

Pick Your Produce: A Role Playing Paper-Based Activity available on the Bio-link web page (requires free registration to log on) (Click for web snapshot) Page 27
http://www.bio-link.org/resMaterial.htm --

Local Contacts:

Montgomery county extension office: 936-344-8414

Texas A&M horticulture department: http://aggie-horticulture.tamu.edu

MCBI: Sponsors a kit for detecting the presence of modified DNA in common corn-containing products. Bring a class to the college or we can take a kit to you!

Textiles and Biotechnology

Biotechnology has changed the textiles industry through the development of more efficient and environmentally friendly manufacturing processes, as well as through the design of improved textile materials. Some of biotechnology's key roles have involved the production and modification of enzymes used for improving textiles. Biotechnology has also facilitated the production of novel and biodegradable fibers from biomass feedstocks.

Enzymes in Textiles

Through biotechnology, enzymes are used to treat and modify fibers during textile manufacturing, processing, and in caring for the product afterwards. Some applications include:

De-sizing of cotton – Untreated cotton threads can break easily when being woven into fabrics. To prevent this breakage, they are coated with a jelly-like substance through a process called sizing. Amylase enzymes are widely used in de-sizing, as they do not weaken or affect cotton fibers, nor do they harm the environment.

Retting of flax – Flax plants are an important source of textile fibers which are often used in biodegradable clothing. Useful flax fibers are separated from the plant's tough stems through a process called retting which requires large quantities of water and energy. Bacteria, which may be bred or genetically engineered to contain necessary enzymes, can be used to make this a more energy efficient process.

Bleaching fibers – When cotton is bleached, a chemical called hydrogen peroxide, which can react with other dyes, remains on the fabric. Catalase enzymes specifically break down hydrogen peroxide and may be used to remove this reactive chemical before further dyeing

Stonewashing and polishing – Instead of using abrasive tools like pumice stones to create a stonewashed effect or to remove surface fuzz, cellulase enzymes may be used to effectively stonewash and polish fabrics without abrasively damaging the fibers.

Detergents – Enzymes allow detergents to effectively clean clothes and remove stains. Without enzymes, a lot of energy would be required to create the high temperatures and vigorous shaking needed to clean clothes effectively. Enzymes used in laundry detergents must be inexpensive, stable, and safe to use. Currently, only protease and amylase enzymes are incorporated into detergents. Lipase enzymes, which break down easily, are being studied and developed through genetic screening and modification.

Novel Fibers

Synthetic fibers made from renewable sources of biomass are becoming more economically feasible. Biodegradable synthetic polymers include fibers such as polyglycolic acid and polylactic acid, which are made from natural materials.

Not all novel fibers are synthetic; they may also be naturally derived. Some natural biological fibers come from basic materials found in nature, including:

- **Chitin** – a type of sugar polymer found in crustaceans
- **Collagen** – a type of protein found in animal connective tissue
- **Alginate** – a type of sugar polymer found in certain bacteria

An example of a synthetic biomass fiber is Polylactic Acid (PLA), which is made by fermenting cornstarch or glucose into lactic acid, and then chemically transforming it into a polymer fiber. PLA minimizes environmental waste, as it may be fully biodegraded by microorganisms under appropriate conditions into carbon dioxide and water. Clothing made from corn using this method can be purchased under the Injeo brand name (Wickers website).

Medical Textiles

Biodegradable fibers may be used to make textiles for medical applications. Such textiles may be used in first aid, clinical, and hygienic practices. Some examples are described below: (information from: **http://www.biobasics.gc.ca/english/View.asp?x=791**)

Polymer	**Use(s)**
Polylactic Acid and Polyglycolic Acid	Used in sutures, absorbable wound closure products, orthopedic repair absorbable pins, and fixation devices, as well as in tissue engineering structures
Chitin	Incorporated into wound dressings
Collagen	Uses in cell engineering structures, such as in artificial skin, or even as surgeon's thread
Alginate	Used to protect and interact with wounds

Synthetic biomass fibers may also be used in drug delivery systems, which are designed to release drugs at a specified rate for a specified time.

Textiles in Texas

- Farmers plant over 6 million acres of cotton in Texas each year, on both irrigated and dryland fields
- Texas cotton has a farmgate value of nearly $1 billion and impacts the overall Texas economy by over $1.4 billion.

Cotton breeding programs at Lubbock and College Station, along with the fiber quality testing program at the Texas Tech University International Textile Center have helped improve the competitiveness and profitability of Texas cotton farmers. Through these efforts, Texas cotton has been bred to produce longer, stronger fibers that are worth more to both the textile industry and the individual producers.

Internet background:

The clothing and fashion industry information. Great place to find fashion schools, textile definitions and recent research.
http://www.apparelsearch.com/education.htm

The American Fiber Manufacturers Association, Inc. *(AFMA)* is the trade association for U.S. companies that manufacture synthetic and cellulosic fibers. The industries employ 30 thousand people and produce over 9 billion pounds of fiber in the U.S. Annual domestic sales exceed $10 billion. AFMA member companies produce more than 90% of the total U.S. output of these fibers. The website contains a link to Fiber World Classroom – great information and graphics about all types of fibers and textiles.
http://www.afma.org/

Ingeo Clothing: Source of t-shirts for men and women made from corn fiber. (Click for web link) Page 29
http://www.wickers.com/main/products/product.cfm?prodId=WA408

Web Activities:

Teen scene contains interactive information and quizzes on agriculture/biotech topics
http://www.agclassroom.org/teen/enter1.htm

An interactive quiz about gm foods – very graphic and informational
http://www.exploratorium.edu/theworld/gm/test.html

Local contacts:

Texas 4-H and Youth Clothing Program
Teresa Smith
Extension Program Specialist
Texas Cooperative Extension, The Texas A&M University System
727 Graham Road
College Station, TX 77845
979-845-1150
t-smith2@tamu.edu

Texas Farm Bureau
Mr. Tad Duncan
P.O. Box 2689
Waco, TX 76702-2689
P: (254) 751-2608
F: (254) 751-2671
E: tduncan@txfb.org
http://www.txfb.org/AgClass/agclass.asp

The Texas Farm Bureau has a link on their web page to their speaker team who would know of a local contact.

Biofuels

In 2002, fossil fuels, which are finite and nonrenewable, supplied 86% of the energy consumed in the United States. The United States imports over half (62%) of its petroleum and its dependence is increasing. Since the U.S economy is so closely tied with petroleum products and oil imports, small changes in oil prices or disruptions in oil supplies can have an enormous impact on our economy - from trade deficits, to industrial investment, to employment levels.

Biofuels are not new products. In the 1908, Henry Ford's Model T was designed to run on alcohol, petrol or any mix of the two. In 1919, when Prohibition began, ethanol in all forms was banned. It could only be sold when it was mixed with petroleum. With the end of Prohibition in 1933, ethanol was used as a fuel again, but it has never caught up to petroleum in the US.

Ethanol use increased temporarily during World War II when oil and other resources were scarce. In the 1970s, interest in ethanol as a transportation fuel was revived when embargoes by major oil producing countries cut gasoline supplies.

There are two types of biofuels:

- Biodiesel: A methylester of vegetable oils, typically soybean or sunflower oil. The oil is reacted with an alcohol in the presence of a catalyst to produce glycerine and methylestars or biodiesel.

- Bioethanol: Basically alcohol, bioethanol is produced by fermentation and distillation of starch plants (grain, mostly corn, and tubers like cassava); sugar plants (sugar beet or sugar cane); and - although large-scale still in the preliminary stages - from cellulose plants.

Contribution of Biotechnology

For most of this century, researchers assumed that many of the sugars contained in biomass were not fermentable - those contained in hemicellulose. This meant that as much as 25% of the sugars in biomass could not be used for ethanol production.

In the 1970s and 80s, microbiologists discovered microbes that could ferment these sugars. Now, with the new tools available, researchers have succeeded in producing several new strains of yeast and bacteria that are able to ferment more of available sugars to ethanol. Microbes found to be capable of metabolizing multiple sugars include:

E.coli
Zymomonas mobilis
Saccharomyces yeast

Internet resources:

Biodiesel recipes: Interesting site with full directions and illustrations on how to make your own biodiesel fuel (in English and Spanish).
http://journeytoforever.org/biodiesel_make.html

U.S. Department of Energy: Lots of information about biomass fuels and current projects and research.
http://www1.eere.energy.gov/biomass/biomass_basics.html

ABC's of biofuels for students http://www1.eere.energy.gov/biomass/abcs_biofuels.html

US Department of Agriculture
http://www.nal.usda.gov/ttic/biofuels.htm --

Biodiesel distributor in Austin, TX
http://www.austinbiofuels.com/index.php/fuseaction/home/pid/12/sid/10.php --

Local Contacts/Field Trips:

Houston Biodiesel
2970 Farrell Rd
Houston, TX 77073
Phone: (281) 443-9009
http://www.houstonbiodiesel.com/links.htm
Quote from website: "We'd be happy to "talk" biodiesel (as long as we have a free moment) to anyone who calls or comes by for a visit. Give us a call - we'd be happy to discuss biodiesel use for your application."

The **Southwest Biofuels Initiative** (SWBI) is a project of the Houston Advanced Research Center, a 501(c)(3) not-for-profit research institution located in The Woodlands, Texas. The biodiesel manufacturing site in Tamina would make a great local field trip.
Houston Advanced Research Center
Karl R. Rabago
281-364-4035
krabago@harc.edu
http://www.harc.edu/harc/Projects/Biofuels/

TREIA
The Texas Renewable Energy Industries Association – Associated with the HARC highlighted above

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ACCESS EXCELLENCE
@ the national health museum
LET'S COLLABORATE

SciTalk

Plant Tissue Culture

Presenter: Lydiane (Ann) Kyte
Host: Kathy Liu
Discussion

Did you ever have a plant that was so unique or so beautiful that you wished you had hundreds or thousands of them to enjoy or to sell? Plant tissue culture (micropropagation) is a technique which will do just that for us. We are going to discuss this tool which is used so extensively in the nursery business and in plant biotechnology. It is a fascinating and useful tool which allows the rapid production of many genetically identical plants using relatively small amounts of space, supplies and time.

Basically the technique consists of taking a piece of a plant (such as a stem tip, node, meristem, embryo, or even a seed) and placing it in a sterile, (usually gel-based) nutrient medium where it multiplies. The formulation of the growth medium is changed depending upon whether you are trying to get the plant to produce undifferentiated callus tissue, multiply the number of plantlets, grow roots, or multiply embryos for "artificial seed".

For many who become superficially aware of the technique it seems shrouded in mystery and is shrugged off as too technical to be of concern. Actually, it is no more of a mystery than taking a cutting of your favorite house plant and growing it to share with a friend. As for being technical, you can begin plant tissue culture with as little as a cookbook approach and a feeling for sterile technique.

Some people have visions of scientists doing plant tissue cultures in white gowns and masks in hospital-clean environments. Such conditions are excessive. While it is true that mold spores, bacteria, and other contaminants will grow and overrun a culture, air that is not moving has a minimum of contaminants. In addition, disinfection of implements, work surface and nearby areas helps eliminate contaminants.

The guidelines for preparation and the laboratory protocol provided here are given as a place to begin. Included with is a limited discussion of some of the many options you have as you explore micropropagation. We can discuss these in more depth if you have questions, concerns or related experiences to share. I would be particularly interested in success and challenges you may have had or are currently having in your classroom.

Some suggestions are given for the following
(a) Selecting plant sources. Some species, or even clones are easier to grow in culture than others. Some respond reluctantly to culture, some do not respond at all, and many plants have never been tried.

(b) Choosing a growth medium (price, convenience, type of plant and purpose of the micropropagation all enter into this decision.) How important are the kinds of hormones used? On limited scale, media ingredients are available at the grocery and health food stores.

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Affordable Plant Tissue Culture for the Classroom

Carol M. Stiff, Kitchen Culture Kits, Inc, Olympia, WA; Janet Clancy, Washington State University, Pullman, WA; Ann Evancoe, Hudson Valley Community College, Troy, NY; and Colleen Fiegel, Ben Franklin High School, New Orleans, LA

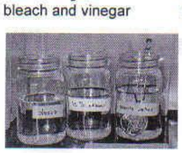
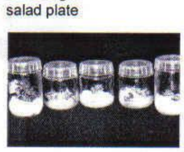
Plant tissue culture (PTC) techniques are used for growing plants in a sterile controlled environment for the purpose of mass production, germplasm preservation, plant breeding, physiological studies, and genetic engineering. By using plant hormones and other growth regulators, small plant parts can be induced to produce hundreds of small "plantlets", which can later be grown in a greenhouse, in the field, or as house plants. PTC can be used as an effective tool to stimulate interest in science by introducing plant biology and biotechnology into K-14 classrooms. In the process of learning PTC techniques, students learn about plant growth, morphology, nutrition, hormones, interaction of microorganisms, aseptic methods, laboratory safety, and organizational skills. Use of plant tissue culture has been limited in the past by the need for expensive equipment (laminar flow hood, analytical balance, and autoclave). However, by using biocides such as PPM (Plant Preservative Mixture from Plant Cell Technology, Inc.) or NaDCC (sodium dichloro-s-triazinetrione is a spa and swimming pool disinfectant), expensive equipment is no longer essential. PTC experiments can be conducted in the classroom or home with little problem of contamination using inexpensive household supplies (microwave oven, baby food jars, bleach, plastic storage box, etc.). In this poster, we describe classroom PTC techniques and successful experiments of affordable plant tissue culture for the classroom or home.

Supplies in Your Classroom, Home Kitchen, or Local Discount Store?


microwave oven with turntable or pressure cooker

Household supplies (sending students on a scavenger hunt might be appropriate and economical)

- pint and quart jars
- food coloring (optional)
- forceps (6 " or longer)
- African violet leaves
- microwave-proof plate
- plastic or cardboard box
- hydroponic fertilizer
- baby food jars
- isopropyl or ethyl alcohol
- florist's tape
- baking soda
- goggles and gloves
- dish detergent
- bleach and vinegar
- measuring spoons
- kitchen knife (about 6" long)
- pyrex pie pan (about 8")
- dusk mask, apron, and shoes
- table sugar
- salad plate

Inexpensive pint jars filled with 70% ethanol, bleach, and sterile water are used to disinfect plant material. Baby food jars are used as media containers to culture plant material.

Supplies Not in Your Typical Classroom, Home Kitchen, or Local Discount Store?

- Murashige and Skoog (MS) medium
- Benzlaminopurine (BAP), a plant hormone that induces shoot formation
- Naphthaleneacetic acid (NAA), a plant growth regulator that induces root formation
- Plant Preservative Mixture (PPM), a biocide that reduces contamination
- Agar, for solidifying the medium
- Polypropylene baby food jar caps (if you are using a microwave oven)
- Plastic (regular) pint jar caps (if you are using a microwave oven)
- pH papers

Where can you find these items? There are several supply companies that will sell to schools and hobbyists. You might also contact the nearest university or college and ask for small samples of things like plant hormones and plant media. Many places conducting research might assist you. Contact us (kck@turbonet.com) if you need help locating supplies or user-friendly scientists.

Safety Recommendations

You need to teach your students some basic laboratory skills and discuss lab safety including: the safe handling and disposal of alcohol and bleach solutions, disinfecting forceps and knives with alcohol (flame sterilization is not recommended), preparation of media (depending on student age, you may need to limit this activity), and the use of protective clothing such as latex gloves, goggles, latex aprons, dusk masks, and leather or tennis shoes.

Material Safety Data Sheets (MSDS) provide information on the safe handling of chemicals. These are required for any chemical used in a classroom, and are obtained from the internet, manufacturers, and chemical supply stores.

[Return to text](#) http://www.une.edu.au/~agronomy/AgSSrHortTCinfo.html

UNE

Horticultural Science Group

Department of Agronomy and Soil Science

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Plant Tissue Culture for Home Gardeners

Micropropagtion is an important alternative to more conventional methods of plant propagation. It involves production of plants from very small plant parts (e.g. buds, nodes, leaf segments, root segments etc.), grown aseptically (free from any microorganism) in a container where the environment and nutrition can be controlled. The resultant plants are genetically identical to parent plants.

Whilst in a research laboratory such as that in the Department of Agronomy and Soil Science at UNE we use many high tech equipment to achieve plant production through tissue culture, it is important to note that many home gardeners and hobbyists could substitute the high tech equipment and instruments with ordinary house hold items.

Items Needed for Home Tissue Culture:

1 - A sterile still air cabinet used to transfer plants. A fish tank on its side makes an ideal transfer cabinet. Any perspex or glass chamber with dimensions of 50 cm (length), 40 cm (height) and 40 cm (depth) could easily be made into a transfer cabinet.
2 - A pressure cooker for sterilisation of media, instruments, water, paper towelling etc.
3 - Glass jars (baby food jars are excellent) and take away food containers with lids which can withstand the heat inside a pressure cooker are ideal vessels to use.
4 - Scalpel and forceps
5 - Paper towelling or even A4 white copy paper, cut to size, can be sterilised and used for a sterile cutting surface.
6 - A spirit lamp containing ethanol for flaming the instruments (avoid using Methanol as it is toxic!).
7 - Hand held spray bottle containing 70% alcohol solution to spray the transfer chamber and other surfaces.
8 - Dilute chlorine solution e.g. 1/4 dilution of the household bleach (e.g. White King) for use in surface sterilisation of plant material.
9 - Any skin disinfectant e.g. Hibitane (obtainable from any chemist shop).
10 - Media (see below)

Media Preparation

All the ingredients indicated below can be purchased using the super market, chemist and a health food shop.

[Return to text](#) http://www.bio.org/foodag/facts.asp#1

Bio
BIOTECHNOLOGY INDUSTRY ORGANIZATION

Biotechnology information, advocacy and business support

contact
Biotechnology Industry Organization
1225 Eye Street NW
Suite 400
Washington, DC 20005
202.962.9200
info@bio.org

Facts and Fiction About Plant and Animal Biotechnology

Printer Friendly

Plant Biotechnology Myths & Facts

- There are no biotech food products currently on the market.
- Biotech foods are unsafe to eat.
- Biotech foods taste different than foods made from conventional crops.
- Organic or conventional crops are more nutritious or safer than biotech crops.
- Biotech foods are not regulated or tested.
- Meat, milk and eggs from livestock and poultry fed biotech feed products are not as safe as similar products from livestock and poultry fed conventionally produced feed.
- The United States does not require labeling of biotech foods.
- Biotech foods and crops are not widely accepted.
- Biotech crops negatively affect the environment.
- Biotech crops are harmful to monarch butterflies.
- Biotech crops increase food allergies.
- Using biotechnology to improve plants is not natural.
- Growing drugs in plants is dangerous - pretty soon there will be drugs in our cereal.
- Biotech foods can't feed the world.
- Biotech crops will cause "superweeds" to develop.
- The only people who benefit from biotech plants are the agricultural companies who develop and sell the seeds. There's no real benefit to consumers and farmers.
- Biotech companies won't disclose where field trials of biotech crops are being grown because they are trying to hide things from the public.

Animal Biotechnology Myths & Facts

- Only humans can benefit from medical biotechnology.
- Pets do not benefit from biotechnology at all.
- Transgenic and cloned animals are different from normal animals.
- Animals cannot benefit from biotechnology.
- Biotech will cause disease outbreaks such as avian flu, mad cow disease and West Nile virus in animals and insects, which will be transferred to humans.
- Organ transplants from animals are an unreal fantasy.
- We are just exploiting animals by applying biotechnology to them.
- Meat, milk and egg products from biotech animals are unsafe to eat.
- Biotech animals suffer more pain or distress than conventional animals.
- If biotech animals or fish escape into the wild, they will endanger wild animals and the environment.
- Animals are misused in research.

Plant Biotechnology Myths & Facts

Myth: There are no biotech food products currently on the market.
Fact: Today, it is estimated that at least 70 percent of processed foods on grocery store shelves contain ingredients and oils from biotech crops. The first biotech crop, a tomato improved through biotechnology, was sold in 1994. The first biotech commodity crops – an insect resistant variety of corn – were grown and sold in 1996. Today, the most popular biotech crops are corn, soybean, cotton and canola.

Myth: Biotech foods are unsafe to eat.
Fact: The Food and Drug Administration (FDA) has determined that biotech foods and crops are as safe as their non-biotech counterparts. The American Medical Association and the U.S. National Academy of Sciences have also

[Return to text](#)   http://www.accessexcellence.org/RC/AB/BA/DODpub/

ACCESS EXCELLENCE
@ the national health museum
ABOUT BIOTECH

Biotech Applied

Dining on DNA: An Exploration into Food Biotechnology

A unit about food biotechnology for high school students and teachers

**Due to the large size of the *Dining on DNA* book, only a sample lesson, Welcome to the World of Food Biotechnology, has been provided in HTML format which can be viewed online. If you would like to check out more lessons, you can download the entire book in Zip compressed PDF format (2.8MB).

In order to view documents in PDF format you will need to get Adobe Acrobat Reader which is available free of charge from Adobe Systems, Inc.**

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Table of Contents
(from complete *Dining on DNA* book)

Originally created and produced by Montana State University, 1996
Extension Service, Bozeman, MT 59717
Extension Publication Number: 6006

[Return to text](#) http://www.pbs.org/wgbh/harvest/engineer

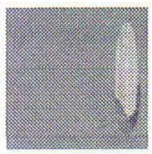
HARVEST OF FEAR

FRONTLINE

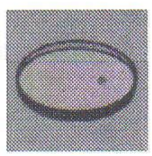
ENGINEER A CROP

BY RICK GROLEAU

From cucumbers and carrots to white rice and wheat, we humans have altered the genes of almost every food we eat. For almost 10,000 years we've been engineering plants by keeping the seeds from the best crops and planting those the next season. Following this practice year after year has resulted in a slow but steady change -- and a substantial cumulative effect. We've been altering the genetic makeup of crops by cross-pollinating, too. About 8,000 years ago, for example, farmers in Central America crossed two mutant strains of a weedy-looking plant called Balsas teosinte and produced the first corn on the cob.



Selective Breeding (251k)
Make the size of your corn bigger using the most basic of techniques. (shockwave plugin required)



Transgenic Manipulation (83k)
Use the latest in biotechnology to engineer a "supercrop." (flash plugin required)

HTML Version

We've had success with the methods mentioned above (especially cross-pollinating), but because they rely on the random mixing of all of a plant's tens of thousands of genes, the odds of producing a crop with a desired trait is akin to winning a lottery. Today scientists can produce a change quickly by selecting a single gene that may result in a desired trait and inserting that gene directly into the chromosome of an organism. Amazingly, genes from organisms as dissimilar as bacteria and plants can be successfully inserted into each other.

These activities let you compare the traditional method of selective breeding with one of the latest transgenic methods.

Rick Groleau is managing editor of NOVA Online.

home + should we grow them? + engineer a crop + what's for dinner? + viewpoints

Return to text http://www.koshlandscience.org/exhibitdna/crops01.jsp# --

MARIAN KOSHLAND
SCIENCE MUSEUM
OF THE NATIONAL ACADEMY OF SCIENCES

at 6th & E Streets, NW, Washington, DC

IMPROVING CROPS

How Does Reading Genes Improve Crops?

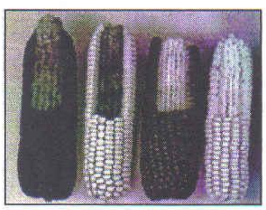
1 2 3 4 5

With the dawn of agriculture, about 10,000 years ago, humans began modifying wild plants. Planting seeds from the most desirable plants is a way of choosing certain genetic traits over others. Although the transformations occurred over many centuries, virtually every cultivated species has been genetically modified from its wild form through classical plant-breeding techniques. The produce sold in markets today is very different from its wild progenitors.

Crop yields have risen dramatically since the advent of scientific crop selection about a century ago. Cross-breeding techniques improved the precision with which specific traits could be selected. Today, DNA sequencing provides new tools for understanding crop traits and for selecting desirable traits with even greater efficiency. In other words, the latest genetic engineering techniques often provide a better way to carry out many of the crop selections of the past.

In the following sections we explore the development of crops, using corn as an example.

From Teosinte to Corn
Increasing Productivity in Corn
Reading Traits in the Corn Genome
Growing GMOs



START ACTIVITY [Requires Flash] **[Get Flash Plug in]**

Maize Mutants
The genes that govern many specific traits have been identified in the maize (corn) genome.

In this activity you can explore some of the genes located on corn's ten chromosomes and see the effects of those genes.

Go to text only version

1 2 3 4 5

From Teosinte to Corn [next]

THE NATIONAL ACADEMIES
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Return to text http://www.geospiza.com/outreach/biolabs/instplant.pdf

Appendix C. Prototype experiments
(per Dr. Sandy Porter)

Finding plant genes in public databases

Objectives:
At the end of this exercise students will be able to:

1. Use Entrez to find a gene sequence associated with a specific plant phenotype
2. Provide evidence to support the hypothesis that the gene found confers that phenotype
3. Use the nucleotide or protein sequence identified above to find similar genes by performing a BLAST search.

Notes to the instructor
Begin this activity with a brainstorming session on plants. The goal of this activity is for students to identify a plant phenotype that they find interesting. Later, they will work to determine if a gene (or more than one gene) for that phenotype can be found in GenBank. Students will be more motivated to find a specific gene if they're working on something that holds their interest.

The first part of the activity involves identifying plant traits that the students find interesting. This is accomplished by reviewing what the students know about plants and having the students work in groups of two to select interesting traits.

The second part of the activity centers around using Entrez to find a gene (or genes) that might be related to the plant traits that they chose and gathering evidence to support that conclusion.

Part I. Identifying interesting traits
First, ask the students to identify factors that affect plant growth. This activity can be carried out with an entire class, or students might work on this in small groups and then share their ideas with the class. You might contribute ideas from time to time if the response is slow. For geographical factors, it might be helpful to have students look at a globe and describe different types of climates. Some examples of the information they might provide are listed below.

1. Factors that affect plant growth:

Climate factors: Alaska, Utah, North Africa, India (monsoons), mountains, rain forest, seashore
Availability of nutrients
Predators/pests: bugs, bacteria, viruses, animals, birds
Reproduction: pollinators, roots, shoots, flowers

World geography and climate:
mountains, northern climates, deserts, high salt, CO2 concentration
heavy metals/pollution, soil pH
concentration of nutrients (potassium, nitrogen, carbon, Mg^{+2}, Fe^{+2}, Mn^{+2}, Ca^{+2}, Na^{+})
too much or too little water

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http://www3.iptv.org/exploremore/ge/teacher_resources/teaching_materials/soc9_where.cfm

Where in the World is the Food?

Subject Area
Social Studies

Activity Overview
Experts say that genetic engineering can increase the amount of food produced on the same amount of land that is currently being farmed. Students will locate the 20 countries most lacking in food that could most benefit from increased food production.

Materials
world map
pencil/pen
paper
research materials

Activity Outline
You will need to provide information and statistics on the top five food producing countries in the world. Provide information/statistics similar to those you expect the students to research.
Have students:
1. Investigate which countries have the lowest per capita food production.
2. Identify and label those 20 countries on a world map.
3. Graph the amount of food produced in those countries compared to the top five producing countries.
4. Write a report on the findings made by analyzing the research data.

Resources
United Nations Food and Agricultural Organization <www.fao.org>
United Nations International Children's Emergency Fund (UNICEF)< www.unicef.org>
The World Food Programme <www.wfp.org>
The Hunger Site <www.thehungersite.com>
Scientific American online <www.sciam.com/2001/0201issue/0201postel.html>

Assessment
Assess comprehension by evaluating the map and graph.

Standards and Benchmarks
Geography
The World in Spatial Terms
Standard 1. Understands the characteristics and uses of maps, globes, and other geographic tools and technologies
2. Uses thematic maps (e.g., patterns of population, disease, economic features, rainfall, vegetation)
4. Knows the advantages and disadvantages of maps, globes, and other geographic tools to illustrate a data set (e.g., data on population distribution, language-use patterns, energy consumption at different times of the year)
7. Knows the characteristics and purposes of geographic databases (e.g., databases containing census data, land-use data, topographic information)

Standard 2: Knows the location of places, geographic features, and patterns of the environment
1. Knows the location of physical and human features on maps and globes(e.g., culture hearths such as Mesopotamia, Huang Ho, the Yucatan Peninsula, the Nile Valley; major ocean currents; wind patterns; land forms; climate regions)

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http://www.colostate.edu/programs/lifesciences/TransgenicCrops/index.html

Transgenic Crops:
An Introduction and Resource Guide

Special Resources for Teachers

Printable Articles

The following articles were developed by the authors for use in various printed formats.

- **Labeling genetically engineered foods** html
  This article from the Autumn issue of "From the Ground Up," a newsletter published by the Cooperative Extension Office at Colorado State University, provides information on the current status of labeling in the United States and arguments for and against labeling.
- **Bt corn questions and answers** html pdf
  Dr. Frank Peairs in the department of Bioagricultural Sciences and Pest Management at Colorado State University developed this set of questions and answers about Bt corn.
- **Protection against corn rootworm** html
  This article from the Autumn issue of "From the Ground Up," a newsletter published by the Cooperative Extension Office at Colorado State University, previews the Bt corn varieties that are being developed by Monsanto and Pioneer.

Slide Presentations

The following PowerPoint presentations were developed by the authors for showing to various audiences in workshops and classes. You may view a presentation on the web.

- **The Basics of Transgenic Technology** view
  This presentation, developed by Pat Byrne, covers many of the steps involved in making a transgenic plant, including design of the transgenic construct and the methods of transformation.
- **How Safe Are Transgenic Crops? Regulatory Systems** view
  This presentation, developed by Pat Byrne, covers the U.S. regulatory agencies and the aspects of transgenic crops that they regulate, insect resistance management and the refuge strategy, and food labelling.
- **Transgenic Crops: Risks, Concerns, and Benefits** view
  This presentation, developed by Sarah Ward, covers many of the issues that have been raised concerning transgenic crops, such as genetic trespass, genetic erosion, effects on non-target organisms, corporate control of the food supply, and potential benefits for developing countries.
- **Transgenic Technology: Ethics and Controversy** view
  This presentation, developed by Sarah Ward, examines the use of transgenic technology issues to teach critical thinking skills in the classroom.

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http://www.pioneer.com/education/lesson_plans/module_1/feed_the_world/activity_feed_the_world.doc

Educational Outreach - Module 1
Why Ag Biotechnology?

Overview

Lesson Plans:

Module 1
Module 2
Module 3
Module 4
Module 5

Lesson Plan: Feed the World

In this activity-based lesson, competing student teams answer questions regarding population growth and food production trends. The goal is to help them understand how productivity is measured and create an awareness of how two critical factors - technology and commitment – impact efforts to feed a growing world. This sets the stage for later lessons/activities in which the students learn how specific factors – such as insects – can reduce the amount of grain available for use in food production.

View Lesson Plan:
Microsoft Word 2000 version (64 KB / 3 pages)
PDF version (22 KB / 3 pages)

View "Feed the World" Game:
Microsoft PowerPoint 2000 version (552 KB / 20 slides)
PDF version (217 KB / 20 pages)

Microsoft PowerPoint 2000 version - Game Cards (13 KB / 4 slides)
PDF version - Game Cards (4 KB / 4 pages)

Lesson Plan: Fill a Basket

Students begin this lesson by shopping for grocery items containing corn products – thus increasing their awareness of the many ways corn is used. The activity also sets the stage for the "Food Chain" game noted below. If they choose to, the students may also purchase or collect food and deliver it to a local organization that helps feed the hungry. Their efforts to obtain and distribute this food provide a great "lead in" for the Global Food Production and Distribution game described below.

View Lesson Plan:
Microsoft Word 2000 version (64 KB / 5 pages)
PDF version (27 KB / 3 pages)

View Handout: "How are Corn/Soybeans/Sunflowers Used?"
PDF version (83 KB / 4 pages)

View "Ingredients Label" Exercise:
Microsoft Excel 2000 version (17 KB / 1 page)
PDF version (4 KB / 2 pages)

Lesson Plan: Value Chain

During this lesson, students create a corn-related food chain and identify and learn about various organizations in it. This activity can set the stage for discussions, tours or other activities that introduce the students to technolologies and processes specific members of the chain use. Corn-related traits specific members of the food chain need or desire can also be identified and integrated into the upcoming plant breeding lesson.

View Lesson Plan:
Microsoft Word 2000 version (22 KB / 5 pages)
PDF version (25 KB / 5 pages)

View "Value Chain" Game:
Microsoft PowerPoint 2000 version (102 KB / 3 slides)
PDF version (25 KB / 3 pages)

Return to text http://agbiosafety.unl.edu/res_suscep.shtml

AgBiosafety University of Nebraska - Lincoln

Education Center Q&A GM Crops About Us

Education Center

glossary of terms
click here

Featured items

Resistance Management Game

Resistance Evolution Simulation

Resistance Management Curricula

Resistance Management Curricula

Bt plant hybrids are engineered to produce an insecticidal protein from, *Bacillus thuringiensis*, a naturally occurring soil bacterium. There are many strains of Bt each toxic to a limited group of insects. For example, one Bt strain may be harmful to beetle larvae but at the same time safe to butterfly larvae. Bt has been used for over 50 years in its topical form by organic farmers and home gardeners. In the 1990's Bt was first engineered into plants to provide protection from insect pests. Due to the increase use of Bt in biotech crops, there was concern that insect pests would quickly become resistant to Bt. Because of Bt's importance to both organic and non-organic farmers, it was decided necessary to create a set of strategies to reduce the occurrence of resistance in crop pests. These strategies are widely referred to as Insect Resistance Management.

The most widely accepted strategy of Insect Resistance Management for Bt hybrid crops is **refuge management**. Refuge management is the practice of planting a percentage of your crop in non-Bt hybrids so that a population of Bt susceptible insects is maintained. Susceptible insects from the refuge mate with the resistant survivors from the Bt portion of the field. Since resistance to Bt is a recessive trait in most target insect groups, the genes for susceptibility will be passed onto their offspring.

Lesson Plans

Resistance and Susceptibility Exercise

Interactive Learning

The Refuge Builder

Resistance Management Simulation

The Resistance Management Game

Teacher Resources on Resistance Management

Resistance Management for European Corn Borer and Bt

International Life Sciences Institute: An Evaluation of Insect

Pick Your Produce ©

(A Role Playing Paper-Based Activity)

by Diana Brandner
Madison Area Technical College

Food Labeling and Detection of Genetically Modified Foods

Background:

Current Policy

The Food and Drug Administration (FDA) regulates the labeling of food products, including foods that are produced through recombinant DNA techniques GMO (genetically modified organism) foods. FDA published a policy in 1992 to provide guidance to industry on scientific and regulatory issues related to GMO foods. FDA did not establish special labeling requirements for GMO foods. If a food, including a GMO food, is significantly different from its conventional counterpart, for example in terms of its nutritional value or because it introduced a know allergen, this information is required in the labeling of the product.

The European Union requires labeling of GMO-derived foods, specifically GMO corn and soy, and recently set a threshold of 1%. Australia and New Zealand are in the process of evaluating a mandatory labeling policy, while Canada is pursuing a voluntary labeling approach.

The Case for Mandatory Labeling

As biotechnology-derived foods steadily enter our markets, consumer and activist groups are campaigning for the labeling of foods containing GMO ingredients. Many argue that the unlabeled foods pose a risk to consumer with allergies. For example, many nut-derived proteins are allergenic and people with severe allergies could suffer greatly from ingesting nut proteins. Furthermore, some vegetarians claim they do not want to eat any animal-derived proteins, and want to be able to identify these products. Additionally, others feel that they should be given the choice of supporting or rejecting biotech-derived foods. There are many groups that do not support the industries that produce GMO technology and they want the choice to not buy these foods.

The Case Against Mandatory Labeling

GMO derived food is not substantially different from its conventional counterpart. No evidence exists that distinguishes it as a class in composition, nutrition, or safety from food developed with traditional plant breeding methods. Mandatory labels cannot replace scientifically based, transparent regulatory systems.

Labels would provide no real information to consumers. Given the extent of GMO foods in the food chain, nearly all food would have to be labeled. These labels would give no information in regards to the amount of GMO content, or which GMO are present. Those wishing to avoid food modified with genes from certain organisms but not others (vegetarians, those who keep kosher, etc) would not be helped by these labels. Similarly, such indiscriminate labeling would not allow consumers to differentiate between different applications of the technology, e.g. between nutritionally-enhanced rice and pesticide-resistant soybeans.

Labels would only mislead consumers, as they might imply that GMO foods are different, unsafe, or inferior to non GMO foods. This would be compounded by the fact that the public has basic biological misconceptions of DNA, food, and genetic engineering.

Extensive sequence similarity exists between unrelated organisms, which raises the question of which genes belong to which species. The cost of identity preservation may be prohibitively expensive, and would affect all consumers, not just those who care.

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Detecting GMO Food Products

Current tests for GMO foods are predominantly PCR-Based, and detect the genes transformed into crop plants or animals. These tests use primers designed to detect the 35S promoter or NOS terminator, which are present in almost all transgenic crops used in foods today. Some tests offer yes/no answers, while others can offer quantitative results. Other tests are protein-based, but are considered less reliable due to protein degradation during food processing.

Directions for the activity:

Post the food pictures and food labels on the blackboard. Have students divide into seven groups, give each group a role and the amount of play money indicated by their role. Send the students shopping. Each group must buy at least one pound of each food. Groups may barter with each other if they run out of money. When all the purchases have been made, have each group explain to the class what their role was, why they made the purchases they did and how did they answer the questions on the role playing sheet.

Questions:

Why did they buy the foods they bought?
Where the food labels clear?
Was there enough of the foods needed?
What would improve the food label game?

Reference:

Hall, A, & Frederick, K., personal communication, UW-Madison

Haslberger, A. G. Monitoring and Labeling for Genetically Modified Products. *Science* Vol. 287 No. 5452 pp. 431-432.

McHughen, A. Uninformation and the choice paradox. *Nature Biotechnology* Vol. 18 No. 10 pp.1018-1019

Miller, H. I. A Rational Approach to Labeling Biotech-Derived Foods. *Science* Vol. 284 No. 5410 pp.1471-1472

US Food and Drug Administration Report on Consumer Focus Groups on Biotechnology. October 20, 2000 on line at: http://www.cfsan.fda.gov/~comm/biorpt.html

http://www.agbios.com/articles/01-183-b.pdf

List of paper resources

- Pick Your Produce Roles These are the defined roles of the produce buyers. There are 7 different roles with different food budgets.
- Pick Your Produce Labels These labels describe the produce and the cost per pound.
- Pick Your Produce Clip Art Colored pictures of the produce

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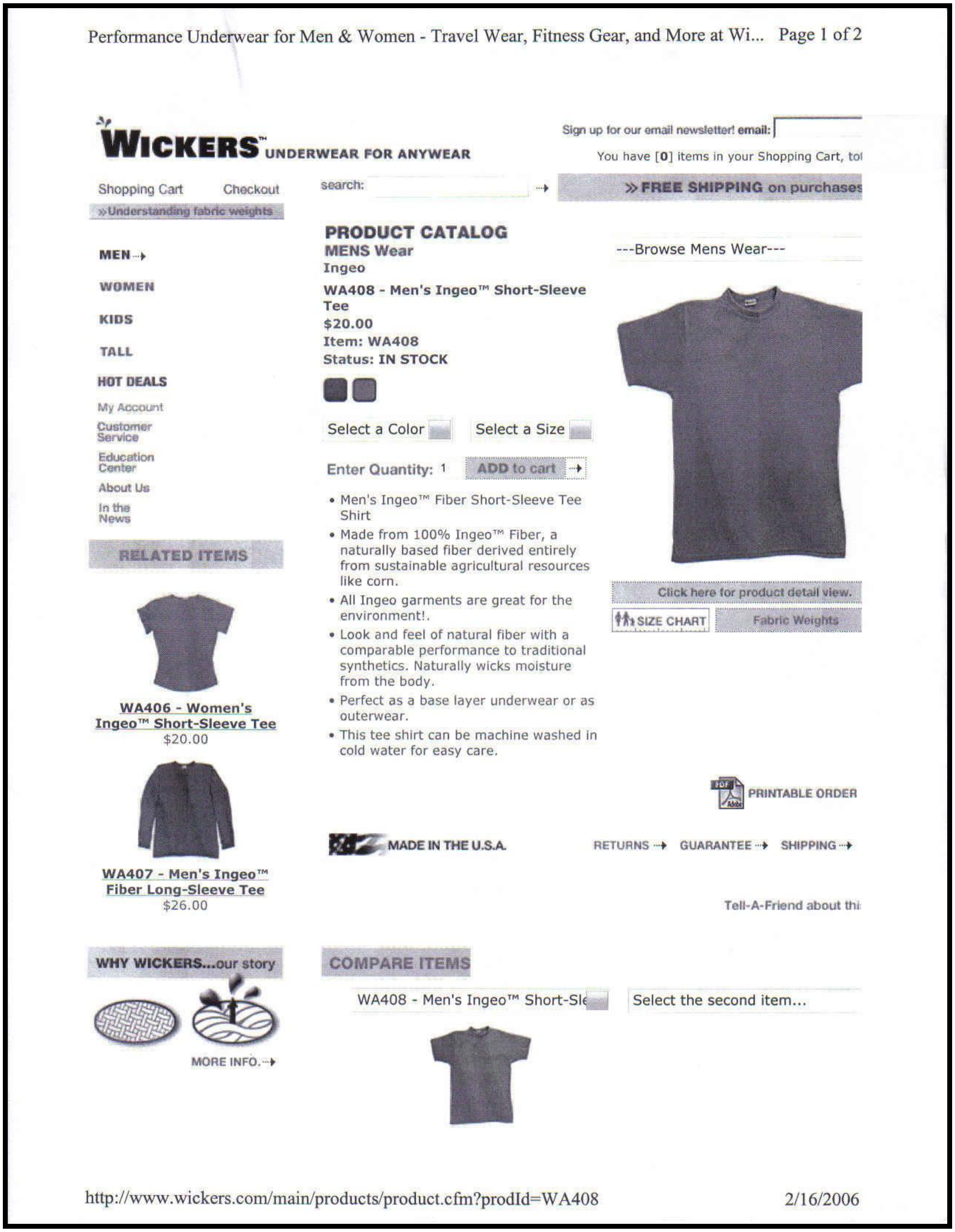
http://www.wickers.com/main/products/product.cfm?prodId=WA408



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