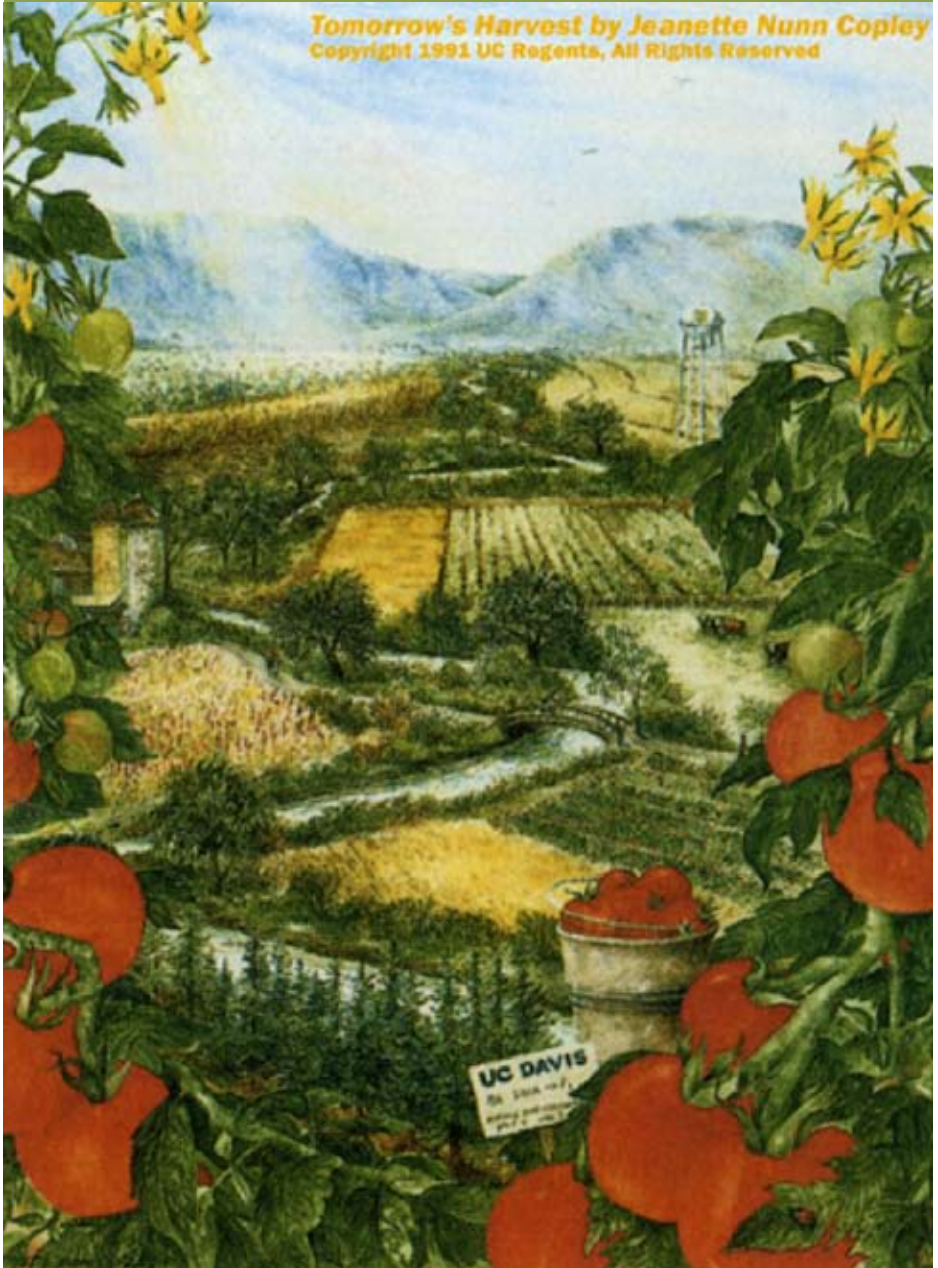


UC Davis Plant Genomics Program

K-12 Art - Science Education

<http://pgp.ucdavis.edu/>

Tomorrow's Harvest by Jeanette Nunn Copley
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About the Plant Genomics Program

Comprised of 42 faculty members from 12 departments on the UC Davis campus, the Plant Genomics Program (PGP) was established in 2004 to encourage interaction between the wide range of people and disciplines involved in plant genomics research.

A primary goal of the PGP is to translate basic knowledge generated at UCD into new crop varieties. PGP faculty and collaborators carry out basic research in plant biology as well as generate tools for varietal identification, marker-assisted breeding and genetically engineered crops.

Through the PGP Distinguished Speaker series and other events, the PGP engages with the local community to generate dialog on plant genomics and plant genetic engineering, to communicate basic research results and discuss the potential societal and commercial applications and impacts.

The PGP is supported by the College of Agriculture and Environmental Sciences and grants to individual faculty.

If you are interested in learning more about the UC Davis Plant Genomics Program, please contact PGP chair Pamela Ronald at pcronald@ucdavis.edu or visit our website <http://pgp.ucdavis.edu/>

Project 1: Science through Art

In 2004, the UC Davis Plant Genomics Program launched the K-12 "Science through Art" education program. This project combines science instruction with art exercises to teach elementary school students about plant biology. UCD graduate students develop lesson plans and projects in collaboration with UCD faculty and local elementary school teachers. In addition to educating elementary school students in an innovative manner, graduate students learn to relay relatively complex scientific information from their own research experiences into terms that are comprehensible, exciting and fun for 4th, 5th and 6th graders. Graduate student and elementary student partnerships are further enhanced through events such as Picnic Day where students present the projects to the UC Davis community. Over 600 elementary school students have participated in this project to date.

The "Science through Art" program is led by Ruth Santer, a local artist and art teacher at Cesar Chavez elementary school. The project was generously supported by a grant from the National Science Foundation to Dr. Pamela Ronald, professor of plant pathology and chair of the PGP. We are grateful to Cesar Chavez parents Stacy Welsh and Mary Nicholson for their invaluable assistance and to teachers Sarah Fonte and Maite Sureda who generously shared their classrooms. We would also like to thank UCD plant pathology graduate student, Becky Bart, for her work with the children and PGP coordinator Victoria Whitworth for arranging classes and setting up the Picnic Day exhibits.



These drawings by the 4th and 5th graders at Cesar Chavez are a colorful result of some of the children's own scientific and artistic explorations. Left to right: Teacher Sarah Fonte and Principal Denise Beck of Cesar Chavez Elementary school; Artist Ruth Santer; UCD Professor and Project Leader Pam Ronald; UCD Graduate Student Becky Bart

The Art of Rice



Drawings and paintings by Cesar Chavez Elementary School students



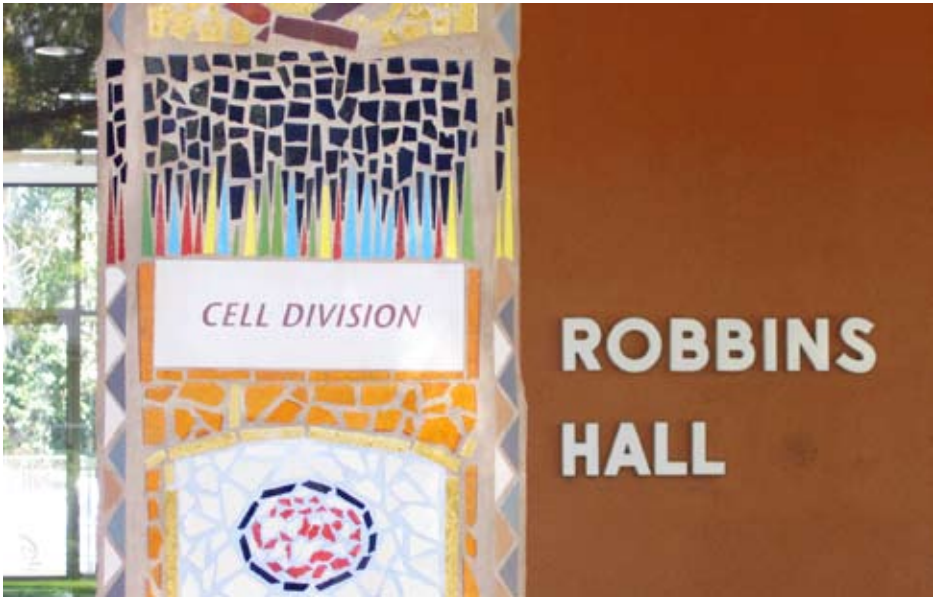
Jacob Muller, 5th grade, 2005



Michelle Felmlee-Gartner, 6th grade, 2005



Artist Ruth Santer and Cesar Chavez 5th grader Jacob Muller.



Project 2:

GATEways Robbins Hall Columns

In 2007, the Plant Genomics Program partnered with local artist Donna Billick, director of Billick Rock Art, to create ceramic mosaic murals on the exterior columns of UCD's Robbins Hall to reflect the academic activities within. Resident groups include the Plant Genomics Program, the Weed Research and Information Center and the Agricultural Sustainability Institute.

Billick, who has 35 years of experience in creating "community-build" public art, designed, fabricated and installed the five columns. Billick worked closely with artist Mark Rivera, elementary school students and teachers and UC Davis scientists to create columns featuring evolution, genomics, plant-microbe interactions, weeds, food and farming. 250 students from four local elementary schools participated.

This project is part of the larger campus-wide GATEways (Gardens, Art, and The Environment) initiative, whose task force is chaired by Pamela Ronald. One of the goals of the GATEways project is to use art, gardens, exhibits, outdoor teaching spaces and events to engage the broader community in the work and scholarship of UC Davis.

The PGP is grateful to the UC Davis Art/Science Fusion program (of which Billick is co-founder) for its contribution of time and technique and to Carmia Feldman, assistant director of the UC Davis Arboretum, for her assistance.

DNA Column

Scientist:

Mariana Pereira, graduate student, Plant Biology
(Doug Cook lab)

School:

Patwin Elementary School, Davis CA

Teachers:

Linda Biewer-Elstob and Pat Wong

Deoxyribonucleic acid (DNA) encodes information needed for biological functions. DNA is a language, in which the chemical bases that make the DNA strand are the alphabet letters and the genes are the words that make the language readable and translatable. All organisms share the same alphabetic properties (DNA) but make up their own language as they play with different set of words (genes). This column depicts the chemical nature of the DNA molecule, how the DNA bases that make the DNA strand fit together and how the information is conserved and passed on to the next generation. In the top part of the column the DNA strand is displayed as a double helix of two chains composed of nucleotides that run anti-parallel to each other and are connected throughout its length. The polymer backbone is composed of sugars linked to each other by phosphate groups (the brown ribbon) and the bases (represented here by the color rectangles) (refer to Fig1). The bottom of the column gives a detailed representation of the chemical structure, with phosphate groups and sugars represented as small black dots and dashes in the corners. The bases are the colorful connecting rectangles. The colors used in the double helix above are the same as the ones used in the mosaic below. This is not by chance. The four available bases (adenine, thymine, cytosine and guanine) that make up the DNA strand pair in specific ways. Adenine pairs with thymine only and cytosine pairs with guanine only. The DNA sequence (ATGCATAÖ) is decoded by a method called sequencing. The chromatogram shown on the column displays the different colored peaks in the correct sequence of bases. The set of five small panels on the bottom of the column display the process of cell division (Fig2). First the DNA content is doubled so the daughter cell possesses a copy of DNA (S-Phase). After DNA is copied it condenses and the chromosomes become visible (Prophase). They align at the middle plane of the cell (metaphase) and then they separate to the poles of the cells (anaphase). Each of the poles of the cell contains one copy of the whole genome of the cells so when the cell divides in two, (cytokinesis), both the mother and daughter cells have the same genetic material. This is how the information is passed through DNA to the descendants.

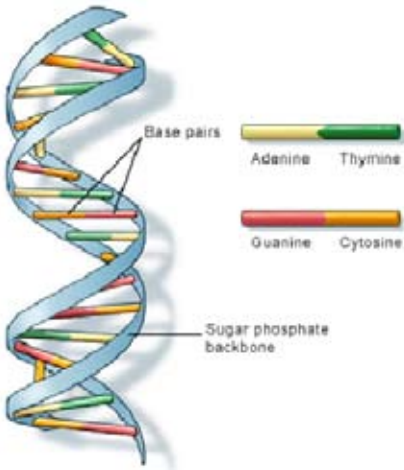


Figure 1. DNA Double helix and schematic representation of the DNA bases

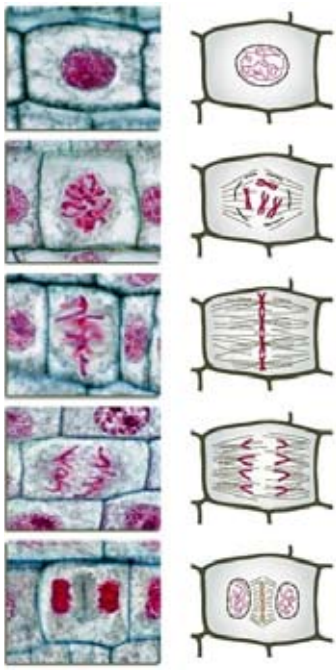


Figure 2. Cell Division displaying the different steps during mitosis. From top to bottom: S-phase; Prophase; Metaphase; Telophase; Cytokinesis



Evolution Column

Scientist:

Laura Bartley, postdoctoral fellow, Plant Pathology
(Pamela Ronald lab)

School:

Cesar Chavez Elementary School, Davis, CA

Teacher:

Sarah Fonte

Evolution is a process that results in heritable changes in a population spread over many generations. Eventually, with enough time and selective pressure for change, a new species will evolve that cannot mate with the old type of organisms. Through evolution, all living things are related to one another by sharing similar genetic material. The Evolution column is composed of three related images, the plant phylogeny at the base, the "Tree of Life" in the center, and a landscape at the top of the column from which the process of evolution proceeds.

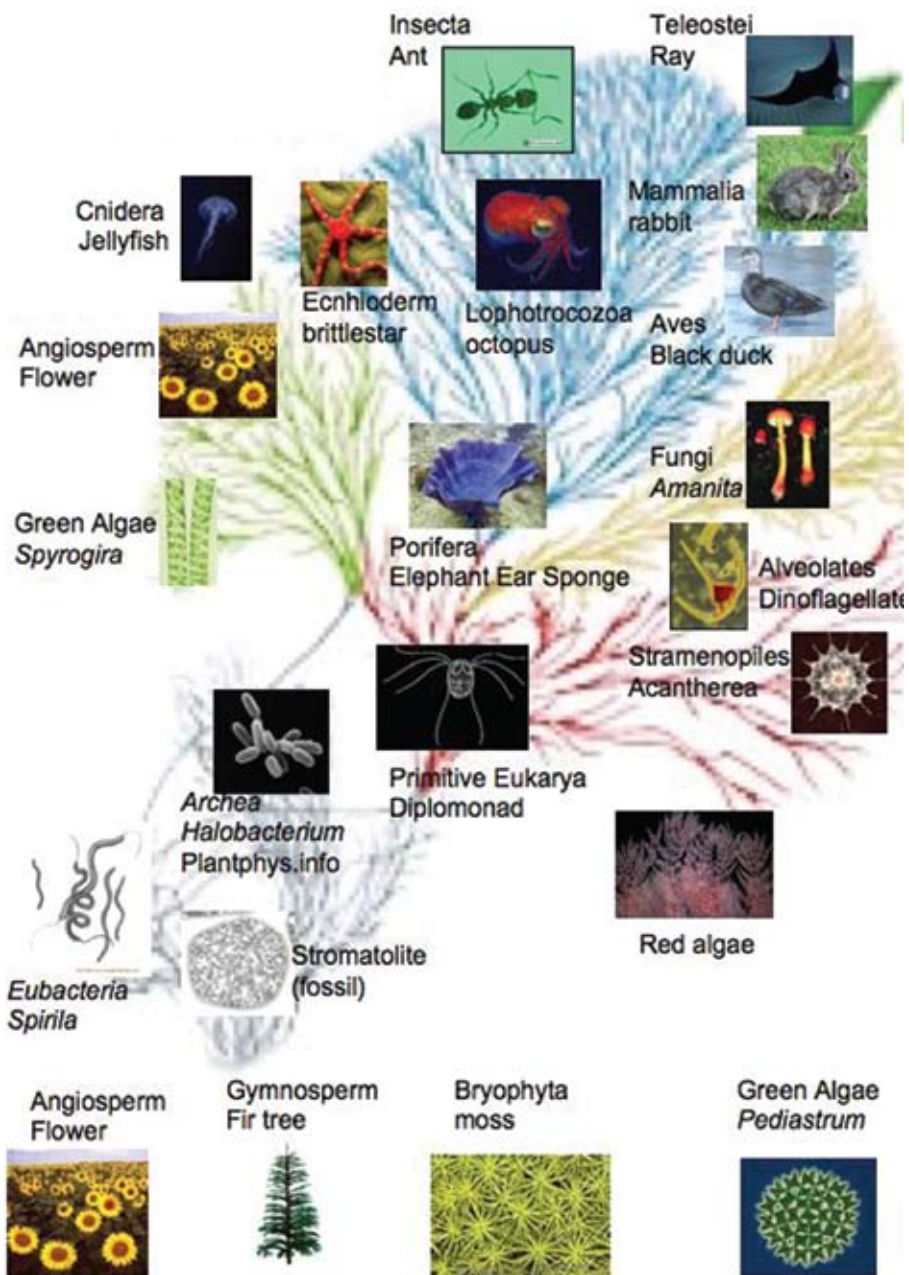
At the base of the column is the green plant (Viridaeplantae)óthe phylogenetic tree. Phylogenetic trees are used to represent the process of evolution; their branches (black lines) depict the historical relationships between organisms. Cesar Chavez elementary students built the panels at the base of the column to show the following four major groups of green plants: green algae, bryophytes, gymnosperms, and flowering plants. The most primitive class of green plants are the green algae, represented by a colony of the organism *Pediastrum*. From green algae, land plants evolved, the most simple of which are represented by a panel showing moss. From the primitive land plants, more complex plants with protected seeds evolved, represented by a pine tree. Finally, flowering plants are represented by a pink flower.

The central image of the column is the Tree of Life, which depicts the evolutionary history, or phylogeny, of all life on Earth. The design for the image is from the Tree of Life Web Project (www.tolweb.org), a collaborative project with the goal of compiling information on, and describing, the evolutionary relationships between all organisms. On the Tree of Life, existing organisms are like leaves at the end of branches. The branch to which each organism is attached represents the history of that organism. Therefore, neighboring organisms on twigs that attach to the same branch are similar to each other. Another feature of the Tree of Life is that less complex organisms are located closer to the roots at the bottom of the tree.



The Cesar Chavez Elementary students who participated in the column project made images representing the major groups of extant organisms on Earth. The exception is the “root organism” located at the base of the tree, which represents the original organism on Earth. It is modeled after Stromatolite-like fossils. Up from the root (and to the left) are the Eubacteria, represented by Spirilla. The next most complex are the Archeobacteria, represented by Halobacteria. From relatives of these simple bacteria, eukaryotes, which carry their genetic material within a nucleus, evolved. Primitive eukaryotes shown on the tree include the following: a diplomonad (at the base of the eukarya); red algae; the Strameanopile, Acantharea (yellow star-shaped organism); and a Dinoflagellate. Above these on the Tree of Life are the fungi, represented by a mushroom from the genus *Aminita*. Across from the fungi are the green plants, represented by a green algae, *syriogira*, and a flowering plant. Animals are depicted at the top of the tree, starting with the Porifera, represented by an elephant ear sponge. Up from the sponge are the invertebrates. The Cnidaria are represented by a jellyfish; an orange brittle star represents the Echinoderms; the Lophotrocazoa are represented by an octopus; and Arthropods are represented by an ant. Finally, vertebrates have the following three representatives: a manta ray for fish, a duck for birds and reptiles, and a rabbit for mammals.







Food and Farming Column

Farmer:

Raoul Adamchak, academic coordinator,
UC Davis Agricultural Sustainability Institute

School:

Fairfield Elementary School, Davis, CA

Teacher:

Mary Ryan

This column represents four plant-based food groups that provide essential nutrients: corn for carbohydrates and oils, beans/legumes for proteins and tomatoes and apples, representing fruits and vegetables, for vitamins, fiber, minerals, etc. Complete meals can be made from these four crops. They are all grown locally as well as throughout California and the world. The cornucopia at the top of each face is receiving bounty from these plants and showering it on us.





Weeds Column

Scientist:

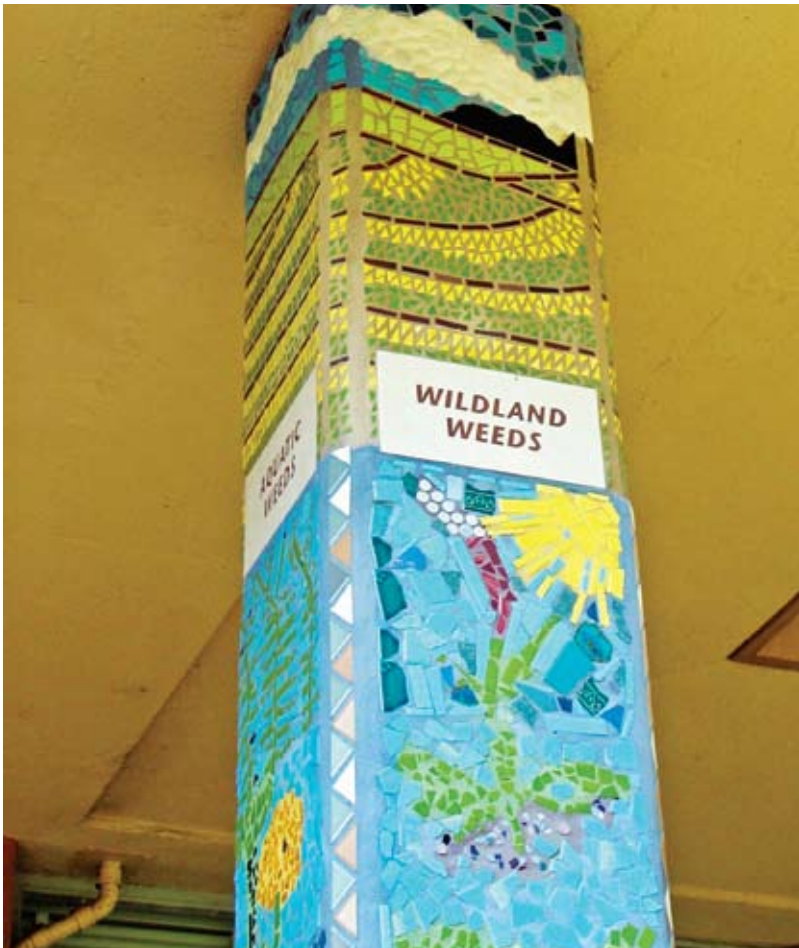
Annabelle Kleist, graduate student, Plant Biology
(Marie Jasieniuk lab)

School:

North Davis Elementary

Teacher:

Kathy Froman



The UC Davis Weed Research and Information Center conducts basic and applied weed research and extension programs in partnership with California growers, agricultural industry, and public agencies. Weeds are native and non-native plants that negatively impact crop production, cause health problems, or are aesthetically displeasing in urban landscapes. Invasive plants are a group of non-native weeds that infest natural ecosystems. Some people call weeds “plants out of place,” but to farmers, conservationists, land managers and homeowners, weeds can be extremely problematic.

This weed science column depicts a subset of California’s weeds and invasive plants and some methods for controlling them. The four sides of the column display four main groups of weeds: aquatic weeds, agricultural weeds, wildland weeds, and urban weeds. The top of the mosaic displays examples of weeds you will encounter throughout the state. The bottom shows ways to control or eradicate weeds. For more information about these weeds and how to control them visit: <http://www.ipm.ucdavis.edu/> and <http://www.cal-ipc.org/>.

Rather than waiting for a weed to become problematic, it is always better to prevent potential weeds from entering an area and becoming established. To do this, familiarize yourself with known weeds, avoid planting them, and be careful not to transport their reproductive structures to a new area. Once weeds are established, the most economical and effective means of controlling them is an integrated approach utilizing several methods, including hand-weeding and cultivation, prescribed burning, mowing, herbicides, and biological controls.



Star Thistle



American Pondweed

Plant – Microbe Interactions

Scientist:

Becky Bart, UC Davis graduate student,
Plant Pathology (Pamela Ronald lab)

School:

Willett Elementary School, Davis, CA

Teacher:

Leslie Whiteford



This column depicts one of the central concepts of plant pathology, the "Disease Triangle." Each side of the disease triangle represents an important component of disease development: the Host, the Pathogen and the Environment. Each component needs to be considered when developing appropriate disease control methods.

Below the disease triangle, some common plant diseases are shown. Viewers can see a healthy plant, a diseased plant, the disease agent and an image of a factor that contributes to disease development. The diseases are, from top to bottom:

- Bacterial Speck of tomato, caused by the bacterium *Pseudomonas syringae*. Environmental factor: rain.
- Citrus Tristeza virus, caused by a virus of the same name. Transmitted by insects.
- Crown Gall, caused by the bacterium *Agrobacterium*. Environmental factor: wounding.
- Tulip Breaking virus, caused by a virus of the same name. Transmitted by insects.
- Pierce's Disease of grapevines, caused by *Xylella fastidiosa*. Transmitted by insects.
- Corn Smut, caused by the fungus *Ustilago maydis*. Environmental factor: temperature.
- Black Rot of broccoli, caused by the bacterium *Xanthomonas campestris*. Spread by contaminated seed.
- Halo Blight of bean, caused by the bacterium *Pseudomonas syringae* pv. *phaseolicola*. Environmental factor: temperature.



Tomato/Pst (speck)



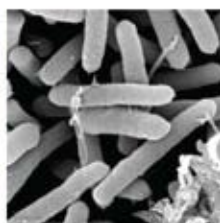
healthy



diseased



rain



bacteria

Project 3:

Bioenergy in the Schools Program

The “Bioenergy in the Schools” program, launched in 2007, builds on the success of the earlier PGP “Science through Art” plant biology project. With the help of a generous grant from the Chevron Corporation to Dr. Pamela Ronald, chair of the UC Davis Plant Genomics Program and director of grass genetics at the Joint Bioenergy Institute (JBEI), plant pathology graduate student Becky Bart and postdoctoral fellow Laura Bartley developed lesson plans and projects for 4th, 5th and 6th grade students, in collaboration with artist Ruth Santer.

In this program, the children learn about potential bioenergy crops for fuel production - in particular, switchgrass (*Panicum virgatum* L). Switchgrass has been used primarily for forage and erosion control, but has recently received renewed attention from breeders for its potential as a promising bioenergy crop. A fast-growing native United States prairie species, switchgrass is a perennial which does not need to be replanted each year and therefore requires very little irrigation, fertilizer or tilling.

The use of switchgrass has the potential to increase the efficiency of biofuel production by five-fold or more, compared with production of biofuel from food crops such as corn. In order to learn more about switchgrass cell walls, geneticists are leveraging information from rice, a related grass species which is the best-characterized member of the grass family.

So far, through the “Bioenergy in the Schools” program of lectures, demonstrations and drawing exercises, over 200 students at Cesar Chavez and Fairfield elementary schools in Davis, California have learned about biofuel production, plant cell walls and structure and the relationship between switchgrass and rice.



Switchgrass drawing by Kennedy, 5th grade, 2007



Switchgrass drawing by Kendal, 4th grade, 2007



Switchgrass drawing by Ariana, 6th grade, 2007



Switchgrass drawing by Kevin, 4th grade, 2007

*For more information on the PGP K-12 Art-Science Education programs,
please contact project leader Pamela Ronald, pcronald@ucdavis.edu*



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