Biotechnology--
Improving Our Lives Through
Scientific Innovation!

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The UCD Biotech Program works to bring all members of the life science community together to promote biotechnology education and workforce development.
Welcome Nagoya University...

Today you will be taking a journey into the world of biotechnology and life science research here at UC Davis...

• Biotech Basics
• UC Davis Fun Facts & Life Sciences Research
• Biotech Careers in N. California

Please ask questions at any time.
What is Biotechnology?

The use of living organisms, or parts thereof, to provide useful products, processes and services.

Cells are the basic building blocks of living organisms.

Scientists in the field of biotechnology modify cellular DNA in order to produce useful proteins & other molecules.

Transcription & Translation
Genetic Engineering

- Cutting and moving specific functional sections of DNA (genes for specific desirable traits) from one plant, animal or microbe to another.

- Gene-encoded desirable traits include:
  - Vitamin or nutrient production
  - Disease resistance
  - Insect resistance
  - Stress tolerance (ability to deal with environmental conditions, such as heat, drought, saline soil, flooding, etc…)
  - Toxin breakdown
  - Drug, vaccine or “useful chemical” production
Preserving Our Planet

Biofuels
- Can we design transgenic plants and microorganisms to produce inexpensive, renewable sources of fuel and energy?

Bioremediation
- Can we effectively clean up toxins (heavy metals, poisons, etc...) in soil and water using genetically modified plants and microbes?

Green Chemistry
- Can we engineer plants and microbes to produce industrial products (plastics, solvents, pigments, etc...) more efficiently and cleanly.
Treating Human Diseases & Disorders

**Stem Cells & Tissue Regeneration**
- Can we use embryonic stem cells or reprogrammed adult stem cells to regenerate all tissues of the human body?
- Can we develop imaging systems to track stem cells in the human body?
- Can we program stem cells to stop dividing once tissue is repaired?

**Pharmacogenomics**
- Can we identify DNA sequence variations in the Human Genome that correlate to specific diseases and other traits?
- Can we use the genome sequences of pathogenic microorganisms and viruses to help us design more effective drug treatments and vaccines?
Molecules produced via biomanufacturing include:

- **Pharmaceuticals** for the treatment of many diseases and disorders (Genentech, Novartis, Amgen, many others...visit [www.baybio.org](http://www.baybio.org) for a list of the local biotech pharma companies)

- **Enzymes** for the production of cheese, bread, detergents, textiles, plastics, etc... (Novozymes)

- **Antibodies** used in vaccines, medical diagnostics, molecular biology research, biosensors, etc...
Modify crops to resist:
- Insect damage *(a HUGE reduction in pesticide spraying has resulted!)*
- Bacterial and viral diseases

Increase crop tolerance for:
- Drought
- High temperatures
- Flooding
- Soil Salinity or other toxins
- Cold/Freezing

Improve crop quality:
- Enhance vitamin & nutrient content
- Increase shelf life and ease of transportation
- Better texture, color, other consumer preferences

Use crops as “plant factories” to produce:
- Vaccines and therapeutic drugs
- “Green” plastics and other industrial precursors
Genetic Engineering Enhances the Process of Conventional Selective Breeding

**TRADITIONAL PLANT BREEDING**

Many genes are transferred in conventional breeding (some for traits that you don’t want!)

**PLANT BIOTECHNOLOGY**

One gene is added at a time, which is faster, more precise and doesn’t require sexual compatibility between donor species and crop.
Agrobacterium tumifaciens is a naturally occurring soil bacterium that causes crown gall tumors in host plants by inserting genes carried on the Ti-plasmid.

A Modified *Agrobacterium* Delivering a Gene of Interest to a Plant Cell

Scientists have genetically modified the bacterium’s Ti plasmid to deliver genes that we are interested in to the plant genome, rather than the bacterial genes for making a crown gall tumor.
1. Wounded plant tissue

2. Formation of a Callus after treatment with Agrobacterium

3. Shoot development from callus (unlike animal cells, plants are pluripotent and any plant cell can develop into a new plant in the right conditions)

4. Shoots are rooting and growing into new plants (hopefully with new transgene)
Ralph M. Parsons Foundation Plant Transformation Facility (RMPFPTF)

College of Agriculture and Environmental Science

Manager: David Tricoli
Staff: Kim Carney

Director: Abhaya Dandekar

Scientific Advisory Board:
John Bowman
Kent Bradford
George Bruening
Dave Burger
Doug Cook
Chuck Gasser
Dave Gilchrist
Carole Meredith
Richard
Michelmore

Transformation Service:
Tomato, Tobacco, Rice, Cannola, Lettuce, Alfalfa, Melon, Carrizo, Lemon

Protocol Development:
Alfalfa, Wheat, Walnut, Almond

Provide service to the research community
GM Crops are Tightly Regulated

The US Dept. of Agriculture determines whether the crop is safe to grow. For example, is it a threat to become a weed; what are its growth and flowering characteristics?

The Food and Drug Administration determines whether the crop is safe to eat. Is it substantially equivalent to other crops with respect to composition, nutrition, allergenicity, digestibility, etc.?

The Environmental Protection Agency regulates crops that have pesticidal properties. Are they safe for humans, for non-target organisms, and for the environment?
GM crops help farmers save $$$ and are better for the environment!

An “apparent” increase of 9.4% or 10.7 million hectares between 2007 and 2008, equivalent to a “real” increase of 15% or 22 million “trait hectares”

Source: Clive James, 2009.
Global Area of Biotech Crops, 1996 to 2008: By Crop (Million Hectares, Million Acres)

Source: Clive James, 2009
Global Area of Biotech Crops, 1996 to 2008: By Trait (Million Hectares, Million Acres)

Source: Clive James, 2009
Soybeans are the most common GM crop.
The USA leads the world in biotech crop acreage.
Developing countries are currently adopting biotech crops at a slightly faster pace than industrial countries
The most common biotech traits are Herbicide Tolerance (HR) and Insect Resistance (IR)

USA Foods:
At least 60-70% of all processed foods now contain at least one ingredient from a genetically engineered plant.
Biotech varieties of potato, tomato, rice, flax, sugar beet, sweet corn, melon and radicchio are approved for use in the U.S. but are not currently on the market.
Over 63% of soybean growers who reduced their tillage since 1996 cited herbicide-tolerant technology as the key factor in doing so.

Conservation Tillage Information Center (2002) Purdue University.
www.ctic.purdue.edu
CAN DNA BE PASSED FROM GM FEED TO HUMANS OR LIVESTOCK?

THIS IS A COMMON QUESTION:

- If this was true, all ruminant animals would have been overcome by large amounts of Plant DNA.
- DNA fragments are broken down into nucleic acids, sugar and phosphate in the GI tract, before being absorbed into the bloodstream.

Three Agencies Regulate Biotech Crops

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Safety Data Requirements for Registration of Biotech Crops

Product description (7 items)
Molecular characterization (17 items)
Toxicity studies (as necessary) (5 items)
Antibiotic resistance marker genes (4 items)
Nutritional content (7+ items)
Substantial equivalence with parent variety
Literature review and background
Allergenicity potential
Similarity to natural toxicants
Anti-nutritional effects
Protein digestibility
Environmental aspects (5 items)
Germination, growth, flowering studies (8 items)
Ecological impact (5 items)

Total regulatory and testing costs: $2,000,000 to $10,000,000.
None of this is required for traditionally bred crops.
Biotech Crops are Safe

- All available evidence to date shows that foods from biotech crops are as safe as foods from non-biotech crops.

- No Approved Biotech food has been recalled due to food-safety issues.

- U.S. food supply is among the safest in the world.

- No food is 100% safe--contamination & spoilage remain the real safety issues.

Raw potatoes can be poisonous due to glycoalkaloids (related to deadly nightshade) in skin.
Careers & Training in Biotechnology
UC Davis is a Global Leader in Life Science Education, Research & Public Service
Biotechnology is Concentrated in the Northeast and California

California is home to one third of the nation’s biotechnology firms. The state has more biotech jobs (250,000+) than all of the other states combined.
Biotechnology has a Strong Presence in N. California

The Interstate-80 corridor between the Bay Area and Sacramento is home to a high concentration of biotech companies (100+)

Our mission is to build a highly skilled regional workforce through K-14 educational outreach, support of industry-academic partnerships and administration of the Designated Emphasis in Biotechnology (DEB) PhD program

http://www.bio-link.org/centersCAN.htm
Some of the Life Science Companies in the Region

- Tethys Bioscience
- Volcano
- Ventria Bioscience
- Glycometrix
- Vitalea Science
- Novartis
- Bio-Rad
- Monsanto Biotechnology
- Seminis
- Affymetrix
- Miltenyi Biotec
- Hygieia Biological Laboratories
- Idexx Laboratories
- Agra Quest
- Pediatric Bioscience
- Pioneer DuPont
- Metamorphix, Inc.
- Thermogenesis
- Arcadia Biosciences
- Davis Sequencing
- Genentech
- GPSG
- Telomolecular
Biotech Careers—The Future Looks Bright!!!!

- Research
- Administration
- Teaching
- Sales & Marketing
- Patent Law
- Government
- Regulatory Affairs
- Health Care
- Technical Writing

Minimum education for biotechnicians: 2-year (AS) or 4-year (BS) college degree in biology, biotechnology, chemistry, engineering or related field.

Most available jobs are at the BS level, though there are many AS, Master’s and PhD positions available.

Average Biotech Salaries ~$50-70,000