**Introduction to Applications in Biotechnology**

**Products of Modern Biotechnology**

* There are a wide variety of products that the biotechnology field has produced.
* More than 65% of biotech companies in the U.S. are involved in pharmaceutical production (relating to drugs developed for medical use).
* 1982 - Genentech developed Humulin (human insulin) to treat diabetes.
* It was the first biotech drug to be FDA approved.
* There are more than 80 biotech drugs, vaccines, and diagnostics with more than 400 biotech medicines in development targeting over 2oo diseases!
* Nearly 1/2 of new drugs target cancer

**Biotech Laboratory**

* Most widely used biotech products are recombinant proteins (produced by gene cloning in cell culture)
* Cell culture refers to the technique of growing cells in a lab under controlled conditions; similar to *in vitro*
* “*in vitro”* refers to working in a controlled environment outside of a living organism
* Bioreactors (large culturing “containers” where DNA of interest can be mass produced) are also used

**Biotech Treatments**

* In the near future, it may be commonplace for treatments to include the use of gene therapy (attempt to replace “defective” gene with “normal” gene) and tissue engineering (designing & growing tissues for use in regenerative medicines).
* 1st Genetically Modified Organism (GMO) to produce human protein was *E. coli* (pictured right) that was given DNA to produce *somatostatin* (hGH -human growth hormone - 1977)

**tPA**

* One of the first genetically engineered (GE) products sold was tissue plasminogen activator (tPA)
* tPA is a blood clot dissolving enzyme used immediately after a heart attack or stroke to clear blocked vessels

**Pharmaceuticals**

* According to Biotech Industry Organization (2005), New Jersey is the 5th leading state in the U.S. in terms of number of biotech companies
* California, Massachusetts, North Carolina, & Maryland are the only higher ranked states

**Other Biotech Products**

* Other biotech products include proteins in:
  + home pregnancy tests (monoclonal antibodies)
  + frost-resistant strawberry plants
* Although many are focused on medical and agricultural applications, some are for our own fashion interests (specialty apparel)!

**Genes for Jeans?**

* Stonewashed jeans use genetically engineered enzymes (amylase & cellulase) to create a faded look
* Originally, pumice stones were used (jeans washed with the stones)
* This method damaged the machines

**Current Applications of Biotech**

Before going in-depth with a few areas of biotech research, it is important to gain a brief understanding of the many applications of biotechnological advancements.

* Microbial
* Agricultural
* Animal
* Forensic
* Environmental
* Aquatic
* Medical

**Microbial Applications**

* Bacteria & yeast are the most frequently used microbes
* Better enzymes and organisms for making foods, simplifying manufacture and production processes, and making decontamination processes for industrial waste product removal more efficient.
* Microbes used to clone and produce *batch* amounts of important proteins

**Agricultural Applications**

* Agricultural Biotechnology is estimated to be $6 billion market (2005), including applications such as:
* Pest-resistant plants
* Higher protein & vitamin content in foods
* Drugs developed and grown as plant products
* Drought-resistant, cold-tolerant, and higher-yielding crops

**Plant Advantage**

* The Ag-Biotech field boasts about the *plant advantage* over microbial biotech.
* Plant advantage refers to the fact that the cost of producing plant material with recombinant proteins is often *significantly* lower than bacteria
* Also, the Ag biotech may combine with medical biotech in order to produce drugs with *molecular pharming*

**Molecular Pharming**

* Molecular pharming is the use of genetically modified plants (or animals) as a source of pharmaceutical products.
* These are usually recombinant proteins with a therapeutic value.
* This is an emerging but very challenging field that requires:
  + manipulation (at the genetic engineering level) of protein glycosylation (addition of polysaccharide chain)
  + subcellular protein targeting in plant cells

**Animal Applications**

* Animals can be used as *bioreactors*!
* Many human therapeutic proteins are needed in massive quantities (>100s of kgs), so scientists create female transgenic animals to express therapeutic proteins in milk.
* Goats, cattle, sheep, & chickens are sources of antibodies(protective proteins that recognize & destroy foreign material)
* *Transgenic* refers to containing genes from another source

**Dolly**

In 1996, Dolly the sheep became the first cloned animal created by the somatic cell nuclear transfer process.

* Born: July 5, 1996
* Announced: February 22, 1997
* Died: February 14, 2003
* Dolly was cloned from a cell taken from a six-year-old ewe
* She became the center of much controversy that still exists today

**Knock Outs**

* Basic research in biotech uses *knock-out*experiments, which are very helpful for learning about the function of a gene.
* A knock-out is created when an active gene is replaced with DNA that has no functional information.
* Without the gene present, it may be possible to determine how the gene affects the organism (its function)

**Forensic Applications**

* **DNA fingerprinting** is the classic example of a forensic application. It is used most commonly for law enforcement and crime scene investigation (CSI).
* It was first used in 1987 to convict a rapist in England.
* Other applications of DNA fingerprinting include:
  + identifying human remains
  + paternity tests
  + endangered species (reduces poaching)
  + epidemiology(spread of disease )

**Environmental Applications**

* The major environmental use is for *bioremediation*.
* Bioremediation is the use of biotech to process or degrade a variety of natural and manmade products, especially those contributing to pollution
* Therefore, cleaning up environmental hazards produced by industrial progress is a major application of this type of biotechnology.
* There is a strong tie to *microbial* biotech (since many microbes are helpful for this area).

**Oil Spill**

* In the 1970s, the first U.S. GMO patent was granted to a scientist for a strain of bacteria capable of degrading components in crude oil.
* In 1989, the Exxon Valdez oil spill in Alaska used *Pseudomonas* species (oil-degrading bacteria) to clean up the spill
* It was 3x faster & without increased environmental effects

**Aquatic Applications**

* Aquaculture is a common aquatic application of biotech.
* Aquaculture is the process of raising finfish or shellfish in controlled conditions for food sources.
* Products include:
  + transgenic salmon (increased growth rates)
  + disease-resistant oysters
  + vaccines against viruses that infect aquatic species
* Overall, aquatic organisms are thought to be rich & valuable sources for new genes, proteins, & metabolic processes.

**Medical Applications**

* Medical applications of biotech include preventative, diagnostic, and treatment.
* The Human Genome Project is very useful within this field.
* Gene therapy and stem cell technologies are two up-and-coming fields within the medical area of biotech.
* Stem cell technologies include immature cells that have the potential to develop and specialize into a variety of other cell types.

**Stem Cells**

* Different chemicals can coax them to develop into different cell types.
* Newest, most promising area
* Most controversial