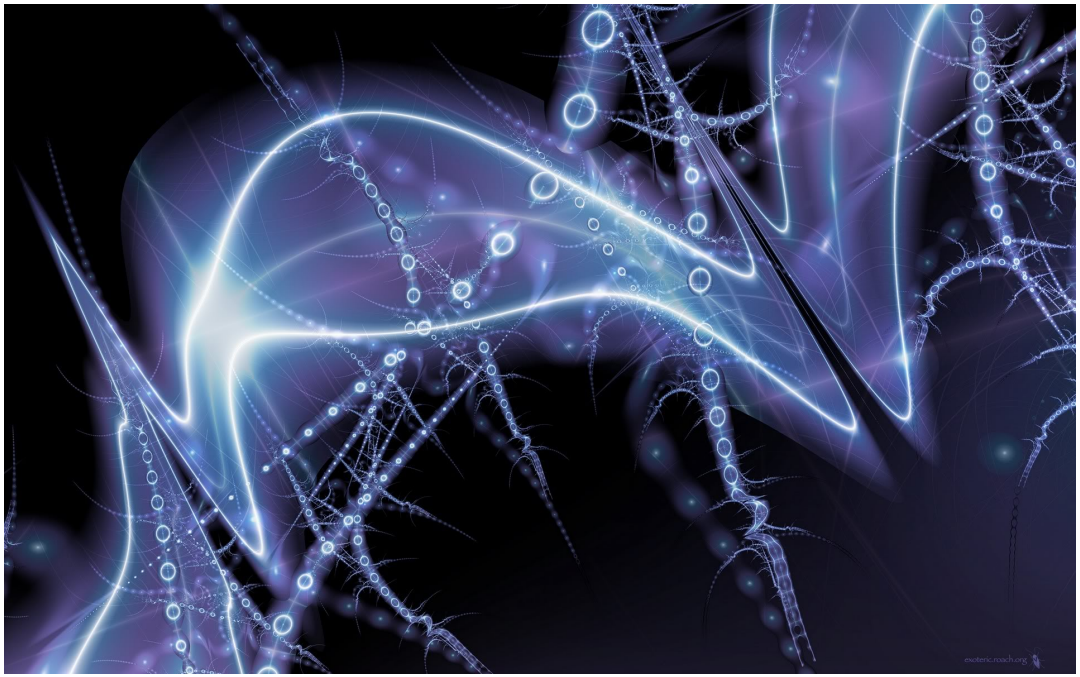
Application of Biotechnology



History of Biotechnology

- The term "biotechnology" was coined in 1919 by Karl Ereky, an Hungarian engineer
- Traditional biotechnology has been used for thousands of years to produce improved food and health care products. Today, modern biotechnology enables us to develop improved products more safely and more rapidly than ever before.

Introduction

- **Biotechnology** is essentially
  - the use of **living** organisms (often **minute** microorganisms) and **their products**
  - for health, social or economic purposes.
- Biotechnology is widely considered to be the **growth** technology of the **21st Century** which will lead to huge growth in the Biotechnology industry and exciting **opportunities** for graduates.

Introduction

- Through genetic engineering scientists can combine DNA from different sources and this process is called "**Recombinant DNA technology**"
- The secrets of DNA structure and functions have led to **gene cloning** and **genetic engineering**, manipulating the DNA of an organism

Introduction

- **Biotechnology** is an **interdisciplinary** science including not only **biology**, but also subjects like **mathematics, physics, chemistry, computing and engineering**.

- It is a blend of various technologies applied together to living cells for **production** of a particular **product** or for **improving** upon it.

BIOCHEMISTRY

GENETICS

PHYSIOLOGY

MICROBIOLOGY

MOLECULAR BIOLOGY

CELL BIOLOGY

EMBRIOLOGY

INMUNOLOGY

INFORMATICS

ANALYTICAL CHEMISTRY

CHEMICAL ENGINEERING

Nature of Work

- The nature of work of biotechnologists, being interdisciplinary, requires working together of people from different fields such as
- **biology**, **chemistry, biochemistry,**
- **microbiology, molecular biology,**
- **immunology, genetics,**
- **engineering,**
- **food science, agriculture** etc.

Application of Biotechnology

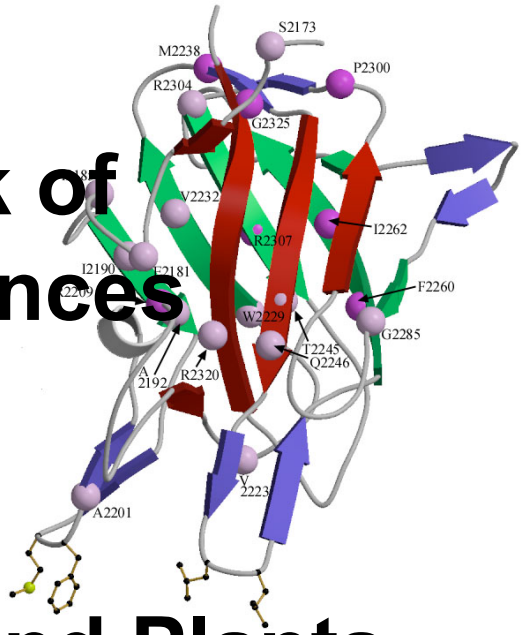
- Its use and application ranges from fields like **agriculture** **to** **industry** (food, pharmaceutical, chemical, bioproducts, textiles etc.), **medicine, nutrition, environmental conservation, animal sciences** etc. making it one of the fastest growing fields.
- The work is generally carried out in the laboratories, as it is a scientific research oriented field.

Biotech Applications

- **Biopolymers and Medical Devices- natural substances useful as medical devices**
  - **hyaluronate- an elastic, plastic like substance used to treat arthritis, prevent postsurgical scarring in cataract surgery, used for drug delivery**
  - **adhesive substances to replace stitches**
- **Designing Drugs – using computer modeling to design drugs without the lab- protein structure**

Biotech Applications

- **Replacement Therapies- lack of production of normal substances**
  - **Factor VIII- missing in hemophilia**
  - **Insulin**



- **Use of Transgenic Animals and Plants**

Biotech Applications

- **Gene Therapy – replace defective genes with functional ones**
  - **ADA (adenosine deaminase) deficiency**
  - **cystic fibrosis**
- **Immunosuppressive Therapies – used to inhibit rejection (organ transplants)**
- **Cancer Therapies -one method is antisense technology**
- **Vaccines – biggest break through in biotechnology- prevention of disease**

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.

Products of Modern Biotechnology

- There are more than **80** biotech drugs, vaccines, and diagnostics with more than **400** biotech medicines in development targeting over **200** diseases!

- Nearly **1/2** of new drugs target cancer

Top 10 Selling Biotech Drugs

Drug	Developer	Function
Betaseron	Chiron/Berlex	Multiple sclerosis
Ceredase	Genzyme	Gaucher's disease
Engerix B	Genentech	Hepatitis B vaccine
Epiver	GlaxoSmithKlein	Anti-HIV
Epogen	Amgen	Red blood cell enhancement
Genotropin	Genentech	Growth failure
Humulin	Genentech	Diabetes
Intron	Biogen	Cancer & viral infections
Neupogen	Amgen	Neutropenia reduction
Procrit	Amgen	Platelet enhancement

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

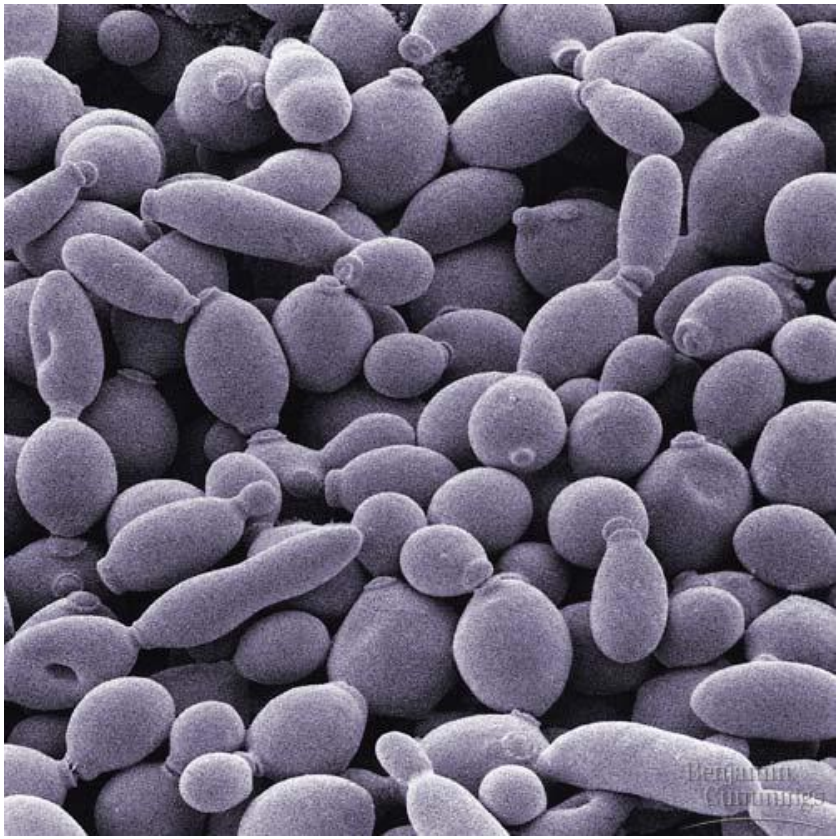
Other Biotech Products

- 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

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 sheep became the first cloned animal created by 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

Dolly the sheep, the first mammal to be cloned from an adult cell

- Dolly gave birth to four lambs

Cloned kitty

The first two cats cloned by chromatin transfer

Human Clone

- Britain grants embryo cloning patent and became the first country in the world to grant a patent covering cloned early-stage human embryos. The decision ignited new controversy among biotechnology critics even though the Geron Corporation, the company licensed to use the patent, has **no intention** of creating cloned humans.

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)

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

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

Waste Management

- Environmental Pollution is a major problem
- Landfills are becoming full
- Old dump sites are creating problems
- Waste is piling up
- Sewage and chemical disposal is a constant problem

Waste Management

- Genetically altered bacteria are used to feed on oil slicks and spills
- Bacteria are being developed to decompose or deactivate dioxin, PCBs, insecticides, herbicides, and other chemicals
- Bacteria are under development to convert solid wastes into sugars and fuel

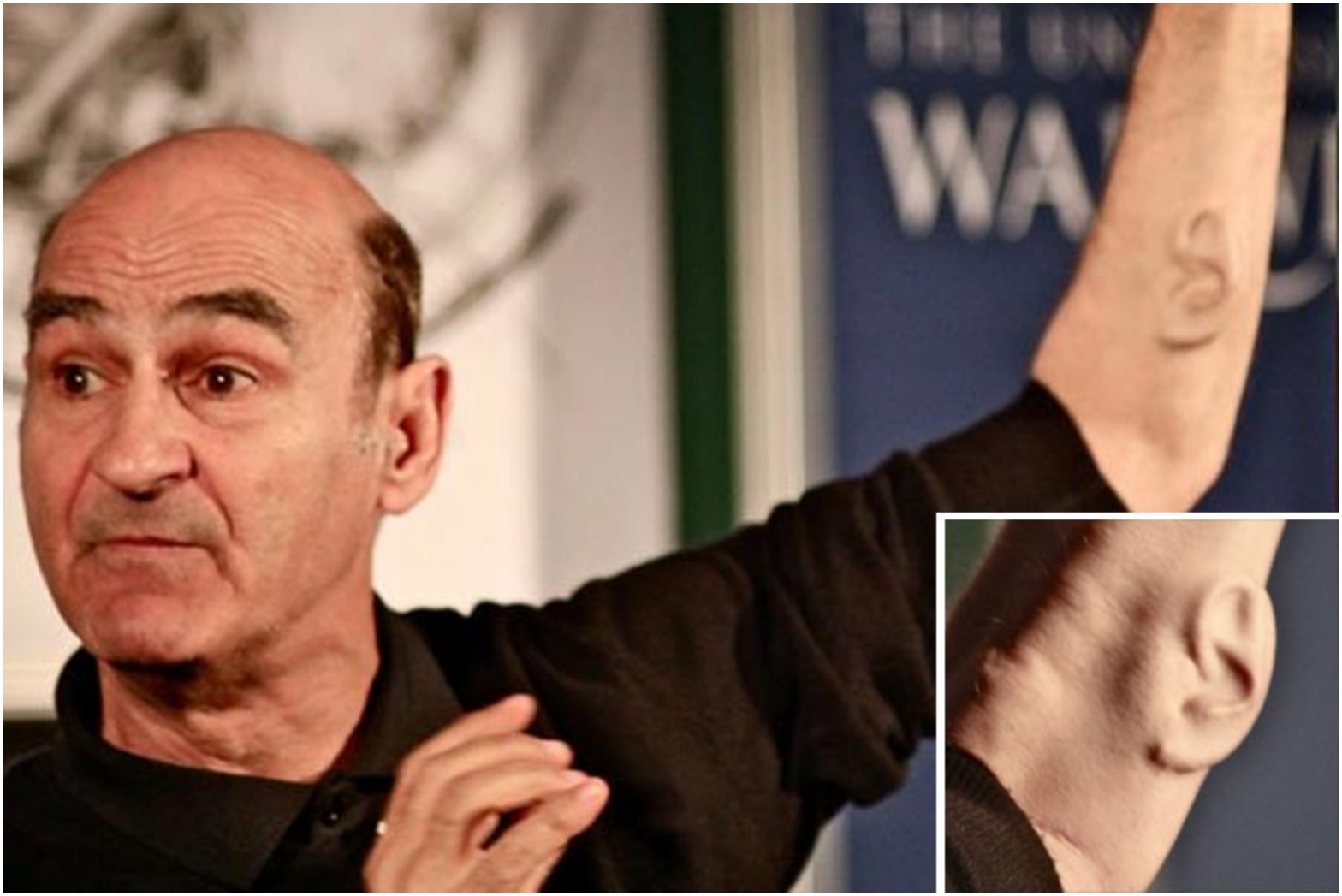
Biomaterials

- Biotechnology is the technology connected with plant, animal, and human life.
- For example, knowledge about the joints, muscles, and nerve endings in our bodies can be combined with engineering to develop an artificial hand.
- These human-made materials designed to be placed within the human body are called biomaterials.

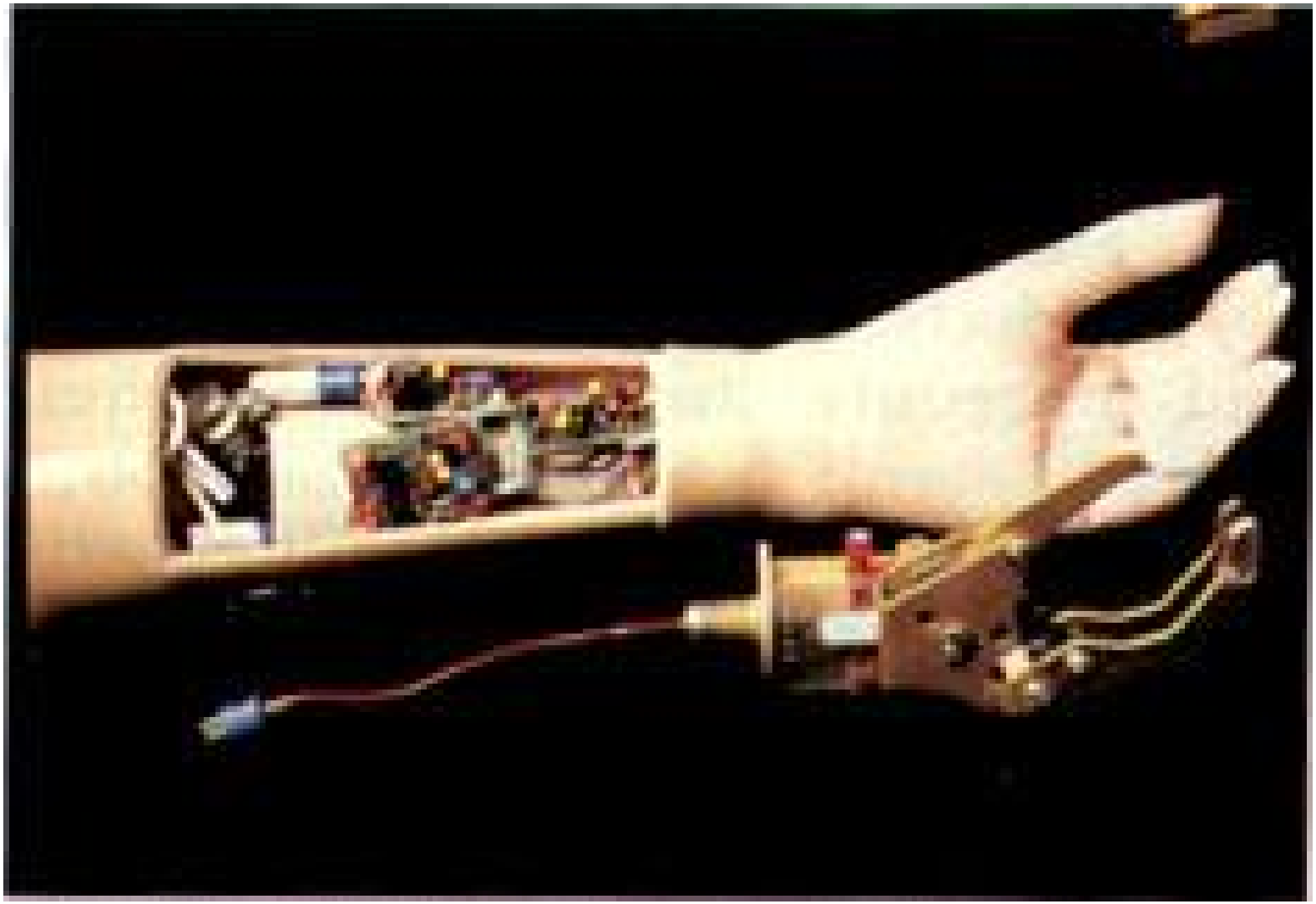
Transplant Organs for Humans

- Inadequate supplies of human organs for transplantation result in more than 25,000 deaths annually.
- Researchers are studying ways to develop organs in animals suitable to be transplanted into humans until human organs become available.
- Especially promising are pig organs!!!

- Photo of mouse growing a "human ear" - a shape made of cartilage



Biohand: knowledge from the joints, muscles, and nerve



Genetically Modified Food

- Can animal genes be jammed into plants? Would tomatoes with catfish genes taste fishy? Have you ever eaten a genetically modified food? The answers are: “yes”, “no” and almost definitely “yes”
- Despite dire warnings about "Frankenfoods“, there have been no reports of illness from these products of biotechnology.


genetically
modified?


GM potato 'could improve child health'

Approved Biotech Products

- 1982: FDA approves genetically engineered human insulin
- 1986: Orthoclone OKT3 (Muromonab-CD3) approved for reversal of kidney transplant rejection.
- 1986: first recombinant vaccine approved- hepatitis
- 1987: Genentech gets approval for rt-PA (tissue plasminogen activatior) for heart attacks

Approved Biotech Products

- 1990: Actimmune (interferon 1b) approved for chronic granulomatous disease
- Adagen (adenosine deaminase) approved for severe combined immunodeficiency disease.
- 1994: first genetically engineered food the Flavr Savr tomato is approved.
- 1994: Genentech's Nutropin is approved (growth hormone deficiency)

Approved Biotech Products

- 1994: Centocor's ReoPro approved (for patients undergoing balloon angioplasty)
- Genzymes Ceredase/Cerezyme approved for Gaucher's Disease (inherited metabolic disease)
- Recombinant GM-CSF approved (chemotherapy induced neutropenia)
- 1998: Centocor's RemicadeTM approved (monoclonal antibody for Crohn's disease)