

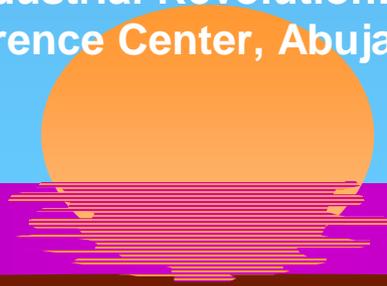
4iR Digital Africa – Biotechnology Impacts and Potentials in Africa: A Systems Centric Perspective

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Outline

- ♦ Introduction & Motivation
- ♦ Biotechnology Defined
- ♦ The need for Biotechnology
- ♦ Integrating Technologies
- ♦ Application Areas & Systems
- ♦ Applicable Sciences
- ♦ Historical Developments of Breakthroughs
- ♦ Focal Development Areas in Africa
- ♦ Major African Health Problem Areas
- ♦ African Centric Case Studies
- ♦ Focus on Engineering & its Role

BIOTECHNOLOGY: A BRIEF INTRODUCTION

INTRODUCTION

Plant, animal and microbes have been used by humans for nutrition and development of products such as bread or beer for consumption. Understanding of Physical phenomena has allowed the invention of different types of electronic gadgets, machines, devices which together have been used to increase the efficiency of human activities. Technological advances have also allowed him to exploit plant, animal and microbial wealth to provide products of commercial or pharmaceutical importance. All these activities (products of research and development) fall under the big umbrella of biotechnology. Simply put, Biotechnology is the summation of activities involving technological tools and living organism in such a way that the efficiency of human production is enhanced. The ultimate goal of this field is to improve the product yield from living organism either by employing principles of bioengineering/bioprocess technology or by genetically modifying the organisms. For example, production of bread or other bakery items from wheat flour after adding yeast as fermenting organism (Figure 1.1). In India, from ancient times wheat flour has been used to prepare “Roti” but yeast has been added to the wheat flour to make it porous by CO₂ generation during fermentation. Since then this process has been very popular in bakery industry and is responsible for preparation of bread, cakes, pizza, etc. In this regard, biotechnology is of great interest to industrial and systems engineering whose founder Frederick Taylor played a major role in the first industrial revolution addressing human productivity enhancements through various intervention mechanisms.





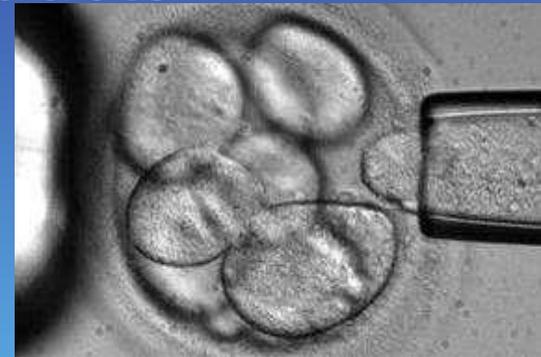
**Figure 1.1: Making of Bread from wheat flour.
(A) & (B) Dough before and after fermentation. (C) Cross section of baked Bread**

It is instructive to note the increase in volume of the dough after fermentation and formation of pores in cross section of bread. Yeast mixed in dough utilizes sugar present in it and produces CO_2 through fermentation; exit of gas causes formation of pores which is responsible for sponginess of bread. Today, bread making, through substitution of wheat with locally available cassava, is advocated in Nigeria



Definition of biotechnology

- “The use of living things and biological processes to produce products”
 - Antibiotics
 - Biofuels
 - Stem cells
 - Beer and cheese



Using a systems centric view, Biotechnology may be regarded as the use of living systems and organisms to develop or make products. It is "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify (transformation) products or processes for specific use". Depending on the tools and applications, it often overlaps with the (related) fields of bioengineering, biomedical engineering, bio-manufacturing, molecular engineering, etc.

For thousands of years, humankind has used biotechnology in agriculture, food production, and medicine. The term is largely believed to have been coined in 1919 by Hungarian engineer Károly Ereky. In the late 20th and early 21st centuries, biotechnology has expanded to include new and diverse sciences such as genomics, recombinant gene techniques, applied immunology, nanotechnology, operations research and development of pharmaceutical therapies and diagnostic tests, assistive technologies, etc. It must be emphasized that its evolution through time is not as discrete as some claim it is but it benefits from technological generations, with overlaps, as is the case in prosthetics for example.



On the NEED For BIOTECHNOLOGY

The population of India is more than 1 billion and as per projection it may cross 1.5 billion by 2030. This will bring huge burden on biological resources (animal/plant) to provide food for all. Naturally occurring animal, plant or microbial strains have few limitations for them to be utilized for desired products due to following reasons-

1. Purity of the living stock
2. Production of undesired products
3. Secretion of toxic metabolic by-products
4. Inability to withstand harsh biochemical processes/treatments.
5. Higher production cost
6. Susceptible to disease and other environmental conditions

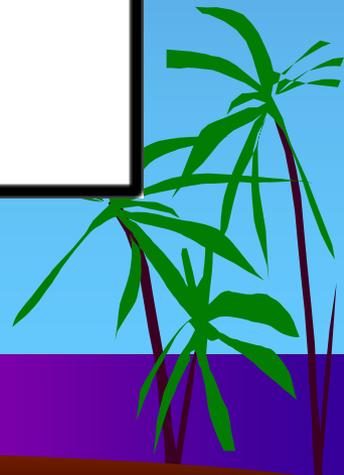
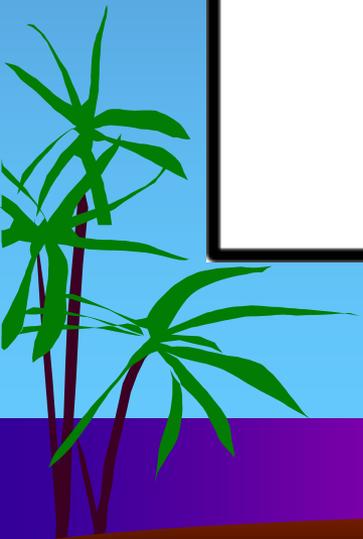
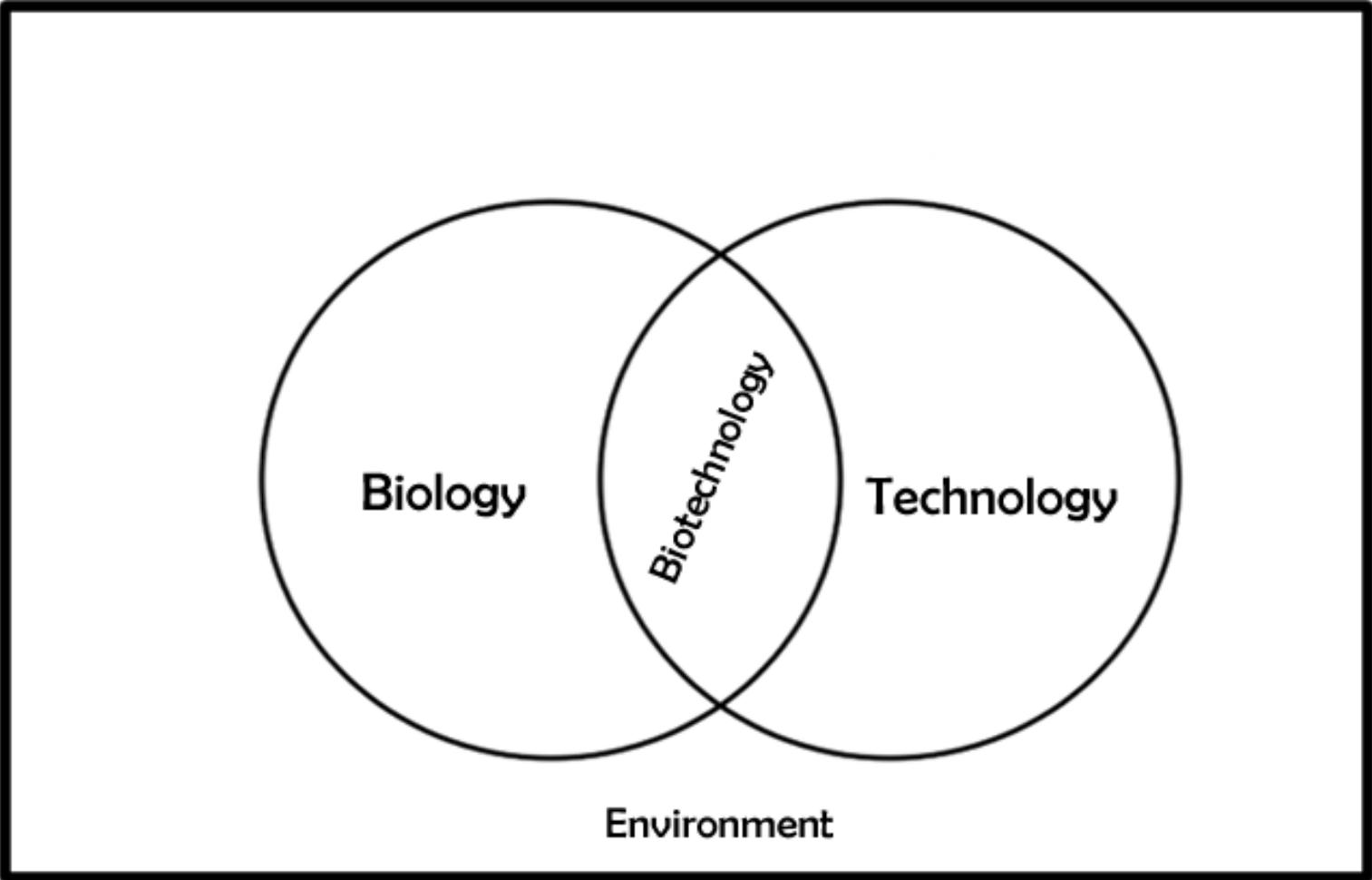
The existing technology today enables us to engineer plants and animals making them suitable for maximum production. Living organism has a complex cellular structure, metabolic pathways, genetic make-up, behavior in the synthetic growth media and understanding these processes can help us to modulate specific process/environmental condition or metabolic pathways to achieve the goal of biotechnology. Advancement in different fields of science has paved ways to solve several issues responsible for lower yield of products. Few of the selected science research areas contributing into the development of biotechnology are given in the Figure 1.2.

The background of the slide features a stylized sunset scene. A large orange sun is positioned in the lower center, with horizontal lines representing its reflection on the horizon. The sky transitions from a light blue at the top to a purple and pink gradient near the horizon. On the left and right sides, there are silhouettes of palm trees with green fronds. The bottom of the slide has a dark brown ground line.

The foundation of biotechnology relies on the research & development activities in different areas of science and interaction of interdisciplinary areas. The research in the field of plant biotechnology allowed us to produce plants through micro-propagation but with the evident advancement of genetic engineering, it is now possible to produce plant with predefined characteristics imprinted at genetic level through genetic engineering. The Joint initiative of IITs and IISc – Funded by MHRD

Biotechnology – Fundamentals of Biotechnology similar relationship may also exist for many other overlapping areas and as a result biotechnological operation output is amplified several folds.





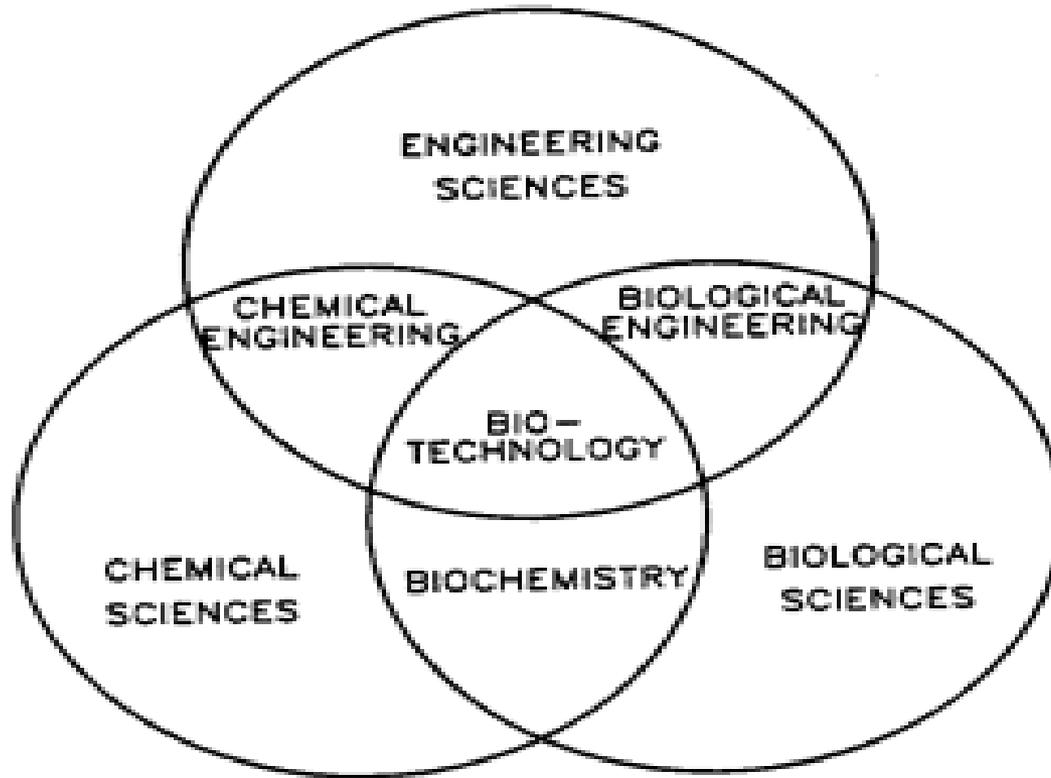
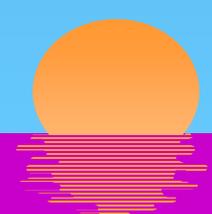
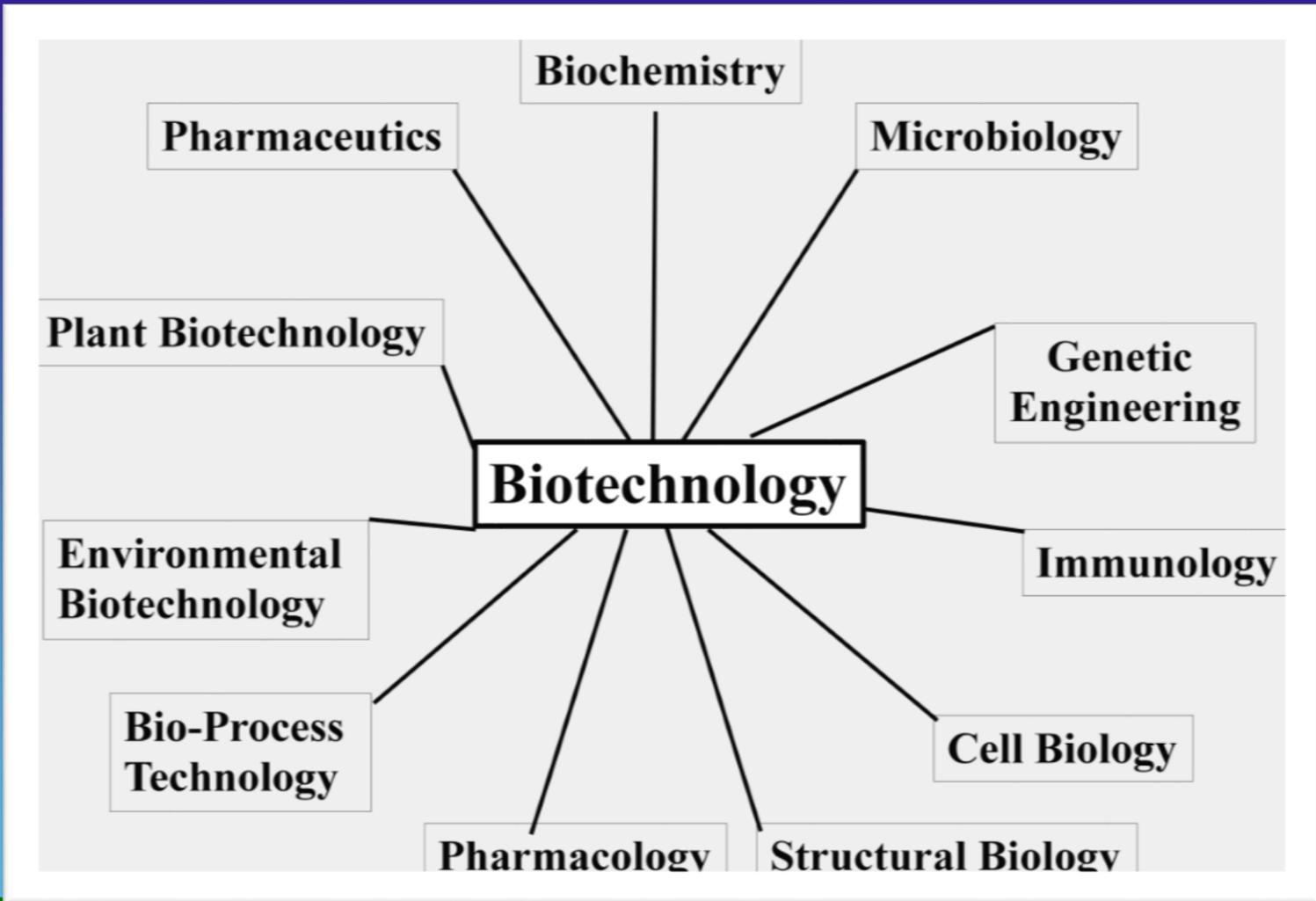


Figure 1. Multidisciplinary nature of biotechnology.



GM- Planting Mats. & Hybrids
Micro-propagation
Bio-fertilizers & Bio-pesticides
Animal Improvement

Agriculture

Environment

Soil & Water remediation
Bio-safety & GMOs

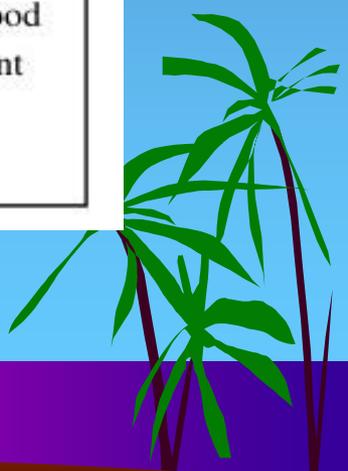
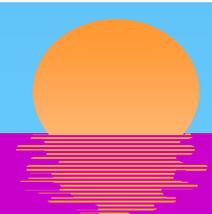
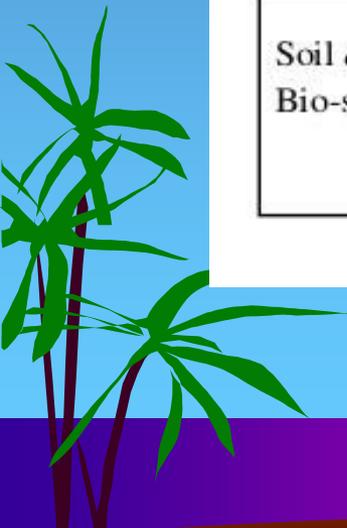
r-DNA Products, Vaccines & Diagnostics
Monoclonal Antibodies
Stem Cells
Tissue Specific delivery methods

Health Care

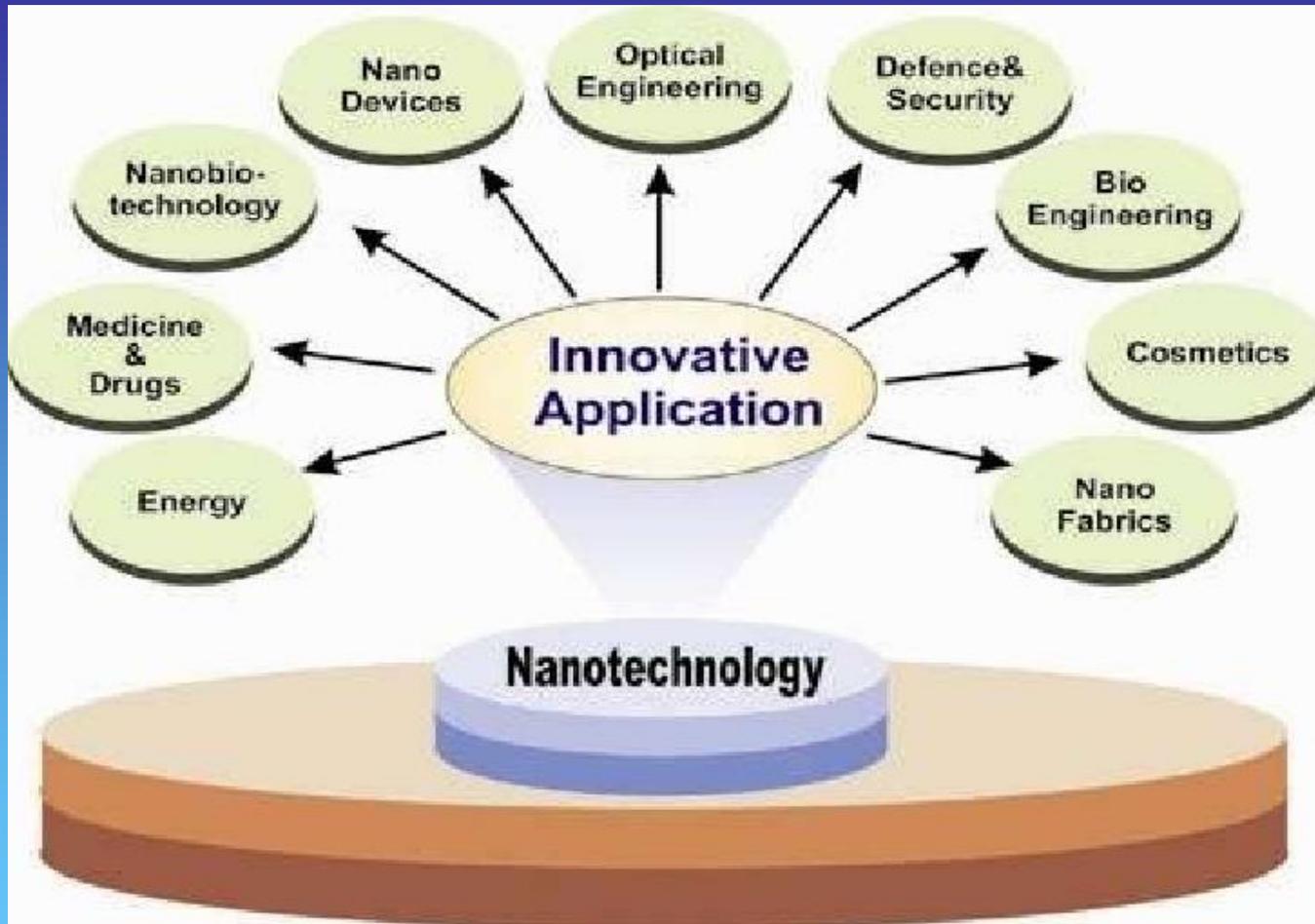
Industry

Enzymes
Fermentation based Products & Food
Biotech Instruments & Equipment
Bio-energy & Bio-fuel
Bioinformatics, Bio-mining

BIOTECH APPLICATIONS

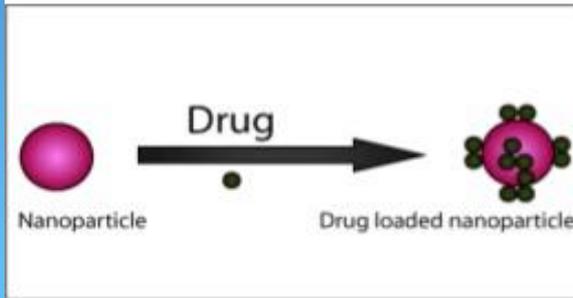


Nanotechnology: A Diversity Approach in Biotechnology



NANOTECHNOLOGY IN BIOTECHNOLOGY (conti.)

- THERAPEUTIC APPLICATIONS:
- **DRUG DELIVERY.**
- **GENE DELIVERY.**
- **BIOMOLECULAR ENGINEERING.**
- **BIOPHARMACEUTICALS.**



HISTORICAL ADVANCEMENT OF BIOTECHNOLOGY

Biotechnology related activities depend on two parameters: Technological advancement and knowledge of available biota.

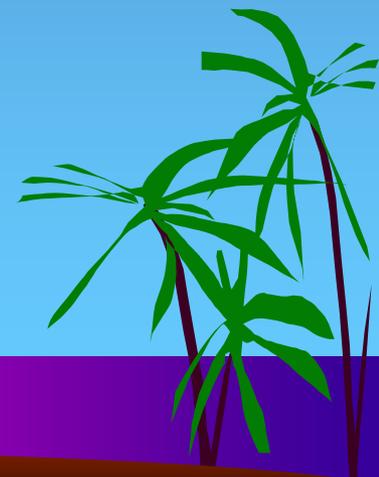
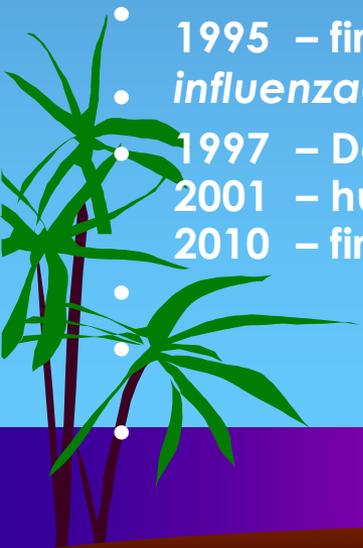
Technological upgradation goes parallel with the over-all understanding of physical and chemical phenomenon in different time periods. Hence, Biotechnology starts as early as human have realized the importance of organism (animal/plants or microbes) to improve their life-style. A systematic chronological description of biotechnological advancement over the course of different time periods (industrial revolution or civilization) is given in Table 1.1. The earliest biotechnology related activities are **selection and cross breeding of high yielding animals, cross breeding of plants to acquire specific phenotype and preserving the seeds of high yielding crop plant for next sowing season.** These were few initial scientific experiments and based on the results, human have made significant modification in available biota. In last century, the **systematic and scientific study of living objects with advanced technology has given immense potential to human imagination to either genetically manipulate living organism**

Biotechnology – Fundamentals of Biotechnology with desired phenotype or mimic metabolic reactions in an in-vitro system (either in test tube or in cells) to produce molecules with therapeutic importance. Such as “Humulin” is the insulin being produced in bacterial expression system and it is now been making life of millions of diabetic patients easier. Similarly during this era, drought, pest or abiotic resistant plants, high milk yielding animals, transgenic bacteria to produce biofuel, degrade environmental hazard or chelation of heavy metal have been developed. In addition, the historical advancement of biotechnology will not be complete without mentioning development of procedure for artificial insemination and test-tube baby for thousands of couples.



Biotechnology timeline

- 1972 – first transformation of bacteria by Boyer and Cohen
- 1980 – U.S. Supreme Court ruled that genetically modified organisms were patentable in *Diamond v. Chakrabarty*
- 1981 – first genetically engineered plant
- 1981 – mice successfully cloned
- 1982 – insulin produced through bacterial transformation approved for use by the FDA
- 1983 – PCR invented
- 1986 – first field trials of GMOs (tobacco)
- 1986 – first biological drugs approved
- 1990 – first federally approved gene therapy treatment
- 1993 – FDA says GMOs are GRAS
- 1995 – first full genome sequence of a living organism (*Hemophilus influenzae*) finished
- 1997 – Dolly is cloned using DNA from adult sheep cells
- 2001 – human genome sequence finished
- 2010 – first synthetic cell



IMPORTANT MILESTONES OF BIOTECHNOLOGY

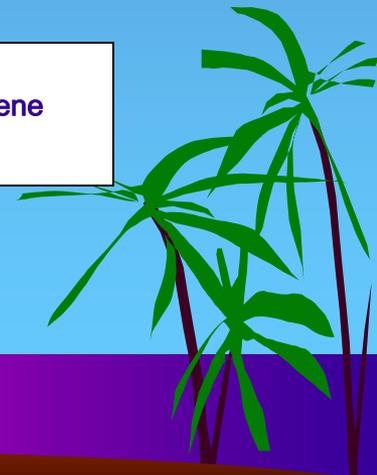
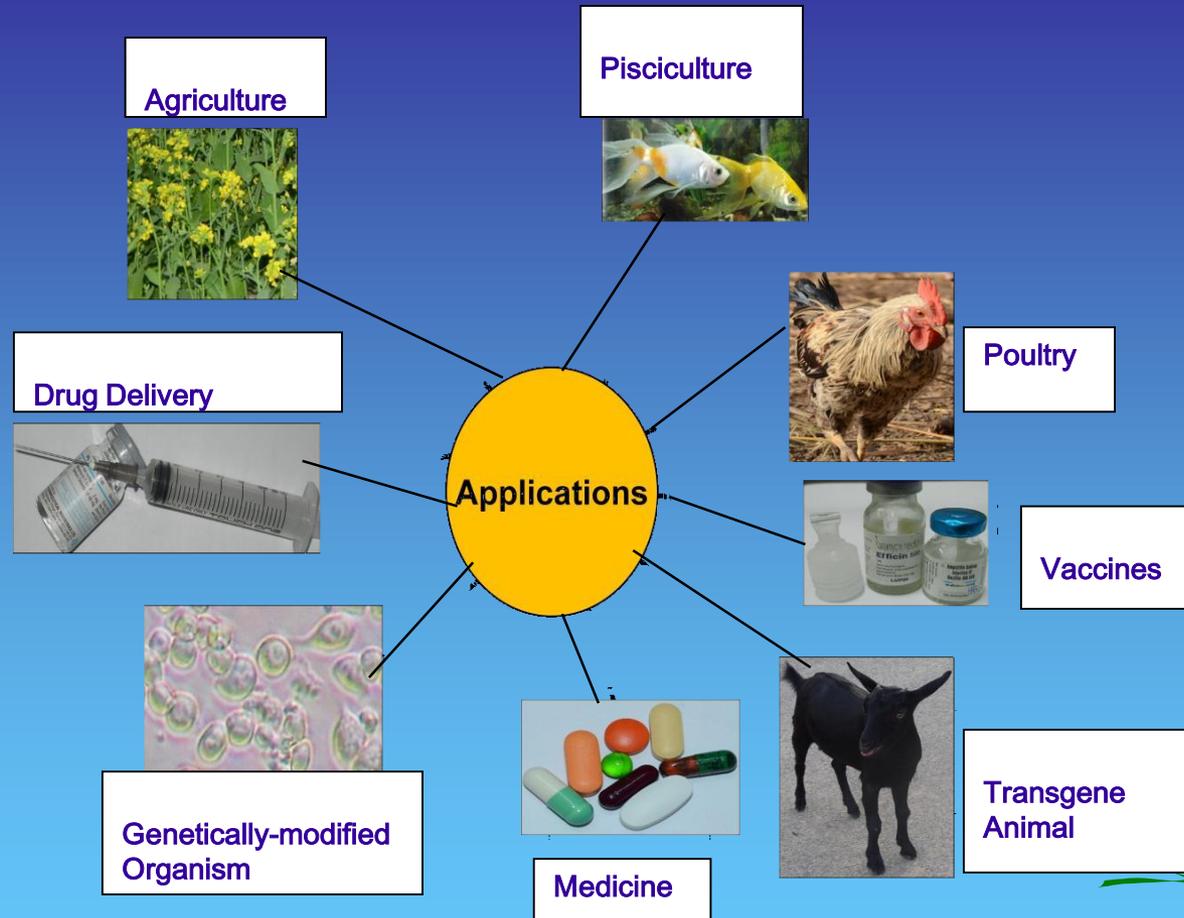
S/No	Time Period	Major Breakthrough
1	7000BC – 100CE	<ul style="list-style-type: none">▪ Discovery of fermentation▪ Crop rotation as a mechanism to improve soil fertility.▪ Animal and plant products as a source of fertilizer and insecticide respectively
2	Pre 20 th Century	<ul style="list-style-type: none">▪ Identification of living cell and bacteria▪ Discovery of small pox vaccine, rabies vaccine.▪ Process development to separate cream from milk,▪ Discovery of artificial sweeteners, “invertase”.▪ Discovery of DNA and chromosome responsible for genetic traits.
3	20 th Century	<ul style="list-style-type: none">• Discovery of Pencillin• 3-D Structure of DNA.• Fabrication of artificial limb and arms,• Production of human insulin in bacteria “Humulin”.• Discovery of PCR.• Gene therapy,• Procedure for artificial insemination and test-tube baby.• Cloning of first mammal “Dolly”.
4	21 st Century	<ul style="list-style-type: none">• Vertebrate, invertebrate and bacterial genome sequences.• Completion of Human Genome sequence.• Sequencing of Rice genome.• Discovery of Nano radio.• Invention of Bionic leg.

Applications of Biotechnology

Biotechnology has influenced human life in many ways by inventions to make his life more comfortable. Many scientific fields contribute to biotechnology and in return it gives product for their advancement. A short list of biotechnology applications is given in Figure 1.3. for illustrative purposes. We present a brief description of these applications in different fields in the sequel. We note that though they have considerable impacts on human life, some of them are the subject of ethical arguments and objections. This inhibits widespread, routine and mindless exportation to African environments. Thus, judicious use and policy driven imperatives are advised.

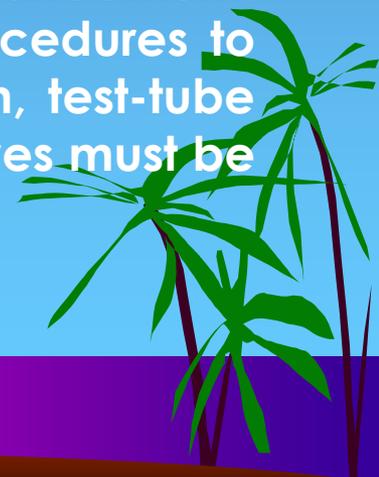
Plant sciences - Genetic Engineering has allowed us to produce genetically modified plants with diversified properties such as resistance against pest, drought and abiotic stress. It has enabled us to produce edible plants with short life-span or ability to grow in different season to increase the number of crops in a year to ultimately increase the food production. Horticulture has used biotechnology tools to produce plants with multiple color, shades, aroma to increase the production of natural colors and scent. A detail description of other biotechnology application in plant sciences is discussed elsewhere.





Animal sciences - One of the early applications of biotechnology in animal science is developing a method to separate cheese and other food products from milk by enzyme and microbes. Genetic engineering in conjunction with cell biology and biochemistry has developed multiple products of animal origin. Transgenic animal strains with desired phenotype such as high milk yielding animals, fishes and hens with more fat content now abound.

Medicine and Medical Sciences - Biotechnology helped identification of drug like molecules, antibiotics and other medicines. At present a number of antibiotics are being produced by fermentation or in cell based systems. Apart from antibiotic, vaccine, diagnostic kits and other immunotherapy are gift of biotechnological advancement. Development of artificial limb, arms, heart and medical procedures to perform open-heart operation, dialysis, artificial insemination, test-tube baby and other medical procedures. Patient safety imperatives must be adhered to.

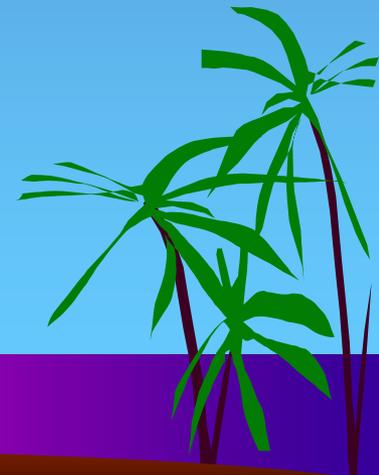


THE CONCEPT OF BIOTECHNOLOGY: OUTLOOK ON AFRICA in a Digital Age under the 4thIR

In this lecture, with respect to Africa, we emphasize

- Agricultural biotechnology(food security)
 - Crop engineering
 - Biofuels
- Medical biotechnology
 - Stem cells and animal cell culture
 - Gene therapy
 - Cloning

• Synthetic life

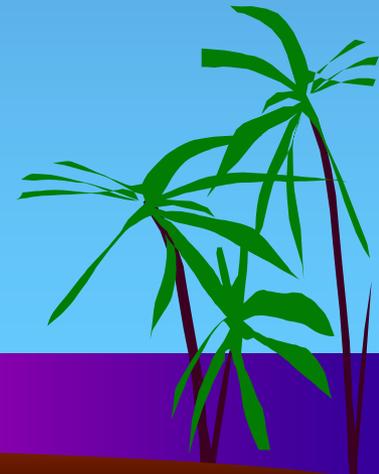


AGRICULTURAL BIOTECHNOLOGY

- **CROP ENGINEERING**

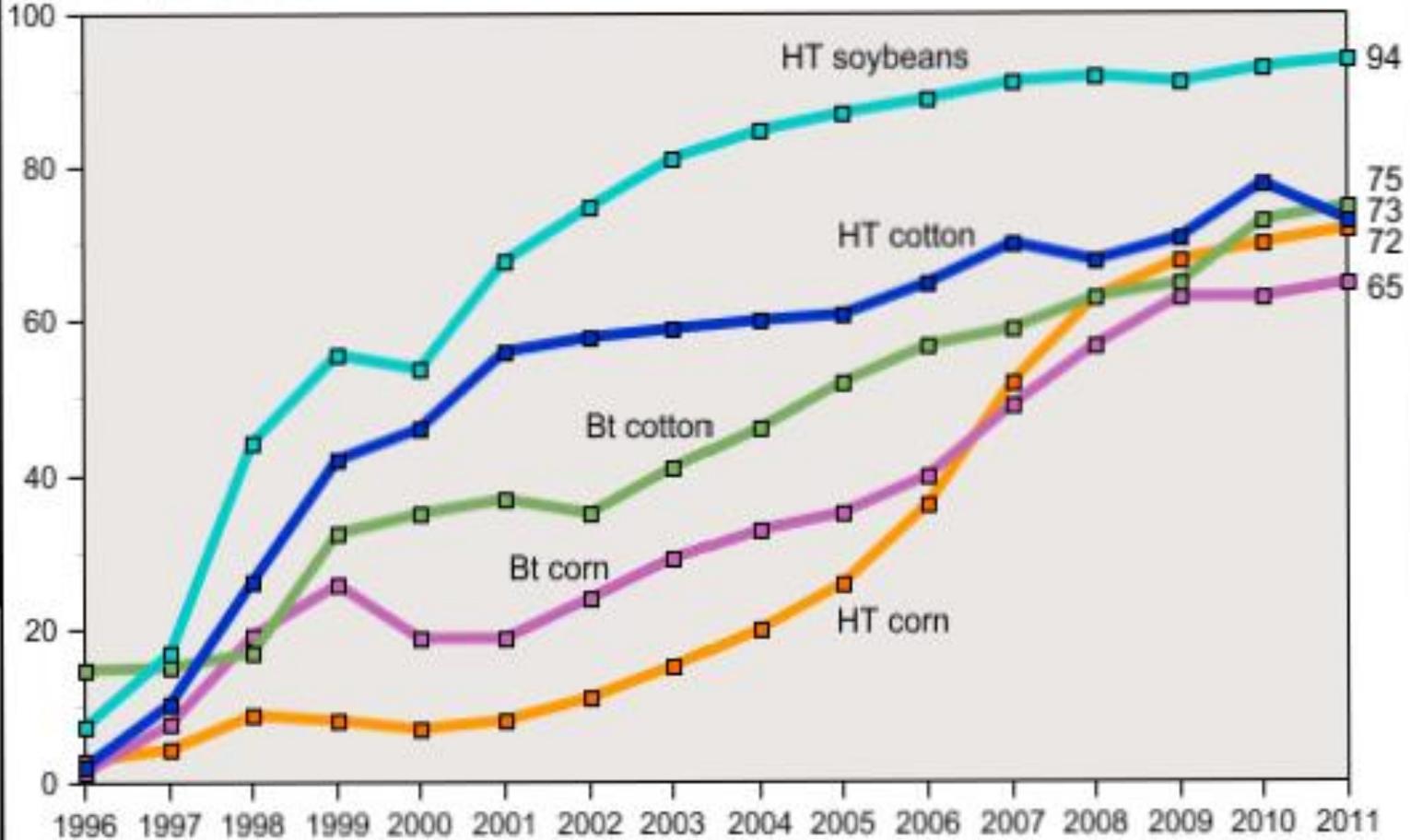
Insertion of gene(s) to improve:

- Taste and nutrition
- Crop yield
- Crop hardiness
- * Reduced dependency on fertilizers, pesticides, etc.
 - Glyphosate, glufosinate, bromoxynil



Growth in adoption of genetically engineered crops continues in the U.S.

Percent of planted acres



Data for each crop category include varieties with both HT and Bt (stacked) traits.

Sources: 1996-1999 data are from Fernandez-Cornejo and McBride (2002). Data for 2000-11 are available in the ERS data product, Adoption of Genetically Engineered Crops in the U.S., tables 1-3.

HT = herbicide tolerance (such as Roundup)

Bt = botulinum toxin

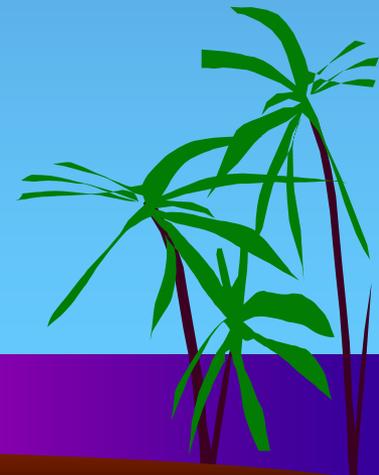
Agricultural biotechnology overview

How do you engineer the plants?

- *Agrobacterium tumefaciens* transformation
- Biolistics

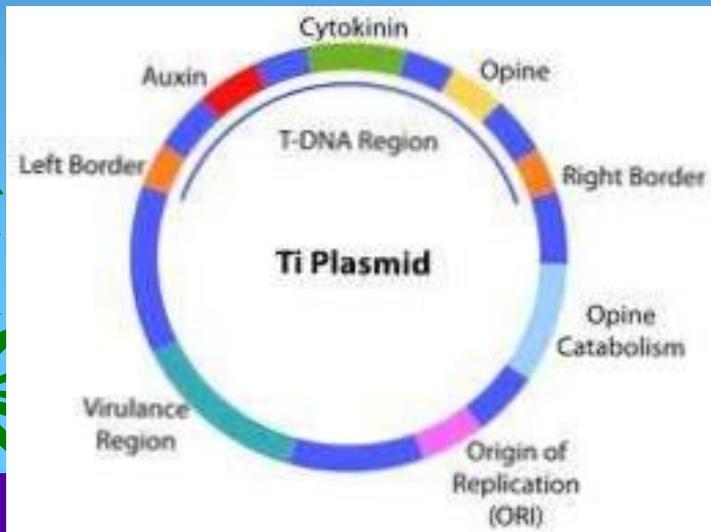
What do you engineer into the plants?

- Herbicide resistance
- Pesticides
- Increased hardiness
- Taste and nutrition



Bacterial transformation

- *Agrobacterium tumefaciens* is a soil-dwelling bacterium that causes crown gall tumors in plants
- *A. tumefaciens* can contain a plasmid called the Ti plasmid
- Tumor formation is caused by the insertion of a plasmid into plant cells from the bacteria

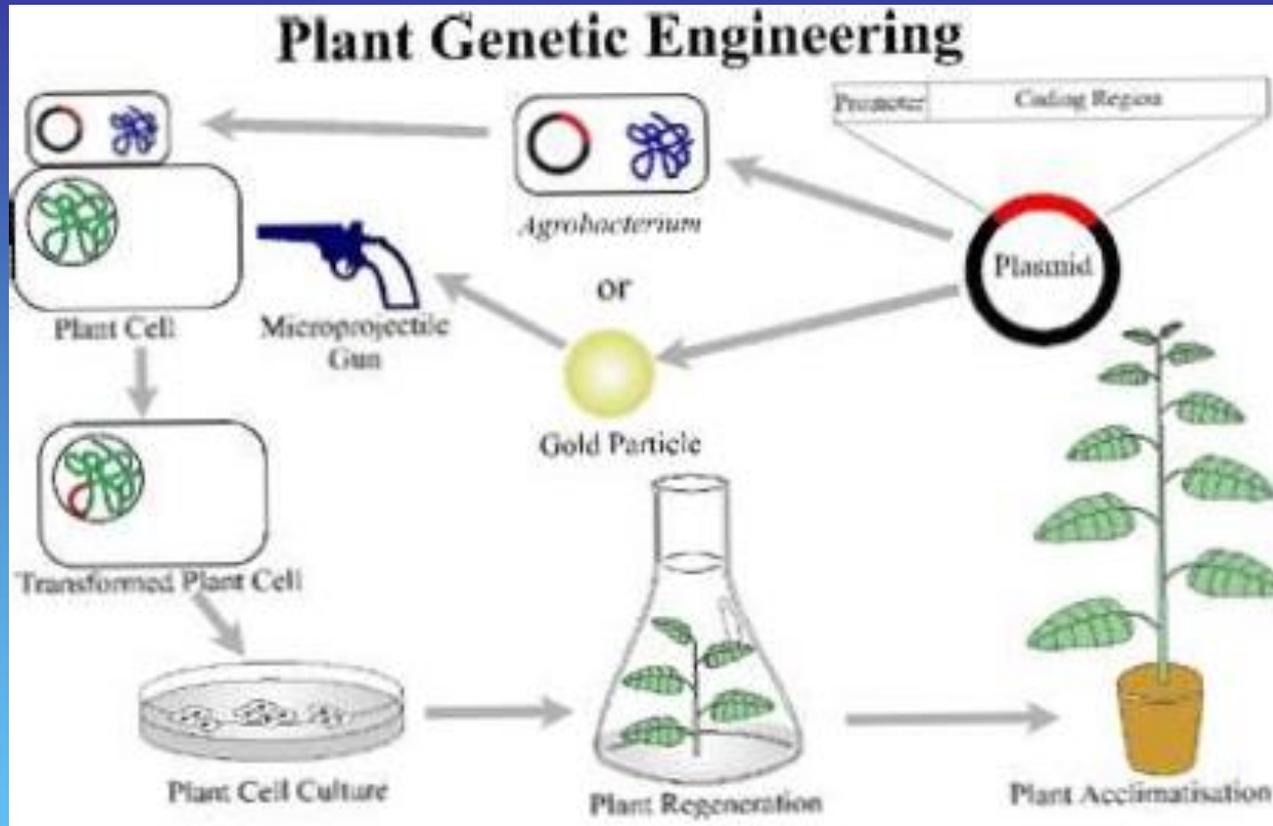


Bacterial transformation

- Isolate your gene of interest (GOI) from the host organism
 - Gene for bt toxin
- Splice together the GOI and the Ti plasmid
 - Considerations: promoter (35S CMV), codon bias, and reporter genes, elimination of virulence region
- Introduce plasmid into *A. tumefaciens*
- Mix transformed *A. tumefaciens* with immature plant cells
- Regenerate/grow plant



Bacterial transformation

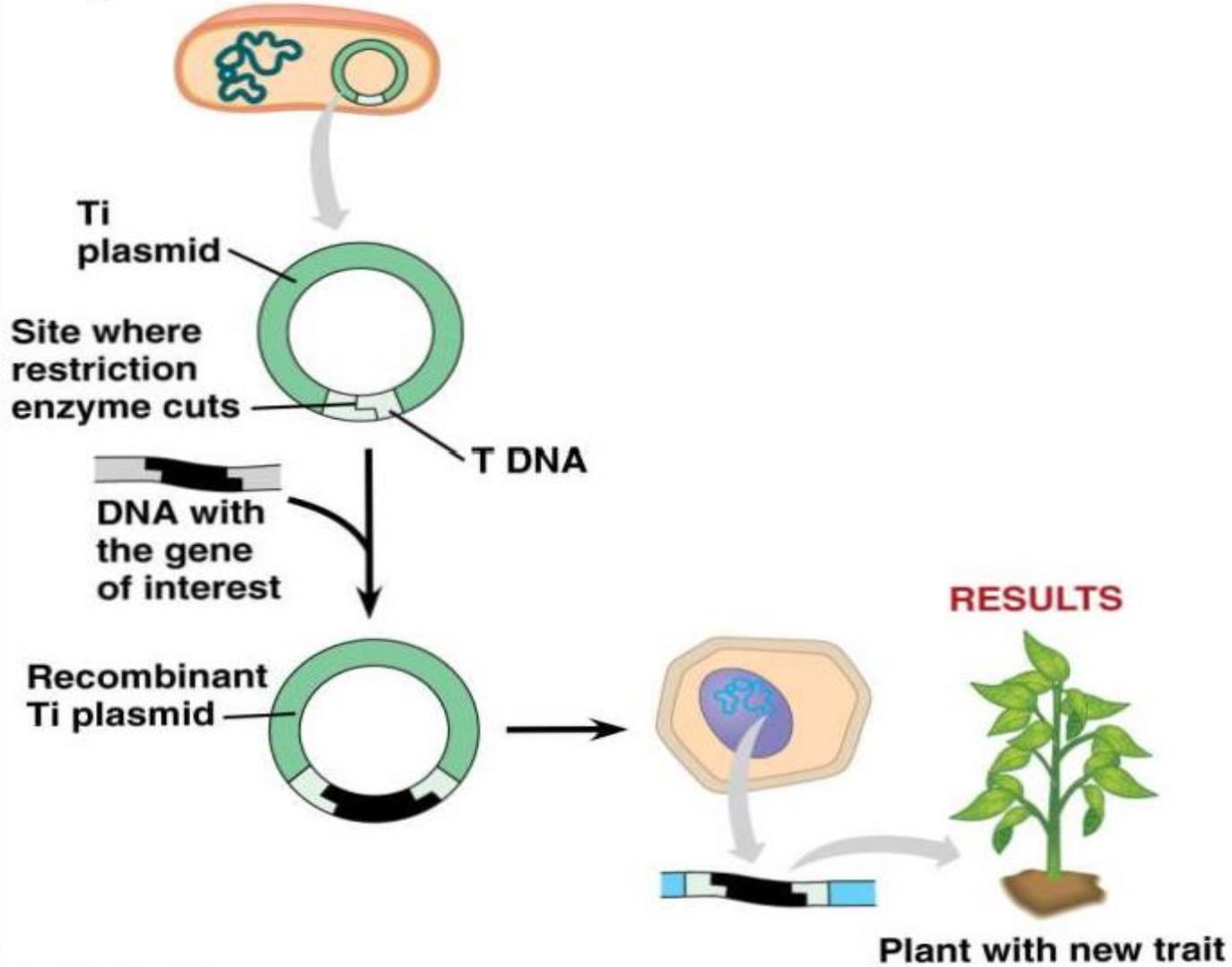


Transformation using *A. tumefaciens* is the most common plant engineering

method

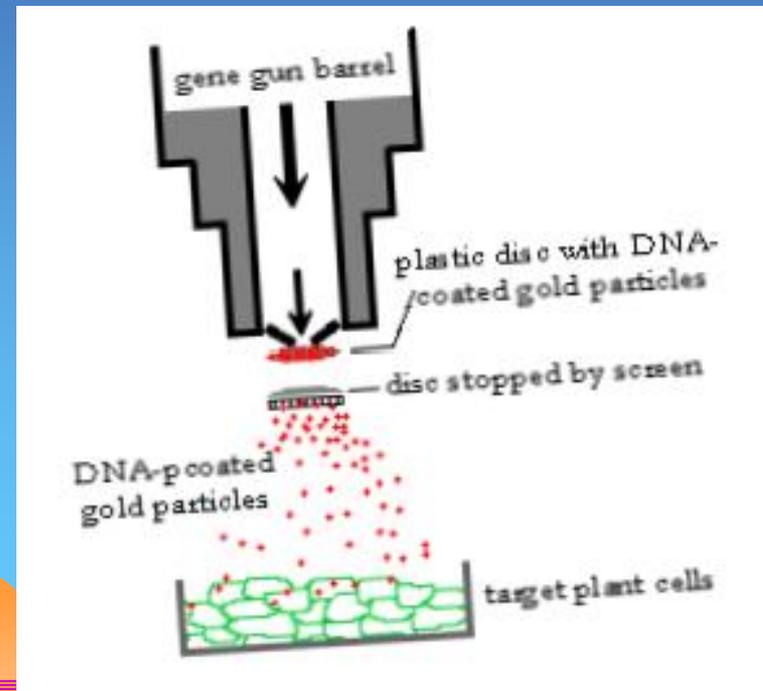
TECHNIQUE

Agrobacterium tumefaciens



Biolistics

- Gold particles coated in plasmid DNA are 'fired' into plant cells using a gene gun
- Gets past cell wall and hopefully hits nucleus



The bt toxin as a pesticide

- *Bacillus thuringiensis* produces a crystal-like (*cry*) toxin deadly to insects but safe for mammals
 - Different bt toxins will affect different insects
- The toxin binds to proteins in insect guts and punches holes through the gut
- Organic – no long-term environmental contamination



Use of Bt toxin in agriculture

- Traditionally the toxin is mass-produced in the bacteria then used as a spray on crops
- Almost all corn and soybeans now contain a gene for production of bt within the plant
- Reduced need for spraying of insecticides
- Acceptable in organic agriculture since it is biological in origin



Roundup-ready

- Roundup (glyphosate) is an herbicide used to kill plants, primarily weeds
- Glyphosate competitively inhibits an enzyme involved in amino acid synthesis
- Crop plants like corn, soybeans, and have been engineered using an enzyme that allows them to break down glyphosate
- They are now resistant to glyphosate so farmers don't risk crop damage when spraying
- Reduces amount of glyphosate necessary for spraying

93% of
soybeans in
the US are
Roundup-
ready



Flavr Savr Tomato

- First commercially grown genetically engineered food approved for human consumption in 1992 through Calgene
- Normal tomatoes are picked unripe so they are firm and easy to handle, then artificially ripened using ethylene gas
- If allowed to ripen on the vine, the enzyme polygalacturonase would kick in and begin to degrade pectin in the cell walls, turning the tomato soft and easy to rot



Flavr Savr Tomato

- Calgene hoped to slow softening while still maintaining tomato nutrition and taste
- Inserted an antisense gene that would interfere with production of polygalacturonase, and allow tomatoes to ripen on the vine yet remain firm
- Flavr Savr tomato discontinued in 1997 due to poor business practices by Calgene and shifting public perception of GMO food
- FDA did not require labeling of GMO food because it deemed the tomato to be identical in terms of nutritional content and safety to regular tomatoes



BIOFUELS

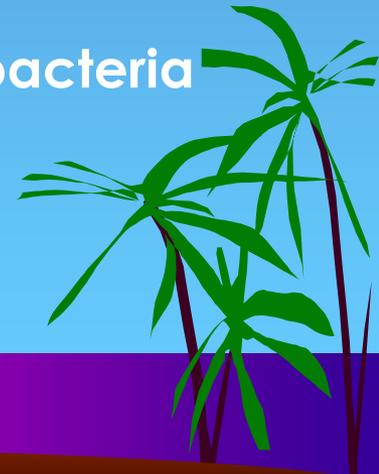
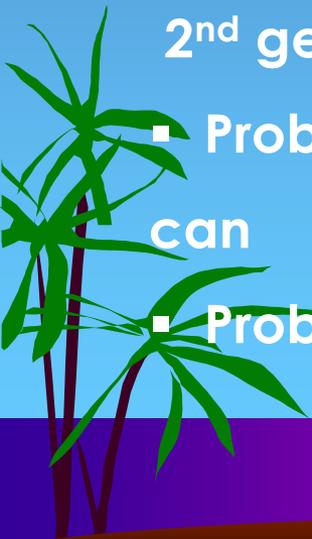
Fuels made from biological processes

- 1ST generation biofuel: made from sugar, starch, or oil, and other non-sustainable feedstock
- 2ND generation biofuel: made from plant portions that are nonedible (cellulose)
- 3RD generation: made from non-food plants (algae, switchgrass)



Ethanol Biofuels

- 55% of the energy of gasoline - \$3.45 per gallon tradeoff
- 1st generation produced through fermentation of starches and sugars.
 - Corn is the major source of starch and sugar in the U.S
 - Other sources include sugar cane and vegetable oil
 - Net energy gain over gasoline is very small due to lack of infrastructure use
- 2nd generation produced from cellulose
 - Problem: hydrolyzing cellulose into glucose so bacteria can ferment it
 - Problem: lignin is very hard to break down



Biodiesels

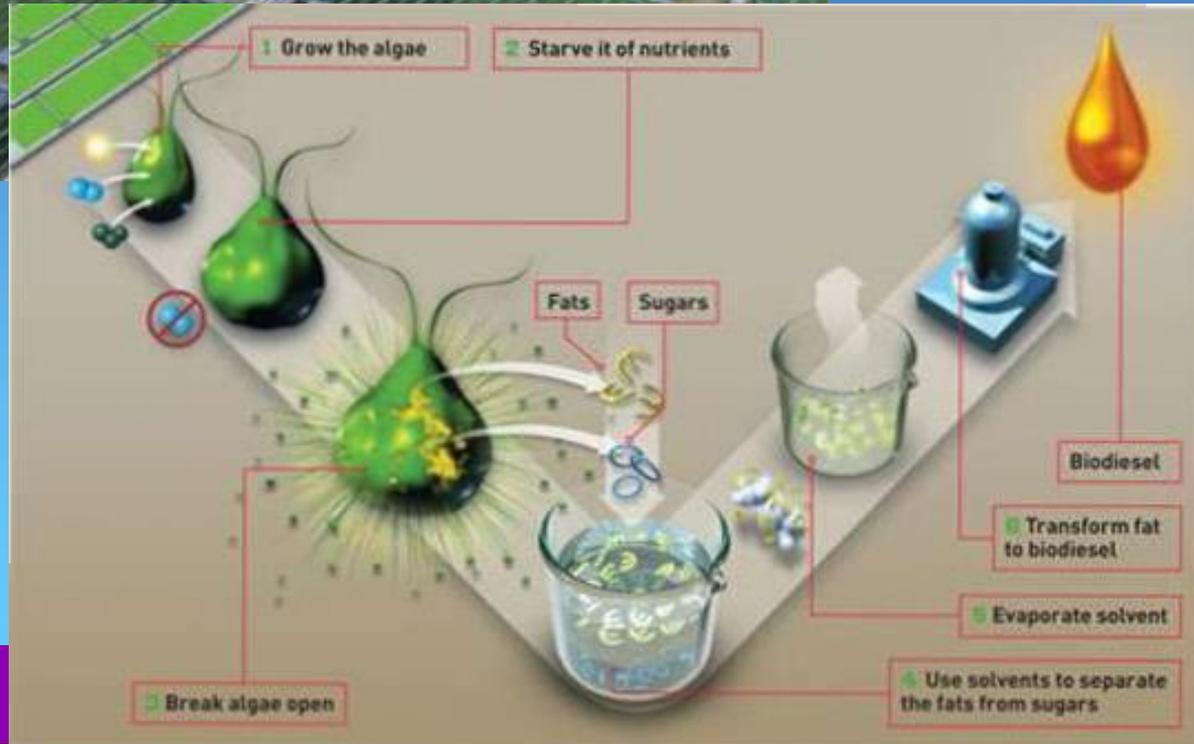
- 90% of the energy of regular diesel
- Produced by reacting animal and plant fats with alcohol (esterification)
 - Soybean oil, vegetable oil, waste oil, frying oil
- Biodiesel can be blended with conventional diesel – up to 20% with no modifications on vehicles required



3rd generation biofuels

- Almost exclusively algae, which produce oil in their cell walls
- The algal oil is refined into usable fuel using esterification
- Algae can be grown almost exclusively indoors, and takes up far less room than corn and other biofuel crops
- Problem: difficult to grow correctly, has not yet been tested thoroughly in cars





'Food vs. Fuel' Debate

- Corn, sugar cane, etc. can be used as both food and fuel
 - 25% of corn in the US goes to ethanol production
 - Does this impact the volatility of food prices?
- 2nd and 3rd generation biofuels use the nonuseful parts of a food plant, or a plant that is not used as food in the first place



AFRICAN CENTRIC APPLICATIONS OF BIOTECHNOLOGY IN DISEASES TREATMENT

1. MALARIA

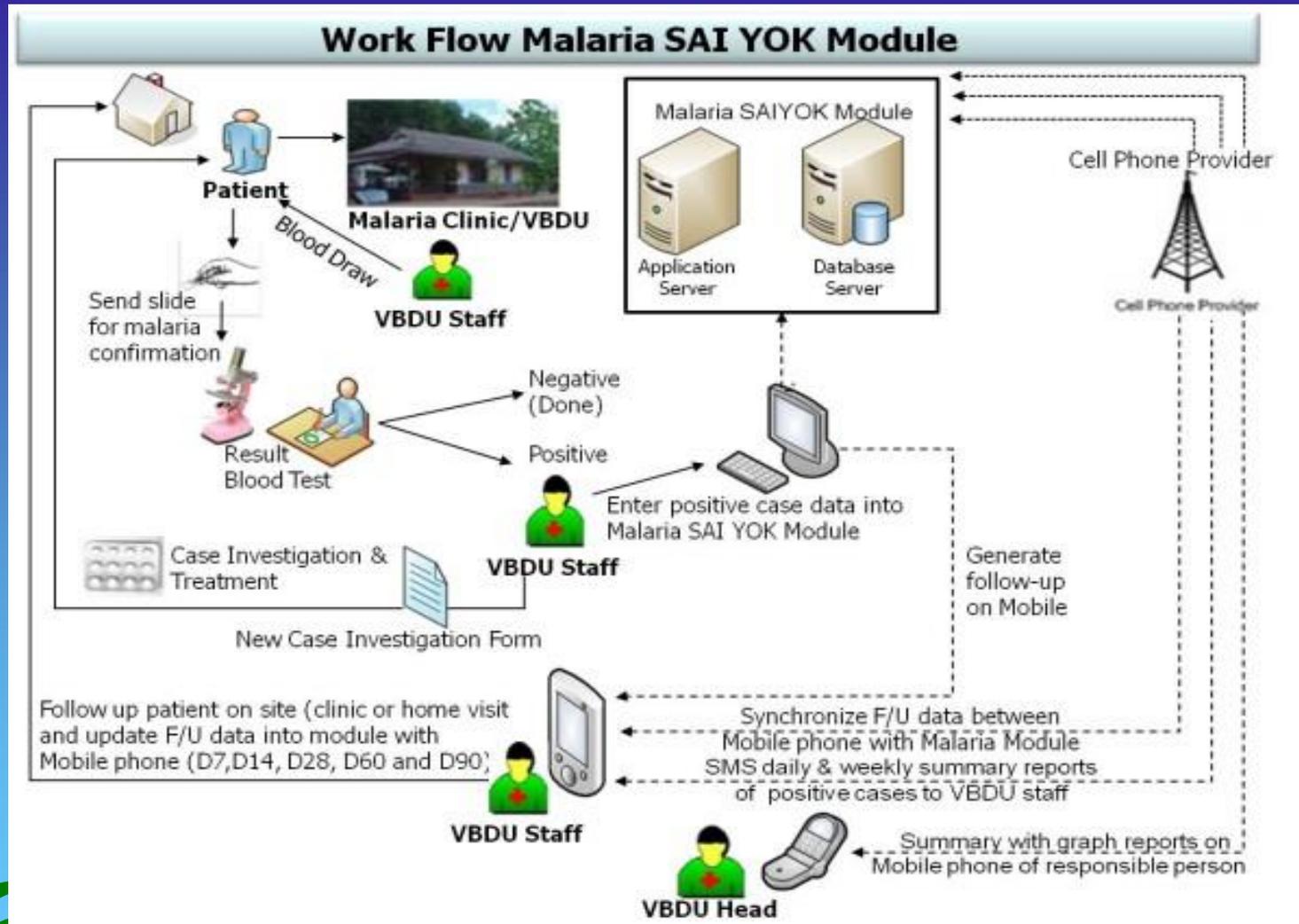
The World Health Organization (WHO) has set ultimate goal to fight against malaria towards the elimination of the disease by 2025 . This starts with good and effective malaria control programme. Several control measures and interventions have been developed and implemented across the region, including :

- mosquito control
- indoor residual spraying
- insecticide-treated nets
- prompt and effective treatment
- intermittent preventive prophylaxis
- behavioral change through education.

One of the key strategies for eliminating malaria is the prompt identification and treatment of malaria patients. To achieve this goal, an effective disease-management system should exist to enable rapid and accurate malaria case detection in target areas, and ensure effective treatment. Therefore, an effective system should allow case detection for early treatment at the point-of-care, and real-time case investigation and active follow-up of positive cases at the community level.



❖ DTMM MODULE



❖ DTMM MODULE

The DTMM was developed under the standard Software development Life Cycle (SDLC) approach to cover malaria case management at the local community MCS and VBDU. This innovative module was designed to be consistent with the existing paper-based workflow to avoid resistance from changing the ways in which malaria staff performed their routine treatment and care activities.

The three main functions of the DTMM are case detection/registry, new case investigation, and case follow-up. The case detection/registry and investigation functions of the DTMM have been adapted from the standard paper-based data collection of the infected patients. In the case-investigation form, details of case characteristics, type of malaria, and treatment, are collected. After a patient receives medication per standard treatment guidelines, a follow-up schedule is generated and updated each time follow-up is performed. Once the data have been entered into the module, each individual case, or list of registered or followed-up patients in the system, who have visited the MC/VBDU, can be examined by the responsible staff



2. TUBERCULOSIS SYMPTOMS

Latent TB is usually asymptomatic in primary infection but may produce nonspecific

symptoms;

Fatigue

Weakness

Anorexia

Weight loss

Night sweats

Low-grade fever.

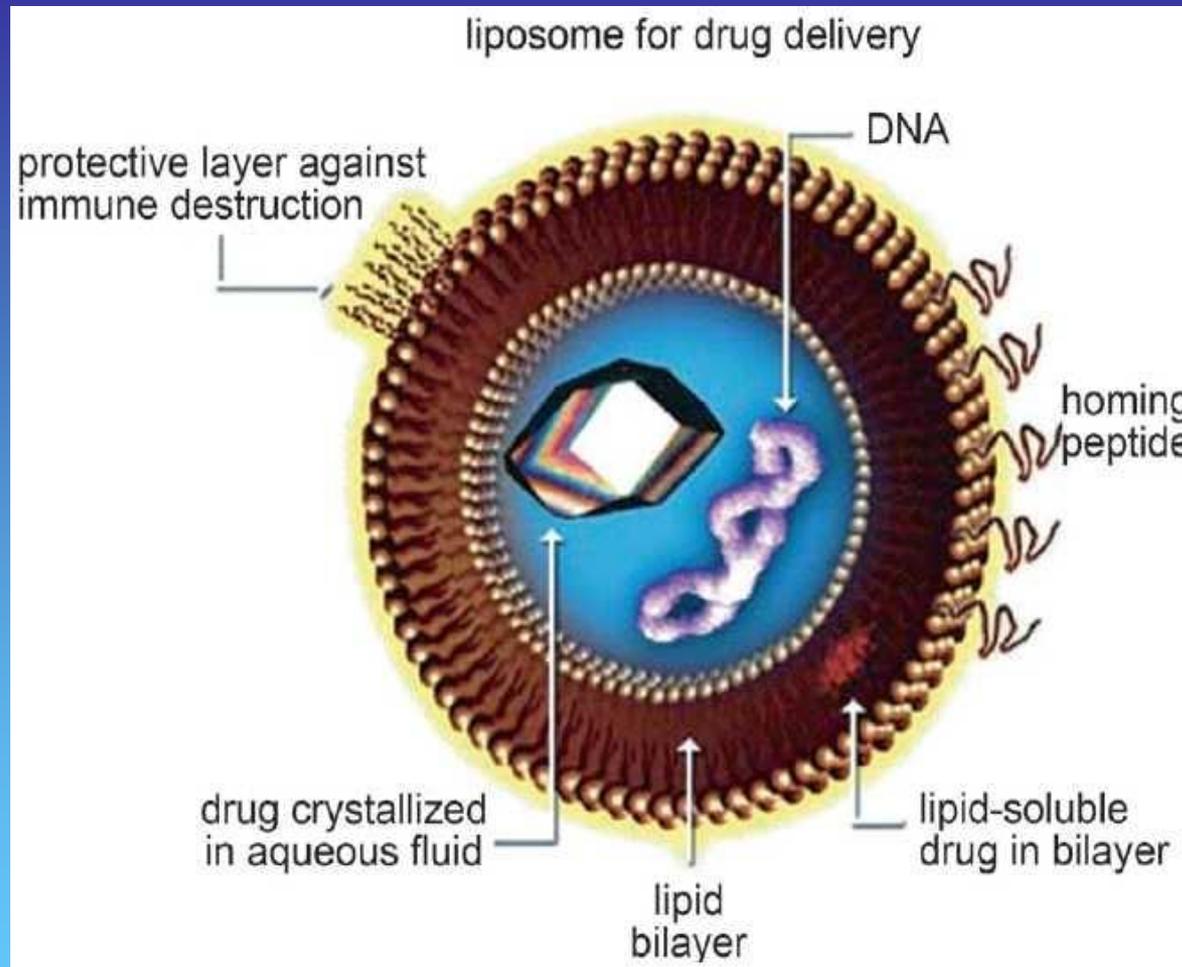
In reactivation, symptoms may include a cough that produces mucopurulent sputum, occasional hemoptysis, and chest pain. Early symptoms of active TB include cough, afternoon fever, weight loss, blood stained sputum, and night sweats.

Forms of TB

Two forms of TB are latent TB and active TB. In latent TB, the bacteria are dormant in body. This phase can last for a very long time-even decades. It is usually treated by taking one medicine for 9 months. In active TB, the bacteria multiply and spread in the body, thereby causing tissue damage.SIS



❖ LIPOSOMES FOR DRUG TARGETING



Liposomes are nano- to micro-sized vesicles comprising a phospholipid bilayer, which surrounds an aqueous core while the core enables the encapsulation of water-soluble drugs, the hydrophobic domain can be exploited to entrap insoluble agents. When administered, these carriers are recognized by phagocytic cells and are rapidly cleared from the blood stream. To prevent elimination and extend circulation times, liposomes are usually PEGylated. In more recent investigations, PYZ and rifabutin-containing liposomes were also produced, stressing the great versatility and potential of these nanocarriers. Reports with INH and rifampin encapsulated in lung-specific stealth liposomes against *Mycobacterium tuberculosis* infection revealed that liposome-encapsulated drugs at and below therapeutic concentrations were more effective than free drugs against TB.



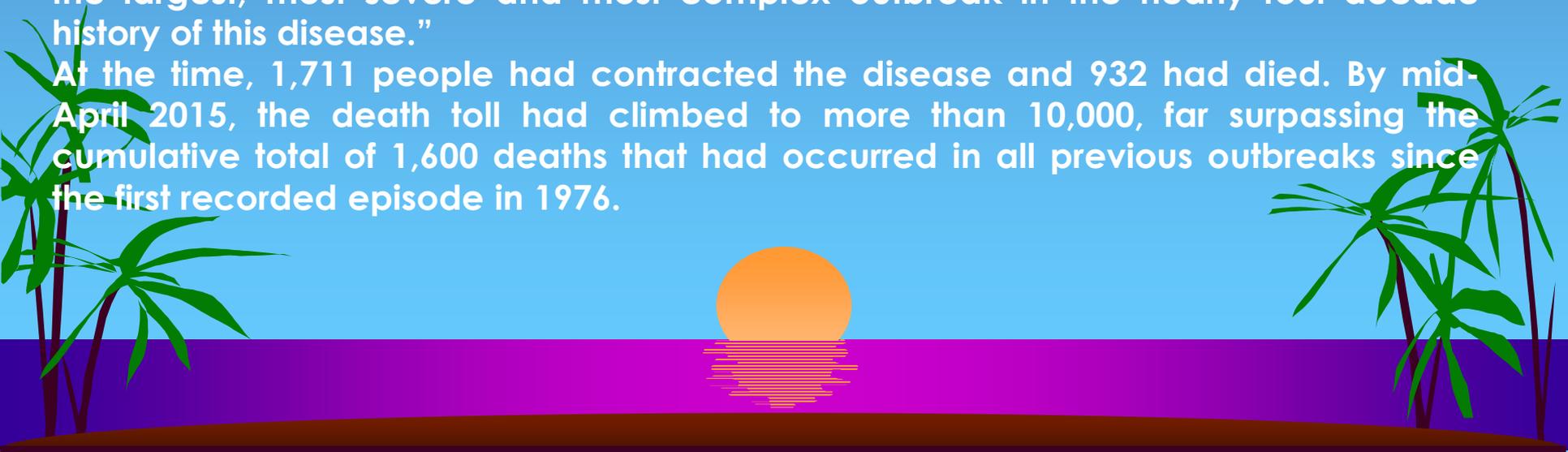
3. EBOLA VIRUS

Historically, Ebola outbreaks have occurred in isolated rural populations in some of the world's poorest countries, for only brief periods because infections progress so rapidly. The epidemics have quickly burned themselves out. Although mortality rates have been high, death tolls have been relatively low. Before the most recent outbreak in 2014–2015, governments had little incentive to invest in Ebola treatments and vaccines.

The worst outbreak

On March 23, 2014, the African Regional Office of the World Health Organization reported the presence of Ebola in Guinea, in three towns near the West African country's southern border. It spread quickly to Liberia, then Sierra Leone and Nigeria, but it wasn't until August at a press conference in Geneva that WHO Director General Margaret Chan declared an international public health emergency: "This is the largest, most severe and most complex outbreak in the nearly four-decade history of this disease."

At the time, 1,711 people had contracted the disease and 932 had died. By mid-April 2015, the death toll had climbed to more than 10,000, far surpassing the cumulative total of 1,600 deaths that had occurred in all previous outbreaks since the first recorded episode in 1976.



HEALTH WORKERS CURBING EBOLA MENACE IN AFRICA

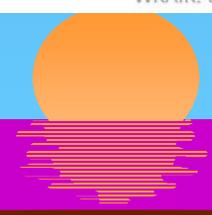
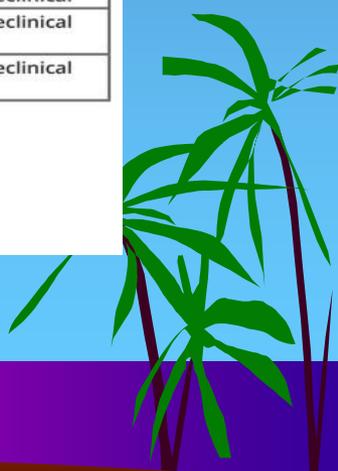
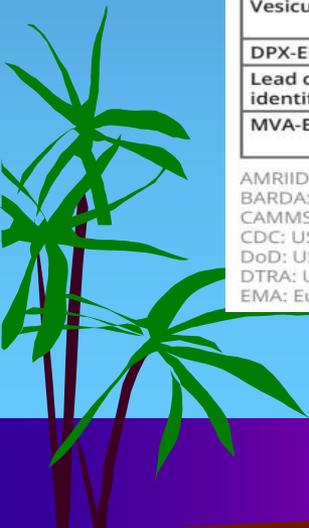


Ebola Drugs and Vaccine in Commercial Pipelines

Drugs	Developer(s)	Gov't. Partners	Technology	Status
ZMapp	Mapp Biopharmaceuticals/ Defyrus/LeafBio	AMRIID, NIAID, PHAC	Humanized monoclonal antibody cocktail	Phase 2
Favipiravir	Toyama Chemical/Fujfilm (Japan) /Medivector	AMRIID	RNA polymerase inhibitor	Phase 2
Brincidofovir	Chimerix	CDC, NIH	DNA polymerase inhibitor that halted Ebola replication in cell culture	Phase 2 discontinued
AVI-7537	Sarepta Pharmaceuticals	DoD	Antisense oligomers against Ebola mRNA	Phase 1
TKM-Ebola	Tekmira (Canada)	AMRIID, DoD	Antiviral siRNA cocktail	Phase 1
BCX4430	BioCryst Pharmaceuticals	AMRIID	RNA polymerase inhibitor	Phase 1
Alfeon and Ampligen	HemiSpherx Biopharmaceuticals	AMRIID	Alpha interferon/immunomodulatory RNA compound combination	Preclinical
FBF002	Fab'Tech (France)	EMA, WHO	Purified polyclonal immunoglobulin fragments	Preclinical
JK-05	Sihuan Pharmaceuticals (China)	CAMMS	RNA polymerase inhibitor	Preclinical
Vaccines	Developer(s)	Gov't. Partners	Technology	Status
rVSV-EBOV	Merck/ New Link Genetics	DTRA, PHAC, WRAIR	Recombinant vaccine against Zaire Ebola strain	Phase II/III
cAD3-EBOZ	GlaxoSmithKline/ Wellcome Trust (UK)	NIAID, UKMRC, UKDID	Recombinant vaccine against the Zaire Ebola strain	Phase II/III
MVA-EBOV and Ad26-EBOV	Crucell (J&J- (Netherlands)/ Bavarian Nordic (Denmark)	NIAID	Combination monovalent vaccine against Zaire Ebola strain	Phase 2
EBOV GP	Novavax		Nanoparticle vaccine against Makona Ebola strain	Phase 1
Syncon	Inovio Pharmaceuticals/ Gene One Life Sciences		Multi-strain synthetic vaccine	Phase 1
Vesiculo Vax	Profectus Biosciences	NIH, DoD, BARDA	Trivalent modified RNA virus vaccine against Ebola and Marburg	Phase 1
DPX-Ebola	Immunovaccine, Inc. (Canada)	NIAID	Novel vaccine delivery technology	Preclinical
Lead candidate not yet identified	Protein Sciences, Inc.	NIH	Insect cell expression technology	Preclinical
MVA-BN Filo	Bavarian Nordic (Denmark)	NIAID	Multivalent modified virus vaccine against Marburg and Ebola	Preclinical

AMRIID: US Army Medical Research Institute of Infectious Diseases
 BARDA: US Biomedical Advanced Research and Development Authority
 CAMMS: Chinese Academy of Military Medical Sciences
 CDC: US Centers for Disease Control and Prevention
 DoD: US Department of Defense
 DTRA: US Defense Threat Reduction Agency
 EMA: European Medicines Agency

NIAID: US National Institute of Allergy and Infectious Diseases
 NIH: US National Institutes of Health
 PHAC: Public Health Agency of Canada
 UKDID: UK Department for International Development
 UK MRC: UK Medical Research Council
 WHO: World Health Organization
 WRAIR: US Walter Reed Army Institute of Research



4. GUINEA WORM

Guinea worm disease (dracunculiasis) is a parasitic infection caused by the nematode roundworm parasite *Dracunculus medensis*. It is a neglected tropical disease contracted when people consume water from stagnant sources contaminated with Guinea worm larvae. Inside a human's abdomen, Guinea worm larvae mate and female worms mature and grow. After about a year of incubation, the female Guinea worm, one meter long, creates an agonizingly painful lesion on the skin and slowly emerges from the body. Guinea worm sufferers may try to seek relief from the burning sensation caused by the emerging worm and immerse their limbs in water sources, but this contact with water stimulates the emerging worm to release its larvae into the water and begin the cycle of infection all over again.

Guinea worm is a particularly devastating disease that incapacitates people for extended periods of time, making them unable to care for themselves, work, grow food for their families, or attend school.



CARTER CENTER FOR ERADICATION OF GUINEA WORM

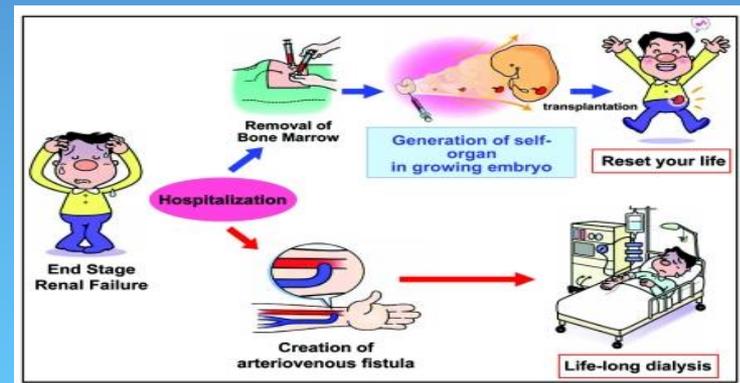
- In 1986, the disease afflicted an estimated 3.5 million people a year in 21 countries in Africa and Asia. Today, thanks to the work of The Carter Center and its partners — including the countries themselves — the incidence of Guinea worm has been reduced by more than 99.99 percent to 25 cases in 2016.
- The Guinea worm eradication campaign has averted at least 80 million cases of this devastating disease among the world's poorest and most neglected people.
- The campaign has helped to establish village-based health delivery systems in thousands of communities that now have networks of health personnel and volunteers who provide health education and interventions to prevent other diseases.
- The Carter Center works to eradicate Guinea worm disease in four remaining endemic countries: [South Sudan](#), [Mali](#), [Chad](#), and [Ethiopia](#).



BIOTECHNOLOGY: A REGENERATIVE MEDICINE FOR ORGAN TRANSPLANT

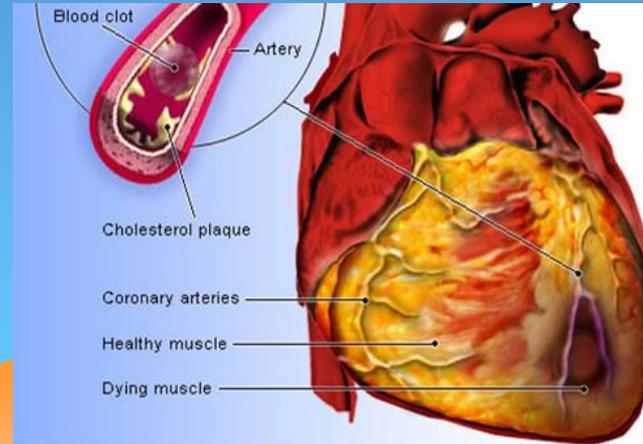
❖ KIDNEY

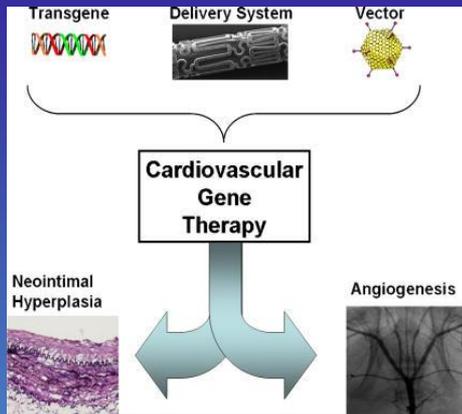
Kidney regeneration may also be applied for the treatment of hereditary renal diseases. In this scenario, once a neonate is confirmed to lack a specific gene that causes an hereditary renal disease, such as Fabry disease, the bone marrow will be removed from the mother and mesenchymal stem cells will be established and transfected with the missing or defective gene. These cells will then be microinjected into the patient under ultrasound control. The new-born baby may then have the gene it would otherwise lack, and have it exclusively in the kidney.



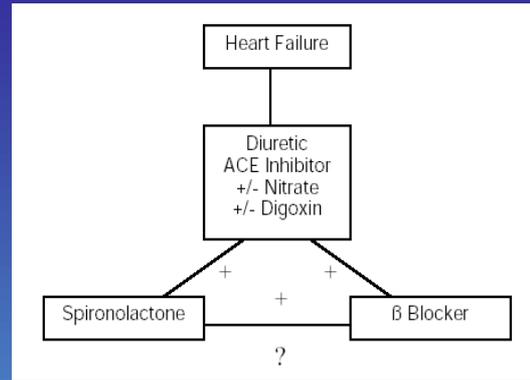
❖ HEART

Gene therapy is emerging as a potential treatment option in patients suffering from a wide spectrum of cardiovascular diseases including coronary artery disease, peripheral vascular disease, vein graft failure and in-stent restenosis. Thus far preclinical studies have shown promise for a wide variety of genes, in particular the delivery of genes encoding growth factors such as vascular endothelial growth factor (VEGF) and fibroblast growth factor (FGF) to treat ischaemic vascular disease both peripherally and in coronary artery disease. VEGF as well as other genes such as TIMPs have been used to target the development of neointimal hyperplasia to successfully prevent vein graft failure and in-stent restenosis in animal models.

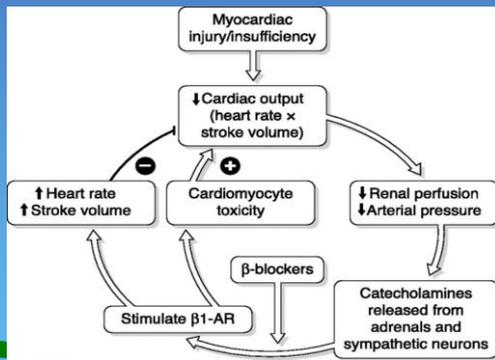




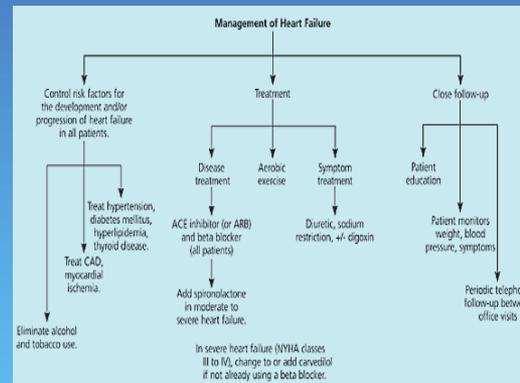
A



B



C

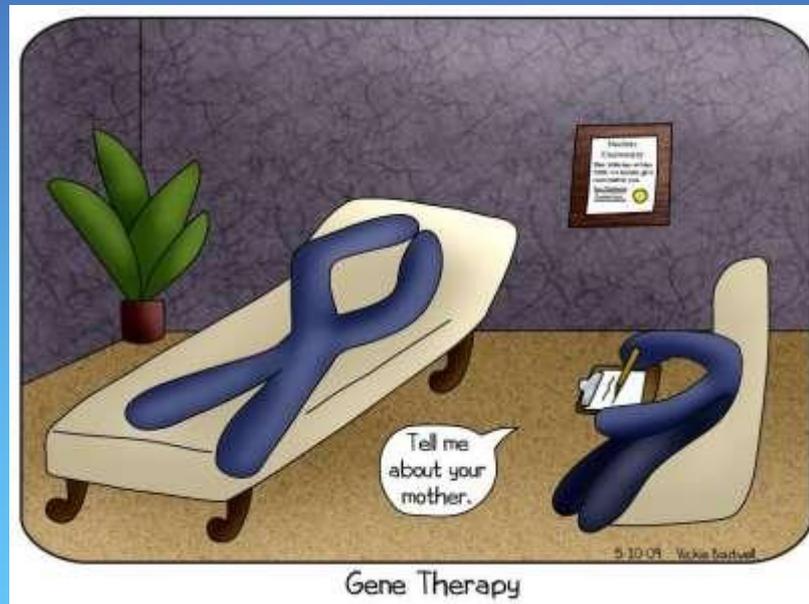


D

❖ **BIOTECH DEVICE & DRUGS FOR TREATMENT OF HEART DISEASES: (A) USING GENE THERAPY (DEVICE); (B), (C) AND (D) ARE BETA BLOCKERS AS CARDIO-PROTECTIVES (DRUGS)**



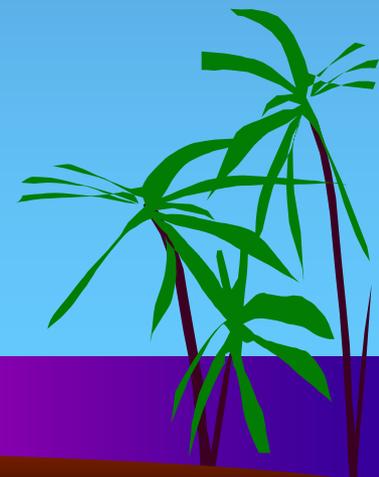
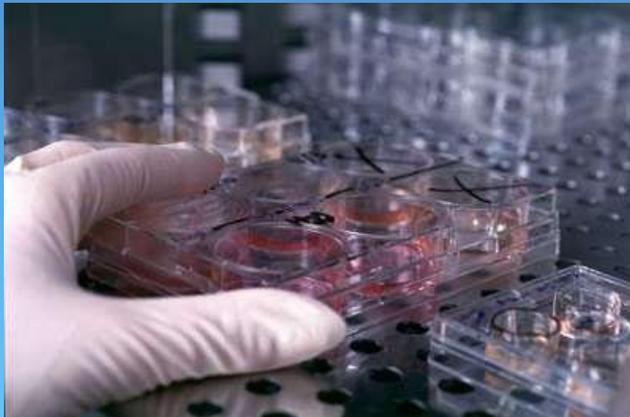
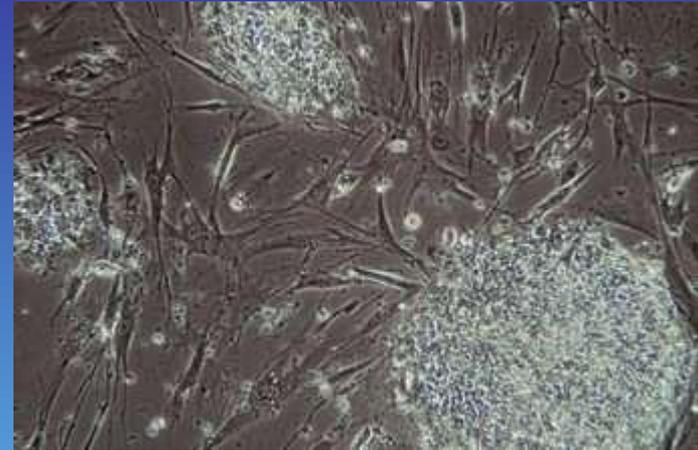
- Stem cells
- Gene therapy
- Gene chips



Stem cell treatments – a biological drug

What are stem cells?

- Adult stem cells
- Embryonic stem cells
- iPS cells



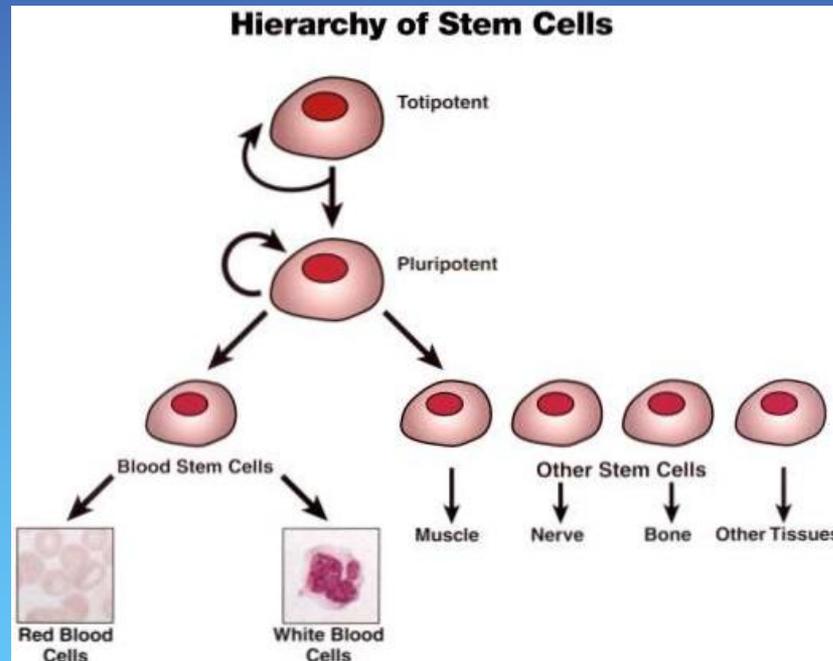
What are stem cells?

- Normal body cells can only produce more of themselves
 - Muscle cells → muscle cells, skin cells → skin cells
 - Limited number of divisions (partly because of telomere shortening)
- Stem cells are undifferentiated cells that can develop into any other cell type in the body
 - Unlimited division – one cell can become millions
 - Totipotent – can give rise to an entire organism and any cell in the body
 - Pluripotent – stem cells that can become any other cell type in the body, but can't form a full organism by themselves
 - Multipotent – can only become a limited number of other types of cells



What are stem cells?

- Stem cells were first derived from mouse embryos in 1981
- Human embryonic stem cells were derived and grown *in vitro* in 1998



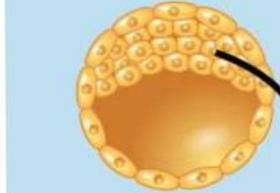
Types of stem cells

- Three types of stem cells:
 - **Embryonic stem cells**
 - **Adult stem cells**
 - **iPS cells**

As stem cells develop and differentiate, their gene expression patterns change – different genes expressed at different times. Methylation probably plays a big role!



Embryonic stem cells



Adult stem cells



Cells generating all embryonic cell types

Cells generating some cell types

Cultured stem cells



Different culture conditions

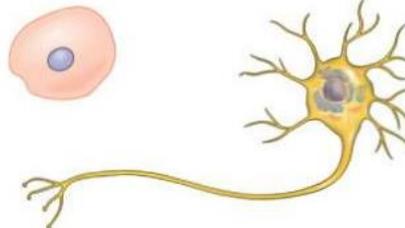


Different types of differentiated cells

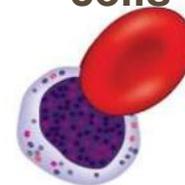
Liver cells



Nerve cells

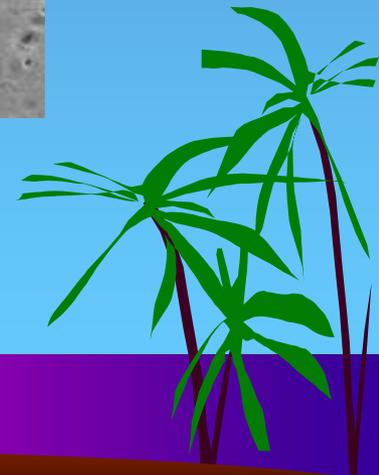


Blood cells



Where do embryonic stem cells come from?

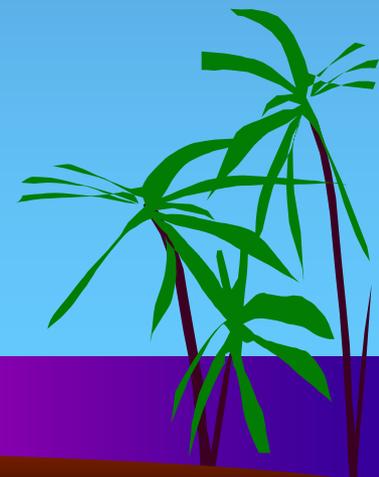
- Derived from the inner cell mass of a fertilized embryo
 - Most are derived from leftover cells from *in vitro* fertilization clinics with donor consent
 - Usually kills the blastocyst



Treatments with adult stem cells

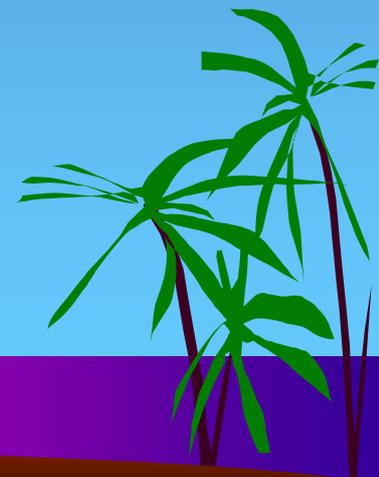
- Regenerating spinal cords using hNSCs
- Replacing dead pancreatic beta cells killed in diabetes
- Regrowing teeth
- Regrowing corneas
- Skin grafts for burn victims
- Transdifferentiation?

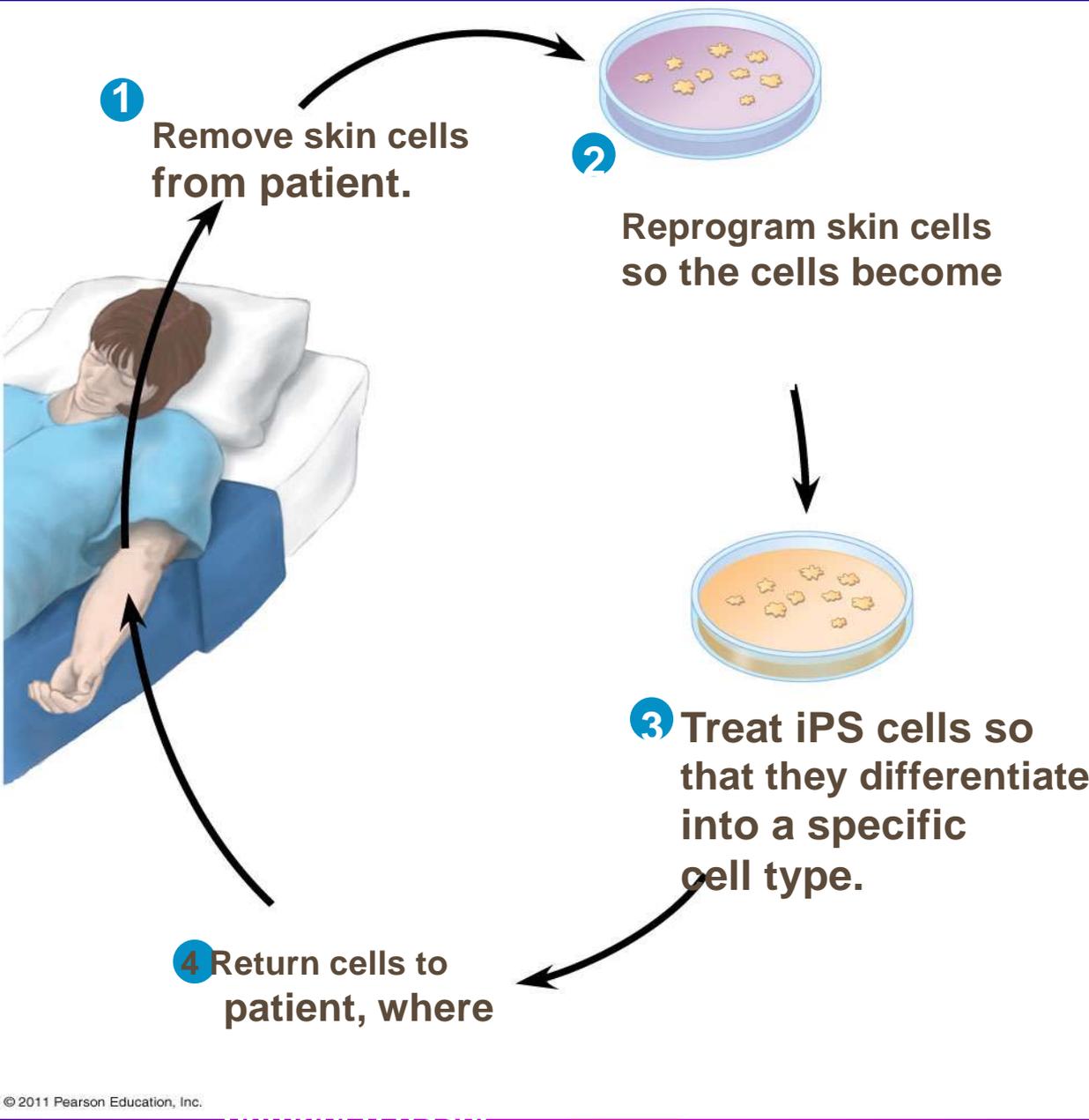
Neural stem cells are the only cells that are not immunogenic



iPS Cells

- Induced pluripotent stem cells, method created in 2006
- Adult cells genetically engineered to become stem cells
- Cells can be taken from a donor, reprogrammed to become iPSCs, then put back into the donor
 - No immunogenicity?
- Not known if they actually have the same properties of normal pluripotent stem cells
- Useful for *in vitro* drug development and disease modeling

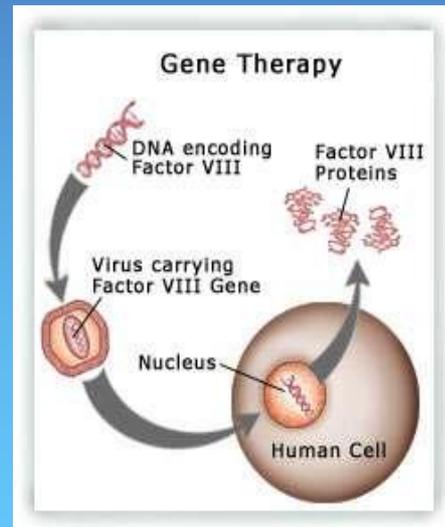


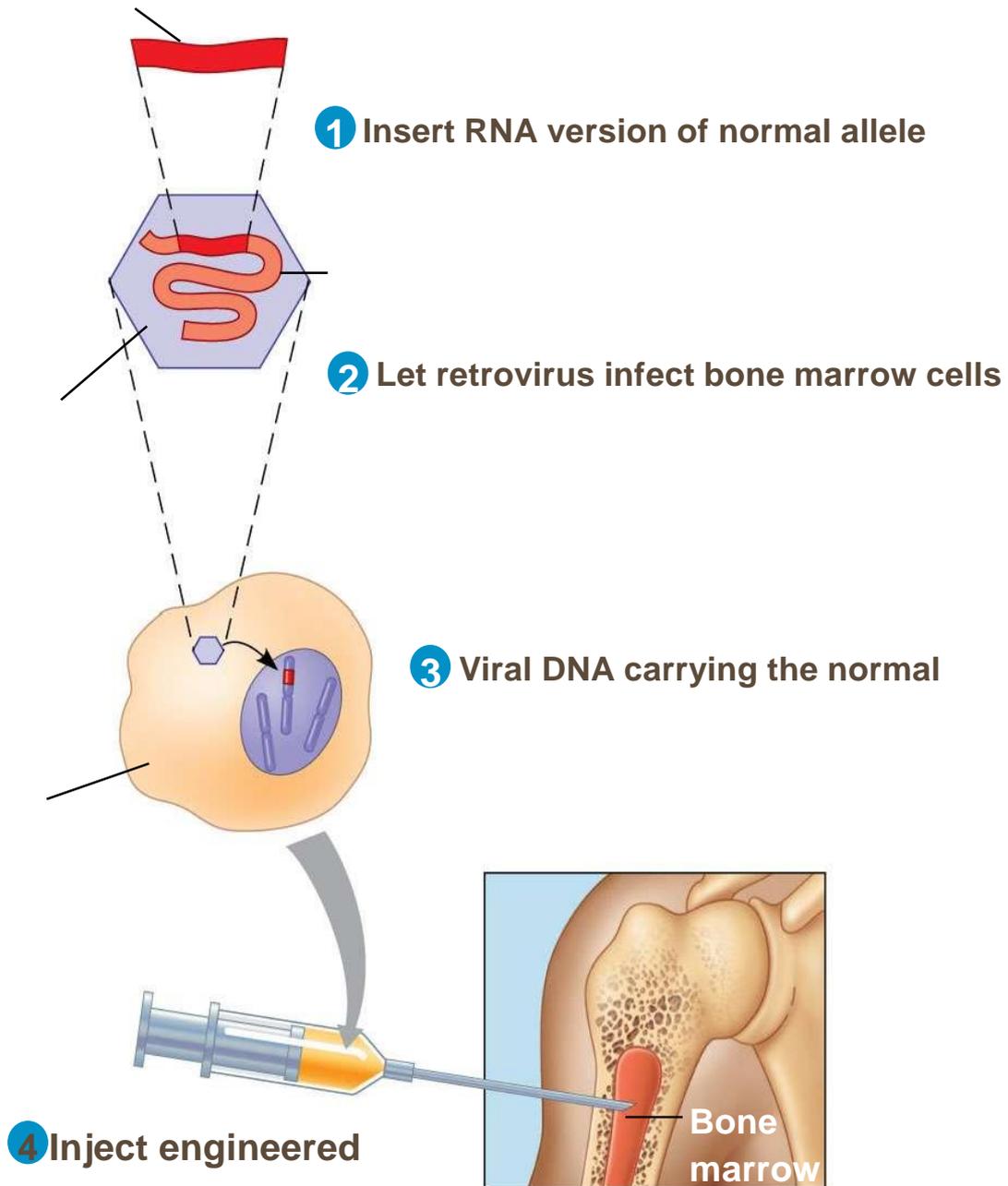


BIOTECHNOLOGY: AREAS OF VISIBILITY

1. Gene Therapy:

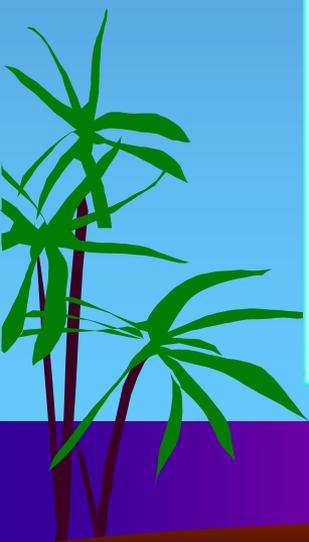
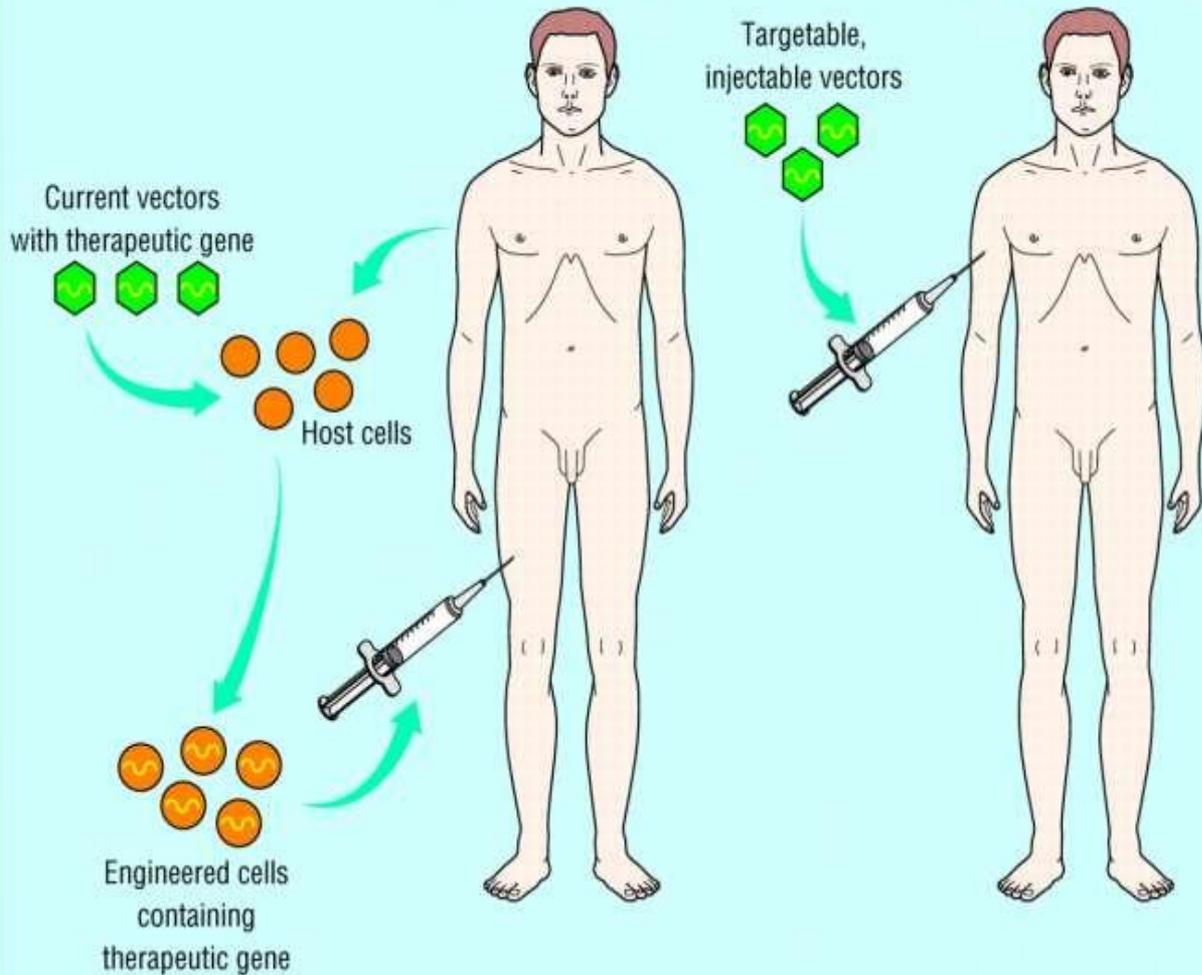
- The replacement of a defective gene or set of genes with
 - a functional copy
- Used to largely treat **monogenic** diseases





Ex vivo gene therapy

In vivo gene therapy



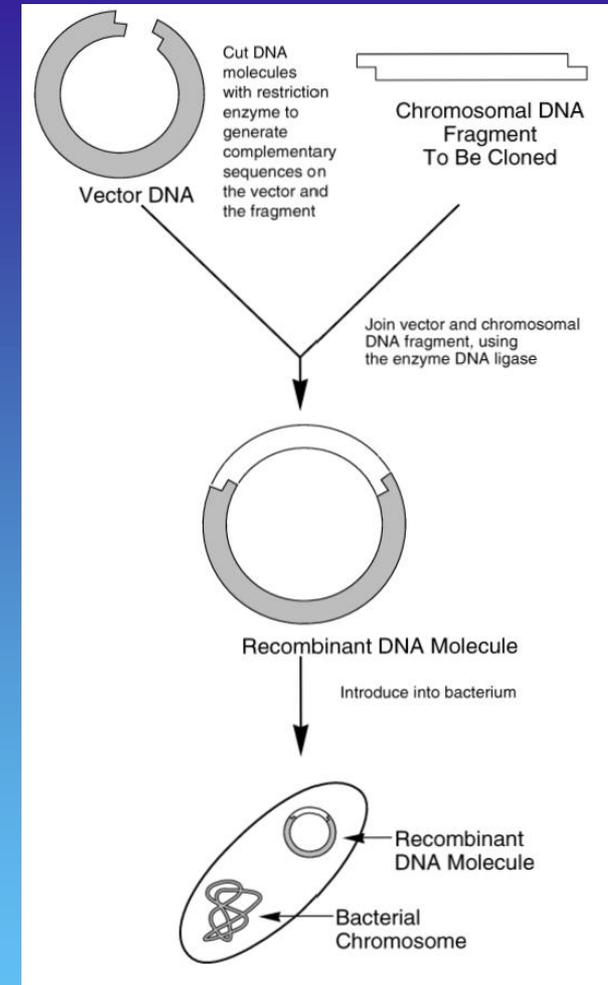
2. Cloning

- Duplication of biological material
 - Creating copies of DNA fragments
 - Creating multiple cells
- Three types of cloning
 - DNA cloning
 - Research/therapeutic
 - Reproductive



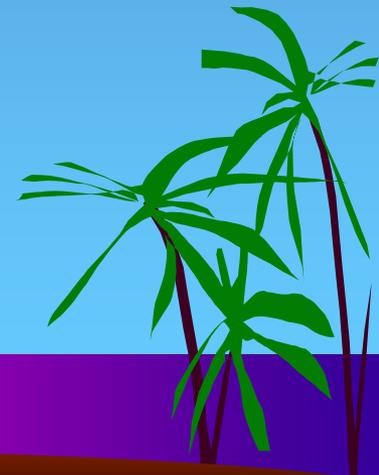
DNA cloning

- “Recombinant DNA technology,” “DNA cloning,” “molecular cloning”
- Transfer of a gene or other DNA fragment from an organism to a vector, such as a plasmid
 - Transform that plasmid into a bacteria
 - **Bacteria multiplies, creating millions of copies of the plasmid**



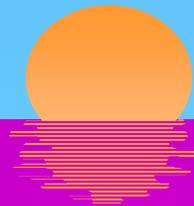
Therapeutic cloning

- AKA embryo cloning – production of human embryos and tissue for use in research
- Used to generate stem cells that can be harvested for stem cell research
- Might also be used one day to create organs for transplant
- Very, very low success rate (<90%) and very expensive



Reproductive cloning

- Used to generate an animal that has the same nuclear DNA as another animal
 - Impossible under normal conditions – animals reproduce sexually
- “Somatic cell nuclear transfer”
 - Remove the nucleus from an egg and replace it with the nucleus from an adult cell
- Cloned animals tend to be less healthy and die earlier – about 4% of genes are abnormally expressed due to abnormal methylation
- Cloned meat does not have to be labeled at the grocery store



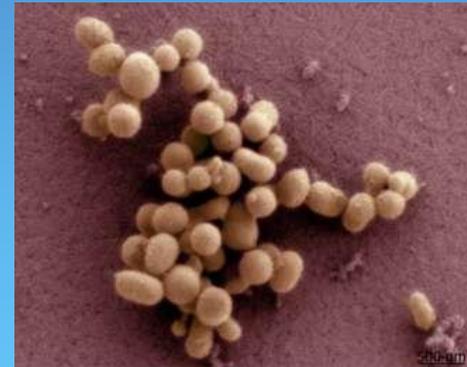
Synthetic Life

- In May 2010, Craig Venter announced the creation of the first synthetically created genome
- We are currently capable of producing lots of short <100bp oligonucleotides on a commercial level
- The team ordered millions of oligonucleotides from a biotech company, then stitched them together through homologous recombination in yeast

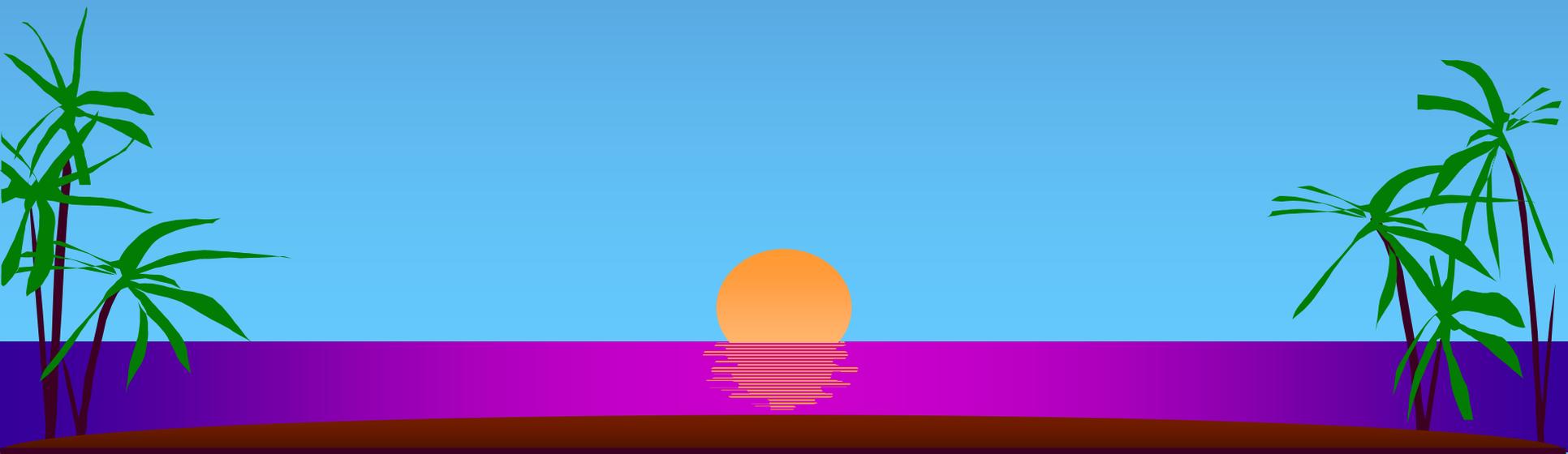


Synthetic Life

- Venter chose *Mycoplasma genitalium* for its tiny genome
- Deleted the genome out of another bacterial strain, and inserted the synthetic genome
- Successfully “booted up” the cell
- Is this really synthetic life?



PROSTHETICS AND THE EMERGENCE OF PARALYMPICS



Old Generation Prosthetics



**Cairo toe – Cairo, Egypt,
700 - 950BC**



**Cairo toe – Cairo, Egypt,
700 - 950BC**



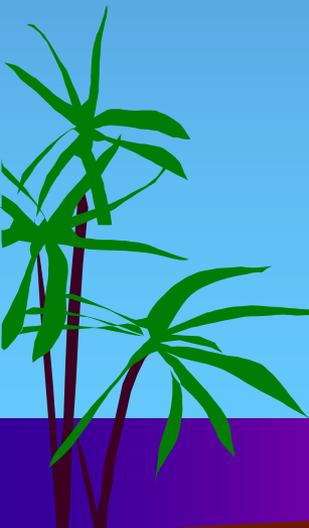
**Cartonage Leg – Roman grave,
Italy – 300BC**



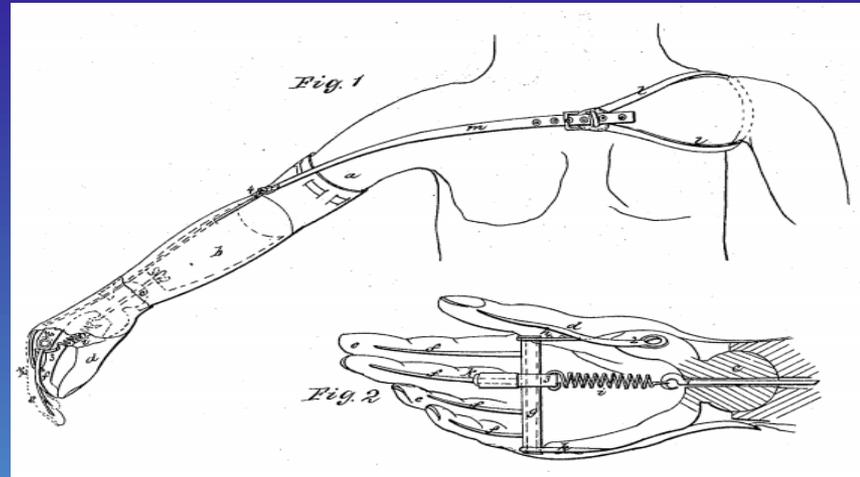
**Gotz Artificial arm – 16th
Century**



**Gotz Artificial arm – 16th
Century**



New Generation Prosthetics



Prototype of Prosthetic Arm Powered by Myoelectric Control of the variety experimented upon by Prof A. Esogbue and Huber at UCLA Biotechnology Laboratory – Summer 1965



IMPACT OF BIOTECHNOLOGY IN HUMAN DEVELOPMENT AND CIVILIZATION

- Manufacturing
- Biopharmaceutical Processes

Modern pharmaceutical manufacturing techniques frequently rely upon biotechnology:

- i. Human insulin
- ii. Human growth hormone
- iii. Human blood clotting factors
- iv. Transgenic farm animals
- v. Paclitaxel (Taxol)
- vi. Artemisinin



IMPACT OF BIOTECHNOLOGY AS SUSTAINABILITY IN HUMAN DEVELOPMENT AND CIVILIZATION

HUMAN RIGHTS VIOLATIONS

Human rights violations occur when actions by state (or non-state) actors abuse, ignore, or deny basic human rights (including civil, political, cultural, social, and economic rights). Furthermore, violations of human rights can occur when any state or non-state actor breaches any part of the UDHR treaty or other international human rights or humanitarian law.

Human rights abuses are monitored by United Nations committees, national institutions and governments and by many independent non-governmental organizations, such as Amnesty International, International Federation of Human Rights, Human Rights Watch, World Organisation Against Torture, Freedom House, International Freedom of Expression Exchange and Anti-Slavery International. These organizations collect evidence and documentation of alleged human rights abuses and apply pressure to enforce human rights laws.

Wars of aggression, war crimes and crimes against humanity, including genocide, are breaches of International humanitarian law and represent the most serious of human rights violations.

The UN Security Council has interceded with peace keeping forces, and other states and treaties (NATO) have intervened in situations to protect human rights.

HUMAN RIGHT WATCH

DISABILITY AND HUMAN RIGHTS

- Disability is a human rights issue because:
 - People with disabilities experience inequalities – for example, when they are denied equal access to health care, employment, education, or political participation because of their disability.
 - People with disabilities are subject to violations of dignity – for example, when they are subjected to violence, abuse, prejudice, or disrespect because of their disability.
 - Some people with disability are denied autonomy – for example, when they are subjected to involuntary sterilization, or when they are confined in institutions against their will, or when they are regarded as legally incompetent because of their disability.

OUTLINE OF VIOLATIONS

- Kidnapping of School Children and the Aged
- Bombing of the Civilians by the Military
- Arrest and Execution Without Trial
- Homosexual and Gay Marriages
- Mass Deportation of Legal Immigrants
- Persecution of Christians and Muslims
- Torture during Interrogation
- Mass murder of Resistance Fighters
- Confiscation of Property
- Cruel Medical Examination without consent
- Ethnic and Tribal Marginalization
- Deprivations, Hunger, Starvation and Depression
- Sentimental Nepotism

DISABLED PEOPLE IN AFRICA

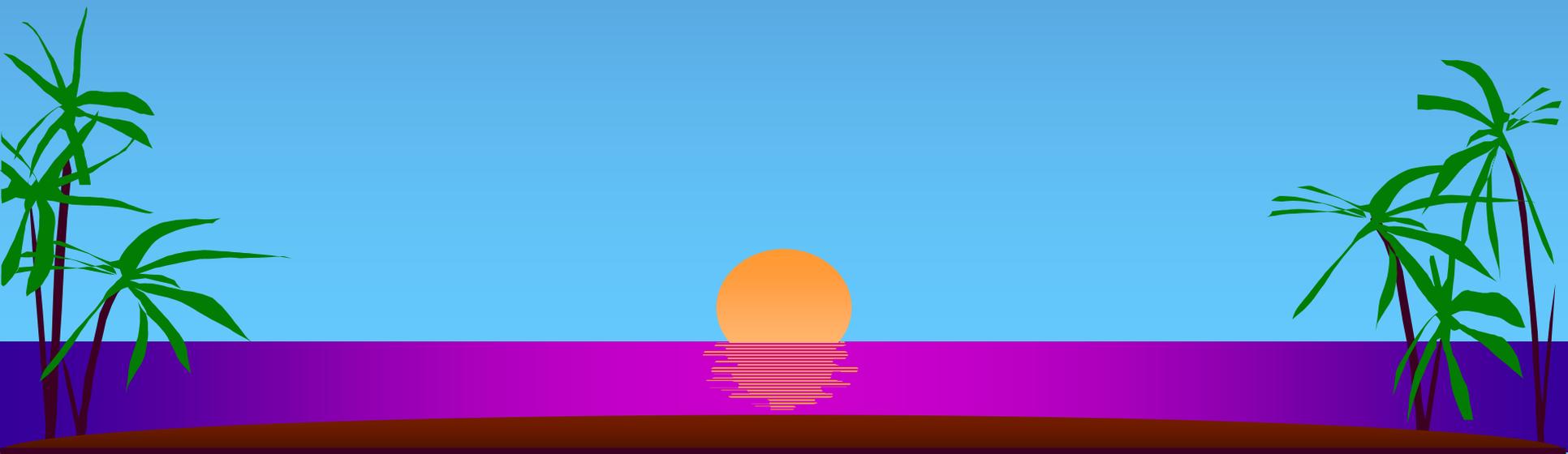
HUMANITY IN NEGLECT



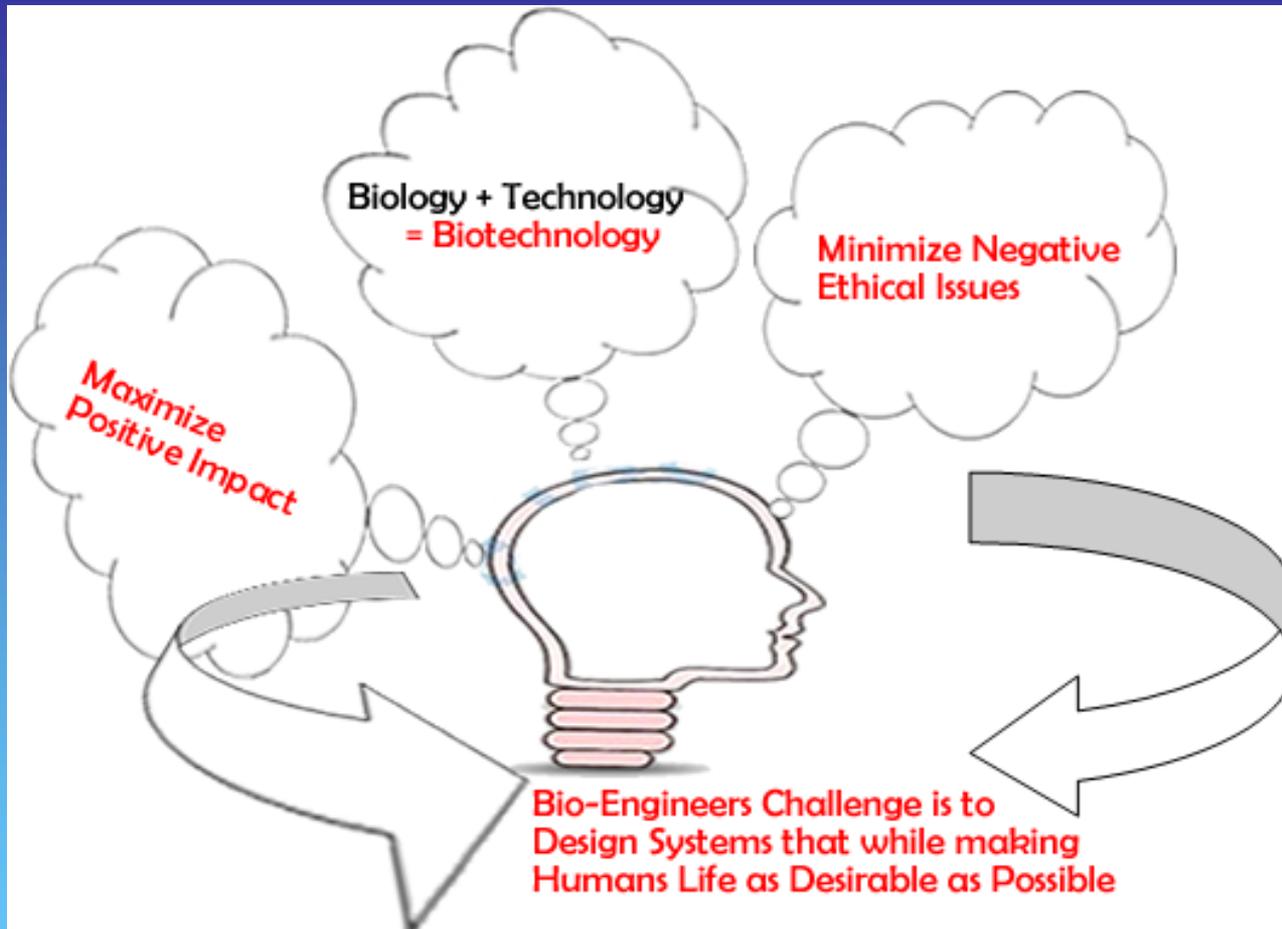
Human Rights Abuse



SOME ETHICAL ISSUES IN BIOTECHNOLOGY ADVANCES AND DEVELOPMENT: Implications for Africa



SO, WHAT EXACTLY DO ENGINEERS DO?



The End

- ◆ THANK YOU FOR LISTENING!

- ◆ ANY QUESTIONS?

