الكلية	العلوم
القسم	علوم الحياة
المادة باللغة الانجليزية	Biotechnology and genetic engineering
المادة باللغة العربية	التقنيات الاحيائية والهندسة الوراثية
المرحلة الدراسية	الرابعة
اسم التدريسي	سعد طه مطلك حميدان بيكات
عنوان المحاضرة باللغة الانجليزية	A historical overview of the origin and development of biotechnology and genetic engineering
عنوان المحاضرة باللغة العربية	نبذة تاريخية عن أصل ونشوء التقنيات الاحيائية والهندسة الوراثية
رقم المحاضرة	الاولى
المصادر والمراجع	Jones and Bartlett Publishers, (October 20, 2010) Introduction to Biotechnology and Genetic Engineering, 1st Edition.
	Gao, J. (2012). Tissue culture and rapid multiplication techniques of Apocynum L. Agricultural Science & Technology, 13(11), 2269.

Origin of the term “Biotechnology”

According to Robert Bud1, this term (Biotechnology) was firstly used by the Hungarian **Károly Ereky** during 1919 to describe a technology based on **converting raw materials into a more useful product** in a book called "Biotechnology of Meat, Fat and Milk Production in an Agricultural Large-Scale Farm ». For Ereky, the term "biotechnology" indicated the process by which raw materials could be biologically upgraded into socially useful products. Since its inception, the concept of biotechnology has been variously defined.

Definitions used by governments and organizations

FDA's working definition of biotechnology is "the application of biological systems and organisms to technical and industrial processes". This definition is necessarily broad. It takes in both the "old" and "new" science: the age-old techniques for making beer or yogurt as well as the most advanced uses of recombinant DNA technology. It takes in many applications, from production of enzymes for laundry detergents, to selective breeding of plants and animals, to genetic engineering of bacteria to clean up oil spills.

Federal Republic of Germany: “Biotechnology deals with the introduction of biological methods within the framework of technical processes and industrial production. It involves the application of microbiology and biochemistry together with technical chemistry and process engineering”

Biotechnology a multidisciplinary field

Biotechnology is a clearly multidisciplinary field involving biochemistry, molecular biology, genetics, immunology, microbiology, pharmacology, fermentation, agriculture, to name just a few. Each of the contributing subject areas brings its own special vocabulary and nomenclature standards and considerable difficulties of communication is the result. It is therefore important to become familiar with terminology.

HISTORY & EVOLUTION OF BIOTECHNOLOGY

This section introduces to biotechnology concepts through the presentation of timeline showing the progression from the earliest domestication of crops and animals (before the Common Era) to modern methods of biotechnology in the 21st Century. The classification in ancient biotechnology (1st generation), classical biotechnology (2nd generation) and modern biotechnology (3rd generation) is presented. Dates are benchmarks of scientific, social responses and regulatory breakthroughs, and scientific evidence on the important of the role of biotechnology as tools to improve food production (crops, food, and animal's husbandry) is highlighted.

Biotechnology Timeline

The historical application of Biotechnology throughout is provided below since before the common era.

Before Common Era:

- **7000 BCE** – Chinese discover fermentation through beer making.
- 6000 BCE – Yogurt and cheese made with lactic acid-producing bacteria by various people.
- 4000 BCE – Egyptians bake leavened bread using yeast.
- 500 BCE – Moldy soybean curds used as an antibiotic.
- 250 BCE – The Greeks practice crop rotation for maximum soil fertility.
- 100 BCE – Chinese use chrysanthemum as a natural insecticide.

Pre-20th Century:

- **1663 –** First recorded description of dying cells by Robert Hooke.
- 1675 – Antonie van Leeuwenhoek discovers and describes protozoa.
- **1798** – Edward Jenner uses first viral vaccine to inoculate a child from smallpox.
- 1802 – The first recorded use of the word biology.
- 1824 – Henri Dutrochet discovers that tissues are composed of living cells.
- 1838 – Protein discovered, named and recorded by Gerardus Johannes Mulder and Jöns Jacob Berzelius.

- **1862 –** Louis Pasteur discovers the bacterial origin of fermentation.
- 1863 – Gregor Mendel discovers the laws of inheritance.
- 1864 – Antonin Prandtl invents first centrifuge to separate cream from milk.
- 1869 – Friedrich Miescher identifies DNA in the sperm of a trout.
- 1871 – Ernst Hoppe-Seyler discovers invertase, which is still used for making artificial sweeteners.
- **1877** – Robert Koch develops a technique for staining bacteria for identification.
- 1878 – Walther Flemming discovers chromatin leading to the discovery of chromosomes.
- **1881** – Louis Pasteur develops vaccines against bacteria that cause cholera and anthrax in chickens.
- 1885 – Louis Pasteur and Emile Roux develop the first rabies vaccine and use it on Joseph Meister.

20th century:

- **1919** – Károly Ereky, a Hungarian agricultural engineer, first uses the word biotechnology.
- 1928 – Alexander Fleming notices that a certain mould could stop the duplication of bacteria, leading to the first antibiotic: penicillin.
- 1933 – Hybrid corn is commercialized.
- 1942 – Penicillin is mass-produced in microbes for the first time.
- 1950 – The first synthetic antibiotic is created.
- 1951 – Artificial insemination of livestock is accomplished using frozen semen.
- 1952 – L.V. Radushkevich and V.M. Lukyanovich publish clear images of 50 nanometre diameter tubes made of carbon, in the Soviet Journal of Physical Chemistry.
- **1953** – James D. Watson and Francis Crick describe the structure of DNA.
- 1958 – The term bionics is coined by Jack E. Steele.
- 1964 – The first commercial myoelectric arm is developed by the Central Prosthetic Research Institute of the USSR, and distributed by the Hangar Limb Factory of the UK.
- **1972** – The DNA composition of chimpanzees and gorillas is discovered to be 99% similar to that of humans.
- **1973** – Stanley Norman Cohen and Herbert Boyer perform the first successful recombinant DNA experiment, using bacterial genes.
- 1974 – Scientist invent the first biocement for industrial applications.
- 1975 – Method for producing monoclonal antibodies developed by Köhler and César Milstein.
- 1978 – North Carolina scientists Clyde Hutchison and Marshall Edgell show it is possible to introduce specific mutations at specific sites in a DNA molecule.
- 1980 – The U.S. patent for gene cloning is awarded to Cohen and Boyer.
- 1982 – Humulin, Genentech's human insulin drug produced by genetically engineered bacteria for the treatment of diabetes, is the first biotech drug to be approved by the Food and Drug Administration.
- **1983** – The Polymerase Chain Reaction (PCR) technique is conceived.
- 1990 – First federally approved gene therapy treatment is performed successfully on a young girl who suffered from an immune disorder.
- 1994 – The United States Food and Drug Administration approves the first GM food: the "Flavr Savr" tomato.
- 1997 – British scientists, led by Ian Wilmut from the Roslin Institute, report cloning Dolly the sheep using DNA from two adult sheep cells.
- 1999 – Discovery of the gene responsible for developing cystic fibrosis.
- 2000 – Completion of a "rough draft" of the human genome in the Human Genome Project.

21st Century:

- 2001 – Celera Genomics and the Human Genome Project create a draft of the human genome sequence. It is published by Science and Nature Magazine.
- 2002 – Rice becomes the first crop to have its genome decoded.
- **2003** – The Human Genome Project is completed, providing information on the locations and sequence of human genes on all 46 chromosomes.
- 2008 – Japanese astronomers launch the first Medical Experiment Module called "Kibo", to be used on the International Space Station.
- **2009** – Cedars-Sinai Heart Institute uses modified SAN heart genes to create the first viral pacemaker in guinea pigs, now known as iSANs.

Plant tissue culture

In general Tissue culture is referred to the culture and maintenance of plant cells or organs in sterile, nutritionally and environmentally supportive conditions (*in vitro*), in which all product cells (clones) have the same genotype (unless affected by mutation during culture). It has applications in **research** and **commerce**. In commercial settings, tissue culture is primarily used for plant propagation and is usually meant to as micropropagation.

⇒ 1920’s known to be as a first commercial use of plant tissue culture on artificial media (germination and growth of orchid plants).

⇒ During 1950’s and 60’s there was a great deal of research specially when a reliable artificial medium was developed and leads to plant tissue culture really ‘took off’ commercially.

⇒ Its methods are used for **virus eradication**, **genetic manipulation**, **somatic hybridization** and other procedures that benefit propagation, plant improvement and basic research.

Several advantages were arisen from using different techniques in plant tissue culture which including:

◊ The production of exact copies of plants that produce particularly good flowers, fruits, or have other desirable traits.

◊ Ability to quickly produce mature plants.

◊ The production of multiples of plants in the absence of seeds or necessary pollinators to produce seeds.

◊ The regeneration of whole plants from plant cells that have been genetically modified.

◊ The production of plants from seeds that otherwise have very low chances of germinating and growing, i.e.: orchids and *Nepenthes*.

◊ To clear particular plants of viral and other infections and to quickly multiply these plants as 'cleaned stock' for horticulture and agriculture.

o It relies on the fact that many **plant cells** have the ability to regenerate a **whole plant** (totipotency).

o **Single cells**, plant cells without cell walls (protoplasts), pieces of leaves, stems or roots **can often be used to** generate a new plant on culture media given the required nutrients and plant hormones.

Tissue culture has several critical requirements:

1. Appropriate tissue (some tissues culture better than others).
2. A suitable growth medium containing energy sources and inorganic salts to supply cell growth needs. This can be liquid or semisolid.
3. Aseptic (sterile) conditions, as microorganisms grow much more quickly than plant and animal tissue and can overrun a culture.
4. Growth regulators - in plants, both auxins & cytokinin's.
5. Frequent subculturing to ensure adequate nutrition and to avoid the build-up of waste metabolites.

Appropriate tissue (Explant):

These explants include (Cell, tissue or organ of a plant) can be used for tissue culture, although axillary buds and meristems are most commonly used. It is important to remove microbial contaminants firstly. Which is usually performed by chemical surface sterilization of the explants with an agent such as bleach at a concentration and for a duration that will kill or remove pathogens without injuring the plant cells beyond recovery.

Nutrition medium:

When an explant is isolated, it is no longer able to receive nutrients or hormones from the plant, and these must be provided to allow growth *in vitro*. The composition of the nutrient medium is for the most part similar, although the exact components and quantities will vary for different species and purpose of culture. Types and amounts of hormones vary greatly. In addition, the culture must be provided with the ability to excrete the waste products of cell metabolism. This is accomplished by culturing on or in a defined culture medium which is periodically replenished.

- A nutrient medium is defined by its mineral salt composition, carbon source, vitamins, plant growth regulators and other organic supplements.

- pH determines many important aspects of the structure and activity of biological macromolecules. Optimum pH of 5.0-6.0 tends to fall during autoclaving and growth.

Mineral salt composition:

⇒ Macroelements: referred to the elements (N, K, P, Ca, S, Mg, Cl) required in concentration > 0.5 mmol/l

⇒ Microelements: referred to the elements (Fe, Mn, B, Cu, Zn, I, Mo, Co) required in conc. < 0.5 mmol/l

An optimum concentration → maximum growth rate

Carbon sources and vitamins:

- Sucrose or glucose (sometimes fructose), concentration 2-5%
- Most media contain myo-inositol, which improves cell growth.
- An absolute requirement for vitamin B1 (thiamine).
- Growth is also improved by the addition of nicotinic acid and vitamin B6 (pyridoxine).

In addition, some media contain pantothenic acid, biotin, folic acid, p-amino benzoic acid, choline chloride, riboflavin and ascorbic acid (C-vitamin).

Plant growth regulators (Body building Plants)

Auxins: (2,4-D, NAA, IAA, IBA, pCPA)

⇒ prompts cell division, cell elongation, swelling of tissues, formation of callus, formation of adventitious roots.

⇒ reduces adventitious and axillary shoot formation.

Cytokinins: (BAP, Kinetin, zeatin, 2iP)

shoot induction, cell division

Gibberellins: GA3

⇒ plant regeneration, elongation of internodes

Abscisic acid: ABA

⇒ induction of embryogenesis

Organic supplements:

⇒ **N** in the form of amino acids (glutamine, asparagine) and nucleotides (adenine).

- ⇒ **Organic acids:** TCA cycle acids (citrate, malate, succinate, fumarate), pyruvate.
- ⇒ **Complex substances**: yeast extract, malt extract, coconut milk, protein hydrolysate.
- ⇒ **Activated charcoal** is used where phenol-like compounds are a problem, absorbing toxic pigments and stabilizing pH. Also, to prevent oxidation of phenols PVP (polyvinylpyrrolidone), citric acid, ascorbic acid, thiourea and L-cysteine are used.

  https://www.youtube.com/watch?v=OFHipYNDVGE

Applications:

Plant tissue culture is used widely in the plant sciences, forestry, and in horticulture and its applications include:

- ⇒ The commercial production of plants used as potting, landscape, and florist subjects, which uses meristem and shoot culture to produce large numbers of identical individuals.
- ⇒ To conserve rare or endangered plant species.
- ⇒ A plant breeder may use tissue culture to screen cells rather than plants for advantageous characters, e.g., herbicide resistance/tolerance.
- ⇒ Large-scale growth of plant cells in liquid culture in bioreactors for production of valuable compounds, like plant-derived secondary metabolites and recombinant proteins used as biopharmaceuticals.
- ⇒ To cross distantly related species by protoplast fusion and regeneration of the novel hybrid.
- ⇒ To rapidly study the molecular basis for physiological, biochemical, and reproductive mechanisms in plants, for example *in vitro* selection for stress tolerant plants.
- ⇒ To cross-pollinate distantly related species and then tissue culture the resulting embryo which would otherwise normally die (Embryo Rescue).
- ⇒ For chromosome doubling and induction of polyploidy, for example doubled haploids, tetraploids, and other forms of polyploids. This is usually achieved by application of antimitotic agents such as colchicine or oryzalin.
- ⇒ As a tissue for transformation, followed by either short-term testing of genetic constructs or regeneration of transgenic plants.
- ⇒ Certain techniques such as meristem tip culture can be used to produce clean plant material from virus stock, such as sugarcane, potatoes and many species of soft fruit.
- ⇒ Large scale production of artificial seeds through somatic embryogenesis.