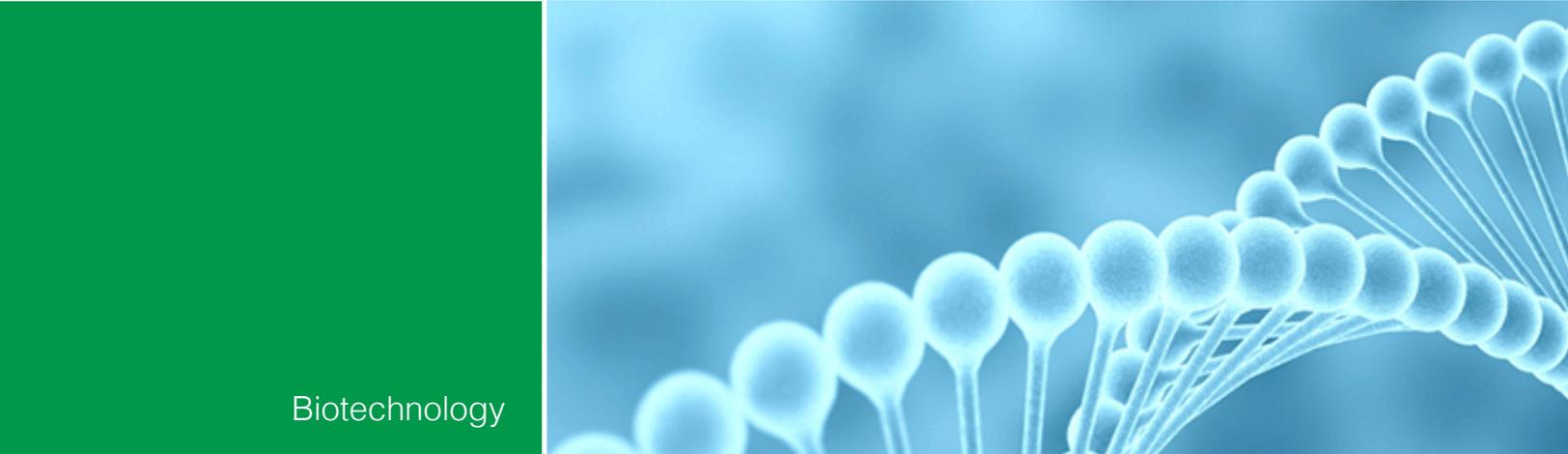






3

Biotechnology



## Biotechnology

### I. History and Background

Biotechnology is known as one of the state-of-the-art technologies in 21<sup>st</sup> century and is among the seven key industries which will determine the socioeconomic destiny of communities in the coming decades.

Biotechnology has a long history and is very well-developed in Iran. The history of biotechnology research and academic centers in Iran goes back to a century ago when traditional biotechnology initially was employed to develop medicines and vaccines at the Pasteur Institute of Iran (PII). The Pasteur Institute, founded in 1921, and the Razi Institute for Serums and Vaccines, founded in 1924, are two well-established centers in Iran for biotechnology research. The Institute of Biochemistry and Biophysics, founded in 1976 and affiliated to the University of Tehran, is also engaged in biological research. The Biotechnology Institute at the Iranian Research Organization for Science and Technology (IROST), founded in 1980, has been actively involved in traditional biotechnology research since its establishment and has gradually shifted its activities to modern biotechnology.

The history of modern biotechnology in Iran dates back to 1980's. The establishment of the National Institute of Genetic Engineering and Biotechnology in 1989 marks a significant point in developing modern methods of biotechnology in the country. With respect to its priority and strategic importance for the Islamic Republic, the Biotechnology Development Council affiliated to the Vice-Presidency for Science and Technology was established in 2008 as the main body for policymaking, planning, executive leadership, coordination and monitoring biotechnological research in the country.

In general, enormous biodiversity in terms of ecosystem, species, and geographical variation; rich natural resources; and unique genetic patterns found in humans, plants, animals, and microorganisms has made obtaining and making use of this vital and transformative technology possible for Iran. Consequently, Iran has made large investments and dramatic progress in biotechnological research, especially over the past decade.

### II. Policies and Strategies

Promoting to the first rank in the Middle East and improving Iran's global rank to be placed among the top ten countries in the world by 2025 are the main goals of the Biotechnology Development Council. Major policies and strategies of the sector are as follows:



### ***A. Macro Level Policies***

- Promoting national sovereignty and enhancing social welfare;
- Expanding scientific and technological cooperation at national, regional, and international levels;
- Meeting the country's strategic demands for food, public health, environment, and energy;
- Observing the ethical and biosafety principles in accordance with domestic and international regulatory frameworks.

### ***B. Macro Level Strategies***

- Maximizing the privatization of biotechnological products;
- Completing and organizing an integrated system for biotechnology management across the country;
- Improving the quality of domestic products with a view to pave the way for entering the international markets;
- Paving the way for making use of the available domestic capacities in Iran and regional countries with a view to expand the market for domestic biotechnology products;
- Exploiting the biotechnology capabilities as a green industry for environmental protection and restoration;
- Creating the basis for the development of domestic and international partnerships and joint ventures.

## **III. Capacities and Capabilities**

### ***A. Human Resources***

Based on the council's latest statistics, currently about 15,010 biotechnology experts are active in the country. The total number of university academic members breaks down as follows: 15 percent instructors, 59 percent assistant professors, 17 percent associate professors and 9 percent full professors. The proportion of faculty members at the level of professorship in biotechnology engineering and medical sciences is respectively higher than that in other groups.

### ***B. Scientific Productivity***

In 2015, Iran ranked 14<sup>th</sup> in the world in terms of the number of published biotechnology articles in the indexed journals (Table 1).

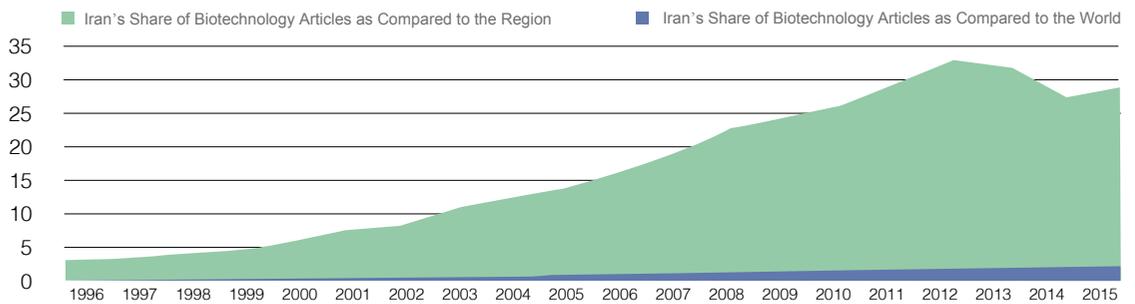


**Table 1**  
Iran's Biotechnology Scientific Productivity Compared to the World (2015)

|   | Country        | Documents |    | Country            | Documents |
|---|----------------|-----------|----|--------------------|-----------|
| 1 | China          | 6320      | 9  | France             | 1022      |
| 2 | United States  | 5892      | 10 | Italy              | 958       |
| 3 | India          | 2874      | 11 | Canada             | 915       |
| 4 | Germany        | 1998      | 12 | Australia          | 808       |
| 5 | South Korea    | 1995      | 13 | Brazil             | 783       |
| 6 | Japan          | 1630      | 14 | Iran               | 618       |
| 7 | United Kingdom | 1565      | 15 | Netherlands        | 616       |
| 8 | Spain          | 1066      | 16 | Russian Federation | 470       |

[Source: Scimago]

Also, Iran's share of biotechnology articles in 2015 as compared to regional countries and the world is 27.22% and 1.27%, respectively (Figure 1).



**Figure 1:** Iran's Biotechnology Scientific Productivity by Year [Source: Scimago]



## C. Some Achievements

### 1. Medicine

• **Generic name:** Trastuzumab

**Brand name:** Hercease™

#### Product Information

Hercease™ is a biogeneric form of Trastuzumab and is used to treat breast cancer. It is a recombinant DNA-derived humanized monoclonal antibody that selectively targets the extracellular domain of the human epidermal growth factor receptor 2 (HER2).

Studies indicate that patients with tumors amplification or over-express HER2 have a particularly aggressive form of tumor and a shortened disease-free survival compared to patients with no tumor amplification or over-expression of HER2. HER2 whether over-expression or amplification can be diagnosed using an immunohistochemistry-based (IHC) assessment of fixed tumor blocks or employment of In Situ Hybridization (ISH) technology. The original studies of Trastuzumab showed that it improved overall survival in late-stage (metastatic) breast cancer from 20.3 to 25.1 months.

• **Generic name:** Etanercept

**Brand name:** Altebrel™

#### Product Information

Etanercept manufacturing is based on expression by a protein recombinant technology using Chinese Hamster Ovary (CHO) cell. This molecule is composed of 934 amino acids weighting 150 KDa and acting as a TNF $\alpha$  Blocker. TNF $\alpha$  is a kind of cytokines which is produced by monocytes and macrophages and increases white cells flow to the swelled areas. Having this property coupled with other related mechanisms, TNF $\alpha$  could increase inflammation. So, Etanercept decreases inflammation responses through inhibiting the mentioned TNF $\alpha$  mechanism which is completely effective in treatment of autoimmune diseases.

#### Conditions of usage

Altebrel™ is a biosimilar product called Etanercept- a generic name. It is used to treat several autoimmune diseases like Rheumatoid Arthritis, Plaque Psoriasis, Psoriatic Arthritis, Spondyloarthritis, Ankylosing Spondylitis and Juvenile Idiopathic.



• **Generic name:** Recombinant Human FVIIa

**Brand name:** AryoSeven™

**Product Information**

AryoSeven™ is indicated to treat and prevent bleeding episodes in patients with Hemophilia A or B with inhibitors; acquired hemophilia; congenital factor VII deficiency; and Glanzmann's thrombasthenia.

**Product specification (Technical Standards)**

AryoSeven™, human activated recombinant blood coagulation factor VII (rFVIIa), is a glycoprotein with 406 amino acids and molecular weight of about 50 KDa which is produced in Baby Hamster Kidney (BHK) cell line via recombinant technology and is highly purified to make the grade as injectable human drug. This biologically similar medicine is produced under strict cGMP standards and is currently used by several thousands of patients in different countries.

• **Generic name:** Pegfilgrastim

**Brand name:** PDLasta®

**Product information**

PDLasta® is used to reduce the duration of neutropenia (low white blood cell count) and the occurrence of febrile neutropenia (low white blood cell count with a fever) which can be caused by cytotoxic chemotherapy (medicines that destroy rapidly growing cells).

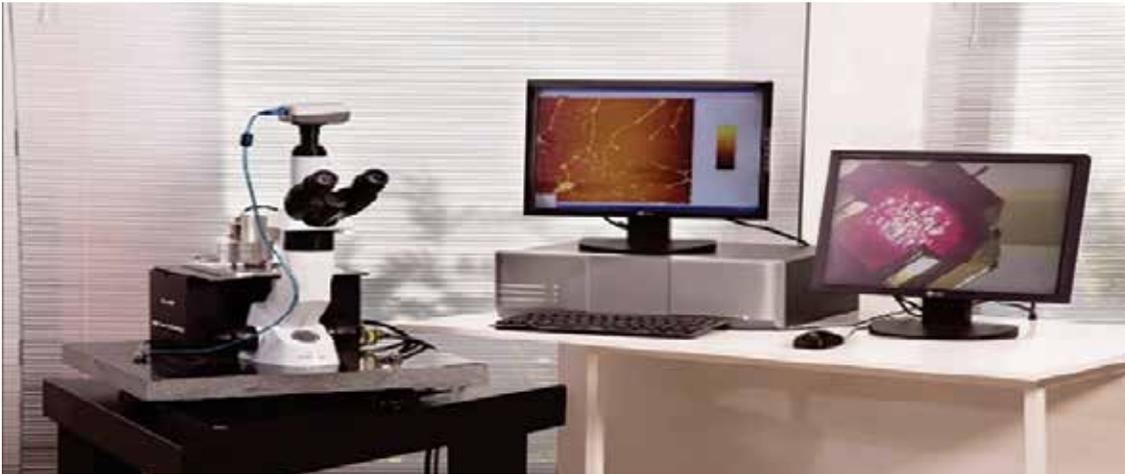
It is used to decrease the incidence of infection (as manifested by febrile neutropenia) in patients with nonmyeloid malignancies receiving myelosuppressive cancer chemotherapy associated with a clinically significant incidence of febrile neutropenia.

• **Generic name:** VitaLact

**Product specification (Technical Standards)**

It is a perfect product to improve overall immune and energy support, rich in probiotics, essential vitamins and minerals. It is also effective to treat digestive disorders and to boost the immune system. The vitamins and minerals help to improve metabolism and general health.

Its advantages compared to the similar ones include: higher count, prebiotics, lower price, strain diversity, product stability, ability of observing the cold chain, and possibility of strains localization for increased effectiveness on Iranians.



• **Generic name:** Interferon  $\beta$ -1a

**Brand name:** Recigen®

**Product information**

Recigen® (interferon beta-1a) is used to control the progression of Multiple Sclerosis. It is a purified 166 amino acid glycoprotein with a molecular weight of approximately 22,500 daltons, manufactured through a biotechnological processing of the naturally-occurring interferons. It is produced using recombinant DNA technology, exactly the same amino acids as the interferon beta found in the human body.

## 2. Medical Equipment

• **Generic name:** Bio Atomic Force Microscope (Nanoscope)

**Brand name:** Pajuhesh Ara Atomic Force Microscope

**Product specifications (Technical Standards)**

Possibility of nanometer-scale imaging from bio samples (bacteria, viruses, DNA, etc.), imaging for samples that cannot be separated from their culture medium, capability of imaging from live nano-scale bio samples in their culture and liquid medium, equipped with fiber microscope up and down in order to view location of sample precisely, using advanced "Stage" to move sample along X and Y axis, having ultra-precise nano scanner, using precise micron operator with negligible mechanical noise, capability to enlarge the received image and re-imaging of the zoom range, and automatic planning to change the parameters of imaging parameters while scanning. Its advantages over the foreign counterparts include imaging from both opaque and transparent samples, multifunctionality-13 operating modes on a nano-scope, rapid imaging up to 30 images per minute.

• **Generic name:** Bio AFM

**Brand name:** Ara Research Bio AFM

**Product specification (Technical Standards)**

Integrated with inverted optical microscopes; two independent, closed-loop XY and z scanner; flat and linear XY scan of up to 50  $\mu\text{m}$   $\times$  50  $\mu\text{m}$  with low residual bow; angstrom resolution in Z axis and nano-resolution on X&Y axis; easy sample or tip exchange; easy head removal; direct on-axis optics for high resolution optical viewing; backlash-free sample stage; sample positioning range of 7 mm in X and Y; tight mechanical coupling yields excellent noise performance; and compatible with both reflection and transmission modes.



- **Generic name:** Iranian Gene Gun Completed by Somatic Embryo Induction Devices

**Brand name:** Kian Gene Gun

**Product information**

Electromagnetic micro projectile device is made as a wounding agent with the capability of throwing nanoparticles towards cell. The key advantages include user-friendliness, reasonable price, no user fees and consumable parts, precision and high performance. It has been used to produce transgenic organisms (plants, animals, fungi, bacteria, insects, etc.).

- **Generic name:** Monoclonal Antibodies against Human CD Markers

**Brand name:** Cyto Matin Gene (CMG)

**Product information**

Monoclonal antibodies can be used to detect the presence of specific antigens on the cell due to their specificity; monoclonal antibodies have become one of the most powerful tools available in the biological sciences. They have wide applications including research, diagnosis and therapy.

• **RoboSPECT**

Nuclear medicine is a medical specialty that uses radioactive tracers (radiopharmaceuticals) to assess bodily functions and diagnose and treat disease. The most widely used field in nuclear medicine is cardiac SPECT imaging that provides the information to diagnose the prognosis of coronary artery disease and heart muscle damage following an infarction.

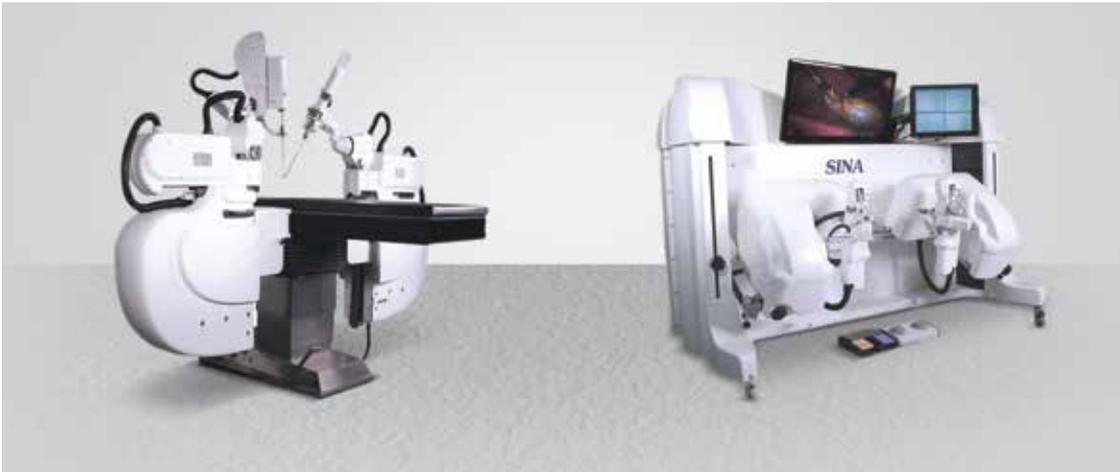
The RoboSPECT, which uses three swivel motors delivering the robotic movements and providing the circular and noncircular SPECT movement, is designed and developed for dedicated cardiac SPECT imaging. Also, the system has Iran MOH production license.

• **SERGEOGUIDE II**

Currently, "Gamma Probe" is the most popular device for surgeons which is considered as an easy-to-use small hand-held tool with the capability of detection and localization of sentinel lymph nodes used not only for breast cancer but also for some cancers in men when detecting sentinel nodes is mandatory. These gamma probe system come in two models SURGEOGUIDE and SURGEOGUIDE II; both meet international standards and have Iran MOH production license.

Some of its clinical applications include:

- Breast cancer;
- Gynecological cancers (cervical, ovarian, uterine, vaginal and vulvar);



- Endocrine cancers (thyroid, parathyroid);
- Urology cancers (prostate, bladder, testicular, kidney and penile).

#### • SINA

Sina is a complete robotic telesurgery system with force feedback. This system has two main subsystems including master robotic system console at surgeon's side and slave robotic console at patient's side with two robots which are installed on the sides of a specific surgery bed. The master robot receives a surgeon's hand movement and transmits them to the patient's side slave robots that mimic the movements in a real-time manner.

Main features of master robot console include:

- Ergonomic console base with adjustable 3DOF;
- Two 5DOF back drivable master robot to be manipulated by surgeon's hand;
- Foot pedals to control the laparoscopic camera and electrocautery.

Main features of slave robot console include:

- Adjustable bed with active 3DOFs;
- Two bed-side 5 DOFs surgery robots;
- Two bed-side passive robots with 3 Cartesian robot motions to adjust active robot's RCM.

• **Generic name:** Aneuquick QF PCR Kit

**Brand name:** KBC Aneuquick QF PCR Kit

#### **Product information**

QF-PCR is a novel, fast, cost-effective and reliable molecular technique based on PCR amplification using fluorescent primers for prenatal 21, 18, 13, X chromosomes and Y aneuploidies diagnosis. DNA extracted from amniotic, chorionic villus samples and blood can be used as the genomic material in this method. In a multiplex assay, specific STR markers are amplified for each chromosome; their peaks represent the number of chromosomes. Commercial kits are designed for European and American populations. In some cases suspicious results had been seen in Iranian population.

"KBC-Aneuquick" is a novel kit especially designed for Iranian population allele frequencies. This kit has 24 markers which have a wide range of heterozygosity and covers the entire length of each chromosome and critical regions. Markers and their primers were chosen considering the CNVs (Copy Number Variations) and SNPs (Single Nucleotide Mutation) to avoid false-positive or false-negative results.



### • DNA Microarray

Nowadays, medicine industry is principally focused on the “Personalized Medicine” as well as “Early Diagnostics”. To achieve either of these goals, ability to investigate the cell genetic content is inevitable. DNA Microarray is a device that studies presence and/or expression of numerous genes simultaneously. The DNA microarray system includes a diagnostic chip, a printing robot, and a chip scanner designed and manufactured in the DNA Analysis Laboratory.

### Features

#### Diagnostic Chip

- Equipped with an extra-smooth surface with an average roughness of 1nm;
- Providing a high-affinity substrate for single molecule binding;
- Conducting reliable hybridization reactions.

#### Printing Robot

- Printing 5-nanoliter droplets of solutions on the chip;
- Moving in 3 perpendicular directions on a course of 0.5m with a 10 $\mu$ m precision.

#### Chip Scanner

- Detecting fluorescence solutions as dilute as 130 molecules per  $\mu$ m<sup>2</sup>.
- Detecting fluorescence dyes in two different channels.

### Uses

- Early Diagnosis for cancer and numerous other genetic disorders and diseases;
- Suggesting an optimized path for the physician to prescribe medication for each individual;
- Diagnosing prenatal genetic diseases;
- Detecting contaminations of food and agricultural products.

### • Milibioreactor

Milibioreactor determines the oxygen transfer rate (OTR), carbon dioxide transfer rate (CTR), and respiratory quotient (RQ) of microbial, plant, and cell cultures online. The respiration rates (OTR, CTR) are the most accurate measurable variables to quantify the physiological state of fermented cultures.

The advantages of this bioreactor include saving time up to 75%, saving raw materials upto



80%, and ease of operation. The bioreactor can handle bio-reaction of cells, microorganisms such as bacteria, yeast, fungi, animal, as well as plant cells in research applications such as pharmaceutical laboratory science, medicine, food, environmental, and oil industry. It is also used to determine the optimum operating conditions for biotechnology products such as human proteins, enzymes, medicine, and scale up procedure for biotechnology processes.

Direct on-line monitoring of a cell's metabolism including pH, substrate concentration, nutrient rate (vitamins, phosphorus, and nitrogen), biomass cells, enzymes, and protein production and its effects on the growth of microorganisms and cells are among other functions of this apparatus. Milibioreactor is also used to study the effects of applying nanoparticles in toxicology of cells and stem cells growth.

Milibioreactor is an appropriate tool to meet the PAT initiative of the FDA regarding shaken bioreactors.

### 3. Agricultural products

#### • Date palm

##### Product information

Direct Somatic Embryogenesis (DSE) tissue culture technology is used for the micropropagation of date palms. So far, 15 species of date palm have been integrated in production lines. DSE has been scientifically proven to produce uniform plants with minimum levels of somaclonal variation as compared to other micropropagation methods. Creating new species, proliferation of disease-free seedlings, capability of reproducing throughout the year, etc. are among the usages of such product.

#### • Food Fraud Detection

Food fraud is originated as a way to extend food's primary ingredients. Food fraud is a growing problem worldwide. According to the World Customs Organization (WCO), food fraud costs \$49 billion annually. Moreover, it is deleterious to health.

Polymerase chain reaction (PCR), a DNA-based method, can be used as an alternative method for rapid and accurate detection of DNA's source in food due to the high stability of DNA compared to RNA.

Now, it is possible to detect food fraud in a wide range of products including processed and raw meat products, canned tuna and the other fish products, dairy products, oil, saffron, pistachio and almond, GMO, and the origin of gelatin derived from different sources (Pastel, Capsule, Jelly powder, etc.).



### Features and Advantages

- Sensitive and specific enough to trace small amounts of target DNA;
- Because of high stability in different products, DNA is a key molecule for detection;
- A species-specific method which can be used in fully processed food products;
- A reliable, accurate, and fast system;
- Applicable to a wide range of products.

### • Nitro Kara Bio-fertilizer

Nitro Kara is a Nitrogen fixing biofertilizer and it has extremely efficient nitrogen fixing bacteria of *Azorhizobium caulinodans* which is isolated from the nature. *A. caulinodans* is found in soil around plant roots (rhizosphere), root surface and inter cellular spaces of stem and root tissue. When *Azorhizobium* is injected to the plant, under ideal conditions, it multiplies on its host plant and can supply 200-300kg of nitrogen per hectare/season. Moreover, *A. caulinodans* produces growth promoting substances like Indole Acetic Acid (IAA), Gibberellins, and causes root proliferation, plant growth and yield.

### Advantages

- Natural and %100 organic;
- Enhancing the crop yields;
- Improving the flavor and scent of crops;
- Organic acids produced by Nitro Kara bacterium increases the dissolution phosphorus and calcium in soil and makes these elements abundantly available to plants;
- Gases produced by Nitro Kara bacteria increases soil porosity, thereby improving flow of air and water in soil;
- Improving the soil quality and root structure;
- Safe for humans, insects, and animals and Eco-friendly;
- Compared to chemical fertilizers, more compact for transportation and warehousing.

### • PhosphoBARVAR-2 (Phosphate Biofertilizer)

Phosphorus is one of the macro-elements absorbed by plants as water-soluble, free-phosphate ions. As the amount is fixed in soil, phosphate ions don't suffice needs of plants.

PhosphoBARVAR-2 biofertilizer is a novel technology which is a safe and effective alternative to chemical phosphate fertilizers. This biofertilizer contains two types of highly efficient phosphate solubilizing bacteria (PSB) that secrete organic acids and phosphatase enzymes which hydrolyze insoluble inorganic and organic phosphate compounds into soluble phosphate ion around roots.

### Advantages

- On average 15% increase in yield (about 25% in trees);
- 50-100% reduction in using chemical phosphate fertilizer;
- Excellent for organic farming;
- Reducing fertilizer, transportation and warehousing costs;
- Reducing the environmental hazards of chemical fertilizers;
- Simple application methods;
- Reducing soil-borne diseases;
- Improving soil structure;
- Using only 100-gram package per hectare (1 gram per tree).

### • Myco-Root

It is the first formulation of a series of products which is based on the useful properties of beneficial soil Mycorrhizal fungi. This product is an easy-to-use powdery form and supports plants throughout their growing seasons. After using this product, Mycorrhizal fungi colonizes roots and absorbs water and mineral elements more quickly and in greater amounts. As a result, Myco-Root consumption will boost plant growth and resistance to environmental stresses.

### Advantages

- Increasing the absorption of mineral elements, growth and plant health;
- Reducing the absorption of harmful elements (Na and Cl);
- Developing flowers and fruits and increasing yield;
- Reducing plant need for water, chemical fertilizers and pesticides;
- Increasing resistance to environmental stress (drought, salinity, and soil compaction);
- Reducing damage to seedlings and plants during the transition from nursery to the farm;
- Increasing water use efficiency;
- Increasing fertilizer use efficiency;
- Decreasing activity of root pathogens.

### Applications

- Field crops;
- Fruit trees;
- Shrubs;
- Ornamental plants;
- Herbs and vegetables;
- Turf grasses and cover crops;
- Some of rangeland plants.

## IV. Authorities

### A. *Biotechnology Development Council*

In line with the expansion of biotechnology across the country, since its establishment, the Biotechnology Development Council affiliated to the Vice-Presidency for Science and Technology sought to eliminate the barriers of biotechnology advancement by providing biotechnology laboratory equipment and infrastructure and supporting developmental research projects. A number of the Council's objectives include:

- Increasing the contribution of biotechnology products to the GDP;
- Expansion of accessibility and application of biotechnology products and methods with a view to prevent and manage genetic diseases (target diseases include cancer, diabetes, inherited diseases, and MS);
- Increasing the market share of biotechnology products and services to 3 percent of the global biotechnology market by 2015;



- Developing biotechnology research, production and application in fields such as medicine, agriculture, food, health, industries, mining, energy, and environment;
- Setting up biobanks, databases and networks such as the National Plant Gene Bank for microorganisms, human genes and vectors (carriers) with a view to record and list the related information.

### **B. Other Authorities**

Currently, there are 25 active biotechnology S&T parks and incubators nationwide. Five specialized biotechnology incubators have also been established in Iran. Besides, 527 biotechnology companies have been registered, of which 211 companies are placed in 20 S&T parks and scientific research towns.

The Iranian biotechnology companies produce more than 230 types of biotechnology products. This wide variety of products include recombinant medicine, monoclonal antibodies, organic phosphate and nitrate fertilizers (in both solid and liquid forms), and biotechnology-related equipment. Almost 30 percent of the Iranian biotechnology companies are qualified to export their products. Over 50 types of Iranian biotechnology products are exported to other countries. Currently, 81 universities and 18 research centers and institutes are engaged in biotechnology research and training in Iran. Also, there are 24 specialized research centers including 15 research centers affiliated to the Ministry of Science, Research and Technology; 7 research centers affiliated to the Ministry of Health and Medical Education; and 2 research centers affiliated to the Academic Center for Education, Culture and Research (ACECR) conduct biotechnology-related research in Iran. Some of the main Iranian biotechnology research centers and institutes with their significant achievements are introduced below.

#### **• National Institute of Genetic Engineering and Biotechnology**

The National Institute of Genetic Engineering and Biotechnology (NIGEB) is an affiliated institute to the Ministry of Science, Research and Technology which provides genomic services, quantitative analysis, proteomics-transcriptomics, cytotoxicity test systems for biomaterials, detection of genetically modified organisms (GMO) in food, bioinformatics laboratory and production of transgenic mice and rat models at the institute's National Center for Transgenic Mouse Research. Table 2 represents some parts of the technical knowledge created in the institute.

**Table 2****Technical Knowledge of the Institute**

| Name            | Description   | Image  |
|-----------------|---|--|
| <b>MicAuxin</b> | Certain bacteria can promote plant growth by stimulating the rooting process. This mechanism works through secretion of auxin hormone. MicAuxin facilitates the microbial production of auxin using soil bacteria. This product is used to stimulate rooting in the semi-hardwood olive cuttings and to promote the olive plant growth.   |    |
| <b>GAMBIST</b>  | The removal of pathogenic strains is a significant step in the treatment of periodontal diseases. Current treatments including antibiotic therapy and common surgeries are associated with several drawbacks. For instance, antibiotic therapy can cause resistant strains. Also, in case of choosing the wrong antibiotics, recurrence of the disease will not be unexpected. Surgeries are also costly despite having clear benefits, and their success depends on controlling the pathogenic bacteria and environmental factors. The probiotic mouthwash solution GAMBIST is an alternative product to treat gum and periodontal diseases. This product lacks the disadvantages of the current treatments and has yielded considerable patient satisfaction. |  |
| <b>Ovafact</b>  | Ovafact is a peptide hormone which stimulates synthesis and release of gonadotropin-releasing hormone (GnRH) in fish through interacting with specific receptors. Ovafact is used to increase productivity in different fish families including sturgeons, trouts, common carp, and gold fish.  |  |

- **Pasteur Institute of Iran**

The Pasteur Institute of Iran (IPI) is an affiliated institute to the Ministry of Health and Medical Education which mainly conducts research, production, education, training, and health-related activities. The IPI was founded in Tehran in 1921 with a view to facilitate health services to the public.

To commercialize its products and services, two centers have been established in the institute using the capacities of the faculty members. One of these two centers is a production and research incubator, based in Karaj, and is home to 60 biotechnology companies. The IPI produces a wide variety of products including antigens, antibody diagnostic sera, recombinant products, vaccines, the required injectable solutions by emergency rooms, and diagnostic kits, among other things. Table 3 represents some of the products produced by the Pasteur Institute.

**Table 3***Some of the Products Produced by the Pasteur Institute*

| Name   | Description   | Image   |
|--|---|---|
| <b>Pastopietin (Recombinant Erythropoietin Alpha)</b>            | Pastopietin has the same biological properties of glycoprotein androgen-binding protein which intensifies the production of red blood cells by stimulating cellular division and differentiation in red blood cell progenitors of bone marrow. It also stimulates the reticulocyte release from bone marrow. This medicine is used to treat anemia associated with chronic renal failure, zidovudine induced anemia in HIV/AIDS patients, chemotherapy-induced anemia in patients with non-myeloid malignancies, and anemia associated with poor clinical outcome in non-cardiovascular surgery patients. |    |
| <b>Pastokinase (Recombinant Streptokinase)</b>                   | Streptokinase is used to treat acute coronary artery thrombosis and acute myocardial infarction (AMI) for the lysis of intracoronary thrombi to limit the extent of infarction. Streptokinase is a bacterial protein (beta-hemolytic type C1) which compounds with plasminogen and forms an activator complex with the effect of converting the plasminogen of blood or clotting into plasmin (enzyme lysis of the fibrin).   |    |
| <b>Pastoferon Alfa-2b (Human Recombinant Interferon Alfa-2b)</b> | Pastoferon Alfa-2b is obtained from fermentation of manipulated strains of Escherichia coli with plasmid containing 2-b human leukocytes interferon alpha gene. The product contains 1.5 mg of human albumin.   |  |

#### • Biotechnology Research Institute of the IROST

Established in 1980, Biotechnology Research Institute is one of the seven research centers at the Iranian Research Organization for Science and Technology (IROST). Through two five-year plans, the institute managed to develop a new series of research laboratories and a biotechnology pilot plant. The pilot plant equipment includes fermenters with 15, 75, 750, and 3000 liter capacities which form a complete production line together with the center's centrifuges and dryers.

By collecting an expert team to design and manufacture fermenters, the institute has developed airlift and stirred tank fermenters with a variety of capacities and added them to the pilot plant.

The Biotechnology Institute is also home to the Iranian Center of Industrial and Medical Fungi and Bacteria Collection. Since its establishment in 1980, the center has provided the microorganisms needed by educational, research, and industrial organizations and pharmaceutical factories. Over 2,000 types of microbial samples including different kinds of bacteria, fungi, yeast, and blue-green algae are kept in the center meeting international standards. In 1984, the center became a member of the World Federation for Culture Collections (WFCC). The WFCC has registered the center as the Persian Type Culture Collection and has assigned the code I124 to identify it. As a member of

the WFCC, the Iranian Center of Industrial and Medical Fungi and Bacteria Collection is connected with similar centers working under the supervision of this international body.

#### • Razi Vaccine and Serum Research Institute

Established about 90 years ago, the Razi Vaccine and Serum Research Institute is one of the oldest and most reputed scientific research centers in Iran. The institute is home to veterinary and biotechnology research. Razi institute is home to the most experienced specialists who work in its six regional branches across the country. The institute is composed of 12 specialized departments and 15 national and reference laboratories. The institute cooperates with the veterinary departments as well as agricultural and natural resources research centers in nearby provinces with a view to make accurate and rapid diagnosis of major diseases in livestock, poultry and honey bees. The institute also makes significant contribution to the promotion of new biological products and improving the current biotechnology products. Razi institute's laboratory for livestock smallpox is known as a world reference laboratory. The institute produces a variety of vaccines and seroma including human vaccines, livestock and poultry vaccines, parasitic livestock vaccines, fish vaccines, as well as therapeutic sera with medical uses and antibodies. Table 4 contains some of the main products of Razi Vaccine and Serum Research Institute.

**Table 4**

*Some of the Main Products of the Razi Vaccine and Serum Research Institute*

| Name               | Description  | Image   |
|--------------------|--|---|
| Gumboro Vaccine    | The Gumboro vaccine contains the intermediate infectious bursal disease virus (Gumboro) inoculated in Specific Pathogen Free (SPF) embryonated chicken eggs. This is a live attenuated vaccine in lyophilized form and is used for immunization against infectious bursal disease (IDB) of Gumboro in local and industrial poultries.  |    |
| Therapeutic Sera   | The institute produces a variety of therapeutic sera including scorpion and snake antivenoms as well as anti-diphtheria and anti-tetanus antitoxins.   |  |
| Laboratory Animals | Razi Vaccine and Serum Research Institute is one of the main producers of laboratory animals in Iran with the primary mission to meet the demands of the institute itself as well as that of other research and academic centers. The institute produces a wide variety of animals including mice (eight types), rats (five types), hamsters (four types), guinea pigs (eight types), and rabbits (one type). These types are different from each other in terms of race and strain. Each type is placed under a different strain and each enjoys a specific application in their respective research and experiments. |   |