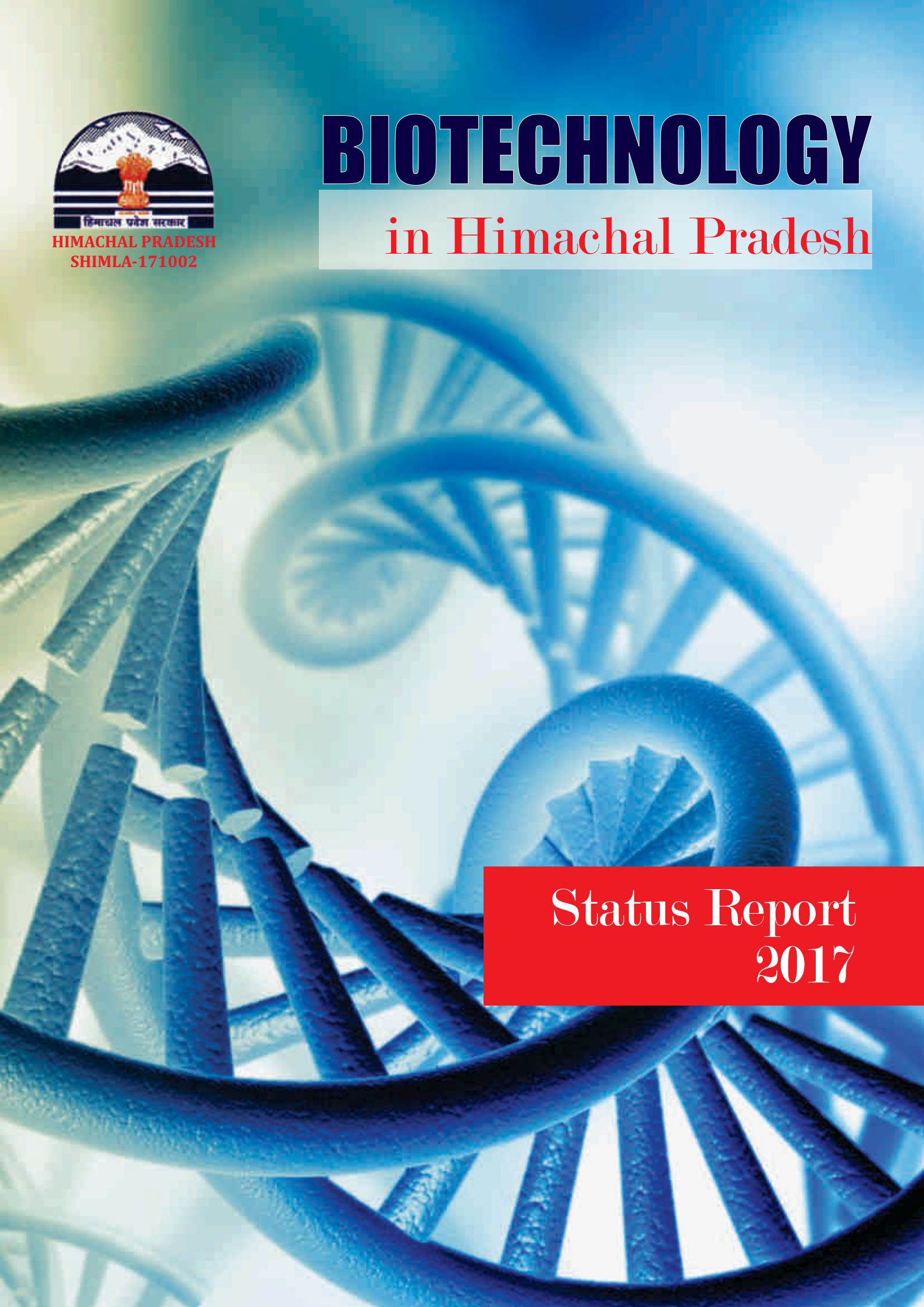
HIMACHAL PRADESH
SHIMLA-171002

BIOTECHNOLOGY

in Himachal Pradesh



Status Report 2017

HIMACHAL PRADESH
SHIMLA-171002

Addl. Chief Secretary
Forest, Environment Science & Technology
Food Civil Supplies & Consumer Affairs
Government of Himachal Pradesh

Foreword

The biotechnology sector of India is highly innovative and growing. India is among the top 12 biotech destinations in the world and ranks third in the Asia-Pacific region. Out of the top 10 biotech companies in India (by revenue), seven have expertise in bio-pharmaceuticals and three specialise in agri-biotech. Bio-pharma is the largest sector contributing about 64 per cent of the total revenue followed by bio-services (18 per cent), bio-agri (14 per cent), bio-industry (3 per cent), and bioinformatics contributing (1 per cent).

India has no dearth of talent in biotechnology, as a number of institutions, both government and autonomous, provide the necessary opportunities for the students seeking to obtain a degree in this sector. The Government of India has provided adequate scope to this sector by providing facilities for Research and Development (R&D) in the field of biotechnology.

Himachal Pradesh offers a huge potential as a Himalayan bio-resources based biotechnology hub that houses 7.32 per cent of countries' bio-resources in the form of high value plants with important medicinal and aromatic properties. More than two dozen R&D Institutions/Department are engaged in innovations, dissemination and promotion of Biotechnology in various areas. In addition to this there is a large pool of highly skilled manpower in Biotechnology in the State produced each year by several Universities and Colleges in Public and Private sector. The Government has notified the State Biotechnology Policy with a vision and objective to promote Biotechnology by supporting R&D Institutions in agriculture, animal husbandry, environment, biodiversity conservation and utilization through setting up of bio-resources based industries in the State. All this combined together, there is a need to have a strong convergence with the Government-Academia –Industries to move faster in translating Himachal Pradesh into the most sought after destination for bio-resources based business hub in the country.

The maiden effort of the Department to take out a comprehensive report on Status of Biotechnology in the State is praiseworthy and would serve as an effective guide for the Biotechnology sector in the State. The compilation of sector wise details of the projects, patents, achievements, facilities etc. of various institutions provides immense scope for biotechnology based entrepreneurs to set up start up ventures in the State. It is a matter of pride that there are about 27 Institutions in Public and Private sectors working for promotion of Biotechnology in the State beside educational institutions producing considerable graduates and post-graduates in Biotechnology in the State.

I hope the Report serves as a useful reference for all concerned stakeholders of Biotechnology in the State for planning and implementing biotechnology based programmes through scientific use of its innovations and bio-resources.

(Tarun Kapoor)
Additional Chief Secretary(Env., S&T) to the
Government of Himachal Pradesh, Shimla-2

HIMACHAL PRADESH
SHIMLA-171002

DIRECTOR
Department of Enviornment, Science & Technology
Government of Himachal Pradesh
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Acknowledgement

Himachal Pradesh has more than 25 R&D Institutions which are dealing in various aspects of Biotechnology on a day to day basis and are generating a large pool of data and information for its application in industries and daily life of common man. Beside this, a large number of highly skilled manpower in Biotechnology sector is produced each year in the State. Keeping in view these facts, the Department of Environment, Science & Technology has endeavored to publish a Status report of Biotechnology in Himachal Pradesh so as to provide first hand information on Biotechnology to all the stakeholders in the State. The information was sought from all these R&D Institutions of the State and based on the information received from these Institutions this report has been compiled in its present form.

I extend my sincere thanks to IHBT, Palampur, CPRI, Shimla, CSKHPKV, Palampur, Dr. YSPUHF, Nauni, Solan, HPU, Shimla, Jaypee University, Waknaghat for providing valuable information on various aspects of Biotechnology in a timely manner; without the same it would not have been possible for us to publish this report.

I also extend my sincere thanks to the scientific and support staff of Biotechnology Division of the Department of Environment, Science & Technology for their valuable contribution and efforts in compiling the Report and giving its present form. I further put on record my sincere thanks to all the organisations/personnel for their valuable suggestions and guidance that has made this Report possible.

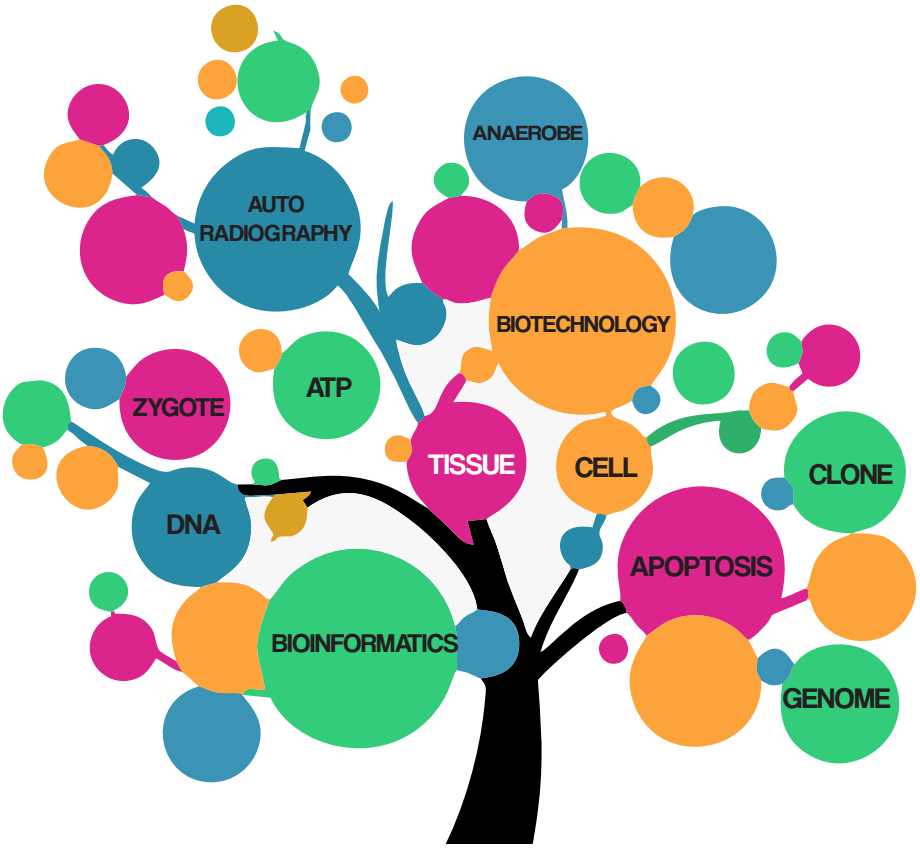
Needless to say, since this is the first attempt of the Department to bring out such Report on Biotechnology, some errors and omissions may have been crept in, which may please be brought to the notice of this Department.

(Archana Sharma),
Director,
Department of Environment, Science & Technology,
Shimla-1

Contents

Background and Developments

'Biotechnology',the term was coined by a Hungarian engineer, Karl Ereky and is defined as per the UN convention on biological diversity as, "Any technological application that uses biological system or living organisms to make or modify the process or products for specific use." Effusing life to life, through life, is what biotechnology is about. The idea of modifying products to suit specific applications and engineer them to make more viable, inspired man to reach the pinnacle where Biotechnology stands today. Biotechnology has touched almost every aspect of human life and has carved its niche too. Biotechnology dealing with medical and health care is termed as Red biotechnology. It is Green biotechnology, when it concerns about agricultural processes and White biotechnology when comes to industrial processes.



In 1953, structure of DNA was proposed, followed by the revolutionary discovery of recombinant DNA technology that eventually paved the way for modern biotechnology. With the discovery of restricted enzyme, it became possible to insert foreign genes to bacteria in 1973. This technique enabled production of human insulin from bacteria and is also considered as the birth of new innovative biotechnology. This legacy of biotechnological breakthroughs, capable of changing lives, is being continued till date.

The Biotechnology sector of India is highly innovative and is on a strong growth trajectory. India is among the top 12 biotech destinations in the world and ranks third in the Asia-Pacific region. India has the second-highest number of US Food and Drug Administration (USFDA)–approved plants, after the USA and is the largest producer of recombinant Hepatitis B vaccine. Out of the top 10 biotech companies in India (by revenue), seven have expertise in bio-pharmaceuticals and three specialise in agri-biotech. Biopharma is the largest sector contributing about 64 per cent of the total revenue followed by bioservices (18 per cent), bioagri (14 per cent), bioindustry (3 per cent), and bioinformatics contributing (1 per cent). India has emerged as a leading destination for clinical trials, contract research and manufacturing activities owing to the growth in the bioservices sector.
India has no dearth of talent in biotechnology, as a number of institutions, both government and autonomous, provide the necessary opportunities for the students seeking to obtain a degree in this sector. The Government of India has provided adequate scope to this sector by providing facilities for Research and Development (R&D) in the field of biotechnology.

The Indian biotech industry holds about 2 per cent share of the global biotech industry. The biotechnology industry in India, comprising about 800 companies, is valued at US$ 11 billion and is growing at a Compound Annual Growth Rate (CAGR) of 20 per cent. The government has to invest US$ 5 billion to develop human capital, infrastructure and research initiatives if it is to realise the dream of growing the sector into a US$ 100 billion industry by 2025, as per Union Minister for Science and Technology, **Mr Harsh Vardhan.**
The high demand for different biotech products has also opened up scope for the foreign companies to set up base in India.

India's biotech sector has attracted significant amount of attention over the past two decades. Several global companies have aggressively joined hands with Indian companies due to India's strong generic biotechnology potential. Some of the recent investments and developments in this sector are as follows:

- The Telangana state government's flagship pharma and biotech event - BioAsia 2017 attracted investments to the tune of Rs 3,382 crore (US$ 507.3 million).

- During the Vibrant Gujarat Global Summit-2017, 54 MoUs worth Rs 5,022 crore (US$ 736.1 million) in the biotechnology sector were signed by 37 companies.

- Syngene International Ltd, the contract research services arm of Biocon Ltd, is setting up a drug discovery and development center in Bengaluru for Amgen Inc., a biotechnology company based in the US.

- US-based medical devices maker Boston Scientific Corp. plans to make India its biggest research and development (R&D) hub outside the US, as it plans to develop devices such as stents, catheters and pacemakers at its Gurgaon facility for the Asia Pacific, Middle East and African markets.

- Frost & Sullivan has signed a memorandum of understanding (MoU) with The Neotia University (TNU) to set up biotechnology parks in India.

- Biotechnology giant Monsanto has planned to set up a seed plant in Buldhana district of Maharashtra.

- Global beverage major Pepsi has planned to set up another unit in the State of Maharashtra to manufacture mango, pomegranate and orange-based citrus juice.

- Biotechnology Industry Research Assistance Council (BIRAC), the funding agency of Department of Biotechnology, has planned to allocate around Rs 100-200 crore (US$ 15-30 million) for its biotech equity fund, which aims to provide financial assistance to biotech and life sciences start-ups.

- Canada's Centre for Commercialisation of Antibodies and Biologics (CCAB) has partnered with ZydusCadila to manufacture antibody-based cancer treatments.

- Shantha Biotechnics Private Limited has started building a facility to manufacture Insuman, an insulin product to treat diabetes. French pharmaceutical company Sanofi SA, which acquired ShanthaBiotechnics in 2009 through its vaccines division, Sanofi Pasteur SA, is investing Rs 460 crore (US$ 69 million) to build the facility that, at full capacity, will produce 60 million Insuman cartridges annually, company executives said.

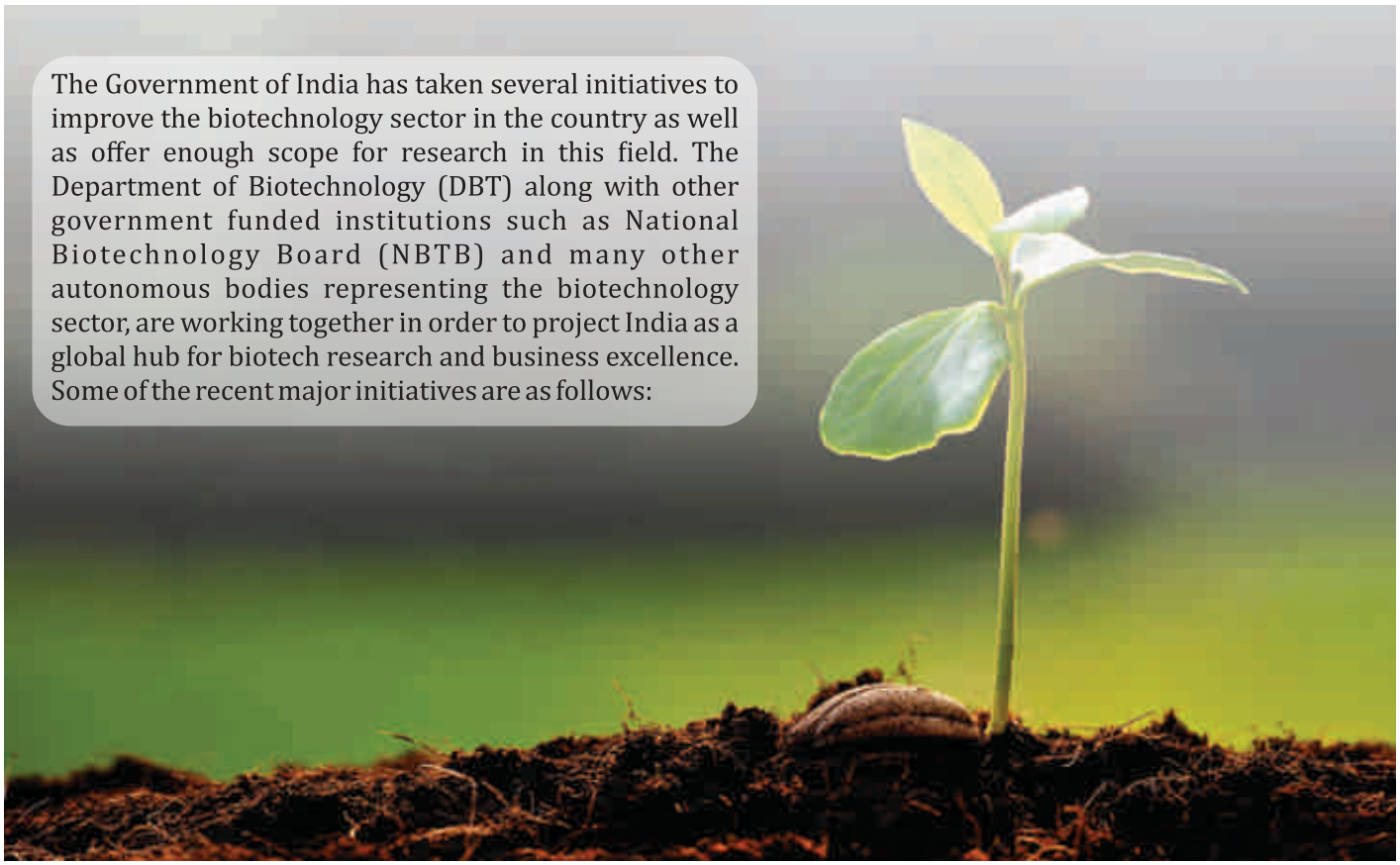
- Hyderabad headquartered vaccine manufacturer Indian Immunologicals Limited (IIL), part of the National Dairy Development Board, is setting up a new vaccine manufacturing facility in Puducherry involving an investment of Rs 300 crore (US$ 45 million). This is the fourth facility for IIL, which currently has two facilities in Hyderabad and one in Ooty.

- Bristol-Myers Squibb and Syngene International, the contract research subsidiary of Biocon, have announced a five-year extension of their drug discovery and development collaboration in India.

- The Bhabha Atomic Research Centre (BARC) through its Centre for Incubation of Technologies (BARCIT) has signed anMoU with M/s Veena Industries, Nagpur, for incubation of technology for biodegradable and edible films for food and pharmaceuticals packaging.

- Aurobindo Pharma announced that its Board of Directors have approved the proposal for setting up a Joint Venture (JV) with Tergene Biotech, a vaccine development company based in India. Tergene is currently working on development of the Pneumococcal Conjugate Vaccine (PCV) through use of novel vaccine technology compressing time and cost, thereby, making such vaccine available at an affordable cost.

Government Initiatives



The Government of India has taken several initiatives to improve the biotechnology sector in the country as well as offer enough scope for research in this field. The Department of Biotechnology (DBT) along with other government funded institutions such as National Biotechnology Board (NBTB) and many other autonomous bodies representing the biotechnology sector, are working together in order to project India as a global hub for biotech research and business excellence. Some of the recent major initiatives are as follows:

- In the Union Budget 2017-18, the Department of Biotechnology (DBT) received Rs 2,222.11 crore (US$ 333.31 million), an increase of 22 per cent, to continue implementing the department's national biotech strategy and target increasing the turnover from the sector to $100 billion by 2025 from $7 billion in 2016.
- The Telangana government also inked an MoU with PE firm Cerestra to explore a 'Life Sciences Infrastructure Fund' with a corpus of Rs 1,000 crore (US$ 150 million) to create a sophisticated modular plug and play infrastructure for pharma, biotech and medical devices industry.
- Dr. HarshaVardhan, Union Minister for Science and Technology & Earth Sciences, inaugurated India first cellulosic alcohol technology demonstration plant developed through indigenous technology with capacity of 10 ton per day.
- The Regional Centre for Biotechnology Bill, 2016 has been approved in Lok Sabha, which aims to provide the status of national importance to the Regional Centre for Biotechnology, for facilitating transfer of technology and knowledge and making it a hub for biotechnology expertise in the Asian region.
- The Government of India has relaxed norms for import and export of human biological samples, doing away with import licences or export permits, in an effort to improve the ease of doing business in the industry.
- The Government of India has signed a cooperation agreement with the European Molecular Biology Organization (EMBO) to strengthen scientific interaction and collaborative research between India and Europe.
- The Government of India aims to scale-up the number of start-ups in biotechnology sector to 1,500-2,000 over next two to three years from 500 currently.
- The Government of India is planning to launch a venture capital fund of Rs 1,000 Crore (US$ 150 million) under the department of pharmaceuticals, to support start-ups in the research and development in the pharmaceutical and biotech industry.
- The Government of Karnataka plans to raise Rs 50 crore (US$ 7.5 million) for a biotechnology-

dedicated fund in addition to the existing Semiconductor Fund of Rs 100 crore (US$ 15 million) in order to engage with the emerging technology and biotech space in the state.

- CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT) has signed an MoU with Phyto Biotech to formalise transfer of technology, for production of unique autoclavable super oxide dismutase (SOD) enzyme, used in cosmetic, food and pharmaceutical industries for end applications.
- DBT has announced the Indo-Australian Career Boosting Gold Fellowships under which it will support the researchers to undertake a collaborative research project at a leading science institute or university in Australia for a period of up to 24 months.
- DBT has allocated Rs 4.6 crore (US$ 0.68 million) to the University of Agricultural Sciences (UAS) to support a national multi-institutional project titled 'A value chain on jackfruit and its products'.
- Under the 12th Five Year Plan, the Government of India plans to strengthen regulatory science and infrastructure, which involves setting up of Biotechnology Regulatory Authority of India (BRAI) and a central agency for regulatory testing and certification laboratories.
- Foreign Direct Investment (FDI) up to 100 per cent is permitted through the automatic route for Greenfield and through the government route for Brownfield, for pharmaceuticals.
- National guidelines have been laid down to ensure that research with human stem cells is conducted in a responsible and ethical manner and complies with all regulatory requirements pertaining to biomedical research in general and of stem cell research in particular.

Himachal Pradesh offers a huge potential to become a Himalayan bioresources based biotechnology hub that houses 7.32 per cent of countries' bioresources in the form of high value plants with important medicinal and aromatic properties. Besides, more than two dozen R&D Institutions/Department are engaged for innovations, dissemination and promotion of Biotechnology in various areas. In addition to this there is a large pool of highly skilled manpower in Biotechnology in the State produced each year by several Universities and Colleges in Public and Private sector. The Government has notified the State Biotechnology Policy having a vision and objective to promote Biotechnology by supporting the R&D Institutions in agriculture, animal husbandry, environment, biodiversity conservation and utilization through setting up of bioresource based industries in the State. All this combined together, there is a need to have a strong convergence with the Government- Academia –Industries to move faster in translating Himachal Pradesh into the most sought after destination for bioresource based business hub in the country.

State Biotechnology Policy

Misssion Statement

To convert Himachal Pradesh into a prosperous Himalayan Bio-business Hub with Biotechnology as one of the engines of growth through scientific and technological empowerment of human resource for enhancing efficiency, productivity, cost effective products, processes and technologies.

Vision

Promotion of Biotechnology through its application in agriculture, animal husbandry, horticulture, medicine, environment, biodiversity conservation and utilization and bio-industrial development in the State.

Objectives

- To make Himachal a preferred and globally competitive destination for development of BT products, processes and services.
- To upgrade infrastructural support to R&D and Educational Institutions to generate highly skilled human resource in biotechnology.
- To support R&D in potential areas of biotechnology, including agriculture, horticulture, animal husbandry, human health, environment and industry.
- To conserve and commercially exploit bio-resources of the State for sustainable development.
- To create awareness about the investment opportunities in biotechnology, genomics, bioinformatics, biofuels, contract research, etc. to entrepreneurs and promote Biotechnology industrial investment in the State.
- To provide suitable Institutional framework to achieve the objectives.

Strategies

- Scientific and technological empowerment of human resource for enhancing efficiency, productivity, cost effective products, processes and technologies
- Identification of areas for sustainably harnessing the rich bioresource available in the State.
- Ensure an effective scientific base and make strategic investments in R&D to support biotechnology innovation and economic development.
- Patenting of research findings using effective patenting regimes.
- Supporting infrastructure for up scaling the research for commercial production .

- Outline a number of incentives for setting up of enterprises based on local resources and commercialization of research base.
- Promotion of industries for manufacture of end products based on bioresources.
- Conservation of bioresources of the State.

Institutional Framework to Achieve the Objectives

The Department of Environment, Science& Technology will be the Nodal Department in the State that will deal with matters concerning biotechnology. The Department will promote appropriate research in different sectors, lay more emphasis on fields like bioresource utilization, conservation and industrial promotion that are likely to create employment and will maintain networking between companies, research centers and institutions.

Regulatory Mechanism

The regulatory mechanism in Biotechnology shall be in line with that of the Acts and Rules as notified by the Central Government under Environment Protection Act, 1986 under Rule for Manufacture, Use, Import, Export and Storage of Hazardous Micro-Organisms, Genetically Engineered Organisms or Cells Rules, 1989 for GMOs and product thereof. These Rules shall be executed by the Department of Environment, Science and Technology in the State.

Beside this, the Department will:

- Link the policy with the existing policies of the line Departments such as Organic Farming Policy of Agriculture Department and Education Policy of Technical Education Department.
- Support R&D Institutions/Universities by providing funds through national and international funding.
- Generate data on status of biotechnology in the State.
- Establish liaison among R&D Institutions/Universities, Industry, farming community and NGOs.
- Help in establishing 'Biotechnology Parks' for promoting biotechnology based industry and R&D Centers in the State.
- Help in managing intellectual property and patenting issues related to Biotechnology.

Area of Operation

The Biotechnology Policy will be operational in the State of Himachal Pradesh

Developing Biotechnology Industry

Development of Biotechnology infrastructure for BT Industry in the State will be facilitated by the Industries Department. The State Government, through collaborative partnerships and provisions of facilities, proposes to encourage and facilitate the private sector, in developing necessary Biotechnology industrial infrastructure such as Biotechnology Parks and other supporting infrastructure for research, training, testing, accreditation, etc.
State's varied regional characteristics such as geographic location agroclimatic conditions, distribution of industries, academic institutes, research center etc. provide comparative advantage to particular biotech sector. In view of such comparative advantages the State Government proposes to encourage the development of dedicated clusters. In the following area:

Establishment of Biotechnology Parks

The State is already in the process of setting up a Biotechnology Park at Aduwal, Teh. Nalagarh, Dist. Solan. It is proposed to setup Biotechnology Parks/ BT Industrial. Cluster in Himachal Pradesh in association with the private sector to boost biotechnology based ventures. Biotechnology based and other auxiliary industries will be located in these Parks. It is proposed to locate these Parks on the Solan and Sirmour districts.

Supporting R&D Infrastructure

R&D activities shall be supported by the Government by part or full funding of Himachal Pradesh specific biotechnology research.

Supporting Human Resource Development

Human Resource Development in Biotechnology sector shall be supported by enhancing course (curriculum) development special HRD programmes support to BT students and faculty networking of BT institutions support for invited talks and experience sharing mechanisms.

Bioresource Conservation

Support institutions engaged in conservation of bioresource and its sustainable utilization in manufacturing sector. Coordinate and support the R&D Institutions to create gene banks of high value bioresource of the State besides promoting scientific cultivation of endangered plants having great commercial importance

Biotechnology Task Force

A Task Force has already been constituted to advise the State Government on making biotechnology related policies and implementing them. The Task Force will also formulate norms for setting up biotechnology based industry.

Present report is prepared on the basis of-

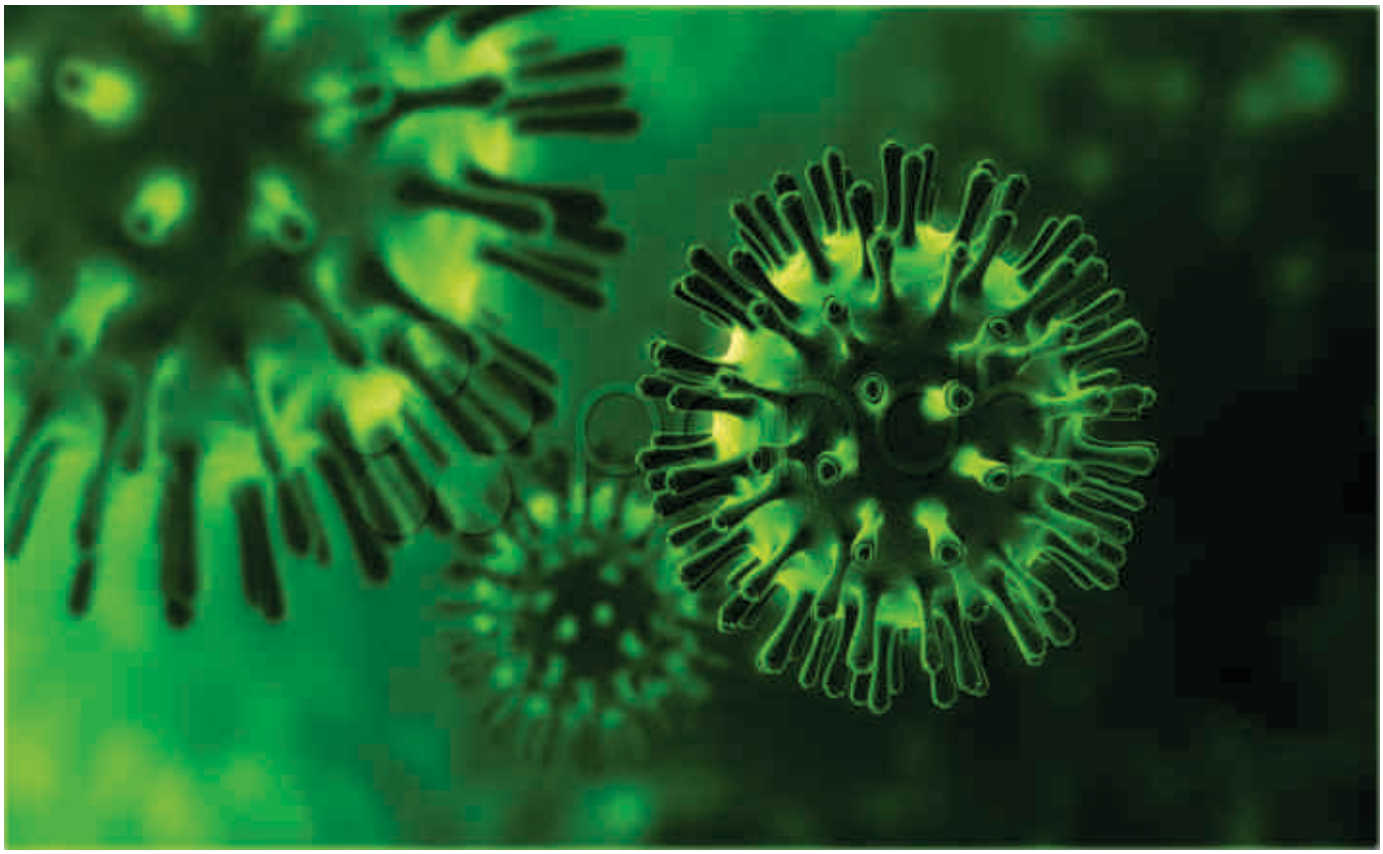
1) Survey on use and application of Biotechnology in various sectors and

2) Information collected/received from various R&D Institutions of the State.

Therefore, the overall objective of this document was to prepare Report on Biotechnology for Himachal Pradesh and as well as to produce a proceedings with experts papers and resolutions in order to enhance Biotechnological capabilities of the State for all round development.

Objectives

- Identify key stakeholders in different Biotechnology sectors in the State.
- Assess the current State status in the use and application of the Biotechnology in terms of Human Resources, Infrastructure and Ongoing Research Projects/Activities in various sectors.
- Identify various government policy/legislation regarding application of Biotechnology in State's development.
- To identify areas of Expertise available for cooperation.
- To identify recent Biotechnology products/ processes developed in HP to be transferred.
- To identify issues and challenges in this frontier area.

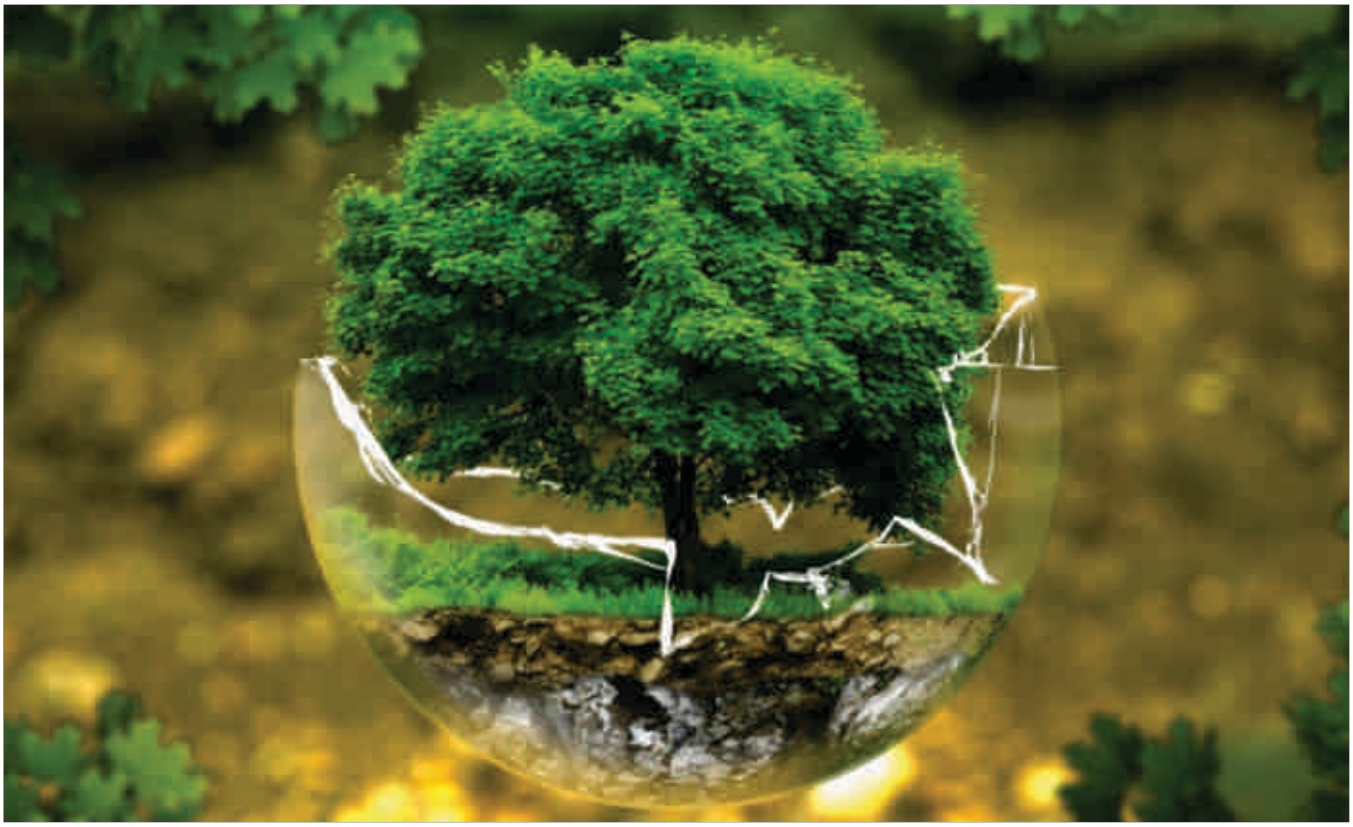


Name and Addresses of Key Stakeholder Institutions of Biotechnology in Himachal Pradesh

Sr.No.	Name of Institution	Address of the Institution
1	Department of Environment, Science & Technology, Government of H.P.	Paryavaran Bhawan, US Club, Shimla-171001.
2	Himachal Pradesh University	Summer Hill, Shimla-171005.
3	Dr. YS Parmar University of Horticulture and Forestry	Nauni, Solan,H.P 173230.
4	CSK HP Krishi Viswavidyalaya	Palampur, Distt. Kangra, H.P.
5	State Forensic Science Laboratory	Junga, Dist. Shimla, H.P.
6	Indira Gandhi Medical College	Shimla, H.P.
7	State Council for Science Technology and Environment	SDA Complex, Kasumpti, Shimla-171009, H.P.
8	Department of Agriculture	Directorate of Agriculture, Shimla-171005, H.P.
9	Department of Horticulture	Directorate of Horticulture, Navbahar, Shimla-171007, H.P.
10	Department of Animal Husbandry	Directorate of Animal Husbandry, Shimla-171005, H.P.
11	Department of Forests	Talland, Shimla-171002, H.P.
12	Department of Ayurveda	SDA Complex, Shimla-171009, H.P.
13	Central Research Institute	Kasauli, Distt. Solan, H.P.
14	Directorate of Mushroom Research Centre	Chambaghat, Distt. Solan-173213, H.P.
15	Central Potato Research Institute	Bemloe, Shimla-171001, H.P.
16	Indian Agriculture Research Institute	Amartara Cottage, Tutikandi, Shimla-171005, H.P.
17	NBPGR, Research Station	Phagli, Shimla-171003, H.P.
18	GB Pant Institute of Himalayan Environment and Development	Mohal, Distt. Kullu, H.P.
19	Indian Institute of Technology	Kamand, Distt. Mandi, H.P.
20	National Institute of Technology	Hamirpur, H.P.
21	Institute of Himalayan Bioresources Technology(IHBT)	Palampur, Distt. Kangra, H.P.
22	Govt. PG College	Dharamshala, H.P.
23	Shoolini University of Biotechnology and Management	Bajhol, Distt. Solan, H.P.
24	Jaypee University of Information Technology	Waknaghat, Distt. Solan, H.P.
25	Himalayan Research Group	Chotta Shimla, Shimla, H.P.
26	Industries & Private Entrepreneurs	Baddi, Kullu, Bilaspur, H.P.
27	Dr. RP Medical College	Tanda, Dist. Kangra, H.P.

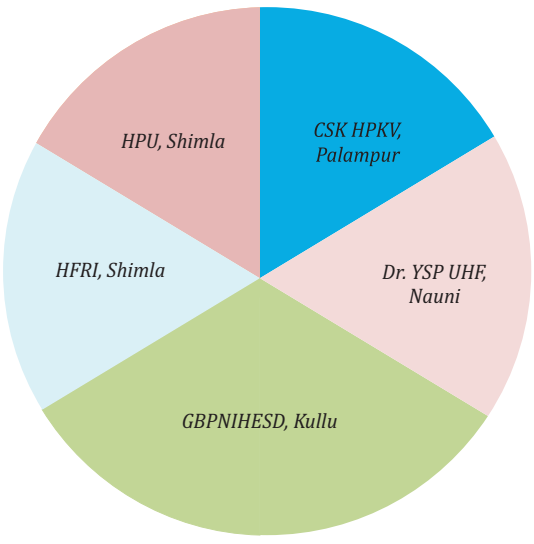
Biotechnology sectors in HP

6.1 Green Biotechnology



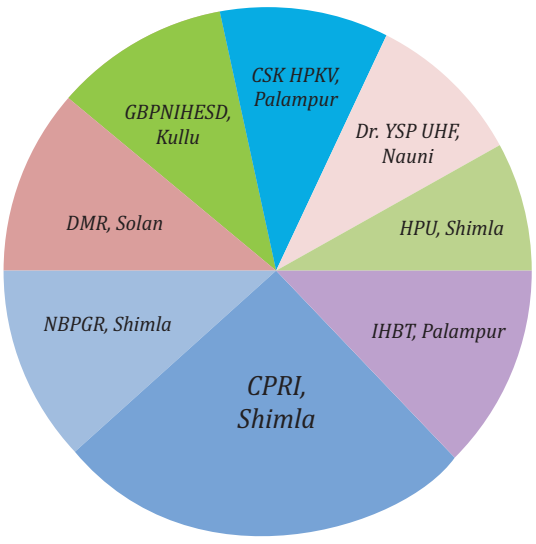
Environmental Biotechnology Sector

Of the listed institutions, five have been identified as key stakeholder institutions in this sector



Plant Biotechnology Sector

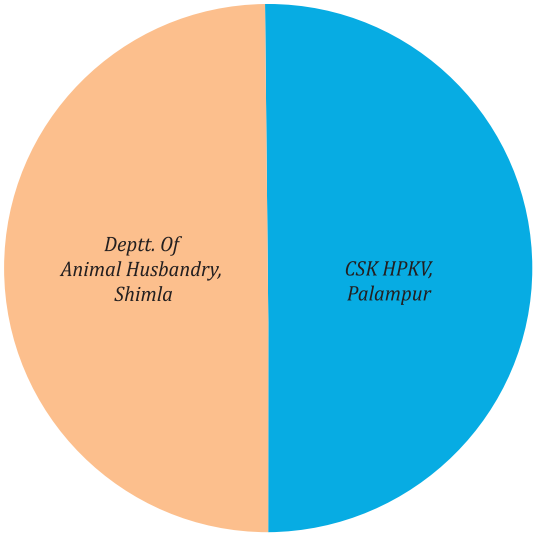
A number of research institutions such as governmental, semi-governmental and private institutions/ their divisions are major stakeholders of plant biotechnology sector in HP. Some of the major institutions of plant biotechnology sector in the State is depicted below:



6.2 Red Biotechnology

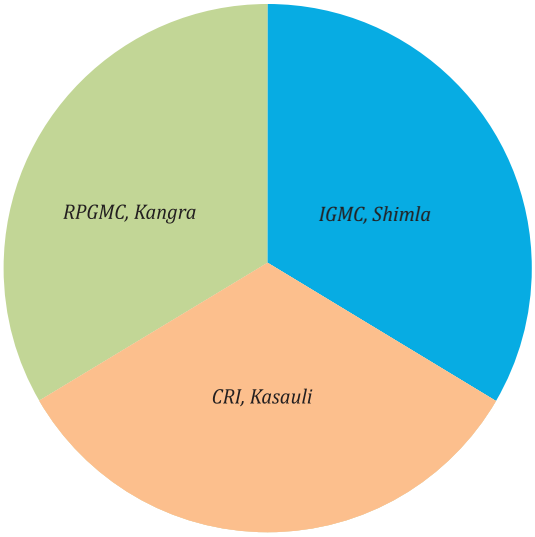
Animal Biotechnology Sector

The State Department and veterinary laboratories/pharmaceuticals are the key institutions of this sector. Two institutions have been identified as key stakeholder institutions in animal biotechnology sector of Himachal Pradesh.



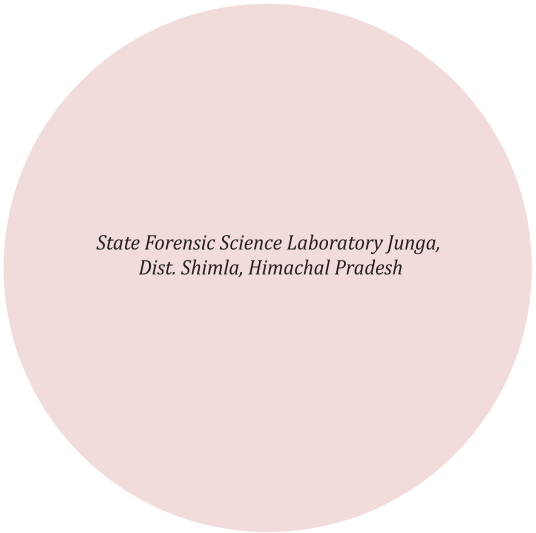
Medical Biotechnology Sector

A number of Medicine related institutions such as government and private hospitals, pharmaceutical companies, pathology laboratories, and university departments are the stakeholders of medical biotechnology sector. Of the listed stakeholders, three institutions were found to be the key institutions in this sector. Name of the respective institutions are shown.



Forensic Biotechnology Sector

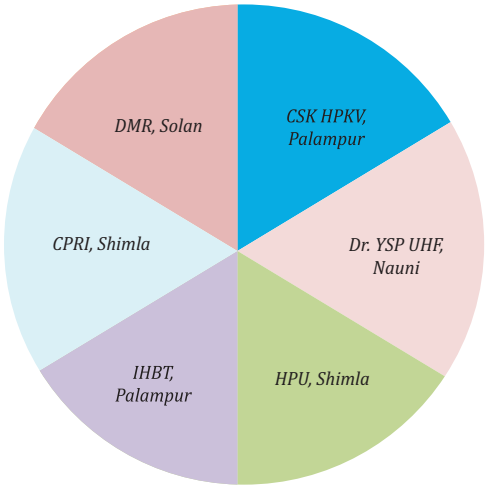
State Forensic Laboratory (SFSL) is the only key institution in forensic biotechnology sector in Himachal Pradesh.



6.3 White Biotechnology

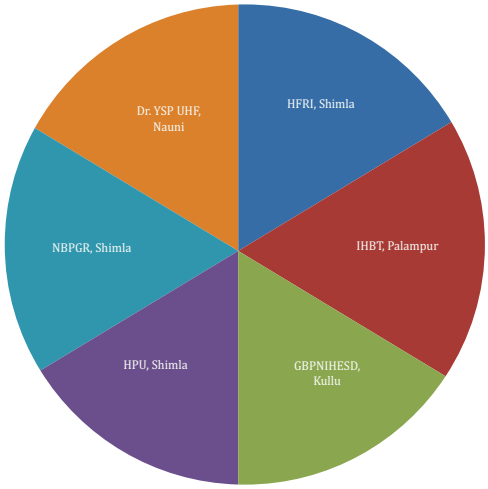
Industrial and Food Biotechnology Sector

Of the listed institutions, six have been identified as key stakeholder institutions in this sector.



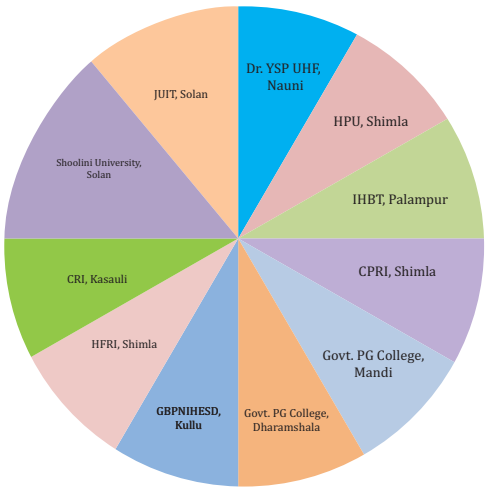
Bio-energy & Bio-conservation Technologies

Six key stakeholders have been identified which are involved in R &D activities pertinent to bio-energy and bioconversion technologies.

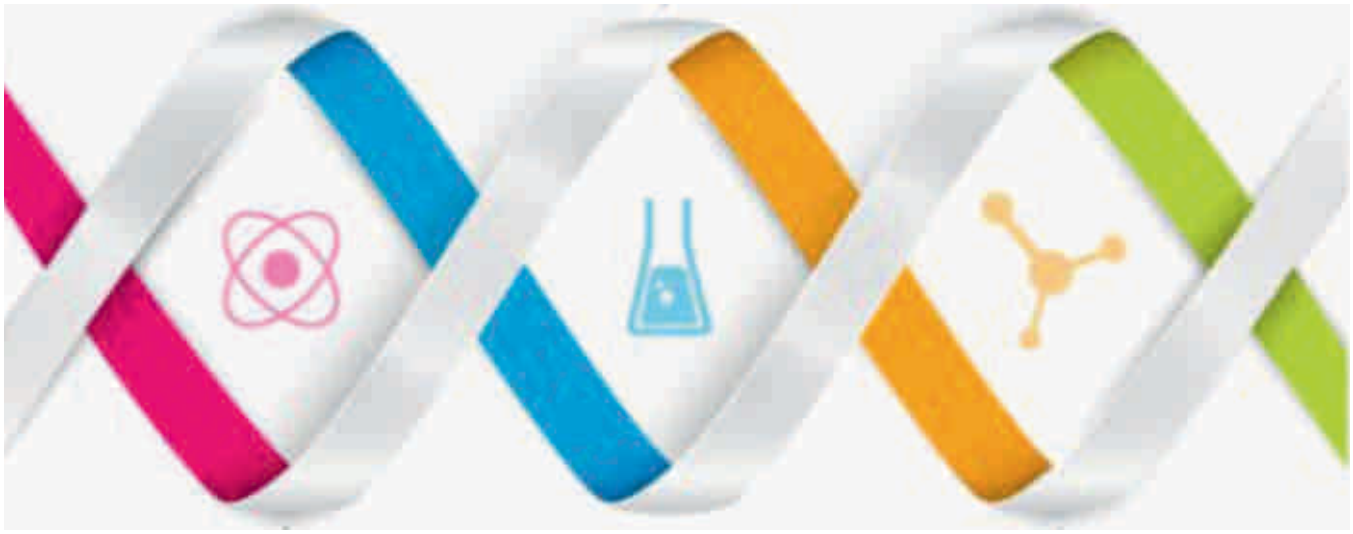


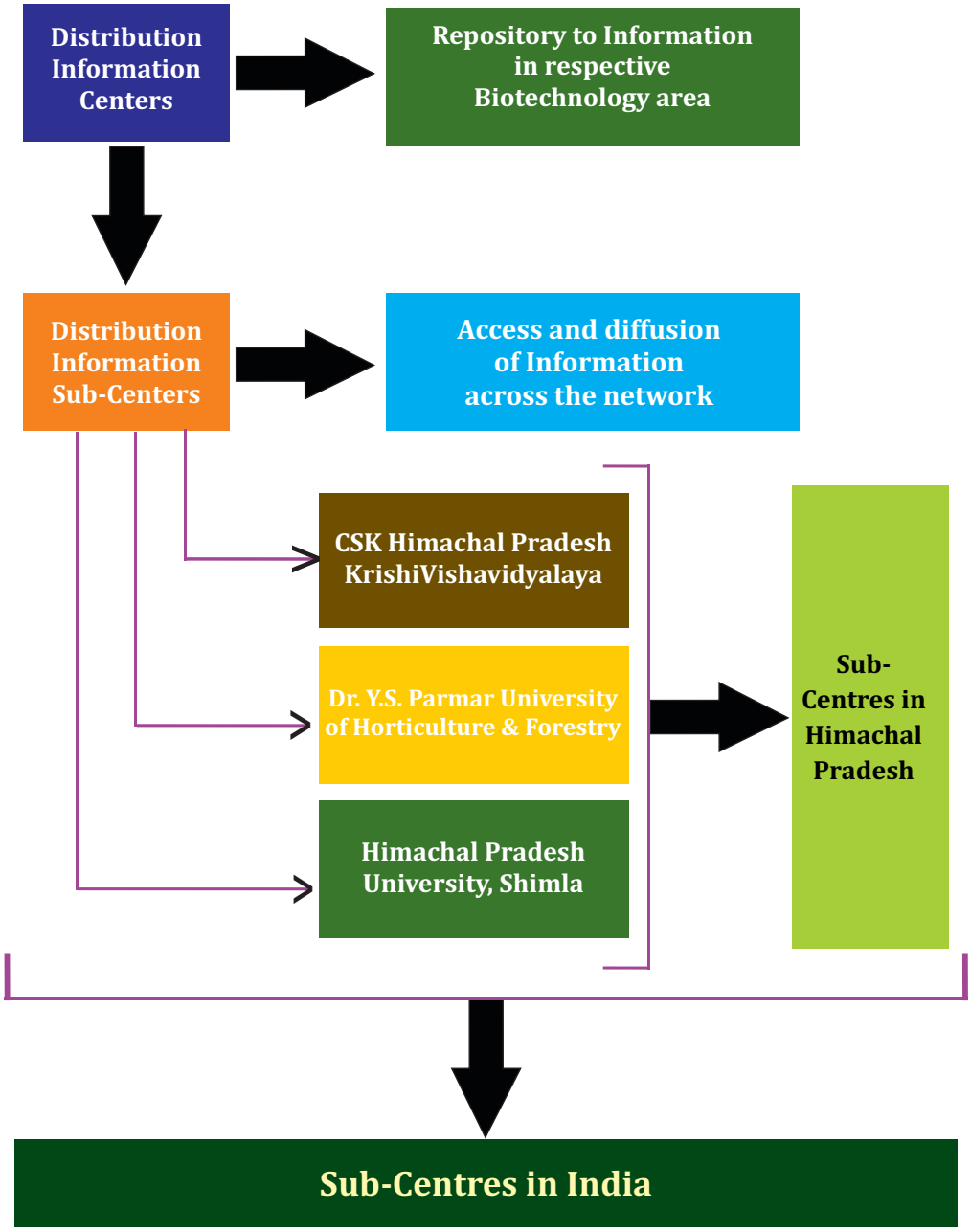
6.4 Biotechnology Education Sector

Eleven institutions have been identified as key stakeholder institutions in Biotechnology Education sector in Himachal Pradesh.



Biotechnology Information System Network in Himachal Pradesh





BIF Centres

Bioinfomatics Infrastructure Facility for Biology teaching through Bioinfomtics

Under BTISNET, namely Development of Bioinformatics Infrastructure Facility to promote innovation in Biology teaching through Bioinformatics. Through this scheme so far eighty one educational institutes were extended bioinformatics Infrastructure facility support which include computer and communication infrastructure, software, database, training resources.

The goal of the scheme is to expose teachers and students to real world of science and use of Bioinformatics in solving hard core biological problems. Tutorials are available online to help students and teachers learn how to navigate those resources through online and gather data that can be applied to original questions. Several sites provide free and unhindered access to Biological Information Resources which include lecture material, video clipping and demonstration and so on. These resources would promote understanding of advanced biology and develop interest to the students, teachers and promote quality human resource to undertake challenging research in the field of modern biology. In Himachal Pradesh only one Institute is there, equipped with this Bioinformatics Infrastructure Facility.

Present status of biotechnology under different sectors in Himachal Pradesh

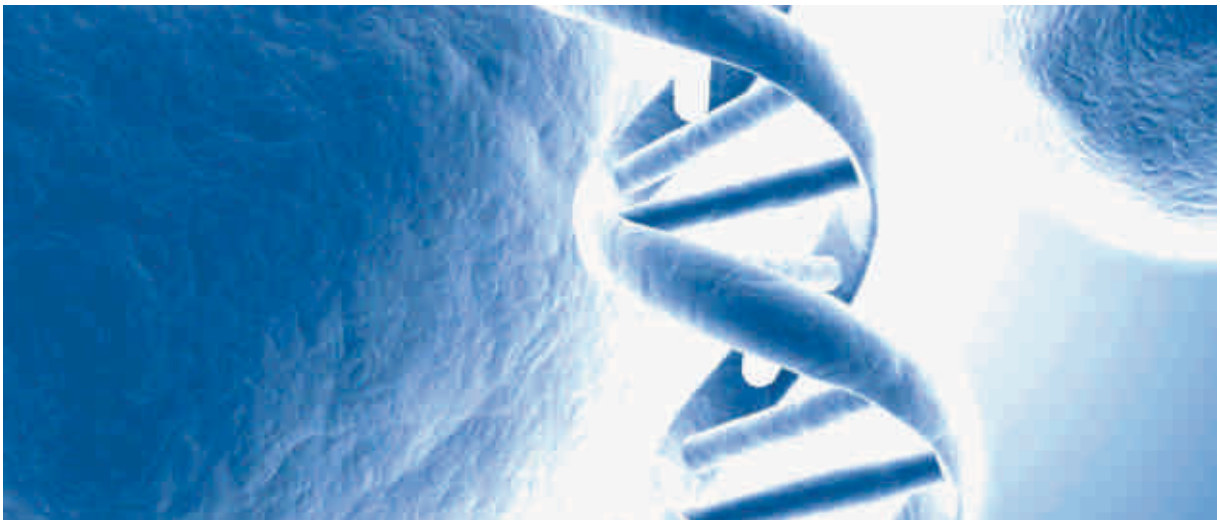
9.1 Plant Biotechnology Sector

Current Biotechnological Projects of key iinstitutions in plant Biotechnological sectors of Himcahal Pradesh

- Studies on Agrobacterium-mediated genetic modification of lignin biosynthesis in Himalayan Poplar(*Populus ciliata Wall* .) for better paper production.
- Studies on isolation and characterizatioin of trypsin inhibitor (TI) gene from *Dolichos Biflorus* I. (Kulth)
- Bioprospecting of thermo-tolerant bacteria from hot water springs of Himachal Pradesh for the production of Taq DNA polymerase
- Refinement for optimization of in vitro rooting and acclimatization of micropropagated plants of clonal rootstocks of stone fruits.
- Biotechnological interventions for establishment of own rooted progeny orchard of some stone fruits.
- Germplasm characterization of model species and assessment of cross-species SSRs transferability in pome and stone fruit crops of family Rosaceae.
- In vitro propagation of *Saussurea Costus*, an endangered medicinal plant of Himalayan region
- Creating a genomics platform for apple research in India.

- Improvement of apple through tools.
- Preventing extinction and improvibiotechnologicang conservation status of threatened plants through application of biotechnological tools.
- Development of innovative methods for resistance induction in cucumber against fungal foliar diseases.
- Biotechnological interventions for establishment of own rooted progeny orchard of some stone fruits.
- Culturable Microbial Diversity of *Arnebia euchroma*, a critically endangered plant growing in trans-Himalayas of Himachal Pradesh.
- Functional analysis and validation of picrosides biosynthetic pathway and development of gene markers for elite chemotypes of *Picrorhiza kurroa.*
- Socio Economic upliftment of high altitude farmers of Himachal Pradesh through transfer of micro-propagation technologies.
- Microbial intervention for generating renewable bioenergy in HP using pine needle forest.
- Transcriptome analysis of seabuckthorn male and female flowers.
- Molecular dissection of biosynthesis of pharmacologically important phenol Glycosides in a high value medicinal plant(*Rhodio la imbricata*) from Trans- Himalayan Region of Ladakh.
- Sustainable management of land through improved *Albizia procera plants* in mid Himalayan region
- Selection of PGPR for improvement of leguminous trees for afforestation in North Western Himalayan region.
- Screening of important medicinal and aromatic herbs for water stress tolerance.
- Ex situ conservation of endangered medicinal herbs of north western Himalayas.
- Development of gene markers for high seed oil content and dissecting molecular basis of female flower development in *J. curcas* towards its genetic improvement for high seed yield.
- Development of herbal product for urolithiasis from Tribulusterrestris.
- Preventing extinction and improving conservation status of the threatened plants through application of biotechnological tools.
- Plant microbe interaction involving virus and virus-like pathogens of apple, pigeonpea and tomato.
- Computational Epigenomics& Epigenetic Study on Tea.
- Unraveling plant-microbe interactions for disease management.

- Genomics of Medicinal Plants and Agronomically Important Traits (PlaGen).
- Plant Breeding, Genomics and Biotechnology (PlOMICS)
- Comparative evaluation of Arnebia species with specific reference to metabolome related to shikonin synthesis–in situ.
- New initiatives to boost agriculture productivity through maximizing pre- and post-harvest yields (AGROPATHY).
- PGPR Tools for Improving Crop Productivity in Stressed Agricultural Systems
- Bioprospecting Microbial Endophytes and their Natural Products from Some Medicinal Plants from Indian Trans Himalayas
- Exploitation of resistance gene derived markers (GDMs) for the development of blast and bacterial blight resistant version of rice var. HPR2143.
- Development of high yielding blight resistant chickpea (*Cicer arietinum L.*) using mutation breeding.
- Molecular genetics analysis of resistance/ tolerance to different stress in rice, wheat, chickpea and mustarded including sheath blight complex genomics.
- Mainstreaming Farmer's Varieties in Himachal and Uttrakhand.
- Development of semi dwarf blast and bacterial blight resistant version of Ranbir Basmati by marker assisted backcross breeding.
- Role of cellulase and xylanase enzymes in biofuel production from forest waste.
- Standardization of sampling methodology for estimation of area and production of apple in HP.
- Development of yield forecasting model(s) based on weather parameters for apple crop.
- Purification and characterization of antimicrobial bioactive compound(s) from *Adiantum capillus-venerus.*
- Isolation, characterization and identification of pesticide tolerating bacteria from contaminated soil for bioremediation
- Phytophthora,Fusarium and Ralstonia of horticultural and field crops (ICAR PhytoFuRanet work project)
- Engineering late blight resistance in susceptible Indian potato cultivars (ICAR/ABSPII collaboration, USA)
- Development of transgenic potato with resistance to major viruses (ICAR network project on transgenics in crops)
- National Certification System for tissues culture raised plants (DBT)
- Symmetric somatic hybridization for late blight resistance in potato (DBT)
- Transcriptome profiling of contrasting potato genotypes during high temperature stress (DST)
- Centre for agricultural bioinformatics (CABin) (ICAR)
- CRP of biofortification (ICAR plaftorm)
- Nanotechnology (ICAR plaftorm)
- Exploring the potentiality of microflora from Himalayan ecosystem for the synthesis of silver nanoparticles and their application in management of *Ralstonia solanacearum* infecting potato (DST)
- Genetic enhancement of potato through molecular and genomic tools (Institutional)



9.2 Animal Biotechnology Sector

Current Biotechnological Programs and Projects/ Activities/ of key Institutions in Animal Biotechnology Sector of Himachal Pradesh.

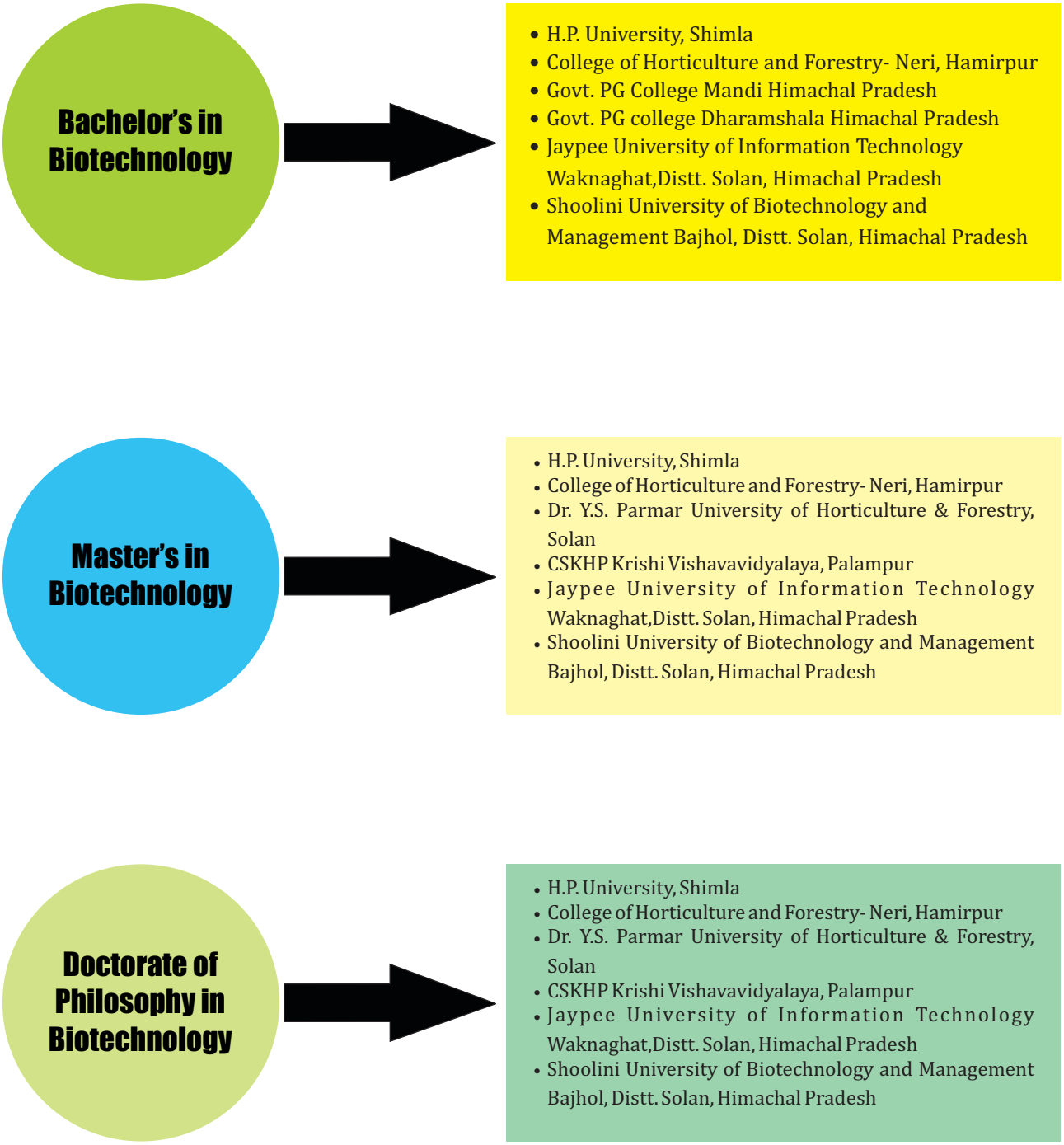
9.3 Food and Industrial Biotechnology Sector

Current Biotechnological Activities/ Programs and Projects of key institutions in Food and Industrial Biotechnology Sector.

- Refinement of technology for production of lactic acid fermented products: As a Postharvest loss reduction tool.
- Standardization and Commercialization of Apple Cider Vinegar Production Technology for the Sustainable Livelihood of Weaker Sections of the Society in Hilly Areas.
- Evaluation of polymer packaging material for retaining quality of some fruits and vegetables.
- Development of low cost value added processed products from ripe pumpkin (*Cucurbita moschata*) and dissemination of technology to the farm women of Himachal Pradesh.
- Research and development of ready to serve and ready-to-cook food recipes for Mid Day Meal Schemes/ ICDS.
- Refinement of Technology for Value Addition of Ginger grown in Solan and Sirmour Districts of Himachal Pradesh.
- Development of novel nutraceuticals fortified with rare fermenting microorganisms isolated from HP and their commercial promotion.
- Bacteriocin : Food biopreservative.
- Value addition of seasonal vegetables/ traditional foods for improved nutritional and livelihood opportunities among highlanders.
- Processes and products from himalayan region and their toxicological evaluation.
- Computational approaches to improve the biophysicochemical properties of industrial important proteins.
- Nanoparticle-Mediated Targeted Delivery of Biomolecules.
- Nano-materials: Applications and Impact on Safety, Health and Environment.
- Bioprocess development for the synthesis of acetohydroxamic acid using acyltransferase from Bacillussp
- Mining of microbial genomes for the novel sources of nitrile metabolizing enzymes
- Production, purification and biochemical characterization of an extracellular cholesterol oxidase from a Bacillus sp.
- Characterization of alvular antigen for diagnosis of Rheumatic Heart Disease.
- To explore anti-microbial potential of few important medicinal and aromatic plants of Himachal Pradesh and green synthesis of silver nanoparticles of plant extracts
- Microbial utilization of industrial and other waste for production of commercially viable and useful products

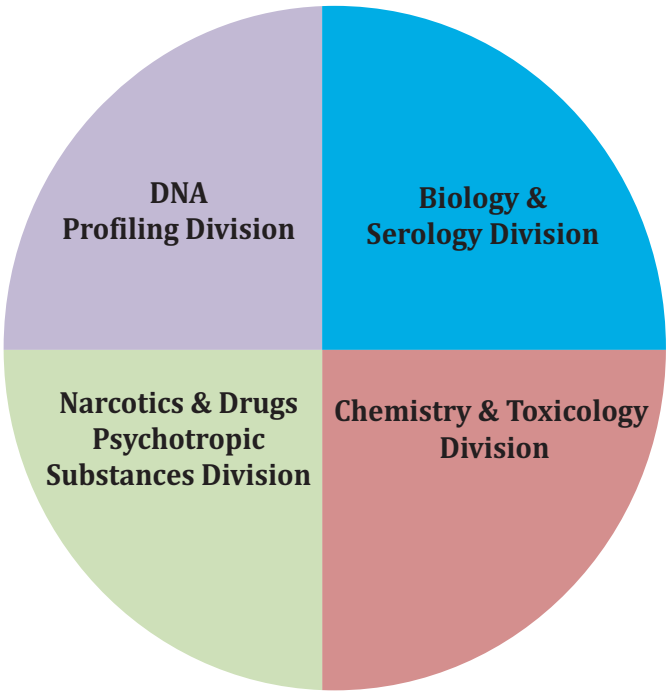
9.4 Biotechnology Education Sector

Specific Biotechnology education (Bachelors and Masters Degree) started only few years back in Himachal Pradesh. Prior to this, different branches of biological sciences (Botany, Agriculture Science, and Zoology) have contributed in generating Biotechnology related human resources in the country. Current status of HR, infrastructure and ongoing activities in various key institutions of Biotechnology education Sector of Himachal Pradesh is presented in the following section.



9.5 Forensic Biotechnology Sector

State Forensic Science Laboratory, Junga, Himachal Pradesh, have a covered area of about 28000 square feet. The work is in progress for planned expansion of additional divisions /specialties in the State FSL.



10.1 Institute of Himalayan Bioresource Technology, Palampur

Number of major projects on biotechnology: 27

Total number of students enrolled in biotechnology: 59

Total number of publications: 61

Number of patents granted/filed: 43

List of Patents Granted/filed:

Sr.No.	Title	Inventor
1	Gel processing and transfer device	Sanjay Kumar and Dhiraj Vyas
2	Cloning of novel genes expressed is the apical buds of Caragana *(Caragana jubata)* growing under snow	Sanjay Kumar, Rajesh Kumar Gupta and Paramvir Singh Ahuja
3	Cloning of novel gene sequences expressed and repressed during winter dormancy in the apical buds of tea (*Camellia sinensis L.* (O.) Kuntze) bush	Sanjay Kumar, LakhvirLal and Paramvir Singh Ahuja
4	Species specific DNA sequences and their utilization in identification of viola species and authentication of "banafsha" by polymerase chain reaction	Mahipal Singh, Chandan Sharma and Brij Lal
5	A universal plasmid vector for transforming chloroplasts of higher plants	Mahipal Singh and Bandana Dhiman
6	Species specific genomic DNA sequence for identification Anacardiumoccidantale and the method for its utilization in detection of cashew husk in made tea samples	Mahipal Singh and Bandana Dhiman
7	A convenient and versatile, compact portable light weight, low power consuming sterile laminar air flow system	Rajesh Thakur, Anil Sood and Paramvir Singh Ahuja

Sr.No.		Inventor
8	An improved method for mass propagation of *Podophyllum hexandrum Royle* using embryo culture technique	Amit Chandra Kharkwal, Amita Bhattacharya, Om Prakash and Paramvir Singh Ahuja
9	An efficient method for micropropagation of tea (*Camellia sinensis)* plants using leaf explants	Indra Sandal, Amita Bhattacharya, Madhu Sharma and Paramvir Singh Ahuja
10	An efficient one step method for micro-production of tea leaves	Indra Sandal, Amita Bhattacharya, Madhu Sharma and Paramvir Singh Ahuja
11	A method for inducing improved seed germination in a high altitude medicinal and endangered plant *Podophyllum hexandrum Royle*	Amit Chandra Kharkwal, Amita Bhattacharya, Om Prakash, Pramod Kumar Nagar and Paramvir Singh Ahuja
12	A novel isozyme of autoclavable superoxide dismutage (SOD)-a process for the identification and extraction of the SOD and use of the SOD in cosmetic, food and harmaceutical compositions	Sanjay Kumar, Rashmita Sahoo and Paramvir Singh Ahuja
13	An efficient new method for protoplast culture	Pratap Kumar Pati, Madhu Sharma and Paramvir Singh Ahuja
14	Cloning of 3 novel genes modulated under drought stress conditions in tea (*Camellia sinensis* L. (O.) Kuntze)	Preeti Sharma, Sanjay Kumar, Paramvir Singh Ahuja
15	Caffeine fraction obtained from tea leaves and a method for inducing *Agrobacterium tumefaciens*-mediated genetic transformation in plants using said caffeine fraction	Indra Sandal, Ajay Kumar, Amita Bhattacharya, SrigurupuramDesikacharyaRavindranath, AshuGulati, Paramvir Singh Ahuja
16	A method for biolistic mediated geneticransformation of tea (*Camellia sinensis L. (O.) Kuntze*) using leaf explants	Indra Sandal, Amita Bhattacharya, Paramvir Singh Ahuja
17	An improved method of tea propagation	Om Prakash, Anil Sood, Madhu Sharma and Paramvir Singh Ahuja
18	An improved acclimatization unit	Anil Sood, Madhu Sharma and Paramvir Singh Ahuja
19	Novel genes from drought stress tolerant tea plant a method (*Camellia Sinensis* (L) O. Kuntz)	Sharma P, Kumar S, Ahuja PS
20	Use of tea leaf extract as a potent bactericidal agent for *Agrobacterium tumefacienns* mediated genetic transformations	Indra Sandal, Amita Bhattacharya, AshuGulati, Srigurupuram DesikacharyaRavindranath, Paramvir Singh Ahuja
21	Transgenic tea through biolistic using leaf explants	Indra Sandal, Amita Bhattacharya, Paramvir Singh Ahuja
22	Use of tea leaf extract for field inhibiting microbial transformant	Indra Sandal, Amita Bhattacharya, AshuGulati, Srigurupuram DesikacharyaRavindranath, Paramvir Singh Ahuja
23	Development of diagnostic kit against the recombinant coat protein gene for the detection of Carnation Mottle virus	GauravRaikhy, VipinHallan, Saurabh Kulshreshtha, AA Zaidi
24	Development of diagnostic kit for the detection of chrysanthemum virus B	Lakhmir Singh, VipinHallan, AA Zaidi
25	Development of diagnostic kit against the recombinent coat protein of prunus necrotic ringspot virus	SaurabhKulshreshtha, VipinHallan, Gaurav Raikhy, AA Zaidi

Sr.No.	Title	Inventor
26	Use of 2-Amino glutarimide in promoting *agrobacterium tumefaciene*	Sandal I, Bhattacharya A, Ravindranath SD, Singh B, Kaul VK, Saini U, Kumar JK, Ahuja PS, Gupta AP
27	A green process for the preparation of substituted cinnamic esters with trans-selectivity	Sinha AK, Sharma A, Swaroop A, Kumar V
28	A cost effective, less hazardous, two-solution system for rapid isolation of RNA	Ghwana Sanjay, Singh Kashmir, Raizada J, Arti Rani, Bhardwaj Pradeep Kumar, Kumar Sanjay
29	Superoxide dismutase (SOD) CDNA from *Potentilla atrosanguinea* and its expression in hetrologous system	Bhardwaj PK, SahooRashmita, Kumar S, Ahuja PS
30	A composition and method for removal of colours and inhibitors from tissues to isolate RNA	Ravi Shanker Singh and Sanjay Kumar
31	A method for cloning functional gene of copper/zinc superoxide dismutases using oligonucleotide primers	BhardwajPardeep, Kumar Arun, Kishore Amit, Ghawana Sanjay,Rani Arti, Singh Kashmir, Singh Harsharan, Ravi Shankar, Kumar Hitesh, SoodPayal, DuttSom, Kumar Sanjay, AhujaParamvir
32	A universal fungal pathogen detection system	Karnika Thakur, GopaljeeJha
33	Superoxide dismutase (SOD) gene and a method of identifying and cloning thereof	Pardeep Kumar Bhardwaj, RashmitaSahoo, Sanjay Kumar, Paramvir Singh Ahuja
34	An expression construct and process for enhancing the carbon, nitrogen, biomass and yield of plants	AnishKaachra, SK Vats, PS Ahuja and Sanjay Kumar
35	An autoclave stable recombinant Cu/Zn superoxide dismutase with enhanced thermoflexibility	Arun Kumar, SomDutt, PS Ahuja, Sanjay Kumar
36	Method and apparatus for the separation of seeds from fruit pulp/slurry/pomace	ShashiBhushan, Sakshi Gupta, Garikapati Divya Kiran Babu, Mohit Sharma, Paramvir Singh Ahuja
37	A bioreactor vessel for large scale growing of plants under aseptic conditions	Rajesh Thakur, Anil Sood, Paramvir Singh Ahuja.
38	A novel hybrid nanocomposite material for optical/mri bimodal molecular imaging and a process for the preparation thereof	AmitabhaAcharya
39	A novel embryo sac specific bidirectional promoter from *Arabidopsis*	Sreenivasulu Y, Sharma Isha, Ahuj PS, Srinivasan R and BhatRamchandraSripad
40	Novel bidirectional promoter trap construct to trap/identify novel promoters	YelamSreenivasulu, RimpyDiman, Ramamurthy Srinivasan, ShripadRamachandraBhat, Paramvir Singh Ahuja
41	A novel medium composition for culturing the entomopathogenic fungus *Lecanicillium lecanii*	SGE Reddy and ShaliniSahotra
42	A nanobiocomposite for wound healing and a process for the preparation thereof	Sudesh Kumar Yadav, Rubbel Singla, Avnesh Kumari,
43	An innovative process for development of ready to eat crispy fruits with high quality	Mahesh Gupta, Jai Prakash Dwivedi and Sanjay Kumar

Latest achievement in the field of Biotechnology:

- Developed micro propagation protocols for endangered and critically endangered medicinal plants of western Himalaya.
- Generated planting materials of saffron
- Developed PGPRs for improved crop growth and yield.
- Identified several microbes as sources of therapeutic enzymes.
- The mechanism of viral infection of apple and *Valeriana jatamansi* deciphered.
- Developed multiplex diagnostics for apple and cherry virus and virus-like pathogens.
- Identified dormancy-related and disease resistance genes that will lead to improvement of phenological traits in apple.
- Developing fluorescent nano materials as cellular imaging probe and also nano materials for delivery of biomolecules
- Identified plant-derived molecules from Himalayas as anti-oral cancer agents.

Department Products /Process Development and Transferred/to be transferred:

- Products: Steriflow, Gel Protrad, Iris Solution, Viral diagnostic kits, Thermostableautoclavable SOD, Rooting vessel for tissue culture raised plants, Bioinformatics regulomics server, Tissue culture raised plants of high value and quality (tea, bamboo, scented rose, lavender, coleus, saffron, endangered medicinal plants etc., PGPRs, therapeutic enzymes), gene and genetic resources of high value plants (tea, bamboo, Picrorhizakurroa etc.), constructs with novel genes from Himalayan bioresource, transgenic plants of apple rootstock.
- Micropropagation protocols for tea, bamboos, scented rose, lavender, aloe vera, endangered plants of higher reaches of Himalayas, virus tested apple rootstocks.
- Tissue culture method for elimination of viruses
- Genetic transformation of woody plants and model plants
- PCR based methods for viral detection
- Identification and production of PGPRs for improved crop growth and yield
- Bioinformatic tools for early detection of human diseases.
- Process for synthesis of bioactive loaded nano-particles.
- Apple pomace for dietary fibres.

10.2 Central Potato Research Institute, Shimla-171001 (HP)

Latest achievements in the field of Biotechnology

To execute structural and functional genomics for potato improvement applying biotechnological intervention (2016-17).

Number of major projects on biotechnology: 12

Total number of students enrolled in biotechnology: 28

- Analysis of full genome sequence of potato dry rot pathogen (*Fusarium sambucinum*).
- Analysis of full genome sequence of potato bacterial wilt pathogen *Ralstonia solanacearum.*
- Mapping of complete mitochondrial genome of potato late blight pathogen (*Phytophthora infestans* A2 mating type)
- Silencing of Phytophthorainfestans multi-genes in potato using single RNAi construct.
- Stability and functionality of RB gene in late blight resistant transgenic potato.
- RNA-sequencing of wild potato species *Solanum demissum* for late blight resistance.
- Gene expression analysis of cyclic dependent gene for potato tuberization.
- Identification of PALCV (potato apical leaf curl virus) resistance genes in potato.
- Molecular diversity in the potato association mapping panel.
- Molecular characterizations of interspecific somatic hybrids (*Solanum tuberosum* dihaploid C-13 + *S. cardiophyllum*) using AFLP markers and their late blight resistance assay.
- Breeding potential of potato somatic hybrids under the sub-tropical plains of India and evaluation of advanced progenies of F1C3 population.
- Molecular profiling of segregating progenies of somatic hybrids developed by crossing with potato varieties.
- Enhancing nitrogen use efficiency (NUE) in potato crop through genomics approaches.
- Plant growth under aeroponics system to study NUE
- Transcriptome sequencing (RNA-seq) for NUE and sequence variations for N-metabolism genes in potato.
- Sequence analyses of late blight resistance homologous genes isolated from wild potato species.

Role of Government in promotion of biotechnology in Himachal Pradesh (Strategy and Framework of the institute; from CPRI Vision 2030)

- *Effective exploitation of genetic resources for varietal improvement*
- *Safe application of biotechnology for potato improvement*
- *Encouraging production of quality planting material*
- *Resource based planning and crop management*
- *Effective and eco-friendly crop protection*
- *Encouraging energy efficient storage and diversified utilization of potato*

10.3 CSK HimachalPradesh Krishi Vishvavidyalaya, Palampur

List of Patents granted/filed:

Number of major projects on Biotechnology: 8
Total number of students enrolled in Biotechnology: 15
Total number of Publications: 57
Number of patents granted/filed: 2

Sr. No.	Title	Inventor
1	Melanin production in Ascochytarabiei is involved in pathogenicity on chickpea	W Chen, K D Sharma, M Wheeler and F Muehlbauer
2	The role of melanin production in Ascochyta blight of chickpea	W Chen, K D Sharma, M H Wheeler and F J Muehlbauer

Latest achievement in the field of Biotechnology:

- Development of genomic resources in Horsegram.
- Whole genome sequencing of Horsegram variety HPK4.
- Powdery mildew resistant pea lines developed by integrating resistance genes 'er1' and 'er2' into the genetic background of susceptible commercial varieties “Lincoln” and Azad Pea-1 through marker-assisted backcross breeding (MAB).
- Identification and mapping of five new blast resistance genes Pi-42(t), Pi-w(t), Pik-l and Pi-tp and Pibl2. The markers linked to these genes can be exploited in marker assisted breeding programs for development of blast resistant rice varieties.
- Near isogenic lines (NILs) and pyramid lines of a mega rice variety SambhaMahsuriharbouring different combinations of blast resistance genes Pi-ta, Pi-1 and Pi-kh.

Department Products /Process Development and Transferred/to be transferred:

- Powdery mildew resistant versions of commercial Pea varieties Lincoln and Azad Pea-1
- Bacterial blight and blast resistant versions of rice variety HPR2143.

10.4 Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni (Solan)

Number of major projects on Biotechnology: 10

Total number of students enrolled in Biotechnology: 140

Total number of Publications: 26

Number of patents granted/filed: 8

Sr.No.	Title	Inventor
1	A process for in vitro use of Asparagus species extracts for carnation latent virus elimination. Indian Patent No. 192157.	Bhardwaj SV, MangalManisha and Anil Handa.
2	A process for in-vitro elimination of plant virus by preparing and using an extract of *Azadirachta indica* plant. Indian Patent No. 193932.	Bhardwaj SV, Shalini, Anil Handa and Manisha Mangal
3	A process for preparation of a bio- reagent for use for elimination of plant virus. Indian Patent No. 199706.	Bhardwaj SV, SJ Roy, ManishaMangal and Anil Handa
4	An extract of fruits and roots of *Asparagu sadscendens* or *Asparagus officinalis* useful for the elimination of carnation latent virus from infected plants by supplementing the tissue culture medium. Indian Patent No. 232448.	Bhardwaj SV, ManishaMangal and Anil Handa
5	Cell lines of chrysanthemum (*Dendranthema grandiflorum Tzelev*) cv. Snow Ball resistant to SeptoriaobesaSyd. Indian Patent application No.1334/DEL/2007 filed on 21.05.2007.	Kumar S, S. Kumar and S. V. Bhardwaj
6	Development of reproducible protocol for direct organogenesis in transgenic male plant of Himalyan poplar. Patent Application No. 1591/DEL/2007 dated 27.7.2007.	Thakur, A.K., Shandil R.K. and Srivastava D.K
7	An extract of corm of Stephaniaglabra useful for the elimination of cucumber mosaic (CMV) and Bean Yellow Mosaic (BYMV) viruses from gladiolus by supplementing in tissue culture medium. Filed through NRDC No.IPR/4.19.1/10053	Bhardwaj S.V, Bhattarai A, Handa A & Parmar N.
8	Molecular markers linked to the gene exhibiting resistance against blackrot (*Xanthomonas campestris* pv. campestris (Pammel) Dawson) in cauliflower (*Brassica oleracea* var. botrytis). Filed through NRDC No.IPR/4.18.13/10020.	Kaur R, Kashyap M, Saxena B, Kanwar H S, Dohroo N P and Bhardwaj S V

Latest achievements in the field of Biotechnology

1) Plant Tissue Culture

- Shoot regeneration protocol for tomato cv. SolanLaima
- Transfer of In vitro propagated plants of Plum - Santa Rosa and Frontier to field
- In vitro mutagenesis in ginger with gamma radiations for selection of Fusarium resistance
- Development of somaclonal variants in apple tolerant to fungus *Phytophthora cactorum*
- Micropropagation of crab apple(Malusbaccata) biotypes
- Micropropagation of *S. costus* (Kuth)-endangered medicinal plant of Himalayan region

2) Plant Molecular Biology *[Genetic Transformation]*

- Studies on Agrobacterium-mediated insect resistance gene [cry1A(a)] transfer in cauliflower (*Brassica oleracea* L. var. botrytis)-
- Studies on Agrobacterium- mediated insect resistance gene [cryIA(a)] transfer in broccoli (Brassica *oleracea* L. var.italica) and molecular analysis of regenerated transgenic plantlets-

3) Cloning and transformation

- Restriction digestion of plant expression vector (pBI 121)
- Integration of trypsin inhibitor gene into plant expression vector and transformation of E. coli top 10 competent cells
- Confirmation of transformed bacterial colony
- Restriction digestion of recombinant plasmid
- Expression of trypsin inhibitor gene in E. coli cells
- Integration of trypsin inhibitor gene into pJET 1.2/blunt cloning vector
- Confirmation of transformed bacterial colonies
- Isolation of recombinant plasmid from transformed bacterial colonies
- Restriction digestion of recombinant plasmids
- Restriction digestion of pET 23a(+) heterologous vector
- Integration of trypsin inhibitor gene into heterologous expression vector (pET23a) and transformation of E. coli BL21 competent cells
- Confirmation of transformed bacterial colonies
- Restriction digestion of recombinant plasmid
- Sequencing of recombinant pJET1.2/blunt cloning vector

Biotechnology products/processes developed and transferred / to be transferred

- The multiple shoot cultures and repeatable micro propagation protocols of some promising, dwarf and semi dwarf apple rootstocks like, MM106, MM111, M7, M26 and Merton 793 developed, refined for large scale plant production and field transfer. These have been successfully used at Pilot scale by TERI (The Energy and Resources Institute), New Delhi under a "Network Programme on Apple", funded by the Department of Biotechnology, Government of India, New Delhi, in 2003-2008.
- Multiple shoot cultures of these apple rootstocks sold to local entrepreneurs engaged in producing large number of apple plants in their tissue culture units established in various parts of HP.
- Micropropagation protocols of EMLA9 and indigenous rootstock crab apple developed for transfer.
- Protocol for in vitro multiplication for strawberry cv. Ofrah has been standardized and handed over to farmer of Rajgarh (HP).
- Bioinformatics centre: i) Developed five video CDs on Temperate Horticulture ii) Developed a training manual on 'Computer Basics'.

Role of Government in promotion of Biotechnology in Himachal Pradesh

Various user agencies / Tissue Culture units for commercial production of tissue cultured plants were set up in HP under National Horticulture Technology mission.

10.5 Himachal Pradesh University,Shimla.

Number of major projects on Biotechnology: 6
Total number of students enrolled in Biotechnology: 61
Total number of Publications: 85
Number of patents granted/filed: 5

Sr.No	Title	Inventor
1	Formulation of antibacterial fern mouthwash solution for oral hygine	Prof. S. S. Kanwar, Department of Biotechnology.
2	Hyper production of an anti-cancer drug Taxol from endophyticAspergillus *fumigatus isolated* from Taxus sp. of Himachal Pradesh	Prof. Duni Chand, Department of Biotechnology
3	Process development for wheat flour treatment using phytase from *Aspergillus fumigatus.*	Prof. Duni Chand, Department of Biotechnology
4	A Nano-Bioconjugate for the Synthesis of Novel Anaesthetic Drug Benzocaine	Abhishek Sharma and Shamsher Singh Kanwar
5	Screening, Isolation and Purification of L-methionase Enzyme from *Klebsiella oxytoca*	Bhupender Sharma and Shamsher Singh Kanwar

Biotechnological products

- Production of various important acids such as nicotinic acid, benzohydroxamic acid, acrylic acid, nicotinahydroxamic acid, 2-hydroxybenzoic acid, picolinic acid, acetohydroxamicacid, butyrohrdroxamic acid, Taxol, propylgallate, 6-aminopenicillanic acid and industrially important acrylamide, nano-particles of Zn, Fe, Ag etc. with and without enzyme loading and antimicrobicides of Fern origin.

- Besides various production of important organic acids, short and long chain esters with anti-oxidant/ free radical scavenging activities/ fragnance compounds etc., the department focuses on the production of biofuels, healthcare and herbal processing.

10.6 Jaypee University of Information Technology, Waknaghat, Solan (HP)

Number of major projects on Biotechnology: 21

Total number of students enrolled in Biotechnology: 291

Total number of Publications: 195

Number of patents granted/filed: 16

Sr.	Title	Inventor
1	Henna Based Dye, Process for Preparing the Same and Use thereof in SDS-PAGE Method	Tandon C, Chaudhary A, Gupta S and Jain S
2	Non-Natural Short Cationic Antimicrobial Lipopeptides	Bisht GS and Lohan S
3	Automated Computer Aided Diagnosis (CAD) of Tuberculosis using Chest X-Ray	Rout C, Chauhan A, Chauhan RS and Chauhan D
4	A process of enriching medicinal constituents in shoot cultures of *Swertia chirayita*	Sood H, Gulati S, Bakshi S, Sandhu BS, Kumar V and Chauhan RS
5	INDITECH - A Novel Bioreactor	Sharma S, Sood H and Chauhan RS
6	A synbiotic formulation of sea buckthorn (*Hippophae rhamnoides* L.) berries with radical scavenging potential	Dey G and Negi B
7	Isolation and purification of Picroside-I and Picroside-II	Sood H, Kumar V and Chauhan RS
8	An economical and improved isolation process of antitumor triterpenoidLantadene B from weed *Lantana camara* L.	Sharma M and Kumar SS
9	An improved process of conversion of Lantadene A & B to reduced Lantadene A & B	Sharma M and Kumar SS
10	Process for production of cellulase and pectinase from herbal industry residue	Kumari M, Kumar S, Chauhan RS and Ravikanth K
11	A novel anti-calcifying protein from Tribulusterrestris	Tandon C and Aggarwal A
12	Thermo-halotolarent Lipase by a New Strain of *Staphylococcus arlettae*	Chauhan RS, Anwar T, Mathur A, Malhotra A and Mathur G
13	Novel method for producing sea buckthorn wine and wine thereof	Dey G and Negi B
14	Gene Markers for Selection and Development of High Oil Content Jatropha	Chauhan RS, Sharma A and Sood P
15	A process of enriching the amount of medicinal compound, Picroside-1 in shoots of medicinal herb, *Picrorhiza kurroa*	Sood H and Chauhan RS
16	Biosynthetic pathway for the production of Picroside-I and Picroside -II and their Intermediates in *Picrorhiza kurroa*	Chauhan RS, Kumar V, Sood H, Pandit S and Shitiz K

Latest achievement in the field of Biotechnology:

- The Department of Biotechnology & Bioinformatics has been ranked 1st among all private universities and institutions in India for the last four years.
- In 2013, the Association of Biotech Lead Enterprises (ABLE) has honored the institution with one of the best private biotech and bioinformatics education institutions in the country for doing outstanding research and education due to its strong R&D program, up-to-date educational curricula, modern laboratory infrastructure, highly qualified faculty, IPR & patents, and placements of graduates.

Department Products /Process Development and Transferred/to be transferred:

- Environmental friendly dye for staining (patent granted).
- Biogas- Biogas Digesters (08 in number) Installed at different places in HP. E.g. Technology transferred to Ayurvet Industry, Eternal University, Govt. Schools, HP State Science Council, Shimla. (2008-2017)
- Vermicompost-Technology transfer to Ayurvet Industry, Baddi, Solan, Himachal Pradesh (2010).
- Antimicrobials: Synthesis of small molecules and peptidomimetics as lead antimicrobial compounds.
- Bioreactor: Development of a novel bioreactor for plant tissue culture (patent applied).
- Diagnostic of Pathogens- Characterization of diarrhoeagenic pathogens in Himachal Pradesh
- Industrial Enzymes- Xylanases&Cellulases for application in paper pulp and biofuels industries
- Electronic waste resource recovery – Metal leaching technology to be transferred to formal e-waste recycling industries

10.7 Directorate of Mushroom Research, Solan - 173212

Latest achievements in the field of Biotechnology

Two non Browning strains and one high yielding strain of white button mushroom were developed (NBS-1, NBS-5 and U3-54) and released for commercial use.

Biotechnology products /process developed and transferred / to be transferred

Variety developed NBS-1, NBS-5 and U3-54.

Priority area of inter-institutional Co-Operation and coordination

Strategic and applied research on collection, conversation, utilization and production of edible and medicinal mushroom.

Infrastructure facility in different biotechnology laboratories of different institutes of Himachal Pradesh

The biotechnology laboratories of different institutions of Himachal Pradesh are well equipped to carry out modern research. A few of the high tech equipment available in these institutions are listed below.

- Fluorescent Microscopes
- HPLC (High Pressure Liquid Chromatography)
- Gas Chromatography
- Micro plate Spectrophotometers
- Scintillation Counter
- 5 KVA generator (soundproof, self-start)
- Automated nucleic acid isolation system
- Plant Bioreactor facility for in vitro production of metabolites as well as raw ingredient of industrially important medicinal crops
- TEM
- SEM
- DLS-Zeta
- UV-Visible Spectrophotometers
- Bioreactors
- Lyophilizer
- Gene analyser
- Gene Gun
- Q-Tof System
- Biorad CHEF-III System
- Tissue culture rooms
- Green house
- Gel DNA and protein running systems
- Cold room
- Gel documentation unit
- Horizontal and vertical gel electrophoresis
- Nanodrop UV-Vis Spectrophotometer

Fluorescent Microscope

Scintillation Counter

Micro plate Spectrophotometers

TEM

Plant Bioreactor

Biorad CHEF-III System

UV-Visible

Lyophilizer

DLS-Zeta

Experts of Biotechnology in Himachal Pradesh from various Institutes

Institute of Himalayan Bioresource Technology Palampur, Himachal Pradesh.

Name of Expert	Designation	Institution
Dr. Sudesh Kumar	Principal Scientist	IHBT- Palampur, [HP]
Dr. Ram Kumar Sharma	Principal Scientist	IHBT- Palampur, [HP]
Dr. Y. Sreenivasulu	Principal Scientist	IHBT- Palampur, [HP]
Dr. Rituraj Purohit	Senior Scientist	IHBT- Palampur, [HP]
Dr. Ravi Shankar	Scientist	IHBT- Palampur, [HP]
Dr.Yogendra S. Padwad	Scientist	IHBT- Palampur, [HP]
Dr.AmitabhaAcharya	Scientist	IHBT- Palampur, [HP]
Dr. Vishal Acharya	Scientist	IHBT- Palampur, [HP]
Dr. Kunal Singh	Scientist	IHBT- Palampur, [HP]
Dr. Ajay Rana	Scientist	IHBT- Palampur, [HP]
Dr. Rajiv Kumar	Scientist	IHBT- Palampur, [HP]
Dr. Ashish Rambhau Warghat	Scientist	IHBT- Palampur, [HP]
Dr. Mahesh Gupta	Scientist	IHBT- Palampur, [HP]
Dr. Dharam Singh	Senior Scientist	IHBT- Palampur, [HP]
Dr. Shashi Bhushan	Senior Scientist	IHBT- Palampur, [HP]
Dr. Amita Bhattacharya	Scientist E-II	IHBT- Palampur, [HP]

Himachal Pradesh- University, Shimla

Name of Expert	Designation	Institution
Prof. T.C. Bhalla	Scientist Emeritus	HPUniversity- Shimla, [HP]
Dr. Arvind Kumar Bhatt	Professor	HPUniversity- Shimla, [HP]
Dr. (Ms) Reena Gupta	Professor	HPUniversity- Shimla, [HP]
Dr. S.S. Kanwar	Professor	HPUniversity- Shimla, [HP]
Dr. Duni Chand	Professor	HPUniversity- Shimla, [HP]
Dr. Wamik Azmi	Professor	HPUniversity- Shimla, [HP]
Dr. Savitri	Asstt. Professor	HPUniversity- Shimla, [HP]

Central Potato Research Institute, Shimla (Himachal Pradesh)

Name of Expert	Designation	Institution
Dr. SK Chakrabarti	Director & Principal Scientist	CPRI- Shimla, [HP]
Dr. Jagesh Kumar Tiwari	Scientist (Senior Scale)	CPRI- Shimla, [HP]
Mr. Hemant Kardile	Scientist, Biotechnology	CPRI- Shimla, [HP]
Mr. VU Patil	Scientist, Biotechnology	CPRI- Shimla, [HP]
Dr. Vinay Bhardwaj	Principal Scientist,	CPRI- Shimla, [HP]
Dr. Sundaresha S	Scientist (Senior Scale),	CPRI- Shimla, [HP]
Dr. Shashi Rawat	Sr. Scientist	CPRI- Shimla, [HP]
Dr. Som Dutt	Sr. Scientist	CPRI- Shimla, [HP]
Dr. G Vanishree	Scientist	CPRI- Shimla, [HP]
Dr. Baswaraj R	Scientist (Senior Scale)	CPRI- Shimla, [HP]
Dr. Ravinder Kumar	Scientist	CPRI- Shimla, [HP]
Dr. Vinay Sagar	Senior Scientist	CPRI- Shimla, [HP]
Dr. Sanjeev Sharma	Senior Scientist	CPRI- Shimla, [HP]
Dr. Brajesh Singh	Principal Scientist & Head	CPRI- Shimla, [HP]
Dr. Aarti Bairwa	Scientist	CPRI- Shimla, [HP]
Dr. Tanuja Buckscth	Scientist	CPRI- Shimla, [HP]
Dr. RK Singh	Head & PS	CPRI- Shimla, [HP]
Dr. Salej Sood	Scientist	CPRI- Shimla, [HP]

Dr. Y S Parmar UHF, Nauni , Solan (H.P)

Name of Expert	Designation	Institution
Dr. (Mrs.) Amarjit K. Nath	Professor & Head	UHF Nauni- Solan, (HP)
Dr. (Mrs.) Nivedita Sharma	Professor	UHF Nauni- Solan, (HP)
Dr. (Mrs.) Poonam Shirkot	Professor	UHF Nauni- Solan, (HP)
Dr. (Mrs.) Manju Modgil	Professor	UHF Nauni- Solan, (HP)
Dr. (Mrs.) Sunita	Assistant Professor	UHF Nauni- Solan, (HP)
Dr. (Mrs.) Rajinder Kaur	Professor	UHF Nauni- Solan, (HP)
Dr. Rajnish Sharma	Assistant Professor	UHF Nauni- Solan, (HP)
Dr. (Ms.) Manisha Thakur	Assistant Professor	UHF Nauni- Solan, (HP)
Dr. (Ms.) Sneh Lata Sharma	Assistant Professor	UHF Nauni- Solan, (HP)

Experts of Biotechnology in Himachal Pradesh from various Institutes

CSKHPKV- Palampur, Himachal Pradesh

Name of Expert	Designation	Institution
Dr. T. R. Sharma	Professor & Head	CSKHPKV- Palampur, [HP]
Dr. K. D. Sharma	Professor	CSKHPKV- Palampur, [HP]
Dr. R. K. Kapila	Associate Professor	CSKHPKV- Palampur, [HP]
Dr. R. Rathour	Assistant Scientist	CSKHPKV- Palampur, [HP]
Dr. Y P Thakur	Professor	CSKHPKV- Palampur, [HP]
Dr. Varun Sankhyan(Animal Genetics)	Assistant Professor	CSKHPKV- Palampur, [HP]
Dr. Subhash Verma	Associate Professor	CSKHPKV- Palampur, [HP]

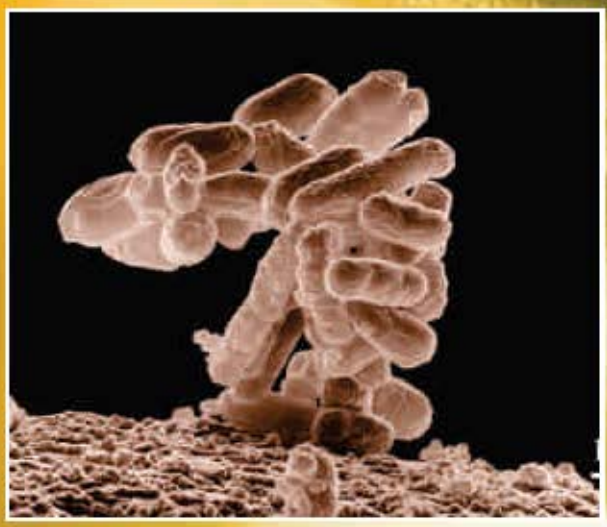
Directorate of Mushroom

Name of Expert	Designation	Institution
Dr. O.P Alahawat	Principal Scientist	ICAR - DMR
Dr. Anupam Barh	Scientist	ICAR - DMR, Solan

Issues and Challenges:

The issues and challenges suggested by various R&D Institutes in the state is listed below so that action related to address these issues and challenges are initiated to promote Biotechnology in the larger public interest.

- State has an urgent need to increase agriculture based products to meet the growing demands under the constraints of depleting natural resources and environmental fluctuations in the state.
- Year after year problems are becoming more intense thereby highlighting the need to focus research on areas like temperature tolerance, disease resistance and quality production of grain, food and horticultural products, etc.
- Despite intensive work by scientists on generation of endangered medicinal plants of particularly, higher reaches of Himalayas, the plants continue to suffer from indiscriminate uprooting and illegal trading.
- Active research in the educational institute that involves approaches, such as, plant biotechnology based approaches and stress biology, healthcare biology, identification of responsive genes/alleles, followed by mutant analysis or transgenic approaches to assign the function of specific gene or its product protein is the new tool to deal with this issue.
- Development of heat tolerant genotypes in the biotechnology research lab is the cheapest means of combating the heat and high temperature stress. New lines should be developed having high yielding attribute in addition to their adaptability to warmer climates.
- Quality seed production.
- Herbicides have a major disadvantage of killing the main plant varieties along with the weeds, which result into greater loss, which is directly or indirectly affect the farmer. Herbicide tolerant varieties provide new options for the control of major weeds, which are constraining agricultural production, Herbicide tolerant verity can be developed in the state by promoting the research in biotech research laboratory.
- Early diagnosis of infectious diseases and effective control of pathogens and safe disposal of waste by microbial interventions.
- Major health care issue in the state is related with lack of awareness; majority of patient seeks consultation only, when the disease is already at an advance stage. To overcome the above challenges, there is an urgent need of research to develop cost effective biomedical devices (based on tissue engineering or nano biotechnology or animal biotechnology) for early diagnosis and treatment of disease in the rural area.
- Blend of innovative research approaches can improve the drowning conditions in the future.
- There is no system in place to take the biotechnology products to the industry due to absence of linkages and partnership development.
- Limited opportunities in Biotechnology in the State.
- Genetic transformation for biotic/ abiotic stress tolerance
- Cloning of genes from various organisms
- Genetically engineered microorganisms



HIMACHAL PRADESH
SHIMLA-171002

"Attaining new heights in biotechnology research, shaping biotechnology into a premier precision tool of the future for creation of wealth and ensuring social justice-specially for the welfare of the poor"

Department of Environment, Science and Technology
Govt. of Himachal Pradesh

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