Biotechnology: An Editorial Overview

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1 Historical Background

"Biotechnology" is considered as a broad area of biology, which depends on the living systems to develop or make products. Biotechnology has expanded to different fields in the late-twentieth and early twenty-first centuries by the successful implementations of genomics, recombinant gene technologies, immune techniques, emerging therapeutic approaches, and diagnostics. There is a closely similar or overlapping field to biotechnology is bioengineering, however, bioengineering mainly emphasizes higher system approaches. Therefore, bioengineering is the application of engineering and natural science to tissues, cells and molecules; and such studies are likely to improve the functions of plants and animals. The term biotechnology has been defined in different angles as shown below (SLH, 2010; Verma et al., 2011; Wikipedia, 2021):

> *Production of products from raw materials with the aid of living organisms—Biotechnology*—Karl Ereky, 1919.

> *Application of biological organism, systems, or processes by various industries to learning about the science of life and the improvement of the value of materials and organism such as pharmaceuticals, crops, and livestock*—American Chemical Society.

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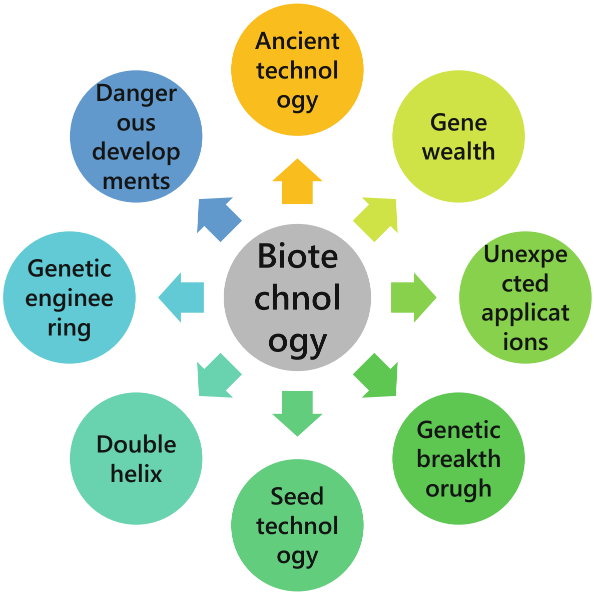
N. R. Maddela, L. C. García (eds.), *Innovations in Biotechnology for a Sustainable Future*, https://doi.org/10.1007/978-3-030-80108-3_1

Fig. 1 Advances in biotechnology



Biotechnology is the integration of natural science and organism, cells, parts, therefore, and molecular analogues for products and services—European Federation of Biotechnology.

The use of living things to make products—American Association for the Advancement of Science (AAAS).

Any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use—Convention on Biological Diversity.

The application of science and technology to living organisms, as well as parts, products and models therefore, to alter living or non-living materials for the production of knowledge, goods and services—Organization for Economic Cooperation and Development (OECD).

According to the growth in human population and their needs, biotechnology incorporates a wide range emerging and innovative techniques and procedures for the modification of living systems, these include but not limited to nano techniques, genetic engineering, cell and tissue culture procedures. According to the developments and achievements in biotechnology with time (Fig. 1), biotechnology can be classified into three stages: (1) Ancient Biotechnology, (2) Classical Biotechnology, and (3) Modern Biotechnology (Verma et al., 2011). *Ancient Biotechnology* belongs to the period before the year of 1800; main breakthroughs in this era were based on the basic observations about nature which could help in the improvisation of human life during this period. One of the historical developments in the Ancient Biotechnology period was fermentation technology. The *Classical Biotechnology* period belongs to the year 1800 to mid of twentieth century. The main achievements in the period were; discovery of laws of inheritance by Gregor John Mendel in 1865,

Table 1 Major inventions in Medical Biotechnology the period 2000–2020 (Timeline, 2021)

Year	Achievement
2001	Human genome sequence draft created by Ceiera Genomics and Human Genome project.
2002	Compete genome of rice has been decoded, and it becomes the first crop to have its genome decoded.
2003	Location and sequence of human genes on all 46 chromosomes has been completed.
2008	First Medical Experiment Module (Kibo) has been launched by Japanese astronomers; Kibo will be used on the ISS (International Space Station).
2009	Modified SAN heart genes were used by Cedars-Sinai Heart Institute to create the first viral pacemaker in experimental animal i.e., guinea pigs.
2012	A nervous system-controlled bionic leg was successfully used to climb the Chicago Willis Tower.
2019	A new method of genetic engineering i.e., Prime Editing has been described which is superior than CRISPR.
2020	3D bioprint graphene oxide with a protein has been developed.
	Development of synthetic red blood cells
	Human thymus was produced by using stem cells and a bioengineered scaffold.
2021	A tenfold effective super-bug targeting formicamycin antibiotic has been produced by using CRISPR/Cas9 genome.

theory of evolution by Charles Darwinin 1858, nucleus in cells by Robert Brown in 1831, DNA as a genetic material and its role of DNA in the transfer of genetic information by Fredrich Miescher in 1869, first ever solid medium for culturing microorganisms by Robert Koch in 1881, principle of genetics in inheritance and theory of gene by T.H. Morgan in 1910, world's first antibiotic i.e., penicillin by Alexander Flemming in 1928, etc. The *Modern Biotechnology* era belongs to the period after mid-twentieth century. Hallmarks of this period include the discovery of double helix model of DNA by JD Watson and FHC Crick in 1953, concept of operon by Jacob and Monad in 1961, synthesis of DNA in test tube by Karl Mullis in 1983, animal cloning by Ian Wilmut in 1996, etc. Likewise, research related to modern biotechnology has led to many breakthroughs in medicine such as transgenics, monoclonal antibodies, vaccines, antibiotics, human genome projects etc. (Table 1).

2 Scope and Branches of Biotechnology

Biotechnology has a marked impact on different aspects of human welfare including food processing, protecting the environment and human health. The principal scope of biotechnology is as follows:

- Sustainable food production by using available land to meet the demand of a growing population.
- Search for disease-resistant and high-yield crop varieties.

- Introducing harmless biofertilizers and subsequently minimize the use of harmful chemical fertilizers.
- Integrated pest management by introducing biocides in agriculture.
- Preservation of germplasm of higher (plants and animals) and lower organisms (microorganisms).
- Production of sustainable pharmaceutical products for the treatment of life-threatening diseases in humans and animals.
- Production of biofuels in order to discourage deforestation which is a common practice fuel wood.
- Achieving sustainability in food safety by means of microbiological applications.
- Highlight the environmental applications of microorganisms such as extraction of minerals for poor quality ores, remediation of contaminated sites, production of microbial based nanomaterials, etc.

Keeping in view of above scope, principally biotechnology has the following branches—Industrial Biotechnology, Agricultural Biotechnology, Environmental Biotechnology, Medical Biotechnology. *Industrial biotechnology* deals with the activities related to production of different organics (such as acetic acid, citric acid, acetone, glycerin, antibiotics etc.) that have significant importance in the medicine and other areas (e.g., food industry). *Agricultural biotechnology* emphasizes on the development of transgenic plants with a better resistance to the biotic and abiotic stress factors, development of haploids, rescue of embryos, multiplication of clones, cryopreservation, mitigation of plant diseases by using biological agents (e.g., virus, bacteria, fungi, etc.). *Environmental biotechnology* deals with various aspects such as detoxification of waste and industrial effluents, treatment of water, and wastewater, etc. (Kuppusamy et al., 2020b; Maddela et al., 2021). Whereas the areas of *Medical biotechnology* including but not limited to diagnosis of diseases, large-scale production of drugs, antibiotics, hormones, and vaccines.

3 Outlines of the Volume: Parts, Chapters

This volume consists of five parts—(I) Biotechnology overview, (II) Industrial biotechnology, (III) Agricultural biotechnology, (IV) Environmental biotechnology, and (V) Medical biotechnology. Two chapters have been included under the part of "Biotechnology Overview." Chapter "Biotechnology: An Editorial Overview" is an "Editorial Overview" where we intended to briefly discuss the purpose of this volume and its salient features. Chapter "Biotechnology of Twenty-First Century" emphasizes on different topics such as major advances in biotechnology between 2000 and 2020, benefits due to advances in biotechnology, global research in biotechnology, and expansion of biotechnology in the private and public sector. Additionally, this chapter has tried to focus on different branches of biotechnology. There is in-depth information on the components and importance of environmental biotechnology, importance of biotechnological applications in bioremediation and phytoremediation, mitigation of pollution in different components of the environment (air, water, and soil). There is also focus on the importance of biotechnology in plant growth and yield, different agricultural engineering techniques (such as breeding techniques, genetic engineering approaches, organic farming practices), and global food security. In this chapters, information related to Industrial biotechnology has also been provided, where an in-depth review of literature has been done related to industrial products and food/dairy industry. Toward the end of this chapter, there is information on biotechnological advances in pharmaceutics, vaccinology, and emergence of novel methodologies. Finally, challenges and knowledge gaps for the future developments in biotechnology have been discussed. It is important to note that a very recent literature review has raised a doubt that is organic produce is free from the environmental contaminants (Ramakrishnan et al., 2021), which implies that the available biotechnological practices in organic farming should be revalidated.

Part II of this volume belongs to Industrial Biotechnology, which has been designed by incorporating five chapters (chapters "Enzymes from Microorganisms", "Biotechnological Applications of Essential Oils: Post-harvest and Food Preservation", "Use of Waste from the Citrus Industry for the Production of Unicellular Biomass", "Organic Waste: A Cheaper Source for Probiotics Production", "Agro-Industrial Waste as an Option for the Sustainable Development of Bioplastic") with recent advances in the respective domain. Chapter "Enzymes from Microorganisms" has paid special attention toward proteases, such as exopeptidases, endopeptidases, cysteine proteases, distribution and sources of proteases, microbial proteases, and applications of proteases in different industries (e.g., detergent, leather, food and feed, silk degumming, photographic, pharmaceutical, and biofuels). Nevertheless, this chapter highlights the microbial proteases over plant and animal counterparts. It is noteworthy that proteases have significant importance in the therapeutic uses (Xue et al., 2021), plant diseases control (Wang et al., 2020b), industrial applications (Barzkar, 2020), etc. Chapter "Biotechnological Applications of Essential Oils: Postharvest and Food Preservation," was intended to provide information on the following parameters—food preservation, essential oils as food preservatives, food biotechnology, conventional and emerging methods of essential oil extraction, essential oils and their biotechnological applications in postharvest, physicochemical parameters of essential oils, essential oils as secondary metabolites, and antimicrobial activities of essential oils. Overall, this chapter compiles information on the biotechnological applications of essential oils to reduce the proliferation of microorganisms that cause foodborne diseases and that decrease the shelf life during storage of the fruits. Nowadays, there is a significant attraction toward plant essential oils for a food safety (Bhavaniramya et al., 2019; Chen et al., 2021a; Zhu et al., 2021). Chapter "Use of Waste from the Citrus Industry for the Production of Unicellular Biomass" deals with the production of unicellular biomass from the waste of the citrus industry. The main contents of this chapter include treatment of lignocellulosic materials, chemical composition of citrus peel powder, growth kinetics and fermentation by *Candida utilis*, and optimization. Overall, this chapter provides useful insights in understanding the viability of using orange peel residues as a substrate for the production of unicellular biomass of *C. utilis*, thus this chapter highlights the reuse of green waste as sustainable substrate in fermentation technology. It should be remembered that biomass production is a sustainable way to achieve bioeconomy (Antar et al., 2021), hence, there is a much attention on the reuse of waste for biomass production (Wang et al., 2020a; Makaroglou et al., 2021; Shahid et al., 2021). Chapter "Organic Waste: A Cheaper Source for Probiotics Production" emphasizes on the production of probiotics by using organic waste as an economical substrate. The chapter starts with a brief overview on organic wastes and probiotics, then this chapter emphasizes on the different organic wastes (e.g., agricultural wastes, waste from vegetable processing, dairy wastewaters, fish processing wastes, fermented silages, waste from meat processing, municipal wastes) as substrate for probiotic production. Likewise, this chapter deals with various sources of organic wastes which can be used as cheaper sources for production of different kinds of probiotics; this could have significant importance in the sustainable production of probiotics (Ashayerizadeh et al., 2017; Vodnar et al., 2019). Chapter "Agro-Industrial Waste as an Option for the Sustainable Development of Bioplastic" is related to the production of bioplastics from agro-industrial wastes. The main contents of this chapter include consumer society versus sustainable production, valorization of agro-industrial waste, biorefineries and transformation processes, and the futurity of bioplastics. On the whole, this chapter addresses the use of agro-industrial waste as second-generation raw material, to obtain bioplastics through sustainable processes that have characteristics similar to traditional plastics, capable of meeting the various needs of use existing in the market. In the recent time, there is a much attention toward bioplastic production of different waste substrates (Tsang et al., 2019; Jõgi & Bhat, 2020; Khatami et al., 2021).

Part III of this volume belongs to the Agricultural Biotechnology, which includes three chapters (chapters "Flow and Distribution of Phosphorus in Soils from a Geochemical and Agronomic Approach", "Environmental Factors Enhance Production of Plant Secondary Metabolites Toward More Tolerance and Human Health: Cocoa and Coffee Two Model Species", "Diversity and Ecology of Arbuscular Mycorrhization Fungi"). Chapter "Flow and Distribution of Phosphorus in Soils from a Geochemical and Agronomic Approach" deals with the flow and distribution of phosphorus in soils as studied by geochemical and agronomic approaches. The focused areas of this chapter include residual effect of phosphorus in soils, phosphorus shapes (organic and inorganic) in soils, fractionation of phosphorus contained in soils, and considerations for studies of phosphorus fertility of soils. Overall, this chapter concludes that agronomic availability of phosphorus, which is estimated through routine laboratory methods, is the result of the distribution and subsequent balance of phosphorus added between the fractions that make up phosphorus in soils. Levels of phosphorus in soil have significant influence on crop yield (Mian et al., 2021; Waani et al., 2021), therefore it is necessary to characterize the flow and distribution of phosphorus in agricultural soils. Chapter "Environmental Factors Enhance Production of Plant Secondary Metabolites Toward More Tolerance and Human Health: Cocoa and Coffee Two Model Species" provides insights on the impact of environmental factors in enhancing the production of plant (cocoa and coffee) secondary metabolites toward tolerance and human health. The contents of this chapter include stress and plant responses, secondary metabolites in plants, production of secondary metabolites under environmental cues and stress, and multifunctionalities of secondary metabolites. Finally, there is a special emphasis on the cocoa and coffee as model species for potential secondary metabolites production and adaptations. Overall, this chapter concludes that cacao and coffee are two plant models having known SMs with pharmaceutical/medicinal/nutritional values that make them tolerant to adverse conditions and positively produced upon plant exposure to stress. Characterization of plant secondary metabolites is one of the active research areas in the field of medicine (Kongkham et al., 2020; Mahajan et al., 2020; Ogbe et al., 2020). Chapter "Diversity and Ecology of Arbuscular Mycorrhization Fungi" deals with the following topics—arbuscular mycorrhizal fungi (AMF), systematics (taxonomy) of AMF, and diversity and ecology of AMF. Overall, this chapter emphasizes on some groups of taxonomists of AMF and some morphological characteristics such as a group of walls, shapes, color, etc., of this group of fungi., as well as its diversity and ecology of this symbiosis in natural ecosystems and agroecosystems. AMF is one of the key elements in the soil fertility and plant growth by minimizing the stress (biotic and abiotic), hence research lines in the area of AMF are always in trending (Riaz et al., 2021; Shen & Zhu, 2021; Zhao et al., 2021).

Part IV of this volume consists of six chapters (chapters "Microbial Reductive Dehalogenation and Its Role in Bioremediation", "Microbial Capacities for Utilization of Nitroaromatics", "Microbial Interaction with Metals and Metalloids", "Microbial Remediation of Pharmaceuticals and Personal Care Products", "Biodetoxification of Toxic Heavy Metals by Marine Metal Resistant Bacteria: A Novel Approach for Bioremediation of the Polluted Saline Environment", "Generalities of the Coagulation-Flocculation Process: A Perspective on Biocoagulants") which are related to Environmental Biotechnology. Chapter "Microbial Reductive Dehalogenation and Its Role in Bioremediation" deals with microbial reductive dehalogenation and its role in bioremediation. This chapter presents the following topics—mechanism of reductive dehalogenation, aerobic growth on halogenated aliphatic and aromatic compounds, halorespiration, factors influencing the dichlorination of polychlorinated biphenyls (PCBs), molecular aspects of dehalogenase gene, genomic diversity of dehalorespiration, PCB-dehalogenating bacteria and consortia, and acquisition and distribution of dehalogenase genes. Overall, this chapter focuses on the types of halo-organic compounds that have become a significant, potent, theoretically significant soil pollution, to be bioremediated. Microbial reductive dehalogenation is one of the principal mechanisms in the restoration of organohalide-contaminated sites (Nijenhuis & Kuntze, 2016; Lu et al., 2021). It is important to note that the remediation of contaminated media is always challenging, and contaminants can only be removed at field level with proper lab- and plot-scale level experiments (Maddela et al., 2015a, b; Kuppusamy et al., 2020a). Chapter "Microbial Capacities for Utilization of Nitroaromatics" is intended to provide latest insights on anaerobic and aerobic biodegradation of nitroaromatics, degradation pathways at molecular level, challenges in the biodegradation, a special emphasis on the biodegradation of selective nitroaromatics such as nitrobenzoate, nitrobenzaldehyde, trinitrotoluene, and chloronitrobenzene, microorganisms degrading nitroaromatics, and their genetics. It is noteworthy that nitroaromatics are important environmental contaminants that are released and have toxic effects on ecosystems; and microbial utilization capacities for nitroaromatics under aerobic conditions is presented in this chapter. Microbial removal of nitroaromatics is one if the active research areas in the bioremediation (Tiwari et al., 2020; Luo et al., 2021). Chapter "Microbial Interaction with Metals and Metalloids" presents latest insights on microbial interactions with metals and metalloids. Topics that are covered in this chapter include types and levels of microbial interactions with metals and metalloids, natural occurrences of interactions, metal–microbes interactions, bioremediation by adsorption, biosorption, natural occurrences of metal–microbe interaction, metal mobilization and immobilization, metal tolerance and resistance in microbes, molecular insights on microbial interactions with the selected metals, and biological remediation of selected metals. The main conclusions of this chapter are—heavy metals are an essential and important trace element, but as these heavy metals increase in concentration due to natural or industrial activities, they become toxic to many microbes; on the other hand, microbes have adapted to tolerate minerals or can even use them for grow; hence this interaction between microbes and minerals on environmental matrices is an essential part of the Earth's biogeochemical cycle. Microorganisms present in the crude oil-polluted soils have great potential to absorb heavy metals (Maddela et al. 2015a), and understanding over the interactions between microorganisms and metals will help in the development of an efficient strategies for the remediation of metals-contaminated sites (Yu et al., 2020). Also, there is a great threat to the ecosystem and human health due to the presence of heavy metals in the soil (Maddela et al., 2020b). Chapter "Microbial Remediation of Pharmaceuticals and Personal Care Products" deals with the microbial remediation of pharmaceuticals and personal care products (PPCPs). In this chapter, there is a special attention on biosorption of PPCPs, role of bacteria, fungi and plants in the remediation of PPCPs-contaminated sites, biodegradation of pharmaceutical compounds, pure and mixed culture studies, and toxic effects of PPCPs. The main conclusion of this chapter is that PPCPs have adverse toxic effects on ecosystems, as well as human health, therefore, it is essential to remediate the PPCPs-contaminated sites by using novel microorganisms. There is a great concern about the toxicity of PPCPs, hence there is a continuous search for the development of emerging bioremediation techniques (Kang et al., 2021). Chapter "Biodetoxification of Toxic Heavy Metals by Marine Metal Resistant Bacteria: A Novel Approach for Bioremediation of the Polluted Saline Environment" is about biodetoxification of toxic heavy metals by marine metal resistant bacteria; and in this direction, this chapter mainly highlights the sources, toxic effects and microbial detoxification of selected heavy metals in the marine ecosystem, The principal conclusions of this chapter are: heavy metals are generally toxic to the body at very low level; the main mechanism of heavy metal toxicity include the generation of free radicals to cause oxidative stress, damage of biological molecules such as enzymes, proteins, lipids, and nucleic acids, damage of

DNA which is key to carcinogenesis as well as neurotoxicity; microbes have various mechanisms of metal sequestration that hold greater metal biosorption capacities; and several microorganisms like bacteria, fungi, and algae have been used to clean up heavy metal contaminated environments. Several microbial systems have been identified for the effective removal of heavy metals in the marine system (Poo et al., 2018; Chen et al., 2021b; Djinni & Djoudi, 2021). Chapter "Generalities of the Coagulation-Flocculation Process: A Perspective on Biocoagulants," is intended to provide in depth insights on colloidal systems, and fundamentals and kinetic aspects of coagulation-flocculation. Overall, the rationale of this chapter is—water treatment is a necessity for social and industrial development; coagulation-flocculation is a fundamental process for the reduction of colloidal particles present in the water to be treated. The use of synthetic coagulants in effluent or wastewater treatment leads to a high production of nonbiodegradable sludge and water containing trace elements that are harmful to ecosystems. Therefore, biocoagulants are a very efficient alternative that produces a low volume of sludge and has no harmful effects on flora or fauna. Now a days, biocoagulants are widely used in the restoration of contaminated media (Frantz et al., 2020; Miyashiro et al., 2021).

Finally, four chapters (chapters "Drug Resistance Mechanism in *Staphylococcus aureus*", "Anticancer Secondary Metabolites Found in Native Ecuadorian Plant Species *Uncaria tomentosa* DC. (Rubiaceae), *Croton lechleri* Müll. Arg. (Euphorbiaceae), and *Equisetum giganteum* L. (Equisetaceae)", "The Carao (*Cassia grandis* L.): Its Potential Usage in Pharmacological, Nutritional, and Medicinal Applications", "Challenges and Future Prospects of Biotechnology") have been included under Part V, and this part is about Medical Biotechnology. Chapter "Drug Resistance Mechanism in *Staphylococcus aureus*" focuses on risk groups, epidemiology, genetic mobile components and *S. aureus* genome, plasmids encode antibiotic resistance, action of antibiotics and mechanism, kinetic mechanism of resistance of *S. aureus* to penicillin, methicillin, Biofilms and antibiotic resistance, and quorum sensing. Overall, this chapter provides in depth insights over the drug resistance mechanism of MRSA (Methicillin-resistant *Staphylococcus aureus*) at the molecular level is of great importance for the treatment of *S. aureus* infections. MRSA is one of the potential bacterial pathogens which is difficult to control, hence, it is always hot-topic in the area of medical microbiology/biotechnology (Hemeg, 2021; Yeager et al., 2021). Furthermore, now a days, quorum sensing and quorum quenching related research is giving much importance (Maddela et al., 2019, 2020a; Maddela & Meng, 2020) as these strategies offer several advantages in the mitigation of biofilm-mediated problems. Chapter "Anticancer Secondary Metabolites Found in Native Ecuadorian Plant Species *Uncaria tomentosa* DC. (Rubiaceae), *Croton lechleri* Müll. Arg. (Euphorbiaceae), and *Equisetum giganteum* L. (Equisetaceae)" is about anticancer secondary metabolites of native Ecuadorian plant species, and the contents of this chapter include detailed description on secondary metabolites (such as alkaloids, terpenoids, phenols), native plant species (*Uncaria tomentosa* DC, *Croton lechleri* Mull. Arg, *Equiseum giganteum* L.) that yield secondary metabolites with anticancer properties. Overall, this review is useful to have a better understanding of the different characteristics, diversity, and concentration of secondary metabolites present in these plants, its biological activity as a therapeutic agent and potential use for medical purposes against diseases such as cancer. There are several plant secondary metabolites have been emerged with anticancer properties (Alzandi et al., 2021; Ramakrishna et al., 2021). Chapter "The Carao (*Cassia grandis* L.): Its Potential Usage in Pharmacological, Nutritional, and Medicinal Applications" is about the potential usage of *Cassia grandis* L. in pharmacological, nutritional, and medicinal applications. This chapter focuses on bioactive compounds and its properties, extraction and characterization techniques of phenolic compounds, antioxidant activities, and proximal analysis. Likewise, this chapter summarizes its chemical composition and describes its potential nutritional, pharmacological, and medicinal applications. Due to its proximal, mineral, and bioactive compounds content, the *Cassia grandis* L. fruit is considered a potential functional and nutraceutical food, which can be used as an active ingredient for the fortification and enrichment of foods in people with special diets. Very recently, several studies have been focused on *Cassia grandis* fruit extract for its pharmacological and medicinal implications (Prada et al., 2018; Lafourcade Prada et al., 2020). Chapter "Challenges and Future Prospects of Biotechnology" is considered as a concluding chapter of this volume, and it mainly highlights the challenges and future directions of Biotechnology for a sustainable future.

4 Contributors

As this volume has been designed to publish the selected papers of IV Convención Científica Internacional de la Universidad Técnica de Manabí (CCIUTM 2020) Ecuador, most of the contributors are the participants of this event. Overall, the contributors of all 20 chapters are subject experts in their concerned chapters. Professionally, contributors are academicians and scientists and are geographically belonging to different regions. Overall, 67 contributors of 12 countries (Argentina, Brazil, Chile, Colombia, Ecuador, Honduras, India, Iran, Mexico, Nigeria, Spain, USA) have been involved in this volume. We strongly believe that this volume could be a single source of information that provides latest insights several emerging topics of in the domain of industrial-, agricultural-, environmental-, and medical biotechnology.

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