Appendix

General Table of Roadmap for Science and Technology Development of Bio-hylic and Biomass Resources

Strategic path and targets			Phases and goals		
			2009 to 2020	2021 to 2035	2036 to 2050
Photosynthesis mechanisms and increasing photosynthetic efficiency of energy plants	**In theory**	To make major original breakthroughs: discovery of the mechanisms and regulation laws of highly efficient photosynthesis energy transformation; discovery of the relevant functional genes and regulation mechanisms of photosynthesis energy transformation efficiency.	√		
		To continue an in-depth research on the molecule mechanism for improving the utilization efficiency of light energy in photosynthesis of major crops and energy plants, achieve breakthroughs in theory, and apply the results to practice.		√	
		To provide a theoretical foundation, new concept, new technologies and approaches for genetic improvement of light energy utilization efficiency of crops (including energy plants) and utilization of solar energy.			√
	In applied	To improve the utilization efficiency of light energy by 10–20% in major crops including rice and wheat.	√		
		To improve the utilization efficiency of light energy by 100% in major crops (energy plants included) and increase the yield per unit accordingly.		√	
		To provide a sound theoretical foundation for R&D in agriculture and biology, as well as a support system for high-and-new technology.			√

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Strategic path and targets			Phases and goals		
			2009 to 2020	2021 to 2035	2036 to 2050
Biomass energy and energy plants	**National demand-driven path**	**Till 2020** ① Important species' genetic, information analysis plan and information platform construction. ② Important species' breeding, improvement program and genetics & breeding platform establishment. ③ Research program about efficient energy's transfer and storage of important species.	① Industrial planning based on energy plant resource reserves and ecological regionalization. ② Defining core germplasm resources& establishing industry platform system. ③ Exploitation & research of model genetic resources and model organisms, scientific basis & technical design for exploitation and sustainable utilization of biological resources. ④ Exploitation efficiency of available genes, breeding innovation, new varieties' creation, energy plant varieties with independent intellectual property, providing basic biological research, securing source material supply. ⑤ Formation of energy plant industry with Chinese characteristics.	① Realizing international high end of energy plant basic research; Being a strong country for source resources in global bioenergy field. ② Biological resources utilization, establishing theoretical and technical system of new genetic resources. ③ Developing bioenergy and biobased products dominating the world market. ④ Forming new biomass energy industry chain, developing the model of comprehensive utilization and balanced development.	Energy plant's comprehensive utilization system, high value added products R&D and industrialization.
		Till 2035 ① Establishing theoretical and technical system of Chinese special energy plant resource exploitation and sustainable use. ② Developing high-tech industry with new species, new germplasms, new genes. ③ Developing large-scale emerging energy industry towards special biological products of marginal land resource.			
		Till 2050 Energy plant's large-scale production forming new eco-industry; realizing large-scale development of biomass energy and biobased products.			
	Scientific research system deploy-driven path	**Till 2020** ① Energy plant resource reserves & ecological regionalization. ② Energy plant resource collection and evaluation, establishing database. ③ Large-scale cultivation technology, ecological effects and economic evaluation.			
		Till 2035 ① Illustrating energy plant's energy enrichment mechanism by Modern analytical techniques and multidisciplinary integration theories. ② Elucidating genetic and growth mechanisms. ③ Genome structure variability. ④ Formulating specific genes and functions forming and plant resistance genetic mechanism.			
		Till 2050 ① Theoretical system of energy plant's energy enrichment regulation. ② Establishment of directed Improvement technology system.			

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Strategic path and targets		Phases and goals		
		2009 to 2020	2021 to 2035	2036 to 2050
Exploitation and utilization of microbial resources	① To develop biosynthesis tech chemicals including chemical and medical raw materials, chiral compounds, functional sugar. ② To study molecular mechanism of directed transfer in organisms and its enzyme, assemble new molecular machine, develop new biosynthesis. ③ Through enzyme or whole-cell catalyst technology to produce new biological products in order to replace chemical synthesis which is complex. ④ To screen and assess current resources of microorganism bacteria in China, and integrate conservation and utilization to fully develop and utilized microorganism resource rationally.	√		
	① To develop bacteria and fermentation process. They can be used to produce biological resource and bio-based chemicals which synthesized by biomass or lignocellulose, to excavate bacteria which can fix CO_2 and produce bulk commodities. ② To develop environmental-friendly biological processes like bio-textile, bio-leather, bio-papermaking and clean fech in order to reduce pollution. ③ To simulate functions of microorganism to develop biological oil, biometallurgy, and biodegradation. ④ To excavate bacteria and enzyme used to degrade lignocellulose efficiently and degrade organic hydro carbons, toxic and radioactive substances in high-acid, high alkaline, high-salt environment. ⑤ Set element genomic library for microorganism breeding in typical and extreme environment, full-fledge high-throughout screening tech to screen bioactive natural products from microorganism.		√	
	① To establish the metabolism simulation based on digital cells and to construct engineered cells and new cell plants in order to synthesize artificial cells, develop low-cost fermentation technology of rare bioactive substances. ② To study functional and structural features of biomass, take advantage of computer to design the structure and improve manufacture method of new biology materials, set assessment system for medical biological materials and expand new products. ③ To study genetic information, metabolism, fermentor signal, material and energy transfer of industrial microorganism, develop self-regulatory fermentation technology and intelligent bioreactor of microorganism. ④ To study calculation of protein science and directed design of enzyme, build structure of protein sequence and function forecast tech to simulate protein catalyst, design and synthesize artificial enzyme and molecular machine, then synthesize special chemicals which not available now.			√

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Strategic path and targets			Phases and goals		
			2009 to 2020	2021 to 2035	2036 to 2050
Exploration and sustainable utilization of strategic bioresources	**National demand-driven path**	**Till 2020** ① Centurial inventory, reserves assessment and innovative capacity-building of bioresources. ② National plans for genome conservation, gene and function discovery and genetic improvement of strategic bioresources.	① Primary bioresources supports to nine main fields of bioindustry; R&D model genes and organisms resources, platforms/systems set up; development of bioindustries with featured bioresources and competitive edge; outputs of new varieties and bioproducts with independent intellectual property rights. ② Scientific basis and high-tech design of exploration and sustainable use of bioresources; multi-discipline integrative research ranging populations-individual-cell-genome-functional genes; crossing sciences and tech integration to upgrade discovery efficiency of useful genes through cross, innovate germplasm and new variety development.	① To upgrade China a leading position in fundamental bioresources R&D platforms of modern life science and biotech and achieve China becoming a global power of strategic bioresources to sustain our nation's industries in agriculture and forestry, bio-energy, natural drug, bio-manufacturing, bio-environment protection. ② To realize balanced development model bioindustries in harmony of ecology, environment and agriculture. ③ To create a leading global market of high value added bioproducts with independent intellectual property rights. ④ To develop theoretical and high tech design and system for use of bioresources, excavation of new gene resources and leading bioactive molecule. ⑤ Scientific advances in breakthrough of understanding essence of biological phenomenon and evolutionary rules, including knowledge of the changing and evolutionary rules of genome in life evolution process. ⑥ To set up integrative countermeasures system based on theoretical and applied high tech advances in temporal-spatial dynamics of bioresources and global climate change biology, as well as reducing CO_2 emission.	① Upgrade recycling utilization system of bioresources and high value added bioproducts for new frontier industry. ② High-end bioproducts created through realization of directional controlled regulation of specific metabolic pathways, bio-part assembly, bioengineering industrialization of artificial cells, organs and even bio-life-machines ultimately to meet the elevated physical and spiritual needs of human being.
		Till 2035 ① To establish theoretical and tech system for discovery and sustainability of endemic bioresources; To develop high-tech industries of new genes, new. ② To develop scalable new emerging bioindustries of manufacturing special bioproduct in the "three north" non-farming and non-pastoral.			
		Till 2050 ① The rationing and recycling of bioresources. ② The industrialization and intelligentialization of biomanufacturing.			
	Scientific research system deploy-driven path	**Till 2020** ① Resource excavation and innovation plan based formation, evolution, and maintaining mechanisms of biodiversity. ② Resource excavation and innovation plan based formation, evolution, and maintaining mechanisms of biodiversity. ③ Informatics/minig genes and genomes and barcode of life to understand existence, revolution and function/service effects of bioresources.			
		Till 2035 ① Knowledge advanced in origin and evolutionary mechanism of biodiversity with integration of multidiscipline of sciences, computer science and modern analysis method. ② Genetic and development mechanism of bio-functions; Structural change of evolution genomes, genetic mechanism of biotic resistance; Theoretical and applied tech advances in the temporal-spatial dynamics of bio resource, climate change biology.			
		Till 2050 Theoretic and high tech systems for directional controlled regulation of specific metabolic pathways, bio-part assembly, bioengineering industrialization.			

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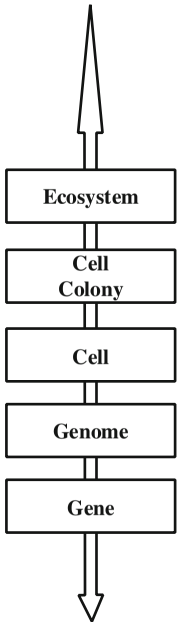
Strategic path and targets		Phases and goals		
		2009 to 2020	2021 to 2035	2036 to 2050
Genome and gene resources		① The complete data collections of genomes, transcriptomes, proteomics, metabonomics and other -omics can be carried out at both the single cell level and community level. ② The method to synthesize a wide size-range of DNA molecules, from viruses to fungi becomes available. ③ De novo design and construction of molecular machines with relatively complex functions from synthesized DNA become possible. ④ Gene expression can be controlled both locally and globally in a cell, and within certain limits, gene functions can be regulated with precision.	① With regard to most biological functions known, representative genes or genomes can be found in the public databases. ② Genomes, transcriptomes, proteomics, metabonomics and other -omics data can be collected at both the microscopic single chemical reaction level and the macroscopic ecosystem level. ③ Simple or model artificial single-celled organisms that perform useful functions begin to appear.	① Artificial chromosomes of algae, vertebrates and higher plants could be synthesized de novo. ② Every function of microbe, plant and animal cells can be manually constructed. ③ Every functional modules of functional and regulatory elements found in nature can be duplicated in vitro. ④ Man-made single cells, communities and ecosystems that can realize complex functions such as photosynthesis, biological nitrogen fixation begin to appear. Every function of microbe, plant and animal cells can be manually constructed.

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Strategic path and targets			Phases and goals		
			2009 to 2020	2021 to 2035	2036 to 2050
Bioinspired sciences and technologies	**National demand-driven path**	**Till 2020** ① Strategic roadmap proposed by Chinese Academy of Sciences. ② Inclusion of the strategic roadmap in the 4th "Knowledge Innovation" of CAS and the 12th 5-year National Development Strategy of Sciences and Technologies of China.	① Establish dedicated research and development platforms for new discoveries of unique biological materials, structures, and functions. ② Make breakthroughs in basic fields such as nanobionics, biomimetic sensing, processing, motion mechanics, informatics, brain and cognition sciences, etc. as well as innovations in research methods. ③ Application and industrialization of biomimetic materials and technologies concerning energy, environment, sensing, medical diagnosis and treatment, etc.	① Make breakthroughs in basic fields of biomimetic informatics, brain and cognition sciences and their physical, chemical, physiological basis, innovation of research methods, etc. ② Application of nanobionics, biomimetic motion mechanics, motion and behavior control, information technology, etc. ③ Industrialization and commercialization of biomimetic materials and technologies concerning processing, sensing, information as well as energy and environment.	① Pursue breakthroughs in both hardware and software technologies for biomimetic informatics, realize the dream of biomimetic neuro-computing. ② Revolutionize the philosophy of engineering design and manufacturing, set its similarity to biological system in reliability, flexibility, energy and cost-efficiency, environment-friendliness as its key evaluation standards.
		Till 2050 Promotion of economical and societal influence of biomimetic technologies in the fields of energy, environment, healthcare, information and national security.			
	Scientific research system deploy-driven path	**Till 2020** ① Adopt interdisciplinary education programs to promote convergence of nanotechnology, biotechnology, information technology, and cognition sciences. ② Setup of dedicated platforms and key laboratories for bioinspired sciences and technologies.			
		Till 2035 ① Optimize a dedicated system of industry-institute-university to speed up the industrialization and commercialization of bioinspired sciences and technologies. ② Setup dedicated databases for achievements of bioinspired sciences and technologies.			
		Till 2050 Enhance the implantation of biomimetics and bioinspiration into the philosophy of engineering design & manufacturing and their coordinative development.			