

Artemisia Annu The Plant Production And Processing And

This book deals with gamma radiation in many fields, which encompasses diverse factors that affect human and animal life inside an environment. These fields include nuclear and medical physics, industrial processes, environmental sciences, radiation biology, radiation chemistry, radiotherapy, agriculture and forestry, sterilization, the food industry, and so on. The book covers an overview of gamma background radiations and measurements, radioactive decay, radioecological applications in environmental gamma dosimetry, gamma-ray interaction, monochromatic gamma, influence of gamma radiation on dynamical mechanical properties, influence of low-dose gamma irradiation treatments on microbial decontamination, gamma-ray ionization enhancement in tissues, gas-filled surge arresters, modeling plastic deformation located in irradiated materials, radiotherapy, application of radiation and genetic engineering techniques, and gamma-ray measurements using unmanned aerial systems. This book is expected to benefit undergraduate and postgraduate students, researchers, teachers, practitioners, policy makers, and every individual who has a concern for a healthy life.

Plants produce more than 30,000 types of chemicals, including pharmaceuticals, pigments and other fine chemicals, which is four times more than those obtained from microbes. Plant cell culture has been receiving great attention as an alternative for the production of valuable plant derived secondary metabolites, since it has many advantages over whole plant cultivation. However, much more research is required to enhance the culture productivity and reduce the processing costs, which is the key to the commercialization of plant cell culture processes. The recent achievements in related biochemical engineering studies are reviewed in Chapter 1. The effect of gaseous compounds on plant cell behavior has been little studied, and Chapter 2 focuses on these gas concentration effects (including oxygen, carbon dioxide, ethylene and others, such as volatile hormones like methyl jasmonate) on secondary metabolite production by plant cell cultures. Two metabolites of current interest, i. e. , the antimalarial artemisinin (known as "qing hao su" in China) that is produced by *Artemisia annua* (sweet wormwood) and taxanes used for anticancer therapy that are produced by species of *Taxus*, are taken as examples. Bioprocess integration is another hot topic in plant cell culture technology. Because most of the plant secondary metabolites are toxic to the cells at high concentrations during the culture, removal of the product in situ during the culture can lead to the enhanced productivity. Various integrated bioprocessing techniques are discussed in Chapter 3.

Medicinal and aromatic plants (MAPs) have accompanied mankind from its very early beginnings. Their utilization has co-evolved with *homo sapiens* itself bringing about a profound increase in our scientific knowledge of these species enabling them to be used in many facets of our life (e.g. pharmaceutical products, feed- and food additives, cosmetics, etc.). Remarkably, despite the new renaissance of MAPs usage, ca. 80 % of the world's population is relying on natural substances of plant origin, with most of these botanicals sourced from the wild state. This first volume and ultimately the series, provides readers with a wealth of information on medicinal and aromatic plants.

Artemisia annua is a well-known medicinal plant that has been utilized for a number of purposes, including malaria, for centuries. This is the first comprehensive book to cover the importance of *Artemisia annua* in the global health crisis and in the treatment against diseases. A component and extract, artemisinin, is the source of other derivatives which are also suitable for pharmaceutical use. The present demand for artemisinin far outpaces its supply. Researchers are working globally towards improving artemisinin content in the plant by various means. *Artemisia annua: Prospects, Applications and Therapeutic Uses* highlights the different approaches, including 'omics', that are being used in

current research on this immensely important medicinal plant. Providing comprehensive coverage of the agricultural and pharmaceutical uses of this plant, *Artemisia annua* will be essential reading for botanists, plant scientists, herbalists, pharmacognosists, pharmacologists and natural product chemists.

This reference work provides a comprehensive review of cell and tissue differentiation and its role in the formation of specific secondary metabolites. Divided into five sections, this book covers the main cellular processes involved in the biosynthesis of secondary metabolites. Chapters from expert contributors offer specific case studies of cell and tissue differentiation, examines secondary metabolites in shoot and root cultures, and present new scientific insights and original technologies with applications in medicinal plants and in plant biotechnology. Students, scholars and researchers with an interest in the fields of botany, agriculture, pharmacy, biotechnology and phytochemistry will find this book an important account. This book will also engage professionals working in plant-based industry.

This new clinical resource clearly explains how to approach integrated care in a way that combines Chinese herbal medicine with Western medicine to enhance and improve medical care for patients with cancer - without undermining or negatively impacting patients' medical treatment. Each chapter covers a different type of cancer, first introducing the conventional medical understanding of that cancer including its etiology, diagnosis, and treatment according to staging and type. The chapter then covers that cancer from the perspective of Oriental medicine. Case studies illustrate the integration of treatment for each cancer type, raising important issues and considerations associated with specific cancers and treatments. Formulas are presented within the context of conventional treatment, intended to enhance the effectiveness of treatment and/or treat side effects without undermining the treatment's function. Each formula is followed by a discussion of how and why the herbs are used, including classical Chinese theory and relevant pharmaceutical studies. Staging and the age and performance status of various patients is used as a means by which to explain how formulas are changed. Case studies explore issues related to the integration of treatment for each type of cancer.

Providing detailed profiles, growing information and medicinal uses for dozens of herbs, a guide for cultivating high-quality herbs at home draws on new scientific data while sharing complementary recipes and coverage of such topics as conservation, crop integration and how to avoid invasive species. Original.

Artemisia annua Prospects, Applications and Therapeutic Uses CRC Press

Malaria is thought to be among the oldest of human diseases. It has long had serious effects on morbidity and mortality, and in turn on the economic and social fabric of nations and society. Various methods have long been utilized to mitigate its frequency and effects in both temperate and tropical climates. Presently the most effective treatment of malaria is based on derivatives of artemisinin, an extract from the plant *Artemisia annua*. Only artemisinin-based combination therapies (ACTs) meets international standards set-up by WHO and UNICEF for the cure of malaria. The present demand for artemisinin is far more than that of supply, therefore, researchers are working round the world towards improving artemisinin content in the plant by various means. This work explains the potential use of radiolytically derived oligomers of sodium alginate together with soil-applied phosphorus induce the productivity and artemisinin (antimalarial

drug) synthesis in *Artemisia annua* plants.

From a symposium at the April 1992 meeting of the American Chemical Society in San Francisco, 22 papers explore the current role and importance of plant-derived natural products in the discovery and development of drugs, in anticancer and cancer chemopreventive agents, in anti-infective and antimicrobial chemotherapeutic agents, and in the potential for products with multiple biological activities. Annotation copyright by Book News, Inc., Portland, OR

This volume begins with a short history of malaria and follows with a summary of its biology. It then traces the fascinating history of the discovery of quinine for malaria treatment, and then describes quinine's biosynthesis, its mechanism of action, and its clinical use, concluding with a discussion of synthetic antimalarial agents based on quinine's structure. It also covers the discovery of artemisinin and its development as the source of the most effective current antimalarial drug, including summaries of its synthesis and biosynthesis, its mechanism of action, and its clinical use and resistance. A short discussion of other clinically used antimalarial natural products leads to a detailed treatment of additional natural products with significant antiplasmodial activity, classified by compound type. Although the search for new antimalarial natural products from Nature's combinatorial library is challenging, it is very likely to yield new antimalarial drugs. This book thus ends by identifying ten natural products with development potential as clinical antimalarial agents.

Medicinal and Aromatic Plants XII comprises 18 chapters. It deals with the distribution, importance, conventional propagation, micropropagation, tissue culture studies, and the in vitro production of important medicinal and pharmaceutical compounds in the following plants: *Artemisia annua*, *Coriandrum sativum*, *Crataegus*, *Dionaea muscipula*, *Hyoscyamus reticulatus*, *Hypericum canariense*, *Leguminosae*, *Malva*, *Ocimum*, *Pergularia tomentosa*, *Phellodendron amurense*, *Sempervivum*, *Solanum aculeatissimum*, *S. chrysotrichum*, *S. kasianum*, *Stephania*, *Trigonella*, and *Vaccinium*. It is tailored to the needs of advanced students, teachers, and research scientists in the fields of pharmacy, plant tissue culture, phytochemistry, biomedical engineering, and plant biotechnology in general.

With over 50,000 distinct species in sub-Saharan Africa alone, the African continent is endowed with an enormous wealth of plant resources. While more than 25 percent of known species have been used for several centuries in traditional African medicine for the prevention and treatment of diseases, Africa remains a minor player in the global natural products market largely due to lack of practical information. This updated and expanded second edition of the *Handbook of African Medicinal Plants* provides a comprehensive review of more than 2,000 species of plants employed in indigenous African medicine, with full-color photographs and references from over 1,100 publications. The first part of the book contains a catalog of the plants used as ingredients for the preparation of traditional remedies, including their medicinal uses and the parts of the plant used. This is followed by a pharmacognostical profile of 170 of the major herbs,

with a brief description of the diagnostic features of the leaves, flowers, and fruits and monographs with botanical names, common names, synonyms, African names, habitat and distribution, ethnomedicinal uses, chemical constituents, and reported pharmacological activity. The second part of the book provides an introduction to African traditional medicine, outlining African cosmology and beliefs as they relate to healing and the use of herbs, health foods, and medicinal plants. This book presents scientific documentation of the correlation between the observed folk use and demonstrable biological activity, as well as the characterized constituents of the plants.

From *Artemisia annua* L. to Artemisinin: The Discovery and Development of Artemisinin and Antimalarial Agents is the first book that systematically introduces the origin and development of artemisinin and artemisinin-based drugs. It includes four distinct sections, including *Artemisia annua* L., Artemisinin, Dihydroartemisinin, and other artemisinin derivatives. Tu Youyou, the chief inventor of artemisinin, together with other members from the research team, have written a book that will be a valuable reference work for both researchers involved in the medical industry and scholars who are interested in undertaking innovative research. Presents a full view of artemisinin, not only its origin and development, but also chemical structure, chemical properties, extracting mode, derivatives, chromogenic reaction, general pharmacological, and toxicology. Provides many aspects of artemisinin-based drugs Includes lots of experimental data, such as the X-ray crystallography result—the first application reported in China in determining the absolute molecular configuration utilizing the scattering effects of oxygen atoms by X-ray diffraction technique

Malaria is an increasing worldwide threat, with more than three hundred million infections and one million deaths every year. The worlds poorest are the worst affected, and many treat themselves with traditional herbal medicines. These are often more available and affordable, and sometimes are perceived as more effective than conventional antimala Includes a DVD Containing All Figures and Supplemental Images in PowerPoint This new edition of Plant Propagation Concepts and Laboratory Exercises presents a robust view of modern plant propagation practices such as vegetable grafting and micropropagation. Along with foundation knowledge in anatomy and plant physiology, the book takes a look into the future and how cutting edge research may impact plant propagation practices. The book emphasizes the principles of plant propagation applied in both temperate and tropical environments. In addition to presenting the fundamentals, the book features protocols and practices that students can apply in both laboratory and field experiences. The book shows readers how to choose the best methods for plant propagation including proper media and containers as well as performing techniques such as budding, cutting, layering, grafting, and cloning. It also discusses how to recognize and cope with various propagation challenges. Also included are concept chapters highlighting key information, laboratory exercises, anticipated laboratory results, stimulating questions, and a DVD containing all the figures in the

book as well as some supplemental images.

This book sheds new light on the role of various environmental factors in regulating the metabolic adaptation of medicinal and aromatic plants. Many of the chapters present cutting-edge findings on the contamination of medicinal plants through horizontal transfer, as well as nanomaterials and the biosynthesis of pharmacologically active compounds. In addition, the book highlights the impacts of environmental factors (e.g., high and low temperature, climate change, global warming, UV irradiation, intense sunlight and shade, ozone, carbon dioxide, drought, salinity, nutrient deficiency, agrochemicals, waste, heavy metals, nanomaterials, weeds, pests and pathogen infections) on medicinal and aromatic plants, emphasizing secondary metabolisms. In recent years, interest has grown in the use of bioactive compounds from natural sources. Medicinal and aromatic plants constitute an important part of the natural environment and agro-ecosystems, and contain a wealth of chemical compounds known as secondary metabolites and including alkaloids, glycosides, essential oils and other miscellaneous active substances. These metabolites help plants cope with environmental and/or external stimuli in a rapid, reversible and ecologically meaningful manner. Additionally, environmental factors play a crucial role in regulating the metabolic yield of these biologically active molecules. Understanding how medicinal plants respond to environmental perturbations and climate change could open new frontiers in plant production and in agriculture, where successive innovation is urgently needed due to the looming challenges in connection with global food security and climate change. Readers will discover a range of revealing perspectives and the latest research on this vital topic.

Artemisinin, a sesquiterpene lactone endoperoxide compound derived from *Artemisia annua* L., is highly effective against multi-drug resistant *Plasmodium* spp. In addition to its antimalaria activity, artemisinin now has been known for its various medicinal properties such as antiviral and anti-cancer activities. Nevertheless, one of the major challenges facing artemisinin production nowadays is its low yield per dry weight. Thus, in this study, enhancement of artemisinin content in plant parts produced from different culturing systems was investigated by using plant bioregulator in order to provide other alternative sources of artemisinin production besides the field grown plants. Our result showed the potential use of CPPU in promoting artemisinin accumulation in both the hairy root system and transplanted pots of *A. annua*. It was also suggested that using effective stimulators with appropriate culturing system could enhance not only production of the target compound but also other useful compounds.

Abstract: Artemisinin is a potent antimalarial drug produced in the plant *Artemisia annua*. Earlier reports suggested that the roots play a key role in artemisinin production; however, it was not clear if other factors actually affected production instead of roots. Here the role of roots and two phytohormones, NAA and BAP, were studied to determine what role each plays in artemisinin production in the plant. Rooted *Artemisia annua* shoots produced significantly more artemisinin, arteannuin B, and deoxyartemisinin, the end products in the pathway, than unrooted

shoots. Although roots do not seem to affect the levels of precursors, artemisinic acid and dihydroartemisinic acid, or regulate the transcription of the genes in the pathway, rooted plants developed larger trichome sacs suggesting that the accumulation of end products is linked to the expansion of the trichome sac. Unrooted shoots are grown in shooting medium containing higher amount of MS salts, vitamins, sucrose and two potent phytohormones, NAA and BAP. Rooted shoots grown in rooting medium containing either one or both of these hormones showed that NAA increased production of arteannuin B in the young leaves and artemisinin in the mature leaves; in mature leaves, however, arteannuin B was inhibited by NAA. BAP induced production of both the precursors and the end products, except for artemisinin, in the young and/or mature leaves. When rooted shoots with their roots removed were grown in rooting medium containing either one of these hormones, artemisinin was significantly less in cultures grown with BAP while there were no differences in metabolite levels in cultures grown with NAA. Although the importance of roots on the artemisinin biosynthetic pathway cannot be concluded, these results help improve our understanding of artemisinin biosynthesis as may prove useful for improving artemisinin production in field-grown crops.

The purpose of this book is to provide the advances in plant in vitro culture as related to perennial fruit crops and medicinal plants. Basic principles and new techniques, now available, are presented in detail. The book will be of use to researchers, teachers in biotechnology and for individuals interested to the commercial application of plant in vitro culture.

Infectious diseases are responsible for one in every two deaths in many developing countries, but people in sub-Saharan Africa are particularly vulnerable, as poverty is rampant and access to health care is limited. Additionally, the unregulated use of antibiotics in some parts of Africa has led to the emergence of resistance in pathogens. Indeed, one of the biggest pandemics is malaria, which kills millions annually. Currently, artemisinin (effective against chloroquine-resistant Plasmodium) is the only weapon available to fight this pandemic, yet the World Health Organization has reported with concern that some countries in Southeast Asia are beginning to witness resistance to artemisinin. As a consequence, increasing attention is being drawn to botanicals, as they have the potential to provide alternative and complementary therapies, as well as potential leads to address emerging infections and resistance. This chapter will review some medicinal plants from the African Herbal Pharmacopoeia that show promise for containing existing and emerging infectious diseases.

Importance of herbs (medicinal plants) can hardly be overemphasized. They are exploited for manyfold applications, ranging from phytopharmaceuticals, to nutraceuticals, to cosmetics and many others. Keeping in view the richness of herbs and their vast potential, this book collates the most up-to-date knowledge of important herbs and herbals. The book also gives an overview of some issues causing hindrance in the promotion of herbals. This book attempts to compile the rich experience of experts working on various herbs. New age single plant species, having multiple medicinal traits worth exploiting i.e. Hippophae rhamnoides (seabuckthorn), and Morinda citrifolia (noni) also find place as full chapters in the book.

Bachelor Thesis from the year 2008 in the subject Engineering - Chemical Engineering, grade: A, Bahir Dar University (Bahir Dar University Engineering Faculty), course: Chemical Engineering, language: English, abstract: Abstract Malaria disease is endemic in least developed countries like Ethiopia. The rapid development of drug-resistant malaria parasite strain leaves the need for new effective anti-malarial drugs. Artemisinin is a sesquiterpene lactone found in the leaves and flowers of plants Artemisia annua L and have different chemical structures and higher efficacy than others. The content of artemisinin is very small and from 0.5 to 1.2 % of dry weight of plants in Ethiopia. Extraction of artemisinin from Artemisia annua is mainly performed using hydrocarbon extraction processes. Extraction with Supercritical CO₂, ethanol, ionic liquids, hydroflourocarbon HFC-134a and hexane extraction are extraction technologies and compared majorly in terms of their

extraction efficiency, cost and drawback to environment. Since artemisinin is only present in the epidermis of the leaves, leaves were only washed on the outside by stirring appeared to be the most appropriate method and the first step in this research was solvent extraction using hexane. Step followed purify by repeated crystallization. Laboratory scale production data and procedures were listed for aremisinin extraction process. By using those data large scale production method was designed. And did material and energy balance calculations for large scale production process carried out by taking scientific approach followed by feasibility study. As a result my extractor was very large and it has 14.37m³ capacities it wasn't found in market. So I designed the required larger extractor that should fulfill the target of the project i.e. with simple, rapid, cost effective, environmental friendly and practical method for the isolation of artemisinin from Artemisia annua. The design the extractor I used the optimum ratio between solvent and leaves, optimum extraction time, optimum extraction temperature and optimum design of the stirrer paddles. In these thesis work extractor design, skirt design, bolt design, reinforcement calculations, preliminary equipment design (sizing), economic analysis calculations were included. In the profitability analysis Return on investment, payback period and net present worth calculated and the project was checked its feasibility. The payback period is 1.22yrs and it is economically acceptable that means this market is promising in Ethiopia in addition to save millions of Ethiopian and African from killer malaria. Key words: artemisinin, sesquiterpene lactone, hexane extraction

This book highlights the advances in essential oil research, from the plant physiology perspective to large-scale production, including bioanalytical methods and industrial applications. The book is divided into 4 sections. The first one is focused on essential oil composition and why plants produce these compounds that have been used by humans since ancient times. Part 2 presents an update on the use of essential oils in various areas, including food and pharma industries as well as agriculture. In part 3 readers will find new trends in bioanalytical methods. Lastly, part 4 presents a number of approaches to increase essential oil production, such as in vitro and hairy root culture, metabolic engineering and biotechnology. Altogether, this volume offers a comprehensive look at what researchers have been doing over the last years to better understand these compounds and how to explore them for the benefit of the society.

Plant gene transfer achieved in the early '80s paved the way for the exploitation of the potential of gene engineering to add novel agronomic traits and/or to design plants as factories for high added value molecules. For this latter area of research, the term "Molecular Farming" was coined in reference to agricultural applications in that major crops like maize and tobacco were originally used basically for pharma applications. The concept of the "green biofactory" implies different advantages over the typical cell factories based on animal cell or microbial cultures already when considering the investment and managing costs of fermenters. Although yield, stability, and quality of the molecules may vary among different heterologous systems and plants are competitive on a case-to-case basis, still the "plant factory" attracts scientists and technologists for the challenging features of low production cost, product safety and easy scale up. Once engineered, a plant is among the cheapest and easiest eukaryotic system to be bred with simple know-how, using nutrients, water and light. Molecules that are currently being produced in plants vary from industrial and pharmaceutical proteins, including medical diagnostics proteins and vaccine antigens, to nutritional supplements such as vitamins, carbohydrates and biopolymers. Convergence among disciplines as distant as plant physiology and pharmacology and, more recently, as omic sciences, bioinformatics and nanotechnology, increases the options of research on the plant cell factory. "Farming for Pharming" biologics and small-molecule medicines is a challenging area of plant biotechnology that may break the limits of current standard production technologies. The recent success on Ebola fighting with plant-made antibodies put a spotlight on the enormous potential of next generation herbal medicines made especially in the name of the guiding principle of reduction of

costs, hence reduction of disparities of health rights and as a tool to guarantee adequate health protection in developing countries. Covers the structurally diverse secondary metabolites of medicinal plants, including their ethnopharmacological properties, biological activity, and production strategies Secondary metabolites of plants are a treasure trove of novel compounds with potential pharmaceutical applications. Consequently, the nature of these metabolites as well as strategies for the targeted expression and/or purification is of high interest. Regarding their biological and pharmacological activity and ethnopharmacological properties, this book offers a comprehensive treatment of 100 plant species, including Abutilon, Aloe, Cannabis, Capsicum, Jasminum, Malva, Phyllanthus, Stellaria, Thymus, Vitis, Zingiber, and more. It also discusses the cell culture conditions and various strategies used for enhancing the production of targeted metabolites in plant cell cultures. Secondary Metabolites of Medicinal Plants: Ethnopharmacological Properties, Biological Activity and Production Strategies is presented in four parts. Part I provides a complete introduction to the subject. Part II looks at the ethnomedicinal and pharmacological properties, chemical structures, and culture conditions of secondary metabolites. The third part examines the many strategies of secondary metabolites production, including: biotransformation; culture conditions; feeding of precursors; genetic transformation; immobilization; and oxygenation. The last section concludes with an overview of everything learned. -Provides information on cell culture conditions and targeted extraction of secondary metabolites confirmed by relevant literature -Presents the structures of secondary metabolites of 100 plant species together with their biological and pharmacological activity -Discusses plant species regarding their distribution, habitat, and ethnopharmacological properties -Presents strategies of secondary metabolites production, such as organ culture, pH, elicitation, hairy root cultures, light, and mutagenesis Secondary Metabolites of Medicinal Plants is an important book for students, professionals, and biotechnologists interested in the biological and pharmacological activity and ethnopharmacological properties of plants. Terpenes belong to the diverse class of chemical constituents isolated from materials found in nature (plants, fungi, insects, marine organisms, plant pathogens, animals and endophytes). These metabolites have simple to complex structures derived from Isopentyl diphosphate (IPP), dimethyl allyl diphosphate (DMAPP), mevalonate and deoxyxylulose biosynthetic pathways. Terpenes play a very important role in human health and have significant biological activities (anticancer, antimicrobial, anti-inflammatory, antioxidant, antiallergic, skin permeation enhancer, anti-diabetic, immunomodulatory, anti-insecticidal). This book gives an overview and highlights recent research in the phytochemical and biological understanding of terpenes and terpenoid and explains the most essential functions of these kinds of secondary metabolites isolated from natural sources.

A comprehensive overview of this genus, Artemisia examines all aspects of the herbs uses and applications, its mode of action and clinical importance. Following a comprehensive introduction to the genus, the book discusses the botanical, phytochemical and biological aspects of a number of important species of Artemisia. Considering that the discover

Artemisia annua is a highly demanded medicinal herb. It is a crop for the production of artemisinin, an important natural sesquiterpene lactone with anti-malarial effect against susceptible and multi-drug resistant Plasmodium species. A-3 is a hybrid cultivar that has been organically grown on ANAMED farm in Germany and contains 20 times more the usual content (0.01-0.42% of dry mass) of artemisinin in wild type. It is especially important for the natural treatment of malaria, because it is adapted for the warmer climates where malaria is endemic. This book could serve an indispensable input to advanced students in the field of Plant Bio-technology, Botanical Sciences, Horticulture etc. and commercial growers as well as pharmaceutical firms as it provides the reader with efficient and reproducible in vitro techniques and procedures (protocol) that enables large scale production of plant materials true-to-type for anamed (A-3) cultivar of A. annua.

Packed with compelling pictures and tables it offers up to date comprehensive information on origin and distribution, botany, medicinal importance and propagation (conventional propagation and micropropagation) of the plant.

Artemisinin, a sesquiterpene lactone originally extracted from the medicinal plant *Artemisia annua* L., is an effective antimalarial agent, particularly for multi-drug resistant and cerebral malaria. However, the concentration of artemisinin in the plant is very low. Because the chemical synthesis of artemisinin is complicated and not economically feasible in view of the poor yield of the drug, the intact plant remains the only viable source of artemisinin production. Therefore, it is necessary to increase the concentration of artemisinin in *A. annua* to reduce the cost of artemisinin based antimalarial drugs. Plant scientists have focused their efforts on *A. annua* for a higher artemisinin crop yield. With the present volume, we are bringing together the research which is being done on this plant throughout the world and future possibilities for scientists and researchers who want to work on it.

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