**Advances in Sustainable Construction Materials**

This book presents select proceedings of the National Conference on Advances in Sustainable Construction Materials (ASCM 2019) held at the National Institute of Technology, Warangal, India. The book includes contributions from academics and practitioners on low-energy cement technologies, innovative materials and structural technologies towards cost-effective, environment friendly, durable, energy-efficient, and sustainable construction. The topics covered emphasize on cutting-edge, economically viable, and sustainable solutions with an aim to increase profitability, and decrease construction time and overall impact on the built environment. The book will be useful for researchers and practitioners interested in sustainable construction and allied fields.

**Proceedings of SECON'19**

The first English-language book which reviews and summarizes worldwide research advances in alkali-activated cements and concrete. Essential topics include: raw materials and their properties for the production of the two new types of binder the hydration and microstructure development of alkali-activated slag cements the mechanical properties and durability of alkali-activated slag cement and concrete other various cementing systems and their applications related standards and specifications. This respected team of authors has produced an important piece of research that will be of great interest to professionals and academics alike, enabling the production of more durable and environmentally sensitive materials.

**Proceedings of the 1st International Conference on Sustainable Waste Management through Design**

The drive to develop more sustainable materials has made fly ash a valuable raw material in many different applications. Comprehensive and authoritative, Handbook of Fly Ash highlights the latest research efforts to develop the properties of fly ash to maximum utility while safeguarding the environment. This book takes an interdisciplinary approach to the research into the classification and compositions of various types of fly ash, such as bottom ash and boiler slag, special classes of fly ash, and their sources around the globe. This is followed by a discussion of fly ash-reinforced composites, such as elastomer-based composites and metal matrix composites. This book also covers a wide range of applications of fly ash in cement, concrete, bricks and blocks, road construction, wastewater treatment, and scrubber sludge solidification. Highlights the recent developments in the utilization of fly ash including its preparation, functionalization, properties, and handling. Places a focus on a wide variety of fly ash applications including recent innovations, such as alkali-activated binder, polypropylene composite, and geopolymer concrete. Includes comprehensive coverage of the characteristics of fly ash with a particular focus on health hazards if it is not properly disposed. Discusses fly ash-reinforced composites, such as polymer/elastomer-based composites and metal matrix composites.

**New Trends in Eco-efficient and Recycled Concrete**

**Making Cities Resilient**

Green Building

This book gathers the latest advances, innovations, and applications in the field of sustainable energy systems, as presented by researchers and engineers at the International Conference on Sustainable Energy Systems: Innovative Perspectives (SES), held in Saint-Petersburg, Russia, on October 29-30, 2020. It covers highly diverse topics, including applications of renewable energy sources, recycling of solid municipal and industrial waste, circular economy based on agricultural waste, energy-efficient and sustainable buildings, innovation management and technologies of sustainable cities, sustainable construction, creative construction technology and materials, construction simulation and virtual construction, BIM and rapid prototyping for construction, consumption practices in the digital era, sustainable operations management, and supply chain management in the digital era. The contributions, which were selected by means of a rigorous international peer-review process, highlight numerous exciting ideas that will spur novel research directions and foster multidisciplinary collaborations.

Ternary and Quaternary Blended Alkali-Activated Binder

This book describes the latest advances, innovations and applications in the field of waste management and environmental geomechanics as presented by leading researchers, engineers and practitioners at the International Conference on Sustainable Waste Management through Design (IC_SWMD), held in Ludhiana (Punjab), India on November 2-3, 2018. Providing a unique overview of new directions, and opportunities for sustainable and resilient design approaches to protect infrastructure and the environment, it discusses diverse topics related to civil engineering and construction aspects of the resource management cycle, from the minimization of waste, through the eco-friendly re-use and processing of waste materials, the management and disposal of residual wastes, to water treatments and technologies. It also encompasses strategies for reducing construction waste through better design, improved recovery, re-use, more efficient resource management and the performance of materials recovered from wastes. The contributions were selected by means of a rigorous peer-review process and highlight many exciting ideas that will spur novel research directions and foster multidisciplinary collaboration among different waste management specialists.

Developments in Mechanics of Structures & Materials

The Handbook of Sustainable Concrete and Industrial Waste Management summarizes key research trends in recycling and reusing concrete and industrial waste to reduce their environmental impact. This volume also includes important contributions in collaboration with the CRI-TEST Innovation Lab, Naples – Acerra. Part one discusses eco-friendly innovative cement and concrete and reviews key substitute materials. Part two analyzes the use of industrial waste as aggregates and the mechanical properties of concrete containing waste materials. Part three discusses differences between innovative binders, focusing on alkali-activated and geopolymer concrete. Part four provides a thorough overview of the life cycle assessment (LCA) of concrete containing industrial wastes and the impacts related to the logistics of wastes, the production of the concrete, and the management of industrial wastes. By providing research examples, case studies, and practical strategies, this book is a state-of-the-art reference for researchers working in construction materials, civil or structural engineering, and engineers working in the industry. Offers a systematic and comprehensive source of information on the latest developments in sustainable concrete; Analyzes different types of sustainable concrete and innovative binders from chemical, physical, and mechanical points of view; Includes real case studies showing application of the LCA methodology.

Green Concrete for a Better Sustainable Environment

Portland cement based concrete is the most versatile, durable and reliable building material. Unfortunately, the production of Portland cement is environmentally unfriendly. An interesting alternative is provided by alkali-activated geopolymer materials (AAGM). This book focuses on fly ash-based alkali-activated geopolymer concrete, its production and characteristic properties. The re-use of waste materials and industrial by-products, such as fly ash, is not only economically of interest but also helps to reduce carbon dioxide emissions. The carbon footprint of these materials is much lower than that of concrete using ordinary Portland cement. They thus offer new sustainable solutions to the construction industry. Keywords: Geopolymers, Geopolymer Concrete, Alkali-activated Geopolymer Materials (AAGM), Portland Cement, Fly Ash-based Geopolymer Concrete, Reduction of Carbon Dioxide Emissions, Concrete Applications, Self-Compacting Concrete, High-strength Concrete, High-performance Concrete.
Green Infrastructure

Eco-efficient Construction and Building Materials provides essential reading about materials for the construction industry in the twenty-first century. It covers the latest findings in the field, especially the toxicity aspects, embodied energy, construction and demolition wastes, the use of wastes in concrete, masonry units, materials reinforced with vegetable fibres, earth construction, the durability aspects, and also the importance of nanotechnology to the development of more environmentally-friendly materials. Based on more than nine hundred references, Eco-efficient Construction and Building Materials is of fundamental importance to academics, engineers and architects who are dedicated to the creation of a greener and more holistic construction industry.

Eco-efficient Construction and Building Materials

Mechanics of Structures and Materials: Advancements and Challenges is a collection of peer-reviewed papers presented at the 24th Australasian Conference on the Mechanics of Structures and Materials (ACMSM24, Curtin University, Perth, Western Australia, 6-9 December 2016). The contributions from academics, researchers and practising engineers from Australasian, Asia-pacific region and around the world, cover a wide range of topics, including: • Structural mechanics • Computational mechanics • Reinforced and prestressed concrete structures • Steel structures • Composite structures • Civil engineering materials • Fire engineering • Coastal and offshore structures • Dynamic analysis of structures • Structural health monitoring and damage identification • Structural reliability analysis and design • Structural optimization • Fracture and damage mechanics • Soil mechanics and foundation engineering • Pavement materials and technology • Shock and impact loading • Earthquake loading • Traffic and other man-made loadings • Wave and wind loading • Thermal effects • Design codes Mechanics of Structures and Materials: Advancements and Challenges will be of interest to academics and professionals involved in Structural Engineering and Materials Science.

Proceedings of SECON 2020

The production of geopolymer mortar using recycled fine aggregate (RFA) generated from concrete waste has significant potential to be a sustainable construction material. In this article, the volume change properties of the produced geopolymer mortar mixes are studied in terms of drying shrinkage up to the age of 180 days and reported as the percentage increase with respect to the shrinkage value of 3 days. The influence of RFA content, alkaline liquid (AL) in terms of the concentration of sodium hydroxide (SH) solution, the ratio of sodium silicate (SS) solution to SH solution, and the ratio of AL to fly ash (FA) were investigated on the drying shrinkage properties of the geopolymer mortar mixes. All the cast specimens were cured at 80°C for 24 hours. Higher drying shrinkage values were observed for the mortar mixes produced with higher RFA content, AL/FA, SS/SH ratio, and lower concentration of SH solution. Scanning electron microscope images were studied for the samples taken from the geopolymer mixes showing lower drying shrinkage values to understand the microstructure.

Green Materials Obtained by Geopolymerization for a Sustainable Future

New Trends in Eco-efficient and Recycled Concrete describes different recycled materials that have been used in eco-efficient concrete, reviewing previous publications to identify the most effective recycled materials to be applied in concrete manufacture. New trends on eco-efficient concrete are presented, filling a gap in the market. Sections cover various recycled materials applied in concrete production, present the latest on the lifecycle analysis of recycled aggregate concrete, detail new trends in recycled aggregate concrete research, and finally, present updates on upscaling the use of recycled aggregate concrete and structural reliability. Focuses on new trends in recycled aggregate concrete and its applications (rather than the more subjective ‘sustainability’ aspects) Contains very important contributions from researchers in eco-efficient concrete, including Chi Sun Poon, Jorge de Brito, Valeria Corinaldesi, Francisco Agrela, etc. Presents a ‘one stop’ reference for a graduate course on sustainable construction

Proceedings of EECE 2020

This book presents selected articles from the 5th International Conference on Geotechnics, Civil Engineering Works and Structures, held in Ha Noi, focusing on the theme “Innovation for Sustainable Infrastructure”, aiming to not only raise awareness of the vital importance of sustainability in infrastructure development but to also highlight the essential roles of innovation and technology in planning and building sustainable infrastructure. It provides an international platform for researchers, practitioners, policymakers and entrepreneurs to present their recent advances and to exchange knowledge and experience on various topics related to the theme of “Innovation for Sustainable Infrastructure”.

Handbook of Sustainable Concrete and Industrial Waste Management

This book comprises select papers presented at the International Conference on Trends and Recent Advances in Civil Engineering (TRACE 2018). The topics covered include the utilization of industrial by-products as
construction materials, sustainable and green materials in construction applications, and latest measures adopted for stabilization techniques. The book also discusses recent advances and techniques related to geotechnical and concrete domain that can be used as a reference guide for various researchers and practitioners around the globe.

**Concrete Planet**

The Nirma University International Conference on Engineering NUICONE is a flagship event of the Institute of Technology, Nirma University, Ahmedabad. NUICONE-2015 is focussed on events/themes in the current trends in Engineering and its research issues. Practicing engineers, technologists and technopreneurs from the industry.

**Volume Change Characteristics of Eco-Friendly Mortar Mixes Produced with Geopolymeric Binder and Recycled Fine Aggregate**

This book highlights the current research, conceptual and practical utilization of waste in building materials. It examines the production of industrial and agricultural wastes that have been generated worldwide and have significant environmental impact. The book discusses how to incorporate these wastes effectively with greener technology and how to address its environmental impact in order to produce environmentally friendly and sustainable green products. This book also will capitalize on its practical application, properties, performance and economic advantages. The topics covered include the physical, mechanical and environmental properties, leaching behaviour, gas emissions and performance of sustainable construction materials. This book offers a valuable reference for researchers, industries and interested stakeholders in sustainable construction or any allied fields.

**Sustainable Construction and Building Materials**

This book comprises the proceedings of the International Conference on Green Buildings and Sustainable Engineering (GBSE 2019), which focused on the theme “Ecotechnological and Digital Solutions for Smart Cities”. The papers included address all aspects of green buildings and sustainability practices in civil engineering, and focus on ways and means of reducing pollution and degradation of the environment through efficient usage of energy and water. The book will prove a valuable reference resource for researchers, practitioners, and policy makers.

**Handbook of Fly Ash**

This book gathers peer-reviewed contributions presented at the 3rd National Conference on Structural Engineering and Construction Management (SECON’19), held in Angamaly, Kerala, India, on 15-16 May 2019. The meeting served as a fertile platform for discussion, sharing sound knowledge and introducing novel ideas on issues related to sustainable construction and design for the future. The respective contributions address various aspects of numerical modeling and simulation in structural engineering, structural dynamics and earthquake engineering, advanced analysis and design of foundations, BIM, building energy management, and technical project management. Accordingly, the book offers a valuable, up-to-date tool and essential overview of the subject for scientists and practitioners alike, and will inspire further investigations and research.

**ICCOEE2020**

This book comprises select proceedings of the International Conference on Trends and Recent Advances in Civil Engineering (T RACE 2020). The book focuses on the latest research developments in structural engineering, structural health monitoring, rehabilitation and retrofitting of structures, geotechnical engineering, and earthquake-resistant structures. The contents also cover the latest innovations in building repair and maintenance, and sustainable materials for rehabilitation and retrofitting. The contents of this book are useful for students, researchers, and professionals working in structural engineering and allied areas.

**Incorporating Sustainable Practice in Mechanics and Structures of Materials**

This book contains papers presented in the 6th International Conference on Civil, Offshore & Environmental Engineering (ICCOEE2020) under the banner of World Engineering, Science & Technology Congress (ESTCON2020) will be held from 13th to 15th July 2021 at Borneo Convention Centre, Kuching, Sarawak, Malaysia. This proceeding contains papers presented by academics and industrial practitioners showcasing the latest advancements and findings in civil engineering areas with an emphasis on sustainability and the Industrial Revolution 4.0. The papers are categorized under the following tracks and topics of research: 1. Resilient Structures and Smart Materials 2. Advanced Construction and Building Information Modelling 3. Smart and Sustainable Infrastructure 4. Advanced Coastal and Offshore Engineering 5. Green Environment and Smart Water Resource Management Systems
Concrete: We use it for our buildings, bridges, dams, and roads. We walk on it, drive on it, and many of us live and work within its walls. But very few of us know what it is. We take for granted this ubiquitous substance, which both literally and figuratively comprises much of modern civilization’s constructed environment; yet the story of its creation and development features a cast of fascinating characters and remarkable historical episodes. This book delves into this history, opening readers’ eyes at every turn. In a lively narrative peppered with intriguing details, author Robert Corland describes how some of the most famous personalities of history became involved in the development and use of concrete—including King Herod the Great of Judea, the Roman emperor Hadrian, Thomas Edison (who once owned the largest concrete cement plant in the world), and architect Frank Lloyd Wright. Corland points to recent archaeological evidence suggesting that the discovery of concrete directly led to the Neolithic Revolution and the rise of the earliest civilizations. Much later, the Romans reached extraordinarily high standards for concrete production, showcasing their achievement in iconic buildings like the Coliseum and the Pantheon. Amazingly, with the fall of the Roman Empire, the secrets of concrete manufacturing were lost for over
a millennium. The author explains that when concrete was rediscovered in the late eighteenth century it was initially viewed as an interesting novelty or, at best, a specialized building material suitable only for a narrow range of applications. It was only toward the end of the nineteenth century that the use of concrete exploded. During this rapid expansion, industry lobbyists tried to disguise the fact that modern concrete had certain defects and critical shortcomings. It is now recognized that modern concrete, unlike its Roman predecessor, gradually disintegrates with age. Compounding this problem is another distressing fact: the manufacture of concrete cement is a major contributor to global warming. Concrete Planet is filled with incredible stories, fascinating characters, surprising facts, and an array of intriguing insights into the building material that forms the basis of the infrastructure on which we depend.

**CIGOS 2019, Innovation for Sustainable Infrastructure**

Sustainable Concrete Made with Ashes and Dust from Different Sources: Materials, Properties and Applications focuses on individual materials, addressing material characterization, their role in the strength and durability of construction materials, and structural applications. Each chapter reflects the current state-of-the-art in terms of the effective and efficient use of the material. Types of ashes covered are Coal Fly Ash, Coal Bottom Ash, Bagasse Ash, MSW Ash, Red Mud, Waste Marble Dust, Sewage Sludge Ash, and Cement Kiln Dust. This book is useful for civil engineers in the design and development of sustainable concrete by utilizing such types of ashes and researchers involved in the design and formulation of new cementitious materials. Focuses on different types of ashes derived from various sources for use in the development of sustainable concrete Discusses the economic and environmental impacts, normative restrictions, and implementation in codes and standards related to the use of these by-products/wastes in concretes Includes coverage of the impact of dust from construction and demolition wastes.

**Geopolymer, Green Chemistry and Sustainable Development Solutions**

This book gathers peer-reviewed contributions presented at the 1st International Conference on Structural Engineering and Construction Management (SECON’20), held in Angamaly, Kerala, India, on 14-15 May 2020. The meeting served as a fertile platform for discussion, sharing sound knowledge and introducing novel ideas on issues related to sustainable construction and design for the future. The respective contributions address various aspects of numerical modeling and simulation in structural engineering, structural dynamics and earthquake engineering, advanced analysis and design of foundations, BIM, building energy management, and technical project management. Accordingly, the book offers a valuable, up-to-date tool and essential overview of the subject for scientists and practitioners alike, and will inspire further investigations and research.

**Alternative Concrete - Geopolymer Concrete**

Geopolymerization techniques allow the conversion of industrial waste materials into environmentally friendly materials. The vast list of applications includes thermal insulation, fire-resistant materials, construction materials, refractory linings, cements and concretes, encapsulation of radioactive and toxic waste etc. The book presents the technological processes involved, as well as the characterization and applications of the resulting ecomaterials. Keywords: Geopolymerization, Industrial Waste Materials, Green Materials, Thermal Insulation, Fire-resistant Materials, Construction Materials, Refractory Linings, Cements and Concretes, Encapsulation of Radioactive Waste, Encapsulation of Toxic Waste, Thermal Power Plant Ash, Aluminosilicates Recycling, Porous Geopolymers, Environmentally Friendly Concrete.

**Advances in Geotechnics and Structural Engineering**

As the world has transformed, so have cities. Today, cities are home to 54 percent of the world’s population, and by the middle of this century that figure will likely rise to 66 percent. According to the United Nations (UN) Habitat I (1972), Habitat II (1996) and Habitat III (2016) summits, cities are facing many serious challenges, including growing inequality, security concerns and the worsening impacts of climate change. Uncontrolled urbanization has led to many problems (haphazard growth of areas, emergence of slums, inadequate water and power supply, poor sanitation, shortage of transport and other civic amenities, shrinking green spaces, pollution, crime, and urban disaster risks such as fire, flood, road and industrial accidents, etc.). Worldwide, communities at the international, national and local level are continuously working to improve human habitats. In order to make our planet more sustainable, the UN has moved from the Millennium Development Goals (MDG) to the Sustainable Development Goals (SDG). Among the latter, the aim of SDG 11 is to “make cities and human settlements inclusive, safe, resilient and sustainable.” In light of these challenges, various terms have emerged to help understand urban issues. Visualizing the problem, the United Nations program “Making Cities Resilient” is focused on mitigating the disaster risk in urban areas. This book analyzes terms such as: sustainable, resilient, livable, inclusive, smart and world class city, which have emerged in the process of combating urban challenges in today’s world. The book addresses emerging concepts for cities, challenges and potentials, urban environments, health and planning/policies. Covering 14 large cities in India, as well as case studies from Japan, Singapore, Thailand, Malaysia, Poland and Sweden, it provides a regional dimension to and micro-level perspective on urban issues.
Multi-disciplinary Sustainable Engineering: Current and Future Trends

This book comprises select proceedings of the International Conference on Design, Materials, Cryogenics and Constructions (ICDMC 2019). The chapters cover latest research in different areas of mechanical engineering such as additive manufacturing, automation in industry and agriculture, combustion and emission control, CFD, finite element analysis, and engineering design. The book also focuses on cryogenic systems and low-temperature materials for cost-effective and energy-efficient solutions to current challenges in the manufacturing sector. Given its contents, the book can be useful for students, academics, and practitioners.

Recycled Ceramics in Sustainable Concrete

Sustainable Resource Management: Modern Approaches and Contexts presents the application of the current concept of sustainability to the management of natural resources, such as water, land, minerals and metals using theoretical field knowledge and illustrative real-world examples. Initially, the book defines sustainability, detailing its evolution and how it has been adapted to each of the contexts in which it is used. Furthermore, sustainability is made up of three main areas of science—environmental, social and economic—which are rarely considered together. This book is a complete reference guide to sustainability of natural resources for academics, researchers, practitioners and postgraduate-level students, and more. As sustainability is an interdisciplinary field, linked to most sciences, it is also of use to all fields of science that need to maintain sustainable practices and specific details on the methodologies and techniques needed for sustainable resource management. Provides an integrated approach for modern tools, methodologies and indicators for sustainable resource management Evaluates emerging trends and advanced approaches in sustainable resource management, detailing the most up-to-date research and management considerations Describes advanced sustainable resource management technologies and presents case studies where applicable

Development of Geopolymer Concrete for Precast Structures

Handbook of Low Carbon Concrete brings together the latest breakthroughs in the design, production, and application of low carbon concrete. In this handbook, the editors and contributors have paid extra attention to the emissions generated by coarse aggregates, emissions due to fine aggregates, and emissions due to cement, fly ash, GGBFS, and admixtures. In addition, the book provides expert coverage on emissions due to concrete batching, transport and placement, and emissions generated by typical commercially produced concretes. Includes the tools and methods for reducing the emissions of greenhouse gases Explores technologies, such as carbon capture, storage, and substitute cements Provides essential data that helps determine the unique factors involved in designing large, new green cement plants

Advances in Sustainable Construction Materials and Geotechnical Engineering

Recycled Ceramics in Sustainable Concrete: Properties and Performance explores the use of novel waste materials in the construction industry as sustainable and environmentally friendly alternatives to traditional cement production technologies. It specifically focuses on using waste ceramics as a binder and aggregate replacement for concrete. Includes a lifecycle assessment Describes recycling of ceramic tile waste as fine and coarse aggregate replacement Discusses microstructure performance of sustainable concrete Evaluates performance of sustainable concrete exposed to elevated temperatures and corrosives Written for materials, chemical, and civil engineers as well as others who develop construction materials, this book provides readers with a thorough understanding of the merits of using waste ceramics to produce sustainable concrete.

Handbook of Low Carbon Concrete

This book comprises select peer-reviewed proceedings of the International Conference on Recent Developments in Sustainable Infrastructure (ICRDSI) 2019. The topics span over all major disciplines of civil engineering with regard to sustainable development of infrastructure and innovation in construction materials, especially concrete. The book covers numerical and analytical studies on various topics such as composite and sandwiched structures, green building, groundwater modeling, rainwater harvesting, soil dynamics, seismic resistance and control of structures, waste management, structural health monitoring, and geo-environmental engineering. This book will be useful for students, researchers and professionals working in sustainable technologies in civil engineering.

Sustainable Concrete Made with Ashes and Dust from Different Sources

This book presents select proceedings of the International Conference on Sustainable Construction and Building Materials (ICSCBM 2018), and examines a range of durable, energy-efficient, and next-generation construction and building materials produced from industrial wastes and byproducts. The topics covered include alternative, eco-friendly construction and building materials, next-generation concretes, energy efficiency in construction, and sustainability in construction project management. The book also discusses various properties and performance attributes of modern-age concretes including their durability, workability, and carbon footprint. As such, it offers a
valuable reference for beginners, researchers, and professionals interested in sustainable construction and allied fields.

**Green Buildings and Sustainable Engineering**

This book gathers the latest advances, innovations, and applications in the field of energy, environmental and construction engineering, as presented by international researchers and engineers at the International Scientific Conference Energy, Environmental and Construction Engineering, held in St. Petersburg, Russia on November 19-20, 2020. It covers highly diverse topics, including BIM; bridges, roads and tunnels; building materials; energy efficient and green buildings; structural mechanics; fluid mechanics; measuring technologies; environmental management; power consumption management; renewable energy; smart cities; and waste management. The contributions, which were selected by means of a rigorous international peer-review process, highlight numerous exciting ideas that will spur novel research directions and foster multidisciplinary collaborations.

**Sustainable Energy Systems: Innovative Perspectives**

**Alkali-Activated Cements and Concretes**

Incorporating Sustainable Practice in Mechanics of Structures and Materials is a collection of peer-reviewed papers presented at the 21st Australasian Conference on the Mechanics of Structures and Materials (ACMSM21, Victoria, University, Melbourne, Australia, 7th 10th of December 2010). The contributions from academics, researchers and practisin

**Advances in Construction Materials and Sustainable Environment**

This volume contains the peer-reviewed papers accepted for presentation at the 18th Australasian Conference on the Mechanics of Structures and Materials held in Perth, 2004. Papers contained describe significant advances in a large number of diverse areas, indicating the range of applications of the basic principles and techniques of mechanics from traditional areas such as steel and concrete structures, through to modern areas such as structural health monitoring and structural rehabilitation using carbon fibre composites. With topics ranging from foundation piles to shaken baby syndrome, this volume reports the results of countless thousands of hours of research and millions of dollars of research funding.

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