

# PROJECT CATEGORIES



GSEF projects must be entered in ONE of the 22 categories below. **Category selection in GSEF registration materials is final.** Your school or regional fair may use different categories; please check with those fairs for category listings at each level of competition.

When selecting a category, consider the following: *Who will be the most qualified to judge my project? What area of expertise is the most important for the judge to have? (for example, a medical background or an engineering background?) What is the emphasis of my project? What characteristic of my project is the most innovative, unique or important? (For example, is it the application in medicine or the engineering of the machine? Is it inserting the proper gene or the method of computer mapping to demonstrate the results?)*

## LIFE SCIENCES CATEGORIES:

### ANIMAL SCIENCES

*Animal Behavior  
Cellular Studies  
Development  
Ecology  
Genetics  
Nutrition & Growth  
Physiology  
Systematics & Evolution*

### BIOCHEMISTRY

*Analytical Biochemistry  
General Biochemistry  
Medical Biochemistry  
Structural Biochemistry*

### CELLULAR & MOLECULAR BIOLOGY

*Cell Physiology  
Cellular Immunology  
Genetics  
Molecular Biology  
Neurobiology*

### MICROBIOLOGY

*Antimicrobials & Antibiotics  
Applied Microbiology  
Bacteriology  
Environmental Microbiology  
Microbial Genetics  
Virology*

### PLANT SCIENCES

*Agriculture & Agronomy  
Ecology  
Genetics/Breeding  
Growth & Development  
Pathology  
Plant Physiology  
Systematics & Evolution*

## MEDICINE & HEALTH CATEGORIES:

### BEHAVIORAL & SOCIAL SCIENCES

*Clinical & Developmental Psychology  
Cognitive Psychology  
Neuroscience  
Physiological Psychology  
Sociology & Social Psychology*

### BIOMEDICAL & HEALTH SCIENCES

*Cell, Organ, & Systems Physiology  
Genetics & Molecular Biology of Disease  
Immunology  
Nutrition & Natural Products  
Pathophysiology*

### BIOMEDICAL ENGINEERING

*Biomaterials & Regenerative Medicine  
Biomechanics  
Biomedical Devices  
Biomedical Imaging*

*Cell & Tissue Engineering  
Synthetic Biology*

### COMPUTATIONAL BIOLOGY & BIOINFORMATICS

*Computational Biomodeling  
Computational Epidemiology  
Computational Evolutionary Biology  
Computational Neuroscience  
Computational Pharmacology  
Genomics*

### TRANSLATIONAL MEDICAL SCIENCE

*Disease Detection & Diagnosis  
Disease Prevention  
Disease Treatment & Therapies  
Drug Identification & Testing  
Pre-Clinical Studies*

## EARTH, ENERGY & ENVIRONMENT CATEGORIES:

### EARTH & ENVIRONMENTAL SCIENCE

*Atmospheric Science  
Climate Science  
Environmental Effects on Ecosystems  
Geosciences  
Water Science*

### ENVIRONMENTAL ENGINEERING

*Bioremediation  
Land Reclamation  
Pollution Control  
Recycling & Waste Management  
Water Resources Management*

### ENERGY: CHEMICAL

*Alternative Fuels  
Computational Energy Science  
Fossil Fuel Energy  
Fuel Cells & Battery Development  
Microbial Fuel Cells  
Solar Materials*

### ENERGY: PHYSICAL

*Hydro Power  
Nuclear Power  
Solar  
Sustainable Design  
Thermal Power  
Wind*

## MATH, COMPUTING & ENGINEERING CATEGORIES:

### EMBEDDED SYSTEMS

*Circuits  
Internet of Things  
Microcontrollers  
Networking & Data Communications  
Optics  
Sensors  
Signal Processing*

### ENGINEERING MECHANICS

*Aerospace & Aeronautical Engineering  
Civil Engineering  
Computational Mechanics  
Control Theory  
Ground Vehicle Systems  
Industrial Engineering-Processing  
Mechanical Engineering  
Naval Systems*

### MATHEMATICS

*Analysis  
Combinatorics, Graph Theory,  
Game Theory  
Geometry & Topology  
Number Theory  
Probability & Statistics*

### ROBOTICS & INTELLIGENT MACHINES

*Biomechanics  
Cognitive Systems  
Control Theory  
Machine Learning  
Robot Kinematics*

### SYSTEMS SOFTWARE

*Algorithms  
Cybersecurity  
Databases  
Human/Machine Interface  
Languages & Operating Systems  
Mobile Apps  
Online Learning*

## PHYSICAL SCIENCES CATEGORIES:

### CHEMISTRY

*Analytical Chemistry  
Computational Chemistry  
Environmental Chemistry  
Inorganic Chemistry  
Materials Chemistry  
Organic Chemistry  
Physical Chemistry*

### MATERIALS SCIENCE

*Biomaterials  
Ceramic & Glasses  
Composite Materials  
Computation & Theory  
Electronic, Optical & Magnetic Materials  
Nanomaterials  
Polymers*

### PHYSICS & ASTRONOMY

*Atomic, Molecular, & Optical Physics  
Astronomy & Cosmology  
Biological Physics  
Condensed Matter & Materials  
Mechanics  
Nuclear & Particle Physics  
Theoretical, Computational, Quantum  
Physics*

## ANIMAL SCIENCES

This category includes all aspects of animals and animal life, animal life cycles, and animal interactions with one another or with their environment. Examples of investigations included in this category would involve the study of the structure, physiology, development, and classification of animals, animal ecology, animal husbandry, entomology, ichthyology, ornithology, and herpetology, as well as the study of animals at the cellular and molecular level which would include cytology, histology, and cellular physiology.

### Subcategories:

- ◆ **Animal Behavior:** The study of animal activities which includes investigating animal interactions within and between species or an animal's response to environmental factors. Examples are animal communication, learning, and intelligence, rhythmic functions, sensory preferences, pheromones, and environmental effects on behaviors, both naturally and experimentally induced.
- ◆ **Cellular Studies :** The study of animal cells involving the use of microscopy to study cell structure and studies investigating activity within cells such as enzyme pathways, cellular biochemistry, and synthesis pathways for DNA, RNA, and protein.
- ◆ **Development:** The study of an organism from the time of fertilization through birth or hatching and into later life. This includes cellular and molecular aspects of fertilization, development, regeneration, and environmental effects on development.
- ◆ **Ecology:** The study of interactions and behavioral relationships among animals, and animals and plants, with their environment and with one another.
- ◆ **Genetics:** The study of genes, genetic variation, and heredity in living organisms. These projects include studies of heredity, dealing with resemblances and differences of related organisms resulting from the interaction of their genes and the environment. Studies may include projects relating to gene expression, gene regulation, genomics, and model organisms.
- ◆ **Nutrition & Growth:** The study of natural, artificial, or maternal nutrients on animal growth, development, and reproduction including the use and effects of biological and chemical control agents to control reproduction and population numbers.
- ◆ **Physiology:** The study of one of the 11 animal systems. This includes structural and functional studies, system mechanics, and the effect of environmental factors or natural variations on the structure or function of a system. Similar studies conducted specifically at the cellular level should select the cellular studies subcategory.
- ◆ **Systematics & Evolution:** The study of animal classification and phylogenetic methods including the evolutionary relationships between species and populations. This includes morphological, biochemical, genetic, and modeled systems to describe the relationship of animals to one another.

## BEHAVIORAL AND SOCIAL SCIENCES

The science or study of the thought processes and behavior of humans and other animals in their interactions with the environment studied through observational and experimental methods.

### Subcategories:

- ◆ **Clinical & Developmental Psychology:** The study and treatment of emotional or behavioral disorders. Developmental psychology is concerned with the study of progressive behavioral changes in an individual from birth until death.

- ◆ **Cognitive Psychology:** The study of cognition, the mental processes that underlie behavior, including thinking, deciding, reasoning, and to some extent motivation and emotion.
- ◆ **Neuroscience:** Studies of the neural basis of cognitive processes, including learning and memory, language and thought, perception, attention, and affect. It investigates the human brain, from the functional organization of large scale cerebral systems to microscopic neurochemical processes.
- ◆ **Physiological Psychology:** The study of the biological and physiological basis of behavior. This field studies the neural mechanisms of perception and behavior through direct manipulation of the brain in controlled experiments.
- ◆ **Sociology & Social Psychology:** The study of human social behavior, especially the study of the origins, organization, institutions, and development of human society. Sociology is concerned with all group activities-economic, social, political, and religious.

## BIOCHEMISTRY

The study of the chemical basis of processes occurring in living organisms, including the processes by which these substances enter into, or are formed in, the organisms and react with each other and the environment.

### Subcategories:

- ◆ **Analytical Biochemistry:** The study of biochemical components found in a cell or other biological sample. The study of the separation, identification, and quantification of chemical components relevant to living organisms.
- ◆ **General Biochemistry:** The study of chemical and physiochemical processes, including interactions and reactions, relevant to living organisms.
- ◆ **Medicinal Biochemistry:** The study of biochemical processes within the human body, with special reference to health and disease.
- ◆ **Structural Biochemistry:** The study of components, functions, and structures of molecules of cells within living organisms. Projects in this subcategory can address various variables of cells through the theories of Chemistry and the laws of Physics.

## BIOMEDICAL AND HEALTH SCIENCES

This category focuses on studies specifically designed to address issues of human health and disease. It includes studies on the diagnosis, treatment, prevention or epidemiology of disease and other damage to the human body or mental systems. Includes studies of normal functioning and may investigate internal as well as external factors such as feedback mechanisms, stress or environmental impact on human health and disease.

### Subcategories:

- ◆ **Cell, Organ, & Systems Physiology:** These studies investigate mechanisms that are involved in maintaining health or when disrupted, cause disease. They could involve investigating such things as the role of cell signaling pathways both within the cell (intracellular) and/or between cells (extracellular). Alternatively, studies in this subcategory could investigate the maintenance of homeostasis at the organ or whole body level (e.g., hormonal control and regulation). These studies may also be in areas such as disease-related, stress-related, biochemical, mechanical, or physical changes at the tissue, organ, and /or cellular level.

CATEGORY CONTINUES ON FOLLOWING PAGE

## BIOMEDICAL AND HEALTH SCIENCES

CATEGORY CONTINUED FROM PREVIOUS PAGE

- ◆ **Genetics & Molecular Biology of Disease:** These studies investigate the genetic and molecular mechanisms involved in the regulatory pathways that maintain normal body and cellular function or if disturbed can lead to disease. Studies could include examining the activation and deactivation of genes (e.g., transcription factors or epigenetic regulation) or involve more classical genetic identification studies.
- ◆ **Immunology:** These studies will investigate any aspects of the immune system that are involved in maintaining health or when altered lead to pathology. These studies can include new investigations of normal immune function (e.g., immune cell interactions and signaling), or they may study diseases caused by disorders in regulation of the immune system (e.g., immunodeficiency or autoimmunity). Alternatively the studies could investigate problems such as graft vs host or host versus graft disease that arise during the treatment of other diseases or conditions.
- ◆ **Nutrition & Natural Products:** The study of food, nutrients and dietary need in humans, and the effects of food and nourishment on the body. These studies may include the effects of natural or supplemental nutrients and nutrition.
- ◆ **Pathophysiology:** These studies will be focused on determining specific causes of disease and on physiological mechanisms responsible for disease development. Investigations in this category will examine changes in the normal physiological balance, or homeostasis that cause a reaction(s) within the body leading to disease.

## BIOMEDICAL ENGINEERING

Projects that involve the application of engineering principles and design concepts to medicine and biology for healthcare purposes including diagnosis, monitoring and therapy. Prominent biomedical engineering applications include the development of biocompatible prostheses, various diagnostic and therapeutic medical devices ranging from clinical equipment to micro-implants, common imaging equipment such as MRIs and EEGs, regenerative tissue growth, pharmaceutical drugs and therapeutic biologicals.

### Subcategories:

- ◆ **Biomaterials & Regenerative Medicine:** These studies involve the creation or use of biomaterials or biocompatible materials to construct a whole or a part of a living structure. These studies can include scaffolds for recruiting or supporting regenerative cells or tissues or the engineering designs for creating the correct environment for regenerative growth.
- ◆ **Biomechanics:** Studies that apply classical mechanics (statics, dynamics, fluids, solids, thermodynamics, and continuum mechanics) to understand the function of biological tissues, organs, and systems and solve biological or medical problems. It includes the study of motion, material deformation, flow within the body and in devices, and transport of chemical constituents across biological and synthetic media and membranes.
- ◆ **Biomedical Devices:** The study and/or construction of an apparatus that use electronics and other measurement techniques to diagnose, prevent and/or treat diseases or other conditions within or on the body.
- ◆ **Biomedical Imaging:** The study and/or construction of an apparatus or technique that combines knowledge of a unique physical

phenomenon (sound, radiation, magnetism, etc) with high speed electronic data processing, analysis and display to generate an image to support biomedical advances and procedures.

- ◆ **Cell & Tissue Engineering:** Studies that utilize the anatomy, biochemistry and mechanics of cellular and sub-cellular structures in order to understand disease processes and to be able to intervene at very specific sites.
- ◆ **Synthetic Biology:** Studies that involve the design and construction of new biological parts, devices and systems. Such studies include biological circuit design, genetic circuits, protein engineering, nucleic acid engineering, rational design, directed evolution and metabolic engineering.

## CELLULAR AND MOLECULAR BIOLOGY

This is an interdisciplinary field that studies the structure, function, intracellular pathways, and formation of cells. Studies involve understanding life and cellular processes specifically at the molecular level.

### Subcategories:

- ◆ **Cell Physiology:** The study of the cell cycle, cell function, and interactions between cells or between cells and their environment. In general, projects could address physiology of membrane transport, neuron transmission, muscle contraction, the digestion of food, circulation of blood, contraction of muscles, or movement and production of nutrients in plant cells. In general, projects could address physiology of membrane transport, neuron transmission, muscle contraction, the digestion of food, circulation of blood, contraction of muscles, or movement and production of nutrients in plant cells.
- ◆ **Cellular Immunology:** The study of the structure and function of the immune system at the cellular level. This includes investigations of innate and acquired (adaptive) immunity, the cellular communication pathways involved in immunity, cellular recognition and interactions between antigens and antibodies.
- ◆ **Genetics:** The study of molecular genetics focusing on the structure and function of genes at a molecular level, genes, genetic variation, and heredity in living cells. These projects explore the consequences of genome variation on human cell biology, and thus gene function in health and disease. Furthermore, projects may study the impact of naturally-occurring and engineered genome mutations in human iPS cells, their differentiated derivatives, and other cell types.
- ◆ **Molecular Biology:** The study of biology at the molecular level. Chiefly concerns itself with understanding the interactions between the various systems of a cell, including the interrelationships of DNA, RNA and protein synthesis and learning how these interactions are regulated, such as during transcription and translation, the significance of introns and exons or coding issues.
- ◆ **Neurobiology:** The study of the structure and function of the nervous system at the cellular or molecular level. This area focuses on the study of cells of the nervous system and the organization of these cells into functional circuits that process information and mediate behavior. Some neurobiology focuses on the molecular structures of the brain and nervous system. Larger complete systems, like the function and structure of the cerebral cortex, may be studied. Projects can look at biological factors that impact learning or mood, or how early genetic material develops into various areas of the brain.

## CHEMISTRY

Studies exploring the science of the composition, structure, properties, and reactions of matter not involving biochemical systems.

### Subcategories:

- ◆ **Analytical Chemistry:** The study of the separation, identification, and quantification of the chemical components of materials.
- ◆ **Computational Chemistry:** A study that applies the discipline and techniques of computer science and mathematics to solve large and complex problems in Chemistry.
- ◆ **Environmental Chemistry:** The study of chemical species in the natural environment, including the effects of human activities, such as the design of products and processes that reduce or eliminate the use or generation of hazardous substances.
- ◆ **Inorganic Chemistry:** The study of the properties and reactions of inorganic and organometallic compounds.
- ◆ **Materials Chemistry:** The chemical study of the design, synthesis and properties of substances, including condensed phases (solids, liquids, polymers) and interfaces, with a useful or potentially useful function, such as catalysis or solar energy.
- ◆ **Organic Chemistry:** The study of carbon-containing compounds, including hydrocarbons and their derivatives.
- ◆ **Physical Chemistry:** The study of the fundamental physical basis of chemical systems and processes, including chemical kinetics, chemical thermodynamics, electrochemistry, photochemistry, spectroscopy, statistical mechanics and astro-chemistry.

## COMPUTATIONAL BIOLOGY AND BIOINFORMATICS

Studies that primarily focus on the discipline and techniques of computer science and mathematics as they relate to biological systems. This includes the development and application of data-analytical and theoretical methods, mathematical modeling and computational simulation techniques to the study of biological, behavior, and social systems.

### Subcategories:

- ◆ **Computational Biomodeling:** Studies that involve computer simulations of biological systems most commonly with a goal of understanding how cells or organism develop, work collectively and survive.
- ◆ **Computational Epidemiology:** The study of disease frequency and distribution, and risk factors and socioeconomic determinants of health within populations. Such studies may include gathering information to confirm existence of disease outbreaks, developing case definitions and analyzing epidemic data, establishing disease surveillance, and implementing methods of disease prevention and control.
- ◆ **Computational Evolutionary Biology:** A study that applies the discipline and techniques of computer science and mathematics to explore the processes of change in populations of organisms, especially taxonomy, paleontology, ethology, population genetics and ecology.
- ◆ **Computational Neuroscience:** A study that applies the discipline and techniques of computer science and mathematics to understand brain function in terms of the information processing properties of the structures that make up the nervous system.

- ◆ **Computational Pharmacology:** A study that applies the discipline and techniques of computer science and mathematics to predict and analyze the responses to drugs.
- ◆ **Genomics:** The study of the function and structure of genomes using recombinant DNA, sequencing, and bioinformatics.

## EARTH AND ENVIRONMENTAL SCIENCES

Studies of the environment and its effect on organisms/systems, including investigations of biological processes such as growth and life span, as well as studies of Earth systems and their evolution.

### Subcategories:

- ◆ **Atmospheric Science:** The study of the Earth's atmosphere, its processes, the effects other systems have on the atmosphere, and the effects of the atmosphere on these other systems as well as meteorological investigations. Further investigation in this field relates to atmospheric chemistry, atmospheric physics, atmospheric changes (both long and short-term) that define average climates and their change over time, and upper layers of the atmosphere, where dissociation and ionization are important.
- ◆ **Climate Science:** Studies of Earth's climate, particularly evidential study of climate change over a period of time. This field studies long-term trends in average meteorological conditions and changes in these averaged conditions from season to season, year to year, decade to decade.
- ◆ **Environmental Effects on Ecosystems:** Studies of the impact of environmental changes (natural or as a result of human interaction) on ecosystems, including empirical pollution studies.
- ◆ **Geosciences:** Studies of Earth's land processes, including mineralogy, plate tectonics, volcanism, and sedimentology.
- ◆ **Water Science:** Studies of Earth's water systems, including water resources, movement, distribution, and water quality. This field includes the occurrence, movement, abundance, distribution, and quality of subsurface waters and related geologic aspects of surface waters. Furthermore, it projects may also address water from the moment of precipitation until it evaporates into the atmosphere or is discharged into the ocean; for example, river systems and the impacts of flooding.

## EMBEDDED SYSTEMS

Studies involving electrical systems in which information is conveyed via signals and waveforms for purposes of enhancing communications, control and/or sensing.

### Subcategories:

- ◆ **Circuits:** The study, analysis, and design of electronic circuits and their components, including testing.
- ◆ **Internet of Things:** The inter-networking of physical devices embedded with electronics, software, sensors, actuators, and network connectivity to enable objects to collect/exchange data and/or provide control. Such devices are to be connected with the internet and/or the cloud.
- ◆ **Microcontrollers:** The study and engineering of microcontrollers and their use to control other devices.

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## EMBEDDED SYSTEMS

CATEGORY CONTINUED FROM PREVIOUS PAGE

- ◆ **Networking & Data Communications:** The study of systems that transmit any combination of voice, video, and/or data among users.
- ◆ **Optics:** The use of visible or infrared light instead of signals sent over wires. The study and development of optical devices and systems devoted to practical applications such as computation.
- ◆ **Sensors:** The study and design of devices that transmit an electrical response to an external device.
- ◆ **Signal Processing:** The extraction of signals from noise and their conversion into a representation for modeling and analysis.

## ENERGY: CHEMICAL

Studies involving biological and chemical processes of renewable energy sources, clean transport, and alternative fuels.

Subcategories:

- ◆ **Alternative Fuels:** Any method of powering an engine that does not involve petroleum (oil). Some alternative fuels are electricity, methane, hydrogen, natural gas, and wood.
- ◆ **Computational Energy Science:** A study that applies the discipline and techniques of computer science and mathematics to solve large and complex problems in Energy Science.
- ◆ **Fossil Fuel Energy:** Studies involving energy from a hydrocarbon deposit, such as petroleum, coal, or natural gas, derived from living matter of a previous geologic time and used for fuel.
- ◆ **Fuel Cells & Battery Development:** The study, analysis and development of fuel cells and batteries that convert and/or store chemical energy into electricity.
- ◆ **Microbial Fuel Cells:** The study of fuel cells that use or mimic bacterial interactions found in nature to produce electricity.
- ◆ **Solar Materials:** The study of materials used to convert and store solar energy through chemical changes. This includes topics such as thermal storage and photovoltaic materials.

## ENERGY: PHYSICAL

Studies of renewable energy structures/processes including energy production and efficiency.

Subcategories:

- ◆ **Hydro Power:** The application of engineering principles and design concepts to capture energy from falling and running water to be converted to another form of energy.
- ◆ **Nuclear Power:** The application of engineering principles and design concepts to capture nuclear energy to be converted to another form of energy.
- ◆ **Solar:** The application of engineering principles and design concepts to capture energy from the sun to be converted to another form of energy.
- ◆ **Sustainable Design:** The application of engineering principles and design concepts to plan and/or construct buildings and infrastructure that minimize environmental impact.

- ◆ **Thermal Power:** The application of engineering principles and design concepts to capture energy from the Earth's crust to be converted to another form of energy.
- ◆ **Wind:** The application of engineering principles and design concepts to capture energy from the wind to be converted to another form of energy.

## ENGINEERING MECHANICS

Studies that focus on the science and engineering that involve movement or structure. The movement can be by the apparatus or the movement can affect the apparatus.

Subcategories:

- ◆ **Aerospace & Aeronautical Engineering:** Studies involving the design of aircraft and space vehicles and the direction of the technical phases of their manufacture and operation.
- ◆ **Civil Engineering:** Studies that involve the planning, designing, construction, and maintenance of structures and public works, such as bridges or dams, roads, water supply, sewer, flood control and, traffic.
- ◆ **Computational Mechanics:** A study that applies the discipline and techniques of computer science and mathematics to solve large and complex problems in Engineering Mechanics.
- ◆ **Control Theory:** The study of dynamical systems, including controllers, systems, and sensors that are influenced by inputs.
- ◆ **Ground Vehicle Systems:** The design of ground vehicles and the direction of the technical phases of their manufacture and operation.
- ◆ **Industrial Engineering-Processing:** Studies of efficient production of industrial goods as affected by elements such as plant and procedural design, the management of materials and energy, and the integration of workers within the overall system. The industrial engineer designs methods, not machinery.
- ◆ **Mechanical Engineering:** Studies that involve the generation and application of heat and mechanical power and the design, production, and use of machines and tools.
- ◆ **Naval Systems:** Studies of the design of ships and the direction of the technical phases of their manufacture and operation.

## ENVIRONMENTAL ENGINEERING

Studies that engineer or develop processes and infrastructure to solve environmental problems in the supply of water, the disposal of waste, or the control of pollution.

### Subcategories:

- ◆ **Bioremediation:** The use of biological agents, such as bacteria or plants, to remove or neutralize contaminants. This includes phytoremediation, constructed wetlands for wastewater treatment, biodegradation, etc.
- ◆ **Land Reclamation:** Studies that apply engineering principles and design techniques to restore land from wetlands, seas, lakes, deserts or mines, through drainage or irrigation to a more productive use or its previous undisturbed state. This subcategory also includes studies involving the restoration of land that is damaged by natural phenomena, such as erosion, or impaired by industrial and urban processes.
- ◆ **Pollution Control:** Studies that use engineering principles and design to prevent or control air, water and solid waste pollution.
- ◆ **Recycling & Waste Management:** Studies involving the extraction and reuse of useful substances from discarded items, garbage, or waste. The process of managing, and disposing of, wastes and hazardous substances through methodologies such as landfills, sewage treatment, composting, waste reduction, etc.
- ◆ **Water Resources Management:** Studies that apply engineering principles and design to the planning, developing, distributing and managing the optimum use of water resources. Studies in this subcategory might include applied surface and groundwater hydrology, forecasting and control of quantity and quality of water or simulation and modeling of water resource systems.

## MATERIALS SCIENCE

The study of the integration of various materials forms in systems, devices, and components that rely on their unique and specific properties. It involves their synthesis and processing in the form of nanoparticles, nanofibers, and nanolayered structures, to coatings and laminates, to bulk monolithic, single-/poly-crystalline, glassy, soft/hard solid, composite, and cellular structures. It also involves measurements of various properties and characterization of the structure across length scales, in addition to multi-scale modeling and computations for process-structure and structure-property correlations.

### Subcategories:

- ◆ **Biomaterials:** Studies involving any matter, surface, or construct that interacts with biological systems. Such materials are often used and/or adapted for a medical application, and thus comprise whole or part of a living structure or biomedical device which performs, augments, or replaces a natural function.
- ◆ **Ceramic & Glasses:** Studies involving materials composed of ceramic and glass – often defined as all solid materials except metals and their alloys that are made by the high-temperature processing of inorganic raw materials.
- ◆ **Composite Materials:** Studies that integrate multiple materials such as ceramics, fiber, metals or polymers to create a superior and unique material.
- ◆ **Computation and Theory:** Studies that develop and apply theoretical methods and/or use computer modeling to design new materials, predict material behavior under differing environmental conditions, understand energy transfer, etc.

- ◆ **Electronic, Optical & Magnetic Materials:** The study and development of materials used to form highly complex systems, such as integrated electronic circuits, optoelectronic devices, and magnetic and optical mass storage media. The various materials, with precisely controlled properties, perform numerous functions, including the acquisition, processing, transmission, storage, and display of information.
- ◆ **Nanomaterials:** The study and development of nanoscale materials; materials with structural features (particle size or grain size, for example) of at least one dimension in the range 1-100 nm.
- ◆ **Polymers:** The study and development of polymers; materials that have a molecular structure consisting chiefly or entirely of a large number of similar units bonded together, e.g., many synthetic organic materials used as plastics and resins.

## MATHEMATICS

The study of the measurement, properties, and relationships of quantities and sets, using numbers and symbols. The deductive study of numbers, geometry, and various abstract constructs, or structures.

### Subcategories:

- ◆ **Algebra:** The study of algebraic operations and/or relations and the structures which arise from them. An example is given by (systems of) equations which involve polynomial functions of one or more variables.
- ◆ **Analysis:** The study of infinitesimal processes in mathematics, typically involving the concept of a limit. This begins with differential and integral calculus, for functions of one or several variables, and includes differential equations.
- ◆ **Combinatorics, Graph Theory, & Game Theory:** The study of combinatorial structures in mathematics, such as finite sets, graphs, and games, often with a view toward classification and/or enumeration.
- ◆ **Geometry & Topology:** The study of the shape, size, and other properties of figures and spaces. Includes such subjects as Euclidean geometry, non-Euclidean geometries (spherical, hyperbolic, Riemannian, Lorentzian), and knot theory (classification of knots in 3-space).
- ◆ **Number Theory:** The study of the arithmetic properties of integers and related topics such as cryptography.
- ◆ **Probability & Statistics:** Mathematical study of random phenomena and the study of statistical tools used to analyze and interpret data.

## MICROBIOLOGY

The study of micro-organisms, including bacteria, viruses, fungi, prokaryotes, and simple eukaryotes as well as antimicrobial and antibiotic substances.

Subcategories:

- ◆ **Antimicrobials & Antibiotics:** Studies involving substances that kill or inhibit the growth of a microorganism.
- ◆ **Applied Microbiology:** The study of microorganisms having potential applications in human, animal or plant health or the use of microorganisms in the production of energy.
- ◆ **Bacteriology:** The study of bacteria and bacterial diseases and the microorganisms responsible for causing a disease. This field focuses on ideas spanning a wide range of topics, from identification and characterization of bacteria, all the way to the development of effective vaccines to combat various types of bacteria.
- ◆ **Environmental Microbiology:** Studies involving microbial interactions and processes within the environment. Air microbiology, soil microbiology and water microbiology as well as the study of biofilms would be included in this subcategory.
- ◆ **Microbial Genetics:** The study of the genetics of microorganisms such as bacteria, archaea and some protozoa and fungi and their chromosomes, plasmids, transposons and phages. Studies can also include gene transfer systems such as transformation, conjugation and transduction.
- ◆ **Virology:** The study of viruses – submicroscopic, parasitic particles of genetic material contained in a protein coat – and virus-like agents. Research in this subcategory may focus on the development and effectiveness of treatments for viruses, the development and life cycle of a particular virus, or how the immune system recognizes a virus and what stimulates immune responses.

## PHYSICS AND ASTRONOMY

Physics is the science of matter and energy and of interactions between the two. Astronomy is the study of anything in the universe beyond the Earth.

Subcategories:

- ◆ **Atomic, Molecular, & Optical Physics:** The study of atoms, simple molecules, electrons, light, and their interactions. Projects studying *non-solid state* lasers and masers also belong in this subcategory.
- ◆ **Astronomy & Cosmology:** The study of space, the universe as a whole, including its origins and evolution, the physical properties of objects in space and computational astronomy.
- ◆ **Biological Physics:** The study of the physics of biological processes and systems.
- ◆ **Condensed Matter & Materials:** The study of the properties of solids and liquids. Topics such as superconductivity, semiconductors, complex fluids, and thin films are studied.
- ◆ **Mechanics:** Classical physics and mechanics, including the macroscopic study of forces, vibrations and flows; on solid, liquid and gaseous materials. Projects studying aerodynamics or hydrodynamics also belong in this subcategory.
- ◆ **Nuclear & Particle Physics:** The study of the physical properties of the atomic nucleus and of fundamental particles and the forces of their interaction. Projects developing particle detectors also belong in this subcategory.

- ◆ **Theoretical, Computational, & Quantum Physics:** The study of nature, phenomena and the laws of physics employing mathematical or computational methods rather than experimental processes.

## PLANT SCIENCES

Studies of plants and how they live, including structure, physiology, development, and classification. Includes plant cultivation, development, ecology, genetics and plant breeding, pathology, physiology, systematics and evolution.

Subcategories:

- ◆ **Agriculture & Agronomy:** Application of the various soil and plant sciences to soil management and agricultural and horticultural crop production. Includes biological and chemical controls of pests, hydroponics, fertilizers and supplements.
- ◆ **Ecology:** The study of interactions and relationships among plants, and plants and animals, with their environment.
- ◆ **Genetics & Breeding:** The study of organismic and population genetics of plants. The application of plant genetics and biotechnology to crop improvement. This includes genetically modified crops.
- ◆ **Growth & Development:** The study of a plant from earliest stages through germination and into later life. This includes cellular and molecular aspects of development and environmental effects, natural or manmade, on development and growth.
- ◆ **Pathology:** The study of plant disease states, and their causes, processes, and consequences. This includes effects of parasites or disease-causing microbes.
- ◆ **Plant Physiology:** The study of functions in plants and plant cells. This includes cellular mechanisms such as photosynthesis and transpiration, and how plant processes are affected by environmental factors or natural variations.
- ◆ **Systematics & Evolution:** The study of classification of organisms and their evolutionary relationships. This includes morphological, biochemical, genetic, and modeled systems.

## ROBOTICS AND INTELLIGENT MACHINES

Studies in which the use of machine intelligence is paramount to reducing the reliance on human intervention.

Subcategories:

- ◆ **Biomechanics:** Studies and apparatus which mimic the role of mechanics in biological systems.
- ◆ **Cognitive Systems:** Studies/apparatus that operate similarly to the ways humans think and process information. Systems that provide for increased interaction of people and machines to more naturally extend and magnify human expertise, activity, and cognition.
- ◆ **Control Theory:** Studies that explore the behavior of dynamical systems with inputs, and how their behavior is modified by feedback. This includes new theoretical results and the applications of new and established control methods, system modelling, identification and simulation, the analysis and design of control systems (including computer-aided design), and practical implementation.
- ◆ **Machine Learning:** Construction and/or study of algorithms that can learn from data.
- ◆ **Robot Kinematics:** The study of movement in robotic systems.

## SYSTEMS SOFTWARE

The study or development of software, information processes or methodologies to demonstrate, analyze, or control a process/solution.

### Subcategories:

- ◆ **Algorithms:** The study or creation of algorithms - step-by-step procedure of calculations to complete a specific task in data processing, automated reasoning and computing.
- ◆ **Cybersecurity:** Studies involving the protection of a computer or computer system against unauthorized access or attacks. This can include studies involving hardware, network, software, host or multimedia security.
- ◆ **Databases:** Studies that create or analyze data organization for ease of access, management and update.
- ◆ **Human/Machine Interface:** Software application that presents information to a user about the state of a process and to accept and implement the operator's control instructions.
- ◆ **Languages & Operating Systems:** Studies that involve the development or analysis of artificial languages used to write instructions that can be translated into machine language and then executed by a computer or system software responsible for the direct control and management of hardware and basic system operations of a computer or mobile device.
- ◆ **Mobile Apps:** A study involving a software application developed specifically for use on small, wireless computing devices. These studies may include front-end development techniques, such as user interface design and cross-platform support, and/or back-end development techniques, such as data services and business logic.
- ◆ **Online Learning:** Studies that focus on utilizing electronic technologies to access educational curriculum outside of a traditional means. Studies explore the design of learning activities and programs with online technologies, as well as the effective use of e-learning systems.

## TRANSLATIONAL MEDICAL SCIENCE

Projects that aim to improve human health and longevity by translating novel discoveries in the biomedical sciences into effective activities and tools for clinical and public health use. Bi-directional in concept, projects can be those developed through basic research moving toward clinical testing (bench-to-bedside) or projects that provide feedback about the applications of new treatments and how they can be improved (beside-to-bench).

### Subcategories:

- ◆ **Disease Detection & Diagnosis:** Studies in this category encompass a variety of novel assay methods to promote the identification, detection and determination of disorders and disease. They may involve studies at the system, organ, or cellular levels.
- ◆ **Disease Prevention:** The study of health promotion and disease prevention activities and research to improve public health. These studies might involve research to protect individuals from actual or potential health threats and their harmful consequences, or they may address novel approaches to aid in compliance for avoiding known health risks (e.g., smoking, drug use, obesity).
- ◆ **Disease Treatment & Therapies:** The use of pharmaceuticals and other therapies, including natural and holistic remedies, intended to improve symptoms and treat or cure disorders or disease.

- ◆ **Drug Identification & Testing:** These studies would be conducted to identify potential drugs or extracts that could be used to treat or cure disorders or disease. Studies in this category would involve initial testing of the compounds against an intended target. This category could also include testing a range of different compounds or extracts to determine relative potency and efficacy.
- ◆ **Pre-Clinical Studies:** These studies of potential drugs or therapies would include testing the intervention in platforms such as cultured cells or animal models of disease. The investigations could be directed toward determining factors such as potential drug permeability, efficacy and/or toxicity. These studies could also investigate the best route of drug administration.