



Research Areas & Industry Collaboration

Universidad Nacional Autónoma de México
CAMPUS MORELOS

Morelos and UNAM's Strengths

UNAM: Strong scientific basis & foundations

- Top rated university in the Spanish speaking world (The Times Higher Education Supplement, 2012, 2013, 2015)
- The "Webometrics Ranking of World Universities" initiative of the Cybermetrics Lab, belonging to the Consejo Superior de Investigaciones Científicas (CSIC) 2015, España.
- 35 years of experience in the State of Morelos, with 6 research entities.

Ranking 9th place, as the most innovative university in the world with the largest quantity of research income from industry. (Times Higher Education –World University Rankings, 2015)

The State of Morelos has reached a world-class recognition for supporting scientific research.

- 41 research centers in Engineering, life Sciences, Physics, Mathematics, Chemistry, Social Sciences & Humanities.

Population active in research: (by thousands of full time employees). *data for Mexico & Morelos from SNI 2014 archives.

- OECD* 1.0 %
- Morelos 0.11%
- México 0.04%

Source: OECD, Main Science and Technology Indicators database, January 2014.
INEGI. Encuesta Nacional de Ocupación y Empleo. Indicadores estratégicos. Cuarto trimestre de 2014. Foro Consultivo Científico y Tecnológico, AC., 2014

Recognized experience in establishing strategic alliances & competencies for technology transfer.

Technology Commercialization Office

Mission/ Vision:

Strengthen UNAM's Campus Morelos scientific and technological capabilities to contribute to society, adding value to its current scientific expertise supporting it with knowledge and practices based upon business development. Our vision is to contribute increasing Mexico's social and economic development and competitiveness regionally and at nationwide levels.

Goals:

Short Term: To provide expert advice to academic institutions concerning the needs of the productive sector. Our expertise upon:

- Management tools and entrepreneurship knowledge
- Technical and business oriented learning-courses and services
- Technology Transfer Consulting

Mid Term: To establish a bridge of cooperation closely bonded with productive sector, providing:

- Licensing experience in high added value technologies & technology transfer
- Collaboration in research, innovation and technology development projects

Long Term: To create strategic alliances at domestic and international levels.

- Network building (domestic and international)
- New business oriented learning platform
- Counseling upon creating business clusters to the entrepreneurial and government sectors

Research Entities in Morelos

41 research entities: 46% in Chemistry, Life Sciences and Health (19 entities), 29% in Physics, Mathematics and Engineering (12 entities) and 25% in Social Sciences and Humanities (10 entities).

Physics, Mathematics and Engineering

- División del Posgrado en Ingeniería, UNAM (IMTA)
- **Instituto de Energías Renovables, IER, - UNAM**
- Centro de Investigaciones en Ingeniería y Ciencias Aplicadas, UAEM
- Centro Nacional de Investigación y Desarrollo Tecnológico, CENIDET
- **Instituto de Ciencias Físicas, ICF, - UNAM**
- Instituto de Investigaciones Eléctricas, IIE
- Instituto Mexicano de Tecnología del Agua, IMTA
- Instituto Tecnológico de Cuautla, ITC
- Instituto Tecnológico de Zacatepec, ITZ
- Tecnológico de Monterrey Campus Cuernavaca, ITESM
- **Unidad Cuernavaca del Instituto de Matemáticas, UCIM, - UNAM**
- Universidad Politécnica del Estado de Morelos, UPEMOR

Chemistry, Life Sciences and Health

- **Centro de Ciencias Genómicas, UNAM**
- Centro de Desarrollo Tecnológico de Tezoyuca, FIR
- Centro de Enseñanza, Investigación y Extensión en Producción Ovina, UNAM
- Centro de Investigación Biomédica del Sur, IMSS
- Centro de Investigación en Biodiversidad y Conservación, UAEM
- Centro de Investigación en Biotecnología, UAEM
- Centro de Investigaciones Químicas, UAEM
- Centro de Productos Bióticos, IPN
- Centro Experimental Zacatepec, Centro de Investigación Regional Pacífico Sur, INIFAP
- Centro Nacional de Investigaciones Disciplinarias en Parasitología Veterinaria, CENID-PAVET
- Centro Nacional de Servicios de Constatación en Salud Animal, CENAPA
- Escuela de Enfermería, UAEM
- Facultad de Ciencias Agropecuarias, UAEM
- Facultad de Ciencias Biológicas, UAEM
- Facultad de Ciencias, UAEM
- Facultad de Farmacia, UAEM
- Facultad de Medicina, UAEM
- **Instituto de Biotecnología, IBt- UNAM**

Instituto Nacional de Salud Pública, INSP

* Source CONACYT (Consejo Nacional de Ciencia y Tecnología) & SICyT (Secretaría de Innovación Ciencia y Tecnología del Estado de Morelos), 2015.





Center for Genomic Sciences (CCG), 1980



Institute of Biotechnology (IBT), 1982



Institute of Physical Sciences (ICF), 1982



Regional Center for Multidisciplinary Research (CRIM), 1983



Institute of Renewable Energies (IER), 1985



Institute of Mathematics, Cuernavaca Branch (UCIM), 1996



Academic entities which are part of Campus Morelos at the Cuernavaca and Temixco facilities

Personnel	IBT	ICF	CCG	IER	CRIM	UCIM	Total
Researchers	102	38	25	44	49	25	283
Technicians	91	12	33	23	23	5	187
TOTAL	193	50	58	67	72	30	470

Academics affiliated to SNI	IBT	ICF	CCG	IER	CRIM	UCIM	Total
	123	41	32	47	36	24	303

47% of the Morelos researchers are from UNAM Campus Morelos.

65% of researchers that integrate UNAM Campus Morelos are affiliated to SNI (National System of Researchers of the National Council of Science and Technology).

Morelos has a total of 999 SNI members.

A large number of them have been awarded internationally

• Source: CONACYT, SNI - Sistema Nacional de Investigadores 2014.

Students	IBT	ICF	CCG	IER	CRIM	UCIM	Total
TOTAL	285	132	72	457	20	64	1,030

This Campus hosts graduate and undergraduate programs in all its research areas, including a pioneer research-oriented undergraduate program in the genomic sciences area. Our researchers supervise over 1,500 students.



Instituto de Biotecnología
UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO

Institute of Biotechnology

Broad range of research areas in Biosciences

- Plant Molecular Biology
- Developmental Genetics & Molecular Physiology
- Cell Engineering & Biocatalysis
- Molecular Medicine & Bioprocesses
- Molecular Microbiology



Department of Plant Molecular Biology

Gladys Cassab, Alejandra Covarrubias, Joseph Dubrovsky, Patricia León, Omar Pantoja, Carmen Quinto, Luis Cárdenas, Federico Sánchez

- Genetic basis of water-deficit in plants
- Ion transport mechanisms and plant adaptation to salinity
- Mechanisms involved in the mutualistic relations in plants
- Developmental genetics and physiology of plant roots
- Stress adaptation in plants and yeast
- Chloroplast development regulation
- Metabolic regulation in plants



Department of Developmental Genetics & Molecular Physiology

Carlos Arias, Susana López, Luis Covarrubias, Alberto Darszon, Patricia Joseph, Jean Louis Charli, Hilda Lomelí, Enrique Reynaud, Mario Zurita

- Molecular physiology of ionic channels in spermatozoa (mouse, sea urchin)
- Cell and molecular neurobiology (rat)
- Genetics, Epigenetics and molecular biology of the embryo development (fruit fly, mouse, zebra fish)
- Molecular biology and functional genomics of the virus-host cell interaction (rotavirus, astrovirus, influenza)
- Stem cell differentiation and cell death regulation (mouse)

Department of Cell Engineering & Biocatalysis

Francisco Bolívar, Guillermo Gosset, Enrique Galindo, Agustín López-Munguía, Enrique Morett, Joel Osuna, Gloria Saab, Lorenzo Segovia, Xavier Soberón, Rafael Vázquez

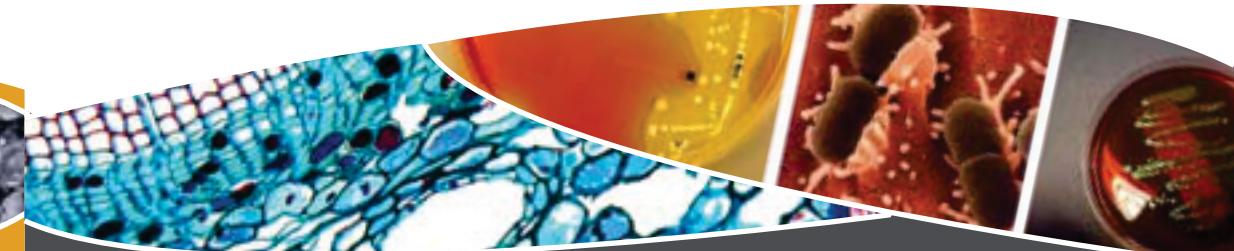
- Metabolic engineering of microorganisms
- Evolution and modification of enzyme catalytic activity
- Genome and proteome bioinformatics
- Enzymatic and bioprocesses engineering
- Environmental biotechnology and bioremediation
- Regulation of the genetic expression in bacteria



Department of Molecular Medicine & Bioprocesses

Alejandro Alagón, Baltazar Bécerril, Gerardo Corzo, Laura Palomares, Gustavo Pedraza, Leonor Pérez, Lourival Possani, Tonatiuh Ramírez, Enrique Rudiño, Yvonne Rosenstein

- Antibody production (monoclonal, recombinant) for diagnostics and therapeutics.
- Structural and physiological characterization of toxins from poisonous animals.
- Development of bioprocesses for producing recombinant proteins in animal cells.
- X-ray protein crystallography.
- Natural compounds extraction and characterization for pharmacological purposes.
- Molecular mechanisms, which activate and regulate the inflammatory process in the central nervous system.
- Signaling pathways underlying the activation of the innate and adaptive immune response.



Department of Molecular Microbiology

Alejandra Bravo, Mario Soberón, Edmundo Calva, Guadalupe Espín, Enrique Merino, José Luis Puente, Adrián Ochoa

- Molecular basis of genetic regulation and cell differentiation in microorganisms
- Structure and function of bacterial toxins
- Molecular basis of pathogenic bacteria – host cell interaction
- Genome and proteome analysis
- Metagenomics and metatranscriptomics of human microbiomes and infectious diseases.

Collaborations with industry



- Recombinant vaccines production with the insect cell-baculovirus system, and services



- Development of a bioethanol production process from agro-industrial wastes.



- Transference of recombinant human insulin production technology. Probiomed established, several years ago, a strategic collaboration agreement with the Institute of Biotechnology to build up the needed infrastructure and necessary knowledge for producing recombinant proteins of medical interest. Some of these products are currently in the bioequivalent market in Mexico and abroad with great success. Today, Probiomed has its own in-house R&D team, which strongly interacts with the Institute of Biotechnology.



- Implementation of the production technology of a recombinant anti-influenza recombinant vaccine FluBlock, to support its transference to Latin American companies.



- R&D projects and services.



- Identification of insecticidal activities in *Bacillus thuringiensis* (Bt) strains.



- Instituto Bioclon and Laboratorios Silanes have maintained for more than 17 years a relationship with the Institute of Biotechnology. As a result, several projects and technologies have been developed and transferred to Silanes: diagnostic kits for hypothyroidism and development of new and improved antivenoms against poisonous stings and bites of scorpions, spiders and snakes. The USFDA approved the use of a first Latin-American drug, a third generation specific antivenom, based on fabotherapy technology against a scorpion sting. This resulted from a strong collaboration between Institute of Biotechnology and Silanes Laboratory. The Mexican antivenom known as "Alacramyn" in Mexico is marketed in the USA under the name "Anascorp".



BP North America (USA)

- Development of R&D projects



PIONEER
A DUPONT BUSINESS

- License of CRY-Mod Toxins technology, developed and based on the knowledge of the mechanism of Bt CRY toxins in the insect gut, elucidated at the Institute. These modified toxins were capable to solve the problem aroused from insect resistance to native CRY toxins. Today PIONEER funds the inventor's laboratory at the Institute for 10 years.



- License of an improved cattle vaccine, co-developed with the British Columbia University



LIOMONT

- Development of bio-equivalents and new antibiotics.



- License for drought tolerant plant cell lines, co-develop with the KU Leuven



- Development of new bioinformatic services



- Transference of a new bio-fungicide for mangoes and other cultures.



COMEXTBIO, (Maalem)

- License of a Bt composition effective against Dengue mosquito vector.



- Development and transference of a new immunogenic cocktail to produce anti-cral snake bite immunotherapeutic in horses.



- License of Kv1.3 immunoblocker peptides to develop therapeutic drugs against autoimmune diseases.

Main research areas

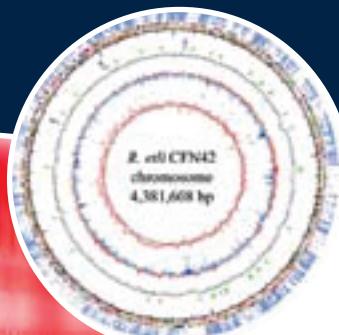
Computational Genomics

- Ecological Genomics
- Evolutionary Genomics
- Functional Genomics of Eukaryotes
- Functional Genomics of Prokaryotes
- Genome Dynamics: Systems Biology and Synthetic Biology Laboratory
- Genome Engineering

Computational Genomics

Julio Collado Vides

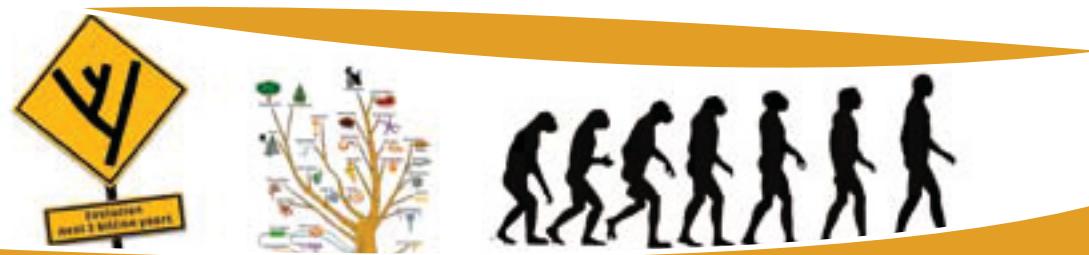
The group has been working for years in the computational modeling of bacterial transcriptional regulation described both in RegulonDB and EcoCyc. This is the basis for a wealth of research questions with bioinformatics approaches to understand the organization and properties of the regulatory networks of the best known organism, *Escherichia coli* K-12. The group has initiated collaborations with two private companies interested in offering bioinformatics services both in the analysis of new generation sequencing projects, as well as in consulting and outreach



Ecological Genomics

Esperanza Martínez-Romero, Otto Geiger, Isabel López Lara, Christian Sohlenkamp

The research in the Program is focused on the study of bacterial populations, their diversity, taxonomy, as well as on the molecular basis of bacterial functions involved in the interactions between bacteria and eukaryotic hosts (plants and insects). Genomic and metagenomic analyses are employed to reveal bacterial genetic determinants required in symbioses with hosts or for living in extreme conditions. They are also devoted to know how bacterial cell surface components contribute to these interactions and the molecular mechanisms that confer resistance to different types of stresses. Derived from their basic research, some applied aspects have been developed for agriculture, medicine, bioremediation and biofuel production.



Evolutionary Genomics

Miguel A. Cevallos Gaos, Víctor González Zúñiga, Julio A. Freyre González, Santiago Castillo Ramírez

The aim of the Program is to contribute to understand the evolutionary genomic processes underlying the symbiotic association between *Rhizobium etli* and the common bean plant. Different genomic approaches are employed to determine the transcriptional profiling of bacteria in symbiosis and stress conditions, to study the incompatibility and plasmid replication, the analysis of the organization, behavior and evolution of complex biological networks and to determine genetic variations of bacterial populations



Functional Genomics of Eukaryotes

Georgina Hernández Delgado, Mario Ramírez Yáñez, Mario A. Serrano Alexandre Tomás

The main biological system studied in this program is the common bean (*Phaseolus vulgaris*) that establishes symbiosis with nitrogen fixing bacteria such as *Rhizobium etli* and *Rhizobium tropici*. Bean is the most important legume for human consumption in the world. In México, and other countries from Latin America, beans are staple crops serving as the primary source of protein in the diet. In America and Africa bean production is low because of plagues and environmental constraints. This program developed the platform for research on functional genomics of bean and this is used to investigate: plant-bacteria interactions, signaling pathways in nitrogen fixing nodules and responses to abiotic stresses (nutrient deficiency, metal toxicity, drought). Other projects that are in progress refer to the study of different aspects of the plant defense responses.



Functional Genomics of Prokaryotes

Jaime Mora Celis, Sergio M. Encarnación Guevara, Michael Dunn

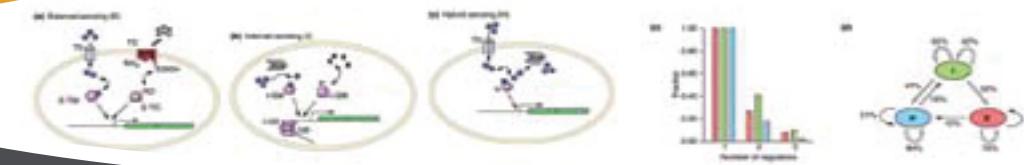
Research in this program includes genetic regulation, metabolism, bacterial genomics, transcriptomics, and proteomics of *Rhizobium* and related organisms. They have experience to take problems and propose solutions in different areas like control of gene expression, genomic localization of genes, transcriptomics by microarray analysis, and proteomics. Recently, they are involved in the study of cervical cancer through proteomics, metabolomics and Systems Biology approaches. They developed the technology for biofertilizers for bean based on *Rhizobium etli*.



Genome Dynamics, Systems Biology and Synthetic Biology Laboratory

María de Lourdes Girard Cuesy, Diego Claudio Cortez Quezada, Rafael Peña Miller, Ayari Fuentes Hernández, José Utrilla Carreri.

The main interest in the lab is to combine systems and synthetic biology using a theoretical-experimental approach to design bacterial phenotypes of biotechnological interest, to study the genetic and metabolic mechanisms that allow bacterial populations to find collective strategies to survive in hostile and unpredictable environments, and to understand the dynamics of the evolution of bacterial resistance to different combinations of antibiotics. Additionally, we build a variety of evolutionary models to analyze specific dynamic regions in the genomes of vertebrates. Furthermore, using bacterial nitrogen fixation as an experimental model, we study the regulation of gene expression in response to various environmental stimuli and the mechanisms directing these responses.



Genomic Engineering

David Romero, Susana Brom, Alejandro García de los Santos, Pablo Vinuesa.

This Program is devoted to the study of the evolutionary and recombination mechanisms that have shaped to the genomic architecture of the genomes of proteobacteria associated with plants. The long-term goal is to use this knowledge to design novel genomic engineering strategies to modify bacterial genomes for secure applications into the field, or in industrial scale. The main lines of research of this program are: homologous recombination, site-specific recombination, plasmid conjugation, functional genomics of native plasmids, molecular systematics, and phylogeography.

Collaborations with industry



- Inoculants to improve crop development and transfer of technology products based on Rhizobium and Azospirillum brasilense to Biofábrica Siglo XXI, S.A. de C.V. which is located in Cuautla, Morelos. Biofábrica has been marketing these products successfully for several years. These biofertilizers were developed by the groups of Dr. Jesús Caballero and Dr. Jaime Mora.

BIOFUELS

- Dr. Esperanza Martínez Romero and Dr. Ivonne Toledo García developed bio-fertilizers for Jatropha curcas L. as an alternative to mass production of oilseeds for bioenergy use.



BIOINFORMATICS TOOLS

- RegulonDB: bioinformatics database that integrates biological knowledge of the transcription control mechanisms in *Escherichia coli*.



Institute of Physical Sciences

Services that could be provided to the industrial, commercial and social sectors.

The highly qualified academic staff of the Institute is capable of providing some reliable services, mainly to the industry. In particular these areas comprise:

- Biophysics, Biotechnology
- Electrochemistry, Corrosion
- Molecular and optical Spectroscopy
- Low temperature plasma physics
- Physics of vibrations

Development of new compounds

- Development of new materials with special optical properties.
- Development and applications of new pharmacological compounds.
- Surface treatments of metal and metal alloys (ionic nitridation).
- Synthesis of advanced, inter-metallic, micro-alloy, coverings and quasi-crystal, materials.
- Design and construction of new materials bearing protection properties against corrosion, of particular hardness and malleability

Materials analysis

- Control and mitigation of corrosion.
- Resistance tests to cracking induced by hydrogen (HIC).
- Hydrogen permeability test.
- Physicochemical analysis (surface tension, density, average molecular weight, viscosity, fusion and crystallization temperature, humidity content, percent of solids, pH, conductivity).
- Fault of structural components analysis.
- Metallographic and image analysis.
- Infrared spectrometry analysis.
- Mechanical tests (tension, impact-compression and hardness).
- Paint analysis (traffic and architectural).

Characterization of gases and surfaces of industrial relevance

- Molecular and compound spectroscopy characterization in gaseous systems or over surfaces and surface treatments for special processes.
- Plasma use and monitoring for surface modifications.
- Analysis and design of contaminant control in industrial processes related to electric and oil- based energy production.
- Use of fast spectroscopy for molecular characterization in gases and surfaces.

Analysis of complex systems

- Optimization of dynamical processes and routes in complex networks. Evolution of regulatory networks. (Gene regulation and neural systems).
- Emergence of organized behavior in groups of many individuals. Example: flight of flocks, vehicle traffic, rumor spreading and evolution of ecosystems.
- Statistical analysis of chaotic and random systems of physical, economic and social origin.
- High performance computer simulation and visualization of many body systems (planetary formation)

Design, manufacturing and training in the management of high-precision equipment, electronics and processing.

- Manufacture of high precision mechanical components
- Design of electronic equipment for monitoring and control of experimental devices .
- Fabrication of high quality optical surfaces
- Training in high-performance computing and data processing.



Pemex. Applied research, diagnostics and consulting regarding pipeline corrosion.



Supported by the National Council for Science and Technology (CONACyT), the Institute for Physical Sciences and Corrosión y Protección, S.A. perform applied research on the development of corrosion inhibitors based on coconut oil and prototypes for the control of pipeline corrosion; computer modeling for the qualification of technical skills of operators for oil and gas pipeline transmission; development of technologies for the evaluation of corrosion levels of steel in concrete.



- Characterization methods upon special materials, corrosion and metallurgy.
- Designs of solutions for innovating nanostructured and metallic materials upon the industry.

ENTREPRISE MANAGEMENT SYSTEMS

Design and construction of a recording system in real time of physical variables associated with the generation of energy in solar panels and gas turbines.



VORSEVI and Instituto Nacional de Antropología e Historia - INAH.

Design and development of automated software for the recording and analysis of historical aspects and physical variables relevant in the classification and cataloging of the historical heritage of Mexico

The Institute of Renewable Energies conducts research in science and technology, particularly in renewable energy; and develops socially acceptable energy technologies leading to a sustainable environment. It carries out research, consultancy and training to institutions, the formation of specialized human resources and the dissemination of knowledge for the benefit of today's society.

Research Areas

- Optical and optoelectronic coatings.
- Solar-hydrogen fuel cells.
- Surfaces, interfaces and composites.
- Solar concentration.
- Geothermal energy.
- Energy planning.
- Refrigeration and heat pumps.
- Theoretical physics.
- Energy and mass transfer.
- Solar Technologies: photovoltaic and photo thermal

Optical and Optoelectronic Coatings

Santhamma Nair Mailepallil, Karunakaran Nair Padmanabhan, Nini Rose Mathew, Aarón Sánchez

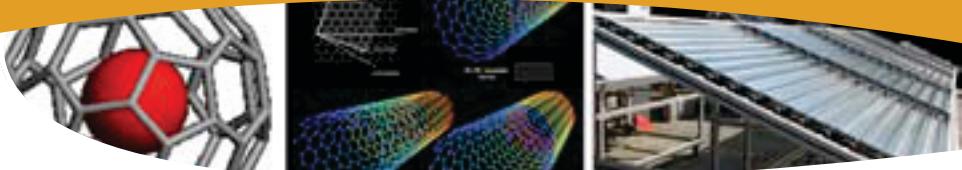
- Thin film photovoltaics.
- Semiconductor coatings and solar control laminated glass.
- Materials for optical and optoelectronic devices.
- Photo-detectors, solar controllers, gas sensors.
- Characterization of materials and optoelectronic devices.
- Development of semiconductor materials using multilayers.
- Photovoltaic systems.



Solar-hydrogen Fuel Cells

Arturo Fernández, Sergio Gamboa, Xavier Mathew, Sebastián Pathiyammaton

- Solar cells and nanostructured thin films based on CuInSe₂ , CdTe and TiO₂.
- Production, storage and application of hydrogen.
- Nano science and nanotechnology in materials synthesis, device fabrication and power generation.
- Metal hydride and lithium batteries.
- Super-capacitors.
- Bio-energy and bio-fuels.
- Study and characterization of semiconductor thin films, to be used as devices of solar radiation control in buildings.



Surfaces, Interfaces and Composites

Ana Karina Cuentas, Antonio Jiménez, Margarita Miranda, Marina Rincón, Raúl Suárez, Hailin Zhao

- Composite materials for multiple applications: sensors, diodes, rectifiers, protective coatings, etc.
- Synthesis of composite semiconductor nanoparticles, in the form of emulsion and thin films for photo-electrolytic and photo-catalytic applications such as hydrogen production.
- Composite materials based on fullerenes and other forms of carbon for energy conversion and storage.
- II-IV compounds by the Sol-Gel technique for designing transparent conductive solar radiation control devices; solar-hydrogen fuel cells.
- Thermoelectric generators.
- Organic solar cells.

Solar Concentration

Camilo Arancibia, Rafael Castrejón, Claudio Estrada, Oscar Jaramillo

- Solar concentrator optics.
- Heat transfer in solar concentrating systems.
- Solar absorber and reflector materials,, development and testing.
- Direct solar energy conversion. Thermionic and thermoelectric systems.
- Solar photo-catalysis and detoxification.
- Concentrated Solar Power.
- High temperature and high radiative flux processes: detoxification and solar fuels.
- Pilot plants for solar concentration applications



Geothermal Energy

Pandarinath Kailasa, Edgar Santoyo, Ignacio Torres, Surendra P. Verma

- Geophysics, geothermal energy and vulcanology.
- Geothermal exploration.
- Analytical Geochemistry.
- Development of computational tools for solving geo-scientific problems.
- Geo-thermometry.
- Water-rock interactions



Energy Planning

Jorge Islas, Fabio Manzini

- Tools for the dissemination of renewable sources.
- Economics of renewable energy systems.
- Technology foresight and energy from renewable sources.
- Dynamics of distributed generation.
- Sustainability of energy systems.
- Mitigation of environmental impacts of energy technologies.
- Structural change of the energy industries.
- Evaluation of externalities.
- Development and economy of energy plantations



Refrigeration and Heat Pumps

Roberto Best, Octavio García, Isaac Pilatowsky, Wilfrido Rivera

- Heat pumps.
- Thermal converters.
- Solar drying/heat pumps.
- Solar absorption cooling, thermo-chemistry by eject compression.
- Simulation of thermal processes and thermodynamics.
- Energy saving in conventional refrigeration.
- Determination of thermo-physical and thermochemical properties of refrigerant/absorbent mixtures

Theoretical Physics

Sergio Cuevas, Mariano López de Haro, Manuel Martínez, Rocío Nava, Antonio del Río, Miguel Robles, Yuri G. Rubo, Julia Tagüeña

- Thermodynamics of irreversible processes.
- Optimization of thermodynamic processes.
- Solar stoves.
- Statistical Physics.
- Solid State Physics.
- Magnetohydrodynamics.
- Photonic crystals.



Energy and Mass Transfer

Guillermo Barrios, Guadalupe Huelsz, Eduardo Ramos, Raúl Rechtman, Jorge Rojas, Ramón Tovar,

- Energy in buildings
- Natural convection.
- Multi-phase flows.
- Oscillatory flows.
- Complex systems.
- Numerical codes for the study of energy and mass transport in fluids.
- Heat transfer in equipment and systems.

Research and technological development

Industry: MABE, MECCANO, INTEL, Módulo Solar, INTERCOVAMEX.



Industrial analysis and energy policies

Government agencies: SENER, CONUEE, State Government of Guerrero.

Autonomous International Agencies: OLADE International Energy Agency



Institutional strengthening and high-level human resources training

National Institutions: UNISON, UAEM.

International Academic Institutions. CIEMAT (Spain), University Rovira I Virgili (Spain)



Technical assessment and technological performance services

Certifying Organizations: ONNCCE, NORMEX

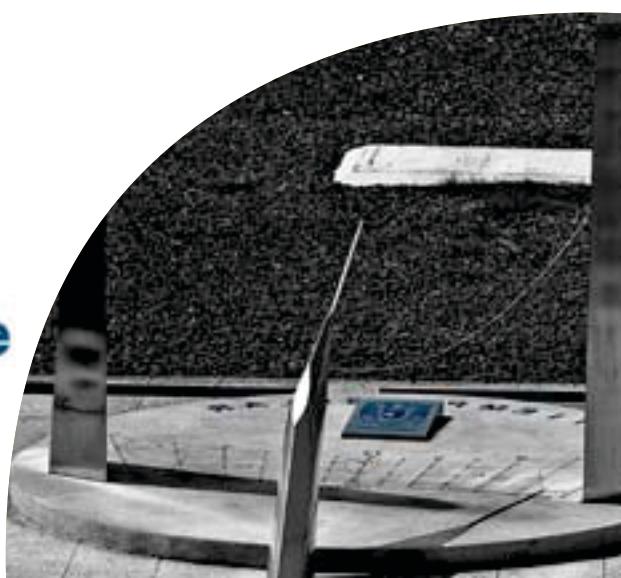


Continuous education

Specialty and graduate courses related with renewable energy

Postgraduate programs

• IER participates in Engineering (Energy) Graduate Programs, Physics and Materials Science and Engineering in which their mission is to train highly academic-level professionals and researchers in their respective knowledge fields which will contribute to Mexico's and other countries sustainable development.



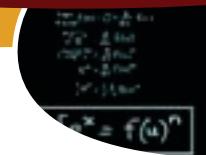
Areas of Research in Mathematics

- Algebra
- Analysis
- Mathematical Physics
- Topology
- Geometry
- Singularities Theory
- Mathematical Modeling and Simulation
- Complex Systems and Optimization
- Dynamical Systems

Algebra

Fuensanta Aroca, José Luis Cisneros, Tim Gendron, Francisco González, Jawad Snoussi, Gregor Weingart

- Group Co-homology and representation theory.
- Algebraic K-theory.
- Classical theory of invariants.
- Lie algebras.
- Commutative algebra and theory of singularities.
- Computer algebra.
- Algebraic number theory.
- Group theory.



$$\begin{aligned}
 \frac{d}{dt} \left(t - \frac{mc^2}{c^2} \right) &= (AT_{12})^2 \quad E = \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}} = mc^2 \approx \frac{mc^2}{t - \frac{mc^2}{c^2}} = mc^2 \approx \\
 &= \frac{dP}{dt} = \frac{d(mv)}{dt} = \cancel{m} \frac{dv}{dt} = \cancel{m} \frac{dM}{dt} \\
 &\approx m \left(1 + \frac{v^2}{2c^2} \right) = mc^2 = \frac{mc^2}{\beta}.
 \end{aligned}$$

Analysis

Natig Atakishiyev, Emilio Marmolejo, Marcos López, Salvador Pérez, Carlos Villegas

- Fourier analysis.
- Harmonic analysis.
- Hardy and Bergman spaces.
- Clifford analysis.
- Banach and Fréchet spaces of holomorphic harmonic functions.
- Inverse problems in parabolic partial differential equations.
- Quantum mechanics.
- Wavelet.
- Harmonic vector analysis.
- Operator theory (Hilbert-Schmidt).



Topology

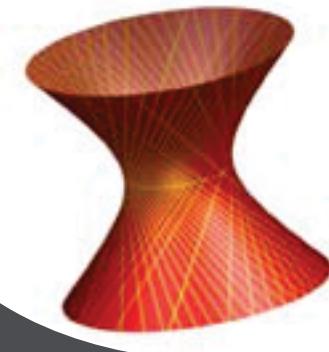
Carlos Cabrera, José Luis Cisneros, Francisco González Acuña, Rolando Jiménez, Fabiola Manjarrez, Max Neumann, José Seade, Alberto Verjovsky, Gregor Weingart

- Algebraic topology.
- Differential topology.
- Geometric topology.
- K theory.
- Homotopic classification of closed manifolds.
- Configuration space.
- Index theory and characteristic classes.
- Homotopy theory and obstructions.
- Theory of Knots.
- Low dimensional manifolds.

Mathematical Physics

Natig Atakishiyev, Tim Gendron, Antonio Sarmiento, Carlos Villegas, Federico Zertuche, Gregor Weingart

- Quantum Mechanics (Schrödinger operators).
- Bargmann transform.
- Group theory.
- Numerical analysis.
- Classical mechanics.
- Semiclassical analysis.
- Dynamical systems.
- Complex systems.
- Cosmology.
- Virasoro algebra



Geometry

Fuensanta Aroca, Carlos Cabrera, Ángel Cano, José Luis Cisneros, Tim Gendron, Adolfo Guillot, Lucía López de Medrano, José Seade, Jawad Snoussi, Alberto Verjovsky, Gregor Weingart

- Differential Geometry.
- Complex geometry.
- Algebraic geometry.
- Tropical geometry.
- Bi-ratios.
- Seiberg-Witten invariants.
- Classification of varieties with non-negative sectional curvature.
- Kleinian Groups.
- Laminations.
- Foliations.
- Riemann surfaces.
- Moduli spaces.

Singularities Theory

Fuensanta Aroca, José Luis Cisneros, Adolfo Guillot, Lucía López de Medrano, José Seade, Jawad Snoussi

- Topological invariants of singular varieties.
- Fibration theorems for real and complex singularities.
- Methods of equi-singularities.
- Modification of Nash and limits of tangent spaces.
- Polar varieties.
- Parameterization of singular spaces.
- Newton polygon.
- Singularities of foliations and differential equations
- Tropicalization of singularities

Mathematical Modeling and Simulation

Luis Javier Álvarez, Gilberto Calvillo, David Romero, Ma. Carmen Valencia, Federico Zertuche

- Molecular dynamics simulations.
- Monte Carlo.
- Mathematical chemistry.
- Simulations of climate change.
- Cellular automata.
- Optimization models.
- Preferences theory.
- Operations research.
- Economics and finance

Complex Systems and Optimization

Gilberto Calvillo, David Romero, Antonio Sarmiento, Federico Zertuche

- Combinatorial optimization.
- Linear programming.
- NP-hard problems.
- Neural networks and cellular automata.
- Discrete dynamics.
- Molecular dynamics simulation.
- Arrangements nonlinear oscillators

Dynamical Systems

Aubin Arroyo, Carlos Cabrera, Ángel Cano, Adolfo Guillot, Peter Makienko, Antonio Sarmiento, José Seade, Alberto Verjovsky

- Differentiable dynamical systems.
- Structural stability and hyperbolic dynamics.
- Strange attractors.
- Ergodic theory.
- Holomorphic dynamical systems.
- Iteration of rational functions.
- Actions of Lie groups.
- Foliations.
- Number theory.
- Complex Kleinian Groups.

Collaborations with industry



- Designing of models and optimization algorithms for the payment system.



- Modeling and optimization algorithms for the design of sampling framework.

Supplementum ex machina

- Development of optimization algorithms routes.

Research Programs

- Global Change, Globalization and Development
- Studies on Education and Training
- Studies on Gender and Equity
- Studies on the Imaginary
- Studies on Population
- Regional Studies
- Culture, Politics and Diversity
- Socio-Environmental Studies
- Violence, Rights and Health

According to the topics addressed by its academics, CRIM has ten research areas grouped around programs:

Global Change, Globalization and Development

The purpose of which is to analyze the dynamics of global change under a spatial and time perspective, as well as the transformations of development processes.

Members:

Prudencio Mochi Alemán, PhD
María Esther Morales Fajardo, PhD
Jorge Serrano Moreno, PhD

Studies on Education and Training

Which seeks to recover, build and develop concepts, analytical perspectives, methods and strategies of inquiry and interpretation of the socio-educational situation from an intra-, multi- and trans-disciplinary perspective.

Members:

María Herlinda Suárez Zozaya, PhD
Norma Georgina Gutiérrez Serrano, PhD
Carlota Guzmán Gómez, PhD



Studies on Gender and Equity

Which addresses gender in cultural and sociological terms in a multidisciplinary manner as one of the axis of social inequality; and to meet the impact and the struggle of women through the feminist movement and the learned society at the global level, in order to maintain its impact on various political, economic, cultural, social and legal contexts.

Members:

Lucero Jiménez Guzmán, PhD
María del Rocío Hernández Pozo, PhD
Úrsula Oswald Spring, PhD
Maribel Ríos Everardo, PhD
Mario Salinas Sosa, MBA
Margarita Velázquez Gutiérrez, PhD



Studies on the Imaginary

in which, the purpose of research lies in the hermeneutical study of aspects related to images, myths, symbols and archetypes inscribed in the process of a culture, a period of time or a creator.

Members:

Blanca Solares Altamirano, PhD
Óscar Figueroa Castro, PhD



Studies on Population

Which addresses the analysis of the present state and the evolution of Mexican population, as well as the historic link between the dynamics of demography and the social economic, political and cultural transformations. This program incorporates the Study Area on Migration and Social Transformations, which promotes and develops an innovative research process, with cross-discipline topics and methodologies on the contemporary issues regarding migration.

Members:

Irene Casique Rodríguez, PhD
Ana María Chávez Galindo, PhD
Héctor Hernández Bringas, PhD
Fernando Lozano Ascencio, PhD
Catherine Menkes Bancet, PhD
Leopoldo Núñez Fernández, MBA
Mercedes Pedrero Nieto, PhD
Liliana Rivera Sánchez, PhD

Regional Studies

The purpose of which seeks to undertake research on socio-territorial processes at the local, regional, and global levels from a spatial perspective.

Members:

Javier Delgadillo Macías, PhD
Héctor Ávila Sánchez, PhD
Igor Lugo Olmos, PhD
Guillermo Olivera Lozano, MBA
Francisco Rodríguez Hernández, MBA
Rodolfo Uribe Iniesta, PhD
Marcos Valdivia López, PhD



Culture, Politics and Diversity

Whose purpose is to show the strategic importance of culture to design policies aimed at improving the quality of life in regional and community environments, as opposed to the neoliberal and globalizing trends, which tend to hinder the capabilities of collective decision making regarding endogenous cultural resources. This program includes the Laboratory of Sentimental Culture and Ethics of Coexistence, whose purpose is to test studies and disciplinary and multidisciplinary reflections based on a perspective of sensitivity and emotional logic as producers of culture itself.

**Members:**

Cristina Amescua Chávez, PhD
Lourdes Arizpe Schlosser, PhD
Héctor Capello García, PhD
Enrique González Pedrero, BA
David Moctezuma Navarro, BA
Héctor Rosales Ayala, PhD
Eréndira Serrano Oswald, PhD
Emma León Vega, PhD



Socio-Environmental Studies

In which, from an analysis of the historical and current processes of their bio-cultural, social, ecological, technological, economic, political and institutional features, it intends to contribute to knowledge, and to develop proposals for public policy, civil participation and of an educational environmental nature that contribute to improve quality of life, ecosystems and the evolutionary potential of nature.

Members:

Jorge Arturo Argueta Villamar, PhD
Inés Arroyo Quiroz, PhD
Eliane Ceccon, PhD
Gabriela De la Mora de la Mora, PhD
Marcia Leticia Durand Smith, PhD
José Raúl García Barrios, PhD
María de Jesús Ordóñez Díaz, PhD
Fernanda Paz Salinas, PhD
Martha Viesca Arrache, MBA

Violence, Rights and Health

Which intends to contribute to the development of knowledge within the social sciences sphere to address, from a multidisciplinary and multi-methodological perspective, the phenomena of health, violence and rights in Mexico.

Members:

María Carolina Agoff, PhD
Roberto Castro Pérez, PhD
Joaquina Erviti, PhD
Sonia Frías Martínez, PhD

Research in Government and Public Policy

Which intends to constitute a space for the study of all three levels of government: federal, state and municipal; to study the state-society relationship at the national, regional, state and local levels; to diagnose, construct, implement and assess public policies in these same areas; to develop regional and local management and government models; and to simultaneously generate a tool for tracking government and public policy, to become a national benchmark in multidisciplinary research and training.

Members:

Medardo Tapia Uribe, PhD





Instituto de Biotecnología
UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO



INSTITUTO DE
CIENCIAS
FÍSICAS



IER
Instituto de Energías
Renovables



Instituto de
Matemáticas
Unidad Cuernavaca

Institute of Biotechnology
www.ibt.unam.mx

Institute of Physical Sciences
www.fis.unam.mx

Center for Genomic Sciences
www.ccg.unam.mx

Institute of Renewable Energies
www.cie.unam.mx

Regional Center for
Multidisciplinary Research
www.crim.unam.mx

Institute of Mathematics, Cuernavaca Branch
www.matcuer.unam.mx



Technology Commercialization Office
UNAM, Campus Morelos

PhD. Isabel Olalde Quintanar
iolalde@morelos.unam.mx
+52 777 329 0882
www.unam.morelos.mx