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Centro Internacional de Física

BOGOTÁ, COLOMBIA

EXCELLENCE IN SCIENCE

Profiles of Research Institutions in Developing Countries

PUBLISHED IN COLLABORATION WITH

COMSATS

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Foreword

Three decades ago, the galvanizing force of the Cold War divided nations into the First World, the Second World and the Third World. The age of personal computing was in its earliest phase, and the architecture of technology, software and coding that would allow creation of the World Wide Web – the Internet – was just being put into place. Few among world leaders or leadership bodies were advancing the idea that the world's poorest countries could benefit by developing skills and facilities for doing research in science and engineering.

But there were some who recognized the power of that idea, and they were working to bring it to life. Abdus Salam, the Pakistani physicist, had already founded the International Center for Theoretical Physics (ICTP) in Trieste, Italy, and it served as a beacon for scientists from the developing world. Soon after winning the Nobel Prize in 1979, Salam and a small cadre of scientists began discussions that would lead to the founding of the Third World Academy of Sciences (TWAS) in 1983.

At the same time, the potential of science for development was winning recognition in Latin America. Over the span of several years, work by Humberto Rodríguez, one of the first Colombians ever to earn his PhD in physics, Galileo Violini, an Italian theoretical physicist, and Colombian physicist Eduardo Posada would lead to the creation of the Centro Internacional de Física (CIF) in Bogotá. Since 1985, CIF has been a profound influence on research in Colombia, Latin America, and beyond.

In this monograph by Colombian science journalist Lisbeth Fog, the remarkable impact of CIF is made clear. From classical questions of physics to tropical diseases and advanced instrumentation for Colombia's energy sector, CIF's wide-ranging work has produced an admirable record of success in basic and applied research. And CIF is playing an important and growing role in engaging with the public and working with business on issues such as environmental protection and climate change.

To be sure, the way has not always been easy. As with many research centres in the developing world, CIF has had to struggle with uncertain funding and shifting political priorities. Today, Fog writes, CIF leaders and researchers are "skilled not only at doing research, but at beating obstacles." They have learned resilience, and that has brought great benefit to the center, the Colombian economy and the people of Colombia.

ICTP and TWAS have maintained a constructive relationship with CIF for more than two decades. Mohamed H.A. Hassan, the founding executive director of TWAS, and Fernando Quevedo, the current director of ICTP, have helped to build upon the partnership established by Salam.

For more than a decade, TWAS has assembled profiles of some of the most innovative, high-impact research centers in the developing world, with results appearing in this Excellence in Science series, in the TWAS Newsletter, on www.TWAS.org and in books and other publications. The rationale is simple: By detailing the challenges and successes at these centres, TWAS gives scientists, policymakers, educators and others throughout the developing world real-life case studies that can shape their own research initiatives.

This year, TWAS is celebrating its 30th anniversary and its new name: The World Academy of Sciences for the advancement of science in developing countries. But the celebration is not for TWAS alone. Rather, it is for the success of CIF and other research centers – and thousands of researchers, South and North – who have committed energy and creativity to building science in developing nations. It is no exaggeration to say that their work has helped to change the world.

Finally, a note of appreciation: TWAS extends heartfelt thanks to CIF Director Eduardo Posada and to the center's directors and researchers for their detailed and patient assistance in the development of this volume. We must also express our gratitude to the Commission on Science and Technology for Sustainable Development in the South (COMSATS), a friend and partner whose support has made this book possible. With 21 member countries and 18 centres of excellence across Asia, the Middle East, Africa and Latin America, it is an influential champion for science and sustainable development.

Over the next 30 years, CIF, COMSATS and organizations like them will play a vital international role. They are models and guides for less developed nations, and they show all the world how research drives innovation and economic growth and improves human lives.

***Romain Murenzi**, executive director*
The World Academy of Sciences
Trieste, Italy

Contents

Sidebars

Key Personnel

Snapshots

Introduction: A Force for Innovation

The South American nation of Colombia has achieved new heights of development, growth and competitiveness in recent years, and the success has inspired its leaders to adopt a new slogan: "The answer is Colombia". Based on its work and accomplishments over nearly three decades, the Centro Internacional de Física (CIF) can be considered a key part of that answer. It works in physics across fields and disciplines to address not only the needs of the nation, but major global challenges.

The focus of the CIF – in English, the International Centre of Physics – ranges from astrophysics and optics to biotechnology and materials science. Since its founding in 1985, the centre has advanced basic scientific understanding, but also has produced important applications to support industry and improve the lives of the people.

The centre's researchers have devised ways to limit the environmental damage caused by palm oil production. They have contributed to the understanding of deadly tropical diseases such as *Leishmaniasis,* and pointed the way to possible treatments. They have explored ways to improve the production of snake anti-venom serum. Now, to offset the damage of a long, armed civil conflict, they are using nuclear physics to design a device that can detect landmines in Colombia's fields.

CIF has been the answer, too, for a number of Colombian companies that needed help improving production systems and developing new products. Its spinoffs have filled a national and regional gap, as in the case of Teclaser, which works in precision laser-cutting. CIF has aided small farmers working in reforestation, and it has supported the flower industry by developing a biochemical mechanism to improve plants' resistance

CENTRO INTERNACIONAL DE FÍSICA, CIF

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to fungi diseases. It has worked to help farmers understand and prepare for the effects of climate change. In optics, CIF was the first in the country to produce a hologram.

Over the years, the Centre has endured through economic and political challenges that sometimes seemed to threaten its very existence. But CIF leaders and staff have learned a fundamental lesson of resilience: They must always have a Plan B ready, just in case Plan A doesn't work. CIF's scientists are now skilled not only at doing research, but at beating obstacles. This could explain why they often remain at the Centre for many years doing research, training new master's and doctoral degree students, and producing new knowledge and novel products.

Indeed, the cumulative accomplishments of CIF are remarkable:

- 80 technological products obtained through contracts with industry;
- Three spin-offs (and two others in process);
- 220 international and national publications;
- 110 articles in proceedings;
- Seven books;
- Five patents;
- 80 finished projects;
- 36 R&D projects completed;
- 40 national cooperation agreements;
- 30 international cooperation agreements;
- 140 trained scientists, including:
  - 30 PhDs
  - 40 masters of science
  - 70 undergraduate / young researchers

The path of progress has required a persistent dedication. But the hard work has paid off: CIF is seen as an important answer for the science community and the industrial sector – and for the people of Colombia. Its impact has been felt not only at home, but also throughout Latin America and worldwide.

CIF leaders and staff have learned a fundamental lesson of resilience: they must be skilled not only at science, but at overcoming obstacles.

History: Embracing Opportunity

In 1985, the Centro Internacional de Física was launched in Bogotá, Colombia, as one of the nation's first research centres. It was the realisation of an ambitious idea, developed over several years that envisioned a centre to serve as a regional and international hub of innovation, filling a gap felt throughout Latin America. In the years since, CIF has produced high-impact research and has had an important influence on national and regional science and technology policy.

To understand CIF, it is important to understand its historical context: In the second half of the 20th century, science activities and research started to come alive in scattered Latin American locations. Universities began to open programmes in basic science, recruiting professionals who were arriving from their graduate studies abroad. But that progress was uneven. In the early 1970s, Colombia had only 20 physicists.

VISION

CIF is an international research and technological development centre with capabilities that span scientific fields, allowing it to conduct research in high-impact disciplines while contributing to the productive transformation of the country and the region.

The United Nations Educational, Scientific and Cultural Organization (UNESCO), the Organization of American States and institutions such as the Ford Foundation and the W.K. Kellogg Foundation helped inspire a new awareness of how Latin America might benefit from building capacity in science and engineering and cultivating young researchers.

But perhaps the single biggest inspiration came from Abdus Salam, founder of the International Centre for Theoretical Physics (ICTP) and later of TWAS, in Trieste, Italy. Salam, who would win the 1979 Nobel Prize in physics, had a vision in which developing nations took the initiative to power their own economic growth and human progress through physics and other basic sciences.

The idea of replicating ICTP in the South, specifically in Colombia, was also in the mind of two physicists. Galileo Violini, an Italian theoretical physicist, had read and followed Salam's work in different scenarios. Salam's speeches ignited Violini's interest in science policy, and when he first met Salam in 1977, he became convinced that there was important work to do in fostering interest in physics in developing countries. The

RELATIONSHIP OF CIF, ICTP AND TWAS

• Since CIF's founding, it has had a close and productive relationship with the International Centre for Theoretical Physics (ICTP) and TWAS. ICTP founder Abdus Salam was the inspiration and then the chairman of CIF's International Scientific Council, for which he was a permanent source of new ideas and initiatives. And many of the courses that CIF has organized through the years have been supported financially by ICTP and TWAS.

CIF leader Eduardo Posada was a member of the ICTP Scientific Council for four years. Recently, ICTP Director Fernando Quevedo has participated in CIF's activities and CIF's scientists have been invited to ICTP's courses in Central America.

Professor Mohamed H.A. Hassan, the founding executive director of TWAS, was also a member of the International Scientific Council of CIF and a constant supporter of the activities the Centre has carried out through the years. Through the initiative of TWAS, CIF became a full member of COMSATS, and Posada has become chairperson of the COMSATS Coordinating Council.

SNAPSHOT

second was Humberto Rodríguez, president at that time of the Sociedad Colombiana de Física (SCF). He was one of the first Colombians ever to earn his PhD in physics, working in methods of physical analysis for materials used in nuclear reactors in Germany.

In 1979, a third party joined the group. The Colombian physicist Eduardo Posada had been studying and working in Switzerland, but when he returned home, he became vice-president of SCF and immediately began working on an idea that would become the Centro Internacional de Física. After an intense effort by Violini, Rodríguez and Posada, Abdus Salam made his first trip to Colombia in January 1980.

The document proposing the creation of the Centre was presented to Julio César Turbay, then the president of Colombia. It had three goals:

- Promoting the development of math and physics in the Latin American and Caribbean region;
- Establishing a regional forum to encourage contact among researchers from the region; and
- Building laboratories and other infrastructure that could be used by scientists of the region.

Salam had just won the Nobel, and so his visit gave a new momentum to the Colombian project by influencing academics, scientists and politicians as well.

But perhaps the region, and Colombia in particular, was not ready yet. A research centre independent from the universities – that was an unfamiliar model in the region. While most of the science community was enthusiastic, the government was not convinced. Initially, it provided no funds. The trio of leaders, backed by other scientists and allies, decided that it would be more feasible to create an organization that could slowly give shape and support to the centre. It could hold workshops and seminars that would give participants up-to-date information on specific areas; it could do promotional activities, cultivate international contacts, and lobby policymakers. So the decision was made to create the Asociación ProCentro Internacional de Física (ACIF), an organization to raise funds, recruit people and in other ways promote the future centre and develop its mission and path. ACIF was born in April 1981.

GALILEO VIOLINI

• *Galileo Violini was born in 1942. He graduated in physics at University of Rome La Sapienza in 1965 and obtained his Libera Docenza in 1971. Between 1965 and 1987, he was at the University of Rome La Sapienza, holding positions including the first professor of algebra, then of mathematical methods of physics. He has been a professor of Theoretical Physics at the University of Calabria since 1987.*

Violini was one of the co-founders in 1985 of the Centro Internacional de Física (CIF) in Bogotá, Colombia, which he co-directed until 1994; he is currently director emeritus. During this time he helped organize more than 100 events in Colombia and other Andean countries.

Violini has been director of a four-year European Union programme at the Universidad de El Salvador, was responsible for higher education scientific programmes at the UNESCO office in Santiago, Chile, and was director of UNESCO's office in Iran. He also has organized workshops in El Salvador and Iran, the latter having led to the cooperation agreement between Iran and CERN (Conseil Européen pour la Recherche Nucléaire, or European Council for Nuclear Research).

In 1995, the American Physical Society (APS) honoured Violini with its John Wheatley Award for the creation and direction of CIF. In 2001, he was appointed APS fellow for broad contributions to physics, the development of new international programmes and the promotion of international cooperation between advanced and developing countries.

He has been a member of several committees for the promotion of international cooperation in science, such as the Latin American Institute at Texas A&M University (USA) and the Pan-American Association of Physics.

Violini has collaborated on several feasibility studies of scientific development programmes in Poland, Japan, Colombia, Italy and Chile. In addition, he performed a study on physics in Central America for UNESCO and collaborated on a mission to explore the possibility of international scientific programmes in the Middle East which could contribute to peace in that region.

Violini's main research activity has been particle physics, an area in which he was co-author of the book Dispersion Theory in High-Energy Physics *(1975). Beside his papers in this area, he has published several papers on science policy and science teaching.*

EDUARDO POSADA

• Was born in Bogotá, Colombia, in 1948. He was the co-director of the Centro Internacional de Física (CIF) for its first nine years, and has served since then as CEO. He received his degree in physics from the University of Lausanne, Switzerland, in 1966, and a PhD in the same field in 1972, with honours from the jury. Among his contributions to science are his work on low-temperature physics and superconductivity, developed both in Europe and in Colombia. Posada served as chief of the cryogenics plant of the Institute of Physics of the University of Lausanne, where he designed and implemented a new production plant of helium that was the most modern in Europe at that time.

When he decided to return to his country, he was appointed as head of the group of technical physics at the research lab of the coffee industry, at the Federación Nacional de Cafeteros de Colombia (FNC), where he conducted research on processing natural products, particularly in freeze-dried coffee and fruits.

A scientist worried about the low level of science activities in Colombia, Posada began to influence science policy in the early 1980s. He was one of the authors of Act 29 of 1990, the first law that regulated scientific research in the country, and Act 1286 of 2009, the second law that reformed the Colombian Research Department for Science, Technology and Innovation, Colciencias.

Posada has been member of several boards and panels, including different science councils at Colciencias; the Commission of Science, Education and Development (1993-1994); the Board of the National Bank Foundation (1992-2003); the Institute of Nuclear Affairs (1991-1994); and the Scientific Council at ICTP in Trieste (1994-1998), to mention just a few. He was also an active member of the group that designed the Interactive Centre for Science and Technology, Maloka, located in Bogotá. He has served as president of a number of high-profile organizations, including the Sociedad Colombiana de Física (1984-1987); the Asociación ProCentro Internacional de Física (1982-1987); Interciencia Association (1992-1995); and the Asociación Colombiana para el Avance de la Ciencia (1986 to date).

Posada has been honoured with several prizes that recognize the development of important projects in basic and applied research, his inputs to science policy and the creation of technology-based companies.

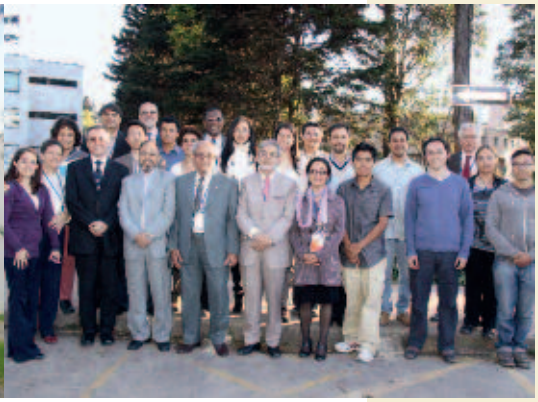
Currently (2013) Posada is associate professor emeritus of the Universidad Nacional de Colombia. Internationally, he is chairman of COMSATS Coordinating Council (2010 to date) and second vice-president of Interciencia.

Its first members were the physical societies of Bolivia, Colombia, Ecuador, Peru and the Dominican Republic, as well as physicists from other countries. With Eduardo Posada as its first president, one year later the ACIF organized a workshop on gravitational waves, which was the first of 25 events on different aspects of science, such as geophysics, alternative sources of energy and medical physics. These activities attracted almost 200 speakers and 1,600 participants. Two of those workshops were organized in Argentina and Chile and the rest in different cities of Colombia. As a whole, those courses helped young researchers find opportunities to attend graduate programmes abroad, mainly in theoretical, high-energy, medical, atmospheric and environmental physics, biophysics, mathematics and physics outreach.

In May 1985, when Salam returned to Colombia, the project had grown and was much stronger. The idea of an independent research centre was familiar and well-accepted across the region.

Since 1985, ACIF and CIF have organized 215 events, with 1,650 lecturers from Europe and the United States, 8,500 local participants and 1,800 international participants.

Gradually, policymakers came to embrace the idea of a research center independent of universities.



CIF is well-known and recognized in the region and worldwide, due to the links it has developed since it was founded and to its high-impact performance.

Regionally, the first milestone came in 1989 when CIF and the Academia Colombiana de Ciencias Exactas, Físicas y Naturales organized the Meeting on Status and Problems of Science in Latin America and the Caribbean, in the context of the National Year of Science (June 1988 – June 1989), attended by Mohamed H.A. Hassan, then executive director of TWAS. This meeting, as Galileo Violini said, "showed that CIF was a source of ideas in the international level and a reference point for TWAS".

Some years later, in 1996, CIF achieved its second milestone: The Centre was recognized by TWAS as an Excellence Centre of the Third World, which allowed it to become a member of the Commission of Science and Technology for Sustainable Development of the South, or COMSATS. Based in Islamabad, Pakistan, COMSATS was created in 1994 to promote South-South cooperation in the fields of science and technology that are most relevant to socio-economic development.

As CIF's accomplishments mounted, it became a hub in regional and international science and engineering networks.

That was not as easy as it sounds. CIF had to go through a complex process that evaluated the scientific staff and its experience in research projects, as well as capacity-building. The assessment identified one key weakness: the lack of sufficient funds to operate.

At the same time, CIF was emerging as a key partner in a range of regional and international networks. In 1996, CIF became a regional node of the Centre for Science and Technology of the Non-aligned and Other Developing Countries (NAM S&T Centre), based in New Delhi, India, which promotes science and technology research activities in its 47 member countries.

Today, CIF's international cooperation is active with COMSATS; ICTP; The World Academy of Sciences (TWAS); the Max Planck Institute for Experimental Medicine in Göttingen, Germany; École Supérieure de Physique et de Chimie Industrielles, Paris; the Biophysics Institute at New York University; and the Marine Biological Laboratory based in Woods Hole, Massachusetts (USA).

CIF has been recognized as one of the top research centres of excellence in Colombia. In 2011, as a result of an evaluation led by Colciencias, which included more than 60 Colombian research centres, CIF got the second position due to its productivity, human and technological resources and investment.

CIF is part of an association of five national research centres of excellence of similar high scientific and technological level and international recognition. The other four are the Corrosion Research Centre (CIC); the International Centre for Training and Medical Research (CIDEIM); the Institute for Biological Research (CIB); and Corpogen, a biotechnology research centre.

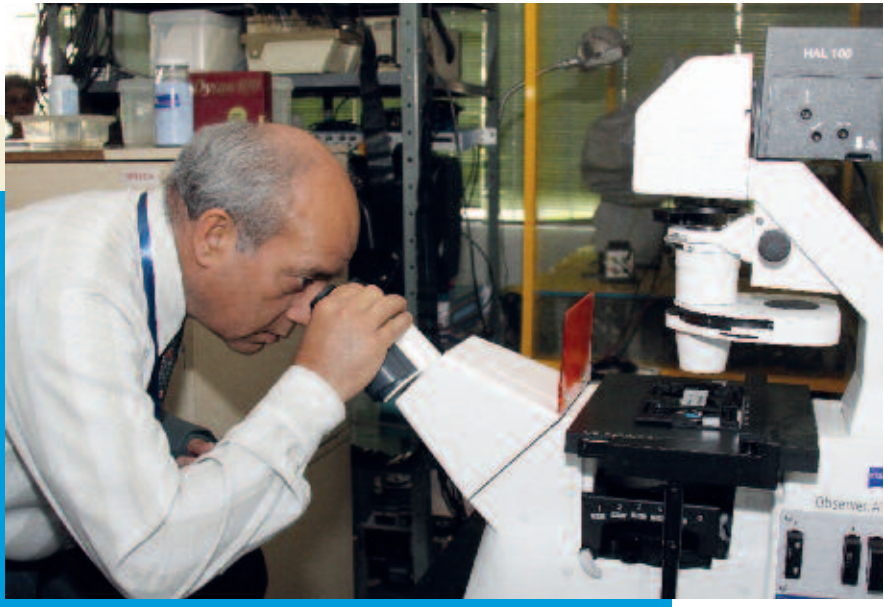
Two years ago, CIF became a member of the Colombian Network of Technological Research Centres.

CIF in Action

"CIF was like an embassy of the international science community, with a circulation of scientists from abroad that would also visit Universidad Nacional."
– **Antanas Mockus**, president of the Universidad Nacional (1990 – 1993)

CIF was officially founded in 4 December 1985 as a private and independent not-for-profit research institution. It was supported by ICTP and Professor Abdus Salam, the Colombian government and the enthusiasm of scientists from many countries, including Argentina, Bolivia, Brazil, Germany, Italy, Mexico, Pakistan, Singapore, Spain and the United States. And of course the scientists of Colombia, who finally saw their goal come true.

Thanks to an agreement with the Universidad Nacional de Colombia in Bogotá, signed in 1987, CIF is located in a 1,600 square-meter building on the university campus.



Currently 48 people work at CIF, including 28 full-time scientists, 11 part-time researchers and nine administrative personnel; more than 40 PhD, MSc and undergraduate students develop their projects in its facilities.

CIF has five goals that have directed its evolution during almost three decades:

- Development of basic and applied research;
- Training of scientists;
- Technological development and innovation in industry;
- Introduction of new technologies in the country; and
- Creation of knowledge-based industries (spin-offs).

At the beginning, CIF was devoted to updating scientists in physics and related areas with a scheme similar to ICTP.

Capacity-building and international contacts were at the core of its activities, in response to the need of researchers in the region, but there was also a need to start building laboratories so that they could continue research projects in Colombia. Courses, workshops, seminars and conferences were designed to communicate up-to-date information on different cutting-edge disciplines, as well as introducing advanced technologies that can be useful in the relationship with industries.

CIF has always done basic and applied research oriented to the solutions of practical problems, both of industry and society.

Beginning in the 1990s, CIF reduced its training activities and strengthened its scientific research. The emergence of the Internet made it easier to build contacts and relationships over a distance, and that made it a tool for strengthening international ties. That created powerful new research potential for the Centre and its partners.

MISSION

To promote new knowledge, capacity-building and technological change through basic and applied research, especially in physics and industrial and technological development that help solve problems and contribute to the advancement and development of the country and the region.

UNIVERSIDAD NACIONAL DE COLOMBIA (UNAL) / NATIONAL UNIVERSITY OF COLOMBIA

• The Universidad Nacional de Colombia, also called UNAL, was founded in 1867 in Bogotá and now has seven branches in the cities of Arauca, Leticia, Manizales, Medellín, Palmira, San Andrés and Tumaco. The university is the largest, best and most important higher education institution in the country with more than 44,000 students. Its academic programmes, about 400 in all, produce the largest number of graduated professionals per year, including those from 38,131 master's degree programmes and 46 PhD programmes. It is an autonomous independent entity of higher education linked to the Ministry of National Education, with a special and defined regime as a national public university to reflect a pluralistic and secular character. The UNAL promotes fair access to the Colombian education system.

SNAPSHOT

Laboratories and Research Groups

With funds from Colciencias and other sources, it was possible to start a **Biophysics lab**, backed by Rodolfo Llinás, a Colombian neuroscientist, currently at the New York University School of Medicine, and Isabel Llano, a Colombian biophysicist, now at Université Paris Descartes. Walter Stühmer, a Colombian biophysicist, now at the Max Planck Institute, helped the group design some of its first projects, financed by Colciencias, focused on ion homeostasis in microorganisms.

Since 1995, the lab has been run by Marcela Camacho, a physician with a PhD in biology; its research projects deal with tropical diseases from a neuroscience and cellular electrophysiology approach, with the help of UNAL, where Camacho is an associate professor, and Colciencias.

In the mid-1990s, CIF started a new era, creating different laboratories, organizing its research groups and developing short- and mid-term science projects with a focus on Colombia's needs and problems.

The **Astrophysics lab**, which was very active in the 1990s, studied cosmic background radiation and was associated with the group led by the Nobel Prize laureate George Smoot at the University of California, Berkeley. Sergio Torres, a Colombian astrophysicist, was in charge of measuring this radiation from a radio

CIF was the first lab doing nanotechnology in the country.

telescope located in Villa de Leyva, a town three hours from Bogotá. The Galactic Emission Mapping Project (GEM) resulted in several science publications and produced three PhDs.

The team that studied Group Theory worked during five years (1990 – 1995) in semiconductor physics and nanotechnology, particularly in fullerenes, under the guidance of a theoretical physicist from New Zealand, Richard Haase, and with the help of his Colombian colleague, Gustavo Holguín. One of the projects led to development of special equipment for the production of fullerenes, which CIF later donated to Universidad Nacional, and also designed and built the first scanning tunneling microscope in Colombia.

"CIF was the first lab doing nanotechnology in the country", says Posada.

The need to understand biodiversity – and to know how to use it – was critically important for a country that is the second most biodiverse in the world, and this triggered the creation of the **Biotechnology laboratory**. Biologist Marta Guardiola has been its director since 1992, focusing not only on research projects but also studying Colombian agricultural problems.

The need to understand biodiversity – and to know how to use it – is critically important for Colombia.

By combining both activities, the lab got a patent for the development of a vaccine-like treatment for plants, based on the biochemical mechanisms used by plants to resist pathogens.

The **Applied Physics and Technological Development Group** was created with the goal of designing and building equipment and other innovative solutions to problems faced by industries in different areas. At that time, beginning the 1990s, it helped develop the scanning tunneling microscope – a type of microscope that shows three-dimensional images of a sample – mentioned above.

The group has become leader in smart-grid technology that is being applied in the measurement of electrical variables in different Colombian cities.

Since the group's founding in the mid-1990s, José García has served as director.

Posada remembers that by that time, ICTP and the École Polytechnique Fédérale de Lausanne donated a microprocessor lab that was used to train young scientists in the design of scientific and industrial instruments.

The **Optics Group** decided to work in the field of holograms, a technique that was brought by two physicists, William McGowan of Canada and Vladimir Markov of Ukraine. Run by Edgar Alfonso since 2006, this group leads research on photonic devices, opto-electronics and LIDAR development.

The **Materials Science Group** began thanks to a donation of equipment by the University of Laussane in Switzerland for the production and growing of thin films. The group focused its activities on materials with properties which can be applied in optics and engineering. Recently it has been working in the development of nanotechnology-based materials. The group is directed by Eduardo Posada.

The **Nuclear Physics Group** that today belongs to UNAL has emphasized its research in the nuclear structure at high excitation energies and high angular momentum, especially in the study of heavy nuclei. Led by physicist Fernando Cristancho, an associate professor at Universidad Nacional, this group also does research in spectroscopy of neutron and gamma rays.

The **Classical Foundations of Physics Group** has focused on fundamental physics, including the Michelson-Morley experiment, which provides a fundamental test of special relativity. Nuclear engineer Héctor Múnera, who joined CIF in the 1980s, has directed this group since its creation in 1999.

An Indispensible Source of Expertise

The Centro Internacional de Física has established a series of strategic alliances applying cutting-edge knowledge derived from contemporary physics to production processes in industries. In this enterprise, partnerships are critically important.

Over almost 30 years, CIF has expanded its activities by cooperating with other independent research centres, industrial companies, academic institutions and political bodies. And because it organizes meetings and international conferences, it is common to encounter researchers from around the world walking through its corridors and working in its labs.

Innovation has been in the nucleus of CIF, a strength that has been emulated by other research groups and has influenced the innovation policy of the country.

Other strengths that CIF has developed during these years are its high-level and qualified basic research, broad experience in technological development and an administrative flexibility.

CIF has become a reliable source of information and expertise in the technological arena for academic, political and industrial communities, thanks to an interdisciplinary professional team able to provide integrated solutions to problems. For example, the Centre develops and produces equipment useful for industries of several fields, and it has been especially active in the energy sector. It is permanently trying to improve the accuracy and precision of the instruments it develops.

Turning Research into Development

The Centro Internacional de Física does both basic and applied research, co-financed by Colciencias, industrial companies and international partners.

Through the years, CIF has established cutting-edge laboratories, in which professional groups, comprised of PhD and master's of science researchers, as well as graduate and undergraduate students, do research in basic science and publish their results in peer-reviewed national and international scientific publications.

Other groups develop applied outcomes, such as the design of products or improving processes that are effective tools for agriculture, energy, health and industrial sectors. For these teams, one benchmarks ranks above all: innovation.

Parallel to the basic and applied research that constitutes the daily life of CIF's groups, hundreds of young researchers have been trained over the course of nearly three decades.

Biophysics Laboratory

Biophysics and Membranes Biology Group

In the 1990s, 6,500 Colombian patients were affected with a tropical disease called *Leishmaniasis*, and in the first 12 years of this century the number rose to almost 14,000. Today, an estimated 10 million people at are risk, mainly in rural areas.

In the scientific literature *Leishmaniasis* is referred as the "disease of the guerrilla", because some of the patients are rebels and live hidden in the woods where the mosquito transmits the parasites, called *Leishmania*. It also affects the Colombian military forces that frequent the same areas. Because of this impact, it has become a public health issue in the country and other tropical nations.

From its inception, says medical doctor and PhD in biology Marcela Camacho, the Biophysics Group focused on the basic relation between pathogen and host. But the approach was unique, using a biophysics and cellular biology perspective. "We explored ionic channels in the membrane of the structure where the parasite lives, called parasitophorous vacuole, and studied the impact of the infection on the macrophage", she explains.

KEY PERSONNEL

MARCELA CAMACHO

• ***Marcela Camacho, PhD*** *– An associate professor in the Biology Department at the Universidad Nacional de Colombia, Camacho has led the CIF Biophysics Lab since 1995. She earned her degree in medicine from the Pontificia Universidad Javeriana in Bogotá, and a PhD on the biology of the* Schistosoma *– a parasite responsible for a highly significant infection in humans – at the University of London's Imperial College of Science, Technology and Medicine. She also has postdoctoral experience in molecular biology from the same educational institution. Her lines of research are cellular and molecular biophysics, public health, comparative physiology and human parasitarian protozoology.*

A macrophage, as the journal *Nature* described it, is the "the big eater of the immune system". It is a cell that resides in every tissue of the body, where they engulf pathogens and produce immune molecules (http://www.nature.com/nri/focus/macrophages/index.html).

However, in the case of *Leishmania*, the pathogen doesn't allow the macrophage to accomplish its goal; instead it uses it for reproduction, meaning that the invasion can be worrisome.

"The macrophages", says Camacho, "are outstanding and interesting cells in terms of the wide repertoire of responses that they are able to give; they are highly sophisticated and we have evidence of the relationship between *Leishmania* and macrophage and how they behave".

The evidence Camacho refers to means that the Biophysics group has the entire electrical information of the macrophage's responses. What are the properties of membranes when they are attacked by microorganisms? And which segment could be the therapeutic target of potential medicines? Those are some of the questions researchers have tried to answer in the field of cell electro-physiology applied to tropical parasitic diseases, in particular *Leishmaniasis*, from the standpoint of physics and electrophysiology.

Today an estimated 10 million Colombians are at risk of Leshmaniasis, *mainly in rural areas.*

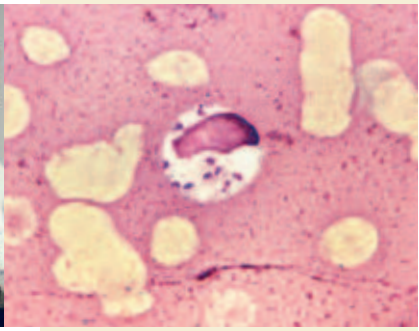
Understanding the impact of intracellular pathogens on the behavior of their host cells is crucial to designing new interventions. This group is interested in how *Leishmania* alters the electrical function of the plasma membrane of the macrophage it infects.

Thanks to the support of UNAL, Colciencias and The Wellcome Trust, this lab is unique: With advanced equipment, it can make functional measurements of ionic channels through the use of electrophysiology and fluorometry techniques. Since its first scientific project, the lab has developed links with Max Planck Institute in Göttingen, Germany, and the École Normale Superieure in Paris.

After so many years of dedicated work, some of the results this group has achieved deal with a method to separate cells and intracellular organelles, and describe the membrane permeability in the model *Leishmania*-macrophage.

In this field, Camacho and her group have approached a theoretical analysis of ion currents by detecting them on the *Leishmania* parasitophorus vacuole.

The study of *Leishmania* through the biophysics and cellular biology of membranes has resulted in new knowledge on the impact that the parasite has in the host cell, leading to developing new ways and strategies to control the disease.



The study of Leishmania *through the biophysics and cellular biology of membranes has resulted in new strategies to control the disease.*

Biophysics and Signal Transduction Group

This group, led by Enrico Nasi, is part of the Biophysics Lab. The research focuses on the analysis of ion currents and the mechanisms involved in the transduction of external stimuli by sensory neurons (eyes and ears), which in some cases attain the sensitivity limits and band-width dictated by physics laws. The research lines of this group include the identification of the molecules responsible for converting external stimuli into electrical impulses, and the evolutionary origin of these mechanisms of cellular signaling.

ENRICO NASI

- ***Enrico Nasi, PhD*** *– Professor at the Institute of Genetics, Universidad Nacional de Colombia, and researcher at CIF since 2007. His research areas are biophysics of signal transduction, ion channels and evolution of photoreception. His current research is the study of the mechanisms of photoreception mediated by melanopsin, using electrophysiological and optical methods in isolated cells, together with molecular biology approaches.*

Before joining the Universidad Nacional, Enrico Nasi had been for over 25 years on the faculty of Boston University School of Medicine, where he was a professor in the Department of Physiology and Biophysics. In addition, since 1988 he has been affiliated with the Marine Biological Laboratory (MBL) of Woods Hole, Massachusetts, where he is currently a senior adjunct scientist and a member of the MBL Corporation, and maintains a permanent research laboratory funded by the U.S. National Science Foundation (NSF). Nasi has served on grant review panels of the U.S. National Institutes of Health (NIH) and has been a grant reviewer of the NSF and several funding agencies in Europe and Latin America, a consultant of the NASA Life Sciences Program, and a referee for numerous scientific journals. He has published over 30 scientific articles in leading international journals, several book chapters, and has given over 60 lectures by invitation at academic and research institutions in the United States, Europe, Japan and Latin America.

MARÍA DEL PILAR GÓMEZ

• ***María del Pilar Gómez, MD, PhD*** *– Associate professor at the Department of Biology, Universidad Nacional de Colombia and researcher at CIF since 2007. Gómez conducts research in areas of phototransduction, cell signaling, and cellular neurophysiology. She is currently working on cellular and molecular mechanisms of light transduction in non-canonical photoreceptors and their evolutionary implications.*

After completing her medical degree at Universidad de Caldas, Colombia, followed by an internship at Hospital San Vicente in Medellin, Gómez obtained a master's degree and subsequently a Ph.D. in physiology from Boston University School of Medicine. She was a post-doctoral fellow at the same institution, and subsequently assistant professor of physiology and biophysics. In addition, she has been for many years an investigator and currently co-director of a laboratory in the United States at the Marine Biological Laboratory in Woods Hole, Massachusetts. She has been a visiting scientist at the Forschungszentrum Jülich (Germany) in the laboratory of Benjamin Kaupp, and at Instituto de Neurociencias de Alicante at the Universidad Miguel Hernandez in Alicante, Spain. She is the author of 30 international publications.

Cell Neurophysiology Group

This group collaborates closely with the Biophysics and Signal Transduction group as well as the Biophysics and Membrane Biology group. The main objective of its researchers is to examine the mechanisms by which visual cells generate an electrical signal in response to light stimulation and their ability to adjust their sensitivity for optimal responsiveness over many orders of magnitude of light intensity. The interest of the group lies mainly in the signal transduction cascades, how they are modulated and the ionic channels that mediate the receptor potential in sensory cells.

Both the previous groups are concentrated in basic research. Even though the groups' researchers are aware that some applications can come up from their work in the future, that is not their main interest. Knowledge is valuable on its own.

Environmental Biotechnology Group

The goal of the biotechnology research group is to design environment-friendly alternatives that allow farmers and industries to optimize the use of natural resources. Such work is focused on the needs of society as well as on global environmental issues. Its research covers a broad range: biological filtration; environmental impact assessments; bioremediation; reforestation; climate change vulnerability and adaptation strategies; and environmental economics, which focuses on the financial viability of biotechnological alternatives for the agricultural and industrial sectors, as well as on cost-benefit analysis.

Since 1994, this group has led basic and applied research and technological development of products and solutions for rural communities as well as for the public and private sectors. It has developed broad experience in building productive alternatives that are socially accepted, economically viable, and environmentally responsible.

Biotechnology is broadly defined by the group as a set of strategies for using live natural resources and related products to benefit human beings. At the beginning, the group studied clean alternatives that could replace pesticides, evaluating natural means of inducing the expression of plant carbohydrates and enzymes as a defense against microbial pathogens. This work had very promising results in the potato and flower industries.

We created a sustainable business model integrating every variable we found in our research.

Most recently, its work has focused on the design of biotechnological solutions to problems such as environment deterioration as a result of human activities and the development of production alternatives for the industrial and agricultural sectors, through bioremediation, agro-ecology, agricultural biotechnology and environmental management.

It is equipped with two labs (microbiology and biochemistry), a growing room for plants and a clean room.

Director Marta L. Guardiola emphasizes that the group's work has broad practical applications related to biodiversity conservation, food security, climate change adaptation strategies and protection of water resources.

Over the past seven years, the group has provided support to small farmers in the production of *panela* (brown sugar) out of sugar cane that sustains approximately 350,000 families in the Andean region. During the process, the farmers typically use the extract of forest tree barks for clarifying sugarcane juices, which causes a huge deforestation without any compensating programmes. As part of a research project which included social aspects, the group evaluated various sustainable practices for the use of the tree bark – using branches instead of the tree trunk, for example – and assessed ways to stimulate the regrowth of valuable species.

"We created a sustainable business model integrating every variable we found in our research," says Guardiola. And now, she continues, the small farmer has more knowledge about the behaviour and care of the species.

KEY PERSONNEL

MARTA LUCÍA GUARDIOLA

• ***Marta Lucía Guardiola, master's of science:*** *– Marta Lucía Guardiola is a biologist of Universidad de los Andes, and an MSc in chemistry of Universidad Nacional de Colombia. She specializes in biochemistry, molecular biology and ecological sanitation. Since 1992, she has led the Environmental Biotechnology Research Group at CIF, an interdisciplinary team devoted to generation of technology and other sustainable environmental solutions for the public and private industrial sectors.*

She has done analysis, design and definition of alternative environmental biotechnological strategies for agricultural production systems, including sanitation, along with agroindustries and small farmers.

She has been an evaluator of projects for universities and Ibero-American institutions.

A local farmer, Israel Bohorques stated: "Panela producers have now a better business, because we learned how to manage the whole system, from plagues and water to sowing sugar cane. We have now a better quality of life."

The group also has given technical support to the palm oil industry (Aceites Manuelita S.A.) to help offset the industry's negative environmental impact. Colombia is the world's fifth-ranking producer of palm oil and the leading producer in Latin America. In this context, some members of the research group have been certified by the Round-table on Sustainable Palm Oil (RSPO), an international non-profit group based in Malaysia, to give technical support to producers in order to meet environmental and social criteria for certification in Latin America.

This research group has helped to raise awareness among Colombians on the finite supply of natural resources and the importance of environmental responsibility.

Hand-in-hand with the Applied Physics and Technological Development group, the researchers have designed, built and tested equipment for biological applications for industry, such as the Temporary Immersion System for massive propagation of plants and bioreactors to produce microbe metabolites.

The group has helped to raise awareness on the finite supply of natural resources and the importance of environmental responsibility.

Both groups solved a huge environmental problem related to a hydropower station near Bogotá with high concentrations of hydrogen sulfide (H_2S), a foul-smelling and toxic gas that can be lethal. The solution was a bio-filter based upon native microorganisms able to eliminate the H_2S, which reduced the problem by 90%, without using chemical products. The instrumentation designed by CIF delivers online measurements of H_2S concentrations and provides automatic operation of the bio-filter.

The environmental biotechnology group has developed special skills in interacting with local communities, encouraging them to participate and engage in the processes.

This group has one patent called "natural elicitor for inducing systemic resistance", a kind of vaccine that, when applied to plants, defends them from fungi. It has become an alternative for the use of fungicides, and has demonstrated efficiency in controlling *Phytophthora infestans* in potato crops.

With government funds drawn from mining royalties, the group has begun a project that focuses on raising awareness of the relationship between natural resources and climate change in the Magdalena River Basin, a vast region in Central Colombia. The project aims to build cooperative relationships with cattle ranchers, sugar and coffee growers, and other groups to develop strategies for addressing the effects of climate change.

One project aims to build cooperative relationships with sugar and coffee growers and cattle ranchers to address the effects of climate change.

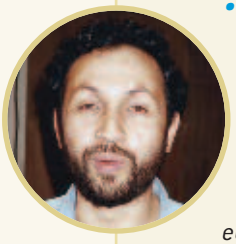
Applied Physics and Technological Development Group

Through the years, this group has been consolidating its human and technological capacities for solving industrial problems in several areas. Its researchers are permanently designing new instruments, and the group has become a reference on industrial automation and electronic instrumentation.

Today, the Applied Physics and Technological Development group is in contact with industries of different fields. With the Energy Company of Cundinamarca, the group designed and developed a system which monitors the quality of electrical energy that the company sells, a requirement of Colombian law. This equipment measures 59 parameters of the electric current. Through wireless communication, it analyzes the quality of the service Colombians are receiving and sends the information on a weekly basis to the official commission in charge of regulating energy and oil in the country. As a result, the company has bought hundreds of units of this equipment and CIF is permanently improving it.

KEY PERSONNEL

JOSÉ ENRIQUE GARCÍA



- ***José Enrique García*** *is a physicist at the Universidad Nacional de Colombia, He has led the Applied Physics and Technological Development group since 1994.*

  His research areas are the development of electronic hardware and solutions for industrial problems; design and building of lab equipment, including biotechnology laboratories; technical advice for buying specialized equipment; satellite engineering; electric measurements; remote and data transmission instrumentation; and nuclear detection methods.

As well as leading his own research group, García also helps the other teams, collaborating to solve their technical problems and questions.

He has been honored for his innovations by Asociación Colombiana de Productores de Concreto (1998) and Colciencias (1998), and received the Best Inventor Prize from the Asociación Colombiana para el Avance de la Ciencia.

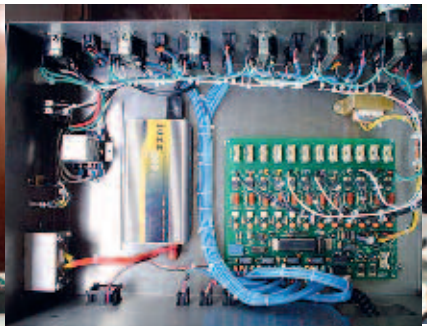
In the same electric sector, this group has developed smart grids for automatic remote measurement of the power consumption of individual users. The group has developed a very sophisticated technology highly useful for electric utilities.

Other automated equipment, called Canister, is used to analyse and measure levels of methane gas that is present in the coal mines. Canister helps to guard against methane levels that can be highly explosive and toxic to miners. It also guides mine operators in collecting methane for use as a fuel, preventing its release into the atmosphere where it contributes to the globe-warming greenhouse effect. The instrument can be used in other sorts of mining, as well.

Funded by the public sector, the group is collaborating to develop an Earth observation satellite that can provide useful information that Colombia is currently buying from commercial international sources. Supported by the Instituto Geográfico Agustín Codazzi (IGAC) and Colciencias, CIF built a pilot station to download satellite images with great resolution. Besides this Satellite Earth Station project, it is working also on a prototype of a spectral radiometer adapted to local conditions that will be used for the calibration of satellite images.

The researchers – physicists and engineers, mainly – have also developed equipment that measures the vibrations produced by cars and trucks when they pass over bridges in Colombian cities. Installed at more than 50 bridges, the equipment monitors vibration in real time and diagnoses the behavior of the structure, making a correlation between the sonic signals and residual resistance in the structure. Such information can help to predict future problems – and accidents.

Director José E. García says the group is ready to design technological solutions, and then build and install them, giving the industries competitive advantages even at the international level. For example, the researchers and engineers, working with the Swiss chemical company Sika AG, developed equipment to measure how new concrete is hardening in structures such as dams. This device has been the basis for a patent submission.



The Applied Physics and Technological Development Group is ready to design technological solutions, and then build and install them, giving industries competitive advantages.

Nuclear Physics Group

This group, led by UNAL professor Fernando Cristancho, started at CIF in 1995 and in 1996 joined the university. Its main research areas deal with nuclear structure and interaction of radiation with matter; its focus is basic research, but it also leads some projects in applied research. In cooperation with the Applied Physics group, it has developed field-test prototype technology for the detection of anti-personnel mines using neutron and gamma back-scattering.

The United Nations-based International Atomic Energy Agency (IAEA) has financed the group's spectroscopy laboratory.

KEY PERSONNEL

FERNANDO CRISTANCHO

• ***Fernando Cristancho, PhD*** *– After earning his master's degree from the Universidad Nacional de Colombia, Fernando Cristancho earned his PhD and a postdoc from Göttingen University in Germany and another postdoc at the University of Pittsburgh in the United States. Cristancho has led the Nuclear Physics Lab since 1995, and is also a senior professor at UNAL, where he teaches nuclear structure, nuclear spectroscopy, nuclear physics and nuclear instrumentation.*

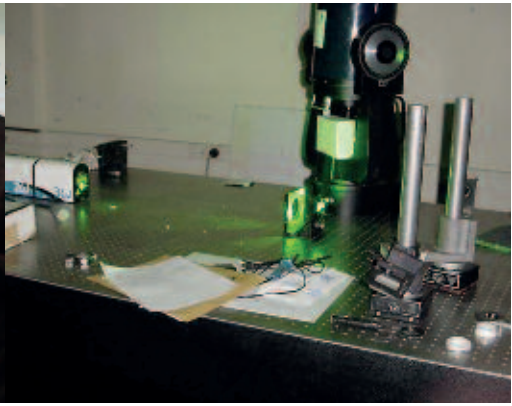
His areas of research are application of radiation in environmental studies, nuclear structure interactions. In the oil industry, the results can be applied to the study of materials behavior, and in the defence sector to the detection of anti-personnel landmines.

Optics Group

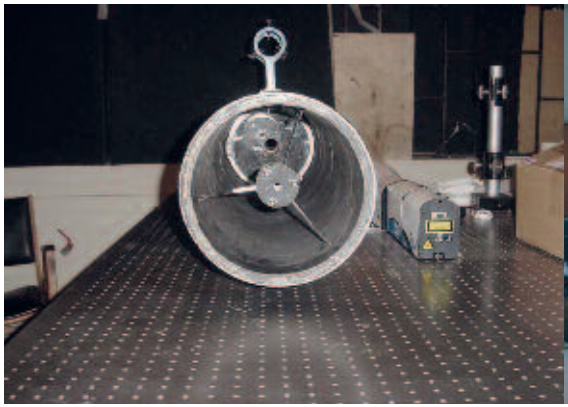
In its first stages, supported by Colciencias, the Optics Group had an important development in the holographic area, with the lead of Ukranian and Canadian scientists working at CIF. Among other developments, the group produced the first colour holograms made in Colombia. It has one of the most advanced optics labs in Latin America, where some industrial applications of holography and thermal laser treatments of materials started successfully in the 1990s.

It has developed optical applications in metrology (the science of measurement), nondestructive analysis of objects and the study of document forgery.

But its main project has been the construction of a Laser Imaging Detection and Ranging (LIDAR) system for measuring atmospheric contamination through laser spectroscopy. The LIDAR identifies heavy particles and pollutants, mainly in the form of aerosols that affect the ozone layer. In addition, the group is developing a LIDAR system for topographic applications.



The Optics Group produced the first colour holograms made in Colombia and has one of the most advanced optics labs in Latin America.



This group, led by Edgar Alfonso, works very closely with the Classical Foundations of Physics Group in a project to detect potential variations of light velocity during the year. The project uses a high definition Michelson interferometer for systematic measurements.

KEY PERSONNEL

EDGAR ALFONSO

• ***Edgar Alfonso, PhD*** *– Associate professor and research coordinator in the Physics Department at the Universidad Nacional of Colombia (UNAL). Alfonso has led the CIF Materials Laboratory since 2000. He earned his master's degree in physics from UNAL and his PhD from Universidad Autónoma de Madrid (Spain).*

Alfonso's main research field has been the development of materials with non-linear optical properties. He has published 40 international and 30 national papers; a book called Teoría Básica de Microscopía Electrónica de Transmisión *(UNAL, 2010, ISBN: 978-958-719-371-8) and a chapter in a book,* Thin Film Growth through Sputtering Technique and Its Applications *(Crystallization, 2011, ISBN: 979-953-307-624-8, p. 1-26)*

Alfonso in 1998 won the Apto Cum Laude award at the Universidad Autónoma de Madrid. He has received several grants and an honourable mention by the Academia Nacional de Medicina de Colombia.

Materials Science Group

The Materials Science Group, led by Eduardo Posada, has two main research fields, the first one being the production of titanium (Ti) and zirconium nitride (ZrN) thin films for industrial applications. In the thin-film lab, researchers work on coatings for industrial materials using Ti; titanium nitride (TiN), an extremely hard ceramic material; titanium II oxide (TiO), an inorganic chemical compound of titanium and oxygen; and TiO2, also known as titania. All have been proven to have mechanical and anticorrosive properties and therefore can be used in the development of devices placed in aggressive environments.

As those materials are non-degradable, the group has started research measuring the biocompatibility when covering human prostheses. These components are successful in improving the adaptation of prostheses to the human body, reducing the rejection risks.

This group also has worked jointly with Empresas Grival and Colciencias in producing the ceramic film (TiN) to cover plastic with metal, so that it gives a more sophisticated look to plumbing products that this industry creates.

The second research field is the production of fullerenes and nanotubes for medical applications and the use of nanotechnology in applications such as the transport of fertilizers and pesticides for the agricultural sector.

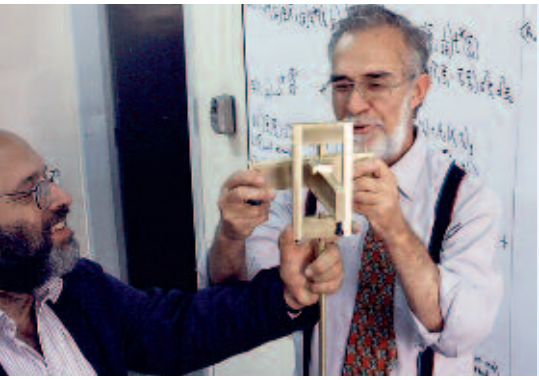
The Materials Science Group is working with thin films that may help prostheses adapt to the human body, reducing the risk of rejection.

Classical Foundations of Physics Group

Héctor Múnera has led this group since 1999. However, in 1988, exploring the question of the meaning of probability in physics, he joined CIF as an independent investigator of classical mechanics and electromagnetism, an association that has continued to the present. He created the Classical Foundations of Physics Group in order to pursue research with graduate and undergraduate students of several universities. Even though he is now retired, he continues doing experimental and theoretical research.

This group has been working in the basics of physics phenomena, mainly in the study of the Michelson-Morley experiment, systematically repeating it to determine the daily, annual and multi-annual effects of the Earth's movements on the speed of light.

This original experiment, which was fundamental for Albert Einstein's design of relativity theory, seeks to confirm or refute results obtained by several researchers. The experiment is planned to take place in different latitudes of both hemispheres.



After systematic repetitions, the group confirmed that there is a daily and seasonal variation in the speed of light.

HÉCTOR MÚNERA

• ***Héctor A. Múnera, PhD*** *– Héctor Múnera earned his first degree as a chemical engineer from the Universidad de Antioquia in Medellin, Colombia, in 1967. He then obtained a magister in systems engineering with emphasis in operational research at Universidad Nacional de Colombia in Bogotá in 1974, and a PhD in nuclear engineering at the University of California at Berkeley (USA). He carried out postdoctoral work from 1984-1986 at the Nuclear Laboratory of the Swiss Federal Institute of Technology in Zurich, Switzerland.*

Múnera started his professional career at the Instituto Colombiano de Asuntos Nucleares. But he has been an independent scientific researcher, mainly, managing to combine his professional activities with his research on the foundations of the theories of risk and uncertainty.

His interests have continually advanced and evolved. He conducted applied research on the peaceful applications of nuclear technology in engineering, hydrology and environment. He shifted to theoretical investigations on the foundations of decision-making under risk and uncertainty, and its implications for the evaluation of risks at nuclear power plants. At the Classical Foundations of Physics Group, he has studied gravitation and nuclear structure, and then causality, probability, space, gravitation, and electromagnetism. Of particular relevance are the new solutions to the wave equation he discovered in the mid-1990s and the theoretical and experimental investigation of the Michelson-Morley experiment from 2002-2005 that led to the only continuous, long-term repetition of that experiment since the 1920s.

Múnera has published about 50 papers and delivered more than 70 technical or scientific papers at international and national gatherings. He contributed to 14 books and has written two: Should the laws of gravitation be reconsidered? The Scientific Legacy of Maurice Allais; and Tecnología Nuclear no Médica en Colombia: pasado, presente y futuro. *He received several recognitions, including the First Graduate Gold Medal Award from the Institution of Nuclear Engineers (London, England, 1970).*

The results obtained in Bogotá at CIF confirm Miller's claims that there is a daily and seasonal variation of the speed of light that can be correlated with the velocity of motion of the Earth relative to some preferred reference frame. A second phase of the experiment, using a one-arm interferometer in a controlled gas atmosphere, is scheduled to begin in the second half of 2013.

Currently, the group is also studying the possible existence of gravitational anomalies that, during a solar eclipse, seem to cause unexpected behavior of pendulums, gravimeters and torsion balances.

The research has three different stages: 1) development of a more detailed mathematical theory for the pendulum; 2) evaluation of assumptions and procedures underlying the data reduction and the interpretation of experiments previously carried out by other investigators; and 3) design, execution and interpretation of new tests.

As part of the second stage, Múnera and his group have recently identified six independent observations with gravimeters during the second half of the 20th century that detected anomalous gravity variations before (or right at the beginning) and after (or just at the end) of the optical phase of solar eclipses. Additionally, Múnera recently revisited the classical experiment carried out by Baron Loránd Eötvös near the end of the 19th century and uncovered some possible evidence for violation of the equivalence principle, evidence that was overlooked by Ephraim Fischbach in his previous revision of the same experiment in the mid-1980s.

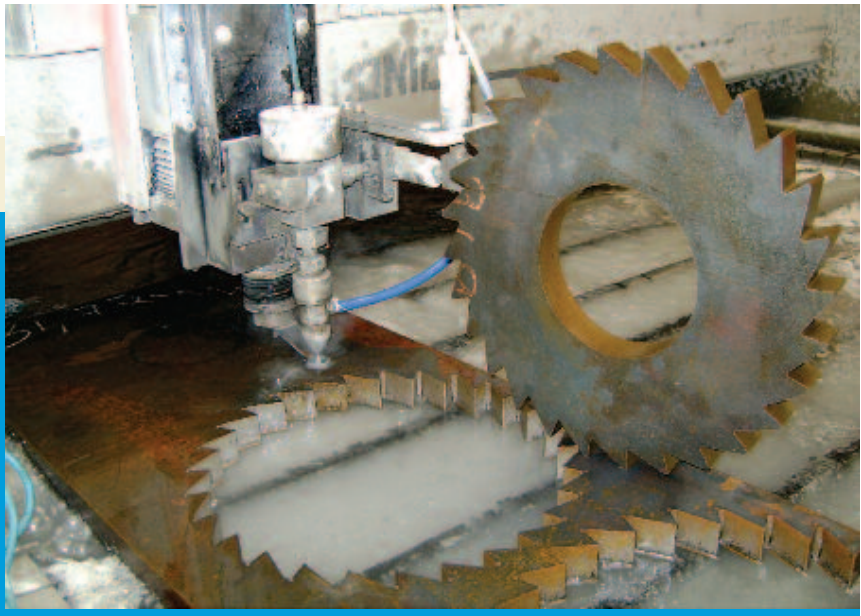
The Classical Foundations of Physics Group has also worked on other ticklish questions of classical mechanics.

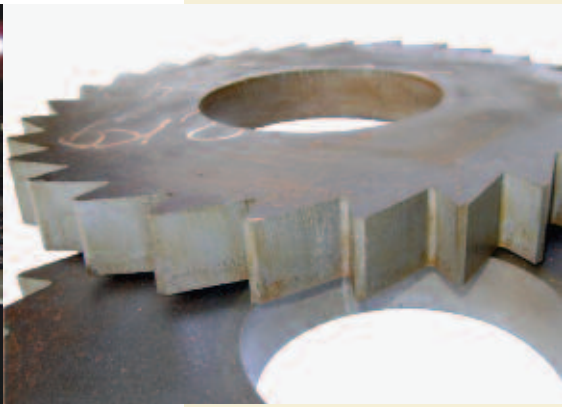
The group is studying the possible existence of gravitational anomalies that, during a solar eclipse, seem to cause unexpected behavior of pendulums.

The Spinoffs: Success Breeds Success

CIF's activity in training researchers, encouraging creativity and applying knowledge to produce solutions for different sectors of society has produced an abundance of new innovation and economic vitality. Other new research centres, such as the Corrosion Research Corporation, plus an incubator and three spin-offs, have been related to CIF's activities, and some of them remain active.

The **Innovar Corporation,** a business incubator based on technology, opened in 1994 and lasted 12 years. Being the first formal incubator established in Colombia, Innovar strived to apply scientific and technological knowledge to the development of commercially competitive products and services to increase added value to the country. Adolfo Naranjo served as the director of Innovar throughout its life, and today he says it filled a critically important need for Colombia.





Studies before Innovar opened its doors, Naranjo said, showed "the importance of creating an incubator for technology companies to assist researchers with enormous potential projects, in making them a reality within a corporate scheme so that they could go to the market and sell their products, services and innovations as a result of knowledge." He added: "Although the initial focus was on physics, the CIF realized very quickly that the incubator should help all types of technology-based companies".

Among the 300 groups that formulated business plans under the aegis of Innovar, 60 were approved. Though there are no firm figures, Naranjo said at least 10 are successful initiatives that have become real biotechnology, information, communication and technology companies.

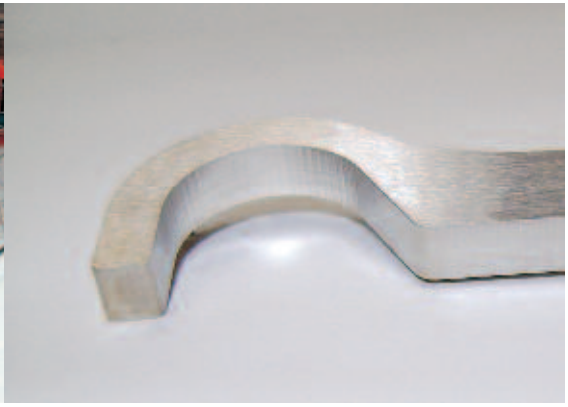
The **Corrosion Research Corporation**, CIC, based in Piedecuesta, a city in northeastern Colombia, was founded in 1994 and supported with public and private funds, mainly from the mining and energy sectors, utilities and companies in the transport area. CIC has become a benchmark in corrosion integrity management; it has strong links with oil companies and develops equipment and technologies such as smart pigs for inspecting oil pipelines, cathode protection systems and software for corrosion management.

Spin-offs Created by CIF

CIF has generated spin-offs since the 1980s, reflecting its conviction that basic and applied research can create a foundation of new knowledge to drive economic growth and support original and competitive business and industrial enterprise. "The idea," says CIF Director Posada, "is to sponsor the creation of spinoffs and enterprises that, based on the technology that you develop, are able to produce goods that can be sold, and to contribute to the growth of the country".

Today, two spin-offs are alive, productive and successful, and at least two others are under development:

TECLASER, a firm based in Bogotá, was founded in 1997. It began when a Swiss innovator sold an old but usable laser machine – at a very good price – to Colombian entrepreneurs who had been studying the technology and the market. Teclaser was the first company that offered this service to Colombian metal-mechanic industries, as well as to business sectors ranging from plastics and wood to advertising and architecture. The company employs young engineering and industrial design students in an environment that constantly reinforces the link between knowledge, innovation and wealth-creation.



CIF spin-offs reflect its conviction that basic and applied research can create new knowledge to drive economic growth.

AIDETEC, started in 2006, produces and commercializes the electronic equipment and systems developed by the CIF Applied Physics and Technological Development Group. Aidetec gives solutions to the needs of the companies through research and implementation of cutting-edge technology, making them more competitive in the market.

Two new spin-off projects are taking shape at CIF.

One would offer industrial sludge-management services, such as services of remediation and final disposition of two types of residues contaminated with hydrocarbons.

The second would produce and commercialize equipment for energy analysis focused on issues such as remote power consumption and the quality of electricity. These services can extend to gas and water consumption, and even river-flow and the production of oil and gas.

Given CIF's experience, it should be possible to enhance its capacity-building in telemetry applications for regional and national electric companies, including telemetry of energy consumption and smart grids, and development of instruments such as high-voltage line-load meters and meter-test equipment.

A Vision for the Future

Eduardo Posada looks 10 years into the future and imagines that the *Centro Internacional de Física* is one of the top research centres not only in Colombia, but also in Latin America. In his view, the dream has important components: "To have a building of our own," he says. "To strengthen links with neighboring countries and play a role in development of the Andean and Caribbean countries. And to create spinoffs that can really participate in the economic growth of the country."

But for CIF, like many scientific and engineering institutions in the developing world – and in the developed world, too – funding for research can never be taken for granted.

A downturn in the economy, or a change in the political environment, can have serious repercussions. And so Posada and others at the Centre must navigate an uncertain landscape in pursuit of their dreams.

Over the past three decades, CIF has continually evolved. From 1994 to 2000, it relied largely on funding from the public sector. From 2000 to 2007, industrial projects supplemented the public funds. Since 2007, the participation of industry has increased, but CIF also has had resources of its own, from the public sector and from its spin-offs. The evolution reflects a recognition: To survive in a difficult environment, you sometimes have to follow opportunities wherever they take you – while assuring that your science is always strong.

But especially over the past decade, the climate for science in developing countries has been transformed. Abdus Salam's vision of science and technology as drivers of development has found remarkable success in nations such as China, India and Brazil, and even in smaller nations such as Malaysia and Rwanda. Other nations have taken notice, and have begun increasing their investments in research and research infrastructure.

In Colombia, historically, science and technology have not been a core government priority. Economic growth *is* a priority, however, and lawmakers have embraced the strategic idea that knowledge and innovation are essential if Colombia is to advance its development and compete economically in world markets. Under a policy inaugurated in 2012, 10% of the royalties that come from mining in the nation now are invested in science, technology and innovation.

That has been good news for CIF. Where the Centre has faced budget challenges for much of its history, the new policy promises a welcome stream of funding for specific projects.

But it is not a cure-all. In Posada's view, the Centre must build on past experience and accomplishment. It is important to continue working with the industrial sector through projects in basic sciences, research and development, he says. It must seek joint projects in the public sector and the private sector.

He welcomes the additional income from consulting and services in fields like instrumentation, efficient use of energy and electron microscopy. But applied research remains a priority, because of its potential to unlock solutions to local and worldwide problems. Research into *Leishmaniasis* is an important example. So is the work to develop palm-oil production that is friendlier to the environment, and the public engagement on issues like climate change.

In fact, climate change is emerging as an important focus for the Centre. The United Nations Development Programme has identified Colombia as one of the most vulnerable countries in the world. Now CIF's biotechnology group has set climate change as a top priority, and has begun looking for ways to contribute to better understanding of the challenge and to help improve national plans for mitigating and adapting to the changes that will come with a warming planet.

Education and training also could play a growing role in CIF's future. In the past, it has provided courses that attracted international students and raised the centre's global profile, and in the process helped to build substantive contacts between senior researchers and early-career colleagues from all over the world. Thanks to advances in information and communications technology, ambitious programmes of online courses can be developed.

To survive in a difficult environment, you sometimes have to follow opportunities wherever they take you – while assuring that your science is always strong.



Posada believes that this formal academic activity also could be done with other developing countries; a good partner, he said, would be the COMSATS. While the commission is based in Pakistan, Posada believes that all of the research centres in its global network share common challenges, and that all can learn from each other. COMSATS, he says, can be a "very useful tool for South-South cooperation".

Returning to past initiatives may also provide important work for the future. Posada proposes to revive research in fields that CIF once pioneered: nanotechnology employed against potato disease, for example, or in optics, where experience in making holograms can lead to new applications.

"I would say that the idea in the future is to have top-level research being done here," he explains. "Quality is the key. We have been able to have high-quality groups that do high-quality research. We need to continue in that way, and that means that we need to have very high-class scientists".

R&D may be the single most important factor for development, Posada says. But how to win more R&D investment from the government? To reach that goal, CIF and the rest of the Colombian research community will have to build a stronger relationship with the public and policymakers. Already, CIF has close ties with the Colombian Association for the Advancement of Science and with the Maloka Museum, an interactive science centre in Bogotá.

To build a strong public mandate for R&D, Posada says, science must make itself more visible and explain itself in a way that excites and inspires. In a sustained, long-term effort, Posada says, CIF and its scientists must join Colombian society in a dialogue about the importance of science to everyday life and to the future health and prosperity of the nation.

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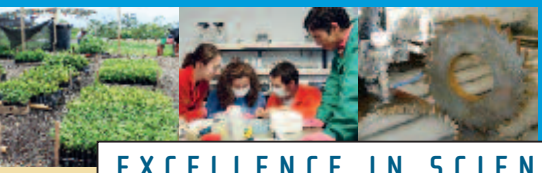

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