

# RESEARCH

AT THE UNIVERSITY OF LUXEMBOURG

LUXEMBOURG  
STUDIES

**360**

PH.D.-STUDENTS

**3**

ACADEMIC  
LANGUAGES

MOLECULAR  
AND SYSTEMS  
BIOMEDICINE

**5**

FOCUS AREAS  
OF RESEARCH

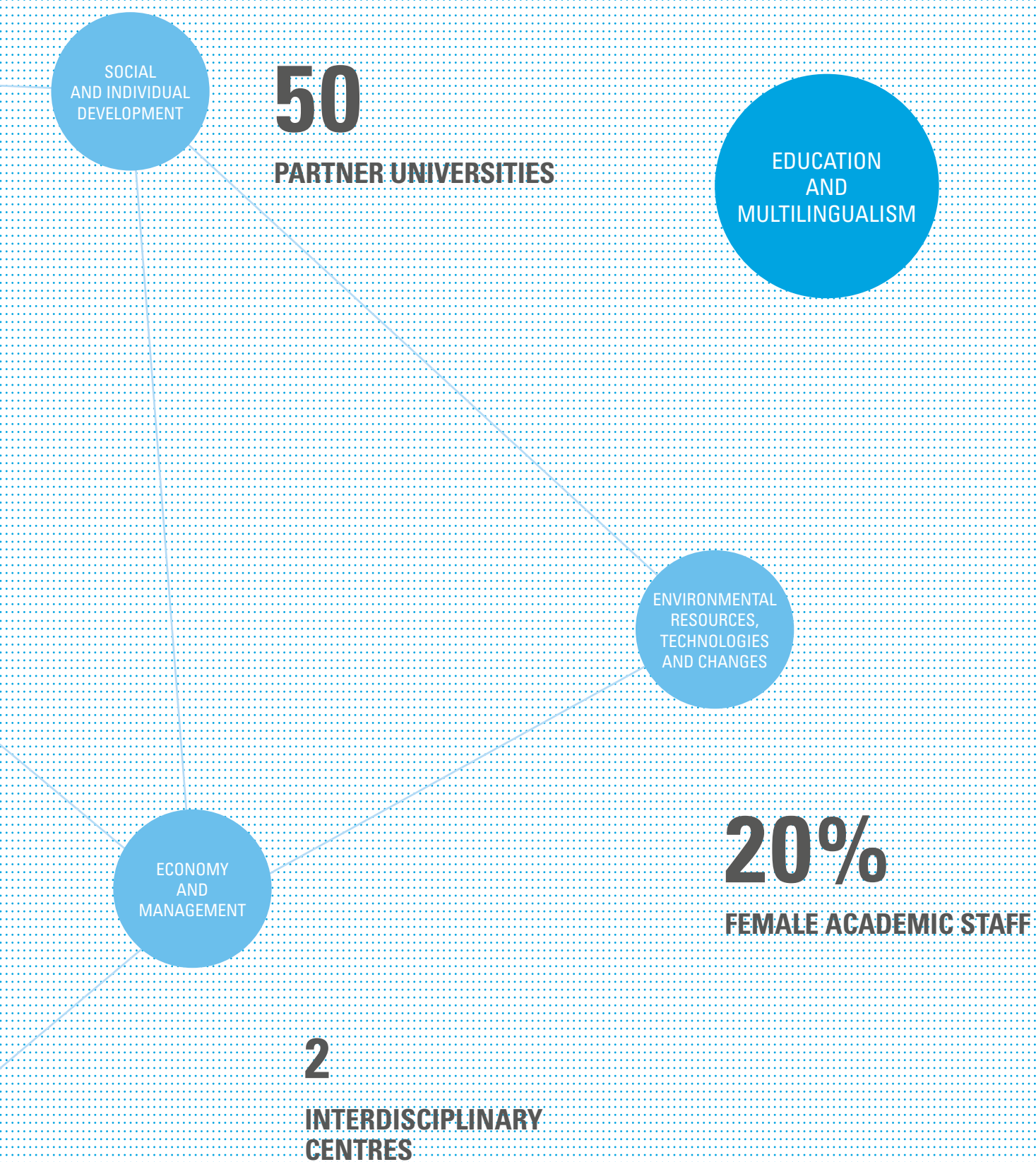
EUROPEAN  
AND BUSINESS  
LAW



UNIVERSITÉ DU  
LUXEMBOURG

# RESEARCH

AT THE UNIVERSITY OF LUXEMBOURG



## EDITORIAL

# Laying the Foundations for Innovation

Four of the five research priorities of the University of Luxembourg have a conceptual link with strengths or challenges of Luxembourg's society and its international context; they were chosen to help reinforce the strengths and master the challenges. Systems Biomedicine originated from a governmental decision to create the knowledge basis which would allow Luxembourg to become in due time, a biotechnological hub.

All five priorities are expected to perform highest quality basic research, but all of them should do so on projects with potential relevance for the societal and economic development of the country. Some of them can do the development themselves which is the foundation of industrial and entrepreneurial innovation; others will need the interface of research centres which are better suited for playing this role. Our two Interdisciplinary Centres have been created with the aim that they should go from basic research all the way to laying the foundations for innovation.

The successful development of our priorities will depend on the governmental and external support they receive, on their capacity to recruit at the highest level and on the willpower of future presidents and boards to keep on focusing on a few priorities and resist the ever present forces of dispersion. Some priorities might not succeed and they would then lose their status. A very few new ones might be chosen and a third Interdisciplinary Centre might be created in a field to be defined. Our admittedly very ambitious goal is that when the country celebrates its 200 years of independence one research priority should be world-class, one or two should enjoy Europe-wide renown and a few should be major players in the Greater Region. This is a tall order but not an impossible challenge!



**Prof. Rolf Tarrach**  
President

## EDITORIAL

# Diversity and Cooperation Leading to Excellence in Research

The University of Luxembourg was founded in 2003, right at the heart of the European Union. The University is multilingual, international and strongly focused on research. Teaching, research and knowledge transfer at the highest international level are the three goals we set ourselves. Establishing a new educational institution, which is truly multinational (with an academic staff of 17 nationalities, and students from 95 nationalities) and multilingual (with our three official languages: English, French and German), is exciting but at the same time very challenging. We have risen to this challenge: a considerable portfolio of research has been built up and in some areas we already have earned a place in the worldwide research community. The increasing number of researchers bears witness to the growing confidence in the university.

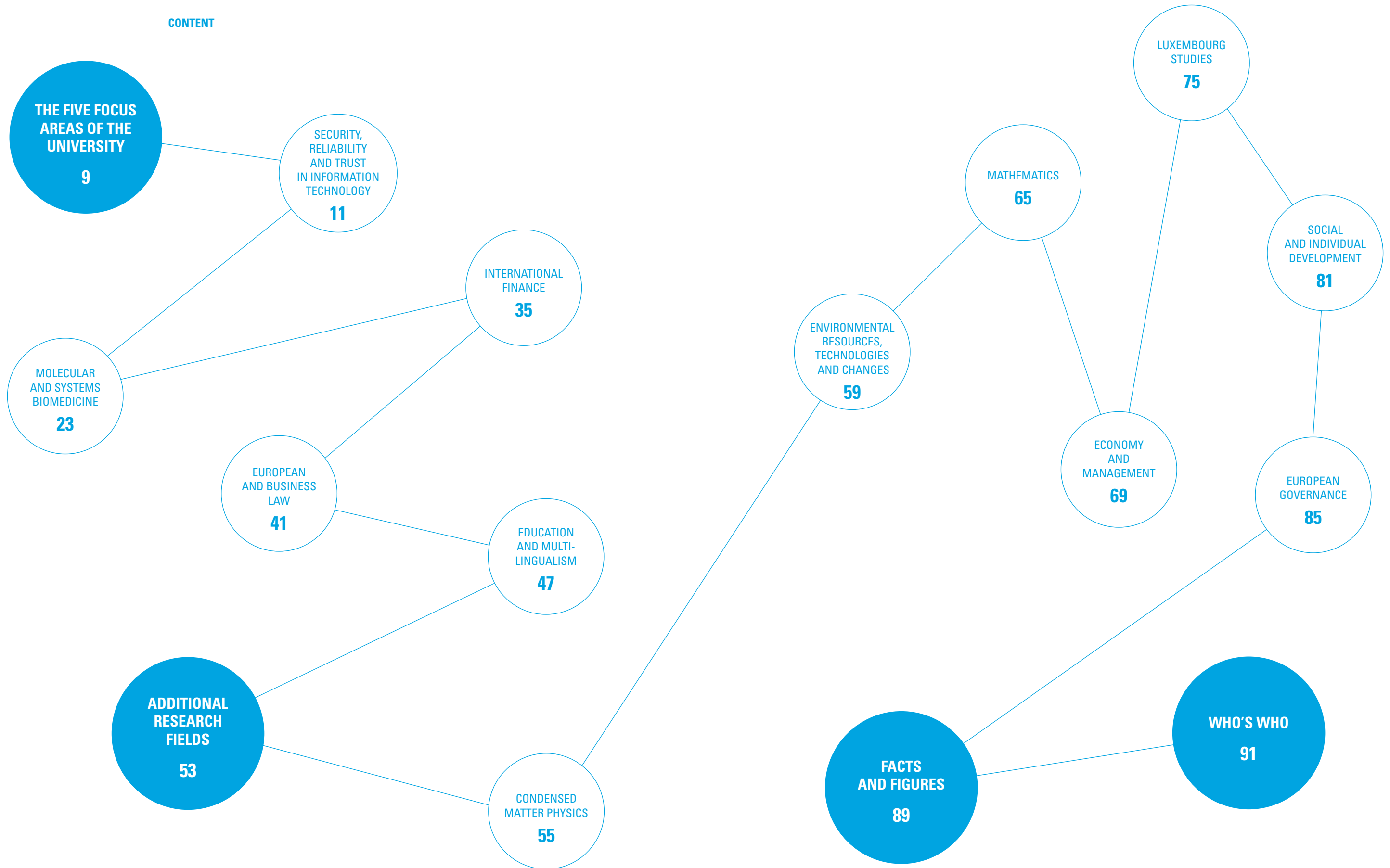
Multinationality enriches a research environment. Researchers bring with them different schools of thought and approaches, providing the variety of perspectives necessary to investigate and address the complex issues science and society are dealing with. For the same reasons, we encourage interdisciplinary research. This is not only reflected in the establishment of two interdisciplinary centres, but also in this brochure: research is described according to themes rather than organisational units, showing how our research crosses the boundaries of faculties and centres. The coming years will see the establishment of doctoral schools, again based around research themes, to strengthen our research and to support training and career development of doctoral candidates. The schools will provide a context, which should provide young researchers with an attractive environment conducive to high quality research.

Although conditions and context certainly contribute to successful research, the driving force behind successful research is the researchers. Jürgen Mittelstrass, a German professor for philosophy of science, once wrote: "Forschung ist eines der letzten Abenteuer" (research is one of the last remaining adventures). I am confident that the university's research community has the ability and motivation to embark on this adventure and bring back treasures well beyond our current imagination. We hope the brochure will give you a flavour of the exciting and challenging research activities of our university and will encourage you to join or collaborate with us.



**Prof. Lucienne Blessing**  
Vice-President for Research

CONTENT



## THE FIVE FOCUS AREAS OF THE UNIVERSITY

SECURITY,  
RELIABILITY  
AND TRUST  
IN INFORMATION  
TECHNOLOGY

# Securing E-Communication

Information technology is omnipresent: at work, at home or on mobile applications. The Luxembourg banking sector for example needs to secure electronic transactions, comply with all the norms or security rules and the telecom industry must ensure safe mobile communications. One of the major challenges in security research consists in developing protocols to replace physical actions by simple electronic actions - like electronic voting, auctions or signatures.

The University of Luxembourg hosts the Interdisciplinary Centre for Security, Reliability and Trust (SnT, see page 15) as well as the Computer Science and Communications Research Unit of the Faculty of Science, Technology and Communication. Both structures are in charge of developing the strategic priority on security and reliability.

COMPUTER  
SCIENCE AND  
COMMUNICATION

# Heading Toward a Common Goal

The primary mission of the Computer Science and Communications Research Unit (CSC) is to conduct fundamental and applied research in the area of computer, communication and information sciences. About 120 people work at the Research Unit CSC, making it the second-largest Research Unit at the University of Luxembourg. The research fields range from the investigation of the theoretical foundations to the development of interdisciplinary applications. The CSC Research Unit is divided into four laboratories:

## COMMUNICATIVE SYSTEMS

The *Communicative Systems Laboratory* does research in information transfer – the information transmission over potentially complex channels and networks – and communicating systems – entities employing communication networks to collaboratively achieve a common goal. Work on the current problems in information technology has already been a key enabler for some industrially and governmentally funded projects at national and European level. Research projects comprise technologies for hybrid wireless networks, mobile communication, network traffic analysis and protection and many more.

## INTELLIGENT AND ADAPTIVE SYSTEMS

Research in the area of intelligent and adaptive systems is done at the *Interdisciplinary Lab for Intelligent and Adaptive Systems*. The overarching subject is information processing – or more specifically, inference – in complex and dynamic environments given limited resources and incomplete or uncertain knowledge. The researchers investigate the theoretical foundations and the algorithmic realisations of systems performing complex problem solving with a high degree of autonomy (intelligent) and exploiting learning to deal with opaque and dynamic contexts (adaptive).

Research Question  
"How can we protect  
secret data  
in electronic  
communication?"

"Designing intrusion detection systems will help determine whether or not someone attempted to break into a system, whether they were successful, and what they may have done."



**ALGORITHMICS,  
CRYPTOLOGY AND SECURITY**

The researchers at the *Laboratory of Algorithmics, Cryptology and Security* work in several fields of information security. First: Cryptography – the science of protecting secrets. Cryptographic protocols enable secure encryption, digital signatures, and authentication between entities. A second field is Computational Number Theory, an important tool in building secure public-key cryptosystems. Many proposals for public-key cryptosystems rely on elaborate mathematical objects that are interesting on their own. Further, System and Network Security intends to stop unauthorized users from accessing any part of a computer system. Designing intrusion detection systems will help determine whether or not someone attempted to break into a system, whether they were successful, and what they may have done. And finally, Information Security Management includes topics like integrity of information, identification of individuals, digital rights management, and information risk and policy assessments.

**ADVANCED SOFTWARE  
SYSTEMS**

The scientists conduct research on methods and tools for mastering the development of complex software systems at the *Laboratory for Advanced Software Systems*. They aim to develop new engineering processes, investigate modelling languages, perform research on the foundations of software engineering, assist in the development and in the use of e-learning tools, and study verification and validation techniques. They focus on the application domains industry-critical systems, e-learning systems, and web-based distributed systems.



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**THE  
INTERDISCI-  
PLINARY CENTRE  
FOR SECURITY,  
RELIABILITY  
AND TRUST  
(SnT)**





# Accelerating Secure ICT

Communication networks and software systems are becoming more and more interconnected as we expect to access services and applications anywhere and anytime. Vital infrastructures and societal functions depend on the security and reliability of these systems. The failure of a network or system can lead to severe financial consequences or even loss of lives. Scientific and technological advances are required to develop secure, reliable and trustworthy information and communication technology (ICT) systems and services.

The Interdisciplinary Centre for Security, Reliability and Trust (SnT) at the University of Luxembourg targets research and PhD education in those important fields of ICT. The interdisciplinary approach is essential, taking not only technical aspects into account but also addressing business, human and regulatory issues.

SnT launched a partnership programme where key partners commit know-how and resources to build the research centre. The current partners are SES S.A., P&T Luxembourg, Telindus S.A., the Ministry of Economy and Foreign Trade, Banque et Caisse d'Epargne de l'Etat, IEE S.A.,itrust and Red Dog Communications S.A..

Along with a large number of cooperating companies, research institutes and universities like the European Space Agency, SES Astra, France Telecom, UCLA (University of California Los Angeles) or the HPI Potsdam (Hasso Plattner Institute Potsdam, Germany) and the Royal Institute of Technology in Sweden, the SnT is contributing to create scientific insight and knowledge.

SnT has undergone an impressive period of expansion. Researchers and PhD students sum up to a total head count of about 75 by the beginning of 2011. The joined work of all SnT researchers passionate joint work contributes to the process of establishing Luxembourg as the European centre of excellence and innovation for secure, reliable and trustworthy ICT systems and services. Director of the Interdisciplinary Centre for Security, Reliability and Trust is Professor Dr. Björn Ottersten. Vice-Director is Professor Dr. Thomas Engel.

**"The failure of a network or a system can lead to severe financial consequences or even loss of lives."**

**Research Question**  
"How can we improve traffic flow with car-to-car communication?"

**Research Question**  
"How can we tackle harmful internet content without imposing censorship on users?"

The following is a selection of research domains the SnT is working on

SATELLITE SYSTEMS

SnT has entered into a partnership framework agreement with the leading provider of satellite communication and transmission services SES. Researchers are working on solutions for future satellite services and applications. Activities include making the receiving antennas smaller, allowing for easier and cheaper mounting of the antennas even on vehicles. Another project involves mobile satellite communication in building networks with redundancies and enabling car-to-car communication in Europe through satellites.

TRUST IN COMPUTER SECURITY AND CYBER CRIME PREVENTION

Luxembourg is moving rapidly towards an "online economy" where citizens make extensive use of the Internet to interact with the Government, and with firms selling goods and services. This promises significant improvements in convenience and significantly lower transaction costs but will not come about if there is a collapse in trust in the Internet as a safe way of communicating. Hence, a growing understanding and development of countermeasures to phishing and other types of e-crime is of key importance not only in preventing criminality per se, but in preserving the trust of Luxembourg citizens in an online future. This project is funded by the Ministry of Economy.

SENSOR FUSION FOR TIME OF FLIGHT 3D CAMERAS

3D cameras based on the 'time of flight principle' measure the time it takes for light waves reflected by an object to reach the lens of the camera – hence the distance between camera and surface of an object. When used to count the number of people entering a building, like, for example, in an airport, 3D cameras present an advantage over regular 2D cameras in that the latter might overlook people wearing dark clothes or hidden behind someone else. However, drawbacks of time of flight 3D cameras are their low resolution and low frame rate. The idea of the researchers at SnT is to fuse 3D and 2D cameras and design one single camera that can collect all the necessary information. This project involves elaborating entirely new mathematical concepts and implementing the methods for real-time applications. The partner of this project is the global leader in automotive safety sensing systems IEE S.A., headquartered in Luxembourg.

VEHICULAR NETWORKS

In 'car-to-car communication' researchers develop safety applications allowing cars to inform those following behind of an accident that has just happened or provide information on traffic density and thus enable exact calculations of the optimal route. Currently, the researchers are working on the project "MOVE", which is designed to evaluate traffic information. Traffic lights are usually operated using models that work perfectly for liquid fluids, but difficultly describe traffic. A new approach, called IP Math Packet, allows optimising traffic flow. The scientists at SnT do the math behind the simulations and experiments. The University has signed a partnership agreement with the postal and telecom service provider P&T Luxembourg, supplying the basis for communication in Europe through the GSM network, and with the French automobile and motorcycle manufacturer PSA Peugeot Citroen.



SECURE, RELIABLE AND TRUSTWORTHY VOTING SYSTEM

Ensuring that the outcome of an election is accurate, while maintaining ballot privacy and minimising the dependency on election officials has been a challenge since the dawn of democracy. Current attempts at such voting systems have proven to be problematic, most notably the more recent use of touch screen machines. Researchers at the Universities in Surrey, Birmingham and Luxembourg are now developing innovative new secure voting technology. The system will combine manual writing on the ballot paper and optical scanning, data processing and encryption. The project will also investigate the issues of public perception and trust of verifiable systems. It is not enough for the system to be trustworthy; it must also be universally perceived as trustworthy.

SAFER INTERNET

The research and development project 'Safer Internet' aims at providing a technical solution for a more protected use of the Internet for families, schools, and Internet users in general. The main goal is to tackle harmful and objectionable content such as pornography, violence or racism based on individual user preferences and without imposing forced censorship on users. The Safer Internet Project is a joint binational project between SES ASTRA, Luxembourg, the Hasso Plattner Institute at the University of Potsdam, Germany, and the University of Luxembourg.

GREEN-IT

A simple concept that has recently emerged is that of cloud computing, whereby end-users do not own or rent any part of the technology infrastructure. Instead, they pay for the services they use, such as databases, computational resources, social networking, and telephonic services. As such, cloud computing can be perceived as huge facilities housing IT services on hundreds of high-end computing servers. A big concern is the extremely high electrical power consumption, most of it being spent on cooling down the underutilised high-end computing servers. Green-IT aims to provide a holistic autonomic energy-efficient solution to manage, provision, and administer the various resources within the cloud computing paradigm. Besides major IT companies, such as Google, IBM, Microsoft, and Amazon, there is no other university-based research group that is conducting cutting-edge research in autonomic energy-efficient management of resources in cloud computing.



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## THE FIVE FOCUS AREAS OF THE UNIVERSITY

MOLECULAR  
AND SYSTEMS  
BIOMEDICINE

## Personalising Medical Care

Luxembourg is making significant investments in health research and development, to support innovation and knowledge transfer. As part of the initiative, the Government aims to develop a centre of expertise in the area of personalised medicine. In personalised medicine, decisions and practices are designed individually according to the patients, in depth analysed health status.

They are mainly based on information on the genetic predescription of each patient with the optimal care. Key players are the University of Luxembourg with its Luxembourg Centre for Systems Biomedicine, and the University's Life Sciences Research Unit, in collaboration with the Integrated Biobank of Luxembourg (IBBL) and the Public Health Research Centre CRP-Santé. LCSB, IBBL and CRP Santé jointly established the Personalised Medicine Consortium (PMC) of Luxembourg.

LIFE  
SCIENCES

## LIFE SCIENCES

# The Cell: A Unifying Principle of Life

### Research Question

"What are the consequences for health when our cells fail to communicate?"

The **Life Sciences** Research Unit has grown to become one of the three largest Research Units at the University of Luxembourg. Combining molecular, cellular and computational approaches, research at Life Sciences focuses on the fundamental understanding of biological processes relevant to human diseases to make use of it for biomedical applications. The centrepiece of this research is the cell which serves as a unifying principle for life. The capacity of cells to divide, to differentiate into various types or to migrate is crucial for tissue integrity, renewal and function. The behaviour of cells is tightly controlled in time and space by signals they receive from their environment.

When cells fail to communicate, the consequences can be severe: Most diseases with high societal impacts are linked to failing cell communication and abnormal cell behaviour. These include inflammatory diseases, such as atherosclerosis, a chronic inflammatory response to the build-up of fatty materials in the arteries, type 2 diabetes and neurodegenerative diseases, such as Alzheimer's, or Parkinson's, as well as cancer, the leading cause of death worldwide.

**The research unit is divided into six laboratories which address complementary research topics.**

### CALCIUM SIGNALLING AND INFLAMMATION

Chronic inflammation is a common denominator of these diseases and the result of the body's defence mechanism against all possible disorders. It leads to a progressive shift in the type of cells, in the reorganisation of the inflamed tissue and in the broad response of the tissue or even organism. New technologies have allowed the scientists of the research group to better understand these communication pathways on a molecular level.

### SIGNAL TRANSDUCTION

The research group studies the transmission path of a signal from the outside to the inside of a cell and the eventual resulting changes in cell function. Research in signal transduction will ultimately aid in designing novel drugs targeting cellular communication pathways. The group's main research focus lies on the signal transduction of cytokines – any of a small number of proteins carrying signals between cells – and the development of cancer.

**"Most diseases with high societal impacts are linked to failing cell communication and abnormal cell behaviour."**



#### Research Question

"How can we resolve the role that chronic inflammation plays in neurodegenerative diseases..."

"... such as Multiple Sclerosis or Alzheimers' disease?"

#### CYTOSKELETON AND CELL PLASTICITY

Genetic reprogramming of epithelial cells to a differentiated, mesenchymal state is cardinal to embryogenesis, wound healing and cancer. Epithelial cell plasticity also involves the reorganisation of the actin cytoskeleton, a dynamic meshwork of protein filaments, which shapes the cell. The team aims at unravelling molecular events which contribute to epithelial cell plasticity – related to carcinoma progression, with the ultimate goal to identify novel biomarkers.

#### NEUROINFLAMMATION

When the brain responds to infections or diseases, the immune system releases regulatory substances, like cytokines, that may have harmful effects on the cellular environment. This process is called neuroinflammation and is the team's centre of focus. The role that chronic inflammation plays in neurodegenerative diseases, such as Multiple Sclerosis or Alzheimer's disease, is yet to be fully resolved. This research has allowed the group to participate in the creation of a start-up in biotechnology called Axoglia Therapeutics.

#### COMPUTATIONAL BIOLOGY

Projects on the molecular mechanisms of Alzheimer's, along with type 2 diabetes, atherosclerosis and cancer, are also part of the team's research, which studies the role of transcription factors and their co-factors on a genome-wide level.

#### SYSTEMS BIOLOGY

The scientists at this research group apply different modelling and data integration techniques to biological systems to develop suitable computational models with the main focus on disease specific signalling and metabolic networks. Computational tools are developed which are applicable to a wide range of biological systems, e.g. Probabilistic Boolean and integrated metabolic modelling.

#### AXOGLIA THERAPEUTICS

The first start-up company generated by the Life Sciences Research Unit: Axoglia Therapeutics is a bio-pharmaceutical enterprise. Axoglia Therapeutics specialises in finding and developing novel drugs for treating degenerative and neuroinflammatory diseases such as Alzheimer's or Multiple Sclerosis.



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THE LUXEMBOURG  
CENTRE  
FOR SYSTEMS  
BIOMEDICINE  
(LCSB)



# Accelerating Biomedicine

Biomedicine is one of the key focal points of the Luxembourgish 'Health Science Plan', therefore the Government is investing a substantial amount of 140 Mio. Euro over five years in building up biomedical research in the Grand Duchy. Key player is the Luxembourg Centre for Systems Biomedicine (LCSB) of the University of Luxembourg. The LCSB was founded at the end of 2009 and has engaged in a 5-year strategic collaboration with Dr. Leroy Hood and the Institute for Systems Biology (ISB) in Seattle, USA, offering intensive knowledge transfer and a flying start for the LCSB.

Professor Dr. Rudi Balling, former director of the Helmholtz Centre for Infection Research in Braunschweig, Germany, leads the LCSB at the University of Luxembourg. The envisaged 80 team members of the LCSB are accelerating biomedical research by closing the link between systems biology and medical research. Collaboration between biologists, medical doctors, computer scientists, physicists and mathematicians is offering new insights into complex systems like cells, organs and organisms.

The Luxembourg Centre for Systems Biomedicine will focus on the analysis of biological mechanisms with a special emphasis on neurodegenerative diseases. The initial focus will be on Parkinson's disease. Using genome wide high throughput technology and computational biology tools, new targets for medical prevention and intervention strategies and new tools to improve the predictability of the efficacy and safety of new treatments will be identified.

Disease pathogenesis will be analysed in the context of complex biological network composition and behaviour and perturbations in the homeostasis of physiological networks. Mathematical descriptions of such networks will be developed and used for the modelling and simulation of how diseases develop and how they are influenced by genetic predisposition or by external environmental parameters, such as drugs, nutrition or life style. The LCSB's overall aim is to develop personalised medicine, which uses information on the individual patient in order to optimise that patient's treatment.

Beside the above mentioned strategic collaboration with the Institute for Systems Biology in Seattle, USA, Rudi Balling and his team are already establishing additional collaborations with MIT in Boston, the Systems Biology Institute in Tokyo and the University of Cambridge, UK. Within the Grand Duchy the 'Integrated Biobank of Luxembourg', the Public Research Centre for Health (CRP-Santé) have recently established a coordinated alliance in personalised medicine.

**"Collaboration between biologists, medical doctors, computer scientists, physicists and mathematicians is offering new insights into complex systems like cells, organs and organisms."**

**Research Question**  
"How can researchers develop personalised medicine, ..."

"... which uses information on the individual patient in order to optimise that patient's treatment?"

#### THE VISION OF THE LCSB IS TO

- understand the mechanisms of complex biological systems and disease processes
- enable new ways to cure and prevent human diseases

#### THE MISSION OF THE LCSB IS TO

- carry out fundamental research in the field of systems biology and biomedicine
- analyse the mechanisms of disease pathogenesis
- identify and validate new targets for disease prevention and intervention
- develop new technology for biological systems analysis
- explore opportunities for the translation of knowledge from basic research into industrial application
- develop new strategic partnerships in the area of computational and systems biology

#### EXPERIMENTAL NEUROBIOLOGY

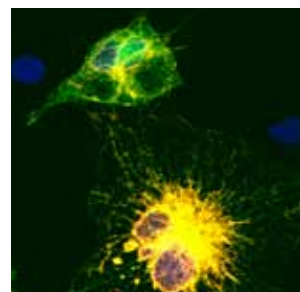
##### The following groups have been established in the LCSB:

Parkinson's disease (PD) affects about 1 – 3% of the population over the age of 65 years and is characterised by progressive degeneration of dopaminergic neurons. Tremor, rigidity, bradykinesia, postural instability and gait dysfunction, are the cardinal features of the disease. In addition PD-patients often have a wide range of "non-motor"-symptoms, such as cognitive dysfunctions, psychiatric and gastrointestinal symptoms, hyposmia and sleep abnormalities.

The molecular mechanisms leading to PD are not well understood. Aging is one of the main contributing factors, however genetic and environmental factors also play an important role in PD pathogenesis. Researchers at the LCSB try to shed light on the molecular and cellular mechanisms of PD, thereby contributing to the development of new preventive or therapeutic strategies. Research projects involve studies on PD-patients, animal models of PD and cell culture studies of dopaminergic neurons, the cell type most severely affected in Parkinson's disease patients. A specific range of bioinformatics and systems biology approaches are used to develop a mathematical description and models of PD. This should support our attempts to understand the detailed molecular and cellular mechanisms of PD.

#### COMPUTATIONAL BIOLOGY

In the past, biology was mainly a descriptive and experimental discipline. With the progress in genome research, large amounts of biological data became available and the necessity to handle them. The discipline of computational biology was born. The *Computational Biology* unit of LCSB is especially interested in studying the mechanisms of complex biological systems and disease processes. Emphasis is placed on understanding normal and abnormal biological function at the molecular, cellular, and tissue levels. For example, they study the different aspects of protein function – such as allostery, appearance of novel functional activities in proteins, protein-protein/ligand interactions, and enzyme catalysis – and how protein functional impairment due to perturbations, such as mutations and protein-metabolite interactions, could yield to the development of certain diseases.



In addition, the scientists analyse diseases as genetic and environmental perturbations of cellular networks leading to malfunctioning of cellular processes. In this respect, they focus on the study of the network's topology and dynamics in combination with network-based biological characteristics to understand those perturbations capable of altering normal cellular functions. Recently, they have been working on the identifications of key genes, whose mutations significantly affect mitosis in HELA cancer cells. In addition, they work on the detection and classification of subnetworks or motifs responsible for maintaining the stability of regulatory networks and possibly involved in the transition from a healthy to a diseased cellular state. This type of analysis has been carried out for diseases like prion disease, lung and breast cancers, and metabolic diseases like diabetes.

#### METABOLOMICS

The researchers are also interested in modelling cell population dynamics based on single cell gene expression and phenotypic profiling data in different systems. They propose an *evolutionary-game model* of cancer cell-cell interactions, which could have relevance for the development of new therapeutic approaches. In particular, a new project involves a close collaboration with a group at ISB. There, they are currently generating single cell gene expression data to study epithelial-mesenchymal cell transition in breast cancer cell lines.

Metabolomics stands for the comprehensive analysis of intracellular and extracellular metabolite concentrations. With up to 400 identified metabolites in one experiment an overall picture of the metabolism emerges. Since the set of all metabolites is directly linked to the actual state of a cell and thus to the phenotype, the metabolome is optimally suited for the determination of biomarkers that are typical for certain genotypes or diseases.

The Metabolomics Junior Research Group has established state of the art mass-spectrometric methodologies for the analysis of cellular metabolism. In combination with stable-isotope labelled tracers, these technologies will be applied for shedding light into cancer specific parts of the metabolism. In this context, stable isotopes are applied to elucidate the metabolic fate of specific compounds like for example sugars or amino acids. This way, yet unknown pathways potentially important for cancer cells can be identified. In addition, stable-isotopes will be used for analysing the metabolic dynamics (enzyme activities) of specific cancer forms in a non-targeted way.



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A vertical stack of numerous coins, likely Euro coins, is shown on the right side of the image. The coins are stacked in a slightly irregular manner, creating a textured, layered appearance. Two circular callout boxes are overlaid on the image. The top one is blue with white text, and the bottom one is white with blue text. A thin white line connects the two circles.

**THE FIVE FOCUS  
AREAS OF THE  
UNIVERSITY**

INTERNATIONAL  
FINANCE

**"Financial crises threaten the wealth of the nations, affect people's well-being and have undesirable redistribution effects; therefore, they should be curbed if not avoided."**

## INTERNATIONAL FINANCE

# Preparing for the Next Financial Crisis

The current financial crisis began in the financial sector but quickly spread over the whole economy, pushing the world into recession and implying mass layoffs in many countries. Even sovereign states in the western world have been threatened by bankruptcy. Scandals, bankruptcies and bailouts of some of the biggest companies have led to an erosion of the confidence in the honesty of financial actors and raised doubts about the financial system as a whole. Generally, financial crises threaten the wealth of the nations, affect people's well-being and have undesirable redistribution effects; therefore, they should be curbed if not avoided.

The Luxembourg School of Finance (LSF) is the Finance department of the Faculty of Law, Economics and Finance. The LSF considers the financial crisis not only as a challenge for economic agents, but also as an opportunity for researchers to make progress in the understanding of financial crises. The general mission of today for research in finance must be the evaluating, dealing, and anticipating of future crises. Obviously, a reevaluation of standard financial economics is required which also offers opportunities for new developments.

Having initiated the Luxembourg School of Finance in 2002, the financial sector in Luxembourg strengthened its commitment to academic research by creating the Luxembourg School of Finance Foundation in 2006. The Foundation's mission is to assist and support the University of Luxembourg in all of its activities in relation to the financial sector, and regrouped under the Luxembourg School of Finance of the University of Luxembourg.

The current research at the LSF is generally concerned with financial crises and particularly concerned with financial crises that may adversely affect the future of Luxembourg's economy. LSF researchers investigate the behaviour of financial markets including its risks and the pricing of financial securities, as well as the behaviour of market participants, such as financial institutions and individual investors. The impact of regulation and law on the development of financial markets and on the behaviour of financial agents is also a focal concern. In the recent years, the LSF has built competences in the following fields of research.

### Research Question

"How can we anticipate or even avoid future financial crises?"

## QUANTITATIVE FINANCE

Most research contributions of the LSF apply quantitative financial economics methods to real-world problems. The current interests focus around the recent financial crisis and address potential future crises. Research projects of the LSF have shown how leverage in commercial banks evolved amid the financial crisis; how the recent crisis has affected the sovereign debt in the Euro zone, how the crisis spread to non-financial companies; and how information flows in financial markets were affected. The LSF has also contributed research to potential challenges of Luxembourg's market-place. The future risks of Luxembourg's pension system have been highlighted and a departure from the pay-as-you-go system has been recommended. LSF-projects also address capital structure, managerial incentives and impact of competition on risk and return in micro-credit and in the traditional fund industry.

## RISK MANAGEMENT

LSF research projects have been dedicated to the measuring of risks during the financial crisis with Luxembourg data. These projects have included market risk exposure in the hedge fund industry, credit risk exposure in the securitization of loans to small and medium-sized enterprises, and market liquidity risk exposure, as well as the recent involvements of the central bank in financial stability. To curb future crises, LSF researchers have suggested contingent capital as an alternative financing for the banking industry. In the case of default, contingent capital bonds are converted by design to increase equity capital and thus decrease the potential needs of bailouts by the tax payer. Further, a new, general numerical method for the pricing of derivatives has been developed in recent research at the LSF.

## LAW AND FINANCE

The LSF studies the causalities between law and the attractiveness of financial markets, and how this attractiveness develops over time. These studies include the relationship of international bankruptcy laws, the implied design of the debt contracts, and the likelihood of filing for bankruptcy. As the Finance department of the Faculty Law, Economics and Finance, the LSF sees great potential for future research in this area.

## EXPERIMENTAL/ BEHAVIOURAL FINANCE

In experimental research, the LSF addresses regulatory issues in institutional market design. At the height of the financial crisis, short-selling of financial securities was banned from many exchanges. Experimental research of the LSF has shown that a ban on short-selling curbs selling pressures and implicates a higher market price under controlled laboratory conditions. The effects of alternative short-selling regulations that were discussed amidst the melt-down of the financial markets are currently examined in the experimental laboratory. Other experimental projects currently conducted with LSF participation involve asset pricing, initial public offerings, and the impact of transaction taxes in financial markets.

Generally, the research at the LSF covers a wide range of research activities in finance, from pure academic research to private-public partnerships. The LSF is collaborating in research with other departments of the University of Luxembourg as well as with other universities and research centres around the world. Beyond academic research, the LSF aims at developing research programmes based on bilateral and well-balanced partnerships, especially within the Luxembourg Financial Centre. The LSF has ongoing research projects with the public institutions BCL, Luxembourg's central bank, STATEC, the Luxembourg's statistical institute, EIB, the European Investment Bank, and the corporations AXA and UBS. The Financial Centre participates in the LSF's governance and supports the LSF in many different forms.

Recently, the LSF has set up a doctoral programme in collaboration with the Economics Department of the University to strengthen the research activity in finance. The LSF organises a weekly research seminar in which internationally renowned scholars present their current research.

### FUNDED CHAIRS: DEUTSCHE BANK CHAIR OF FINANCE

In September 2010, the Deutsche Bank Luxembourg S.A. announced the funding of the „Deutsche Bank Chair of Finance“. The chair is based at the Luxembourg School of Finance, located within the Faculty of Law, Economics and Finance, and is to cover research topics in banking and finance that have applications within the banking sector in Luxembourg.

As Ernst-Wilhelm Contzen, General Director of Deutsche Bank Luxembourg, emphasised in his speech at the celebration of the 40th anniversary of Deutsche Bank Luxembourg in September 2010, investment in training and research is essential for the future of the financial centre Luxembourg.



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**THE FIVE FOCUS  
AREAS OF THE  
UNIVERSITY**

EUROPEAN  
AND BUSINESS  
LAW

**"Luxembourg is an ideal location to conduct pioneering research and offer excellent academic training in European and Business law."**

## EUROPEAN AND BUSINESS LAW

# Assuring Fairness through Law

The overall objective of Law is to structure and define the relations within a society while ensuring the highest level of justice. The design of the necessary rules used to be a privilege of single countries exercising their national sovereignty rights. The Member States of the European Union (EU) have accepted to share that competence to a large extent and moreover to approach their respective legal systems. The search for unified solutions or at least common standards at a European level has extended over the last decades to all fields of law, triggering at the same time a strong need to understand and compare the rules in force in the different Member States.

This development offers a vast field for research to which the research programme Law is dedicated. A specific emphasis is placed on the constitutional and administrative framework of the EU, the regulation of the banking sector and the financial markets, the establishment of a European Criminal Justice System, the progressive 'Europeanisation' of private law, European and International tax law, as well as Media, Electronic and Satellite Communications Law. The impact of European law and more generally the modernisation of Luxembourg law is a complementary goal of the research activity undertaken.

Luxembourg is an ideal location to conduct pioneering research and offer excellent academic training in the above-mentioned fields. The proximity of the Court of Justice of the EU and other European institutions, a vibrant international financial sector and the presence of innovative industries form natural allies for the Research Unit in Law. These are elaborated through partnerships in research or the financing of Chairs (ATOZ Chair in European and International Tax Law, SES Chair in Satellite Communications and Media Law) but also via the participation of practitioners from these institutions in teaching at the academic programmes in law.

Another distinct feature of the research undertaken in the field of law is the exercise of an innovative approach where comparative law and empirical research methods are broadly applied. An interdisciplinary approach is also fundamental for the Research Unit in Law combining philosophy, history, political sciences, sociology, finance and economics. In particular, a great emphasis is put on forming synergies with the economics and finance units within the Faculty of Law, Economics and Finance (Centre for Research in Economic Analysis-CREA and Luxembourg School of Finance-LSF respectively).

The general ambition of the University's Research Unit in Law is to position itself as a centre of excellence bringing together a team with truly transnational abilities, experiences, reach and outlook, which develops its research activities in European law, economic and business law as well as Luxembourg law.

In the recent years, the Research Unit has developed competences in the following fields of research:

### Research Question

"How is the attractiveness of financial markets linked to law?"

### Research Question

"How can we approach the legal systems of EU member states?"

### CONSTITUTIONAL AND ADMINISTRATIVE LAW

Researchers are working extensively on issues resulting from the ongoing general revision of Luxembourg's Constitution. Furthermore, a significant contribution has been made concerning procedural law in Luxembourg's public administration, analysing the jurisprudence of the Administrative Court and Tribunal respectively. It aims primarily at identifying the main principles of litigation both on substance and procedure.

**BANKING, COMPANY  
AND TAX LAW**

In this field, a valuable contribution has been made in the reform of Luxembourg Company Law. Furthermore, long-term research is undertaken under the general framework of Company Law in Europe as well as the participation rights by workforce in companies in the EU. The Geneva Convention on intermediated securities is another area in which meaningful research has been conducted. In addition, the interdependencies and comparative performance measures associated to banks, financial markets and legislations have also been at the forefront of research in Law at the University of Luxembourg. In European and International Tax Law critical research is developed concerning issues such as double taxation within the EU, the exchange of information and others.

**CRIMINAL LAW**

Judicial control and procedural rights in the area of freedom, security and justice of the European Union, as well as the concept of a future European Public Prosecutor are selected themes researched in this field.

**PRIVATE AND PUBLIC  
INTERNATIONAL LAW**

Main research topics are centred on the impact of human rights, on the recognition of judgments and choice of law and the enforcement of choice of courts agreements. Cross border debt recovery is also a field with a substantial research contribution.

**CONTRACT AND CONSUMER  
PROTECTION LAW**

The policy options for progress towards a European contract law for consumers and businesses are at the centre of current research in this area. The Research Unit in Law is also working on different ways to balance consumer protection law and explore the boundaries on European private law.

**MEDIA  
AND ELECTRONIC  
COMMUNICATIONS LAW**

The analysis of the European legal framework and its transposition to Member States' law in a comparative approach is the focus of research in this field. Issues for traditional media as well as the new information technologies – examples are protection of minors or liability for user-generated content on the internet – are topics of publications, including country reports on the situation in Luxembourg.

**LUXEMBOURG CASE LAW**

In this area the researchers are making a significant contribution to the oldest Luxembourg Journal in Law "Pasicrisie" publishing a selection of most relevant case decisions.



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**FUNDED CHAIRS: ATOZ CHAIR FOR INTERNATIONAL AND EUROPEAN TAX LAW**

In 2009, the company ATOZ Tax Advisors funded a Chair for International and European Taxation. The ATOZ Chair is held by Asst Prof. Dr. Alexander Rust, LL.M. The chair is organizing a conference series on all areas of tax law and setting up a master programme which will attract students from all over the world to Luxembourg and qualify them for a future job at Luxembourg's financial centre.

In a globalized world the avoidance of double taxation becomes essential for cross-border trade and services. Taxation of the same income by two or more countries constitutes one of the biggest obstacles for international businesses. The chair focuses its research on the analysis of double taxation convention and the ever growing influence of European law on the national tax system.

**FUNDED CHAIRS: SES CHAIR IN SATELLITE COMMUNICATIONS AND MEDIA LAW**

In 2010, the University and the global satellite operator SES S.A. signed an agreement that foresees an endowed chair in space, telecom and media law as well as a partnership to jointly develop Luxembourg as a European centre of excellence and innovation for advanced information communications technology (ICT) in satellite systems.

The University and SES will collaborate on research in satellite applications and services, satellite hybrid networks, transmission and reception technologies. From the perspective of law, research will be centered around the legal and regulatory challenges in satellite communications. The professor holding the SES Chair will contribute to the interdisciplinary research at SnT. In addition, existing media law research will be reinforced and expanded by including space law and global telecommunications issues.



**THE FIVE FOCUS  
AREAS OF THE  
UNIVERSITY**

**EDUCATION  
AND  
MULTILINGUALISM**

**"The Luxembourg society, made up of people from many different national origins, is a model of a modern society with accordingly high expectations towards school, education and learning."**

## EDUCATION AND MULTILINGUALISM

# Meeting Expectations in a Globalised World

Modern societies are both multilingual and multicultural. The particular challenges raised by this diversity are most commonly assigned to the domains of education in an endeavour to promote social cohesion and educational equity. In this respect, the Luxembourg society, made up of people from many different national origins, is a model of a modern society with accordingly high expectations towards school, education and learning.

Committed to international and comparative research perspectives the research priority "Education and Learning in Multilingual and Multicultural Contexts" assesses these expectations and their feasibility on a macro, meso and micro level analytically, empirically, and historically. Accordingly, it includes a broad range of disciplines such as educational sciences, psychology, sociology, linguistics, history, political sciences, cognitive sciences, and neurological sciences.

The aims of all five domains (following below) of the research priority *Education and Learning in Multilingual and Multicultural Contexts* are the same: Excellence in research, the establishment of an Interdisciplinary doctoral school in educational sciences and contribution to developments in the educational and social field.

### EDUCATIONAL SYSTEMS IN HISTORICAL, CULTURAL, AND SOCIOLOGICAL PERSPECTIVES

#### Research Question

"Can an education system that works well in one culture be implemented in another?"

#### Research Question

"What can our modern societies do to better manage the linguistic and cultural diversity?"

Enhancing school quality has been an effort ever since the modern education system became established in the nineteenth century. For more than a century these efforts have been on improving the quality of teacher education, the curriculum, or the textbooks. During the second half of the twentieth century this paradigm of enhancing school quality shifted. Rather than providing more (and costly) inputs to the educational system, schools were defined as in part autonomous to reach predefined goals (standards). Large-scale assessments were developed to compare the outcomes of the individual schools or school systems and provide information about deficits. PISA (Programme for International Student Assessment) is probably the best-known large-scale assessment in the Western world, organised by the OECD (Organisation for Economic Co-operation and Development).

Whether or not or to what extent large-scale assessments are helpful to develop educational systems is being disputed. The researchers at *Educational systems in historical, cultural, and socio-logical perspectives* analyse the history of educational systems in their respective cultural contexts, examining the way the individual modern educational systems have (been) developed since their beginnings. They also focus on the role of the so far three key actors in school reform that succeeded each other without replacing the predecessors completely. Some spotlights give an idea about this development:

Until about 1800, school in the area that is now Luxembourg, just like anywhere in Europe, was ruled by the church. After the European nation-states had gone through territorial changes during and after Napoleon's reign, the school system altered. School was now supposed to reinforce citizens' commitment towards their country. This nationalism altered after the two World Wars and gradually developed into the system that we know today. All three key actors wanted to have 'their' schools serving their interests, and all neglected to a certain degree the persistence of what may be called the "grammar of schooling".

The focus of the research is on this third period beginning after 1945. International organisations such as the World Bank or the UNESCO began to influence the national school curricula based on



the academic achievements that were thought necessary to advance technological development, economic growth and democracy. The belief in one global, "right" school system grew. The question however is: Which part do the different cultural heritages of different nation-states play in these global visions of school governance? Can a historically grown system that works well in one country be implemented unaltered in another cultural context (reliability of idea of "best practice")?

Large-scale assessments like PISA concentrate on mathematics, science and languages and are themselves part of a distinguishable culture – though with global aspirations. How persuasive is the theory behind its agenda and how sustainable are the conclusions and effects in the individual countries?

**MULTILINGUAL SOCIETIES,  
LANGUAGE AND  
EDUCATIONAL POLICIES,  
LEARNING AND LITERACIES**

In the 19th century, the educational systems were erected in order to integrate a normally mono-lingual but multicultural society, uniting the population from different social and cultural backgrounds into the nation. From the beginning, Luxembourg was in this respect one of the exceptions in Europe, because its upper class spoke French whereas the broad public spoke Luxembourgish. Luxembourg's very first school law (1843), bilingually written, foresaw among other subjects the teaching in both languages, French and German, German being understood as a formal mother tongue of Luxembourgish: The nation and its school was seen as bilingual.

Later on, Luxembourgish was identified as a language of its own so that the nation and the school became trilingual. Today, the school curricula reflect this trilingualism: In preschool, teachers use Luxembourgish to communicate with the children. Once these get to primary school, they all have to go through the same German literacy programme, and French is later introduced as a foreign language. However, today, Luxembourg counts the highest number of resident foreigners in the EU with 43.1 percent, most of whom are from Portugal, France, Italy and Belgium. As a result, the languages spoken in families often do not coincide with the three institutionalised languages that children are taught and have to use in school.

Specifically, the researchers at *Multilingual societies, language and educational policies, learning and literacies* study how our late modern societies attempt to 'manage' the linguistic and cultural diversity in their midst. They examine the assumptions and visions underlying the Luxembourgish educational system (as well as other educational systems) and explore numerous related questions including the following: What, for instance, are the possibilities offered by flexible programmes of simultaneous literacy or 'biliteracy'? Alternatively, what are the possibilities offered by a flexible programme in which children choose either German or French as their language of literacy and the other as the foreign language, while the two resulting groups of students learn from each other in mentoring tandems? What are the empirical effects of one or the other programmes and how do student respond to them in the daily classroom-interactions? And if it is true, what many researchers in literacy and education have pointed out, namely that basic literacy is best taught in a language that children speak fluently and that this is the key to educational success – how does this affect the social integration in a multilingual and multicultural society?

**Research Question**

"How can we explain and predict motivated learning and learning outcomes?"



**MODELS, METHODS,  
AND INSTRUMENTS  
TO ANALYSE EDUCATIONAL  
PROCESSES**

Educational measurement is a field of growing importance, especially for our modern service-oriented and IT-driven knowledge society, which requires from its members a continuous update of their competency profiles. Instruments for the assessment of competency profiles are used across the lifespan and in an ever-growing number of fields. They are today essential tools in human resources management.

Furthermore, educational measurement instruments play a crucial role in school monitoring programmes intended to provide feedback on the proficiency of pupils, of schools and of the whole educational system. They are the core parts of large-scale international comparative studies such as PISA, which are used to compare the efficiency of school systems across countries. Data from school monitoring and large-scale studies can be used to scrutinize the manifold relationships between students' competencies on the one side and school-related learning environments in Luxembourg on the other.

A special challenge has been introduced in the last years due to the increasing use of computer-based tests which open up new avenues for the design of innovative assessment instruments taking advantage of the dynamic and interactive characteristics offered by modern IT equipment. While these new types of tests are very promising, they are also largely dependent on the development of new measurement models that are able to fully take advantage of the variety of data that are produced by these tests. Finally, it can be foreseen that on the basis of this new IT equipment it will be possible to design new learning environments in which learning processes and the successful assessment of these learning processes will be fully integrated.

The conditions and consequences of societal change are the focal point of current debates concerning competency development of actors in the educational domain, most notably teachers. The major goal is to make teacher education a profession with a research-base and formal body of knowledge and to ensure that teachers are fully prepared in accordance with professional standards. The core components of general pedagogical knowledge include knowledge about learning and learners, pedagogical planning instruments, classroom management, student-teacher interactions as well as general principles of assessing, testing, and evaluating learning outcomes.

**PROFESSIONALISATION  
OF ACTORS IN EDUCATIONAL  
DOMAINS**

The researchers have identified conditions under which teachers' assessments such as marks and grades, recommendations for students' transition from primary to secondary school etc. are biased by the social background of students (socioeconomic status, migration status) while others more adequately reflect students' abilities.

The researchers also track the progress of students and compare current grades to grades in earlier stages of schooling. This ties into the vitally important issue of developing and evaluating training and intervention programs to improve the quality of teacher assessments and evaluations of students, of educational materials, and of classroom management (and those of other actors in educational domains).

The research field also encompasses the conceptualisation and assessment of teacher trainings and the analysis of the interaction between teacher-students and trainers. The focus of corresponding investigations is on the question of how to support trainers and teachers in developing their professional identity. In this context, the field of research conceptualises, develops, supports analysis, and evaluates training dispositives (such as mentoring / tutoring, supervision, analysis of own practice). These dispositives are evaluated in terms of their effectiveness with respect to the professionalisation by trainees in the field of education.

## EDUCATION AND LEARNING IN NONFORMAL CONTEXTS

Modern societies have created manifold opportunities for social and educational interactions beyond the school ground limits. Institutions such as pre-school and youth centres, adult education and senior centres, were created in order to cover societal needs. Besides these specific functions, all institutions increasingly serve as opportunities for enhanced educational and learning processes. The rapid dynamics of demographic, social and economic changes in a globalized world have enhanced the complexity of social interactions and the plea for establishing a knowledge-based society. The different existing concepts in this field, such as non-formal education, informal learning, vocational training or Lifelong learning claim for a shift from a focus on what teachers do and schools can offer to a focus on what learners do. Accordingly, extra-curricular learning does not focus on individuals of a specific age (children and youth), it also includes pre-school learning of young children as well as learning processes and learning opportunities for adults and for older people.

Learning has to be seen as the effect of cumulative experiences emerging over time through manifold activities in a variety of situations. Therefore research in this field is -on the one side- based on empirical studies on the individuals' own reflections of their learning activities. Research here stresses the interplay of individual factors (e.g., motivation, attitudes and values, self-esteem) and socio-cultural aspects (e.g., family resources and habitus, institutional settings) for the explanation and prediction of motivated learning and learning outcomes. On the other side research has to recognize the importance of a life span perspective in describing, analysing and exploring the cumulative effects of many of these learning experiences for the individual and social development.

## RESEARCH UNITS

The researchers involved in the research priority Education and Learning in Multilingual and Pluri-cultural Contexts all work at the Faculty of Language and Literature, Humanities, Arts and Education, which is divided into four Research Units:

**Languages, Culture, Media and Identities (LCMI)** is the unit for socio-cultural research on learning and development. LCMI is dedicated to interdisciplinary and international research by addressing two different levels of educational research: the social and political level of the educational system(s) and the (micro) level of individual interaction(s) in educational processes.

The Research Unit **IPSE – Identités, Politiques, Société, Espace** (Identities, Politics, Societies, Space) is the largest Unit, not only within the Faculty, but of the whole University. A total of about 130 people work at IPSE, which focuses its research on societies examined from a point of view of developments in time and space. The fields range from history, geography, literature, arts, philosophy, linguistic, political science, sociologies and gender studies.

The **EMACS** Research Unit is primarily focused on **Educational Measurement and Applied Cognitive Science**. Its main objective is to contribute to the growing body of knowledge related to cognitive science as applied to education and learning, mainly through the construction and use of new assessment or learning tools.

The **Integrative Research Unit: Social and Individual Development (INSIDE)** is an interdisciplinary research unit comprising researchers from psychology, sociology, educational sciences, and social work dedicated to the study of individual and social development in times of rapid social change.



### CONTACT

Education and Learning in Multilingual and Multicultural Contexts

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ADDITIONAL  
RESEARCH FIELDS

CONDENSED  
MATTER PHYSICS

**"The Laboratory for Photovoltaics is working on thin film solar cells, an alternative to silicon solar cells. The active surface is ten times thinner than a human hair"**

## CONDENSED MATTER PHYSICS

# Looking into the Characteristics of Advanced Materials

### Research Question

"How do properties of magnets change when structured on the nanoscale?"

### PHYSICS OF ADVANCED MATERIALS

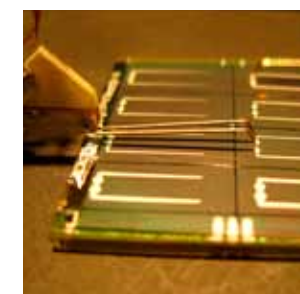
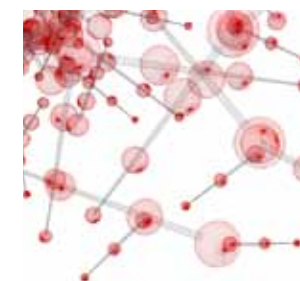
Research in Physics and Materials at the University of Luxembourg has a strong focus on condensed matter. The term condensed matter covers those areas of physics that investigate the properties of liquids and solids. Condensed Matter Physics is of high interest in basic research and also important for the development of technological and knowledge transfer industries working with materials.

The Research Unit **Physics and Materials Science** relies on three laboratories involved in Condensed Matter Physics: the *Laboratory for the Physics of Advanced Materials*, the *Laboratory for Photovoltaics*, and the *Theory of Soft Condensed Matter* group.

The scientists at the *Laboratory for the Physics of Advanced Materials* work on the basic research of novel materials that hold specific custom-made characteristics. The researchers are currently focussing on analysing new characteristics that emerge when materials are structured at nanoscale. The prefix 'nano' denotes a factor of  $10^{-9}$ : a nanometre (nm) is a million times smaller than a millimetre. Scientists speak of nanoscale structures, if the particles within the structure are less than 100 nm in at least one of the three dimensions length, width or depth. At the Laboratory, two groups are currently working on nanoscale materials: The *Nanomagnetism* group and the *Polymer* group.

### NANOMAGNETISM

The researchers at the *Nanomagnetism* group work on the correlations between the structure and properties of nano-crystalline magnets. The average crystallite measures about 10 nm and is therefore given the prefix 'nano'. These novel materials are of great interest in the material sciences, as their magnetic properties are often superior to those of conventional magnets. Nanomagnets have gained great importance in technology as they are largely applied in for example engines, loudspeakers, computers, transformer cores or mobile phones. The researchers are particularly studying the magnetic microstructure of nanomagnets based on neodymium, iron and boron.



## POLYMERS

The *Polymer* group focuses on the analysis of interface induced properties and structure formation in polymer based materials. Bringing together different materials, yields interphases with possibly differing properties and structures than those of the original materials. If one of the components is nanoscopic, then giant interfaces dominate the behaviour of the entire system. Advanced materials with new properties evolve that are highly interesting for technological applications. For example, mechanic hardness and impact strength of polymers can be increased by nanoscopic particles – this is not possible with “conventional” materials. Nanocomposites also play a role in the manufacturing of tires (improving road resistance, saving gasoline) and in everyday life.

## PHOTOVOLTAICS

The *Laboratory for Photovoltaics* is working on thin film solar cells, an alternative to silicon solar cells. These cells convert sunlight into electricity. The active surface is ten times thinner than a human hair. Consequently, they require less expensive semiconductor material and less energy in production. The active surface is usually applied to conventional window glass, favouring production processes that allow coating large areas in one go – like with the coated panes on office buildings. The advantage is that the solar panel is ready right away, without having to interconnect the cells first. These solar panels are available already today. Another advantage is that the cells can also be set up on metal screens, which results in very light and flexible solar cells. The researchers now work on improving the degree of efficiency of thin film solar cells.

Another working group at the *Laboratory for Photovoltaics* seeks to produce parts of thin film solar cells using low cost methods and non toxic materials. The cells consist of a sandwich structure with up to seven different layers. The most important being the absorber layer, whose role is to adsorb sunlight and to produce excited electrons. The scientists work with two types of absorber materials named chalcopyrite and kesterite.

## THEORY OF SOFT CONDENSED MATTER

The *Theory of Soft Condensed Matter* group develops computer programmes to predict materials properties. They are interested in soft materials such as paints and liquid crystals, as well as in composite materials such as plastics with carbon nanotube fillers. Their programmes compute properties such as melting temperatures and surface tensions as well as processes such as e.g. crystallisation or gelation. Together with researchers from the University of Mainz, Germany, and RMIT University in Melbourne, Australia, they have recently discovered that liquid crystallises – other than so far expected – in a two step process.

### FUNDED CHAIRS: TDK EUROPE CHAIR „NEW MATERIALS FOR SOLAR CELLS“

The Japanese electronics company TDK founded the TDK Europe chair „New materials for solar cells“ in 2006. This chair was allocated to Prof. Dr. Susanne Siebentritt, head of the Laboratory for Photovoltaics at the University of Luxembourg. The laboratory focuses not only on the development of solar cells but also on furthering the physical understanding of the materials and interfaces involved in these solar cells. In 2009, the laboratory has made its first thin film solar cells. This new generation of solar cells is expected to be considerably cheaper because they need much less material and energy in their production than today's photovoltaic modules.

The Laboratory's kesterite solar cells have already resulted in a new European record efficiency of 6.1 percent. The efficiency has been certified by the Fraunhofer Institute for Solar Energy Systems, one of eight labs in the world that are authorized to certify solar cell efficiencies.



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ADDITIONAL  
RESEARCH FIELDS

ENVIRONMENTAL  
RESOURCES,  
TECHNOLOGIES  
AND CHANGES

### Research Question

“Can we develop a new type of solar cells that is more efficient?”

**"Buildings consume a lot of primary energy, most of it due to cooling, lights, heating and water heating. The challenge is to find energy-saving solutions in building technologies."**

## ENVIRONMENTAL RESOURCES, TECHNOLOGIES AND CHANGES

# Finding Sustainable Solutions

Engineering Science joins the traditional fields of engineering with mathematics and the natural sciences in order to find scientific solutions to practical problems. In particular, the researchers at the University aim to create advanced techniques, to develop the sustainable and economical use of resources and to investigate competitive manufacturing technologies and processes.

The Research Unit **Engineering Science** is an interdisciplinary group active in the classical domains of civil, electrical and mechanical engineering. The main research activities are cooperative efforts of specialists in the classical engineering domains organised in the main research areas: *Construction & Design, Energy & Environment, Automation & Mechatronics and Geophysics.*

### CONSTRUCTION AND DESIGN

The research within the *Cluster Construction & Design (C&D)* investigates the stability, resistance and fatigue behaviour of constructions and building elements by simulations and experiments. The following examples give an interesting overview of the C&D research activities.

A group studies dynamic testing methods to assess the state of civil constructions. They then compare these methods to known assessment techniques. Within such projects, field work has been done at different places in Luxembourg. The researchers aim to improve stability, resistance, vibration and fatigue behaviour of the constructions. They use numerical simulation and validate their models by experiments.

In *Construction and Design* the researchers are also active in the medical field. The challenge posed by the health sector was on how to optimise the bearing capacity of easily breakable interim hip and knee prosthesis. The idea was to analyse the load transmission in the human knee and consequently to present a solution, namely a titan rod, which would make the interim prosthesis more resistant and thus to allow the patient a higher mobility during the healing phase. For this project, the University and its partners were awarded the 2nd prize of the Greater Region's Inter-regional Science Award in 2010.

#### Research Question

"Can we develop energy-saving facades?"

#### Research Question

"What is the energetic state of public buildings in Luxembourg?"

## ENERGY AND ENVIRONMENT

The *Cluster Energy & Environment (E&E)* covers areas such as energy production and management of hybrid systems for reliable electrical supply, energetic optimisation of buildings, efficient thermal combustion, renewable energies (biogas), energy efficient waste water treatment plants and advanced manufacturing technologies.

The E&E team works on analysing the energetic state of public buildings, including the new University buildings in Esch-Belval. The engineers also measure the actual heat energy consumption of newer office and school buildings to set-up a reliable database for Luxembourg and work out the most important influence factors to successfully reduce it. Current findings show slightly higher rates for single family houses for the period 1997-2007 than those measured in Germany or Switzerland for heating, simply due to the fact that the legal requirements in this period were less stringent here in Luxembourg.

Another promising research field studies the energy potential of the water cycle: There is an enormous amount of energy that is lost in the urban water cycle. The idea is to improve the energy balance by recovering the energy from all different parts within the urban water cycle. Moreover, this recovered energy will be used for the treatment of the waste water itself. In this way the transport and purification of waste water will be energy neutral.

A group of researchers is working on new technologies in facade engineering. Buildings consume a lot of primary energy, most of it due to cooling, lights, heating and water heating. The challenge is to find energy-saving solutions, such as high-tech double skin facades made of glass and steel, which explore the circulation of air as cooling in summer and insulating in winter; innovative technical installations inside the buildings and innovative building techniques exploring the use of green open spaces.

These technologies can be seen for example in impressive buildings like the European Investment Bank in Luxembourg, the Commerzbank in Frankfurt, Germany, or the Hearst Tower in New York, USA. Nevertheless, the full possibilities of energy saving and sustainability are far from being fully explored. This line of research has been acknowledged by the world leading steel industry Arcelor-Mittal, amongst others supporting the chair on Facade Engineering at the University since June 2010.

## AUTOMATION AND MECHATRONICS

The *Automation & Mechatronics (A&M)* research domain is also multifaceted embracing research on dynamic modelling of ground antennas, analysis and modelling of noise generation, dynamics of moulding machines, mechanical structure analysis, production engineering and distributed control and automation systems.

The activities of A&M can be exemplified by a project developed together with the Ministry of Economy and HITEC Luxembourg SA. The researchers obtained an accurate static and dynamic electro-mechanical model of a full motion antenna based on simulations using independent modern computational tools. The simulation results have been validated by experiments in-shop and on-site with the live Galileo antennas and can be ported to any other antenna that HITEC Luxembourg will design and supply.



## GEOPHYSICS

The Geophysics Laboratory focuses on climate, sea level variability and geodynamics. The primary goals include obtaining reliable geodetic measurements of environmental change and assessing the influence of human and natural factors in those changes. The group has developed a patented differential free-fall gradiometer, has advanced high-accuracy Global Navigation Satellite Systems (GNSS) techniques, interpreted time variable gravity observations from space and improved the modelling of environmental effects on geodetic observations.

The Geophysics Laboratory hosts the International Earth Rotation and Reference System Service (IERS) Global Geophysical Fluid Center. It maintains and operates several gravimeters in the Walferdange Underground Geophysics Laboratory and has established a number of geodetic GNSS stations around the world, including their participation in an international collaboration to install and maintain 60 continuously operating receivers on the Greenland Ice Sheet, and it also exploits the Luxembourg GPS network for scientific research.

Currently, the laboratory investigates ice mass changes in Greenland and Antarctica, monitors geodynamic processes in the vicinity of the Yellowstone caldera and at globally distributed tide gauge sites. The latter improves sea level studies, which help to assess flood risks in low-lying coastal areas and feed our overall understanding of climate change.

### FUNDED CHAIRS: ARCELOR MITTAL ENDOWED CHAIR IN FACADE ENGINEERING

In September 2010, the world's largest steel producer Arcelor Mittal, headquartered in Luxembourg, sealed the "Arcelor Mittal Endowed Chair in Facade Engineering" with the University. The aim is to advance the development of energy efficient high-tech buildings made of steel, composite steel and glass. The chair was awarded to Prof. Dr. Christoph Odenbreit.

Modern facades in buildings equipped with advanced technology make up as much as one third of construction costs. They integrate construction technology, ventilation and climate control, playing a significant role in the building's energy consumption. High-tech facade systems reduce the energy consumption of buildings. To achieve a reduction in energy consumption, the basic building structure, technology and facade have to mutually complement each other. The researchers at the University of Luxembourg aim to make a contribution in this regard.



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Environmental Resources, Technologies and Changes

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**ADDITIONAL  
RESEARCH FIELDS**

**MATHEMATICS**

**"Signal processing, prediction and filtering of noise are typical problems where stochastic analysis and the theory of differential equations provide powerful tools."**

**Research Question**  
"Can music and gambling help to solve mathematical problems?"

**GEOMETRY AND THE MATHEMATICAL THEORY OF QUANTIZATION**

**MATHEMATICS**

# Unravelling the World's Mysteries

Besides being a human endeavour to, for example, measure time and distance, mathematics is a universal language indispensable to many academic disciplines. Mathematics is a sophisticated additional human sense organ, an intellectual eye, which allows us to enter the important fields of modern high technology and science, inaccessible to our every day experience.

Mathematicians try to understand structures, derive consequences from their very definitions, create new objects of human reasoning or try to find them as the essence of pattern of nature. It might sound surprising that there is also the notion of beauty in mathematical structures, theorems, and proofs. For some mathematicians it is just the search for this beauty of mathematics, which is their driving force.

Quite often unexpected applications result by chance. A well-known example is number theory, formerly considered as the purest of pure mathematics far away from any application; nowadays it plays an essential role in modern cryptography. Today there would be no online banking or e-commerce without number theory.

The **Mathematics Research Unit** is part of the international research community in mathematics, has cooperations with other research institutes around the world and participates in European and international networks. The Mathematics Research Unit encompasses the following topical research groups.

Quantum mechanical effects are of relevance in many fields. It is at the basis of the technology of mobile phones, computers, in fact of all modern electronic devices. But as a matter of fact, quantum mechanics can only be understood with the help of mathematics.

One of the big challenges in contemporary physics is to unite the general relativity theory of Einstein, i.e. gravitation theory which is of relevance in the large macroscopic scale, and quantum theory which is the theory of the microscopic small. The problem is that the naive concept of a point in space as a physical reference creates problems for a unified theory. Two approaches to circumvent these problems are *string theory* and *non-commutative geometry*.

These theories are in their very essence of mathematical and in particular of geometric nature. Described in a simplified manner, in string theory the "troublesome" points in space will be replaced by little strings moving in a certain "background space". The evolution of the moving strings generates geometric objects accessible by mathematical methods.





*Non-commutative geometry* is a fairly recent research direction in mathematics. In a non-commutative space the geometric object is associated to an algebra of certain objects, for which the multiplication is not commutative. Mathematical research is done in the group to understand these non-commutative spaces better. In both fields one is forced to consider spaces with singularities, i.e. spaces which have cusps, crossings, or other irregularities.

#### NON-COMMUTATIVE HARMONIC ANALYSIS AND RELATED FIELDS

This research group deals with symmetries. If a system has symmetries the data needed to recover the system can be reduced. The mathematical concepts describing symmetries is the notion of a mathematical group. One of the simplest but nevertheless fundamental symmetries is periodicity. If a wave has the fundamental frequency  $f$ , then the full multiples  $2f$ ,  $3f$ ,  $4f$ , etc. are called harmonics. Harmonics and also the sum of harmonics are periodic with the fundamental frequency, which means that the wave values repeat themselves from thereon. This periodicity allows decomposing complex problems into sums of comparably simple components. The mathematical study of such problems is called harmonic analysis. Harmonic analysis gives very useful insights into the system under inspection. The theory of Fourier series and Fourier integrals has become a major instrument in physics, signal theory, engineering, medical imaging, economics, and many more fields. A lot of phenomena observed in nature are highly non-commutative. The research group examines – for certain classes of continuous groups (i.e. groups which are also geometric spaces) – their representation theories and in particular also their function algebras.

#### PROBABILITY THEORY AND ITS APPLICATIONS

Consider a gambler betting on the outcome of a sequence of fair coin tosses: heads, he wins – coins, he loses. Such a game can be seen as a random walk on the integers, which has some similarity with a drunkard exiting the bar and moving randomly, with equal probability, one step to the left and one step to the right. Random walks may be considered also in two or more dimensions.

Imagine a random walk in which smaller steps are taken more and more frequently; then one gets what probabilists call a Brownian motion. Robert Brown was a Scottish botanist who was intrigued by the observation that under the microscope, pollen grains suspended in water perform a rapid oscillatory and highly irregular motion.

In 1905 Albert Einstein predicted the same phenomenon on theoretical grounds and formulated a correct quantitative theory of it: the motion can be explained by irregular collisions of the particles with permanently moving molecules in the liquid. In modern probability theory Brownian motion plays the role of a universal concept for modelling random fluctuations in complex dynamical systems.

In the research group Brownian motion is studied under various aspects, with applications ranging from pure mathematics to modelling in computational biology and mathematical finance. Signal processing, prediction and filtering of noise are typical problems where stochastic analysis and the theory of stochastic differential equations provide powerful tools.

Furthermore, Brownian motion on curved spaces is also studied as a unifying concept of connecting local and global geometry, with important consequences both in Geometric Analysis and Mathematical Physics. “*Mathematics is a way of discovering the hidden aspects of reality*”, states Prof. Dr. Martin Schlichenmaier, head of the Research Unit. Other areas of research include decision theory and operation research. Both are concerned with finding (near-) optimal solutions to decision-making problems.



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## ADDITIONAL RESEARCH FIELDS

## ECONOMY AND MANAGEMENT

**"International migration is another main research area. The objective is to understand the impact of migration on the macroeconomic performances of both the source and the receiving countries."**

## ECONOMY AND MANAGEMENT

# Understanding Allocation Mechanisms

The word "economy" comes from the Greek "oikonomia" which we could translate almost literally as "rules of the house" looked at from a management point of view. This term is typically associated nowadays to broader entities like countries. "Economic analysis" focuses on the rules that govern the working economic entities like households, firms or regions, however largely defined. Adam Smith's *Wealth of Nations* (1776) remains one of the best examples of early attempts to develop an economic analysis at the country or world level.

The focus of the programme in Economics and Management is on the mechanisms by which economic resources are allocated to their many different uses (production of private or public goods and services, R&D, education, etc... ). Actual allocation mechanisms are quite complex. They are the outcome of individual behaviours and their interactions through market exchanges and institutions. The research objective is to better understand these mechanisms, evaluate their efficiency and the role of specific regulations and policies, be it within a firm, a country or at world level.

## RESEARCH

The research activities in economics and management are organised within the Research Unit CREA (Center for Research in Economic Analysis). Recent contributions and projects bear on the following issues.

## INTERNATIONAL ECONOMICS

Financial markets and capital movements are one research area. A three-year project (2007 – 2010) entitled *The impact of real financial integration on asset pricing co-movement* was supported by an FNR (National Research Foundation) grant.

International migration is another main research area. The objective is to understand the impact of migration on the macroeconomic performances of both the source and the receiving countries, as well as the determinants of the size and skill composition of these migration flows (distances, colonial links, wage differentials, networks and of course migration policies, etc). A four-year project on *International Migration Policy and Law Analysis* started in 2009 with the objective of gathering and analysing comparable data on immigration law and policy in over 25 countries of immigration between 1960 and 2010. This international project involves researchers from five different universities (Harvard University, University of Amsterdam, London School of Economics, University of Sydney, and University of Luxembourg).

### Research Question

"Can brain drain have positive effects on the source country also?"



#### REGIONAL DEVELOPMENT AND GLOBALISATION

Regional economics study the economic interactions (through channels such as trade, capital movements, environmental constraints, knowledge spillovers, tax competition, etc.) between regions. The research focuses on the determinants of capital and labour mobility, and how agglomeration effects and location choices affect the productivity and relative income of a region or country. A three-year project (2008 – 2010) funded by the University of Luxembourg has been devoted to these issues.

A series of annual projects funded by STATEC focused on the determinants of regional competitiveness. The University is also supporting a three-year project (2011 – 2014) on *The Economics of Carbon Capture and Storage*, studying the effects of pollution reduction policies, including the case of cross-boundary pollution.

#### INDUSTRIAL ORGANISATION

Industrial economics is concerned with strategic behaviours and interactions between firms, and their impact on innovation and management practices. It provides the framework needed to evaluate the impact of industry regulations on competitiveness.

Research projects financed by the Alphonse Weicker Foundation have focused on the attractiveness of the Luxembourg market places, the banking industry, the effects of innovation and information technologies, the effects of foreign direct investment (FDI). A three-year project (2010 – 2013) on *Economic Geography and Quality*, funded by the University of Luxembourg, is devoted to the analysis of innovation in product quality and its impact on cross-regional trade, firms' competitiveness and FDI choices.

#### MACROECONOMICS, GROWTH AND FLUCTUATIONS

Macroeconomics is about the determinants (including economic policy) of the aggregate economic performance of a country or region, especially output growth and (un-)employment. Recent research activities (in collaboration with researchers from the University of Louvain and Ecole polytechnique, Paris) focused for instance on the link between sustainable development and environmental quality.

Another part of the research was on the macroeconomic implications of ongoing demographic changes, both through endogenous growth channels (in collaboration with the University of Bolzano) and through the interactions between pension reforms, job creation and equilibrium unemployment (collaboration with the Banque Centrale du Luxembourg and the University of Louvain).

#### MANAGEMENT

The research in management has specialised in two areas, corporate governance and innovation networks. A FNR-CORE project (2009 – 2011) entitled *The Small World of Banking in Benelux* studies the board membership and ownership networks of the banking and finance industry in the three Benelux countries Belgium, Netherlands, and Luxembourg, and the link between the position and performance of banks in these networks.

#### LUXEMBOURG BUSINESS ACADEMY

The expertise accumulated in the "Economics and Management" research programme is disseminated through collaborations and interactions with institutions like the national statistics agency STATEC, the Banque Centrale du Luxembourg (BCL), the European Investment Bank (EIB), the OECD, and others.

The expertise in "Economics and Management" is also valued through two master programmes: *Master in Economics and Finance* (with two specializations, professional and research), organised in partnership by the CREA and the LSF, and the *Master in Entrepreneurship and Innovation*. The latter is a result of collaboration between the University and the Chamber of Commerce of the Grand-Duchy of Luxembourg. They have initiated a partnership whose first outcome is the **Luxembourg Business Academy**, a new programme on Entrepreneurship and Innovation.

The broader objective of the collaboration is to stimulate the creation and development of innovative companies by providing students with an advanced education in the fields of entrepreneurship and the management of technological and organisational change, and by immersing these students into daily business practice through a privileged relationship with a mentor company.



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**ADDITIONAL  
RESEARCH FIELDS**

LUXEMBOURG  
STUDIES

**"The researchers analyse the bonds, mutual influences and possible tensions between different socio-cultural groups within the Luxembourg society. These bonds are largely due to the changes taking place on a local and national level and on a European and global level."**

## LUXEMBOURG STUDIES

# Accompanying the Development of Society

At the University, research on cultural, social, political and spatial developments in the Grand-Duchy of Luxembourg is interdisciplinary: It includes numerous fields of research such as geography, history, linguistics, literature, political science, sociology, arts and gender studies, forming a wide spectrum of cultural studies. Any project aiming at analysing and explaining aspects of society in Luxembourg is eligible to be part of this research axis. The researchers' main goal is to analyse and accompany the development of society by using scientific tools that are interdisciplinary, transnational, comparative and prospective.

The Luxembourg society has been strongly affected by several cultural, political, and economic changes. The researchers within Luxembourg Studies analyse the bonds, mutual influences and possible tensions between different socio-cultural groups within the Luxembourg society. These bonds are largely due to the changes taking place on a local and national level on one hand and on a European and global level on the other. They are described by the terms 'social cohesion' and 'glocalisation' and will play a major part in future research in this field.

At present, four research groups of the IPSE Research Unit within the Faculty of Language and Literature, Humanities, Arts and Education are working in this field.

### Research Question

"What if everything we want to know about the Greater Region could be found on one map?"

### IDENTITIES IN LUXEMBOURG: LANGUAGES, LITERATURE, HISTORY AND MEMORY, MEDIA

Research in the section Identities in Luxembourg: Languages, Literature, History and Memory, Media are dealing with the processes of identity building, perception of space, cultural memory and social and linguistic dynamics. Projects focus e.g. on Luxembourgish 'lieux de mémoire', on nation building, on the transition of cultural memory across generations or on the structure of Luxembourgish family names.

### MIGRATIONS AND SOCIAL STRUCTURES

The researchers in Migrations and social structures focus on the European Migration Network – an information provider for migration and asylum aspects at European and Member State level. Further areas are social cohesion and social justice, the history of migratory phenomena and gender studies. The field will be further developed after the appointment of the professor for social sciences specialised in the field of migration.

**NATIONAL, CROSS-BORDER AND REGIONAL GOVERNANCE**

The National, Cross-border and Regional Governance team is working on the functioning of democracy, the history of citizenship, and governance in Luxembourg and the Greater Region. The activities comprise, amongst others, an online atlas of the Greater Region (so called GR-Atlas) and the contributions of the national contact point for the ESPON programme to the Greater Region's cross-border integration (European Spatial Planning Observatory Network). Synergies are in particular being developed with the research programme *European Governance*.

**SPATIAL DEVELOPMENT, URBANISM, ARCHITECTURE**

Finally, the group Spatial development, Urbanism, Architecture focuses on town and country planning and spatial analysis, as well as the somewhat metropolitan development of the City of Luxembourg, urban governance, and identity issues of place and space. Current research activities include the FNR (National Research Foundation) – funded project "SUSTAINLUX" on the governance of sustainable development, the exploration of the new university location at Belval-Sanem as a place of knowledge production and thus of regional significance, and also a critical analysis of the housing market in the Grand Duchy.

All four groups work together on numerous projects, still further collaborations with other faculties are planned such as with the Faculty for Finance, Law and Economics.

**IDENT – SOCIO-CULTURAL IDENTITIES AND IDENTITY POLICIES IN LUXEMBOURG**

The research project IDENT, concluded successfully in 2010, aimed at researching various forms of identity constructions through interdisciplinary collaboration in terms of subjects, methods, concepts, and theories. At the centre of the non-essentialist and dynamic concept of identities were attribution and appropriation processes of complex and multi-layered identities in Luxembourg, as well as their specific interactions.

The dialectics, which are seen as institutionally and medially 'desirable' on the one hand and which are actually 'lived' in society on the other, were explored in the notions of spaces, languages, images on a quantitative, qualitative and text-analytical level. The level of reference was in all instances the analysis of socio-cultural milieus, conducted for the first time in Luxembourg.

A follow-up project with the title "IDENT2 – Strategies of Regionalisation: Constructing Identity Across Borders" (2011 – 2014) aims to further develop the issues addressed by IDENT.



**PRIZE-WINNING 'GR-ATLAS'**

GR-Atlas, which received the 1st Science Award of the Greater Region 2009, is a web-based map portal of the Greater Region comprising geographical, historic, political, linguistic, climatical and sociological maps, descriptions, data, pictures and scientific commentaries by the authors. Experts, scientists, journalists, teachers, students and the general public can look up information such as where medieval hospitals were located, at which service stations people fill up their vehicles with gasoline or how the national borders changed over time, beginning with the Congress of Vienna in 1814.

**FUNDED CHAIRS: CITY OF LUXEMBOURG CHAIR IN URBAN DEVELOPMENT RESEARCH**

In 2007, the City of Luxembourg funded a chair in urban studies, located within the „Laboratoire de Recherche en Géographie et Aménagement du Territoire“ at the University. Professorship holder is Prof. Dr. Markus Hesse. As a part of the geography and spatial planning research centre, he is involved in teaching courses in the Master programmes on Spatial Development and Analysis (FLSHASE) and on Sustainable Development (FSTC); he also supervises Ph.D. students in these fields. His research focuses on principles of urban and regional development, on globalisation, flows and related consequences for cities and regions, on the emerging European urban policy agenda, and on metropolitan governance, policy and planning.

One of the current issues explored by the chair is concerned with appropriate interpretations of ongoing urban change associated with an "urban renaissance"; another deals with transformations of suburban landscapes. Also, developments in Luxembourg and in the Greater Region play a particular role, e.g. the future potential of Belval, the future headquarters of the University, as a nucleus of a "knowledge-region" or the governance of spatial development in the light of sustainability (funded by the National Research Fund FNR).



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**ADDITIONAL  
RESEARCH FIELDS**

**SOCIAL  
AND INDIVIDUAL  
DEVELOPMENT**

**"Within the coming years both individuals and the European society will have to face unprecedented economic and social challenges."**

## SOCIAL AND INDIVIDUAL DEVELOPMENT

# The Consequences of Demographic and Social Changes

### Research Question

"What are the bonds, the mutual influences and possible tensions..."

"...between different socio-cultural groups within the Luxembourg society?"

Europe is experiencing substantial social and demographic changes. These are characterised in most European countries by a progressively declining and low birth rate as well as greater longevity. Recent extrapolations by Eurostat predict that there will be a dramatic increase of the "old old" above 80 people within the next 15 years, while the proportion of persons within the active age (between 15 to 64) will decrease. The ratio between active and inactive people will dramatically change from now till 2040 and threaten the sustainability of public finances and resources which are fundamental for the future development of the social welfare system and the coherence of the Luxembourg society.

One of the leading tasks of a University is to develop research programmes that elaborate key knowledge structures and action models which will *promote a sustainable social development* by studying social change phenomena. Especially, the Integrative Research Unit on Social and Individual Development (INSIDE) is mainly committed to this goal, since it aims at conducting interdisciplinary studies on the impact of social change, both at individual and at social level. The unit comprises researchers from psychology, sociology, educational sciences, social work and social pedagogy.

Three major domains constitute current research within the priority on Social and Individual Development: *Psychosocial Stress and Health*, *Generations and Development across the Life-span and Processes* and *Systems of Social Regulation*. All domains reflect "areas of concern" in modern society which are strongly affected by demographic and socio-economic changes. Furthermore, all domains identify demands and tasks that are novel in Europe and Luxembourg underlining the need for descriptive data as well as knowledge about steering and regulating these processes.

### PSYCHOSOCIAL STRESS AND HEALTH

Societal development and inherent changes of the social environment constitute challenges requiring the individual continuously to adapt, both at behavioural and physiological level; maladaptation may lead in the long run to civilization diseases and stress disorders. The investigation of the links between these diseases and social change as well as individual parameters in all age groups completes the research programme of this domain.





Research within this domain focuses on the Psychobiology of Life Style Diseases and Stress Disorders, Social Psychology (Health Promotion and Aggression Prevention), and Clinical Health Psychology (Mental Disorders and Chronic Physical Conditions). Current research projects investigate i.e. burnout, eating disorders and cyber-bullying.

#### GENERATIONS AND DEVELOPMENT ACROSS THE LIFE-SPAN

Threats to social security and public welfare will challenge developmental and educational contexts as they will challenge the relations between generations. Research within this domain is integrative and life-span oriented; it investigates educational and care contexts in early childhood, resources, contexts and structures of youth development as well as individual and social conditions of ageing. A special emphasis is given to intergenerational relations.

Research within this domain focuses on Education and Care in Early Childhood, on Youth Research on Resources, Contexts and Structures of Growing-up, and on Ageing and Life-span Development. Current research projects investigate i.e. care and educational structures in early childhood, youth cultures and psychosocial burden of family carers.

#### PROCESSES AND SYSTEMS OF SOCIAL REGULATION

Social change will also affect models of social justice and social inclusion, most notably with respect to already vulnerable groups. The empowerment and quality of life of these groups constitute therefore a dominant area of concern and interdisciplinary field of research. Within this context the distribution of resources, social inequality and especially the treatment of vulnerable groups (e.g., children and young people in care; persons with special needs, the elderly) represent current and future research questions.

Research within this domain focuses on Social Inclusion and Exclusion as well as on Social Inequality. A current research project investigates practices of professional reinsertion of long-term unemployed people.

#### RESEARCH LABORATORIES

The research priority has four laboratories:

- 1 the Media and Experimental Lab, a scientific laboratory for media and experimental research, covering a broad range of prevalent experimental issues, including aggression research related to social psychology, media psychology, developmental psychology and cognitive psychology;
- 2 the Clinical Psychophysiology Lab, designed for the experimental investigation of risk factors and psycho-physiological processes which are important for the development or maintenance of chronic physical and mental disorders;
- 3 the Laboratory of Psychophysics and Sensory Psychophysiology, aiming at the experimental investigation of bio-psycho-social modulators of endogenous pain control systems and their role as potential risk factors for the development of chronic and cancer pain;
- 4 the Psychological Diagnostic Laboratory, having over 300 psychological tests, which comprise paper-and-pencil as well as computer-assisted testing procedures covering a wide range of personality characteristics and human behaviour.

#### Research Question

"Do the threats to social security have an influence on the relations between generations?"



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ADDITIONAL RESEARCH FIELDS

EUROPEAN GOVERNANCE

"The researchers examine the evolution of public politics in other post industrial societies in order to better define the distinctive features and limitations of the 'European Governance' model."

## EUROPEAN GOVERNANCE

# Politics and Decision Making in Europe

The University of Luxembourg provides researchers the opportunity to live and work in a European Capital. Not only is the Grand Duchy of Luxembourg geographically located at the heart of Europe, but Luxembourg City belongs to the three capital cities of Europe, the other two being Brussels and Strasbourg, and is the home to significant European institutions. For instance, the European Court of Justice, the European Investment Bank and the Secretariat of the European Parliament are based in Luxembourg, and the world-known Schengen Agreement was signed in Schengen in 1985.

It is the ideal location to gain insight into and work on new findings relating to European Governance, as is one of the many projects that the researchers at **Identiés, Politiques, Sociétés, Espace** (IPSE) of the University of Luxembourg are involved in. They have developed the research programme *European Governance* with the aims to formulate research and teaching projects, support foreign researchers and interns, and develop collaborative relationships with research centres, foundations and universities, which focus on European and Comparative questions.

In the last 5 years, the program won more than 2.2 million € for research projects. These projects were funded mainly by the European Commission, the European Parliament, the Government of Luxembourg and the national Parliament. Furthermore, the research unit European Governance responded with success to international calls and national research type CORE from the European Science Foundation, the National Research Fund and within the University, all evaluated by external committees. The program hosts four collections and has already published fifteen books since its foundation in 2005.

The research programme, bringing together political scientists, historians and philosophers, adopts an interdisciplinary and comparative approach in its treatment of European questions, articulated along five research domains:

### SOCIAL AND ECONOMIC COHESION

This group focuses on the economic and social politics of the European Union, of its Member States, of the European Investment Bank and of the European Investment Fund by adopting a comparative approach. In March 2008, it inherited a bibliographic collection of outstanding dimension from the European Investment Bank. Its library will thereby be completed by more than 10000 books and documents, making it a sizable asset for EU researchers. In September 2009, the programme obtained a Jean Monnet chair ad personam in 'European History'.

Research Question  
"What is the best way to govern Europe?"

Research Question  
"Which are the values for the European Union in terms of economical, ethical and external relations?"



**DEMOCRACY, LEGISLATIVE STUDIES, DECISION-MAKING PROCESSES IN THE EU**

The researchers study decision making processes, the values and opinions of Europeans, and the actors in the European political system. They also analyse the Europeanization of political and legal systems in the Member States, the parliamentary government in Europe and the part which different regions with legislative power play in European governance. In March 2010, they held the annual international conference of the International Political Science Association titled "Is there a European Model of Governance? A comparative perspective." This group is partner of many networks and international research programmes (including Providing Infrastructure for Research on Electoral Democracy in the European Union & European Union Democracy Observatory, coordinated by the European University Institute in Florence).

**COMPARATIVE GOVERNANCE – EUROPE IN THE WORLD**

The *Comparative Governance* team compares the "European model" with other models of regional integration on a world level (Alena, Mercosur, Asean, etc.). The result is an orientation of the notion of European Governance toward a global dimension. Furthermore, the group engages in a discussion on the impact of European Governance in the world. The axis hosts the sixteen-institution Consortium for Comparative Research on Regional Integration and Social Cohesion (RISC) and the Human Rights observatory.

**ANALYSIS OF PUBLIC POLICIES**

The *Analysis of Public Policies* group focuses on Europeanisation, searching to better understand the dynamics of political wordings in complex, multilevel governance systems. A part of the research focuses on the impacts of public policies of the European Union on their national counterparts, but the analysis not be limited to the study of this unilateral dynamic. But also the research discusses more broadly multiple forms of "dialogue" about public policies that are established in the European political space.

The group also examines the evolution of public politics in other post industrial societies in order to better define the distinctive features and limitations of the "European Governance" model

**THE PHILOSOPHICAL FOUNDATIONS OF FEDERALISM**

The researcher's aim here is to reconstruct the philosophical foundations of federalism as a constitutive element of European Governance. In light of modern and contemporary theories of political and legal philosophy, it's about discovering anthropological, rational and practical foundations determined for the idea of modern constitutional patriotism and federalism.



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European Governance

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**FACTS AND FIGURES**



## FOUNDATION

Founded in 2003 as the first and only public university of the Grand-Duchy of Luxembourg, the small state in the heart of Europe between France, Germany and Belgium.

## PROFILE

The University of Luxembourg is multilingual, international and strongly focused on research. Its students and researchers have chosen a modern institution with a personal atmosphere, close to European institutions, international enterprises and the financial place Luxembourg.

## GOVERNANCE

The Board of Governors, made up of 7 members, decides upon the university's general policies and strategies. The university president, the government commissioner, a representative from the teaching body and a student representative participate on equal terms in a consultative capacity at Board meetings.

The rectorate is the executive body of the university and consists of the president, the vice-president for research, the vice-president for organisation and international relations, the vice-president for academic affairs and the administrative director.

## MULTILINGUALISM AND INTERNATIONAL RELATIONS

Generally, programmes are bilingual (French/English – French/German), some are trilingual degrees and some are entirely taught in English; The academic staff originates from 17 different countries; students originate from 95 countries\*. There are foreign language courses for students and the environment in a multilingual country is multicultural.

About 50 general university agreements for student exchange with universities in Europe, Asia and North America as well as 300 ERASMUS agreements for different programmes. Undergraduate students have to spend at least one semester abroad.

## STAFF

180 professors, associate professors and Senior lecturers, supported by 650 professional experts.\*  
Total number of staff: 1004\*

## NUMBER OF STUDENTS

5177 students (3093 Bachelor students, 900 Master students, 358 PhD students, 826 others)\*  
37% international students (students with foreign nationality and not holding a Luxembourgish school system secondary diploma.)

## DEGREES

11 Bachelor degrees and 25 Master degrees, 9 other courses

\* End of 2010



WHO'S WHO?

## FACULTY OF SCIENCE, TECHNOLOGY AND COMMUNICATION

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## FACULTY OF LAW, ECONOMICS AND FINANCE

### RESEARCH UNITS

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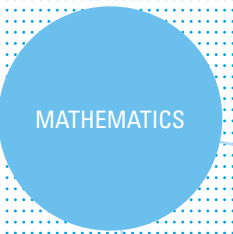


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\* on 31 December 2010

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