
AXA
Research Fund
Supporting science
to help our wishes
come true

Contents

Editorial

“With the AXA Research Fund’s support, AXA is committed to progress through science.”

I wish that tomorrow, my children will know snowy winters like those of my childhood.

I wish for a long and healthy life, with my loved ones.

I wish that we could all breathe clean air, far from pollution warnings.

I wish I could use the Internet safely, without worrying about my personal data.

I wish we would no longer see news coverage of flooding…

My wish list is endless, but so is the progress of science.

At AXA, we strive to empower people to live a better life and to help make their wishes come true. We believe in scientific research as a means to achieve both.

For the past 10 years, through the scientific philanthropy of the AXA Research Fund, AXA has been committed to societal progress through research in the key areas of health, environment, new technologies and socio-economics.

We have supported over 500 projects to advance knowledge led by innovative scientists in 35 countries.

10 years old, 10 years young! And a wonderful journey that positions the AXA Research Fund as a reliable and supportive partner of a Science that keeps looking forward.

THOMAS BUBERL
Chief executive officer of AXA

“We believe that science can improve lives.”

Science has the power to transform

To transform the sun into electricity, silicon into data, titanium into limbs.
Science can help improve our health,
protect our environment and better understand our societies.
We cannot write our future without it.

But sometimes, science can feel distant and far from the aspirations we have for tomorrow:
to live a long and healthy life,
to be protected from serious diseases,
to provide a safe environment for our children to grow and play.
to travel the world without fear.

While our wishes may differ, we all share the same hope of a better life.

At the AXA Research Fund, we believe that science can improve lives. Our mission, for the last 10 years, has been to support, accelerate and share the best scientific research for a better future.

In 10 years, the AXA Research Fund has supported over 500 projects led by top-tier scientists across 35 countries and has helped them share their findings to the public, so that, tomorrow, science can help our wishes come true.

10 years
of supporting science

The AXA Research Fund was born out of the belief that science has a crucial role to play in responding to the most important issues facing our planet today, and to help us build better lives for ourselves.

AXA's scientific philanthropy initiative is committed to supporting science, contributing to societal progress and encouraging researchers to share their work with the larger public for the benefit of all.

The AXA Research Fund supports scientific projects in the areas of health, environment, new technologies, and socio-economics.

Based on an independent and transparent academic evaluation process, the AXA Research Fund's Scientific Board selects innovative top-tier academic research projects that contribute to progress. Targeted calls for projects aim at responding to priority emerging questions, such as energy transition or women's health.

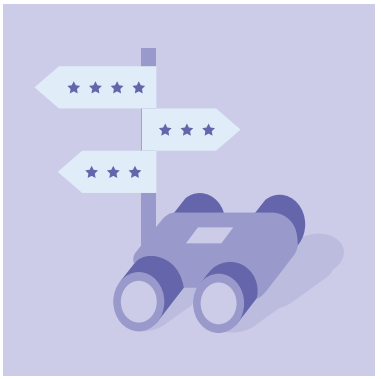
Beyond its financial support, the AXA Research Fund helps scientists share their work with the general public and the media. By helping scientists disseminate their findings, AXA helps them to contribute to the public debate.

We support science to help our wishes come true, and to build a better life for everyone.

Since 2008...

563
projects supported

58
nationalities



35
countries

€ 180 M
invested

Explore more than 500 projects on
www.axa-research.org

Data as of 01/01/2018

HEALTH

“I’d like to move around freely despite my disability.”

“I hope that tomorrow's medicine can offer treatments that are tailored for each of us.”

“I’d like to see epidemics controlled better.”

“I want to be able to take advantage of my energy for a long time.”

Tomorrow, better health for everyone

The considerable progress in medicine has undoubtedly improved our health, manifesting itself in the eradication of centuries-old diseases, and in the extension of life expectancy almost everywhere in the world. But our modern lifestyles also bring with them new challenges for research, such as chronic diseases, diseases related to old age, obesity, resistance to antibiotics, or inequality in access to healthcare.

To meet these major global health challenges, the AXA Research Fund supports innovative and promising research projects in cutting-edge fields ranging from nanomedicine to molecular oncology and including the strategic study of health systems.

Responsible for 63% of deaths, chronic diseases (heart diseases, strokes, cancers, chronic respiratory diseases, diabetes, etc.) are the leading cause of mortality in the world.

World Health Organisation

NEW APPROACHES TO NON-COMMUNICABLE DISEASE CONTROL

According to WHO projections, cancer deaths are expected to continue to increase, reaching 22 million per year by 2030.

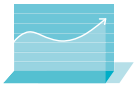
Fortunately, cancer research has come a long way in recent years, and progress is accelerating. Innovative treatment approaches are emerging around the world, such as that of **Professor Mariano Barbacid**, holder of the **AXA Chair in Molecular Oncology**, at the **National Cancer Research Centre (CNIO)** in Spain. One of the pioneers in the discovery of the first human "oncogene" – a gene that causes cancer – this researcher studies the very first stages of the appearance of a tumour, in order to build therapeutic approaches capable of hindering its progression.

This is also the approach adopted by **Doctor Parvin Tajik**. During her research at the **Academic Medical Centre (AMC)** at the **University of Amsterdam**, she became interested in ovarian cancer – which is difficult to detect at an early stage – and in the development of a diagnostic method allowing the implementation of personalised treatments, based on the examination of a certain number of clinical signs.

This personalised and predictive approach to medicine is booming. **Professor Helen Colhoun**, holder of the **AXA Chair in Medical Informatics and Biographical Epidemiology** at the **University of Edinburgh**, applies it even more extensively to diabetes. Her work, based on the use of Big Data – the availability of a large amount of electronic data such as medical records – aims to predict the evolution of cases of diabetes and the complications specific to each case, in order to foresee the most appropriate support.

Another example of how two disciplines can come together is the **AXA Chair in Cardiovascular Cellular** Engineering at **École Polytechnique**. **Professor Abdul Barakat**, head of the research programme, uses modern engineering tools to shed new light on how mechanical parameters such as pressure, tension forces and friction forces regulate cell function. His work has in particular made it possible to improve the design of stents and to design intelligent stents that will allow non-invasive monitoring of the state of the arteries.

At the crossroads between chemistry, physics, biology and medicine, supramolecular chemistry also represents a promising approach to combat chronic diseases, but also neurodegenerative diseases, autoimmune diseases, obesity, etc. **Professor Luisa de Cola**, holder of the **AXA Chair in Supramolecular Chemistry** at the **University of Strasbourg**, is studying how the complex molecular structures that constitute matter interact. In addition, the research programme also aims to create nanocontainers for the targeted transport of biomolecules, DNA or enzymes within diseased cells or tissues. This approach paves the way for new non-invasive therapeutic applications against diseases such as cancer, Alzheimer's disease, HIV, autoimmune diseases, orphan diseases, allergies and obesity.



442 million

(approximately) people suffer from diabetes in the world.
World Health Organisation (latest estimates).

50 million

people worldwide suffer from dementia and there are nearly 10 million new cases each year. Alzheimer's disease is the most common cause of dementia and is thought to cause 60 to 70% of these cases.
World Health Organisation (2017 figures)

MEETING THE CHALLENGES OF HEALTHY OLD AGE

Living longer is an opportunity, but only if it means living in good health. Older people now represent the fastest growing proportion of the population. But do these people aged 85 and over benefit from these extra years in good conditions?

"The situation remains unclear", says **Professor Carol Jagger**, holder of the **AXA Chair in Longevity and Healthy Active Life** at the **University of Newcastle**. *"We still lack solid data to answer this question, but we are working tirelessly on this at Newcastle"*.

“ Professor Barakat and myself are working together on an artificial lung project for patients with pulmonary hypertension. We are attempting to work on the 'biologization' of this device, so that cells in the body can 'live' and develop there.”

Prof Olaf Mercier, surgeon at the Department of Thoracic, Vascular and Cardiopulmonary Transplantation Surgery at the Marie Lannelongue Hospital.

The objective of this research programme is a comprehensive understanding of the mechanisms through which good habits improve healthy life expectancy, in particular as regards diet, physical exercise and social interactions.

Meanwhile, **Professor Harald Hampel** is studying one of the most widespread diseases affecting old age, but which still remains mysterious.
As holder of the **AXA Chair on Alzheimer’s disease at University Pierre and Marie Curie**, he is working to implement an early diagnosis of the disease so that more effective treatments can be put in place.

TOWARDS MORE EFFICIENT AND FAIRER HEALTH SYSTEMS

Today's health systems will need to evolve to meet the major challenges of the future: an ageing population, austerity measures, etc. These vary from country to country and countries can learn from each other and move towards universal and equitable access and improved care in line with medical progress.

This is precisely the aim of **Professor Pedro Saturno's Chair at the National Institute of Public Health** in Mexico. To achieve this goal, he relies on a thorough understanding of social, economic and health system factors.

Carol Jagger has contributed to the development of the first European Health and Life Expectancy Information System (EHLEIS).

220 projects in 24 countries

He shares this approach with other researchers around the world, including **Doctor Soo Hong Kim** of **Seoul National University**, who compares and evaluates health policies to provide decision-makers with the keys they need to adapt health systems to the challenge of an ageing population in South East Asia. At the **London School of Economics and Political Science (LSE)**, **Doctor Emily Freeman** is studying the implications of the same phenomenon, but in Sub-Saharan Africa, where the number of senior citizens is expected to increase considerably in the coming years.

In Canada, at **Wilfrid Laurier University**, **Doctor Karen Grépin** focuses on a surprising form of inequality of access to health systems, one caused by environmental, social and political shocks, such as a power outage in India, a terrorist attack in Pakistan, etc. Another original approach is the feature film on women living with HIV in Tanzania, directed by **Doctor Sophie Harman** of **Queen Mary University in London**. Her film, 'Pili', which won an award at the Dinard Film Festival, as well as the graphic novel and book that the researcher intends to publish, are innovative tools for raising public and decision-makers' awareness of this health issue.

Professor Sarah Pressman, a researcher based at the **University of California, Irvine**, is interested in the benefits of happiness as an anti-stress elixir for better health. Her study of physiological responses due to positive emotions aims to have happiness and its determinants considered as an integral component of medical care.

ANTICIPATE THE SPREAD OF EPIDEMICS

The innovative techniques for modelling the spatial spread of infectious diseases developed by Doctor Simon Cauchemez of the **Institut Pasteur** are now used by Santé Publique France, the body that manages epidemics in France.

In particular, he collaborated in public health efforts during the Chikungunya epidemic in 2005 in Reunion Island and against the Zika virus in Martinique in 2016. His team also collaborated with the **Pasteur Institute of Madagascar** to overcome the plague epidemic in 2017.

Emmanuel Fort: image hunter

Professor Emmanuel Fort,
holder of the AXA Chair in Biomedical Imaging at ESPCI.

Imagine the application possibilities of a medical imaging system capable of visualising and tracking a single molecule inside the human body. Thanks to Professor Emmanuel Fort's innovative work, this is now possible: supercritical fluorescence microscopy, or nanoscopy, promises multiple therapeutic applications.

The research programme of Professor Emmanuel Fort, holder of the AXA Chair in Biomedical Imaging at the Langevin Institute, ESPCI-ParisTech, focuses on wave-matter interactions and innovative imaging and optical detection techniques for biomedical applications. At the crossroads of physics, biomedicine and technological innovation, his research has as its main objective a better understanding of the mechanisms at work in the body and the refining of diagnostics and therapeutic treatments. This is particularly true of his work in fluorescence microscopy, an extremely promising imaging technique.

*"Together with researchers from the **Institut des Sciences Moléculaires d'Orsay (ISMO)**, we have developed an innovative technique that now enables nanometric imaging in 3 dimensions. This new instrument with unequalled levels of performance reveals the architecture of cells down to the molecular level and helps us understand how they function. The applications in the biomedical field are numerous. This technology has already made it possible to understand the molecular architecture of the structures that allow cancer cells to move. It has shown why antibiotic treatments sometimes prove ineffective in the fight against bacteria such as staphylococci. It is, for example, providing answers regarding the proliferation of green algae and the parasite responsible for sleeping sickness. Finally, in the medium term, this technology could become a valuable personalised medical diagnostic tool for testing the effectiveness of a treatment for a given patient."*

Prof. Emmanuel Fort

"Fluorescence microscopy is a revolutionary imaging tool for medicine and biology. It enables molecular structures inside cells to be observed with a nanometric resolution (that is on the scale of a billionth of a metre)".

Prof. Emmanuel Fort

WHICH USES FOR THIS TECHNOLOGY?
To develop this new technology, Emmanuel Fort co-founded Abbelight in March 2016.

"The technology developed by **Emmanuel Fort**, in collaboration with **Sandrine Lévêque** of the **Institut des Sciences Moléculaires d'Orsay**, provides a resolution 40 times higher than that of conventional microscopes. This means we are now able to have sharp images of the inside of a cell, with a new acuity. This type of imaging tool is revolutionary for biology and medical research. It will allow for a better understanding of what happens inside neurons, for example, when a patient is suffering from Alzheimer's or Parkinson's, but that is not all. Nanoscopy brings new information in all fields related to classical microscopy: cancer treatments, personalised immunotherapy, understanding bacterial resistance phenomena, and more. The Abbelight system has already been used in several scientific studies, two of which have been published."

Nicolas Bourg, Biophotonics researcher and CTO of Abbelight.

"I met the Abbelight team in 2014 at a major CNRS microscopy gathering. I was looking for imaging technology that was powerful enough to conduct my research on macrophages, those extremely important cells in our immune system. Their nanoscopy technique enabled me to observe the molecular architecture of structures involved in the displacement of these cells, on which until then, very little was known because they are too small (around 500 nanometers). Yet this is an essential mechanism of our body's innate immune defence system. In the longer term, a better understanding could help us, for example, to combat the proliferation of tumours. Macrophages have an unfortunate tendency to accumulate within tumours and help them develop – some tumours are made up of 50% of them! With this imaging technique, we hope to discover how to prevent macrophages from getting closer to a tumour and to prevent them from helping it proliferate. Our collaboration was so fruitful that IPBS, the laboratory where I work, decided to acquire this new technology. Many other projects will now benefit from this."

Dr. Renaud Poincloux, research engineer at the CNRS, Institut de Pharmacologie et de Biologie Structurale (IPBS), Toulouse.

"As Richard Feynman, the famous American physicist, once said, biology is really quite simple, you just have to observe things to better understand them."

Jean-Baptiste Marie, CEO of Abbelight

ENVIRONMENT

“I wish I could breathe everywhere air as clean as in the mountains.”

“I want to be able to live peacefully by the river, without any fear of flooding.”

“I hope there will always be polar bears on the polar ice caps.”

“I would like solutions to be found to feed all the inhabitants of the planet.”

In the eye of the storm: New environmental issues and challenges

Our planet is not an inert mass. Like a living being, it moves, breathes and changes, causing meteorological, geological, volcanic and maritime related hazards. Added to these phenomena of natural origin are those linked to human activity: climate change, pollution, soil and biodiversity depletion... To mitigate their impact and provide lasting solutions, research is our best ally.

The AXA Research Fund supports research projects that aim to better understand, model and preserve our environment. Convinced of the urgent need to act to protect our planet, we have made the fight against climate change and the environment a priority for the past 10 years.

200 projects in 28 countries

According to the latest report from the **Intergovernmental Panel on Climate Change (IPCC)**, greenhouse gas concentrations in the atmosphere have reached the highest levels in 800,000 years. The adverse effects of climate change are already being felt around the world: changes in rainfall, changes in the distribution of marine and terrestrial species, more frequent heat waves, declining agricultural yields, etc. Fortunately, researchers around the world are proposing solutions.

UNDERSTANDING TOMORROW'S CLIMATE

African countries are amongst those most affected by and most vulnerable to climate change. The **AXA Chair on Climate Risks in Africa**, created as part of the African Climate and Development Initiative (ACDI) at the **University of Cape Town**, aims to strengthen the resilience of populations by determining which sectors should receive the most investment in order to minimise the adverse consequences of climate change in Africa. The first holder of the Chair, **Professor Mark New**, has the initial objective of studying how extreme climate events and their impacts on the population and environment are changing as a result of human activity.

Professor Joaquim Pinto, meteorologist and holder of the **AXA Chair on Regional Climate and Weather Hazards** is leading further continental-wide research. His research programme aims to improve our understanding of extreme weather events in Europe, such as storms, floods, heat waves, etc. To allow us to prepare for them, the objective is to predict their frequency and intensity under present and future climate conditions. *"The currents of the Atlantic Ocean seem to have played a driving role, hitherto underestimated, in the heat wave in Europe during the summer of 2015,"* explains **Doctor Aurélie Duchez**, post-doctoral fellow at the **UK's National Oceanography Centre**. She is specifically interested in extreme heat waves and studies the possible influence of weakening ocean currents on the atmosphere and climate. At the origin of this phenomenon: the melting of the polar ice caps. It is on this problem that **Doctor Sarah Thompson**, another AXA laureate and based across the Channel, is working. From the **University of Swansea**, she is attempting to assess the probability of the break-up of Antarctic ice shelves in order to shed light on their future contribution to the rise in sea-levels.

Professor Carlos Pérez García-Pando, for his part, is concerned about more arid regions. Holder of the **AXA Chair on Sand and Dust Storms** at the **Barcelona Supercomputing Centre (BSC-CNS)**, he is trying to better understand and predict these phenomena and their potentially devastating effects His research aims to prevent their impacts on society and the economy, as well as on the climate, through the implementation of strategies in key sectors such as health, energy production, agriculture and transport.

PREPARING FOR THE SOCIO-ECONOMIC CONSEQUENCES OF TOMORROW'S CLIMATE

Understanding to better predict is essential, but it is not enough. The authors of the Intergovernmental Climate Report called on decision-makers to consider broad-based adaptation measures to prepare for the impacts of climate change. Among the most serious expected consequences are those related to the depletion of resources, such as food and drinking water, which could give rise to severe conflicts of use.

The **AXA Chair in Genome Biology and Evolutionary Genomics** at the **International Rice Research Institute (IRRI)** in the Philippines, for example, aims to provide solutions to threats to global food security. For **Professor Rod Wing**, holder of the Chair, the solution lies in rice. The objective is to make available to growers varieties with higher yields and nutrient intake, while having a lower ecological impact.

“There have always been climate-related natural disasters, but climate change is altering their frequency and intensity.”

Prof. Mark New, holder of the AXA Chair on Climate Risks in Africa at the University of Cape Town.

Doctor Cosmin Corendea, during his post-doctorate at the United Nations University in Germany, explored the link between climate change, human rights violations and migrations. *“The law has the power to respond to different risks related to climate change,”* he says. His work focuses in particular on the Pacific islands, a region badly affected by climate change and whose inhabitants could be rapidly driven out by rising sea levels.

REDUCING OUR IMPACT ON THE ENVIRONMENT

As the world's urban population continues to grow – the UN predicts that by 2050 it will account for 66% of the 10 billion human beings – scientists face another crucial challenge: rethinking the city.

Doctor Fulvio Amato, a researcher at the Institute of Natural Resources and Agrobiology in Seville, is working on pollution and its harmful effects on humans. By installing measuring instruments, he was able to identify the role played by different sources on air quality in the city and in the metro and thereby draw up recommendations to reduce their impact.

Rapid urbanisation is also a threat to biodiversity. Professor Dagmar Haase of Humboldt University in Germany is concerned about the environmental impact of urban sprawl. Her objective is to highlight ways to reduce our urban footprint and the risks to our ecosystems. At the Zoological Institute in London, Oliver Wearn is looking for ways to protect the fauna of tropical forests *“Despite the considerable risks that forest fragmentation poses to wildlife populations, our ability to assess the damage caused to them, both in the short and long term, is poor”*, he says. His aim is to remedy this shortcoming in South East Asia, in order to inform forest and biodiversity conservation policies in the region.

Roshanka Ranasinghe: protecting the coasts

Professor Roshanka Ranasinghe,
holder of the AXA Chair on Climate Change Impacts and Coastal Risks at UNESCO IWE (Institute for Water Education) in the Netherlands.

Professor Roshanka Ranasinghe and his research team recently developed a prediction model that proposes a new way to estimate coastal erosion due to climate change, thereby improving our visibility on the future of vulnerable coastal communities for the next 100 years.

RESEARCH, SUPPORTING INFORMED DECISION-MAKING

The AXA Chair on Climate Change Impacts and Coastal Risks is an ambitious 10-year research programme, which aims to better understand the physical laws governing coastal erosion, in order to learn in detail how climate change can affect the appearance of our coastline. This new knowledge has made it possible to develop simplified models that are faster to calculate, to measure the impacts of climate change and to create innovative predictive methods for coastal risks. The end result? Practical risk information that can be used directly by planners and coastal area managers to make more informed decisions.

One of the main results of Roshanka's project so far is a simplified multi-scale physical and probabilistic model that simulates coastal changes related to climate change. *"It's actually a simple and fast modelling tool to predict shoreline erosion, or in other words, the extent to which the coastline could retreat, or advance, over a period of 100 years (or more)"*, he explains.

WHAT CONCRETE IMPACTS ON THE GROUND?

"Roshanka came to the Sri Lanka Coastal Protection Department to help model the impact of climate change on the east coast of Sri Lanka. Using his approach, we were able to identify new setback lines* to delimit the locations of current and future coastal developments and infrastructure along the east coast of the country. In some areas they have remained the same, but in other areas they have varied considerably, changing from setback lines from 100 metres to 25 metres from the sea. These refined results have been very useful to us in our engagement with coastal community stakeholders and other local groups working in urban development, agriculture or nature conservation".

Mangala Wickranayake, Chief Research and Resource Planning Engineer, Sri Lanka Coastal Protection Department.

"The last 10 to 20 years have seen a significant increase in coastal hazards such as storms, tsunamis, typhoons, floods, etc. Their impact is more severe today than it was 50 years ago. "

Prof. Roshanka Ranasinghe

**Setback lines define the distance between the coastline and the first authorised urban developments. These buffer zones protect homes and other facilities from flooding and coastal erosion by ensuring that buildings are not located in the areas most at risk.*

20 cm

Between 1901 and 2010, the average global sea level rose by about 20 cm. The rate of sea level rise since the middle of the 19th century has been higher than the average rate over the previous two millennia. *Intergovernmental Panel on Climate Change (IPCC), 5th Assessment Report.*

40%

Today, nearly 40% of the world's population lives within 100 km of a coast. *(United Nations figures)*

"Before Roshanka presented his model, only one model was available to predict the evolution of the shoreline as a function of sea level: Bruun's rule. This is a fairly old model – it was first formulated in 1962 – so we have limited confidence in it. Rosh's approach is different: his model is based on different physical assumptions, and therefore also gives different results. We set it up on the sandy coast of Aquitaine: in the event of a 1 metre rise in the sea level, for example, the tool developed by Rosh predicts a retreat of the coastline of 10 metres. Bruun's rule, on the other hand, provides for a retreat of some 100 metres. The advantage of having several models, even imperfect ones, is that their multiplicity makes it possible to appreciate the margins of error of our shoreline recession projections. Models such as Roshanka's help us to clarify recommendations for coastal zone management, and we have recommended that it be taken into account in the methodological guideline for coastal risk prevention plans driven by the French Ministry for an Ecological and Solidary Transition (MTES)".

Gonéri Le Cozannet, Risk and Prevention Department, Coastal and Climate Change Risks Unit, Geological and Mining Research Bureau (BRGM), France.

“Deltares (an independent institute for coastal research application in the Netherlands) was already working with Rosh Ranasinghe even before the launch of the AXA Chair.
The probabilistic coastal recession tool he has developed provides great added value for our existing model on coastal evolution and sea level rise. Our role as consultants demands a very sound scientific foundation.
In this respect, Rosh Ranasinghe's contributions are invaluable.
His model helps us advise planners and coastal managers on where they can allow buildings to be built, on the risk associated with each parcel of land, and so on. For example, we are currently using Roshanka's models in a multi-million Euro project, the European Climate Prediction (EUCP) project, which seeks to quantify the risks of coastal flooding and erosion in the European Union. Based on the probabilistic results given by this model, we will be able to determine the adequate recession lines, which establish the flood risk according to the typology and the distance to the sea”.

Dirk-Jan Walstra, Head of the Applied Morphodynamics Department and expert in Coastal Morphodynamics at Deltares.

“Models such as Roshanka's help us refine coastal zone management recommendations”.

Gonéri Le Cozannet, Risk and Prevention Department, Coastal and Climate Change Risks Unit, Geological and Mining Research Bureau (BRGM), France.

NEW TECHNOLOGIES

“I’d like to see artificial intelligence at the service of humankind.”

“I want my children to be able to surf the net safely.”

“I’d like to be able to make my payments with trust.”

“I want to be confident in the use of my personal data.”

The challenges of new technologies

The power and storage capacity of modern computers now allow the collection, analysis and use of huge quantities of data. Inextricably linked to other booming technologies, such as the Internet of Things, machine learning and artificial intelligence, the Big Data phenomenon is revolutionising many fields, from medicine to finance, political science and robotics. The convergence of these new technologies offers immense prospects, some of which are still not even dreamt of. Their disruptive nature, as well as the speed with which they progress, is also a serious challenge – as well as an opportunity – for the future

To help both public and private players in this transition, the AXA Research Fund supports projects that meet the most important challenges of the new era of *Big Data*, with security very much at the forefront.

16 projects in **8** countries

DATA CONFIDENTIALITY AND IT SECURITY

Data sets are now as valuable as gold. Because of their storage and processing in heterogeneous environments, outside the direct control of their owners, they are also, *de facto*, more exposed to security breaches. The **AXA Chair of Cybersecurity**, based at **Singapore Management University**, is one of many projects supported by AXA to address this critical issue. The particularity of this research programme is that it aims to integrate protection mechanisms within the data themselves. *"The aim is to maintain the ease and flexibility of control and processing of protected data, while ensuring their confidentiality and inviolability"*, explains **Professor Robert Deng**, who heads the Chair.

This is also the objective of the **AXA Chair on Information Security and Privacy** at the **Federal Polytechnic University of Lausanne**. *"Our socio-economic system is becoming inextricably dependent on the Cloud"*, says **Professor Bryan Ford**, holder of the Chair. *"It is a practical but potentially unstable computer model. That is why it is urgent for research to ask the right questions and develop innovative solutions to protect it".*

"Gopal Ramchurn's work is critical to framing the contribution of artificial intelligence to disaster management. The rapid collection of viable and verifiable information is one of the most important aspects of our activity. In this, drones can be very useful; they can map areas, take aerial photos, serve as communication relays and even detect possible traces of chemical compounds."

Hannah Pathak, Deputy Executive Director of Rescue Global, a non-profit disaster management and emergency response organisation.

An average of 4.5 million data sets are stolen every day.

"In the age of the digital economy, data are undoubtedly one of the main assets of companies and individuals".

Prof. Robert Deng, AXA Chair Professorship of Cybersecurity.

On the other side of the Atlantic, at **Georgetown University**, **Professor Paul Ohm** is studying the social impact of Big Data and new digital technologies. His research aims to better prepare us, particularly at the legal level, for possible abuses, such as violations of privacy or discriminatory measures.

TOWARDS ARTIFICIAL INTELLIGENCE THAT IS FAIR AND RESPONSIBLE

"The controversy surrounding the opacity of the criteria for allocating baccalaureate holders in France [for higher studies] is a good example of the obstacles and possible abuse of data analysis technologies", notes **Professor Christophe Marsala**, of the **Pierre and Marie Curie University**, who is interested in how to guarantee the interpretability of machine learning systems.

How can we guarantee the validity of decisions taken unilaterally by computers? How can we ensure their legality, impartiality and accountability? Another project in the UK, supported by the AXA Research Fund, is asking these same questions. **Professor Sarvapali Gopal Ramchurn** of the **University of Southampton** is studying the main technical and practical challenges for the development of responsible artificial intelligence. *"Interactions between people and machines have become infinitely more complex"*, he says. *"This raises new fundamental questions, such as, for example, the equality between men and machines within a team".*

Joanna Bryson: Man and machine

Doctor Joanna Bryson,
AXA Award, Computer Science Department,
University of Bath.

Doctor Joanna Bryson's work on the design of intelligent systems and AI ethics recently attracted the attention of the OECD, the Organisation for Economic Co-operation and Development. Her research sheds valuable light on the major political and societal challenges posed by the advent of artificial intelligence in our lives.

Artificial intelligence and robotics are revolutionising the world of tomorrow. A source of extraordinary hopes, as well as nightmarish predictions, the reality about these technologies and their disruptive potential are still relatively unknown to the public at large. How can we ensure their proper integration into our societies? *"First and foremost, it's important to dispel misconceptions about AI and intelligent robots"*, says Doctor Joanna Bryson. She is exploring with her team the ethical issues of AI through experiments on how people behave and interact with robots. Since 2016, she has been working as a consultant to the OECD, an international organisation whose goal is to promote policies that will improve economic and social well-being around the world. *"People tend to both be afraid of AI and to expect too much of it. People have in mind what movies show, but that's science fiction. In reality, AI is very different – it's a tool, it's a way of programming".*

> **"People tend to both be afraid of AI and to expect too much of it. People have in mind what movies show, but that's science fiction"**
>
> **Dr. Joanna Bryson**

THE 5 ETHICAL RULES OF THE "PRINCIPLES OF ROBOTICS"

PUBLISHED IN THE UK IN 2010

-1-
Robots should not be designed as weapons, except for national security reasons.

-2-
Robots should be designed and operated to comply with existing law, including privacy.

-3-
Robots are products: as with other products, they should be designed to be safe and secure.

-4-
Robots are manufactured artefacts: the illusion of emotions and intent should not be used to exploit vulnerable users.

-5-
It should be possible to find out who is responsible for any robot.

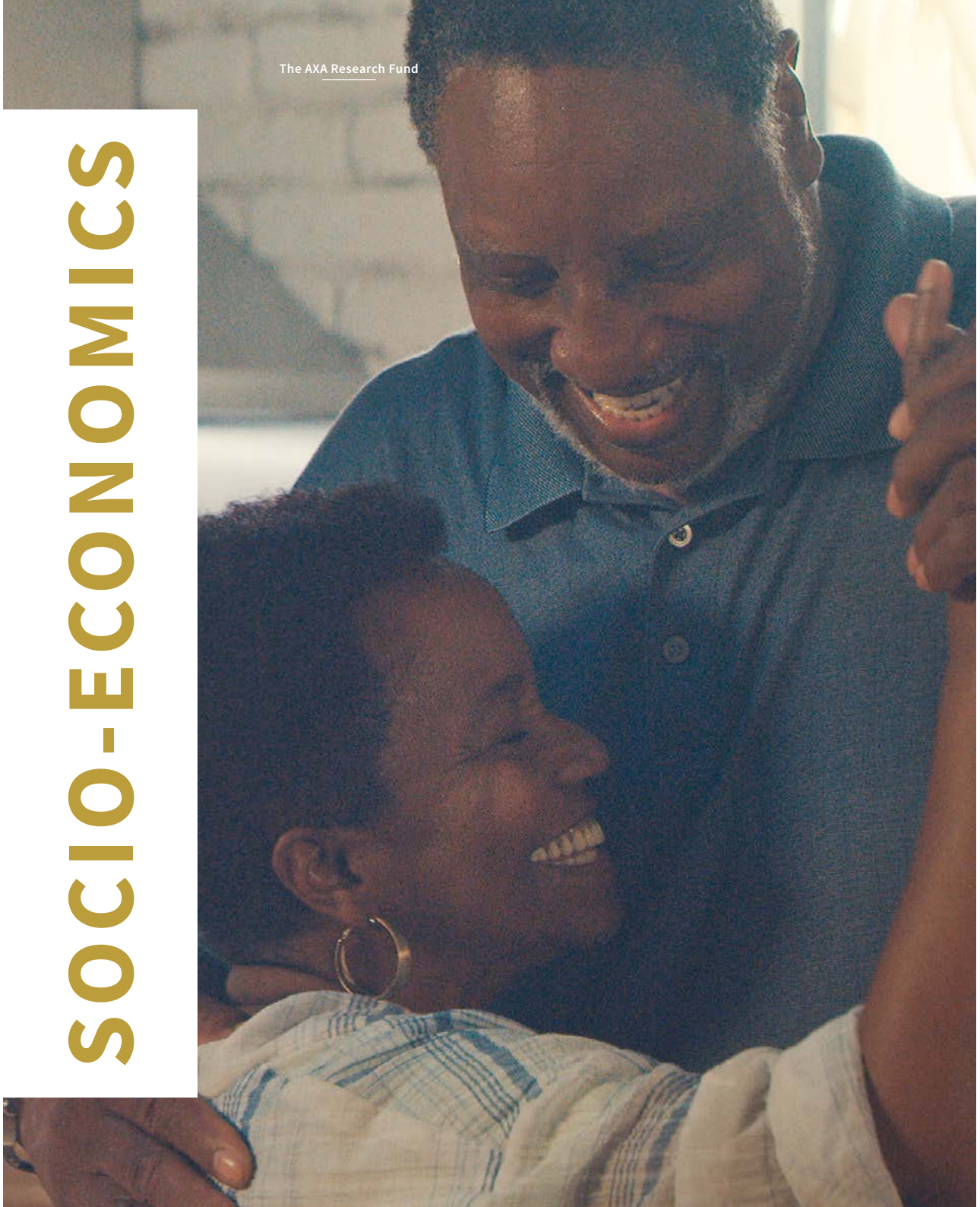
In 2010, her work resulted in the drafting of the first-ever national-level document on AI ethics. Entitled "Principles of Robotics", it is a set of 5 rules published by the UK to inform those who design, sell and use robots of their responsibilities.

WHAT IMPACT FOR THE OECD?

"The OECD began looking at artificial intelligence in 2016. That same year, we organised an international conference on this theme, and Joanna was one of our speakers. She talked about sociology, history, ethics... Her expertise was extremely well received, so much so that we asked her to become a consultant for the Digital Economy Policy Committee. Since then, she has spoken at two of our other conferences. Her research is particularly useful to us in building a solid foundation on which to base our international measurements and comparisons. This is at the heart of the OECD's mission: to define the problem, identify the stakes and issues and then compare and measure what is happening in the 35 member countries and at European Commission level. In this way, we are able to judge what works and what does not work, gather the opinions of experts and stakeholders and then publish our recommendations".

Karine Perset, policy and economic analyst for the Digital Economy Policy Committee, coordinates OECD work on AI.

SOCIO-ECONOMICS



“I hope that we will be able to prevent a collapse of the financial markets.”

“I wish we could be protected from terrorist attacks.”

“I would like to better understand what is at stake in global finance.”

“I wish I could better control my decisions under stress.”

New social and economic dynamics

Technological and social developments are rapidly redrawing the contours of our societies. The increasing globalisation of the economy brings with it risks and opportunities, sometimes with serious consequences such as the 2007 crisis. To ensure that these transitions benefit everyone, the AXA Research Fund supports projects that study systemic risks, strengthen political stability and confidence in institutions and build on the major trends in society to develop tomorrow's business models.

To pave the way for fairer economic policies and more effective political institutions, the AXA Research Fund supports projects that address the most pressing challenges of globalisation, primarily macroeconomic and financial risks.

150 projects in **22** countries

DEALING WITH THE FINANCIAL AND ECONOMIC UPHEAVALS

Globalisation and the financialisation of the economy have been under way since the second half of the 20th century. The growing interdependence of economies carries specific risks, linked to complex mechanisms, as shown by the recurrence of financial crises during the past 20 years. the AXA Research Fund is particularly proud to have created the **AXA Chair in Economics and Finance**, contributing to the creation of the first French centre of excellence in economics, the **Toulouse School of Economics (TSE)**. Its holder, **Jean Tirole, 2014 Nobel Prize winner in economics**, and his team of internationally renowned experts have contributed in particular to the global debate on environmental policies, competition policy and financial sector regulation.

The **AXA Chair in Global Finance** at **London's SOAS University** is another major research project aimed at identifying new dominant trends in international finance. **Professor Victor Murinde**, at the head of the project, is particularly interested in African economic growth and the implications of its rise on the international scene. *"Understanding the new rules that govern global finance will help adapt government regulations accordingly to avoid another global financial breakdown".*

"I intend to model and monitor the dynamics governing the major trends in global finance, such as the major change taking place at the moment with digital innovations in the financial sector. And to do this even at the household level."

Professor Victor Murinde, AXA Chair in Global Finance at SOAS University, London.

TOWARDS TOMORROW'S ECONOMY

Especially since finance is far from finished with the upheavals. Technological innovation in the financial sector (FinTech) is profoundly transforming the industry. **Doctor Marco Gazel**, a researcher at **SKEMA Business School in Paris**, is examining these new dynamics and studying the type of ecosystem needed to support this emerging industry.

The same approach is taken by **Professor Marco Percoco** of the **Bocconi University in Milan** who is studying the impact of the sharing economy on our lives and cities. His project, in close collaboration with AXA Italy, aims to shed light on the resilience of urban markets to these new disruptive companies and, in an innovative way, on the geography of this resilience.

The AXA Research Fund primarily supports innovative research projects. As **Professor Katarina Graf** of the **SOAS University in London**, who works on the price of bread as a measure of urban stability in Morocco, explains: *"The link between rising bread prices and recent political upheavals in Arab countries has been discussed many times in the media, but has never been researched".*

Doctor Lesley Ann Daniels, of the **Barcelona Institute of International Studies**, has also chosen an innovative approach to political conflicts and the way peace agreements are drafted. *"Identity claims are an essential component of most contemporary conflicts, including terrorism"*, she explains. *"Despite this, we lack perspective on how minority rights affect peace and stability in a post-conflict environment".*

SHED LIGHT ON DECISION-MAKING FOR THE BENEFIT OF ALL

Ensuring a better future for all is AXA's core business. Risk decision making and uncertainty management are therefore key themes for the AXA Research Fund.

The **AXA Chair in Adversarial Risk Analysis, led by Professor David Rios at ICMAT in Madrid**, is an excellent example of the importance of fundamental research in these fields. His research programme intends to revisit how mathematics approaches complex decision-making involving several opposing parties and an uncertain outcome. Adversarial risk analysis is a major issue in many areas, including security and terrorist risk.

In a more applied way, the **AXA Chair in Aviation Safety Neuroergonomics at ISAE, Toulouse,** seeks to better understand decision-making in the specific context of an aircraft cockpit. Indeed, accident analysis reveals that modern transport aircraft warning systems sometimes prove ineffective in crisis situations even for the most experienced crews. The aim of **Professor Frédéric Dehais**, who heads the Chair, is to discover the underlying neural mechanisms involved in order to design warning systems best suited to decision-making in these specific stress contexts.

J. Peter Burgess: The social dimension of risk

Professor J.Peter Burgess,
holder of the AXA Chair in the Geopolitics of Risk at the École Normale Supérieure (ENS), France.

The AXA Chair in the Geopolitics of Risk at the École Normale Supérieure challenges the dominant concepts of risk and security. The innovative social approach to risk analysis of Professor J. Peter Burgess, who heads the Chair, offers new solutions to security sector stakeholders from all over Europe, in response to key issues such as the fight against terrorism.

Risk is generally the product of the interaction between a natural phenomenon and human activities. However, traditional approaches to risk analysis and management generally favour hard sciences and minimise the cultural, social and political aspects. From this initial observation, the AXA Chair in the Geopolitics of Risk, led by philosopher and political scientist J. Peter Burgess, seeks to explore the societal aspect of uncertainty and how it impacts our lives. The multidisciplinary network of researchers is working to develop new methodologies to understand and assess risks. By combining analyses in the fields of religion, the media and ethics with studies in human geography, international law and decision theory, it aims to give risk management a more human resonance. The research programme wants to adopt a global, geopolitical approach to risks and insecurity.

"These notions have become increasingly globalised", he explains. New risks have emerged and others have intensified: our concerns for the future of our environment influence our consumer behaviour and fear of terrorism can influence elections.

The work of Professor J. Peter Burgess questions the prevailing visions of risk and security in international organisations such as the United Nations, within the European Union, but also in NGOs such as the International Committee of the Red Cross or Médecins sans Frontières. Professor J. Peter Burgess is involved in various research projects, in particular with the European Commission, which link international cooperation players and researchers. For example, he is the scientific coordinator of two projects in the European Commission's Seventh Framework Programme: SOURCE (Virtual Centre of Excellence for Research Support on Societal Security) and DRIVER (Leading Innovation in Crisis Management for European Resilience).

"My working hypothesis is that risk should be seen more as a cultural, social and even moral issue."

Prof. J. Peter Burgess

WHAT APPLICATIONS FOR RISK SCIENCES?

"As a criminologist working at the School of Police of Catalunya, my objective is to make the formation of police officers more empirically funded. In other words, I work on how to train police officers in a 'real' way while limiting the costs. To make training sessions realistic, to model a terrorist attack for example, you have to hire many actors, for instance. Since this is very expensive, it is rarely done, and as a result, police officers are not well prepared for some severe crisis scenarios. In the TARGET project (Training Augmented Reality Generalised Environment Toolkit), I have been working with Peter since 2015. He and his team have developed a VR and augmented reality tool, that is used to train police for firearms attacks. His technology offers promising opportunities for severe crisis management. Once a scenario has been developed, VR is cheap to use and can be altered at almost no cost. This way the scenario is always a surprise to the police officers. It even incorporates a science-based assessment of the performance of the trainees, which makes for better evaluation. Other schools of police, in France, Slovakia and Germany, are already interested in developing their own VR/augmented reality training tool. At the moment this type of tools is developed only by North-American companies, with a specific mindset in the scenario, for example in the way firearms are employed. There is a strong demand and need for a similar tool at a reasonable cost that is geared towards European mentalities and societies; and that is what Peter's tool is providing."

Lola Vallès Port, criminologist in charge of the research unit at the Police School of Catalonia, Institute of Public Security of Catalonia, Spain.

“J. Peter Burgess' expertise on security research is essential to help us in particular on the societal aspects of ethical issues raised by emerging technologies.”

Christian Baumhauer, founder of ARTICC, in charge of Security Research Development.

“Security is more and more of a burning issue in Europe. As European leaders in consultancy and management services for research and technical development, ARTICC is in a good position to know just how much. Research and technologies can go a long way towards increasing security, or preventing and fighting terrorism, but they raise serious ethical questions, which in the long run can become a destabilizing factor for society as well. J. Peter Burgess’s expertise is essential to help us with the methodology of security research, particularly with the societal aspect of ethical issues raised by emerging technologies. We’re working alongside him on different projects, including two European Commission projects, SOURCE and DRIVER, as well as the TARGET project, co-financed by the Commission. He is the scientific coordinator; we are the technical coordinators. These initiatives bring together stakeholders with very different views on security and crisis management: policemen, human rights NGOs, industrialists… The point is to sit down and discuss issues in a non-emotional, evidence-based, scientific manner, in order to take the best possible decisions. In the context of SOURCE, for example, Peter hosted a workshop on the Internet of Things, which promises great things, but poses serious cultural, societal threats at the same time. The issues raised concerned IoT governance, the acceptable level of security, trust, etc. These are all issues that will become extremely relevant in the near future.”

Christian Baumhauer, founder of ARTICC, in charge of Security Research Development.

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"SUPPORTING SCIENCE TO HELP OUR WISHES COME TRUE"

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