#### PHYSICS AND ASTROPHYSICS, FROM FUNDAMENTAL THEORY TO ADVANCED ENGINEERING

PSL★ institutions are leaders at the highest international level in several pioneering research areas in contemporary physics. The teams of the ENS, ENSCP, ESPCI, Observatoire and Collège de France have a century-long track record of excellence and a rich tradition of leadership on the national and international scenes (PSL★ institutions have trained or employed all 6 of the French laureates of the Nobel Prize in Physics since 1960).

The ambition of  $PSL \star$  for physics is (1) to maintain its leadership in basic science; (2) to explore ground-breaking new types of research; (3) to improve valorisation with the creation of innovative materials and devices and the creation of high-technology companies.

#### Current research

Tight networks of outstanding research groups are distributed among PSL institutions:

- <u>Research in quantum mechanics</u> ranges from atomic physics to applications in metrology using space-borne experiments. Applied work such as space-borne atomic clocks to test general relativity at an unprecedented precision builds on Nobel-winning research also carried out in the perimeter of PSL★. Test in the drift of fundamental constants with time combines lab experiments and astrophysics observations.
- <u>Theoretical physics research</u> encompasses pioneering insights in cosmology at the Collège de France, breakthroughs in statistical physics at ENS and ESPCI, including the physics of glasses, with important applications. Much of this work forms the backbone of modern fundamental physics.
- <u>Soft condensed-matter research</u>, including the physics of polymers which was spearheaded at PSL, stretches the entire spectrum from basic theory to industrial applications involving polymers, colloids and biophysics.
- <u>Hard condensed-matter physics</u> ranges from nanophysics and world-leading mesoscopic research, to studies of quantum phase transitions, electronic properties of single nano-objects, strongly correlated systems.
- Magneto-<u>hydrodynamics and plasma physics, nonlinear physics</u>: research groups at ESPCI, ENS, and Observatoire de Paris are pioneers in that field, with world-leading expertise in experiment, astrophysical observation, computational-physics and theory.
- <u>All domains of astrophysics</u> are present at the highest level at Observatoire de Paris which represents about one third of the national astronomical community acting in the fields of planetology, stellar physics and exoplanets, galactic and extragalactic physics and the physics of interstellar medium.

These research axes cover the forefront of physical theory, conduct pioneering work in instrumentation and in experiments, and share several world-renowned platforms for the fabrication of devices and for the exchange of information.

#### Projects in the framework of the IDEX

Research in physics finds its primary expression in four Labex proposals. The ambition of  $PSL \star$  in physics is to become the connecting hub catalysing these four major and transforming projects.

- <u>ENS-ICFP</u> is a project carried by the ENS Physics department, aiming at positioning itself durably as a world leading centre of research and training in fundamental physics. The actions will include the creation of an ENS Junior research chair programme, an ENS master/graduate school of Physics, and a dedicated technology transfer project.
- <u>The Institut Langevin WIFI</u> aspires to become the world reference in the field of wave physics and imaging, by combining in a multidisciplinary approach high-level fundamental research, applied

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research, business creation and training of students who will be tomorrow's researchers and entrepreneurs. This activity has a very high potential for technology transfer and the creation of start-ups.

- <u>Astronomy, Astrophysics and Gravitational Systems</u> project builds on the growing potential of the Astronomical Virtual Observatory. Research objectives are oriented towards specific areas where significant achievements are expected in the forthcoming years: the GAIA space astronomy mission, the PHARAO space experiment, and the development of numerical simulation activities (in the framework of the EQUIPEX project EQUIP@MESO). An important aspect of the AASG project is the development of specific tools for making the scientific data collections accessible to the large public.
- <u>Space Exploration for Planetary Environments</u> (ESEP). The ESEP LABEX project is a scientific network among space laboratories coordinated by the Observatoire, devoted to the exploration of planetary environments. This project will allow the Observatoire and its partners to keep playing a leading role in this strategic field and develop their recognised expertise in remote sensing and *insitu* space instrumentation.

# Detailed IDEX actions: Connecting actions for an enhanced international visibility

- All the projects will take advantage of an important rehabilitation programme covering more than 25 000 sqm. within the perimeter of PSL★. The complete renovation of physics laboratories will boost a new life and a real potential for international visibility.
- Creation of a "Physics Centre" to animate the physics teams, organise common events, sharing best practices and centralising knowledge. This dedicated space for the physics research community aims to share progress between the four Labex projects and to create a programme dynamics.
- Creation of a prestigious senior research grant on the model of the Blaise Pascal Research Chairs, to attract a prominent international scientist, to work during twelve months on the PSL★ campus, on topics of common interest for the physics, astrophysics and space science field, including education and public outreach challenges.
- Invitation of professors from institutions all over the world to become PSL★ physics "observers" for periods of 6 months, guaranteeing challenge and questioning of the research teams.
- Organisation of common research events: (a) a physics week where researchers of the domain will present their activities and organise Q&A sessions open to the general public or focused on young students; (b) a common PSL★ seminar around the key research fields materialised by the four Labex proposals; (c) a summer school in physics.

#### Key IDEX projects:

- A "Physics Centre" to organise of common research events:
- A prestigious senior research grant to attract a prominent international scientist,
- Invitation of professors from institutions all over the world to become PSL + physics "observers" for periods of 6 months

• Internationalisation of formations with courses delivered in English

#### Funding requested: 2 880 KEUR for four years and 7 200 KEUR for ten years

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#### CHEMISTRY FOR THE MANAGEMENT OF ENERGY AND MATTER: FROM LIFE TO PROCESS

In the field of Chemistry, PSL★ institutions are active in both research and engineering: ESPCI-ParisTech and Chimie ParisTech are engineering schools with a strong emphasis on sciences and valorisation; the ENS is mainly involved in fundamental research and trains professors; and the Collège de France has two chairs in this domain.

The complementarities of  $PSL \star$  institutions are an undeniable strength for the research-industry continuum. The academic expertise, with its fine-grain approach, translates into new concepts and new tools that enable engineers to solve problems and therefore innovate. Moreover, the chemists of  $PSL \star$  will develop research and training programs with their colleagues in the humanities to develop transdisciplinary approaches around key issues such as, for example, resource management.

The chemists of PSL★ are thus in a position to answer new challenges for a sustainable chemistry, related to the management of resources and energy. Cosmetics, pharmaceuticals, nuclear energy, petroleum, energy storage: each of them is strategic for France and its industry, and face key challenges that cannot be solved by chemistry unless it is practised in synergy with other fields such as physics and biology. Every innovation in these sectors will have a direct impact on the economy.

#### The challenges include:

- design renewable raw materials, which do not require fossil fuels and ores;
- create or improve processes to minimize energy input and waste;
- develop new systems for the production and storage of energy

#### Thus the major themes of PSL \* 2020's chemistry will be:

- · chemistry of resources: new raw materials, mixtures management;
- life cycle of materials and molecules: control of degradation processes, remediation, analytical sciences;
- original processes for chemical engineering;
- Chemistry and physical chemistry for life, chemistry in living organisms.

## $PSL \star$ has proposed two Labex to promote its goals.

- <u>The LABEX METACEN</u> will address upstream research on metallic materials, which are
  particularly important in France due to their major impact on energy policy. This Labex will focus
  on the study of material resistance, notably within the context of the lifetime extension of current
  nuclear power plants from forty to sixty years, the development of materials for the 4th generation
  nuclear power plants, the development of metallic materials for the emerging renewable energies
  in particular for fuel cells, and the development of materials resistant to corrosion in any country
  and any operative conditions.
- <u>The LABEX ChemVivo</u> is based on the idea that living microorganisms, which obey evolutionary
  principles that optimise management of matter and energy, will become common auxiliaries to
  achieve chemical tasks. We are indeed convinced that the approach of chemistry assisted by
  living organisms will allow researchers to solve real problems such as the ones listed above.

The projects in both Labex will also involve other researchers present in PSL (biology, physics...) and benefit from the creation of the Institut Pierre-Gilles de Gennes for microfluidics.

The chemists involved in the Labex ChemVivo and METACEN, with their expertise and innovative projects of research and research-supported education and their close relation to industrial partners, have the ambition to become the French leaders in their field and major international actors.

#### Detailed IDEX actions:

- Besides these LABEX, PSL★ defends a new structuring project: the Paris Institute for Chemical Engineering ("Institut d'ingéniérie pour la chimie de Paris"). This Institute will gather the entire ENSCP and the ESPCI chemistry laboratories in a common location in Paris. The ideal location is the building presently occupied by AgroParisTech, rue Claude Bernard, close to ESPCI, to become available when AgroParisTech moves to Saclay. The target is to design a low-power building in Paris that will be the most modern French facility for practicing safe and green chemistry.
- Priorities of ENSCP in the 10 coming years will be metallurgy, chemistry for energy, solid chemistry, and molecular chemistry for drug design; in areas concerned with this project, ESPCI has very active research in pharmaco-chemistry, analytical and environmental chemistry, physical chemistry and chemistry of soft and complex matter (for instance polymers), nano-materials. Both schools are and will be more and more involved in common projects in the four major themes mentioned above, with consequences on education programs (both schools plan to have common sessions, especially practical ones) and on laboratories organization (common technical platforms are planned).
- To achieve this, two new joint scientific groups will be set up, each with one prestigious senior chair, and new scientific equipment will be purchased.

#### Key IDEX projects:

- The Paris Institute for Chemical Engineering ("Institut d'ingéniérie pour la chimie de Paris").
- One distinguished senior chair and two new joint scientific groups

- Acquisition of new scientific equipment
- Funding requested: 5 200 KEUR for four years and 11 500 KEUR for ten years

# BIOLOGY: AN INTEGRATED APPROACH FROM GENES TO NEURONAL NETWORKS, CANCERS AND ECOLOGICAL SYSTEMS

Biology in the PSL★ perimeter is present at the ENS, College de France, ESPCI, and Institut Curie.

The Institute of Biology of the ENS (IBENS), created in 2010, is affiliated to the ENS, CNRS and INSERM. The research staff (30 teams) is organised around 4 main axes: developmental biology; neurosciences; functional genetics; environmental and evolutionary genomics. All levels of biological research are represented: from molecules, genes, cells, and organisms to ecosystems.

Multidisciplinary research is a strong point for excellence, reinforced by local collaborations with the departments of physics, chemistry, mathematics, cognitive studies, and computing science at the ENS. Since 2006, 6 new junior groups and 3 senior ones have been recruited. IBENS excellence is well established as proved by both the AERES evaluation and prestigious prizes and honours received by team leaders. Bibliometrics illustrate the quality of IBENS research with 1029 publications over the past 10 years, almost 30% of which are in the top 10%.

The Centre of Interdisciplinary Research in Biology of College de France (CIRB) to be created in January 2011 will be composed of 14 research teams working around 4 axes: cardio-vascular, developmental biology, neurophysiology and cell biology. Since 2006, five new junior groups and two senior ones have been recruited. CIRB excellence is well established as proved by both the AERES evaluation and prestigious prizes and honours received by researchers. Bibliometrics illustrate the quality of CIRB research with 391 publications over the past 10 years, almost 27% of which are in the top 10%.

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The Laboratory of Neurobiology (ESPCI) and especially the two teams "Genes and Dynamics of Memory Systems" and "Genetics and Physiopathology of Neurotransmission" address several related topics: neuroplasticity, neuromodulation and applied studies of various neuropathologies. Excellence is well established as proved by AERES evaluation and the prestigious prizes and honours received by researchers. Bibliometrics illustrate the quality of research with 80 publications over the past 10 years, almost 23% of which are in the top 10%.

The Institut Curie includes a multidisciplinary Research Centre, comprising 14 well rated research units and one department of clinical research. The goal of the Research Centre is to increase and disseminate knowledge about mechanisms underlying cancer biology (in particular, the molecular and cellular mechanisms of tumour initiation and progression). The Institut Curie also includes a Translational Research department, in order to reinforce the interactions between clinicians and researchers (Institut Curie's Labex project in translational research is described in the section "Hard Sciences / Life Sciences and Health").

## The ENS, Collège de France and ESPCI have proposed within the PSL perimeter:

 <u>The LABEX MemoLife</u> which regroups all the teams of IBENS, CIRB and the two previously mentioned teams of the Laboratory of Neurobiology at ESPCI. This programme will reinforce interaction between scientists from all biological domains and foster multiple interactions with mathematicians, chemists and physicists with a strong interest for biological processes. The goal of MemoLife is to integrate all aspects of living memories from gene to consciousness. The MemoLife project will include a number of facilities such as ImaChem (an imaging IBiSA facility), PhoBiol (EQUIPEX project aimed at developing imaging techniques to monitor the dynamics of photonic and optogenetic manipulations), the Genomic, Sequencing and Proteomic IBiSA facilities. Besides, MemoLife has interactions with five other LABEX projects supported by PSL.

#### Key IDEX projects:

- Two distinguished chairs
- One senior chair
- Centre for Mesoscopic Biology (see hard Sciences/Life Sciences interface part)

Funding requested: 6 000 KEUR for four years and 15 000 KEUR for ten years

#### EARTH SCIENCES: GÉO-PSL TO GATHER COMPLEMENTARY SKILLS

The field of Earth Sciences within PSL★ will be organised under the disciplinary project Géo-PSL. It involves four of the partners: ENS (Département des Géosciences, Département de Physique), Observatoire de Paris (Laboratoires SYRTE, IMCCE, LERMA, LESIA), ESPCI (Laboratoire de Physique et Mécanique des Milieux Hétérogènes, Institut Langevin, Laboratoire de Physico-Chimie théorique), and Collège de France (Edouard Bard and Barbara Romanowicz Chairs).

GéoPSL includes 4 members of the Académie des Sciences, 5 members of the Academia Europaea, 13 laureates of silver or bronze CNRS medals and more than 20 laureates of other French or international scientific awards.

It unites a set of complementary thematic fields currently dispersed between multiple different institutions. Some teams study spatial or meteorological problems, others deal with geology and the physical makeup of the planet, while yet others develop innovative approaches towards geosciences and information systems. Géo-PSL is particularly active in domains of major importance for our society such as natural hazards (seismic, volcanic, meteorological), environmental studies (climatic change and its consequences; air, water and soil pollution, waste disposal and CO<sub>2</sub> sequestration), and prospecting and management of the energy, water and mineral resources for a green economy.

GéoPSL is well connected to other disciplines within PSL $\star$ , in particular biology, chemistry, physics, computer science and the social sciences, and offers a unique vantage point from which to develop

new research at the boundary of geosciences.

It has a strong tradition of cooperation with the public and private sectors, thanks to numerous collaborative projects with industry or public agencies (for example Total, Shell, Areva, EDF, BRGM, Météo-France, Astrium, Thales, AirParif, AXA, CNES, CEA).

Internationally, Géo-PSL members are active in several international networks and laboratories (LIA France-Chili, EU and COST programmes), participate in international panels or programmes (IPCC, WRCP, GEWEX, ESA and ECMWF) and in the editorial boards of numerous international scientific journals.

# Within the framework of IDEX, GéoPSL proposes four major research tracks, three of them in cooperation with existing Labex within the PSL $\star$ perimeter:

- In the field of Seismology (ENS, CdF, ESPCI, OP), GéoPSL aims to work towards two goals. One is a better understanding of the source and generation of earthquakes, in particular the role of microseismicity, direct measurements of tectonic deformation linked to the earthquake cycle using spatial techniques (GPS, InSAR), transient deformations, friction, dynamics of slip pulses, earthquakes and the rotation of the Earth and the imaging of seismic sources using time reversal techniques. The other broad goal is seismic imaging of the Earth using seismic waves: passive tomography from noise correlation, interferometry with coda waves, imaging the whole Earth using the complete wave field as well as numerical methods for 3D wave propagation. The latter topic will be coupled with the international laboratory Paris-Berkeley, and the Labex WIFI in the hard sciences/life sciences transversal axis is associated with this project.
- Within Geodesy (ENS, CdF, OP), we aim to improve the measurements of Earth rotation and our knowledge of the couplings between the fluid and solid Earth, sea-level variations, post-glacial rebound, terrestrial reference frame links between climate, rotation and the long-term deformation of the Earth. On the applied level, this includes geophysical applications of ultra-stable spatial clocks (developed through the Labex FIRST-TF "Réseau National temps fréquence") as well as the study of tropospheric delays.
- The field of Climate (ENS, CdF, and OP) aims to develop innovative numerical methods for the next generation of climate models. Methodologically this area makes heavy use of modelling and simulation, creating tie-ins with computer science and mathematics, as well as the PSL★ knowledge management initiative. Climate studies here include modelling the tropopause region and the stratosphere, seasonal and inter-annual modes, meteorological modelling on the micro, meso and macro level, as well as the links and processing problems between satellite data and modelling. On the astronomy level, it includes the relations between solar activity and the climate as well as the study of the climate of other terrestrial planets. This research track is linked to the Institute for the Environment, in particular the Labex L-IPSL on climate change, and will benefit from the Equipex SOFRAEX, PAPRICA and EQUIP@MESO.
- Finally, **Complex media** (ESPCI, ENS) is active in the field of geology and aims to study porous and granular geological media, the mechanical properties of heterogeneous and stratified media with particular emphasis on instabilities. Apart from the pure science aspects, this research is closely tied into application problems for state and industry needs, such as risk assessment for natural hazards, CO<sub>2</sub> sequestration, geomorphology, erosion, nuclear waste disposal, oil exploitation and soil pollution.

## Detailed IDEX actions:

- Common ANR applications on the above topics
- Development of the synergy on some satellite observations
- Creation of an international seismic laboratory (Berkeley, ENS, CdF, IPGP).

- New teaching modules to attract physics students and engineers to geosciences and sharing L3, Master and PhD modules between partner institutions.
- · Creation of a Géo-PSL seminar and a Géo-PSL day for PhD students

#### Key IDEX achievements:

- Two distinguished chairs
- An international seismic laboratory (Berkeley, ENS, CdF,).
- New teaching modules to attract physics students and engineers to geosciences and pooling of L3, Master and PhD modules between partner institutions.
- Géo-PSL seminar and a Géo-PSL day for PhD students

Funding requested: 2 000 KEUR for four years and 5 000 KEUR for ten years

#### COGNITIVE SCIENCES: FROM BIOLOGY TO PHILOSOPHY

Cognitive Sciences within PSL★ currently represent an axis of cutting-edge excellence. The strengths of PSL★ in Cognitive Sciences are based on several high-level research laboratories, such as the Department of Cognitive Studies (DEC), institutional cooperations with the Institute of Biology of ENS, the Laboratorie de physique statistique and the Willow, Sierra and Classic teams of the DI/LIENS and DMA at ENS, the RTRA Ecole d'Economie de Paris (EEP) of the Department of Social Sciences at ENS, the UMR LPPA at College de France, the UMR Sigma and the Institut Langevin at ESCPI-ParisTech, etc.

This powerful existing tradition of interdisciplinary research in the Cognitive Sciences brings together the following six major fields:

- Experimental Psychology and Cognitive Developmental Psychology, Psychophysics
- Integrative Neuroscience, Cognitive Neuroscience, Neuropsychology, Neuropsychiatry
- Mathematical Modelling and Computer Simulation, Computational Neuroscience
- Theoretical Linguistics (phonology, syntax, semantics, pragmatics)
- · Cognitive anthropology, economics and the social cognitive approaches
- Philosophy of Mind and Philosophy of Language, Philosophy of Cognitive Sciences.

The strength and interdisciplinary of PSL  $\star$  in Cognitive Sciences is also evident in teaching, exemplified by the existing high-standard disciplinary and interdisciplinary courses offered to students from very different backgrounds (arts, sciences, medicine, etc.). The Cognitive Sciences axis of PSL  $\star$  aims therefore to promote interdisciplinary symbiosis among training programmes and research units with diverse but complementary skills, encompassing diverse disciplines – from biology to philosophy – as well as a remarkable range of scales of observation – from the molecular level to the study of the human mind.

Within  $PSL \star$ , Cognitive Sciences play a crucial role for two reasons. On the one hand, they are right at the interdisciplinary interface between hard sciences, life sciences, engineering as well as the humanities and social sciences. On the other hand, they provide a strong methodological basis. Mathematical Modeling and Computer Simulation play a key role in this area, with many applications in the field of engineering and biomedical sciences, but also the geosciences and social sciences. Therefore, the Cognitive Sciences are of crucial logistic and methodological importance for PSL  $\star$ .

In the context of IDEX funding, a scientific committee and a teaching committee will be set up to coordinate scientific actions and teaching in Cognitive Sciences across the different institutions (ENS, College de France, ESPCI-ParisTech, etc). A Learning Centre in Cognitive Sciences will also be installed in the vicinity of the DEC (ENS). This Learning Centre will provide high-standard, audiovisual

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and computer-assisted teaching systems & equipment, seminar rooms, computer platforms and administrative support to PSL\* students in Cognitive Sciences and faculty. The Learning Center will be supported by the LiberLabo, Savoir & Multimedia and UMS RISC for fast access to scientific information (e.g., libraries) scientific dissemination, and various actions aiming to engage the public more broadly. It will therefore play a key role in the knowledge management strategy of PSL\*.

# Detailed IDEX actions:

- Funding fast-track annual research programmes (AAP) in five core themes (perception, learning & memory, language, decision making & rationality, social cognition);
- Creation of a learning centre
- Mutualisation of technical platforms and creation of "methods groups" (e.g., signal processing & data analysis group; modelling group; etc) across the different institutions ;
- · Initiation of seminars and courses across partners
- Establishment of a coherent and individualised interdisciplinary training in Cognitive Sciences for PSL students
- Invitation of high-level foreign scientists;
- Creation of an interdisciplinary Ph.D. programme in Cognitive Sciences (Ph.D. programme "Frontiers in cognition") with specific Ph.D. grants in Cognitive Sciences

#### Key IDEX projects:

- 2 senior chairs
- A Cognitive Sciences learning center
- Trans-institutional seminars and courses
- Creation of an interdisciplinary Ph.D. programme in Cognitive Sciences (Ph.D. programme "Frontiers in cognition") with specific Ph.D. grants in Cognitive Sciences

Funding requested: 6 000 KEUR for four years and 15 000 KEUR for ten years

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# HUMANITIES, SOCIAL SCIENCES, AND CREATIVE ARTS

Humanities, Social Sciences and Creative Arts are key disciplinary fields because they enable a critical discourse on society, its history, evolution and modes of organisation. As such they provide tools and concepts for the analysis of contemporary social changes and make it possible to answer the major contemporary challenges at the origin of "*Investissements d'avenir*".

Within PSL★ these disciplinary fields are particularly strong at the Collège de France, the ENS and the UPD and form two main sets of disciplinary approaches, in constant interaction: **Humanities, Social Sciences and Arts** on the one hand; **Political Science, Decision Sciences and Management** on the other.

The IDEX will enable PSL  $\star$  to further interdisciplinary initiatives and programmes between the various approaches and fields (archaeology, art history, history, languages, linguistics, literature, philosophy, but also anthropology, sociology, economics, law, political sciences, management and decision sciences, as well as theory and practice of the arts), in order to produce challenging and critical insights on societies and cultures.

#### I. Humanities, Social Sciences and Arts

- The ENS hosts: 2 laboratories in Social Sciences (PSE in economics, CMH in sociology and anthropology), 2 laboratories in Philosophy ("Pays germaniques" and CIRPHLES), 2 laboratories in Literature and Languages (ITEM for textual genesis, LATTICE for diachronic and synchronic linguistics on French language), 1 laboratory in Archaeology and Science of ancient texts (AOROC), 1 laboratory in Modern History (IHMC).
- The College de France has 15 Chairs in Humanities and Social Sciences and hosts 3 laboratory (Laboratoire d'Anthropologie Sociale, Proche-Orient, and Centre de documentation des Instituts d'Orient);
- Université Paris-Dauphine hosts: 1 laboratory in Social Sciences (IRISSO); 1 laboratory in Sciences of Decision (LAMSADE), 1 laboratory in Management (DRM), 1 laboratory in Economics (LEDa).
- The ENSAD hosts the research program EnsadLab, created in 2007, the ENSBA a new research program created in 2010 (previously called La Seine), and the CNSMDP the Centre de recherche et d'édition du Conservatoire (CRIC).
- The Observatoire de Paris hosts a team in History of Astronomy (SYRTE)

# 1) Centres and peripheries: material and cultural circulations

a. Studies on the Ancient Worlds, including not only Classical Antiquity, but conceived broadly polycentric more as and multicultural, covering large parts of Europe, Asia and Africa. The approach includes a wide range of studies on both material and intellectual productions, with a strong focus on archaeology, epigraphy, papyrology, history, philology, philosophy and languages. Finally, it reaches beyond ancient cultures to investigate the crucial issue of their transmission and resonances in medieval and modern periods.

b. *History of cultural and intellectual circulation from the middle Ages to the Second World War.* This project will study the history of cultural circulations encompassing economic, material and intellectual aspects, as well as social representations in order to shed a new light on the construction of identities, ethnicities

and cultures. The intellectual history of Europe is represented by different projects, such as the history of the book, intellectual circulations between France and Germany, or the process of structuring an intellectual and scientific community across Europe (Republic of Letters).

c. Anthropology. The ENS and Collège de France regroup important teams in anthropology, focusing in particular on the history of anthropology, and anthropology of contemporary globalisation, acting as a powerful instrument against ethnocentrism. In the framework of PSL\*, the links between the unity of mankind and the diversity of human cultures will be studied, with a focus on the scientific impact of debates between Humanities and Natural Sciences. Social anthropology will thus be a key element of the Institute of Environment and of the Centre for the Study of Rationalities and Human Behaviour.

## 2) Concepts and theory, from ethics to history of sciences

a. *Ethics* is a major area of renewal of philosophical thought, where abstract and sophisticated theories meet everyday life issues. Topics stretch from moral realism, the relation between literature and philosophy, to issues of meta-ethics (cognitivism), ethical ontology (moral realism, theories of moral rationality) and to applied ethics and in particular bioethical issues.

b. *History of sciences and interfaces*. History of sciences is studied from the double perspective of the history of scientific sociability and of the epistemology of transfers of methods and concepts, from one established disciplinary field toward another, during the process of knowledge creation.

c. *Concepts and Semantics* is represented by cutting-edge research in phenomenology, based on a comprehensive historical study of manuscripts of the pioneers of the phenomenological school ; by the study of metaphysics ; and theoretical reflections on the conceptual frameworks implicit in all disciplinary fields (subject, action, responsibility, identity, etc.).

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#### 3) Aesthetics, Evolution of Forms, and Creation

*a. Aesthetics, Genetics and History of Forms.* Based on current research in literary genetics and aesthetics developed at the ENS and Collège de France, this project will extend research on translations and textual genesis and include extensions towards art and film studies as well as musicology. It will thus constitute an original and dynamic field studying the process of creation and notably the impact of the multiplicity of languages on thought and evolution of art forms.

*b. Interfaces Arts/Science.* This project will explore new paths of research at the intersection between artistic practices and science. It will be developed thanks to a reinforced collaboration between PSL ★ institutions and the partner schools of creative and performing arts and through the common creation of an experimental Centre "*Science-Art-Création-Recherche*" (SACRE).

## II. Decision, Management and Political Science

One of the strong assets of  $PSL \star$  in Humanities and Social Sciences consists in the articulation between social and political science on the one hand, and economics, management and decision sciences on the other.

Major axes of research focus on management, organisations and institutions, modelling and decision and are supported by transversal research programmes in economics. These axes fuel the five initiatives described below in the framework of the IDEX.

The two Labex proposals testify to the dynamism of these synergies:

\* The **Labex TransferS**, coordinated by the Collège de France and the ENS, will study how cultural transfers have been shaping societies and cultures from Antiquity to the present day. It will develop the use of digital data in the humanities, and explore synergies between the methodological and conceptual frameworks developed in the humanities and social sciences, and those from the natural and formal sciences, and is directed not only towards the scholarly world but towards society as a whole.

\* The **Labex "Risques"**, coordinated by the UPD combines several disciplinary perspectives (political science, sociology, law, economics, management, computer science) in order to identify issues and clarify the stakes linked to risk prevention and sharing. At a first level, scientific advances on models applied to specific issues facilitate the identification of effective strategic actions in an existing organisation and contribute to the emergence of organisational improvements. At a second level, research on risk modelling helps anticipate model abuses and provides a critical perspective.

<u>On the basis of these disciplinary and interdisciplinary building blocks, PSL-IDEX will develop the following projects:</u>

## Project 1: Launching a new research topic "Humanities / Humanity"

From the late Middle Ages, humanities have not only been a set of disciplinary fields, but a way of life aiming at the humanisation of man and the realisation of humanity in each individual. However, such a model has been profoundly challenged during the last decades through a reconfiguration of cultural forms, a new way of conceiving the relation of the human being to nature and animality, and a thorough criticism of the ethnocentrism of the European narrative on civilisation and progress.

The ambition of  $PSL \star$  is therefore to launch a series of research initiatives in order to investigate the concept of humanity and its evolution. This answers an important social need and serves contemporary issues on the development of the human being.

The investigation of such issues can now be done in a new light thanks to the emergence of digital humanities, which offer a new organisation and access to data. Quantitative studies are therefore a tool to better understand the specificity of humanistic disciplinary fields.

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The resources needed for such a project involve the creation of interactive tools and programming in the framework of the Institute for Advanced Research created by  $PSL \star$ . During the first year, a one-week workshop will be organised to launch the research project and organise 6 months of study during the following years for four fellows. The research will lead to publications and to the organisation of international conferences.

# Project 2: Structuring research teams on "Norms and World"

The evolution and transformations of social norms and political institutions are central to Social Sciences. Such a study will have (1) a conceptual dimension with a philosophical reflection on the concept of norm; (2) a historical dimension with enquiries highlighting the evolution of norms in time; (3) a sociological dimension with a study of the social realities of their implementation and their impact on governance, at all levels. It will require investigating case studies on many topics including security of persons; economic rules ; construction of rules for the market; political decisions; use of rules as a condition of reproduction of social groups, etc. The elaboration of moral norms is of particular interest notably in the context of the development of new technologies (numerous researchers of PSL  $\star$  are involved in the national ethics committees).

# Project 3: Creation of 6 Research initiatives at the interface between Management, Economics and Social Sciences

6 institutes will be created in the framework of  $PSL \star$  in order to highlight social issues benefiting from the competence and methodologies of various disciplinary fields.

#### \* International Migrations

Development economics is well represented at UPD and ENS, with a particular focus on migrations, investigating their causes, consequences and modalities, and especially on the roles of education, remittances and local investments.

#### \* Economic Decision and Behaviour Lab

The lab will offer a widely accessible and flexible venue for experimental approaches to marketing. Applications to saving decisions, attitude towards risk, information treatment will contribute to the design of products, services and commercial strategies. The laboratory will notably rely on inputs from cognitive sciences.

## \* Managerial Practices and Innovation

Research in managerial innovation examines the practices associated with management devices and tools, analyses their life cycles and evolutions, and describes their relation with managerial government. Changes in managerial practices suggest an organisational innovation in the way managers monitor and influence behaviours in order to insure goal achievement. It also focuses on the organisational impact of the information systems on which these tools and devices both rely. This approach is therefore tightly connected with political and social sciences.

#### \* Corporate Governance

Research on corporate governance will examine the mechanisms that may resolve the collective action problem resulting from dispersed ownership or from the wish of an outside investor to exercise control in a different fashion from the manager in charge of the firm.

#### \* Public Management and Policies

The researchers will rely on the variety of rules used over time or space to examine their relative performances, through approaches tightly connected with management sciences and labour sociology. Thanks to health economics research developed at UPD (LEGOS), the project covers comparative analysis of health insurance schemes, compensation scheme (ways payments to professionals and hospitals are calculated and insured), hospital organization. Employment policies

and public administration are also in the agenda.

#### \* Real Estate

The institute will gather researchers on the various aspects of the sector of real estate, which is the major investment for many households. The aim is to enhance research on the organization and functioning of the markets, on the role of mortgages and other forms of credit.

Beyond these three research topics, Humanities, Social Sciences, Management Sciences and Arts will form an essential component within the 3 transdisciplinary Centres conveyed by the project PSL IDEX (developed in the following sections):

- Environment, Energy, Universe
- Life Sciences/Hard Sciences Interface
- Rationalities and Human Behaviour

#### Key IDEX projects:

- Two senior chairs
- Six attractive post doctoral positions
- Funding requested: 3 840 KEUR for four years and 9600 KEUR for ten years

#### TRANSVERSAL TOPICS OF RESEARCH: GATHERING EXPERTISE FOR INTERNATIONAL VISIBILITY

In addition to the disciplinary centres outlined above, the proposal of PSL **\*** aims to further strengthen and institutionalise the existing interdisciplinary outlook of much of the research taking place within its constituent and partner institutions. For this purpose, the proposal calls for the establishment of three major transdisciplinary research axes along the lines of transversal research programmes, namely (1) Environment, Energy and Universe, (2) Interface Life Sciences/Hard Sciences and Health, and finally (3) Centre for the Study of Rationalities and Human Behaviour. A fourth centre will focus on Knowledge Management and Methodological Frameworks.

## KNOWLEDGE MANAGEMENT AND METHODOLOGICAL FRAMEWORKS

In order to implement the research agenda outlined above, PSL IDEX requires a strong and integrated Knowledge Management Infrastructure. This will ensure that data can be shared between research groups within PSL IDEX but also with the wider academic community and, just as importantly with the business world and society as a whole. This will boost research productivity, increase visibility and ensure interoperability. Within PSL IDEX two research groups will be created:

- 1. The working group on Scientific Knowledge Management will develop a strong common scientific toolkit (including semantic and self-governing approaches), for data extraction, processing and analysis.
- 2. The working group on Methodological and Theoretical frameworks will focus on the transfer of methodologies and theories between disciplines, the implications of this process and its potential value.

These groups will ensure the implementation and dissemination of best practices and techniques and assist researchers in developing knowledge-based approaches. They will work in close collaboration with industrial partners. This project will require a post of Knowledge Management Officer, as well as that of qualified technicians and researchers. It will be nourished by the strong existing expertise in these domains of the Institutions of PSL IDEX.

#### THE INSTITUTE OF ENVIRONMENT, A PLATFORM FOR INNOVATIVE TRANSDISCIPLINARY RESEARCH

The creation of the PSL★ Institute on Environment will contribute significantly to i) high-level research since it aims to become a meeting centre for the leading experts of the field, ii) high-level training thanks to new facilities, iii) high-level dissemination of knowledge in Environment and Sustainable Development (ESD) themes, and iv) start-up incubation in partnership with industrial or economic groups operating in the energy and environment sectors. It will thus answer one of the major challenges of the present day, highlighted by the Stratégie Nationale de Recherche et d'Innovation (SNRI). The Institute aims to be ranked after 10 years among the world leaders on Environment.

#### The consequences of the interactions between climate-biosphere-society

The main environmental questions nowadays require the analysis of complex systems which are still considered as isolated or analysed as such by traditional scientific fields, *i.e.* climate, ecosystems, economy and society. In fact, these systems influence one another and the analysis of the consequences of the feedbacks in environmental systems can be applied to fields are as diverse as mathematics, physics, chemistry, earth sciences and astronomy, life-ecology sciences and social sciences.

These scientific fields are investigated by internationally renowned researchers within PSL★ and include members of more than 20 PSL IDEX research laboratories situated at the Collège de France, ENS, ENSCP, ESPCI, and Observatoire de Paris.

#### In the framework of the IDEX, the following projects will be implemented:

The research agenda of the Institute for the Environment follows a series of tripartite structures. On the most basic level, research, dissemination and teaching govern the whole activity of the Institute. The projects themselves are broadly structured around the study of observations, models, and theory, with a temporal outlook concerning the past, present and future, at all time scales. They are linked by a common theoretical and methodological framework on the investigation, modelling and simulation of dynamic and complex systems, which is tied into the Knowledge Management architecture of PSL\*. The research projects include:

- Ecosystems Climate: this theme studies the feedbacks between Ecology & Climate: (links with EQUIPEX PLANAQUA and TGIR Ecotron Ile-de-France). Evolution & Climate, Soil moisture & precipitation feedback (link with L-IPSL LABEX), Present state of Planet Earth & Climate, Astronomy & Climate, Dust & Climate (link with L-IPSL LABEX).
- Ecosystems Society: this theme studies the feedbacks between Vulnerability and adaptation of territories & Climate, Terrestrial ecosystem & management practices, Water resource availability & state of aquatic ecosystems: (links with TGE FT-ICR-Platform affiliated to the "Spectrométrie de masse FT-ICR à très haut champ"), Development of new energies & energy savings (link with VALTECX EQUIPEX)
- Society Climate: this theme studies the feedbacks between Climate & Economy (links with IRT "Finance et croissance durable" and LABEX Risques), Constraints, Dynamics and Public policies & Climate (link with LABEX Risques), Sustainable development & a changing world, Human dimension of climate change

Some of the proposed activities are also associated to ODYSSEE and rely on infrastructures, such as the CEREEP-TGE Ecotron IIe-de-France which is PI of the PLANAQUA EQUIPEX, but also on the EQUIP@MESO EQUIPEX managed by Observatoire de Paris and the VALTECX EQUIPEX directed by ESPCI.

The Institute of Environment also aims at improving training, education, and outreach in the field of ESD. It will coordinate and rationalize present teaching curricula organized in different disciplines and will propose new ways of teaching such as virtual teaching rooms, similar to those mentioned in the L-IPSL LABEX proposal. Furthermore, it will develop outreach actions such as the extension of public

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seminars to the existing ones at the chairs "Evolution du Climat et de l'Océan", or "Equations différentielles et Systèmes dynamiques" of the Collège de France.

	Key IDEX projects :
*****	<ul> <li>Institute for Environment supported by:         <ul> <li>One distinguished senior chair,</li> <li>One senior chair</li> <li>Two junior chairs</li> <li>Doctoral and post-doctoral positions</li> </ul> </li> </ul>
- - în	Funding requested: 5 600 KEUR for four years and 14 000 KEUR for ten years

## HARD SCIENCES / LIFE SCIENCES & HEALTH

PSL★ and its partner institutions are already a world-class place for scientific research at the hard sciences / life sciences interface. The Fondation Pierre-Gilles de Gennes (FPGG) was established in 2007 as a network for advanced research (RTRA) with the objective of providing an institutional environment for the existing scientific community in the area of overlap between biology, physics and chemistry, as well as with the aim of transforming technological breakthroughs and major innovations into marketable products for industry. It unites high-level research teams in a wide range of fundamental and applied fields, providing unique knowledge for applications in the health sector.

On the basis of the strong existing position of the Foundation in the hard sciences/life sciences continuum,  $PSL \star$  aims to expand this work into a total of three thematic directions along LABEX lines together with a new Centre on Mesoscopic Biology. Building upon the close-knit community of scientists from multiple disciplines in physics, biology and chemistry and the existing creative and vibrant research environment, these research agendas encompass both fundamental research as well as the development of medical devices, workflows and applications of biotechnology for treatment and diagnosis. In the context of IDEX funding, the following four high-impact domains are to be developed as projects within PSL  $\star$ :

## LABEX Pierre-Gilles de Gennes Institute for Microfluidics (LABEX IPGGM)

The aim of the project is to create a new institute dedicated to fundamental research in microfluidics and "lab-on-a-chip" applications. This is a recent field, characterized by an explosive rate of innovation and growth in the number of publications. This development is driven by a strong downstream demand from life science and medicine, chemistry and environment. Microfluidics is the main enabling technology for the development of lab-on-chips, which aim at integrating into a single miniaturized device a multiplicity of operations needed for chemical, physical or biological processes. Lab-on-chips are the equivalent for chemistry or biology of microprocessors in the electronics and computers industry. Its applied potential is huge.

The Institute will host more than 100 researchers and 12 highly classified UMR and serve as a nucleus for a community of several hundred researchers with expertise in "upstream" fundamental science, and end-users interested in applications. The field of lab-on-chips is highly interdisciplinary, requiring competences in physics (hydrodynamics, soft matter), technology (microsystems, micro-nanofab), chemistry (surface science, analytical chemistry, and biochemistry), biology and medicine. The project will be associated with a unique micro-fabrication platform proposed by an EQUIPEX programme. This will be the first national-scale platform in France, entirely dedicated to microfluidics and lab-on-chips and it will collaborate with the best world centres such as those of Stanford and Harvard.

It will have immediate outcomes in fields such as pharmaceutics and energy and has already resulted in the creation of half a dozen start-ups.

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# Imaging of Living and Inert objects – LABEX Langevin Institute "Waves and Imaging from Fundamentals to Innovation (WIFI)"

The LABEX WIFI aims to become the world reference in the field of Wave physics and Imaging, by combining in a very multidisciplinary approach high-level fundamental research, applied research, business creation and training of students who will be tomorrow's researchers and entrepreneurs. Numerous fields should benefit from this research including medicine (imaging and therapy), defense, biology, acoustic touch technology, geophysics and communications.

The project will exploit the synergies between acoustics and optics to learn how to manipulate waves in complex environments and to design new instruments for imaging and communicating in these environments. The Institute brings together researchers with a unique experience in sub-wavelength interaction and imaging in optics, as well as in acoustics and electromagnetism. The concept of multi-wave imaging will lead to significant breakthroughs in wave propagation and control in complex media, MIMO (Multiple Input-Multiple Output) imaging, sub-wavelength interactions and imaging and wave physics for medicine.

This project aims at rebuilding a French biomedical industry and at contributing to the development of new information and communication technologies as well as at training innovative engineers. Six startups have been successfully created by researchers of the Langevin Institute.

# Redesigning Biological objects for discovery and processes (LABEX ChemVivo)

Biological systems evolution of living organisms is guided by transformation efficiencies, characterised by a minimum waste of energy. This is the main underlying idea of the project LABEX ChemVivo in which the microorganisms will be a « flask/tool ». The project addresses the choice of chemical reactives, analytical tools, and microorganisms to achieve transformations, presently performed by chemists. The development of chemistry assisted by living organisms involves multidisciplinary teams with complementary technical and scientific abilities and will make it possible to solve problems related to matter and energy management.

## Translating science into cancer patients (LABEX Transic)

It is crucial to transfer scientific discoveries from laboratory, clinical and population studies into clinical applications, with a feedback effect, to reduce cancer incidence, morbidity and mortality. The success of translational research depends on the common work of theoreticians, and clinical and epidemiological researchers in order to solve problems focused on patient care. For example, basic sciences deliver biomarkers useful for diagnosis and prognosis of cancer, as well as valuable targets for therapeutic intervention.

The objective of Transic, presented by the Institut Curie, is to improve and implement structures with the aim of allowing a rapid and efficient translation of knowledge in cancer biology into medical cancer applications. TRANSIC also has ambitious objectives in education, notably through core courses in translational research. The ideal location for this ambitious project is the building presently occupied by ENSCP, which is to become available when ENSCP moves into the future Paris Institute for Chemical Engineering. New research facilities will be provided by the IDEX from 2017 on.

## Detailed IDEX actions: creating a specific Centre of "Mesoscopic Biology"

- The aim of the project is to combine multiple scientific communities in a synergetic manner so as to study the molecular organisation of living beings. Direct visualization of molecular behaviour using molecular imaging has provided evidence for the unexpected but predominant role of stochastic processes and weak interactions in biological regulation. These phenomena, which occur over distances of a few nanometers, define Mesoscopic Biology.
- This research opens new perspectives in numerous fields of biology, in particular in the



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understanding of the stability of genomes and regulation of gene expression but also for enzymology in cellulo, molecular pharmacology, immunology, carcinogenesis and neuronal transmission and signaling. Currently, no research structure exists in Europe that is dedicated to addressing in a multidisciplinary and systematic manner this new domain of biology between molecules and organelles. It would represent a centre of excellence in the development and application of new instrumentation. Such a structure would be original and innovative. To succeed, it is imperative for it to be situated in an environment where the multiple disciplines exist and to which the best researchers can be attracted. The potential partners of this centre are mostly members of the IDEX perimeter including the departments of Biology, Physics and Chemistry of the ENS. The Observatoire de Paris and the Ecole des Mines (for adaptive optics and image analysis), as well as INRIA (for signal analysis) will be natural partners.

#### Key IDEX projects:

• Creation of the Centre on Rationalities and Human Behaviour supported by:

- One coordinator position
- 4 invited professorships
- Eight post doctoral positions per year
- Creation of seminar rooms and offices

Funding requested: 5 040 KEUR for four years and 12 600 KEUR for ten years

#### CENTRE FOR THE STUDY OF RATIONALITIES AND HUMAN BEHAVIOUR

The third transversal research initiative promoted by PSL★ has for main object the study of human beings in societies. It is therefore at the interface between Humanities, Social Sciences and Management, but also Cognitive, Natural and Formal Sciences.

The Centre for the Study of Rationalities and Human Behaviour will be a light structure: the aim is by no means to supplant disciplinary research, but rather to create the material and institutional conditions to empower disciplinary research in a place devoted to work at the interface of disciplinary fields. The Centre will not impose themes but let researchers define, from the bottom, pertinent collaborations in order to study objects requiring the common effort of different disciplinary fields. In this way, the Centre is similar to initiatives such as the Centre for Humanities of Stanford University or the AHRC Centre for the Evolution of Culture Diversity of UCL.

The Centre on Rationalities and Human Behavior will be structured around topics of social interest requiring the attention and study of various disciplinary fields, with different tools, concepts and methodologies.

Empirical research will be based on four methodological approaches: modelling tools, experimentations, reflexive ethnography and historical methodology. Each of them raises ethical and epistemological issues. Are models useful to think human history? Which kinds of experiments are allowed within human populations? How could reflexive ethnography be generalized? Is historical knowledge specifically different from scientific study of processes and dynamics?

During the first four years, the main areas of research will be structured around the following topics, which are due to evolve according to the development of research and social needs.

#### 1) Economic rationality and practical rationalities

The assumption of a universal and a-historical rationality is often an implicit premise in economics, even if the characteristics of human rationality have long been an object of debate. However, both economic history and economic anthropology have suggested either the succession or the coexistence of different practical rationalities. Empirical studies will be conducted in order to test the existence of different individual rationalities within different institutional frameworks and to describe cognitive boundaries and institutional boundary-work. At each moment of history, one of these

rationalities tends to be considered as a normative one and to overwhelm the very perception of other rationalities.

The research groups involved include 3 departments of the ENS (the department of Social Sciences, the department of Philosophy with the CIRPHLES and the department of Cognitive Studies) as well as the Paris School of Economics, economists at UPD, the Centre Maurice Halbwachs, the LAS at Collège de France and IRISSO at the UPD and the Collège de France.

The double dimension, both thematic and strongly methodological, of this research programme gives it an important role in the research project of  $PSL \star$ . One of the applications of these research projects on rationality and decision, in particular in economy and finance but also in political sciences and in ethnographical case-studies, is the understanding of crisis as a moment of time where previous cognitive schemes are irrelevant.

## 2) Exchanges, organisations and networks

Exchanges are at the core of the processes of globalisation of economies, cultures and communications. A better understanding of this phenomenon and of its implications depends on a comprehensive study of its precise modalities and historical development at different periods in time. Such a topic requires a transdisciplinary approach involving economists, specialists of management, historians of technology, anthropologists, archaeologists, linguists, philosophers and sociologists. This research direction will expand on the two LABEX in Human and Social Sciences proposed by PSL  $\star$  institutions (TransferS and Risques).

The LABEX "TransferS" will be the core research-centre on material and symbolic exchanges in both a synchronic and diachronic perspective; it will put into light the process of cultural import and its reinterpretation/remodelling in a new context.

The LABEX "Risques" will study the many ways in which risk is displaced and shared. Through the association with UPD Laboratories and thanks to interactions with the Paris School of Economics, the IDEX will enlarge this research to economics and organisation theory, and other transversal research themes like Environment, in particular through a comparative analysis of economic tools for environment protection, and historical description of the ways these tools enter national and transnational organisations.

#### 3) Perceptions, disabilities and socialisation

One of the biggest challenges for the research at the interface between Social Sciences and Cognitive Sciences is to understand how human bodies are both cultural and biological facts. Two main research directions will be chosen to improve our understanding of human perceptions and movements: competitive sports on the one hand, disabilities on the other. Social and cognitive anthropology is at the core of the study of these "techniques of the body", where cognitive research is being used either as a way of achievement or as a compensation tool.

A first stage will be to find out how cognitive experiments could test sociological assumptions on sportive competition practices, in particular the existence of cultural differences between individual perceptions linked to more or less efficient movements. A second stage will be to grasp perceptions of disabled people through a comprehensive study of their everyday life experiences. If three kinds of disabilities have to be strongly differentiated (reduced mobility, sensory deprivation, cognitive deficits), the study of their interconnections could help to understand the links between perception, movement and cognition. Three partners will cooperate on these topics : the LAS (Collège de France), the Department of Cognitive sciences (ENS) and the Department of Social Sciences through the Chair on Mental Disability at the new Maison des Sciences sociales du handicap in Paris.

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#### Key IDEX achievements:

Creation of the Centre on rationalities and human behaviour supported by:

- One coordinator position
- 4 invited professorships
- Eight post doctoral positions per year
- Creation of seminar rooms and offices

Funding requested: 5 040 KEUR for four years and 12 600 KEUR for ten years

# **3.2 EDUCATIONAL STRATEGY**

#### THE EDUCATIONAL MODEL OF **PSL★**: TRAINING THROUGH RESEARCH

 $PSL \star$  aims to define a new type of high level education, adapted to the specific needs of our time. This educative model will foster critical thinking, encourage well structured yet open minded professionals, train students to be innovative and give them the general intellectual skills necessary to adapt rapidly to new fields.  $PSL \star$  students will thus be able to respond in a creative and flexible way to the challenges of contemporary societies, whatever their professional orientation.

By encouraging such minds, our country will transform its scientific potential into a strength for innovation and a source for future growth.

The educational offer of PSL $\star$  covers all the major academic disciplinary fields, from the Humanities and Social Sciences to the Natural and Formal Sciences, and beyond to Management, Cognitive Sciences and Creative and Performing Arts. However, in every one of these fields, all the institutions of PSL $\star$  share a common approach, which can be defined as follows:

- A clear orientation towards graduate studies, with an exceptional graduate/undergraduate ratio.
- A demanding and carefully designed process of selection based either on competitive exams or on written applications and interviews, in order to screen and select the students who can best benefit from formation through research.
- A pedagogical method based on student tutoring, made possible by the very high student/professor ratio (1,2).
- A systematic and well-established practice of education through research, which encourages students to think in an innovative manner.
- A close relation between research teams and educative programmes.
- An emphasis on key intellectual and scientific abilities (argumentation and expression).
- A strong emphasis on the importance of a comprehensive education (characteristic for example of the Diplôme of the ENS and the ESPCI educative programme, which encourage students to take classes in other disciplinary fields).

These characteristics make PSL IDEX institutions extremely competitive on the international scene since they correspond to the main criteria of excellence in education, taken into account by the major international ranking systems, and clearly position  $PSL \star$  as a leading Research University.

 $PSL \star$  will take full advantage of this expertise to offer a comprehensive and innovative educative programme. It will be aimed at all the students within the excellence perimeter of  $PSL \star$ , that is at all the students of ENS, ESPCI, ENSCP, Observatoire, Collège de France, as well as students enrolled in selected curricula of Paris-Dauphine University, and graduate students from the Schools of Creative Arts.

PSL★ institutions consider equal opportunity of access to the best higher education as one of their missions. A consistent effort will therefore be made so as to promote students from socially and culturally underprivileged areas notably by proposing bridges between curricula in order to attract and

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enrol them, without this implying a lowering of the extremely high standards expected. All students having the capacity to benefit from a high-level training through research will be welcome independently of their scholarly background.

The educative programme will thus affect a diverse student population, the total number of which corresponds closely to that of leading world-class universities (8200 students within the perimeter of excellence). Its transformative effect will be visible in the short term since it will also encompass all levels from undergraduate studies to doctorate and all academic disciplinary fields represented in PSL IDEX. Furthermore, it will impact on the career strategy of students and in the mid-term on a wide range of professions since the different institutions of PSL  $\star$  train: (a) researchers and innovators in all fields; (b) engineers (ENSCP, ESCPI); (c) highly qualified public servants, managers and administrators (ENS, UPD); (d) creative and performing artists (ENSAD, ENSBA, CNSMDP, CNSAD).

Finally, the new educative model of PSL IDEX will answer a number of major challenges by giving a clear coherence to the educative offer, increasing its visibility on the international scene and focussing it in an explicit way to the social and economic needs of the country.

The educative programme of  $PSL \star$  is articulated around four main projects:

- Creating a Leading Program for Graduate Studies.
- Creating a Pluridisciplinary Undergraduate Degree.
- Developing Research Education for Executives
- Offering a Research Diploma in Creative Art / Science

These projects will notably involve creating a Graduate Program encompassing PSL★, offering new courses and developing existing relations with the business world and no-profit economic sector and increasing in a targeted manner and in specific disciplinary fields the total number of students. They also require a strong concerted effort on five transversal principles: equal opportunity, quality evaluation, international strategy, campus life and online educative offer.

## PSL★ MAIN PROJECTS

## Project 1. A leading Graduate Programme (Masters and Doctorates)

#### Ambition:

Like all Research Universities, PSL★ focuses primarily on graduate education. It is already characterised by a high proportion of graduate students, a unique ratio of professor/student and a privileged scientific environment, but needs to maximise this potential. This will be achieved by ensuring coherence between the educative programmes of the different institutions, creating graduate programmes encompassing the existing masters and Écoles Doctorales active on the PSL★ perimeter and giving them additional value, focusing on increasing visibility so as to attract the best students, increasing relations with the business world and society and providing common scientific services and utilities services. In order to achieve these aims, PSL★ will focus on the following actions:

#### A new common educative programme

The PSL  $\star$  framework will propose new inter-institutional curricula and will also allow students to profit from the synergies between institutions by enabling them to combine existing educative offers.

Courses offered by the institutions of  $PSL \star$  will progressively be opened to students from other institutions and, in certain cases, directly integrated into their curricula. This will give students access to a wide range of complementary courses from other disciplinary fields. The coherence of their individual educational curricula will be guaranteed by close individual tutorship and by the specific diploma for which they are studying.

• This increased flexibility will notably enable a much greater emphasis on courses in topics such as management, decision making, economy and law (offered by the UPD), which are a key

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aspect of the training of elites and which were so far lacking in most institutions of PSL.

- A number of trans-institutional courses will be created, notably at the Master level, by pooling teaching resources between the different institutions. These courses will be designed specifically to profit from the dynamism offered by the Labex projects submitted by PSL\* and other research initiatives implemented in the PSL\* framework (examples include a Masters based on the Labex TransferS and ChemVivo).
- Priority will be given to new courses, with transdisciplinary perspectives, open to a wide public such as the Training in Cancer and Translational Research for students and physicians proposed by the Institut Curie.
- A common PSL★ board of graduate education will be created for concertation and review and so as to guarantee a maximal visibility of each initiative.

For instance, a student-engineer at the ENSCP Chimie-ParisTech, acquiring a major in Metallurgy, will be able to follow courses in Social Sciences offered by the ENS or the UPD, about social impact and issues related to energy and resources.

## PSL★ Graduate Centre

The Graduate Centre will be at the heart of the educative experience of all PSL★ students. It will offer a comprehensive range of services, ensure optimal integration into the PSL★ community and pool existing resources of individual institutions. Key services will include:

- Comprehensive information on PSL★ educative and research programmes as well as studying abroad and post-doctoral grants.
- A Research Centre with seminars in economy, management and finance aimed at developing the skills of decision-making, advice on writing papers and PhDs, material resources and a space in which students will regularly present and discuss their work.
- A Teaching Centre providing support for Teaching Assistants.
- A wide offer of foreign language courses.
- A Career Service providing advice on general career strategy, writing curriculum vitae and applications, mock interviews and placement committee.

Life on Campus services including: health resources: doctors, psychologists; access to libraries, sport and leisure facilities; a cafeteria and convivial space.

The PSL $\star$  Graduate Centre will collaborate closely with the business world and with public administration so as to offer students a direct relation with their future work environment and to ensure that business and administration actors are aware of what is happening on the PSL IDEX campus and of what kind of competencies they can find there.

It will be highly visible both online and in the PSL★ campus and will organise events (PSL★ graduation day) as well as give out distinctions such as a yearly PhD PSL★ award.

## Matching student numbers to research potential and social needs

The excellence of Research Universities depends directly on the close articulation between education and research. It is therefore logical for  $PSL \star$  to define optimal student numbers both by the research potential and the career perspectives of specific disciplinary fields. Over the long term,  $PSL \star$  will therefore closely monitor student numbers, research potential and social needs so as to ensure that they remain as balanced as possible. Currently, the strength of  $PSL \star$  research teams allows for an increase in the number of students in fields such as computer science, physics, biology and economy, domains in which a critical number of creative students is decisive for future growth. During the first

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phase of implementation of the IDEX, we therefore plan to:

- Increase the number of students in a targeted manner and in disciplinary fields identified as having a good potential for growth, such as computer science (where numbers will be more than doubled), engineering and economy (c. 50 students).
- Increase the educative offer in disciplinary fields with a high research output (certain domains of physics, geosciences, biology) and especially in emerging interdisciplinary fields (c. 50 students).
- Increase the educative offer at the interface of medicine and translational research, the number of students in medicine and doctoral students (c. 8 students)
- Other actions described below will secure the recruitment of c. 100 foreign students (mainly at doctorate level).

Depending on the success of these measures, the perimeter of excellence will be stabilised at around c. 9 000 students, maintaining the professor/student ratio at a level that guarantees the quality of the educative process. These measures entail an increase in the number of grants and an increase in the admission flux (notably for foreign students). In no case will they imply a lowering of our standards in terms of education.

#### Project 2. Creating a common pluridisciplinary undergraduate cycle

#### Ambition:

To create an undergraduate curriculum will enable  $PSL \star$  (1) to offer a complete university cycle, from first year through to PhD; (2) to test pilot programmes; (3) to develop equal opportunity initiatives with high schools throughout France.

This new undergraduate course, based on a comprehensive approach, will offer an alternative to the classical training by universities or *"classes préparatoires"*. It will be perfectly adapted to students who do not want to specialize too rapidly, or enter the *"classes préparatoires"*.

Aimed at a true *éducation de l'esprit*, this undergraduate cycle will be available in different modalities. It will rely on the same principles as the graduate cycles of PSL★ institution: the combination of disciplinary excellence, multidisciplinary approaches, and an education geared towards producing innovative specialists with critical mindsets. It will adapt the open pedagogical model of programmes such as the "Core Curriculum" at Columbia University to French higher education and will profit from the experience acquired by the UPD, thanks to their pluridisciplinary Licence "Sciences de la Société".

At the end of the cycle, students will obtain the PSL undergraduate diploma, one or two "Licence" in specific disciplinary fields and will be able to apply for admission to  $PSL \star$  institutions and affiliated schools. Besides, at each stage of the programme, bridges will be established to and from *classes préparatoires*.

#### Pluridisciplinary Degree

The main project will combine an education in human and social sciences with one in natural and formal sciences. It will allow students to acquire key skills thanks to original and individualized pedagogical methods relying on tutoring and the acquisition of a good general knowledge.

The curriculum will be basically structured as following:

- 2 semesters of foundation courses in sciences, humanities and foreign languages,
- 4 semesters of progressive specialization, organised around various curricula: (a) Life Sciences;
   (b) Mathematics and Computer Science; (c) Sciences of Matter; (d) Humanities and Social Sciences; (e) Management and Economy.

The student selection process will be based both on academic results in high school, and on