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Biological research in France

The life Sciences account for a large share of research activity because of the challenges they pose and because their implications are so obviously important for the future of our planet.

The Institut Pasteur, from vaccines to the human genome, more than a century of Medical research in France

It is hard to discuss Biology in France without conjuring up the name of the great Louis Pasteur–the first Professor of Microbiology and the founder of Immunology.

Established in 1888, the Institut Pasteur has long enjoyed international support thanks to universal recognition of the quality and importance of its work. Today its network comprises 29 institutions on 5 continents outside France. Having battled rabies, plague, diphtheria, tetanus, typhus, yellow fever, tuberculosis, and polio, Institut Pasteur scientists (8 Nobel prizes since 1900) have become major forces in the struggle against AIDS.

Following in the footsteps of Alexandre Yersin–the Franco-Swiss biologist who discovered the pathogenic agent of the bubonic plague (Yersinia Pestis), planted the Institut Pasteur in Vietnam, and helped found the school of medicine in Hanoi – we have professors Jean-Claude Chermann, Françoise Barré-Sinoussi, and Luc Montagnier, who isolated the AIDS viruses (VIH1 and VIH2) and shared the Nobel Prize in 2008.

The team of Professor Pierre Charneau in the viral Oncology unit of the Institut Pasteur) is developing a new vector to deliver “good” genes to cells that so far have been inaccessible to gene therapy.

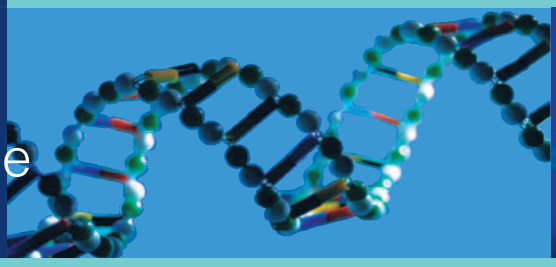
A similar type of research is being done by Professor Daniel Scherman at Généthon, in close collaboration with CNRS, INSERM, and the Université d’Evry-Val d’Essonne. Généthon is Europe’s leading nonprofit biotechnology firm and a pioneer of **Research on the human genome**.

The international imperative

The Franco-American career of Professor Luc Montagnier is just one of many that exemplifies the imperative of cooperation between laboratories in different countries. (The example of Jules Hoffmann, discussed below, is another. Hoffmann’s lab in France collaborated with labs at Yale and Cambridge.) In fact, Biological Research exemplifies the growing internationalization of Science.

Young scientists from around the world come to the Institut Pasteur for advanced courses in microbiology and immunology. They numbered 382 in 2007, in addition to 800 doctoral students of 56 different nationalities who came to hone their skills in Pasteur labs.

The influence of the Institut Pasteur has spread to non-French-speaking countries through specialists trained in France. In Angola, for example, the struggle against AIDS is being led by Institut Pasteur scientists from Brazil, a country that leads the world in care for AIDS victims. International cooperation in monitoring flu viruses is another vivid example of the growing trend.



From brain imaging to Bioethics, the end of compartmentalized disciplines

Like all of the sciences today, Biology demands minds that are highly specialized but also open to multidisciplinarity. The compartmentalization of Biology, Chemistry, and Physics, in particular, is a thing of the past. Computer scientists, biophysicists, and crystallographers work together on studies of nuclear magnetic resonance, X-ray crystallography, and modeling. *"Our array [of competencies], ranges […] from psychiatry to mathematics and includes Physics, Chemistry, and Biology,"* says Professor Denis Le Bihan, scientific director of NeuroSpin, a large-scale intense-field neuro-imaging facility built in 2005 to meet the needs of biological researchers.

NeuroSpin alone makes France a leader in brain imaging using nuclear magnetic resonance. In 2011 the facility will become the home of the world's most powerful magnet, with a magnetic field of 11.7 T and a diameter of 90 cm. The magnet was designed by DAPNIA, the laboratory for research into the fundamental laws of the universe. DAPNIA is housed at the French atomic energy commission, CEA, a leader in brain imaging for 30 years.

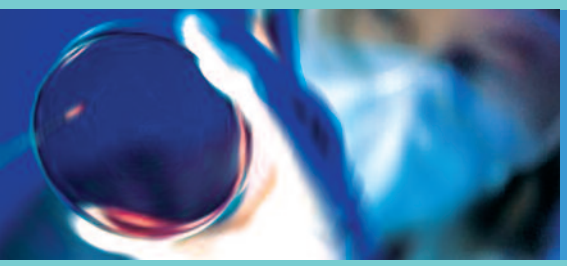
A collaborative effort of French and German engineers, NeuroSpin will facilitate research on neurodegenerative conditions, cerebral infarction, and the correction of sensory handicaps. But its ultimate ambition is far greater, extending to the study of the healthy brain to learn, for example, why we do not all think in the same way, how learning might be improved, and how to optimize man–machine interactions. One of NeuroSpin's scientists is Professor Stanislas Dehaene, whose current research is pushing back the frontiers of brain imaging, using it to search for the origin of computational difficulties. From that research we have already gleaned the first images of the brain's subliminal processing of words.

Nanobiotechnologies, another area of rapid development, make it possible to greatly increase the amount of data available to medical professionals about their patients, while minimizing the invasiveness of obtaining those data. A research field in their own right, nanobiotechnologies use nanotechnologies to discover new molecules, opening promising pathways toward a new generation of so-called intelligent medicines. Another benefit to be expected from the growth of nanotechnologies is the reconstruction of tissues affected by lesions using materials that are biocompatible at the cellular level.

But the most revolutionary field in the coming years may be prevention, with new approaches emerging that promise to free human beings from ancient fears–while perhaps also stimulating new ones. Systemic biology predicts the physical evolution of an individual, a possibility that, like medically assisted procreation, genetic manipulation of plants, cloning, and the use of human embryos, raises serious questions that are the stuff of bioethics.

Thinking about human evolution

The research touched on above has raised many questions and concerns that have fueled the debate on bioethics. Those questions are part of the very frank dialogues being conducted by neuroscientist Jean-Pierre Changeux with mathematician Alain Connes (on the relations between the brain and mathematics) and philospher Paul Ricœur. The second dialogue was published in a volume entitled *Ce qui nous fait penser: La nature et la règle,* Paris, O. Jacob, 1998 (What makes us think: Nature and rules). Jacques Monod, one of the fathers of molecular biology, who shared the 1965 Nobel prize for medicine with François Jacob and André Lwoff for their discoveries related to the enzymatic adaptation in cells and genetic regulation, urged us *« to look for the fundamental causes–that is, the molecular mechanisms–of the phenomena of life, from simple bacteria to the reflective capacity of human beings ».* That was a half-century ago. Today, NeuroSpin and similar organizations are pursuing Monod's quest, further confirmation that biologists are not alone in pondering the limits of science.



The transgenesis revolution and the challenges of sustainable development

The field of plant biology has been radically altered by the transgenesis revolution, which has made it possible to endow a species with characteristics that it does not possess naturally through the transfer of genes from one organism to another, hurdling the barriers of species and genus.

The challenges of sustainable development have led to a reconsideration of the role of innovation in the design of an environmentally and socially acceptable agricultural system. Research efforts at INRA, the French national institute of agronomic research, are focused on mastering plant biotechnologies through the study of the molecular and cellular mechanisms involved in the the organization and expression of genes. INRA is also supporting programs to develop global postgenomic approaches that promise to yield significant fruit, notably in the area of integrative plant biology and plants' interactions with bioagressors and their environment.

Finally, INRA is working on techniques designed to strengthen plant biotechnologies, transgenetic or otherwise, by assessing the benefits, impacts, and risks of different forms of innovation. For the time being, genetically modified organisms are the subject of controlled experimentation in France and, for precautionary reasons, have not been adopted for use in agriculture.

French breakthroughs in cellular biology

In cellular biology, pluripotent stem cells, or embryonic stem cells, are of critical importance, because they are capable of reproducing infinitely and growing into every kind of tissue found in the adult organism. Using stem cells, researchers can study how the embryo develops, gain a better understanding of how cancers start, and assess the effect of various medications. It is almost certain that embryonic stem cells will soon be at the center of the practice of cell therapy, wherein abnormal or missing cells are replaced with healthy ones.

Professor Marc Peschanski, a research scientist at INSERM, the French National Institute of Health and Medical Research, heads a team that performed the first grafts of fetal neurons in patients suffering from Huntington's disease, but he urges us not to declare victory right away. Research in France using embryos and embryonic stem cells is strictly controlled by the bioethics law of 2004, which was revisited in 2009.

Another breakthrough in Biology has come through the work in immunology of Professor Jules Hoffmann, former president of the French Academy of Sciences. With his team from the *Centre National de la Recherche Scientifique* (CNRS, national center for scientific research) in Strasbourg, Hoffmann identified germ-fighting molecules that appeared in fruit flies (Drosophila) after an injury. Current research is focusing on possible applications of that discovery to the innate antimicrobial defenses of humans, which are still poorly understood.

In the field of experimental embryology, INRA is using cloning as a tool for research on the interactions between cell nuclei and their surrounding cytoplasm. Having developed a unique body of expertise based on livestock cloning, INRA is studying the possible risks of using cloned animals for human consumption. A parallel program is considering the ethics of animal cloning.

Major research bodies

- CEA, Commissariat à l'Énergie Atomique (French atomic energy commission): http://www.cea.fr
  An important actor in research, development, and innovation in energy, information technology, and health life sciences at CEA: http://www.dsv.cea.fr/content/cea/home/
  Dapnia Saclay laboratory on the fundamental laws of the universe: http://irfu.cea.fr/index.php
  CEA library catalog: http://www-ist.cea.fr/sygeca/exl-php/cadcgp.php

- CEMAGREF: http://www.cemagref.fr
  biology of aquatic ecosystems, hydrobiology, microbiology, bioprocessing of wastes

- CIRAD: http://www.cirad.fr
  Centre de coopération internationale en recherche agronomique pour le développement (center for international cooperation on agronomic research for development).
  biology, biodiversity

- CNRS, Centre National de la Recherche Scientifique (national center for scientific research): http://www.cnrs.fr
  life sciences at CNRS: http://www.cnrs.fr/sdv/

- GÉNÉTHON: http://www.genethon.fr
  development of bioprocesses, therapeutic strategies and assessment of therapies, human genomics, rare genetic diseases, gene transfer

- IFREMER, Institut Français de Recherche pour l'Exploitation de la mer (French research institute for exploitation of the sea): http://www.ifremer.fr
  biology of species

- INCA, Institut National du Cancer (national cancer institute): http://www.e-cancer.fr/
  biology of cancer, research training

- INRA, Institut National de la Recherche Agronomique (national institute of agronomic research): http://www.inra.fr
  plant biology, genetics, microbiology, nutrition, animal and plant physiology, health, social sciences

- INSERM, Institut National de la Santé et de la Recherche Médicale (national institute of health and medical research): http://www.inserm.fr
  biostatistics, genetic epidemiology, health

- Institut Curie: http://www.curie.fr
  cellular and developmental biology, the fight against cancer, cellular and molecular imaging, immunotherapy, epigenetics, and geno-toxicology, genetics and oncogenesis, molecular mechanisms in oncogenesis, pharmaceutical chemistry, physical chemistry of living things

- Institut Gustave Roussy: http://www.igr.fr
  the fight against cancer, epidemiology, genomics, oncogenetics, therapy

- Institut Pasteur: http://www.pasteur.fr/ip/index.jsp
  molecular biology, immunology, microbiology

- IRD, Institut de Recherche pour le développement (institute of development research): http://www.ird.fr
  biodiversity, biotechnologies, microbiology

Useful links

- ADEME, Agence de l'Environnement et de la Maîtrise de l'Energie (French environment and energy management agency): http://www.ademe.fr
- Agence de la Biomédecine (agency of biomedicine) founded in 2005, issues research authorizations on the advice of the agency's steering committee; evaluates and monitors research programs:
  http://www.agence-biomedecine.fr/fr/activite-recherche.asp
  2006 report on stem cells and ethical choices,
  http://lesrapports.ladocumentationfrancaise.fr/BRP/064000623/0000.pdf
- National database of biotechnology: http://biotech.education.fr/
- E-BioSci platform: access and retrieval of life sciences information (molecular data, scientific literature, images):
  http://www.e-biosci.org/
- European Molecular Biology Organisation: http://www.embo.org
- Génoplante, a federation of groups working on plant genomics:
  http://www.genoplante.com/
- Génopole, a center for the gene and biotechnologies:
  http://www.genopole.fr/html/fr/home/index.htm
- Medicine manufacturers: http://www.leem.org
- Fédération Réaumur des sciences du vivant (FRSV, Réaumur life sciences federation): http://www.reaumur.org/
  Groupement des Protistologues de Langue Française (GPLF), Club Exocytose – Endocytose, Société de Biologie Cellulaire de France (SBCF), Société Française de Biologie du Développement (SFBD), Société Française de Génétique (SFG), Société Française des Microscopies (Sfμ), Microscopie fonctionnelle du vivant (GDR 2588)
- Fédération pour la recherche sur le cerveau (FRC,brain research federation) a federation of five neurological research associations: http://www.frc.asso.fr
- Fondation pour la Recherche médicale (foundation for medical research): http://www.frm.org/
- Institut français de l'environnement (French environmental institute): http://www.ifen.fr
- Laboratoire de biométrie et de biologie évolutive UMR 5558, Lyon 1 (laboratory of biometrics and evolutionary biology, joint research unit 5558, Université de Lyon 1):
  http://biomserv.univ-lyon1.fr/sitelabo/index.php
- Employment:
  http://www.adebio.org - http://www.arborescience.com/
  (see also Société Française de Génie Biologique et Médical and Association Bernard Grégory)
- Société des neurosciences (neuroscience society), the world's third-largest community of researchers:
  http://www.neurosciences.asso.fr
- Société française de biométrie (French society of biometrics):
  http://biomserv.univ-lyon1.fr/SFB
- SFGBM, Société Française de Génie Biologique et Médical (French society for biological and medical engineering):
  http://www-sfgbm.enst-bretagne.fr
  Employment:
  http://www-sfgbm.enst-bretagne.fr/rubrique.php3?id_rubrique=13
  Doctoral and postdoctoral openings:
  http://www-sfgbm.enst-bretagne.fr/rubrique.php3?id_rubrique=14
- SFDS, Société française de statistique (French society of statistics): http://www.sfds.asso.fr/

General information

- Agence CampusFrance: http://www.campusfrance.org
  Everything students need to plan a period of study in France, from choosing a program to planning their stay

- Catalog of doctoral departments -
  campusfrance.org>Find your course>level D
  http://www.campusfrance.org/ecoledoc/
- CampusBourse directory of grants and scholarships:
  campusfrance.org>Finance your studies

- AFII, Agence française pour les investissements internationaux (French agency for international investment), brochures on biotechnologies and nanotechnologies under the heading "Publications sectorielles":
  http://www.invest-in-france.org/international/fr/sectorpublications.html
- OSEO Innovation (French innovation agency):
  http://www.oseo.fr
- Annuaire de l'Enseignement supérieur et de la Recherche (CNRS, directory of higher education and research):
  http://www.urec.cnrs.fr/annuaire/

  CNRS quarterly (in English): http://www2.cnrs.fr/en/2.htm
- AERES, Agence d'évaluation de la recherche et de l'enseignement supérieur (agency for the assessment of higher education and research): http://www.aeres-evaluation.fr
- ABG, Association Bernard Grégory (career-related assistance for young professionals): http://www.abg.asso.fr/
- EURAXES mobility of researchers in Europe:
  http://ec.europa.eu/euraxess/index_en.cfm
- Fondation Alfred Kastler (hosting of foreign researchers in France): http://www.fnak.fr/
- Ministère de de l'Enseignement supérieur et de la Recherche (ministry of higher education and research):
  www.enseignementsup-recherche.gouv.fr
- Web portal for mobility of European researchers in France:
  http://www.eracareers.fr/

Doctoral training in France

Doctoral departments

Training students for careers in research is a key mission of the universities. Fulfilling that mission is the business of about 300 doctoral departments staffed by 62,000 research faculty working in close cooperation with more than 1,200 research laboratories. Doctoral departments offer students an advanced scientific and scholarly environment in which to pursue their work, prepare for a career (through education and training, Seminars, and Internships), and connect with prospective employers. The doctoral departments coordinate doctoral education and ensure the coherence of research programs. Doctoral candidates work within research teams or units (known as URs) attached to Doctoral departments. Each candidate is supervised by a dissertation adviser. Most doctoral departments are affiliated with a host institution (usually a university) that is authorized to grant doctoral degrees. Doctoral departments are accredited by the minister of higher education following an assessment by AERES, the French national agency for the evaluation of research and higher education.

Applying to a doctoral program

Prospective doctoral candidates must apply for admission to a specific doctoral department. Once admitted, they register with that department.

- Applicants must hold a degree equivalent to a European master's.
- Upon contacting a doctoral department, prospective candidates may make an original research proposal or consult the department's list of research priorities.
- The doctoral department will refer the candidate to a dissertation adviser and explore with the candidate the available options for financing doctoral study.
- Once accepted by the department and the dissertation adviser, the candidate signs a dissertation agreement.

A complete list of doctoral departments in France can be found online at www.campusfrance.org

The online catalog provides direct links to the research units within each doctoral department. A bilingual (French and English) search engine enables users to obtain results by selecting from among 20,000 keywords and 80 disciplinary themes. Departmental profiles are also provided.

CAMPUS FRANCE campusfrance.org **www.campusfrance.org>Find your course>level D**

Financing doctoral study

A sound plan to pay for one's doctoral education is usually a prerequisite for admission to a doctoral department.

Financing plans must cover the 3 years typically required to complete a dissertation so that the candidate will be free to conduct research full time. The doctoral department is the candidate's principal partner in the search for financial aid.

- **Doctoral contracts** are a new public mechanism for financing doctoral education. The 3-year contracts, which are open to any student enrolled in a doctoral program, provide a guaranteed minimum salary (1 600 euros before withholding) and benefits. The terms are the same at all French institutions of higher education, though each doctoral department is responsible for managing the contracts that it awards. With the full legal force of a true employment contract, the doctoral contract emphasizes the professional research experience that is a key component of doctoral education.

- **Industrial agreements for training through research (CIFRE)**

CIFRE agreements (for conventions industrielles de formation par la recherche) enable doctoral candidates to prepare their dissertation while working for a corporation. The candidate is supported by an external academic research team. The doctoral candidate and the firm enter into a 3-year employment contract for a monthly salary of approximately 1,900 euros. Applications are submitted jointly by the candidate and his or her doctoral program to ANRT, the National Association for Technical Research. http://www.anrt.asso.fr/

Other sources of financial assistance for doctoral study include bilateral agreements, grants from France's Ministry of Foreign and European Affairs, grants from France's regions, grants and scholarships from corporations, and assistance from the candidate's home country or institution.

- **CampusBourse, directory of grant programs : http://www.campusfrance.org>Finance your studies**