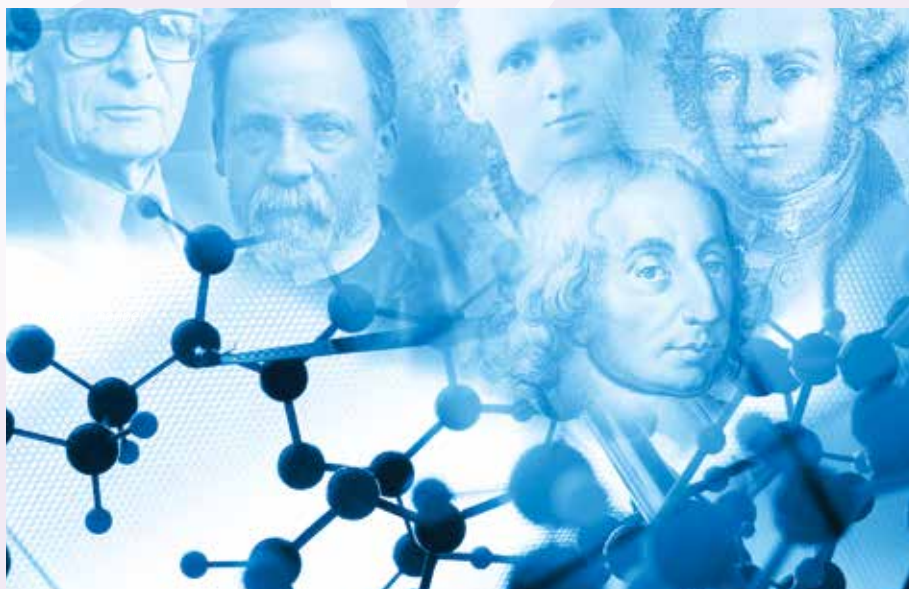




RESEARCH IN CHEMISTRY

French chemist Antoine Lavoisier (1743-1794) laid the foundations of chemistry as the science of the transformation of matter. A long line of great French chemists followed in his footsteps—notable among them Claude Berthollet (1748–1822), Louis-Joseph Gay de Lussac (1778–1850), Marcellin Berthelot (1827–1907), and Louis Pasteur (1822–1895). France's chemical industry (including pharmaceuticals) is the world's sixth-largest, and ranks second in Europe, after Germany. In terms of spending on research and development, the chemical industry (again including pharmaceuticals) is the leading manufacturing sector in France and the country's second export industry.



A WIDE RANGE OF PRACTICAL APPLICATIONS AND CHEMICAL PRODUCTS

During the nineteenth century, the number of known compounds rose from several dozen to hundreds of thousands and the number of reactions from just ten to several hundred. Every industry came to rely on chemistry to produce raw materials from metal ores and to transform metals and alloys. The manufacture of cement, lime, and plaster; the refining

of oil and sugar; and the processing of natural textile fibers all depend on chemical processes, as do the production of fertilizer, glass, macromolecules, explosives, medicines, perfumes, paints, dyes, antibiotics, insecticides, detergents, and more. Other industrial applications of chemistry are found in appliances; swimming pools; optical technologies; and the cabins and cockpits of airplanes, automobiles, ships, and trains—the examples are countless.

CROSS-DISCIPLINARITY, ETHICS, AND SUSTAINABLE DEVELOPMENT

The discipline's traditional organizational scheme—molecular, physical, and mineral chemistry—has evolved with the development of new disciplines and cross-disciplinary applications. Advances in biology have introduced numerous new specialties—among them biochemistry, which studies chemical reactions within biological entities such as cells or between biological entities (such as proteins and other biomolecules); medical applications; synthetic biomaterials; and bio-inorganic chemistry.

Physics is also closely linked with today's chemistry through thermochemistry, thermodynamics, chemical kinetics, electrochemistry, radiochemistry, sonochemistry, homogeneous catalysis, and the chemistry of solutions. Specialties include surface chemistry and the application of quantum mechanics to chemistry, which has given birth to quantum chemistry.

Chemistry today favors an ethical and responsible approach in the areas of human biology, with medical chemistry and immunochemistry, and the environment, with the notion of "green chemistry" (agrochemistry, environmental chemistry, the chemistry of clays and zeolites, phytochemistry, and so on). La chimie de synthèse a permis et permet encore des progrès importants dans les domaines de la santé et de l'alimentation. Advances in modeling software have made possible the development of digital or computational chemistry.

9 NOBEL PRIZES AWARDED TO FRENCH CHEMISTS



■ The Nobel prize in chemistry has been awarded since 1901. The first French winner was **HENRI MOISSAN** (1852–1907) for the discovery of fluorine and its properties.

■ In 1911, **MARIE CURIE** garnered the prize for the discovery of the elements radium and polonium.

■ In organic chemistry, **VICTOR GRIGNARD** and **PAUL SABATIER** developed a method for the hydrogenation of organic compounds that earned them the prize in 1912.

■ In 1935, the prize went to **FRÉDÉRIC** and **IRÈNE JOLIOT-CURIE**, who synthesized new radioactive elements.

■ **JEAN-MARIE LEHN**, a professor at the Collège de France and holder of the chair in the chemistry of molecular interactions, shared the 1987 prize with Americans Donald J. Cram and Charles Pedersen for the development and use of molecules capable of selective interaction.

■ In 2005, **YVES CHAUVIN**, research director at the French Petroleum Institute (IFP) and a member of the French Academy of sciences, shared the prize with Americans Robert Grubbs and Richard R. Schrock for the development of the metathesis method in organic synthesis.

■ Le prix Nobel de chimie 2016 a été attribué à trois chercheurs, le Français Jean-Pierre Sauvage, le Britannique James Fraser Stoddart et le Néerlandais Bernard Lucas Feringa, pour avoir créé des molécules dont le mouvement peut être contrôlé. Au sein de l'Institut de science et d'ingénierie supramoléculaire de l'université de Strasbourg et du CNRS, les travaux de Jean-Pierre SAUVAGE ont permis de développer des boucles moléculaires se contractant à la manière de muscles nanométriques.

TRÈS GRANDES INFRASTRUCTURES DE RECHERCHE (TGRI)

(FRANCE'S LARGE RESEARCH ORGANIZATIONS)

ASTRONOMY AND CHEMISTRY

ALMA's chief objectives are to study molecular gas and dust in space. Its main scientific themes are the formation and evolution of galaxies (from the distant universe of high spectral shift to the local universe), the physics and chemistry of the interstellar medium, the formation of stars and planetary systems, and the study of comets, planetary atmospheres, and small bodies in the solar system.

GREEN CHEMISTRY

French facilities dedicated to innovation, training, and technology transfer in the field of metabolomics make up MetaboHUB, a federation of four platforms operating under the authority of France's National Institute for Agricultural Research (INRA) and its Alternative Energies and Atomic Energy Commission (CEA). The facilities support laboratories in the fields of human health, nutrition, food production, toxicology, agriculture, green chemistry, the environment, and biotechnologies. www.metabohub.fr

CLIMATE AND ATMOSPHERIC CHEMISTRY

> *Aerosol, Cloud, and Trace Gases Research Infrastructure* (ACTRIS-FR): ACTRIS operates data and calibration centers that provide services to a large community of users working on climate chemistry models, the validation of satellite data, and analysis of weather and air-quality forecasting www.actris.eu

> CONCORDIA, the antarctic base operated by France and Italy, carries out research and observation programs in numerous scientific and technical fields (glaciology, atmospheric physics and chemistry, astronomy, geophysics), several of which are linked to climate change.

www.institut-polaire.fr/ipev/infrastructures/les-bases/concordia/

> METSA (electronic microscopy for atomic probes and transmission) is a national network of eight regional platforms specializing in the physics of materials in a broad sense: nanotechnologies/nanosciences, materials chemistry, materials engineering, and health materials. www.metsa.fr

> RENARD (national network for interdisciplinary electronic paramagnetic resonance) combines 27 cutting-edge electronic paramagnetic resonance spectrometers in 10 laboratories and 5 cities. These platforms are sites for interdisciplinary exchanges at the highest levels in chemistry, biology, and earth sciences and for the pooling of complementary techniques and competencies from a variety of thematic areas of science. <https://renard.univ-lille1.fr>

> SAFIRE deploys three research aircraft (ATR 42, Falcon 20, and Piper Aztec) with different flight profiles to conduct measurement campaigns in the following fields: atmospheric physics and chemistry, continental surfaces, ocean surfaces, and aerospace research and technology. www.safire.fr

OCEANOGRAPHY AND BIO-GEOCHEMISTRY

> The French oceanographic fleet consists of national research vessels that ply coastal and offshore waters to conduct research in the geosciences, physical and biological oceanography, ocean bio- and geochemistry, paleoclimatology, and biodiversity, among other areas. www.flotteoceanographique.fr

> GODAE – MERCATOR : www.mercator-ocean.fr

> France's concentrated solar thermal installations (FR-SOLARIS) expand knowledge in the following areas: photophysics, photochemistry (e.g., photocatalysis, thermochemistry (e.g., production of synthetic fuels), thermics, nanomaterials (e.g., development of nanopowders),

USEFUL LINKS

- Agence européenne des produits chimiques : <http://echa.europa.eu>
- Axelera, pôle de compétitivité à vocation mondiale Chimie-Environnement Lyon et Rhône-Alpes : www.axelera.org
- Annuaire des entreprises de la chimie et de la pharmacie : <http://chimie-pharmacie.europages.fr>
- Association chimie du végétal : www.chimieduvegetal.com
- Centre de développement informatique enseignement chimie (CDIEC) : www.unice.fr/cdiec/
- Culture Sciences-Chimie : <http://culturesciences.chimie.ens.fr>
- Cluster de recherche en chimie, Rhône-Alpes : www.cluster-chimie.fr
- Docteurs Chimie : www.docteurs-chimie.org
- Fédération des Écoles de chimie et de génie chimique (Fédération Gay Lussac) : <https://www.20ecolesdechimie.com>
- Fondation de la Maison de la Chimie : www.maisondelachimie.com
- Forum horizon Chimie : www.forumhorizonchimie.fr
- InfoChimie & ChimiePharma : www.industrie.com/chimie/
- Institut de chimie - CNRS : www.cnrs.fr/inc/
- Institut National de la Recherche Agronomique (INRA) : <http://www.inra.fr>
- Institut national de la santé et de la recherche médicale (INSERM) : <http://biblioinserm.inist.fr>
- International Union of Pure and Applied Chemistry: www.iupac.org
- Les entreprises du médicament : www.leem.org
- Novachim, CRITT Chimie & Matériaux : <http://www.novachim.fr>
CRITT : <http://www.critt-chimie-paca.com>
- Pôle Chimie Balard : www.polechimie-balard.fr
- Portail de l'industrie – Industries chimiques : www.industrie.gouv.fr/enjeux/chimie/
- Portail cours sup : www.chimie-sup.fr
- REACH - enregistrement, évaluation, autorisation et restriction des produits chimiques : <https://echa.europa.eu/fr/regulations/reach>
- Réseau des Écoles Doctorales de chimie : <http://docteurs-chimie.org>
- Société Chimique de France (SCF) : www.societechimiquedefrance.fr
- Société de Chimie Thérapeutique (SCT) : www.sct-asso.fr
- Union des Industries Chimiques (UIC) : www.uic.fr

metallurgy, and ceramic materials. The FR-SOLARIS research facilities consist of 12 medium-power solar furnaces, a parabolic concentrator, a solar microplant, and a tower concentrator.



PHYSICS AND PHYSICAL CHEMISTRY

- > Scientific research at the Institut Laue-Langevin (ILL) spans a broad range: biology, chemistry, soft matter, basic and nuclear physics, and materials science. ILL remains the world standard neutron source. www.ill.eu
- > The Léon Brillouin Laboratory performs scientific work in the fields of biology, physical chemistry, magnetism and superconductivity, and materials in a broad sense. www-llb.cea.fr
- > FT-ICR, the national network for very-high-field mass spectrometry, represents six French spectrometry labs operating in the fields of health, biology, materials found at heritage sites, analytical and synthetic chemistry, and the environment.
- > A multidisciplinary network of research teams applies very-high-field nuclear magnetic resonance spectrometry to problems in biology, chemistry, physics, space sciences, and medicine, among other areas www.ir-rmn.fr
- > SOLEIL (intermediary energy light source optimized for use in electromagnetic radiation laboratories) is a research platform and a source of extremely bright light. As France's national source of synchrotron radiation, its purpose is to explore matter at various scales. SOLEIL facilitates basic and applied research in physics, chemistry, biology, historic preservation, environment, and space sciences.
- > ESRF (European Synchrotron Radiation Facility) provides high-energy X-rays (10 to 300 keV) to 43 experimental stations (light lines) working in vast array of fields: life sciences, biology and medicine, soft matter sciences, the physical chemistry of materials, environmental sciences, and the preservation of cultural heritage. www.esrf.eu

FRENCH RESEARCH

PORTAL

www.campusfrance.org/en/researcher

A UNIQUE, **ONLINE-ACCESS INFORMATION POINT**
FOR LOCATING RESEARCH PROJECTS



◆ UNDERSTANDING FRENCH RESEARCH

- > Understanding how PhDs operate in France;
- > Knowing how to start and finance a PhD;
- > Applying to international research programs (Hubert Curien Partnerships, *Make Our Planet Great Again*, etc.).



◆ DIRECTORY OF DOCTORAL SCHOOLS

Point of entry for starting a PhD and the 270 doctoral schools organizing and supervising doctoral training.

- > Search by ke-words, regions, and disciplines;
- > Comprehensive information on doctoral schools: Research areas, criteria and points of contacts for admission, welcome mechanisms, proposed topics, current financing, international dimension, and points of contacts for associated research laboratories;
- > Access to fields offered by each doctoral schools.

24 doctoral schools in chemistry accessible at

<https://doctorat.campusfrance.org>

Type «Chemistry» in the search field.



◆ PhD TOPICS, MASTER INTERNSHIPS, AND POST-DOCTORAL POSITIONS:

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- > Offers for Master internships for experience in a research laboratory;
- > Post-doctoral offers for work in French laboratories;
- > A detailed financing mechanism for each research offer (PhD topics, post-docs, and internships).

More than 100 offers made public in chemistry each year, accessible at: <https://doctorat.campusfrance.org/phd/offers>

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