

# CHEMISTRY

2010

“The art of breaking down substances, analyzing them, and recombining them.” That was how the dictionary of the Académie Française, published in 1762, defined chemistry. Today, chemistry plays a part in every field in which matter is subjected to change: aeronautics, agriculture, cosmetics, electronics, materials, metallurgy, and pharmaceuticals, to name just a few. In fact, chemists are so omnipresent in these sectors, in association with practitioners of other disciplines, that chemistry can no longer be distinguished from the sectors themselves.

Chemistry is France’s second-largest manufacturing sector (after automobiles) and the country’s leading export sector, with its numbers continuing to climb. France’s chemical industry (including pharmaceuticals) is the world’s fifth largest, after the United States, Japan, Germany, and China (which recently moved into fourth place). France is the world’s third-largest exporter of chemical and pharmaceutical products.

Chemistry’s applications include fertilizers, plastics, paints, beauty products, adhesives, medications, scents and flavors, and phytosanitary products. Product safety and environmental friendliness are constant preoccupations of today’s chemists.

#### Branches of chemistry:

- Biochemistry: the study of water, carbohydrates, fats, proteins, and nucleic acids.
- Analytical chemistry: chromatography, chemometrics, spectrometry.
- Materials chemistry: metals, polymers, semiconductors, ceramics and glass, biomaterials.
- Inorganic chemistry: organometallic chemistry, coordination chemistry.
- Organic chemistry: petrochemistry, carbon chemistry, polymer chemistry.
- Physical chemistry: thermochemistry, chemical kinetics, electrochemistry, radiochemistry, sonochemistry, spectroscopy.
- Theoretical chemistry: quantum chemistry, digital (or computational) chemistry.

#### Career opportunities:

##### In industry:

- Organic chemistry: carbochemistry, polymer chemistry, chemistry of sugars, biochemistry (immunochemistry, pharmacology), petrochemistry, photochemistry.
- Mineral chemistry: organometallic chemistry, chemistry of clays and zeolites.
- Physical chemistry: nuclear chemistry, the chemistry of combustion and plasma media, the chemistry of surfaces and solutions, electrochemistry.

##### In research:

- Green chemistry: environmental chemistry, geochemistry, phytochemistry.
- Basic research: astrochemistry, atmospheric and upper-atmospheric chemistry, quantum chemistry, digital chemistry.

## ORGANIZATION OF STUDIES IN FRANCE

Because chemistry is central to so many economic sectors, it is the subject of many different programs in French higher education—professionally oriented, academically oriented, and research oriented—in the universities and in schools of engineering.

#### Short programs and professionally oriented programs

Nearly 30 DUT programs (leading to the *diplôme universitaire de technologie*) are offered with 3 different concentrations: chemistry, materials, and industrial automation.

A dozen BTS programs (leading to the *brevet de technicien supérieur*) combine the study of chemistry with biology, quality analysis and control, or aspects of hydrology.

#### Licence

120 programs offered in France’s universities offer multidisciplinary instruction focused on engineering, physics, environmental sciences, materials, chemical processes, or health. More than 40 are *licences professionnelles* that prepare graduates for work in the pharmaceutical and agri-food industries, or in health and quality control.

#### Master

More than 400 programs prepare students for professional work or research in biology, pharmacology, ecology, physics, materials chemistry, engineering, or teaching.

#### Doctorate

Nearly 80 doctoral departments around the country conduct research that combines chemistry with physics, health, environmental sciences, or earth and life sciences. Chemists are key members of basic and applied research teams striving to understand matter or the composition of the universe.

## RESEARCH THEMES

It is impossible to separate research in chemistry from the industrial sectors in which that research is used. In terms of research and development spending, the chemical and pharmaceutical industries top the list in France. Every strategic review of the future of France's chemical industry cites the key role of research, innovation, environmental protection, and sustainability.

### Chemistry of and for living things

Chemists and researchers from the institute of biological sciences of France's national center for scientific research (CNRS) are working together to:

- Discover, understand, and put to use new forms of biosynthesis and biodegradation so as to produce renewable energy from biomass as an alternative to fossil fuels in basic and fine chemistry;
- Diagnose the toxicity of chemical products created for the agri-food industry and for use in biotechnologies, and assess their impact on the environment;
- Refine the vectorization and monitoring of medicines;
- Synthesize tracers for use in medical diagnostics and cellular imaging.

### Green chemistry and sustainable development

Environmental researchers collaborate closely, whether their home discipline is in the humanities, social sciences, life sciences, or environmental sciences. Chemists contribute to that collaboration by seeking new reactions that are:

- Economical in terms of atoms used, steps required, energy consumed, and wastes produced;
- More efficient and selective;
- Safer in the reagents they employ.

Catalysis—adding a substance to a chemical transformation in order to hasten the reaction—is an essential aspect of the new reactions on which green chemistry depends. For that reason, catalytic research is expanding rapidly.

### Functionalization of matter

Chemists have formed new partnerships with physicists and engineers to develop new materials and control their properties. Current priorities in this area are:

- Functional oxides
- Glasses and amorphs
- Fluorochemistry
- Energy materials
- Hybrid materials
- Metallurgical engineering

## INTERNATIONAL RECOGNITION

Among the recipients of the great prizes and honors for research in chemistry (Davy Medal, Nobel Prize in Chemistry, Hudson Prize, Leverhulme Medal) one finds a large number of French chemists—among them François Lecoq de Boisbaudran (discovery of gallium), Louis Paul Cailletet (liquefaction oxygen, hydrogen, and atmospheric air), François-Marie Raoult (general law for the freezing of solutions), Marcellin Berthelot (research on the esterification reaction, heat, the principle of combustion, saponification of fats, and on glycerine), Antoine-Jérôme Balard (discovery of bromine), Henri Becquerel (discovery of and research on spontaneous radioactivity in association with Pierre and Marie Curie), Antoine Lavoisier (law of the conservation of matter, identification and naming of oxygen), and Henri Moissan (isolation of fluorine). It is no exaggeration to state that there is a great tradition of chemical research in France.

Today, the ever-growing internationalization of scientific research is expressed in collaborations among researchers and research organizations on all continents. The institute of chemistry at the CNRS promotes a policy of active international relations and itself participates in many exchange programs (including bilateral workshops and CERC3). The institute also maintains multiple international exchange frameworks such as PICS (international programs for scientific cooperation), LIA (associated international laboratories), GDRI (international research groups), and UMI (international mixed research units).

A number of uniquely French sectors of excellence also find expression through chemistry. Underpinning the restaurant field is research in so-called molecular gastronomy. Developed by Hervé This and a team in the chemistry laboratory at AgroParisTech-INRA in Paris, this new method of studying the phenomena that occur during cooking and other culinary processes has inspired many chefs—among them Ferran Adrià (Catalonia), Heston Blumenthal (England), Pierre Gagnaire, Thomas Keller (United States), and Thierry Marx—while spreading a new “molecular cuisine” of French origin.

## Web sites

- Centre National de la Recherche Scientifique (CNRS, national center for scientific research) : <http://www.cnrs.fr>
- French Research Institute for Exploitation of the Sea (IFREMER) : <http://www.ifremer.fr>
- Institut national de la recherche agronomique (INRA, national agronomic research institute) : <http://www.inra.fr>
- Institut national de la santé et de la recherche médicale (INSERM, national institute of health and medical research) : <http://biblioinsERM.inist.fr>
- Société française de chimie (French chemical society) : <http://www.sfc.fr>
- Manufacturers of medications : <http://www.leem.org>
- Union des Industries Chimiques (chemical industries federation) : <http://www.uic.fr>
- Information and databases in chemistry, pharmaceuticals, and parapharmaceuticals : <http://www.france-chemistry.com>
- Web portal for internationally mobile researchers : <http://www.ec.europa.eu/euraxess>
- Agence Nationale de la Recherche (national research agency) <http://www.agence-nationale-recherche.fr>
- Fondation Alfred Kastler (hosts international researchers in France) : <http://www.fnak.fr>
- Association Bernard Gregory (from dissertation to employment) : <http://www.abg.asso.fr/>
- New regulation of the European Commission on registration, evaluation, authorization, and restriction of chemical substances (June 2007) : [http://ec.europa.eu/enterprise/reach/index\\_fr.htm](http://ec.europa.eu/enterprise/reach/index_fr.htm)

## Keywords

agri-food, analytical chemistry, aromas and scents, atmosphere, biochemistry, bioindustry, biology, cosmetics, electrochemistry, engineering, environment, flavor chemistry, general chemistry, geochemistry, geosciences, health, materials chemistry, microbiology, minerals, modeling, nanochemistry, nuclear, oceanography, optics, organic chemistry, packaging, perfumes, petrochemistry, pharmacology, plastics, polymers, spectrometry, sustainability, synthesis, textiles, water