



## Block calendar/Éphéméride

## Paul Sabatier – The father of the chemical theory of catalysis

Paul Sabatier was the most outstanding chemist in the history of France. He won a noteworthy place in the history of French science because of the outstanding value of his scientific work, which is universally recognized. Sabatier was a French genius who worked hard to reach a superior degree of human perfection. He was defined by high standards of honor. Sabatier is known for his outstanding contributions to the field of catalysis, which had a profound impact on industrial and economic advancements and garnered considerable attention during the twentieth century. Sabatier identified anomalies in Faraday's physical theory and, in response, formulated his own chemical theory, which postulated the formation of unstable intermediaries. His subsequent painstaking work and discovery of the use of finely divided metal hydrogenation catalysts subsequently formed the basis for the margarine, oil hydrogenation, and synthetic methanol industries. He demonstrated the selectivity of catalytic action and the selectivity of catalysts to poisons as well as he introduced the use of supports and demonstrated the resultant enhancement in activity. He also made a close study of catalytic hydration and dehydration, carefully examining the feasibility of specific reactions and the general activity of various catalysts. In 1912, Paul Sabatier won the Nobel Prize in Chemistry for his work on heterogeneous catalysis, specifically his method of hydrogenating organic compounds in the presence of finely disintegrated metals, by which progress in organic chemistry was greatly advanced.

The celebration of the 350th anniversary of the French Academy of Science in 2016 provides the possibility to remember the central life and work of Sabatier, a universal scientist and ubiquitous chemist who gained his fame through patience, sacrifice, hard work, and only by merit of his own strengths.

### 1. Life of Sabatier or one hope of happiness...

Paul Sabatier was born on 5 November 1854 in Carcassonne, a small medieval town with an impressive

fortress near Toulouse in southwestern France. He was the youngest of the seven children of Alexis Sabatier and Pauline Guilhem. He attended primary school in Carcassonne before moving to the "Lycée" in Toulouse in 1868. After one year, he joined the Collège Saint-Marie. He finished his secondary studies at Sainte-Marie, a Catholic high school. In June 1872, after receiving his diplomas as a 'bachelier ès sciences' (bachelor of sciences) and 'bachelier ès lettres' (bachelor of humanities), he departed for Paris to prepare for the entrance examinations to the 'Grandes Écoles' ('École polytechnique' and 'École normale supérieure'). He placed highly in the entrance competitions for both schools; however, he chose the 'École normale supérieure', where Louis Pasteur was teaching chemistry, which he entered in 1874. At the 'École normale', he took courses given by Charles Friedel, Jean Gaston Darboux, Henry Sainte-Claire Deville, and Pierre Auguste Bertin. In 1877, Sabatier graduated first in his class in the competitive national physics 'agrégation' examination (the 'agrégation' is a competitive examination for teaching in high schools), and received his 'license de physique' and 'license de mathématiques' from the 'École normale'. For one year, he taught in Nîmes as a professor of physics at the local school. *Mutatis, mutandis...* Afterward, Louis Pasteur and Marcellin Berthelot each offered him a position as an assistant in their laboratories. In 1878, he chose to become an assistant in the laboratory of Marcellin Berthelot, then at the Collège de France. It is curious that he chose Berthelot, a man who was philosophically opposed to Sabatier's opinions, instead of Pasteur, a practicing Catholic with a philosophy closer to Sabatier's. However, this choice served as the first small step propelling him toward his ultimate accomplishments. In 1880, he received his Doctor of Science ('docteur ès sciences') degree for his work on *The Thermochemistry of Sulfides*, supervised by Berthelot. Sabatier took over responsibility for courses in physics offered by the Faculty of Sciences at Bordeaux until January 1882, when he accepted a similar post at the University of Toulouse. He additionally became responsible for courses in chemistry

in 1883 and was elected Professor of Chemistry in 1884, a post which he retained until his retirement in 1930. He became Dean of the Faculty of Science in 1905, a post which he occupied until 1929. He subsequently remained faithful to Toulouse throughout his entire life, turning down many offers of attractive positions elsewhere, notably including offers to succeed Moissan at the Sorbonne in 1908 and Berthelot at the Collège de France. He retired from his professorship in 1930, after nearly fifty years of uninterrupted service to the Faculty of Science. After his retirement, he continued to lecture until his death in 1941.

### 1.1. *The man sanctifies the place...*

When Sabatier was appointed to Toulouse in 1884, he arrived to find dilapidated premises that were not conducive to scientific work. At that time, such research was effected almost exclusively in Paris. Sabatier decided otherwise, and he created the first research laboratory of the Faculty of Science, which he would facilitate and lead for 55 years. “Consciousness is the glory of self-independence” (A. Plesu). During this time, he achieved his greatest happiness by assuming the three core functions of a university professor: teaching, researching, and managing. At the time of his arrival, the decrepit faculty rooms were said to have looked like an alchemist’s cave. Bunsen burners were rare, and charcoal stoves were used to heat retorts and flasks. Sabatier rearranged basement rooms in the old faculty building to create a larger laboratory for teaching and research, and he acquired new research equipment.

As the Dean of the Faculty of Science, Sabatier was the originator of revolutionary reforms: he created a brainstorming committee that proposed to abandon all encyclopedic education, and, of more personal interest to the students, he required the declaration of a specialization during the second semester of the third year of study. Sabatier received and championed a modern style of education, often with particular focus on applications, as evidenced by his first book, *Elementary Lessons on Agricultural Chemistry*, published in 1890. That same year, he endorsed the periodic table of the elements proposed by Mendeleev.

### 1.2. *To live is to fight (Seneca)*

Furthermore, Toulouse was not a true university at that time since it had only three individual faculties, whereas four were the minimum to be deemed a university. This later changed when Toulouse became one of 17 national universities. Sabatier fought with Jean Jaurès, then the deputy mayor of Toulouse, who was responsible for education issues, to meet this quota to become a university town. In 1896, the University of Toulouse was created. Desiring academic institutions to participate in the social and industrial life of the nation, he successively founded the Chemical Institute in 1906 (which became, in 1953, the ‘École nationale supérieure de chimie de Toulouse’,

ENSCT), the Electrotechnical Institute and the Institute of Applied Mechanics in 1907, and the Agricultural Institute in 1909. These institutes, which issued engineering degrees, became preeminent national schools that are currently part of the National Polytechnic Institute of Toulouse. Dean Sabatier founded these institutes for the training of technicians and foremen and allowed non-graduate students to be admitted. Sabatier knew that “science knows no country” (Louis Pasteur). Finally, engineering students had the opportunity to pursue part of their studies in a foreign country; thanks to exchange programs with American students, students of the Chemical Institute could complete their studies at Harvard, whereas reciprocally, two-thirds of the students of the Chemical Institute were foreigners.

Sabatier was awarded numerous awards and decorations for his scientific work. He was very active in the Toulouse branch of the SCF (‘Société chimique de France’). There he presented his first results on catalysis, in a presentation entitled “Mineral Ferments”, through which he wished to show the similarity among various mechanisms related to the general phenomenon of catalysis. He received the medal of the SCF in 1922. He was an honorary member of the SCF at the same time as Haller and Le Chatellier. In 1955, after the commemoration of the centenary of his birth in November 1954, he was posthumously promoted to honorary president of the SCF.

### 1.3. *At Toulouse, he built a cathedral to science*

Although he was aware that all candidates for the ‘Académie des Sciences’ were required to be residents of Paris, he nevertheless chose to remain at Toulouse (*or the ties that bind*). In 1913, he became the first scientist elected to one of six chairs newly created by the Académie for provincial members. At various times, he was a member of the Academy of Sciences and Letters as a representative of Toulouse (1885), a corresponding member of the Institute (1905), and a non-resident member of the Institute (1913).

Sabatier was a Commander of the Legion of Honor. He was a Doctor of Science, *honoris causa*, of the Universities of Philadelphia (1926), Louvain (1909), Zaragoza (1922), Porto (1923), Liège (1924), and Athens (1937), and an honorary member of the Royal Society of London, the Academy of Madrid, the Royal Netherlands Academy of Sciences, the American Chemical Society, and many other foreign institutions. He was awarded the Lacaze Prize (1897), the Prix Jecker (1905), the Davy Medal (1915) and the Royal Medal (1918) of the Royal Society of London, the Albert Medal of the Royal Society of Arts (1926), and the Franklin Medal of the Franklin Institute (1933). For his method of hydrogenating organic compounds in the presence of finely divided metals, he was awarded the Nobel Prize in Chemistry in 1912.

He was an honorary member and/or president of more than 30 scholarly associations, national commissions and French consulting administrations. He was an Officer of Public Instruction (1889) and an Officer of Agricultural Merit (1913). He was decorated as a Grand Officer of Nichan

Iftikhar (1923), a Commander of the religious order known as the Order of Saint-Jacques of the Sword (1922), a Commander of the Royal Order of Cambodia (1925), a Grand Officer of the Order of the Crown of Italy (March 1936), and a Grand Officer of the Order of the Crown of Yugoslavia (1936). He was also an honorary member or a corresponding member of more than fifteen foreign academies and societies of learning in Spain, Great Britain, the Netherlands, Italy, Belgium, Romania, the United States, Ireland, Sweden, and elsewhere.

## 2. Scientific work or labor omnia vincit improbus

During his doctoral thesis work, Sabatier prepared anhydrous sodium monosulfide and hydrosulfides in the pure state. He established the formula for a hydrated potassium hydrosulfide and showed that a number of alkaline polysulfides that had been described as distinct chemical species were actually mixtures containing free sulfur.

He developed an original method for the preparation of sulfides of calcium, barium, and strontium in the pure state based on passing a stream of hydrogen over the corresponding carbonates heated to live red (approximately 500 °C). He was the first to describe a method for the preparation of pure and crystallized aluminum sulfide by reacting hydrogen sulfide with alumina heated to red heat in a carbon boat. He prepared 'persulphure d'hydrogène' (hydrogen persulfide) and studied its properties, particularly its ability to decompose violently under the influence of light or in the presence of substances that react with it to form unstable combinations. He found that in the presence of water, it formed a rather unstable form of amorphous sulfur, which was insoluble in carbon disulfide, whereas the influence of ether led to the formation of a crystalline variety of sulfur known as 'soufre nacre' (pearl sulfur) or 'soufre de Gerne 3'. He developed a new preparation method for silicon disulfide.

He studied the selenides and was the first to isolate a silicon selenide. He discovered the formation of a non-volatile subselenide of boron.

From 1881 onward, he studied various hydrates of metallic chlorides, determining their heats of hydration, their stability, the possibility of their dehydration under cold conditions, and their reactions with cold concentrated hydrogen chloride. He showed that the absorption of hydrogen chloride into a solution of cupric chloride decreased the solubility of this salt, yielding crystals of hydrated cupric chloride that dissolved in the presence of an additional amount of hydrogen chloride, leading to the formation of complex hydrochlorides. Sabatier was one of the first to use absorption spectroscopy to study hydrates, particularly those of cupric bromide. He observed in 1896 that the reactions of all copper compounds with a nitrosulfuric solution (nitrosulfuric acid), obtained by dissolving nitric acid in sulfuric acid, yielded an intense blue-purple solution because of the reduction of the nitric acid into a new acid, which he named nitrosodisulfonic acid (also known today as nitrososulfonic acid). He developed a

method for the direct synthesis of dark blue nitrososulfonic acid. He proved that nitrososulfonic acid could produce several metallic salts. After Berthelot and Mond in 1891, he also independently succeeded in producing iron carbonyl. Sabatier and his doctoral student Senderens speculated that other unsaturated gaseous molecules, such as nitric oxide, nitrous oxide, nitrogen peroxide, acetylene, and ethylene, could also be fixed on nickel or on reduced iron, yielding well-defined, stable, and volatile products comparable to nickel carbonyl. Sabatier studied the reactions of "incompleted" or "unsaturated" molecules on various metals. Between 1893 and 1894, Sabatier and Senderens succeeded in fixing nitrogen peroxide on copper ( $\text{Cu}_2\text{NO}_2$ ), nickel and iron; they named these compounds "Nitro Metals." They also found that they could produce the major types of natural petroleum by modifying the conditions of the hydrogenation of ethylene, and they achieved the synthesis of methane by hydrogenating carbon dioxide or carbon monoxide.

Sabatier then formulated a chemical theory of catalysis involving intermediate stages consisting of the formation of unstable chemical compounds, which determined the direction and rate of the reaction. He assumed that various nickel hydrides were involved in hydrogenation, whose compositions depended on the activity of the nickel. He found that carefully prepared nickel resulted in very active  $\text{NiH}_2$ , which would act on benzene, whereas impure nickel or nickel prepared at too high a temperature resulted in an impoverished hydride,  $\text{Ni}_2\text{H}_2$ , which was inactive for benzene but acted on ethylenic carbides or nitrate derivatives. Having made certain that Moissan was not thinking of continuing to study the reaction, Sabatier and Senderens repeated the experiment using ethylene instead of acetylene. When a stream of ethylene was applied to nickel, cobalt, or iron that had been freshly reduced, they observed the same results as Moissan and Moureu. However, the gas that exited the apparatus was not hydrogen, but instead consisted mainly of ethane, a saturated molecule. Ethane could arise only from the hydrogenation of ethylene, and this hydrogenation had been induced by the metal. In fact, they found that if a mixture of ethylene and hydrogen was applied to reduced nickel, then ethylene would be hydrogenated into ethane and the same metal could be used indefinitely (June 1897).

Sabatier and Senderens studied the hydrogenation of unsaturated hydrocarbons in depth and then turned to their next challenging problem: the hydrogenation of benzene. Using the same experimental method, they obtained nearly pure cyclohexane in 1901. After these successes, Sabatier was absolutely confident of the general nature of the experimental method they were using, stating its principle as follows: "Vapor of the substance, together with an excess of hydrogen, is directed on to freshly reduced nickel held at a suitable temperature (between 150° and 200 °C)."

After 1901, Sabatier proceeded from one type of reaction to another, transforming unsaturated or functionalized

compounds into saturated or newly functionalized ones. Among these reactions, two were of particular interest: the transformation of water gas, the domestic gas used at that time, which contained small quantities of toxic carbon monoxide, into a completely nontoxic gas and the production of the major types of natural petroleum (Pennsylvanian, Romanian, Galician, and Baku) by modifying the conditions for the hydrogenation of acetylene. In addition to studying hydrogenation and other catalytic reactions, Sabatier demonstrated the reversibility of the catalytic process, namely, that the same catalyst can be used for both the direct and reverse reactions (hydrogenation and dehydrogenation). One of his most important contributions to the development of catalysis was his hypothesis regarding this phenomenon: “Powdered nickel is comparable in every way with a ferment and, as in the case of the living organism which constitutes ferments, infinitesimal doses of certain substances are sufficient to attenuate and even suppress altogether their functional activities.”

Sabatier was the father of the chemical theory of catalysis. According to his theory, during catalysis, a temporary unstable intermediate between the catalyst and one of the reactants forms on the surface of the catalyst. Since nickel is absolutely necessary for combining acetylene and hydrogen, it can be assumed that the nickel begins by attracting the hydrogen, but the capricious hydrogen soon breaks from the metal to join with the acetylene.

In 1912, Sabatier was awarded the Nobel Prize in Chemistry for his method of hydrogenating organic compounds in the presence of finely divided metals, which led to great progress in organic chemistry.

Sabatier's discoveries lie at the root of most of the largest chemical industries of today: almost all commercially produced chemicals involve catalysis at some stage of the process of their manufacture (e.g., petroleum treatment, petrochemicals, chemical synthesis, synthetic fuels, fat hydrogenation). The same principles outlined by Sabatier also apply in the ubiquitous automotive catalytic converter, which breaks down some of the more harmful byproducts of automotive exhaust. Nanotechnology and nanoparticles represent a new frontier in catalysis because the total surface area of a solid has an important effect on its catalytic reaction rate. An example is the synthesis of fuels from carbon dioxide and hydrogen. At the beginning of the twentieth century, Sabatier developed a process using a catalyst that reacts with carbon dioxide and hydrogen to produce methane and water. This reaction provides a means of producing water from the byproducts of the current life-support systems onboard the International Space Station and, thus, a way to produce water without the need to transport it from Earth. A system based on this principle was integrated into the station's water recovery system in October 2011. The six-astronaut crew aboard the ISS now uses water synthesized via this reaction. The hydrogen used is a waste product of the oxygen generation system; carbon dioxide is generated by the crew's metabolisms and released through respiration. The generated water is retained, whereas methane is vented

outside of the space station. This “Sabatier Reaction System” can produce as much as 2500 liters of water per year.

Sabatier and Espil made the interesting discovery that after being used to hydrogenate nitrobenzene, nickel poisoned by chlorine recovers its ability to hydrogenate benzene. With Mailhe, another of his doctoral students, Sabatier found that certain metal oxides were catalysts not for hydrogenation and dehydrogenation, but instead for hydration and dehydration. They also observed that amorphous oxides were more active catalysts for dehydrogenation or dehydration than crystalline oxides, with the calcination of the latter at temperatures higher than 500 °C leading to marked agglomeration. This was the first observed example of sintering effects, which were later exploited to graduate the activity of catalysts.

### 2.1. To work gives man freedom...

Sabatier's scientific work was extensive; in addition to large numbers of speeches and reports as well as eight patents, he published over 250 scientific memoirs and his famous book *La catalyse en chimie organique* (1913), which saw a second edition in 1920, of which an English translation by E.E. Reid was published in 1923, in addition to *Leçons élémentaires de chimie agricole* (1890), and he collaborated on several major works, such as *L'Encyclopédie* with Edmond Frémy (1814–1894), *Dictionnaire de chimie* with Charles-Adolph Würtz (1817–1884), and *Chimie minérale* with Moissans. *La catalyse en chimie organique* was first published in 1913; this book on catalysis marks a milestone in the evolution of modern chemistry and is still widely quoted today.

Paul Sabatier was a very reserved man. He married M<sup>lle</sup> Herail, and they had four daughters, one of whom married the Italian chemist Emilio Pomilio. He was fond of art and gardening. Educated in science and philosophy, he was open to any form of art: he was a painter of some talent, and he even had a musical gift, which allowed him to improvise on the piano. He had the spirit of an encyclopedist. He also loved literature and poetry. In 1909, he was elected a member of the Academy of the Floral Games in Toulouse, an ancient literary and dramatic institution founded in 1323.

### 2.2. Because of life's challenges, happiness has worth (Mother Teresa)

Is death the final consequence of entropy? Even a man such as Sabatier passed away in Toulouse in August of 1941, at the age of 87. Sabatier remained eternal because “To create by hard work is to live twice” (A. Camus). He was defined by high standards of honor.

### 2.3. Sabatier – the Sanctus Sanctorum

In memoriam, on 12, October 2012, a museum dedicated to Paul Sabatier was inaugurated in the library of the ‘École nationale supérieure des industries et arts chimiques’, Toulouse.

## References

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## November

NOVEMBER	MEMBERS OF THE FRENCH ACADEMY OF SCIENCES
1	<p><b>Navier, Pierre Toussaint</b> (1 November 1712–16 July 1779), French medical doctor.</p> <p><b>Oehlert, Daniel Victor</b> (1 November 1849–17 September 1920), French scientist.</p> <p><b>Daniel, Lucien Louis</b> (1 November 1856–26 December 1940), French botanist.</p> <p><b>Colin, Henri Ernest</b> (1 November 1880–21 March 1943), French clergyman and physiologist.</p> <p><b>Portevin, Albert Marcel Germain René</b> (1 November 1880–12 April 1962), French metallurgist.</p> <p><b>Beer, Gavin Rylands de</b> (1 November 1899–21 June 1972), British evolutionary embryologist.</p>
2	<p><b>Périer, Jacques Constantin</b> (2 November 1742–16 August 1818), French engineer.</p> <p><b>Serullas, Georges Simon</b> (2 November 1774–25 May 1832), French pharmacist.</p> <p><b>Malleman, René Jean Gérard Henri de</b> (2 November 1885–8 December 1969), French physicist.</p> <p><b>Shapley, Harlow</b> (2 November 1885–20 October 1972), American astronomer.</p> <p><b>Halpern, Bernard Naftali</b> (2 November 1904–23 September 1978), French immunologist.</p> <p><b>Edlén, Bengt</b> (2 November 1906–10 February 1993), Swedish physicist and astronomer.</p>
3	<p><b>Huzard, Jean-Baptiste</b> (3 November 1755–1 December 1838), French veterinarian.</p> <p><b>Petit, Marc-Antoine</b> (3 November 1766–7 July 1811), French surgeon.</p> <p><b>Warming, Johannes Eugenius Bülow</b> (3 November 1841–2 April 1924), Danish botanist.</p> <p><b>Tian, Albert</b> (3 November 1880–18 July 1972), French chemist.</p> <p><b>Colonetti, Gustavo</b> (3 November 1886–20 March 1968), Italian mathematician.</p> <p><b>Janot, Maurice-Marie</b> (3 November 1903–10 December 1978), French chemist, biologist and pharmacist.</p> <p><b>Roseau, Maurice</b> (3 November 1925–16 April 2015), French mathematician.</p>
4	<p><b>Argenson, Marc-René de Voyer de Paulmy</b> (4 November 1652–8 May 1721), French politician.</p> <p><b>Tressan, Vergne Louis-Élisabeth de la</b> (4 November 1705–31 October 1783), French physicist.</p> <p><b>Magalhães, Joao Jacinto de</b> (4 November 1722–7 February 1790), Portuguese scientist.</p> <p><b>Lescallier, Daniel</b> (4 November 1743–14 May 1822), French Maritime administrator, Maritime Prefect, Colonial prefect, Governor, and Consul General.</p> <p><b>Girard, Pierre Simon</b> (4 November 1765–30 November 1836), French physicist and engineer.</p>
5	<p><b>Du Petit-Thouars, Louis Marie Aubert-</b> (5 November 1758–12 May 1831), French botanist.</p> <p><b>Sabatier, Paul</b> (5 November 1854–14 August 1941), French chemist and Nobel laureate (1912).</p> <p><b>Bort, Léon Teisserenc de</b> (5 November 1855–2 January 1913), French meteorologist.</p>

(continued)

NOVEMBER	MEMBERS OF THE FRENCH ACADEMY OF SCIENCES
	<b>Tiffeneau, Marc</b> (5 November 1873–1945), French chemist, pharmacist and medical doctor. <b>Léauté, André Pierre Marcel</b> (5 November 1882–12 December 1966), French physicist and engineer. <b>Turpin, Raymond Alexandre</b> (5 November 1895–24 May 1988), French pediatrician and geneticist.
6	<b>Andral, Gabriel</b> (6 November 1797–13 February 1876), French pathologist. <b>Teisserenc de Bort, Philippe Léon</b> (6 November 1855–2 January 1913), French meteorologist. <b>Pluvinel, Aymar Eugène de La Baume</b> (6 November 1860–18 July 1938), French astronomer. <b>Prianichnikov, Dimitri Nicolaïevitch</b> (6 November 1865–30 April 1948), Russian scientist. <b>Decaux, Bernard François</b> (6 November 1899–8 February 1981), French physicist. <b>Kotlyakov, Vladimir Mikhaïlovitch</b> (6 November 1931), Russian geographer. <b>Herman, Michaël Robert</b> (6 November 1942–2 November 2000), French American mathematician. <b>Lafforgue, Laurent</b> (6 November 1966), French mathematician.
7	<b>Lagny, Thomas Fantet de</b> (7 November 1660–11 April 1734), French mathematician. <b>Kowalesky, Alexandre Onoufrievich</b> (7 November 1840–9 November 1901), Russian embryologist. <b>Dastre, Albert Jules Frank</b> (7 November 1844–22 October 1917), French medical doctor. <b>Tiffeneau, Marc Émile Pierre Adolphe</b> (7 November 1873–20 May 1945), French chemist. <b>Raman, Chandrasekhara Ventaka</b> (7 November 1888–21 November 1970), Indian physicist and Nobel laureate (1930). <b>Roy, Paul Mary Ferdinand Maurice</b> (7 November 1899–23 June 1985), French physicist. <b>Coulomb, Jean Marie François Joseph</b> (7 November 1904–26 February 1999), French Geophysicist. <b>Leray, Jean</b> (7 November 1906–10 November 1998), French mathematician.
8	<b>Krusenstern, Adam Ivan de</b> (8 November 1770–12 August 1846), Russian explorer and admiral. <b>Berthelot, Paul Alfred Daniel</b> (8 November 1865–8 March 1927), French biologist and physicist. <b>Esnault-Pelterie, Robert Albert Charles</b> (8 November 1881–6 December 1957), French inventor and aeronautical engineer. <b>Curasson, Georges Maurice Charles</b> (8 November 1889–23 October 1970), French veterinarian. <b>Pomey, Jacques</b> (8 November 1897–5 September 1971), French engineer. <b>Barbier, Reynold</b> (8 November 1913–10 February 2001), French geologist.
9	<b>Dupont de Jumeaux, Jacob Louis</b> (9 November 1755–27 October 1823), French intellectual. <b>Rogniat, Joseph, vicomte de</b> (9 November 1776–9 May 1840), French general. <b>Wolf, Charles Joseph Étienne</b> (9 November 1827–4 July 1918), French astronomer. <b>Blakeslee, Albert Francis</b> (9 November 1874–18 November 1954), American botanist. <b>Mayer, André</b> (9 November 1875–27 May 1956), French biologist. <b>Weyl, Hermann</b> (9 November 1885–8 December 1955), German mathematician. <b>Tréfour, Jacques Gustave Marie</b> (9 November 1897–11 July 1977), French chemist. <b>Mayer, Jean</b> (9 November 1920–1 January 1993), French-American scientist. <b>Slonimski, Piotr</b> (9 November 1922–25 April 2009), French biologist.
10	<b>La Galissonnière, Roland-Michel Barin de</b> (10 November 1693–26 October 1756), French officer. <b>Tillet, Mathieu</b> (10 November 1714–13 December 1791), French botanist and agronomer. <b>Ferrner, Bengt</b> (10 November 1724–18 November 1802), Swedish astronomer. <b>Rio, Andres Manuel del</b> (10 November 1765–23 March 1849), Spanish-Mexican scientist. <b>Quoy, Jean René Constant</b> (10 November 1790–4 July 1869), French naval surgeon. <b>Brøgger, Waldemar Christofer</b> (10 November 1851–17 February 1940), Norwegian geologist and mineralogist. <b>Baillaud, René</b> (10 November 1885–2 July 1977), French astronomer. <b>Legendre, Robert Georges</b> (10 November 1907–27 April 1994), French engineer.
11	<b>Müller, Gerhard Friedrich</b> (11 November 1705–11 October 1783), Russian-German historian and pioneer ethnologist. <b>Bourgelat, Claude</b> (11 November 1712–3 January 1779), French veterinary surgeon. <b>Bougainville, Louis-Antoine de</b> (11 November 1729–31 August 1811), French officer. <b>Thunberg, Carl Peter</b> (11 November 1743–8 August 1828), Swedish naturalist. <b>Clouet, Jean-François</b> (11 November 1751–4 June 1801), French chemist. <b>Van Mons, Jean-Baptiste</b> (22 November 1765–1842), Belgian chemist and botanist. <b>Margerie, Emmanuel Marie Pierre Martin Jacquin de</b> (11 November 1862–24 December 1953), French intellectual. <b>Laubry, Charles</b> (11 November 1872–11 August 1960), French medical doctor. <b>Gibbs, Martin</b> (11 November 1922–24 July 2006), American biochemist.
12	<b>Bougainville, Louis-Antoine de</b> (12 November 1729–31 August 1811), French officer. <b>Charles, Jacques Alexandre César</b> (12 November 1746–7 April 1823), French chemist, physicist and inventor. <b>Rollet, Martin Pierre Joseph</b> (12 November 1824–2 August 1894), French medical doctor and surgeon. <b>Méray, Hughes Charles Robert</b> (12 November 1835–2 February 1911), French mathematician. <b>Rayleigh, John William Strutt</b> (12 November 1842–30 June 1919), English physicist and Nobel laureate (1904). <b>Yermolov, Alexis Sergeevitch</b> (12 November 1847–4 January 1917), Russian scientist. <b>Skobeltzyne, Dmitry Vladimirovitch</b> (12 November 1892–16 November 1990), Russian intellectual.
13	<b>Plana, Giovanni Antonio Amedeo</b> (13 November 1781–20 January 1864), Italian astronomer. <b>Tillo, Alexis Andreevitch de</b> (13 November 1839–30 December 1899), Russian geographer. <b>Albert I, Honoré Charles Grimaldi</b> (13 November 1848–26 June 1922), Prince of Monaco and Duke of Valentinois and oceanographer. <b>Agid, Yves</b> (13 November 1940), French scientist. <b>Salençon, Jean</b> (13 November 1940), French physicist.
14	<b>Du Petit-Vendin, Robert Xavier Ansart</b> (14 November 1713–1 February 1789), French officer. <b>Villars, Dominique</b> (14 November 1745–20 June 1814), French botanist <b>Dietrich, Philippe Frédéric de</b> (14 November 1748–28 December 1793), French scientist.

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NOVEMBER	MEMBERS OF THE FRENCH ACADEMY OF SCIENCES
	<p><b>Dutrochet, René Joachim Henri</b> (14 November 1776–4 February 1847), French medical doctor and botanist.  <b>Lyell, Charles</b> (14 November 1797–20 January 1862), British geologist.  <b>Laurent, Augustin</b> (14 November 1807–15 April 1853), French engineer.  <b>Pierre, Joachim Isidore</b> (14 November 1812–7 November 1881), French chemist.  <b>Freycinet, Louis Charles de Saulces de</b> (14 November 1828–14 May 1923), French engineer.  <b>Engelmann, Theodor Wilhelm</b> (14 November 1843–20 May 1909), German botanist and microbiologist.  <b>Sedov, Leonid</b> (14 November 1907–5 September 1999), Soviet physicist.  <b>Mandel, Paul</b> (14 November 1908–6 October 1992), French biochemist and medical doctor.  <b>Grivet, Pierre Auguste</b> (14 November 1911–1 June 1992), French physicist and engineer.</p>
15	<p><b>Klinkenberg, Dirk</b> (15 November 1709–3 May 1799), Dutch mathematician.  <b>Baer, Frédéric Charles</b> (15 November 1719–23 April 1797), French intellectual.  <b>Gouan, Antoine</b> (15 November 1733–1 September 1821), French naturalist.  <b>Herschel, Friedrich Wilhelm</b> (15 November 1738–25 August 1822), British astronomer.  <b>Fossombroni, Vittorio</b> (15 November 1754–13 April 1844), Italian mathematician, economist and engineer.  <b>Charles, Michel</b> (15 November 1793–18 December 1880), French mathematician.  <b>Racoviță, Emil G.</b> (15 November 1868–17 November 1947), Romanian biologist and zoologist  <b>Tschermak von Seysenegg, Erich</b> (15 November 1871–11 October 1962), Austrian agronomist.  <b>Hulubei, Horia</b> (15 November 1896–22 November 1972), Romanian physicist.  <b>Bessis, Marcel</b> (15 November 1917–28 March 1994), French medical doctor.  <b>Rich, Alexander</b> (15 November 1924–27 April 2015), American biologist and biophysicist.  <b>Le Gall, Jean-François</b> (15 November 1959), French mathematician.</p>
16	<p><b>Belgrado, Jacques</b> (16 November 1704–26 March 1789), Italian mathematician.  <b>D'Alembert, Jean le Rond</b> (16 November 1717–29 October 1783), French mathematician.  <b>Chanonier, Jean</b> (16 November 1746–29 May 1806), French agronomer.  <b>Rogniat, Joseph</b> (16 November 1776–9 May 1840), French general.  <b>Girardin, Jean Pierre Louis</b> (16 November 1803–30 May 1884), French chemist.  <b>Amser, Jacob</b> (16 November 1823–3 January 1912), Swiss physicist, mathematician and engineer.  <b>Beltrami, Eugenio</b> (16 November 1835–18 February 1900), Italian mathematician.  <b>Violle, Louis Jules Gabriel</b> (16 November 1841–12 September 1923), French physicist.  <b>Warnecke, Robert Raymond</b> (16 November 1906–26 June 1977), French physicist.  <b>Monier, Roger</b> (16 November 1924–14 September 2008), French biologist.  <b>Jouvet, Michel</b> (16 November 1925), French neurobiologist.</p>
17	<p><b>Lémery, Nicolas</b> (17 November 1645–19 June 1715), French chemist.  <b>Alembert, Jean Le Rond d'</b> (17 November 1717–29 October 1783), French mathematician.  <b>Valmont de Bomare, Jacques-Christophe</b> (17 November 1731–24 August 1807), French naturalist.  <b>Laval, Guy</b> (17 November 1935), French physicist.  <b>Lebeau, Gilles</b> (17 November 1954), French mathematician.</p>
18	<p><b>Bayle, Pierre</b> (18 November 1647–28 November 1706), French philosopher and writer.  <b>Gray, Asa</b> (18 November 1810–30 January 1888), American botanist.  <b>Boscha, Johannes</b> (18 November 1831–15 April 1911), Dutch physicist.  <b>Nordenskiöld, Nils Adolf Erik</b> (18 November 1832–12 August 1901), Finnish and Swedish geologist, mineralogist and Arctic explorer.  <b>Richard, Jules</b> (18 November 1863–24 January 1945), French intellectual.  <b>Blackett, Patrick Maynard Stuart</b> (18 November 1897–13 July 1974), British physicist.  <b>Jeanmart, Claude</b> (18 November 1933–6 June 2010), French chemist.  <b>Pisier, Gilles</b> (18 November 1950), French mathematician.</p>
19	<p><b>Chaillou, Antoine-Jean Amelot de</b> (19 November 1732–20 April 1795), French politician.  <b>Vilmorin, Pierre Philippe André Levéque de</b> (19 November 1776–21 March 1862), French botanist.  <b>Lesseps, Ferdinand Marie de</b> (19 November 1805–7 December 1894), French diplomat.  <b>Jurien de La Gravière, Jean-Pierre Edmond</b> (19 November 1812–5 March 1892), French admiral.  <b>Czerny, Vincent-Joseph</b> (19 November 1842–3 October 1916), German-Czech surgeon.  <b>Riquier, Charles Edmond Alfred</b> (19 November 1853–17 January 1929), French mathematician.  <b>Ferrié, Gustave Auguste</b> (19 November 1868–16 February 1932), French radio pioneer and army general.  <b>Lavrentiev, Mikhail Alesievitch</b> (19 November 1900–15 October 1980), Soviet mathematician.</p>
20	<p><b>Hellot, Jean</b> (20 November 1685–15 February 1766), French chemist.  <b>Le Monnier, Pierre-Charles</b> (20 November 1715–3 April 1799), French astronomer.  <b>La Faille, Clément de</b> (20 November 1718–4 June 1782), French naturalist.  <b>Bourgoing, Jean-François de</b> (20 November 1748–20 July 1811), French diplomat.  <b>Latreille, Pierre-André</b> (20 November 1762–6 February 1833), French entomologist.  <b>Hubble, Edwin Powell</b> (20 November 1889–28 September 1953), American astronomer.</p>
21	<p><b>Norbec, Étienne Benjamin Texier de</b> (21 November 1724–20 January 1797), French scientist.  <b>Alzate y Ramirez, Joseph Antonio de</b> (21 November 1738–2 February 1799), Mexican scientist.  <b>Chauveau, Jean-Baptiste Auguste</b> (21 November 1827–4 January 1817), French medical doctor and anatomist.  <b>Francotte, Charles Joseph Polydore</b> (21 November 1851–21 April 1916), Belgian medical doctor.  <b>Riollet, Gilbert Jacques Henri</b> (21 November 1927–31 October 1993), French engineer.</p>
22	<p><b>Voyer, Antoine-René de</b> (22 November 1722–13 August 1787), French diplomat.  <b>Néel, Louis Eugène Félix</b> (22 November 1904–17 November 2000), French physicist and Nobel laureate (1970).</p>

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NOVEMBER	MEMBERS OF THE FRENCH ACADEMY OF SCIENCES
	<b>Ruffié, Jacques</b> (22 November 1921–1 July 2004), French hematologist, geneticist and anthropologist. <b>Léna, Pierre</b> (22 November 1937), French astrophysicist.
23	<b>Darquier, Augustin de Pellepoix</b> (23 November 1718–18 January 1802), French astronomer. <b>Kokscharow, Nicolas</b> (23 November 1818–21 December 1892), Soviet scientist. <b>Van der Waals, Johannes Diderick</b> (23 November 1837–8 March 1923), Dutch theoretical physicist and Nobel laureate (1910). <b>Dangeard, Pierre Clément Augustin</b> (23 November 1862–10 November 1947), French botanist. <b>Laubeuf, Alfred Maxime</b> (23 November 1864–23 December 1939), French engineer. <b>Antoine, Louis Auguste</b> (23 November 1888–8 February 1971), French mathematician. <b>Moras, Dino</b> (23 November 1944), French biochemist.
24	<b>Maldonado, Pedro Vicente</b> (24 November 1704–17 November 1748), South-American scientist. <b>Hell, Ignace Xavier Hommaire de</b> (24 November 1812–29 August 1848), French engineer. <b>Hannover, Adolf</b> (24 November 1814–7 July 1894), Danish doctor. <b>Roussy, Gustave</b> (24 November 1874–30 September 1948), Swiss-French neurologist, neuropathologist and oncologist. <b>Joret, François Louis Georges Jules</b> (24 November 1884–27 June 1966), French agronomer.
25	<b>Séguier, Jean-François</b> (25 November 1703–1 September 1784), French botanist. <b>Dagelet, Joseph Le Paute</b> (25 November 1751–1788), French astronomer. <b>Mathieu, Claude Louis</b> (25 November 1783–5 March 1875), French astronomer. <b>Mayer, Julius Robert von</b> (25 November 1814–20 March 1878), German physicist. <b>Baccelli, Jacques</b> (25 November 1832–10 January 1916), French scientist. <b>Jumelle, Henri Lucien</b> (25 November 1866–6 December 1935), French botanist. <b>Cantacuzino, Ioan</b> (25 November 1863–14 January 1934), Romanian physicist and bacteriologist.
26	<b>Mairan, Jean-Jacques Dortous de</b> (26 November 1678–20 February 1771), French mathematician. <b>Read, Jacques Philippe Joseph</b> (26 November 1738–12 March 1803), French intellectual. <b>Wurtz, Charles Adolphe</b> (26 November 1817–12 May 1884), French chemist. <b>Maige, Louis Albert</b> (26 November 1872–29 November 1943), French intellectual. <b>Lindblad, Bertil</b> (26 November 1895–25 June 1965), Swedish astronomer. <b>Bombieri, Enrico</b> (26 November 1940), Italian mathematician.
27	<b>Aguesseau, Henri-François d'</b> (27 November 1668–9 February 1751), French magistrate. <b>Euler, Johann Albrecht</b> (27 November 1734–17 September 1800), Swiss-Russian astronomer and mathematician. <b>Rowland, Henry Augustus</b> (27 November 1848–16 April 1901), American physicist. <b>Sherrington, Charles</b> (27 November 1857–4 March 1952), English neurophysiologist and Nobel laureate (1932). <b>Grassé, Pierre-Paul</b> (27 November 1895–9 July 1985), French zoologist. <b>Couder, André</b> (27 November 1897–16 January 1979), French engineer and astronomer. <b>Howell, Francis Clark</b> (27 November 1925–10 March 2007), American anthropologist.
28	<b>Pézénas, le P. Esprit</b> (28 November 1692–4 February 1776), French mathematician and astronomer. <b>Ridolfi, Cosimo</b> (28 November 1794–5 March 1865), Italian agronomer. <b>Colin, Édouard Élie</b> (28 November 1852–10 April 1923), French astronomer. <b>Scott, Dukinfield Henry</b> (28 November 1854–29 January 1934), British botanist. <b>Andrussow, Leonid</b> (28 November 1896–15 December 1988), German chemist. <b>Véron, Marcel Charles</b> (28 November 1900–23 August 1984), French scientist.
29	<b>La Chambre, Marin Cureau de</b> (29 November 1596–29 November 1669), French physicist. <b>Latreille, Pierre André</b> (29 November 1762–6 February 1833), French zoologist. <b>Piobert, Guillaume</b> (29 November 1793–9 June 1871), French scientist. <b>Verneuil, Aristide Auguste Stanislas</b> (29 November 1823–11 June 1895), French physicist and surgeon. <b>Charcot, Jean Martin</b> (29 November 1825–16 August 1893), French neurologist. <b>Peron, Pierre Alphonse</b> (29 November 1834–2 July 1908), French paleontologist. <b>Benoît, Justin Miranda René</b> (29 November 1844–5 May 1922), French physicist. <b>Greenhill, Alfred George</b> (29 November 1847–10 February 1927), British mathematician. <b>Hadfield, Robert Abbott</b> (29 November 1858–30 September 1940), English metallurgist. <b>Brown, Ernest William</b> (29 November 1866–22 July 1938), British mathematician. <b>Fauré-Fremiet, Emmanuel</b> (29 November 1883–6 November 1971), French zoologist. <b>Malissen, Bernard</b> (29 November 1953), French biologist.
30	<b>Estrées, Victor-Marie d'</b> (30 November 1660–27 December 1737), French soldier. <b>Duméril, Auguste Henri André</b> (30 November 1812–12 November 1870), French zoologist. <b>Chatin, Gaspard Adolphe</b> (30 November 1813–4 July 1901), French botanist. <b>Pringsheim, Nathanaël</b> (30 November 1823–6 October 1894), German botanist. <b>Zeuner, Gustav Anton</b> (30 November 1828–17 October 1907), German physicist. <b>Adrian of Cambridge, Edgar Douglas</b> (30 November 1889–4 August 1977), English electrophysiologist and Nobel laureate (1932). <b>Aubréville, André Marie Alphonse</b> (30 November 1897–11 August 1982), French botanist. <b>Pochon, Jacques</b> (30 November 1907–7 February 1978), French scientist. <b>Jarvik, Erik Anders Vilhelm</b> (30 November 1907–11 January 1998), Swedish palaeozoologist. <b>Flower, William Henry</b> (30 November 1931–1 July 1899), English anatomist and surgeon.