

# Nicolas Bourbaki

**Nicolas Bourbaki** is the collective pseudonym of a group of mathematicians, predominantly French alumni of the École normale supérieure (ENS). Founded in 1934–1935, the **Bourbaki group** originally intended to prepare a new textbook in analysis. Over time the project became much more ambitious, growing into a large series of textbooks published under the Bourbaki name, meant to treat modern pure mathematics. The series is known collectively as the *Éléments de mathématique* (*Elements of Mathematics*), the group's central work. Topics treated in the series include set theory, abstract algebra, topology, analysis, Lie groups and Lie algebras.

Bourbaki was founded in response to the effects of the First World War which caused the death of a generation of French mathematicians; as a result, young university instructors were forced to use dated texts. While teaching at the University of Strasbourg, Henri Cartan complained to his colleague André Weil of the inadequacy of available course material, which prompted Weil to propose a meeting with others in Paris to collectively write a modern analysis textbook. The group's core founders were Cartan, Claude Chevalley, Jean Delsarte, Jean Dieudonné and Weil; others participated briefly during the group's early years, and membership has changed gradually over time. Although former members openly discuss their past involvement with the group, Bourbaki has a custom of keeping its current membership secret.

The group's namesake derives from the 19th century French general Charles-Denis Bourbaki,<sup>[3]</sup> who had a career of successful military campaigns before suffering a dramatic loss in the Franco-Prussian War. As a result, Bourbaki's name became known to early 20th century French students. Weil remembered an ENS student prank in which an upperclassman posed as a professor and presented a "theorem of Bourbaki"; the name was later adopted.

The Bourbaki group holds regular private conferences for the purpose of drafting and expanding the *Éléments*. Topics are assigned to subcommittees, drafts are debated, and unanimous agreement is required before a text is deemed fit for publication. Although slow and labor-intensive, the process

## Association of Collaborators of Nicolas Bourbaki

Association des collaborateurs de Nicolas Bourbaki



Bourbaki congress at Dieulefit in 1938. From left, Simone Weil,<sup>[a]</sup> Charles Pisot, André Weil, Jean Dieudonné (sitting), Claude Chabauty, Charles Ehresmann, and Jean Delsarte.<sup>[2]</sup>

<b>Named after</b>	Charles-Denis Bourbaki
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results in a work which meets the group's standards for rigour and generality. The group is also associated with the Séminaire Bourbaki, a regular series of lectures presented by members and non-members of the group, also published and disseminated as written documents. Bourbaki maintains an office at the ENS.

Nicolas Bourbaki was influential in 20th century mathematics, particularly during the middle of the century when volumes of the *Éléments* appeared frequently. The group is noted among mathematicians for its rigorous presentation and for introducing the notion of a mathematical structure, an idea related to the broader, interdisciplinary concept of structuralism.<sup>[4][5][6]</sup> Bourbaki's work informed the New Math, a trend in elementary math education during the 1960s. Although the group remains active, its influence is considered to have declined due to infrequent publication of new volumes of the *Éléments*. However the collective's most recent publication appeared in 2016, treating algebraic topology.

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<b>Formation</b>	10 December 1934 (first unofficial meeting) 10-17 July 1935 (first official, founding conference)
<b>Founders</b>	Henri Cartan Claude Chevalley Jean Coulomb Jean Delsarte Jean Dieudonné Charles Ehresmann Szolem Mandelbrojt René de Possel André Weil
<b>Founded at</b>	Latin Quarter, Paris, France (first unofficial meeting) Besse-en-Chandesse, France (first official, founding conference)
<b>Type</b>	Voluntary association
<b>Purpose</b>	Publication of textbooks in pure mathematics

Praise  
Criticism

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## Background



Charles-Denis Bourbaki, 19th century general and namesake of the collective

Charles-Denis Sauter Bourbaki was born on 22 April 1816 in Pau, France, to a family of Greek origin. He became a successful general during the era of Napoleon III, serving in the Crimean War and other conflicts. During the Franco-Prussian war however, Charles-Denis Bourbaki suffered a major defeat. At the time of the Siege of Metz, he was lured to Britain on false pretenses of a peace conference, and upon return to the continent he was tasked with lifting the Siege of Belfort, an effort which failed. Charles-Denis Bourbaki was forced to retreat with his army—the Armée de l'Est—across the Swiss border. The force was disarmed by the Swiss, and the general unsuccessfully attempted suicide. Charles-Denis Bourbaki later died on 27 September 1897, and the dramatic story of his defeat entered the French consciousness.<sup>[7][8]</sup>

In the early 20th century, the First World War affected Europeans of all professions and social classes, including mathematicians and male students who fought and died in the front. For example, the French mathematician Gaston Julia, a pioneer in the study of fractals, lost his nose during the war and wore a leather strap over the affected part of his face for the rest of his life. The deaths of ENS students resulted in a lost generation in the French mathematical community; the estimated proportion of ENS mathematics students (and French students generally) who died in the war ranges from one-quarter to one-half, depending on the intervals of time (circa 1900-1918, especially 1910-1916) and populations considered.<sup>[9][10]</sup> Furthermore, Bourbaki founder André Weil remarked in his memoir *Apprenticeship of a Mathematician* that France and Germany took different approaches with their intellegentsia during the

war: while Germany protected its young students and scientists, France instead committed them to the front, owing to the French culture of

<b>Headquarters</b>	École Normale Supérieure, Paris
<b>Membership</b>	Confidential
<b>Official language</b>	French
<b>Website</b>	<span>www.bourbaki.ens.fr</span> ( <span>http://www.bourbaki.ens.fr/</span> )
<b>Formerly called</b>	Committee for the Treatise on Analysis

egalitarianism.<sup>[11]</sup>

A succeeding generation of mathematics students attended the ENS during the 1920s, including Weil and others, the future founders of Bourbaki. During his time as a student, Weil recalled a prank in which an upperclassman, Raoul Husson<sup>[fr]</sup>, posed as a professor and gave a math lecture, ending with a prompt: "Theorem of Bourbaki: you are to prove the following...". Weil was also aware of a similar stunt in which a student claimed to be from the fictional, impoverished nation of "Poldevia" and solicited the public for donations.<sup>[12][13]</sup> Weil had strong interests in languages and Indian culture, having learned Sanskrit and read the Bhagavad Gita.<sup>[14][15]</sup> After graduating from the ENS and obtaining his doctorate, Weil took a teaching stint at the Aligarh Muslim University in India. While there, Weil met the mathematician Damodar Kosambi, who was engaged in a power struggle with one of his colleagues. Weil suggested that Kosambi write an article with material attributed to one "Bourbaki", in order to show off his broad knowledge to the colleague. Kosambi took the suggestion, attributing the material discussed in the article to "the little-known Russian mathematician **D. Bourbaki**, who was poisoned during the Revolution." It was the first article in the mathematical literature with material attributed to the eponymous "Bourbaki".<sup>[16][17][18]</sup> Weil's stay in India was short-lived; he attempted to revamp the mathematics department at Aligarh, without success.<sup>[19]</sup> The university administration planned to fire Weil and promote his colleague Vijayaraghavan to the vacated position. However, Weil and Vijayaraghavan respected one another. Rather than play any role in the drama, Vijayaraghavan instead resigned, later informing Weil of the plan.<sup>[20]</sup> Weil returned to Europe to seek another teaching position. He ended up at the University of Strasbourg, joining his friend and colleague Henri Cartan.<sup>[21]</sup>



Gaston Julia (right), who was not a member of Bourbaki, lost his nose during World War I. The war created a lost generation of mathematical knowledge, which the Bourbaki founders sought to fill.

## The Bourbaki collective

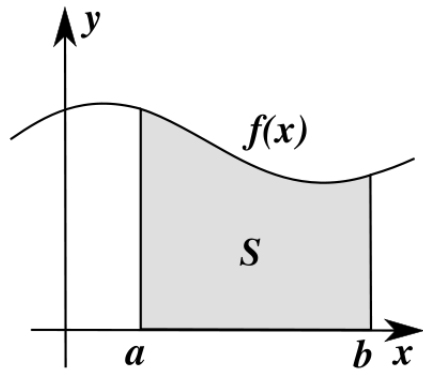
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### Founding

During their time together at Strasbourg, Weil and Cartan regularly complained to each other regarding the inadequacy of available course material for calculus instruction. In his memoir *Apprenticeship*, Weil described his solution in the following terms: "One winter day toward the end of 1934, I came upon a great idea that would put an end to these ceaseless interrogations by my comrade. 'We are five or six friends', I told him some time later, 'who are in charge of the same mathematics curriculum at various universities. Let us all come together and regulate these matters once and for all, and after this, I shall be delivered of these questions.' I was unaware of the fact that Bourbaki was born at that instant."<sup>[21]</sup> Cartan confirmed the account.<sup>[22]</sup>



The first, unofficial meeting of the Bourbaki collective took place at noon on 10 December 1934, at the Café Grill-Room A. Capoulade, Paris, in the Latin Quarter.<sup>[23][24][b][c]</sup> Six mathematicians were present: Henri Cartan, Claude Chevalley, Jean Delsarte, Jean Dieudonné, René de Possel, and André Weil. Most of the group were based outside Paris, and were in town to attend the Julia Seminar, a conference prepared with the help of Gaston Julia at which several future Bourbaki members and associates presented.<sup>[26]</sup> The group resolved to collectively write a treatise on analysis, for the purpose of standardizing calculus instruction in French universities. The project was especially meant to supersede the text of Édouard Goursat, which the group found to be badly outdated, and to improve its treatment of Stokes' Theorem.<sup>[23][27][28]</sup> The founders were also motivated by a desire to incorporate ideas from the Göttingen school, particularly from exponents Hilbert, Noether and B.L. van der Waerden. Further, in the aftermath of World War I, there was a certain nationalist impulse to



Bourbaki was founded to produce a text in mathematical analysis, a branch of mathematics entailing calculus

save French mathematics from decline, especially in competition with Germany. As Dieudonné stated in an interview, "Without meaning to boast, I can say that it was Bourbaki that saved French mathematics from extinction."<sup>[29]</sup>

At the initial meeting, Jean Delsarte was particularly favorable to the collective aspect of the proposed project, observing that such a working style could insulate the group's work against potential later individual claims of copyright.<sup>[30][27]</sup> As various topics were discussed, Delsarte also suggested that the work begin in the most abstract, axiomatic terms possible, treating all of mathematics prerequisite to analysis from scratch.<sup>[31]</sup> The group agreed to the idea, and this foundational area of the proposed work was referred to as the "Abstract Packet" (Paquet Abstrait) .<sup>[32][33]</sup> Working titles were adopted: the group styled itself as the **Committee for the Treatise**

**on Analysis**, and their proposed work was called the *Treatise on Analysis* (*Traité d'analyse*).<sup>[34][35]</sup> The group held another nine preliminary meetings at A. Capoulade on a biweekly basis before the collective's first official, founding conference in July 1935. During this early period, Paul Dubreil, Jean Leray and Szolem Mandelbrojt joined and participated. Dubreil and Leray left the meetings before the following summer, and were respectively replaced by new participants Jean Coulomb and Charles Ehresmann.<sup>[36][35]</sup>



Bourbaki's initial meetings were held in a restaurant in the Latin Quarter of Paris, near the Panthéon

The group's official, founding conference was held in Besse-en-Chandesse, from 10-17 July 1935.<sup>[37][38]</sup> At the time of the official founding, the membership consisted of the six attendees at the first lunch of 10 December 1934, together with Coulomb, Ehresmann and Mandelbrojt.



Sign marking the official founding of Bourbaki in Besse-en-Chandesse

On 16 July, the members took a walk to alleviate the boredom of unproductive proceedings. During the malaise, some decided to skinny-dip in the nearby Lac Pavin, repeatedly yelling "Bourbaki!"<sup>[39]</sup> At the close of the first official conference, the group renamed itself "Bourbaki", in reference to the general and prank as recalled by Weil and others.<sup>[32][d]</sup> During 1935, the group also resolved to establish the mathematical personhood of their collective pseudonym by getting an article published under its name.<sup>[41][38]</sup> A first name had to be decided; a full name was required for publication of any article. To this end, René de Possel's wife Eveline "baptized" the pseudonym with the first name of Nicolas, becoming Bourbaki's "godmother".<sup>[42][38][43][44]</sup> This allowed for the publication of a second article with material attributed to Bourbaki, this time under "his" own name.<sup>[45]</sup> Henri Cartan's father Élie Cartan, also a mathematician and supportive of the group, presented the article to the publishers, who accepted it.<sup>[41]</sup>

At the time of Bourbaki's founding, René de Possel and his wife Eveline were in the process of divorcing. Eveline remarried to André Weil in 1937, and de Possel left the Bourbaki collective some time later. This sequence of events has caused speculation that de Possel left the group because of the remarriage,<sup>[46]</sup> however this suggestion has also been criticized as possibly historically inaccurate, since de Possel is supposed to have remained active in Bourbaki for years after André's marriage to Eveline.<sup>[47]</sup>

## World War II

Bourbaki's work slowed significantly during the Second World War, though the group survived and later flourished. Some members of Bourbaki were Jewish, and therefore obliged to flee from certain parts of Europe at certain times. Weil, who was Jewish, spent the summer of 1939 in Finland with his wife Eveline, as guests of Lars Ahlfors. Due to their travel near the border, the couple were suspected as Soviet spies by Finnish authorities near the onset of the Winter War, and André was later arrested.<sup>[48]</sup> According to an anecdote, Weil was to have been executed but for the passing mention of his case to Rolf Nevanlinna, who asked that Weil's sentence be commuted.<sup>[49]</sup> However, the accuracy of this detail is dubious.<sup>[50]</sup> Weil reached the United States in 1941, later taking another teaching stint in São Paulo from 1945-47

before settling at the University of Chicago from 1947-1958 and finally the Institute for Advanced Study in Princeton, where he spent the remainder of his career. Although Weil remained in touch with the Bourbaki collective and visited Europe and the group periodically following the war, his level of involvement with Bourbaki never returned to that at the time of founding.

Second-generation Bourbaki member Laurent Schwartz was also Jewish and found pickup work as a math teacher in rural Vichy France. Moving from village to village, Schwartz planned his movements in order to evade capture by the Nazis. On one occasion Schwartz found himself trapped overnight in a certain village, as his expected transportation home was unavailable. There were two inns in town: a comfortable, well-appointed one, and a very poor one with no heating and bad beds. Schwartz's instinct told him to stay at the poor inn; overnight, the Nazis raided the good inn, leaving the poor inn unchecked.<sup>[51]</sup>

Meanwhile Jean Delsarte, a Catholic, was mobilized in 1939 as the captain of an audio reconnaissance battery. He was forced to lead the unit's retreat from the northeastern part of France toward the south. While passing near the Swiss border, Delsarte overheard a soldier say "We are the army of Bourbaki".<sup>[52][53]</sup> The 19th century general's retreat was known to the French; a founder of the mathematical collective which took the same name, himself coincidentally led a similar retreat after the name had been chosen.

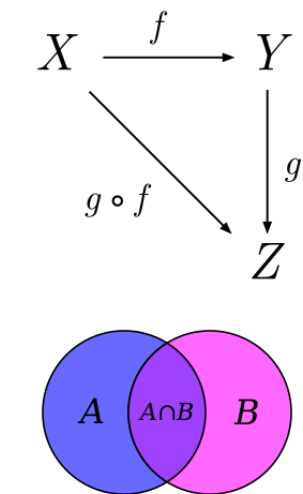
## Postwar until the present

Following the war, Bourbaki had solidified the plan of its work, and settled into a productive routine. Bourbaki regularly published volumes of the *Éléments* during the 1950s and 1960s, and enjoyed its greatest influence during this period.<sup>[54]</sup> Over time, the founding members gradually left the group, slowly being replaced with younger newcomers including Jean-Pierre Serre and Alexander Grothendieck. Serre, Grothendieck and Laurent Schwartz were awarded the Fields Medal during the postwar period, in 1954, 1966 and 1950 respectively. Later members Alain Connes and Jean-Christophe Yoccoz also received the Fields Medal, in 1982 and 1994 respectively.<sup>[55]</sup>

The later practice of accepting scientific awards contrasted with some of the founders' views. During the 1930s, Weil and Delsarte petitioned against a French national scientific "medal system" proposed by the Nobel physics laureate Jean Perrin. Weil and Delsarte felt that the institution of such a system would increase unconstructive pettiness and jealousy in the scientific community.<sup>[56]</sup> Despite this, the Bourbaki group had previously successfully petitioned Perrin for a government grant to support its normal operations.<sup>[57]</sup> Like the founders, Grothendieck was also averse to awards, albeit for pacifist reasons. Although Grothendieck was awarded the Fields Medal in 1966, he declined to attend the ceremony in Moscow, in protest of the Soviet government.<sup>[58]</sup> In 1988, Grothendieck rejected the Crafoord Prize outright, citing no personal need to accept prize money, lack of recent relevant output, and general distrust of the scientific community.<sup>[59]</sup>

Born to Jewish anarchist parentage, Grothendieck survived the Holocaust and advanced rapidly in the French mathematical community, despite poor education during the war.<sup>[60]</sup> Grothendieck's teachers included Bourbaki's founders, and so he joined the group. During Grothendieck's membership, Bourbaki reached an impasse concerning its foundational approach. Grothendieck advocated for a reformulation of the group's work using category theory as its theoretical basis, as opposed to set theory. The proposal was ultimately rejected in part because the group had already committed itself to a rigid track of sequential presentation (with multiple already-published volumes). Following this, Grothendieck left Bourbaki "in anger".<sup>[61][28]</sup> Biographers of the collective have described Bourbaki's unwillingness to start over in terms of category theory as a missed opportunity.<sup>[62][63]</sup>

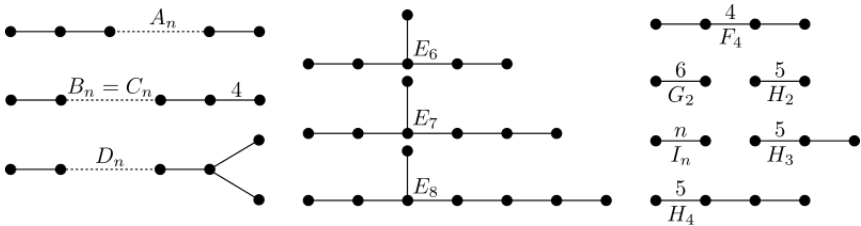
During the founding period, the group chose the Parisian publisher Hermann to issue installments of the *Éléments*. Hermann was led by Enrique Freymann, a friend of the founders willing to publish the group's project, despite financial risk. During the 1970s, Bourbaki entered a protracted legal battle with Hermann over matters of copyright and royalty payment. Although the Bourbaki group won the suit and retained collective copyright of the *Éléments*, the dispute slowed the group's productivity.<sup>[64][65]</sup> Later editions of the *Éléments* were published by Masson, and modern editions are published by Springer.<sup>[66]</sup> From the 1980s through the 2000s, Bourbaki published very infrequently, with the result that in 1998 Le Monde pronounced the collective "dead".<sup>[67]</sup> However, in the 2010s Bourbaki resumed publication of the *Éléments* with a revised chapter on algebra and a new book on algebraic topology.



Alexander Grothendieck proposed that Bourbaki revise its foundational basis in terms of category

## Working method

Bourbaki holds periodic conferences for the purpose of expanding the *Éléments*; these conferences are the central activity of the group's working life. Subcommittees are assigned to write drafts on specific material, and the drafts are later presented, vigorously debated and re-drafted at the conferences. Unanimous agreement is required before any material is deemed acceptable for publication.<sup>[69]</sup> Although the writing process is slow, it yields a final product which satisfies the group's standards for mathematical rigour, one of Bourbaki's main priorities in the treatise. Bourbaki's emphasis on rigour was a reaction to the style of Henri Poincaré, who stressed the importance of free-flowing mathematical intuition at the cost of thorough presentation.<sup>[e]</sup> During the project's early years, Dieudonné served as the group's scribe,



At Armand Borel's urging, Bourbaki's treatment of Lie groups and Lie algebras included uncharacteristic illustrations, such as graphs of finite Coxeter systems<sup>[68]</sup>



theory as opposed to  
set theory; the proposal  
was not adopted

authoring several final drafts which were ultimately published. For this purpose, Dieudonné adopted an impersonal writing style which was not his own, but which was used to craft material acceptable to the entire group.<sup>[71]</sup> Dieudonné reserved his personal style for his own work; like all members of Bourbaki, Dieudonné also published material under his own name,<sup>[72]</sup> including the nine-volume *Éléments d'analyse*, a work explicitly focused on analysis and of a piece with Bourbaki's initial intentions.

Most of the final drafts of Bourbaki's *Éléments* carefully avoided using illustrations, favoring a formal presentation based only in text and formulas. An exception to this was the treatment of Lie groups and Lie algebras (especially in chapters 4-6), which did make use of diagrams and illustrations. The inclusion of illustration in this part of the work was due to Armand Borel. Borel was minority-Swiss in a majority-French collective, and self-deprecated as "the Swiss peasant", explaining that visual learning was important to the Swiss national character.<sup>[73][70]</sup> When asked about the dearth of illustration in the work, former member Pierre Cartier replied:

The Bourbaki were Puritans, and Puritans are strongly opposed to pictorial representations of truths of their faith. The number of Protestants and Jews in the Bourbaki group was overwhelming. And you know that the French Protestants especially are very close to Jews in spirit.

— Pierre Cartier, in an interview<sup>[70]</sup>

The conferences have historically been held at quiet rural areas. These locations contrast with the lively, sometimes heated debates which have occurred. Laurent Schwartz reported an episode in which Weil slapped Cartan on the head with a draft. The hotel's proprietor saw the incident and assumed that the group would split up, but according to Schwartz, "peace was restored within ten minutes."<sup>[74]</sup> The historical, confrontational style of debate within Bourbaki has been partly attributed to Weil, who believed that new ideas have a better chance of being born in confrontation than in an orderly discussion.<sup>[74]</sup> Schwartz related another illustrative incident: Dieudonné was adamant that topological vector spaces must appear in the work before integration, and whenever anyone suggested that the order be reversed, he would loudly threaten his resignation. This became an in-joke among the group; Roger Godement's wife Sonia attended a conference, aware of the idea, and asked for proof. As Sonia arrived at a meeting, a member suggested that integration must appear before topological vector spaces, which triggered Dieudonné's usual reaction.<sup>[74]</sup> Despite the historical culture of heated argument, Bourbaki thrived during the middle of the twentieth century. Bourbaki's ability to sustain such a collective, critical approach has been described as "something unusual",<sup>[75]</sup> surprising even its own members. It has been suggested that the group survived because its members believed strongly in the importance of their collective project, despite personal differences.<sup>[76]</sup>

## Humor

Humor has been an important aspect of the group's culture, beginning with Weil's memories of the student pranks involving "Bourbaki" and "Poldevia". For example, in 1939 the group released a wedding announcement for the marriage of "Betti Bourbaki" (daughter of Nicolas) to one "H. Pétard" (H. "Firecrackers" or "Hector Pétard"), a "lion hunter". Hector Pétard was itself a pseudonym, but not one originally coined by the Bourbaki members. The Pétard moniker was originated by Ralph P. Boas, Frank Smithies and other Princeton mathematicians who were aware of the Bourbaki project; inspired by them, the Princeton mathematicians published an article on the "mathematics of lion hunting". After meeting Boas and Smithies, Weil composed the wedding announcement which contained several mathematical puns.<sup>[77]</sup>

During the 1950s,<sup>[78]</sup> the American Mathematical Society received an application for individual membership from Bourbaki, which was rebuffed by J.R. Kline who understood the entity to be a collective, inviting them to re-apply for institutional membership at a higher rate. In response, Bourbaki floated a rumor that Ralph Boas was not a real person, but a collective pseudonym of the editors of *Mathematical Reviews* with which Boas had been affiliated. The reason for targeting Boas was because he had known the group in its earlier days when they were less strict with secrecy, and he'd described them as a collective in an article for the *Encyclopædia Britannica*.<sup>[79]</sup> In November 1968, a mock obituary of Nicolas Bourbaki was released during one of the seminars.<sup>[80]</sup>

Bourbaki's culture of humor has been described as an important factor in the group's social cohesion and capacity to survive, smoothing over tensions of heated debate.<sup>[81]</sup> As of 2020, a Twitter account registered to "Betty\_Bourbaki" provides regular updates on the group's activity.<sup>[82]</sup>

## Works

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Bourbaki's work includes a series of textbooks, a series of printed lecture notes, journal articles, and an internal newsletter. The textbook series *Éléments de mathématique* (*Elements of mathematics*) is the group's central work. The Séminaire Bourbaki is a lecture series held regularly under the group's auspices, and the talks given are also published as lecture notes. Journal articles have been published with authorship attributed to Bourbaki, and the group publishes an internal newsletter *La Tribu* (The Tribe) which is distributed to current and former members.<sup>[83]</sup>

### *Éléments de mathématique*

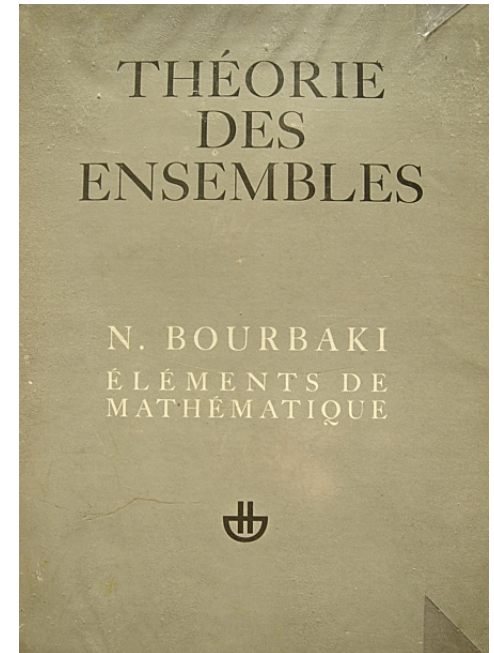
The content of the *Éléments* is divided into *books*—major topics of discussion, *volumes*—individual, physical books, and *chapters*, together with certain summaries of results, historical notes, and other details. The volumes of the *Éléments* have had a complex publication history. Material has been revised for new editions, published chronologically out of order of its intended logical sequence, grouped together and partitioned differently in later volumes, and translated into English. For example, the second book on *Algebra* was originally released in eight French volumes: the first in 1942 being chapter 1 alone, and the last in 1980 being chapter 10 alone. This presentation was later condensed into five volumes with chapters 1-3 in the first volume, chapters 4-7 in the second, and chapters 8-10 each remaining the third through fifth volumes of that portion of the work.<sup>[84]</sup> The English edition of Bourbaki's *Algebra* consists of translations of the two volumes on chapters 1-3 and 4-7, with chapters 8-10 unavailable in English as of 2020.

When Bourbaki's founders began working on the *Éléments*, they originally conceived of it as a "treatise on analysis", the proposed work having a working title of the same name (*Traité d'analyse*). The opening part was to comprehensively deal with the foundations of mathematics prior to analysis, and was referred to as the "Abstract Packet". Over time, the members developed this proposed "opening section" of the work to the point that it would instead run for several volumes and comprise a major part of the work, covering set theory, abstract algebra, and topology. Once the project's scope expanded far beyond its original purpose, the working title *Traité d'analyse* was dropped in favor of *Éléments de mathématique*.<sup>[32]</sup> The unusual, singular "Mathematic" was meant to connote Bourbaki's view that mathematics is a unified discipline, in which all branches support and relate to each other.<sup>[85][86]</sup>

The volumes of the *Éléments* published by Hermann were indexed by chronology of publication and referred to as *fascicules* (<https://en.wikipedia.org/wiki/fascicule>): installments in a large work. Several volumes did not consist of the normal definitions, proofs and exercises in a math textbook, but contained only summaries of results for a given topic, stated without proof. These volumes were referred to as *Fascicules de résultats*, with the result that *fascicule* may refer to a volume of Hermann's edition, or to one of the "summary" sections of the work (e.g. *Fascicules de résultats* is translated as "Summary of Results" rather than "Installment of Results", referring to the content rather than a specific volume). The first volume of Bourbaki's *Éléments* to be published was the Summary of Results in *Set Theory*, in 1939.<sup>[84][87]</sup> Similarly one of the work's later books, *Differential and Analytic Manifolds*, consists only of two volumes of summaries of results, with no chapters of content having been published as of 2020.

Later additions to the *Éléments* appeared infrequently during the 1980s and 1990s, although Bourbaki increased productivity during the 2010s. A new chapter of *Commutative Algebra* appeared in 1983, followed by another later chapter of the same book in 1998. A re-written and expanded version of the eighth chapter of *Algebra* appeared in 2012, and a book treating *Algebraic Topology* was published in 2016.

Year	Book	References
1954	<u>Theory of Sets</u>	[88]
1942	<u>Algebra</u>	[89][90][91]
1940	<u>General Topology</u>	
1949	<u>Functions of a Real Variable</u>	
1953	<u>Topological Vector Spaces</u>	
1952	<u>Integration</u>	[92][93]
1960	<u>Lie Groups</u> and <u>Lie Algebras</u>	
1961	<u>Commutative Algebra</u>	[94]
1967	<u>Spectral Theory</u>	
1967	<u>Differential</u> and <u>Analytic Manifolds</u>	
2016	<u>Algebraic Topology</u>	[95]
1960	<u>Elements of the History of Mathematics</u>	



First book of the *Éléments de mathématique*, 1970 edition

## Séminaire Bourbaki

The Séminaire Bourbaki has been held regularly since 1948, and lectures are presented by non-members and members of the collective. As of 2020 the Séminaire Bourbaki has run to over a thousand recorded lectures in its written incarnation, denoted chronologically by simple numbers.<sup>[96]</sup> At the time of a June 1999 lecture given by Jean-Pierre Serre on the topic of Lie groups, the total lectures given in the series numbered 864, corresponding to roughly 10,000 pages of printed material.<sup>[97]</sup>

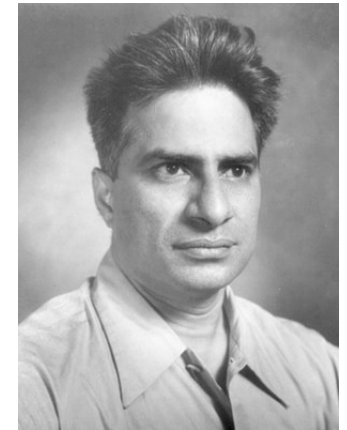
## Articles

Several articles have appeared in the mathematical literature with material or authorship attributed to Bourbaki.<sup>[84]</sup>

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Damodar Kosambi  
authored the first article  
attributing material to  
"Bourbaki"

## Membership

As of 2000, Bourbaki has had "about forty" members.<sup>[98]</sup> Historically the group has numbered about a dozen members at any given point, although it was briefly (and officially) limited to nine members at the time of founding.<sup>[34]</sup> Bourbaki's membership has been described in terms of generations:



Bourbaki was always a very small group of mathematicians, typically numbering about twelve people. Its first generation was that of the founding fathers, those who created the group in 1934: Weil, Cartan, Chevalley, Delsarte, de Possel, and Dieudonné. Others joined the group, and others left its ranks, so that some years later there were about twelve members, and that number remained roughly constant. Laurent Schwartz was the only mathematician to join Bourbaki during the war, so his is considered an intermediate generation. After the war, a number of members joined: Jean-Pierre Serre, Pierre Samuel, Jean-Louis Kozul, Jacques Dixmier, Roger Godement, and Sammy Eilenberg. These people constituted the second generation of Bourbaki. In the 1950s, the third generation of mathematicians joined Bourbaki. These people included Alexandre Grothendieck, François Bruhat, Serge Lang, the American mathematician John Tate, Pierre Cartier, and the Swiss mathematician Armand Borel.<sup>[99][70]</sup>

After the first three generations there were roughly twenty later members, not including current participants. Bourbaki has a custom of keeping its current membership secret, a practice meant to ensure that its output is presented as a collective, unified effort under the Bourbaki pseudonym, not attributable to any one author (e.g. for purposes of copyright or royalty payment). This secrecy is also intended to deter unwanted attention which could disrupt normal operations. However, former members freely discuss Bourbaki's internal practices upon departure.<sup>[100]</sup>

Prospective members are invited to conferences and styled as "guinea pigs", a process meant to vet the newcomer's mathematical ability.<sup>[101]</sup> In the event of agreement between the group and the prospect, the prospect eventually becomes a full member.<sup>[8]</sup> The group is supposed to have an age limit: active members are expected to retire at (or about) 50 years of age. At a 1956 conference, Cartan read a letter from Weil which proposed a "gradual disappearance" of the founding members, forcing younger members to assume full responsibility for Bourbaki's operations.<sup>[103][28]</sup> This rule is supposed to have resulted in a complete change of personnel by 1958.<sup>[43]</sup> However, historian Liliane Beaulieu reported never having found written affirmation of this rule.<sup>[6]</sup> The age limit is thought to express the founders' intent that the project should continue indefinitely, operated by people at their best mathematical ability—in the mathematical community, there is a widespread belief that mathematicians produce their best work while young.<sup>[103]</sup> Among full members there is no official hierarchy; all operate as equals, having the ability to interrupt conference proceedings at any point, or to challenge any material presented.<sup>[104]</sup> However, André Weil has been described as "first among equals" during the founding period, and was given some deference.<sup>[104]</sup> On the other hand, the group has also poked fun at the idea that older members should be afforded greater respect.<sup>[105]</sup>

Additionally, Bourbaki conferences have been attended by members' family, friends, and other visiting mathematicians, non-members of the group.

Generation		Name	Born	ENS <sup>[h]</sup>	Joined <sup>[i]</sup>	Left	Died
First <sup>[j]</sup>	Core members	<u>Henri Cartan</u>	1904	1923	1934	c. 1956–1958	2008
		<u>Claude Chevalley</u>	1909	1926	1934	c. 1956–1958	1984
		<u>Jean Delsarte</u>	1903	1922	1934	c. 1956–1958	1968
		<u>Jean Dieudonné</u>	1906	1924	1934	c. 1956–1958	1992
		<u>André Weil</u>	1906	1922	1934	c. 1956–1958	1998
	Minor members	<u>Jean Coulomb</u>	1904	1923	1935	—	1999
		<u>Paul Dubreil</u>	1904	1926	1935	1935	1994
		<u>Charles Ehresmann</u>	1905	1924	1935	—	1979
		<u>Jean Leray</u>	1906	1926	1935	1935	1998
		<u>Szolem Mandelbrojt</u>	1899	—	1935	—	1983
		<u>René de Possel</u>	1905	1923	1934	—	1974
Second <sup>[k]</sup>		<u>Jacques Dixmier</u>	1924	1942	—	—	—
		<u>Samuel Eilenberg</u>	1913	—	c.1951	1966	1998
		<u>Roger Godement</u>	1921	1940	—	—	2016
		<u>Jean-Louis Koszul</u>	1921	1940	—	—	2018
		<u>Pierre Samuel</u>	1921	1940	1947	1971	2009
		<u>Laurent Schwartz</u>	1916	1934	—	—	2002
		<u>Jean-Pierre Serre</u>	1926	1945	—	—	—
Third <sup>[l]</sup>		<u>Armand Borel</u>	1923	—	c. 1953	1973	2003
		<u>François Bruhat</u>	1929	1948	—	—	2007
		<u>Pierre Cartier</u>	1932	1950	1955	1983	—
		<u>Alexander Grothendieck</u>	1928	—	—	—	2014
		<u>Serge Lang</u>	1927	—	—	—	2005
		<u>John Tate</u>	1925	—	—	—	2019

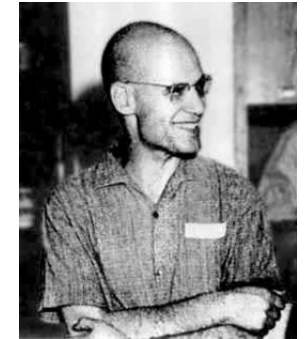


Jean Dieudonné,  
founding member



Jean-Pierre Serre,  
second generation  
member

Later members <sup>[m][n]</sup>	<u>Hyman Bass</u>	1932	—	—	—	—
	<u>Arnaud Beauville</u>	1947	1966	—	1997	—
	<u>Gérard Ben Arous</u>	1957	1977	—	—	—
	<u>Daniel Bennequin</u>	1952	1972	—	—	—
	<u>Claude Chabauty</u>	1910	1929	—	—	1990
	<u>Alain Connes</u>	1947	1966	—	—	—
	<u>Michel Demazure</u>	1937	1955	—	c. 1985	—
	<u>Adrien Douady</u>	1935	1954	—	—	2006
	<u>Patrick Gérard</u> <sup>[fr]</sup>	1961	1981	—	—	—
	<u>Guy Henniart</u>	1953	1973	—	—	—
	<u>Luc Illusie</u>	1940	1959	—	—	—
	<u>Pierre Julg</u>	1959	1977	—	—	—
	<u>Olivier Mathieu</u>	1960	1980	—	—	—
	<u>Joseph Oesterlé</u>	1954	1973	—	—	—
	<u>Charles Pisot</u>	1909	1929	—	—	1984
	<u>Michel Raynaud</u>	1938	1958	—	—	2018
	<u>Marc Rosso</u>	1962	1982	—	—	—
	<u>Georges Skandalis</u>	1955	1975	—	—	—
	<u>Bernard Tessier</u>	1945	—	—	—	—
	<u>Jean-Louis Verdier</u>	1937	1955	—	—	1989
	<u>Jean-Christophe Yoccoz</u>	1957	1975	—	—	2016



Alexander Grothendieck, third generation member, left Bourbaki over a disagreement concerning set theory versus category theory

## Influence and criticism

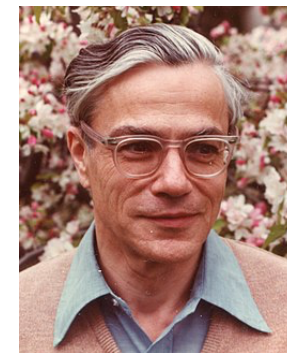
Bourbaki was influential in 20th century mathematics, and also had some interdisciplinary impact on the humanities and the arts. The group has been praised and criticized for its method of presentation, its working style, and its choice of mathematical topics.

## Influence

Bourbaki introduced several mathematical notations which have remained in use. Weil took the letter  $\emptyset$  of the Norwegian alphabet and used it to denote the empty set,  $\emptyset$ .<sup>[110]</sup> This notation first appeared in the Summary of Results on Set Theory,<sup>[111]</sup> and remains in use. The words injective, surjective and bijjective were introduced to refer to functions which satisfy certain properties.<sup>[112][113]</sup> Bourbaki used simple language for certain geometric objects, naming them *pavés* (paving stones) and *boules* (balls) as opposed to "parallelotopes" or "hyperspheroids".<sup>[114]</sup> Bourbaki also employed a "dangerous bend" symbol in the margins of its text to indicate an especially difficult piece of material. Bourbaki enjoyed its greatest influence during the 1950s and 1960s, when installments of the *Éléments* were published frequently. Bourbaki's influence during this period has been partly attributed to the scarcity of other graduate-level texts in mathematics at the time.

Bourbaki had some interdisciplinary influence on other fields, including anthropology and psychology. This influence was in the context of structuralism, a school of thought in the humanities which stresses the relationships between objects over the objects themselves, pursued in various fields by other French intellectuals. In 1943, André Weil met the anthropologist Claude Lévi-Strauss in New York, where the two undertook a brief collaboration. At Lévi-Strauss' request, Weil wrote a brief appendix describing marriage rules for four classes of people within Australian aboriginal society, using a mathematical model based on group theory.<sup>[5]</sup> The result was published as an appendix in Lévi-Strauss' *Elementary Structures of Kinship*, a work examining family structures and the incest taboo in human cultures.<sup>[115]</sup> In 1952, Jean Dieudonné and Jean Piaget participated in an interdisciplinary conference on mathematical and mental structures. Dieudonné described mathematical "mother structures" in terms of Bourbaki's project: composition, neighborhood, and order. Piaget then gave a talk on children's mental processes, and considered that the psychological concepts he had just described were very similar to the mathematical ones just described by Dieudonné.<sup>[116][117]</sup> The psychoanalyst Jacques Lacan liked Bourbaki's collaborative working style and proposed a similar collective group in psychology, an idea which did not materialize.<sup>[118]</sup> In *The Postmodern Condition* the postmodern philosopher Jean-François Lyotard presented a critique of the "legitimation of knowledge" in various disciplines, the processes and rules by which statements become accepted as valid. Lyotard cited Bourbaki as an example of a collective which establishes knowledge within a given system of rules.<sup>[119]</sup>

Biographer Amir Aczel stressed Bourbaki's influence on other disciplines during the mid-20th century. However, Maurice Mashaal moderated the claims of Bourbaki's influence in the following terms:



Armand Borel, third generation member



Hyman Bass, later member

While Bourbaki's structures were often mentioned in social science conferences and publications of the era, it seems that they didn't play a real role in the development of these disciplines. David Aubin, a science historian who analyzed Bourbaki's role in the structuralist movement in France, believes Bourbaki's role was that of a "cultural connector". According to Aubin, while Bourbaki didn't have any mission outside of mathematics, the group represented a sort of link between the various cultural movements of the time. Bourbaki provided a simple and relatively precise definition of concepts and structures, which philosophers and social scientists believed was fundamental within their disciplines and in bridges among different areas of knowledge. Despite the superficial nature of these links, the various schools of structuralist thinking, including Bourbaki, were able to support each other. So, it is not a coincidence that these schools suffered a simultaneous decline in the late 1960s.

— Maurice Mashaal, citing David Aubin<sup>[116]</sup>

Bourbaki also had some influence in the arts. The literary collective Oulipo was founded on 24 November 1960 under circumstances similar to Bourbaki's founding, with the members initially meeting in a restaurant. Although several members of Oulipo were mathematicians, the group's purpose was to create experimental literature by playing with language. Oulipo frequently employed mathematically-based constrained writing techniques, such as the S+7 method. Oulipo member Raymond Queneau attended a Bourbaki conference in 1962.<sup>[116][120]</sup> In 2018, the American musical duo Twenty One Pilots released a concept album named Trench. The album's conceptual framework was the mythical city of "Dema", ruled by nine "bishops"; one of the bishops was named "Nico", short for Nicolas Bourbaki. Following the album's release, there was a spike in internet searches for "Nicolas Bourbaki".<sup>[28][o]</sup>

## Praise

Bourbaki's work has been praised by some mathematicians. In a book review, Emil Artin described Éléments in broad, positive terms:

Our time is witnessing the creation of a monumental work: an exposition of the whole of present day mathematics. Moreover this exposition is done in such a way that the common bond between the various branches of mathematics become clearly visible, that the framework which supports the whole structure is not apt to become obsolete in a very short time, and that it can easily absorb new ideas.

— Emil Artin (Bull.AMS 59 (1953), 474–479)

Jean-Pierre Bourguignon expressed appreciation for the Séminaire Bourbaki, saying that he'd learned a large amount of material at its lectures, and referred to its printed lecture notes regularly.<sup>[122]</sup>



## Criticism

Bourbaki has also been criticized by several mathematicians—including its own former members—for a variety of reasons. Criticisms have included the choice of presentation of certain topics within the *Eléments* at the expense of others, dislike of the method of presentation for given topics, dislike of the group's working style, and a perceived elitist mentality around Bourbaki's project and its books, especially during the collective's most productive years in the 1950s and 1960s.

Bourbaki's deliberations on the *Eléments* resulted in the inclusion of some topics, while others were not treated. When asked in a 1997 interview about topics left out of the *Eléments*, former member Pierre Cartier replied:

There is essentially no analysis beyond the foundations: nothing about partial differential equations, nothing about probability. There is also nothing about combinatorics, nothing about algebraic topology,<sup>[p]</sup> nothing about concrete geometry. And Bourbaki never seriously considered logic. Dieudonné himself was very vocal against logic. Anything connected with mathematical physics is totally absent from Bourbaki's text.

— Pierre Cartier, in an interview<sup>[70]</sup>

Although Bourbaki had resolved to treat mathematics from its foundations, the group's eventual solution in terms of set theory was attended by several problems. Bourbaki's members were mathematicians as opposed to logicians, and therefore the collective had a limited interest in mathematical logic. As Bourbaki's members themselves said of the book on set theory, it was written "with pain and without pleasure, but we had to do it." Dieudonné personally remarked elsewhere that ninety-five percent of mathematicians "don't care a fig" for mathematical logic.<sup>[123]</sup> In response, logician Adrian Mathias disparaged Bourbaki's foundational framework, noting that it did not take Gödel's results into account.<sup>[124]</sup>

Founder Jean Dieudonné later regretted that Bourbaki's success had contributed to a snobbery for pure mathematics in France, at the expense of applied mathematics. In an interview, he said: "It is possible to say that there was no serious applied mathematics in France for forty years after Poincaré. There was even a snobbery for pure math. When one noticed a talented student, one would tell him 'You should do pure math.' On the other hand, one would advise a mediocre student to do applied math while thinking, 'It's all that he can do! ... The truth is actually the reverse. You can't do good work in applied math until you can do good work in pure math.'"<sup>[125]</sup>

Bourbaki's style has been described as a particular scientific paradigm which has been superseded in a paradigm shift. For example, Ian Stewart cited Vaughan Jones' novel work in knot theory as an example of topology which was done without dependence on Bourbaki's system.<sup>[126]</sup> Bourbaki's influence has declined over time;<sup>[126]</sup> this decline has been partly attributed to the absence of certain modern topics

—such as category theory—from the treatise.<sup>[62][63]</sup>

The strict, ordered presentation of material in the *Eléments* was meant to form the basis for any further additions. However, subsequent developments in current (ongoing) mathematical research have proven difficult to adapt in terms of Bourbaki's organizational scheme, for the reason that ongoing research is fluid.<sup>[127]</sup>

Although multiple criticisms have pointed to shortcomings in the collective's project, one has also pointed to its success: Bourbaki was a "victim of its own success" in the sense that it accomplished what it set out to do, achieving its original goal of presenting a thorough treatise on modern mathematics.<sup>[128][129]</sup> Biographer Maurice Mashaal concluded his treatment of Bourbaki in the following way:

Such an enterprise deserves admiration for its breadth, for its enthusiasm and selflessness, for its strongly collective character. Despite some mistakes, Bourbaki did add a little to 'the honor of the human spirit'. In an era when sports and money are such great idols of civilization, this is no small virtue.

— biographer Maurice Mashaal<sup>[130]</sup>

## See also

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- Bourbaki dangerous bend symbol
- Bourbaki–Witt theorem
- Jacobson–Bourbaki theorem

### People

- Arthur Besse
- Blanche Descartes
- John Rainwater
- G. W. Peck

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## Notes

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- Simone Weil was not a member of the group; she was a philosopher, not a mathematician. However she attended multiple early conferences to support her brother André, and also to learn mathematics.<sup>[1]</sup>
- The restaurant's address was 63 Boulevard Saint-Michel, near the Panthéon and the Luxembourg Gardens. The restaurant no longer exists; the current occupant of the same address is "a fast-food outlet",<sup>[23][24]</sup> specifically (as of 2020) a Burger King.<sup>[25]</sup>
- The minutes are in the Bourbaki archives — for a full description of the initial meeting consult Liliane Beaulieu in the *Mathematical Intelligencer*.
- The mathematician Sterling K. Berberian suggested another possible origin for the Bourbaki name: Octave Mirbeau's 1900 novel *The Diary of a Chambermaid*, which describes a hedgehog named Bourbaki that eats voraciously. However Mashaal dismissed this connection as being unlikely, since the founders never referred to the novel, but only to the general and the Husson anecdote.<sup>[40]</sup>
- "Bourbaki came to terms with Poincaré only after a long struggle. When I joined the group in the fifties it was not the fashion to value Poincaré at all. He was old-fashioned." Pierre Cartier, interviewed by Marjorie Senechall. <sup>[70]</sup>
- Years refer to the date of publication of each book's first volume, which also contains its first proper chapter. There are two exceptions: The first published installment of *Set Theory* was a summary of results in 1939, and its first proper chapter did not appear until 1954. For *Differential and Analytic Manifolds*, only a two-volume summary of results was published in 1967 and 1971, with no proper chapters appearing.
- Examples of "guinea pigs" who attended conferences without necessarily joining include one "Mirlès", who attended the official founding conference in Besse-en-Chandesse, one "Malgrange", and Marcel Berger.<sup>[102]</sup>
- Dates refer to entrance into the university, not graduation.
  - Bourbaki's secrecy and informality have made it difficult to establish members' dates of joining and leaving. For past members with uncertain dates, it has been suggested that the members' periods of flourishing (circa age 25-50) is the best available estimate.<sup>[103]</sup>
  - The collective's founding generation included a core group of five who led its activities and established its norms, remaining active for several years. Another six minor members participated on shorter-term bases during its earliest days, ranging from a few months to a few years.
- Aczel described Schwartz as an inter-generational member, the only one to join during the Second World War. However Schwartz did not participate in the group's founding.
- Pierre Cartier first attended a Bourbaki conference as a guinea pig in 1951, becoming a full member in 1955 and departing in 1983.<sup>[108]</sup>

- m. Most other members were born after the above three generations and were therefore active in the group at later dates. However, two were born contemporaries of the founding generation: Charles Pisot in 1909, and Claude Chabauty in 1910.
- n. Aczel also described a fourth generation of Bourbaki members (as opposed to later members in general), former students of Grothendieck who joined during the 1960s.<sup>[61]</sup> This may refer to those of Grothendieck's doctoral students who later became Bourbaki members, such as Michel Demazure and Jean-Louis Verdier.<sup>[109]</sup>
- o. Similarly, Bourbaki created nicknames for its members as part of its internal culture of humor. Jean Delsarte was referred to as "bishop", which may have been a reference to his Catholicism.<sup>[121]</sup>
- p. Bourbaki has since published a book on algebraic topology.

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## External links

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- Official Website of *L'Association des Collaborateurs de Nicolas Bourbaki* (<http://www.bourbaki.ens.fr/>) (in French)
  - Archives of the association (<http://sites.mathdoc.fr/archives-bourbaki/>) (in French)
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