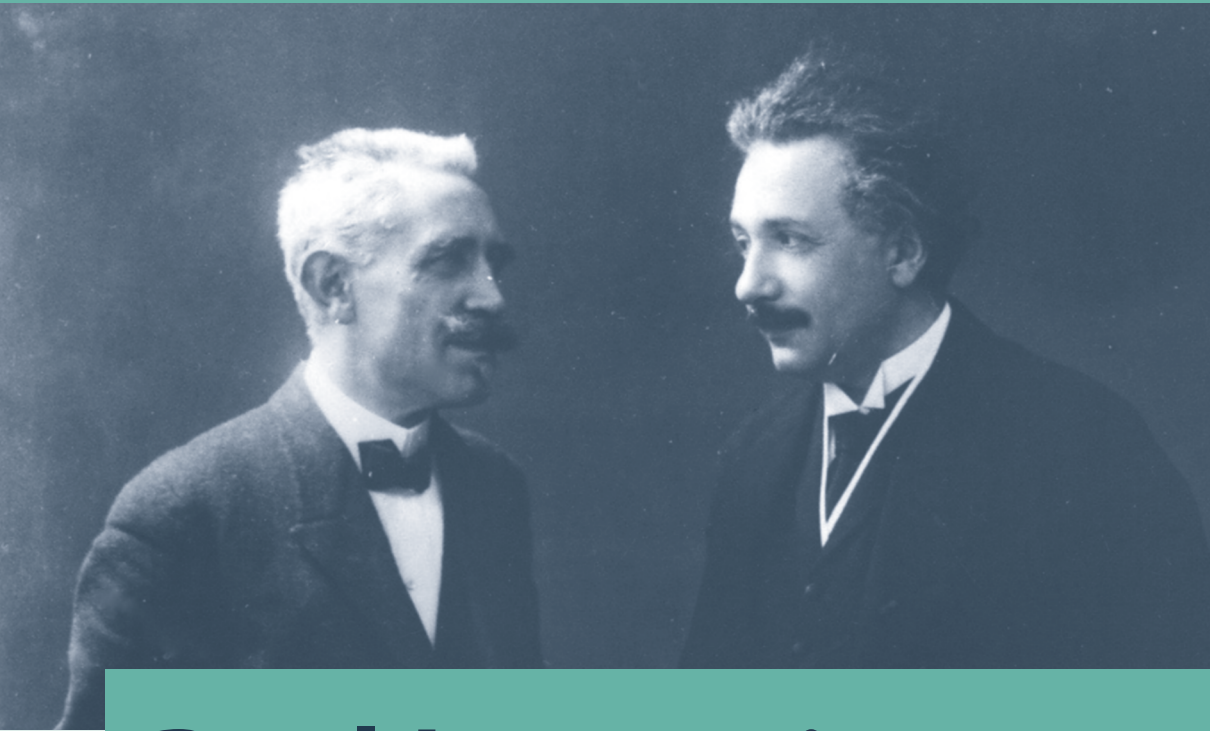


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# Paul Langevin: Physicist and Social Activist

BERNADETTE BENSAUDE-VINCENT  
FRANCIS DUCK

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Bernadette Bensaude-Vincent • Francis Duck

# Paul Langevin: Physicist and Social Activist

First Edition

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## **Preface to the English Revision of *Langevin, science et vigilance***

*Langevin, science et vigilance* was written in the 1980s. When it was published in 1987, it was the most recent of five full biographies of Paul Langevin published since he had died in 1946: three of them were in French and two in Russian. Another brief volume had also been published in German. Most of these books were testaments to the high regard in which Langevin was held in some quarters during this era. *Langevin, science et vigilance* was the first true biography to be written by a professional historian on the basis of primary sources, thanks to the archives opened to the public by the Langevin family. Since 1987, many of them have been digitized and are now freely available online through *Université PSL Explore*. This facility has enabled deeper research into Langevin's papers. Further archived records have also been accessed, including the Einstein papers published in digital format by Caltech, British Government papers from the UK National Archives, Kew, the British Newspaper archive and French police records from World War II.

Langevin's dual profile as a scientist of high reputation and an intellectual committed to the public arena still retains relevance in the 2020s. Even so, no full account of his life and work has been available to English-speaking readers, apart from the recent translation and publication of André Langevin's descriptive biography of his father.

Our primary purpose in preparing this English revision of *Langevin, science et vigilance* is to move beyond a purely archive-based narrative. We now can provide a more critical evaluation of Langevin's role in science and society during the first half of the twentieth century, in the light of the recent historiographical scholarship. During the time since *Langevin, science et vigilance* appeared, there have been a number of developments that make it appropriate to revisit the narrative. Most recently, 2022 marked the 150th anniversary of the birth of Paul Langevin on January 23, 1872. This anniversary was the occasion for several meetings, talks and presentations, both in France and elsewhere, that served as a reminder of the breadth of Langevin's contributions, to society as much as to science. In particular, medical ultrasound has grown into a multi-billion-dollar industry, and there are few who have never benefitted from this technology. For this reason, the narrative on Langevin's place as the originator of ultrasonics has been expanded, including a

number of aspects that have rarely or never appeared in other accounts. It also served to emphasize the continuing scholarship into various aspects of Langevin's private life and views about science and society, which was not available when the biography was originally composed.

In carrying out this translation we have therefore taken the opportunity to revise, enrich and update the original text, taking account of the recent historiography. In particular, the chapters on his private life, on ultrasonics, on the Solvay councils and on his relations with communism and Marxism have been significantly expanded. We have also added 30 new images to enhance the selection of 78 that now illustrate the revised text.

We want to express our gratitude to Catherine Kounelis, head of the Historical Resources Centre of the *Ecole supérieure de physique et de chimie industrielles*, where the Archives of Paul Langevin are kept, and her predecessor Monique Monnerie. They both have been encouraging and extremely helpful throughout this biographical enterprise.

We are also grateful to Martha Cecilia Bustamante for sharing the manuscript of her volume on Jacques Solomon and her views on quantum mechanics.

This biographical account also benefited from the memories of late members of the Langevin family or friends whom one of us interviewed in the 1980s: Luce Langevin, Jean Langevin, Hélène Solomon, Noémie Koechlin and Marie-Élisa Nordmann-Cohen.

Finally, thanks are due to those who have read drafts of this manuscript: Diana Buchwald, Jean-Marc Lévy-Leblond as well as Catherine Kounelis and Martha-Cecilia Bustamante.

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Francis Duck

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**A note on the textual citations** References to Langevin's works are not included at the end of each chapter, and reference is made as (Langevin 19xx) to the bibliography at the end of the book. Documents from the Langevin digital archive are identified as (Archives) with a reference number (<https://bibnum.explore.psl.eu/psl/item-set/249135>).

**A note on the images** The sources of some images used in this book are identified in the captions as follows: ESPCI, for *ESPCI Centre for Historical Resources*; PSL University, for *Université (Paris Sciences et Lettres)*; Science et Vigilance for *Bernadette Bensaude-Vincent (1987) Langevin, science et vigilance*, Paris, Belin, for which this book is the authorized English revision. Sources for widely available portraits are not given. Cover images (front) Hebrew University of Jerusalem: (back) *ESPCI Centre for Historical Resources*.

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# Chapter 1

## A “Secular Saint”



**Abstract** The name Paul Langevin, inscribed on the walls of many French cities, is a figure of French heritage. He is neither quite legendary, like his illustrious friends Albert Einstein and Marie Curie, nor completely obscure like so many other activist scientists of his generation. He is just famous enough to be unknown. He was depicted as “the most human of scientists” and “a man of deep kindness, constantly putting his devotion at the service of those who suffered”. Langevin combined ethical with intellectual qualities, courage with patience, and reason with generosity and intelligence with humanity. He had all the qualities of a “secular saint”. He was also a “dispersed scholar”, who crossed boundaries and refused to confine himself to a single research area, but who, as a counterbalance, developed a strong aspiration to unification, to the synthesis of knowledge.

### 1.1 A Public Icon

Langevin belongs to that uncertain fringe of the past situated between memory and history. The story of his life has been told by relatives, friends and collaborators. These recollections have the qualities of testimony and the flavour of memories. But they tend to create a stereotype, capturing the character into a frozen vignette. They have composed a three-faceted portrait of Langevin: the scientist, the educator and the citizen. All three faces are unified under the banner: a man of progress. Langevin the scientist was a pioneer of the atomic era, always supporting new theories that had shaken the foundations of physics by the beginning of the twentieth century. Langevin the educator was a fierce opponent of tradition and denounced the routine and sclerosis of French education. Finally, as a political activist, Langevin fought tirelessly for justice and to build a world of peace. The image of a man of progress is so powerful that it seems to encapsulate his entire work. Georges Cogniot, who

fought many political and educational battles with Langevin,<sup>1</sup> selected this trait to depict the character in his obituary.

The mystery of Paul Langevin was his perpetual youthful spirit. He pushed forward, into battle and to victory, until the end. He renewed himself with an inexhaustible curiosity and ardour at an age when, usually, his peers enjoy, in stillness, a consecrated glory. His intellectual and practical life was, for fifty years, a drama, a progression, a conquest. As we knew him, as this book would like to revive him, in motion. [5, p. 14]

The physicist Pierre Biquard<sup>2</sup> did not hesitate to attribute this progressive inclination to some instinct:

Faced with the problems of scientific knowledge, Paul Langevin adopted instinctively an attitude oriented towards progress. Far from being frightened, the boldest innovations led to his adherence and active participation. He understood, enriched, taught, spread the truth. Faced with the problems of man and society, his behaviour was exactly the same ... [1, p. 78]

The intellectual portrait of Langevin immortalized by his disciples was enriched with moral features when his death was announced by the press. He was depicted as “the most human of scientists” in *Les Lettres françaises* (27 December 1946); “This genius physicist was also a man of deep kindness, constantly putting his devotion at the service of those who suffered” in the protestant weekly *Réforme* (5 January 1947). Langevin combined ethical with intellectual qualities, courage with patience, reason with generosity, intelligence with humanity. He had all the qualities of a “secular saint”.

## 1.2 Profile of a Third Republic *Notable*

It would not be difficult to denounce the hagiographic, ideological and political components of these heroic portraits. Patiently deconstructing the myth to substitute a more realistic portrait is a relatively easy task, with the hindsight of history. But it would be at the risk of maintaining the mirage of historians as impartial observers of the past. It seems to us more appropriate to take the popular icon seriously in

---

<sup>1</sup>Georges Cogniot (1902–1978), a professor of literature and an activist, collaborated with Langevin on several occasions notably in peace and antifascist movements in the 1930s as well as in the Commission for Educational Reform in 1944–1946. A member of the Central Committee of the French Communist Party (PCF) for about 30 years, in 1938 he co-founded *La Pensée* with Langevin, a journal that was supported by the PCF to spread Marxist thought among intellectuals.

<sup>2</sup>Pierre Biquard (1901–1992), started his career in the General Electricity Laboratory headed by Langevin at the *École municipale de physique et de chimie industrielles* (EPCI), then worked with Frédéric Joliot Curie. During the war, he joined the French Resistance. One of the founders of the French Atomic Energy Commission (CEA) in 1945, he was chief of staff to Frédéric Joliot, the CEA’s high commissioner from 1946 to 1950.

order to grasp its meaning and thereby shed light on the mentalities of an age when scientists enjoyed a high prestige in Western societies.

The oxymoron “secular saint” was in vogue in the early twentieth century to refer to an exemplary person respected for his or her contributions to a noble cause.<sup>3</sup> In France, the phrase “saint laïc”, often applied to scholars like Emile Littré or Louis Pasteur, testifies to the fascination for great intellectuals and political figures during the Third Republic. It suggests that Langevin embodied the values that prevailed in the French society of that time.

And indeed, Langevin’s profile and career have been deeply marked by the values and aspirations of the Third Republic, a regime that covers all his lifetime, since he was born in 1872 (2 years after the proclamation of the Third Republic) and died in 1946, at the dawn of the Fourth Republic. Frock coat and stiff collar, small moustache and brushed hair, Langevin has the look typical of the honourable professors of the Third Republic (Fig. 1.1). He belongs to a long lineage of French intellectuals who coupled intellectual achievements with engagement in the public sphere. Dating back to the eighteenth century with figures like Voltaire and Diderot, brilliantly pursued in the nineteenth century with Victor Hugo, this tradition was rejuvenated by the Dreyfus Affair which prompted famous writers such as Emile Zola,<sup>4</sup> scientists such as Emile Duclaux,<sup>5</sup> and many others to accuse the government of lies and injustice [10].

Langevin was by no means a marginal. Let’s not imagine an eccentric scientist, away from official science, a kind of “terrible child of the university”, a label occasionally used for Einstein. Even when he was a scientist in rebellion against governmental measures, Langevin remained a “notable”, a prominent member of the regime, so respected that his ashes were transferred to the Pantheon in 1948 together with the remains of his friend Jean Perrin.

Furthermore, Langevin is an example of the mechanism of social ascent through education typical of the Third Republic. Thanks to the non-clerical system of public education implemented by Prime Minister Jules Ferry it was possible for a youth of modest origin, like Langevin, to be able to become an international star in the physics community. As a student, he bravely climbed all the rungs of the education ladder from compulsory primary school to the elitist Ecole normale Supérieure. He subsequently remained in the educational system for all his life, becoming a

---

<sup>3</sup>According to Google Books Ngram viewer, the phrase “secular saint” first used in English language in 1885 reached a peak in 1890 and a second lower peak in 1940–1945. In French literature, “saint laïc”, hardly used until 1900, became more and more popular in the first half of the twentieth century with a first peak in 1930–1935 and a second higher one in 1945.

<sup>4</sup>Emile Zola (1840–1902), a French writer, critic, and political activist was the most prominent French novelist of the late nineteenth century. Zola fully committed himself in defending Alfred Dreyfus, a Jewish officer in the French army who was accused of treason by the government.

<sup>5</sup>Emile Duclaux (1840–1904), chemist and biologist was a close collaborator of Louis Pasteur whom he succeeded as director of the Pasteur Institute. He was also fully committed in defence of Captain Dreyfus.

**Fig. 1.1** Photograph of Langevin by Genia Reinberg. (ESPCI)



professor at the *Collège de France*<sup>6</sup> and the Director of the Paris *Ecole municipale de physique et de chimie industrielles* (EPCI). Finally, it is in the reorganization of public education that he attempted to materialize his ideal of social justice when he chaired the big reform project of the French educational system set up at the Liberation in 1944, known as the Langevin-Wallon plan.

### 1.3 Science and Action

How did Langevin manage to become so famous? What did he achieve in his scientific, educational, or political career to become such an icon of progress? Is he the author of a groundbreaking scientific discovery, the founder of a new discipline or theory? Did he invent a new pedagogy? Was he the leader of a revolutionary movement? None of these labels really suits him. Such is the paradox that makes the interest and complexity of this biography. Langevin never became a political leader,

---

<sup>6</sup>The *Collège de France*, created in the sixteenth century, is a prestigious public institution teaching cutting edge research.

nor a party man; and the reform project that bears his name has never been implemented.

In physics, he had already established for himself a high international reputation by his 30s, through important research on ionized gases and the theory of magnetism. Many of his colleagues also commented on his experimental skills, presumably acquired in his laboratory training under the supervision of Pierre Curie at EPCI. His later work on ultrasound and piezoelectricity added the accolade of engineer to the fame of the theoretical and experimental physicist. However, Langevin was neither a discoverer nor a Nobel Prize winner, although he was nominated 15 times. Sometimes, he didn't even bother to publish his results and was content to present them, mixed with those of others, during his courses at the *Collège de France*, according to his colleagues and students.<sup>7</sup> In 1905, he was exploring the implications of relativity but he was content to disseminate Einstein's ideas. Einstein himself emphasized this effacement in his obituary:

The burden of duties always undertaken of his own free will however hindered his own research, which is why the fruit of his work appeared more in the publications of others than in his own. It seems certain to me that he would have developed the special theory of relativity if it had not been done elsewhere; for he had clearly recognized the essential points. [4, p. 13]

Like many intellectuals of his generation, Langevin was affected by the shock of the First World War that deeply undermined faith in the progress of civilization and society. Seeking to overcome the shock he found remedies through public engagement. In the 1920s, he joined various world movements with the hope that through campaigns targeting young people and through scientific cooperation, it would still be possible to restore peace. Later, in the face of rising international tensions in the 1930s, he embarked into vibrant activism, restlessly fighting against fascism. Thus, Langevin increasingly spread his activities in multiple directions. He ran from congress to committees, from meetings to commissions, multiplying commitments. Was this at the risk of dissipating his energy in vain? Certainly, one can observe a fairly rapid decline in his scientific production at this time, in stark contrast to the pre-war, extremely fruitful, years. A glance at his list of publications shows that Langevin produced about as many results in the 15 years before the war as during the 30 years that follow.

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<sup>7</sup>“Three quarters of Langevin's work has not been published” estimates Léon Brillouin, physicist who graduated under Langevin's supervision and collaborated with him. He emigrated to the United States during the First World War and founded information theory. The estimate may be exaggerated but all the testimonies of Langevin's colleagues and those who attended his courses at the *Collège de France* point in the same direction [1, p. 69]. Langevin himself speaks of his “reluctance to publish his work” in a letter dated 13 January 1925, addressed to Albert Einstein [8, p. 23].

## 1.4 A Dispersed Scholar

While praising the courage, modesty and self-sacrifice of Langevin, one can nevertheless worry about the consequences of his choice. Did he not miss a brilliant scientific career? Did he not waste his talents through his activism? “Dispersed scholar”: is this the label that should be substituted for that of “secular saint”? Yes, the young Langevin was dissipated in many senses. The young Langevin was a dandy who led a dissolute life and had love affairs. The mature scientist and activist always opted for dispersion in his scientific works as well as in his social activism. Regardless of his strong pacifist or social convictions, he never identified with any party or movement. He rather diversified his commitments in dozens of organizations. As a young researcher, he decided to work on several subjects at the same time. From the start, Langevin crossed boundaries and refused to confine himself to a single research area. In the single year 1905, he published on electrons, on ionized gases, on the kinetic theory, on magnetism, on the impossibility of demonstrating the translational motion of the earth, on the inertia of energy. Later, in the 1930s, he remained apart from the competition that was taking place in atomic physics as he chose to devote the largest part of his scientific activity to communication and dissemination. Dissipation is, for Langevin, an intellectual strategy, a good practice based on his conviction that disseminating and sharing scientific knowledge matters as much as producing it.

Even in his ways of spreading the most recent developments in physics, Langevin inclined towards maximum dispersion. His work is made of a mosaic of scattered pieces: articles, lectures, talks, pamphlets. He never wrote a big treatise, a textbook, nor a popular science book. Instead, he delivered talks at a variety of institutions and at events all over the world.<sup>8</sup> His preference for oral communication largely shaped his style of thought. Langevin liked to display brilliant synoptic reviews on a topic rather than delivering patient and meticulous analyses. He was fond of images and metaphors and he was able to talk to all kinds of audiences, from colleagues and experts to the lay public. This scientist was a good performer. He used the technical skills that he acquired during his training at the EPCI to accompany his lectures with spectacular experiments on electricity. For example, he used a quadrant electrometer to project a light spot onto a screen, displaying to a large audience the quantities of electricity measured by this device. He fully participated in the new culture of sensitivity that the “fairy electricity” and radiations developed around 1900 with a taste for spectacular demonstrations shrouded in mystery [9].

As a counterbalance to his dispersive inclinations and the spread of his research interests, Langevin developed a strong aspiration to unification, to the synthesis of

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<sup>8</sup> Langevin’s main scientific papers published in scientific journals have been collected in a volume published by the *Centre national de la recherche scientifique* after his death [6]. Twelve of his talks delivered between 1894 and 1946, published in obscure and hardly accessible brochures or journals, have been selected and published by Vuibert in 2007 [7].

knowledge. He developed broad panoramas of the evolution of mankind in his public talks. As Louis de Broglie noted in his portrait of Langevin:

A lover of general ideas, he was keen to consider the philosophical aspects of advances in physics and, coming at a time when the outlook for science was constantly changing, he enjoyed looking at the ever-changing panorama of our knowledge as a whole and drawing out its broad outlines. [3, p. 237]

Indeed, Langevin was never a professional philosopher. As we will see, his considerations on scientific progress, society and civilization were far from original or innovative. However, his philosophical convictions shaped under the pressure of circumstances, sometimes under the shock of events, deserves the attention of historians. By virtue of their very banality, they open a window on the mentalities of a generation. Moreover, they also provide a key to grasp what makes the unity of Langevin's dispersed life and the coherence of his work. Finally, they afford clues to better understand the meaning of the public icon of Langevin as a secular saint. For this icon may express his unabated attempts to save his faith in progress despite his own doubts and anxieties, and the external threats of barbarism. A human voice trying to drown out the noise of weapons.

So the strong public image of Langevin is not built on the basis of a specific aspect of his work. It rather proceeds from the conjunction of the various and multiple facets of his life. Here was a leading figure of science, an expert in abstract physics who was capable of communicating and interacting with people from all walks of life. A son of the working class who rose to the level of the Collège de France, he remained a friend of the people. Romain Rolland,<sup>9</sup> who long rubbed shoulders with Langevin in peace movements, depicted him in 1934 as “a master of science who leads the popular classes”. The same terms are found in the press articles announcing Langevin's death: “A great Frenchman who put his intelligence at the service of the people” (*France nouvelle*, 21 December 1946); “The scientist never ceased to share the aspirations of the people” (*Ce soir*); “The ardent life of a child of the people who became one of the greatest scientists in the universe”; and as a subtitle “An example for the youth of France” (*L'Avant-garde*, 25–31 December 1946). Even those who disapproved of Langevin's project, like Étienne Gilson for instance, considered he was moral authority above the parties (*L'Aube*, 7 August 1947).

Obituaries published in the British press represented the dispersion of his talents. The *Illustrated London News* emphasized his work on magnetism. John D. Bernal, writing in *Nature*, emphasized the importance of Sonar, and of quartz-controlled oscillators, both arising from Langevin's work in the First World War. *The Times* noted that Langevin had long been interested in politics and was “known for his advanced ideas”. The British physicist James Crowther remembered “his influence over persons arose from his selflessness; his attention was always directed outside

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<sup>9</sup>Romain Rolland (1866–1944) was a French essayist and novelist who was awarded the Nobel Prize for Literature in 1915. He put his fame in the service of peace especially in his early membership in the World Committee against War and Fascism.

himself. He was a wonderful listener and friend; young men of talent always felt he was genuinely devoted to them” [2, p. 268].

Bernal recalled that Langevin said: “The scientific work which I can do, can be done and will be done by others, possibly soon, possibly not for some years; but unless the political work is done there will be no science at all”. Throughout his career Langevin might have faced the ethical dilemma since he noted at the end of his life:

Allow me, an old man, to evoke my personal experience, to retrace the path along which circumstances led me to reconcile various tasks as best I could, and along which I was able to verify how much easier it is to fulfil one’s duty than to know it. In this way, I was led to an at least apparent dispersion that, before the war and the recent occupation, some of my best friends reproached me for, not so much in the interest of Science, which could do without me, but in my own personal interest. (Langevin 1946a, p. 13)

How to write the biography of such an emblematic character, now that the speeches that held students or the public spellbound are frozen words printed on yellowing paper? Rather than attempting to provide a complete overview of all his achievements we will focus on a few key moments in his life and works. There will therefore inevitably be gaps, differences in tone and breaks in style through the chapters. We will strive, as much as possible, to provide the background of Langevin’s claims and actions in order to contextualize them and to better discover how, as a scientist and an activist, he achieved such high social prestige in mid-twentieth-century France.

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## Chapter 2

# The Road to Glory



**Abstract** Langevin grew up in the Montmartre district in the aftermath of the violence of the Paris Commune. His background hardly predestined him for a brilliant career as a physicist, but he benefited from the educational system introduced by the French Third Republic. Langevin graduated top of his year at the *École municipale de physique et de chimie industrielles de Paris* (EPCI) in 1891. Continuing his education at the prestigious *École normale supérieure* he was ranked first in the *agrégation* of physics in 1897, in addition to making many life-long friends. The world of physics was febrile, with X-rays, radioactivity and ether, challenging experimentalists and theoreticians who were conflicted in their approaches. A year's scholarship with J.J. Thompson in Cambridge, the basis for his PhD in gas ionization in 1904, gave him a springboard for a dazzling career. His 12 publications that year included topics as disparate as gas ionization, the inertia of energy, the ether and kinetic theory, followed the next year by seminal contributions to Brownian motion and magnetism.

Langevin could serve as a model for graduate students and young researchers because he is a self-made scientist. His background hardly predestined him for a brilliant career as a physicist. But he benefited from the educational system introduced by the French Republic and succeeded thanks to hard, intense work, and a social network of friends.

### 2.1 Child of the *Butte*

Paul Langevin's grandfather was a locksmith and his father Victor left school to enlist in the army at the age of 18. From 1854 to 1868, he travelled in Algeria with the imperial troops. When Victor Langevin returned to Paris in 1870, he married Marie-Adèle Pinel, great-niece of the famous psychiatrist Philippe Pinel. The couple settled on the Butte Montmartre, a working-class hilltop suburb annexed to the city of Paris in 1860. This neighbourhood was the crucible where the Paris Commune

ignited on 18 March 1871. The Langevins thus found themselves on the front line during the revolt that ended up in the “bloody week” at the end of May 1871, while they were expecting their second child. Paul, this second son, was born shortly afterwards, on 23 January 1872, in a family still traumatized by the repression of the riots. He was born on rue Ravignan, which remains famous because, at the turn of the century, many years after the departure of the Langevins, it hosted a group of painters and poets at the *Bateau-lavoir*. André Langevin described the Langevin’s apartment during the first year of Paul’s life, as “beautiful and very simple”, with a “bulls-eye” window above the door, and large-paned windows “each surmounted by an elegant and very sober coat of arms”. These architectural details remain.

Paul Langevin is therefore a “child of the Butte”, like Gavroche the fictional character in Victor Hugo’s novel *Les Misérables*. He could run in the narrow streets of a Montmartre, in complete upheaval because, at the top of the hill, the Sacré Coeur Basilica was under construction. The decision to build this massive basilica at the height of the popular revolt was part of the establishment of a bourgeois “moral order” following the events of the Paris Commune. This did not arouse many religious feelings in the young Paul Langevin who seems to have been much more imbued with the republican past of Montmartre:

I grew up, in the aftermath of the war of 1870, between a republican father and a mother devoted to sacrifice. Eyewitnesses of the siege of Paris and the bloody repression of the Commune, they instilled in me, through their stories, the horror of violence and the passionate desire for justice. (Langevin 1945d, p. 45)

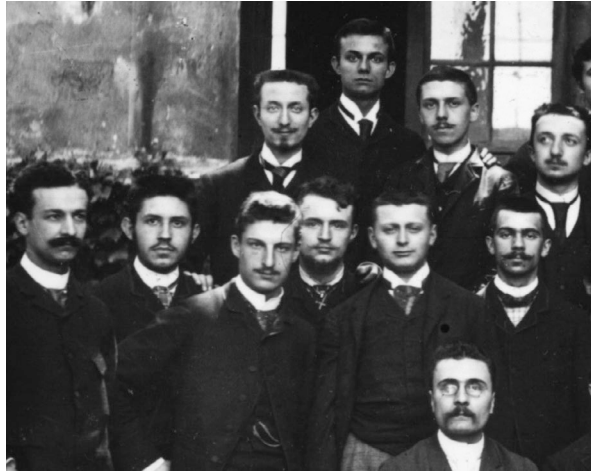
In 1880, the family moved to another neighbourhood. Paul went to a “communal” primary school in the 15th arrondissement, and passed the primary school certificate in 1883 (Fig. 2.1). Since he was a brilliant pupil this diploma did not mark the end of his educational journey, as was the case for the majority of pupils. Langevin was admitted to the *Ecole primaire supérieure Lavoisier*. This was a new type of public institution officially created in the 1880s and nicknamed *collège du peuple* (the people’s high school), because it was attended by children from the working class whereas the *lycées* which delivered the *baccalauréat* were reserved for the bourgeoisie [2]. Following the course of study at the Superior Primary School, Langevin obtained the highest score at the entrance exam of the *École municipale de physique et de chimie industrielles de Paris* (EPCI) in 1888. The EPCI had been founded in 1882 by the Alsatian chemists Paul Schutzenberger and Charles Lauth on the model of the Mulhouse school [13]. Its aim was to train competent engineers for the industrial sector, and to give them a high level of theoretical background in physics and chemistry as well as experimental skills, thanks to practical classes in the laboratory or the workshop. The municipality of Paris offered scholarships for able students. Langevin attended Pierre Curie’s classes here, graduating top of his year in 1891 (Fig. 2.2). He remained part of the school for the rest of his life, becoming director of studies and then director in 1926.

By the end of this 3-year course of study at EPCI, Langevin seemed more attracted to teaching than to industry. Having acquired some teaching skills out of necessity through giving fee-paying maths or physics lessons to make ends meet, he



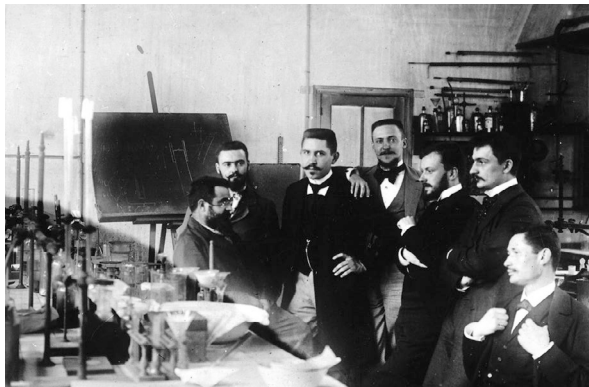
**Fig. 2.1** At the “communale” about 1880: Langevin is the third student from the right, bottom row. (ESPCI)

**Fig. 2.2** Seventh graduation of the EPCI: Langevin is the second on the left. (ESPCI)



chose to pursue a career in education. Following the BA (*licence*) of physics that he obtained at the University of Paris in 1892, he prepared for the highly competitive entrance exam at the *Ecole normale supérieure* (ENS), an elite institution created by the French revolution to train future teachers. The exam required that he learned Latin and classics but he was motivated by the expected salary paid to the *normaliens* (ENS students). He successfully passed the entrance exam in 1893, at the age of 21 (Figure 2.3). For nearly 12 years, Langevin has been a diligent and hard-working student who passed exam after exam. But now he had a break, a rest, his

**Fig. 2.3** Langevin at the bench at the Ecole normale supérieure, about 1895. (ESPCI)



entrance delayed for a year because of compulsory military service (1893–94). Returning to three years more study, he finally prepared for the additional and final exam, the *agrégation* of physics, that he passed in 1897 and was ranked first.

So remarkable was this achievement that, on Wednesday 10 August 1897, the daily paper *Le Figaro* included a succinct summary of his past and present successes and a prescient observation on his future prospects:

In the examinations that ended last week for the aggregation in physical sciences, Mr. Paul Langevin achieved a success that deserves to be noted. Having entered the *Ecole normale supérieure* at the top of the class, Mr. Langevin has constantly kept this position and was admitted to the aggregation with the same position, 10 points above the student who followed him. Previously, Mr. Langevin had triumphed in the same way at the *Ecole de physique et de chimie industrielles de la Ville de Paris*. In summary, since 1888, he has not taken any examination without coming out in first place. This is a fine example of perseverance at work and it would be surprising if Mr. Langevin did not, under these circumstances, quickly make progress.

These three years at the ENS proved decisive not only for the excellence of the scientific training but also for the relationships forged with other students from various disciplines who made up a solid network of long-lasting relations for future collaborations.

Langevin was a student at the ENS during a period of political turmoil that was caused by the Dreyfus Affair. When Captain Alfred Dreyfus, a graduate of the *École Polytechnique* and a Jew, was accused of treason and sentenced to life imprisonment, the ENS students, encouraged by the librarian Lucien Herr, supported the petitions against this unfair condemnation [1, 6]. Presumably Langevin was among the students supporting Dreyfus, but he was primarily focused on his studies in physics and was anxious to complete his education with a PhD. Thanks to a scholarship from the city of Paris he was able to commence work for his doctorate in the Cavendish Laboratory, Cambridge, UK. Langevin successfully defended his PhD in 1902 and he immediately got a teaching position as substitute and then supply professor for Eleuthère Mascart at the *Collège de France*.

## 2.2 An Effervescent Scientific Community

What was the state of physics, in 1900, when Langevin entered this international scientific community? He was immersed into an effervescent research community shaken by a series of major recent discoveries. Roentgen's discovery of X-rays at the end of 1895 attracted considerable public and medical attention. This invisible short-wavelength electromagnetic radiation created astonishment in the popular mind by making the inside of a human body visible without the body being cut open. The boundary between matter and radiation, between the theories of mechanics and electromagnetics was becoming increasingly uncertain. When he arrived in Cambridge as the first foreign research student to be permitted to study there, Langevin found himself immersed in the eye of a tornado. In 1897, John J. Thomson, head of the Cavendish Laboratory, demonstrated that cathode rays were negatively charged particles smaller than atoms and with a negligible mass.<sup>1</sup> In 1898, at the EPCI, Pierre and Marie Curie extracted and isolated from the uranium mineral pitchblende a substance that emits radiation that they named "radium". Electrons and radioactivity marked the end of an era dating back to antiquity. And, to complete the revolution, in 1900 Max Planck predicted that electromagnetic radiation should be considered, theoretically, to consist of quanta, or packets, of energy. The stable "Victorian era" of the indivisible atom [12, p. 79], and the fundamental pillar of the conservation of matter, was giving way to a wonderful world, populated with mysterious particles and powerful rays.

When considering possible theories to explain these observations, the climate was tense because of the conflict between mechanics and electromagnetism. It crystallized around the problem of the speed of light, because light waves were believed to propagate through an all-pervasive imponderable material, known as the ether. This concept raised the question of the mutual influence between matter and ether and of the relative motion of bodies. On the one hand, a number of physicists, Hendrik Lorentz in particular, assumed that the ether was motionless and that light propagates in this stationary environment, as a transverse wave. On the other hand, George G. Stokes claimed in 1845 that ether is dragged along by matter. In this case, it should be possible to demonstrate the translational motion of the Earth relative to the ether. In 1881, Albert Michelson tried to measure this movement with an interferometer. Morley repeated the experiment in 1887 but they both got negative results. The repeated failure of these experiments challenged the physics community. George Fitzgerald, Hendrick Lorentz and Henri Poincaré all suggested various hypotheses to account for these negative results. Finally, in 1905, Einstein, showed how to get physics out of this impasse, thanks to the two hypotheses of the relativity of space and time and the constancy of the speed of light relative to any inertial

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<sup>1</sup>J.J. Thomson (1856–1940) is a pioneer of atomic physics. His work led him to consider electrons as the universal constituents of the atom, in vibratory motion that Lorentz mathematically described. Thomson also conceived a model of the atom, sometimes called the "plum pudding model" with positive and negative charges distributed throughout the sphere of the atom.

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