

I



A young provincial in Paris

‘I have not chosen a career which will lead me to a
great fortune, but that is not my principal ambition’

Gay-Lussac¹

Introduction

By the late eighteenth century science was fairly well established as an intellectual activity in western Europe. The scientific movement had reached a zenith with the work of Isaac Newton (d. 1727) who had applied his mechanics to the whole solar system in his law of universal gravitation. Among the many followers of Newton in Britain in the eighteenth century, specially distinguished for their studies of the nature of matter were Joseph Black, Henry Cavendish and Joseph Priestley. Each in turn made important contributions to the knowledge of ‘airs’ or gases, but the interpretation of the role of gases in the physical and chemical world had to wait for the Frenchman, Antoine Laurent Lavoisier (1743–1794). France was not only Britain’s political rival in the eighteenth century but also shared with her supreme honours in literature, the arts and sciences. With a population of over twenty million, France had a major advantage over Britain with less than half that estimated number. But several factors encouraged the beginnings of an industrial and economic revolution in Britain, while France, with her government-regulated industry and more rigid social stratification, carried on the traditional methods of manufacture and production. One of the few areas where France could claim important industrial innovation towards the end of the eighteenth century was in chemical industry and at least some of this advance was due to Lavoisier and the Royal Academy of Sciences in Paris.

Lavoisier brought about a revolution in chemistry by his new understanding of chemical composition and reaction. He presented a list of some thirty simple substances or elements which could combine in certain ways to form compounds. In his system he gave particular prominence to combination with oxygen (usually by combustion) to form oxides or, with excess oxygen (he thought), acids. By the early 1780s this oxygen-centred chemistry had begun to win converts. One

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of the first of these was a chemist who had come to the subject via medicine, Claude Louis Berthollet (1748–1822), soon to become director of dyeing at the Gobelins dyeworks. Another convert to the new chemistry was Antoine François Fourcroy (1755–1809), a brilliant lecturer who held one of the few official teaching positions in chemistry in Paris before the Revolution. These three were to be joined in 1787 by the Dijon lawyer and chemist Guyton de Morveau (1737–1816) in the reform of chemical language. It seemed sensible when the theory was being reformed to abandon the chaotic and often arbitrary names given to substances in favour of a systematic nomenclature in which chemical compounds were given names reflecting their composition.

All four chemists became involved in the French Revolution, and in the stormy days of 1793–4 their leader Lavoisier was tragically to lose his head. Guyton and Fourcroy both became members of the Revolutionary Convention and like Berthollet, the least politically active, survived the storm. Indeed during the period when France was threatened with foreign invasion all three had applied their chemical knowledge and administrative talents to the organisation and production of supplies and munitions. Fourcroy played an influential part in the educational debates in the Convention and, in the constructive period after 1794, helped to establish several major institutions of higher education, notably the Ecole Polytechnique and several new medical schools. Guyton played a prominent role in the first years of the Ecole Polytechnique and also carried on the journal *Annales de chimie*, which had been founded by Lavoisier. Berthollet became the friend of a brilliant young artillery officer who was soon to alter the shape of France and the map of Europe, Napoleon Bonaparte. Bonaparte took him to Egypt and, when he returned to France in 1799 and seized power, Berthollet was made a member of the newly-established Senate. The Senate was supposed to safeguard the constitution, but duties were minimal and, with a very high salary, membership could be regarded as a sinecure.

Berthollet used his new wealth to buy a country house at Arcueil just outside Paris. There he wrote his *Essai de statique chimique* (1803) in which he formulated a new approach to chemical reaction which was to be taken up later in the nineteenth century. Arcueil was a base for some important scientific research much of which was actually carried out not by Berthollet himself but by various protégés. First and foremost of these was Gay-Lussac. They were soon joined at Arcueil by the great applied mathematician Pierre Simon Laplace (1749–1827), also a friend of Napoleon and Chancellor of the Senate. Laplace was particularly interested during this period in the study of short-range

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forces of attraction which might explain a whole range of phenomena in physics and chemistry. Although Berthollet flourished under the Napoleonic regime, after the defeat of Napoleon in 1814/15 he went into retirement. As Fourcroy had died in 1809 and Guyton died in 1816 Gay-Lussac became increasingly prominent as the leading French chemist under the restored Bourbon monarchy.

Because there was continuity between Berthollet's conception of chemistry and that of his protégé it may be worthwhile stressing the discontinuity of social support caused by the upheaval of the Revolution.² Gay-Lussac was in many ways typical of the new men of science who emerged from post-Revolutionary France. His was the first generation which could receive a full training in science and go on to earn a living as a scientist. Before his time, one was fortunate if one could follow a single course of lectures on some branch of science to supplement what could be learned from books. The great chemists of the generation before Gay-Lussac in France: Lavoisier, Berthollet, Guyton de Morveau, Fourcroy, qualified in medicine or law before turning to chemistry, of which they made virtually a new science. Mathematics had previously been taught at quite a high level in the military academies, but with the foundation of the Ecole Polytechnique young men were able to have mathematical training while remaining civilians.

Of course there were some apparent similarities between the two generations, such as membership of the Academy of Sciences, although closer examination tends to reveal important differences. To understand these it may be useful to review briefly Berthollet's early career. When he came to Paris from Piedmont in 1772 he managed to enter the circle of the Duke of Orleans. Berthollet had taken a degree in medicine and the Duke recommended him for the position of personal physician to Madame de Montesson; this provided him with the necessary leisure to do chemical experiments. His chemical work was favourably received and gained him admission to the Academy of Sciences, thus providing him with credentials as a scientist. But, like every other new member he was elected in the lowest grade (originally known as 'pupil' but then 'assistant'). He could aspire to promotion to 'associate' member when one of the more senior chemists died and eventually to the highest grade of 'pensioner'. After the Revolution, however, the new Institute³ had no hierarchy of membership. Specialised education and publication could now precede election. This desirable state of affairs was taken too far later in the nineteenth century when the age of election rose steadily so that membership became a final accolade in a scientist's career rather than an honour a scientist could use in his most creative period.

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Gay-Lussac was fortunate to be elected at the beginning of his scientific career.

Before the Revolution there was no scientific education at university level with a recognised qualification at the end. Gay-Lussac achieved this through his training at the Ecole Polytechnique. Moreover, his early years after graduation were followed by fruitful research under expert guidance. When Gay-Lussac looked for a livelihood, the days when Lavoisier had earned his living by association with a tax company might have been a century away instead of a mere decade. Berthollet, who depended so much after 1799 on the patronage of Bonaparte, was almost in the position of a royal favourite. This was not to be the pattern of science in the modern world.

For the new generation science was not a leisure-time pursuit for the wealthy bourgeois or nobleman; it was to be a full-time occupation. The scientist had a place in the new state and Condorcet had envisaged him as a civil servant. The scientist was to be paid out of public funds and had a public duty to perform, usually teaching, but occasionally research, as in the Bureau des Longitudes. It is true that there had been a few teaching posts in Paris before the Revolution but the political change brought a national investment in education at all levels; higher education received its full share of attention and resources. The new institutions provided educational opportunities never before available and they also required staff to teach in them. In the acceptance of the principle that education was the responsibility of the state we can see a qualitative change which begins a chapter in the history of the modern world.

Gay-Lussac may be considered as one of the first of the moderns. The analysis we give of his scientific output throughout his life could hardly have been applied before the main method of publication became the scientific paper rather than the book. Gay-Lussac also represents the new era in his many joint publications, a procedure almost unknown before 1800. He was one of the first generation of professional scientists, 'professional' in the sense that, after undergoing a prolonged period of specialised training in the theory and practice of physical science, he was employed to use that training. He made a living out of science and thus helped to establish science as a career to which any young man, in France at least, could aspire. In Britain professionalisation came rather later, but that is another story.

Early education

The region of France from which Gay-Lussac came was to become at

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the time of the Revolution the department of Haute Vienne, after the river Vienne which runs through it and its principal city Limoges before turning north to join the Loire more than 200 kilometres to the south west of Paris. About 22 kilometres to the north of Limoges was the small market town of Saint Léonard en Noblat with its eleventh-century church where the future scientist was baptised. Arthur Young, who travelled through France in 1787, described the country to the north of Limoges as the most beautiful he had seen in that country; thickly wooded with many chestnut trees, an undulating countryside giving picturesque groupings of rock, wood and water.⁴ The district was not rich agriculturally, or in any other way, but Turgot, who had been *intendant* of Limoges, had left a memorial to himself in the splendid roads of the region, on which Young commented.

Joseph-Louis Gay-Lussac was born at Saint Léonard on 6 December 1778, one of five children of Antoine Gay-Lussac, advocate and public prosecutor at Saint Léonard, and Leonarde Bouriquet. Joseph-Louis was not the eldest child but he was the eldest son, and family correspondence would suggest that the family hopes were largely pinned on him. He had three sisters, Fanchette, Marguerite and Mariette, and one brother, Pierre, who was to qualify in medicine.

Law and medicine were both represented in the Gay family, which towards the end of the eighteenth century began to use the name Gay-Lussac after their property at the hamlet of Lussac a few miles from Saint Léonard. This distinguished them from other branches of the family which also found some place in history, notably the Gay de Vernon family. Gay-Lussac's contemporary, the military engineer, Simon François Gay de Vernon (1760–1822) was also born at Saint Léonard. The scientist's ancestry can be traced back to members of the Gay family in the seventeenth century who were merchants. Louis, the grandfather of Gay-Lussac, studied medicine at Bordeaux and practised as a physician at St Léonard. Louis' only son Antoine, the father of the scientist, was born in 1744. He was sent to Bordeaux to study law and in 1769 he passed examinations in civil and canon law. In 1775 he became *Procureur du Roi* at St Léonard thus definitely establishing the Gay-Lussac family as one of local importance.

Such a local officer of the crown was not likely to escape the social and political upheaval of the Revolution. The early stages were slow and it seemed then that some reform would be possible under the monarchy. Under political and financial pressure Louis XVI agreed in May 1789 to a calling of the Estates General, a body of representatives of nobility, clergy and the 'third estate', which had not met since 1626. The government as evidence of their sincerity in considering

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reform invited the people to draw up *cahiers de doléances* or lists of grievances to be discussed by the Estates General. There still exist the suggestions drawn up in the handwriting of Gay-Lussac's father on behalf of the third estate of the region of Saint Léonard. In this preliminary *cahier de doléances*, dated 1 March 1789, it was suggested that the three orders should meet together rather than separately and that each man should have one vote. This document shows that the older Gay-Lussac was opposing the traditional stranglehold of the nobility in the political life of France. By 1793, however, men who had previously appeared as liberals were considered reactionary and in September 1793 the Convention invited the public to denounce as 'suspects' those whose full support of the course of the Revolution was in doubt. Gay-Lussac's father was arrested 'for reasons of aristocracy founded on public opinion'. As he was ill at the time, he was at first placed under house arrest, instead of being sent to the prison in Limoges. A petition of the accused was considered by a local committee on 7 January 1794 and although no definite charges were brought, it was not until after the fall of Robespierre (July 1794) that he was released.

The case of the Gay-Lussac family is typical of many of the bourgeoisie during the Revolution, who after a comfortable existence were reduced to straitened circumstances. As *Procureur du Roi* Gay-Lussac senior had a salary of 2400 livres (just over £100 sterling) but the source of this income dried up when the monarchy was abolished in 1792 and his appointment ceased. The income from his land was reckoned at 800 livres, not much for a family of seven together with servants. The head of the household's first concern was to stay alive but he was also concerned to find some employment, preferably making use of his administrative and legal experience. Under the new regime he had to swallow his pride and on 10 December 1796 he accepted the appointment of bursar at the almshouse of Saint Léonard. He subsequently became the local postmaster. Thus the immediate effect of the Revolution was to depress the fortunes of the Gay-Lussac family and to bring them down in the social scale. Although Joseph-Louis Gay-Lussac at first seemed to his father mindless of such considerations, the humiliation of the family may well have been felt by the eldest son and may have been one factor in his later desire for fame and fortune. The French Revolution, of course, not only brought people down the social scale but also provided opportunities for rising. By his genius, good fortune and hard work Gay-Lussac was to embark on a new career open to talents – that of scientist, professor and consultant.

Before the Revolution education was accepted as the responsibility

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of the Catholic Church and Gay-Lussac's first education was in the hands of the abbé Bourdeix. In fact there were two brothers Bourdeix at Saint Léonard who were both priests.⁵ It seems to have been the elder, Jean-Joseph Bourdeix (b. 1752) who was to be the tutor of Gay-Lussac. He had studied humanities, philosophy and theology at Limoges. He was formally attached to the chapel at Artiges near Saint Léonard, but this position left time for him to make some contribution to education in the Saint Léonard area as a tutor. The Revolution had a considerable effect on the Church in France. In November 1790 all beneficed clergy were required to take an oath to uphold the new political order. Many refused and the following year witnessed the beginning of a mounting campaign of repressive measures against the 'refractory' or non-juring priests. On 6 February 1793 the abbé Bourdeix was arrested and probably later fled the country to return only at the time of the Concordat⁶ in 1802, when he opened a school.

In eighteenth-century France boys who were not educated privately by a tutor might have attended a Church school. Although Saint Léonard did not have its own school, there were *collèges* at Limoges and Eymoutiers.⁷ Without the Revolution Gay-Lussac would probably have gone to the *collège* at the nearby town of Eymoutiers. A detailed syllabus of examinations for the respective classes in the 1780s was found in the family papers.⁸ These include the names and origins of the pupils, several of whom came from Saint Léonard either as *pensionnaires* (boarders) or as *externes* (day pupils). Pupils even came from the city of Limoges to attend the school and one is impressed by the academic classical education offered. Examinations included not only oral translations of texts and recitations but also 'declamation', a useful training for later public speaking. A little science was included in the third class in the form of elementary astronomy, but Latin prose and verse was the staple study with scripture and catechism.

However, political circumstances kept Gay-Lussac for the moment in his home town. As the role of the clergy in education came under challenge we see the beginning of the emergence of the lay teacher. For the next year Gay-Lussac had lessons from two teachers, Courty and Albert, but probably the family did not feel that this local education was at a very high level. The fall of Robespierre in July 1794 marked the beginning of the swing of the pendulum towards moderate opinion. It was in this more constructive period when new educational institutions were being set up that Gay-Lussac senior sent his eldest son to Paris, where he arrived in November 1794 just before his sixteenth birthday.

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Gay-Lussac's first months in Paris were of winter and what a winter! There had only been two previous winters as cold in the whole of the eighteenth century. The cold spell lasted from 16 December to 5 February.⁹ The cold undermined the morale of everyone. For those with little or no fuel available it was disastrous and it drove back to their homes many of those young students a few years older than Gay-Lussac who had enrolled at the short-lived Ecole Normale and the newly-founded Ecole Polytechnique.

We have no direct evidence about Gay-Lussac's first months in Paris. According to one source he was in the care of the abbé Dumonteil. However, a letter in the family archives of 27 March 1795, signed Daniel Monteil and addressed to Gay-Lussac père, suggests that all had not been well at the beginning.¹⁰ Father Dumonteil spoke of the difficulty of finding him suitable lodgings and of the 'idle and disorganised life' which he had been leading. However the priest had now found a suitable establishment for him where 'food for the body is healthy and sufficient in quantity while that of the spirit and the soul is not neglected'. The family had scraped together enough money to pay for their boy to stay there.

This establishment was a boarding school, called the Pension Savouré, which had been founded about 1729 on the principles of the ancient university of Paris.¹¹ The education provided was to be based on 'religion and piety without neglecting the progress of studies'. The founder had insisted on the close surveillance of pupils by masters on the principle that, in the absence of a master, the devil might take over. From 1770 to 1803 the school was run by Jean-Baptiste-Louis Savouré, Master of Arts, and was situated in the rue de la Clef near the site of the future Ecole Polytechnique. Gay-Lussac did not stay very long at this school, which seems to have temporarily closed for economic reasons.

Gay-Lussac then went to another private boarding school run by a Monsieur Sencier. Sencier's school had originally been at Nanterre but had moved to Passy near the Bois de Boulogne, then in the country outside Paris. There was a distinct advantage for Gay-Lussac in living in the country in a time of food scarcity. His surviving letters home give us some idea of his life at the school. There is evidence of an enlightened curriculum with, for example, not only Latin but a *modern* language. Gay-Lussac confessed to his father that he had at first been reluctant to undertake the study of English, but Sencier had convinced him of its great utility in the modern world. Drawing too was taught at the school, a subject which should be understood in the post-Revolutionary context of a useful art for engineers and architects. Gay-Lussac

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sent his father some examples of his architectural drawings and hoped for some encouraging words from home about them.

There would be room for considerable speculation about the exact circumstances which led Gay-Lussac to adopt a scientific career if it were not for the fortunate discovery of a letter written to his father in January 1803 and reviewing his career in Paris.¹² In the first place his father had wanted him to follow in his own footsteps and study law. When the father had subsequently suggested that a grounding in mathematics would also be useful the son had obediently turned to this study and had substituted mathematics for Latin which, perhaps because of the departure of the classics teacher, was no longer available to him at M. Sencier's school. His personal copy of Caesar's *Gallic War*¹³ has inside the front cover some long multiplication, as if to symbolise his new concern with mathematics.

The Ecole Polytechnique

It was the study of mathematics which provided the opportunity for Gay-Lussac to enter the Ecole Polytechnique. Mathematics had received a tremendous stimulus after the Revolution by being made the basis of the entrance examination to the Ecole Polytechnique, the new élite scientific institution. No one therefore could study mathematics, particularly in Paris, without being conscious of the Ecole Polytechnique. We must appreciate the publicity and prestige which this Revolutionary institution had acquired in the first few years of its existence. Although the historian of science is interested in the school as the training ground of many of France's future physical scientists, it was seen at the time in a much broader educational context. The father of Balzac hoped that the future novelist would enter the Ecole Polytechnique and to this end he arranged for him to have additional lessons in mathematics. The writer Stendhal came even nearer to a scientific education. In Grenoble young Stendhal had distinguished himself in mathematics and won a place in the Ecole Polytechnique. Once in Paris, however, Stendhal took fright at the discipline of higher education and used his examination success to escape from the provinces and to taste the life – in all its aspects – of the French capital.

The Ecole Polytechnique was intended primarily for the training of both civil and military engineers although the curriculum was much wider than any purely vocational training. In 1797 the Minister of the Interior, who had overall responsibility for the school, claimed that the curriculum provided 'an education which was complete and yet general enough to serve as a foundation for all possible applications'.¹⁴ The

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'applications' here should be understood in the context of the Schools of Public Service or *Ecoles d'application* such as the Artillery School, the School of Mines, the School of Bridges and Highways, etc. After some initial confusion it became the rule that entry to these schools was only available to graduates of the Ecole Polytechnique. This decision had two main effects. It increased the importance of the Polytechnique, giving it a virtual monopoly of recruitment of skilled scientific and technical manpower. It also enabled the Polytechnique to strengthen its tendency to provide a general scientific rather than a strictly vocational training.

The entrance examination to the Ecole Polytechnique was held each year in the last week of October. Candidates were expected to know the rules of arithmetic, algebra, including the solution of equations of the first four powers and the theory of series, geometry, trigonometry, analytic geometry and conic sections. The examiners were instructed to look for promise as much as actual achievement but were obviously able to report more confidently on the latter. From the foundation of the school the examiners were also required to be satisfied as to the 'moral and civic qualities' of the prospective student. Gay-Lussac took the entrance examination in October 1797 and was successful. It has been noted that he was the first student from the department of Haute Vienne to enter the school. This is literally true but it is important to note that he did so from a Paris base. A disproportionately large number of successful candidates took the entrance examination not at one of the provincial centres but in Paris with its special educational facilities. If Gay-Lussac had been an isolated provincial candidate he would have been less likely to have known what was expected from him. He was admitted to the Ecole Polytechnique on 27 December 1797.

His motives in taking the entrance examination for the Ecole Polytechnique were probably of several kinds. First there was the educational one. A new and prestigious institution for higher education was open in Paris and could be entered simply by success in a competitive examination. Secondly one might consider the economic aspect. Gay-Lussac as a student at the Ecole Polytechnique would receive a government grant and no longer be a burden on the family's precarious financial resources. Thirdly there was the problem of conscription. We shall consider the economic and military aspects of Gay-Lussac's life before discussing the details of academic work at the Ecole.

On arrival in Paris, young Gay-Lussac had found himself in a large city with few friends and many problems. Judging from his letters home his greatest problems were economic ones but, even when he had