Born: 23 March 1749 in Beaumont-en-Auge, Normandy, France Died: 5 March 1827 in Paris, France

Pierre-Simon Laplace's father, Pierre Laplace, was comfortably well off in the cider trade. Laplace's mother, Marie-Anne Sochon, came from a fairly prosperous farming family who owned land at Tourgéville. Many accounts of Laplace say his family were 'poor farming people' or 'peasant farmers' but these seem to be rather inaccurate although there is little evidence of academic achievement except for an uncle who is thought to have been a secondary school teacher of mathematics. This is stated in [1] in these terms:-

There is little record of intellectual distinction in the family beyond what was to be expected of the cultivated provincial bourgeoisie and the minor gentry.

Laplace attended a Benedictine priory school in Beaumont-en-Auge, as a day pupil, between the ages of 7 and 16. His father expected him to make a career in the Church and indeed either the Church or the army were the usual destinations of pupils at the priory school. At the age of 16 Laplace entered Caen University. As he was still intending to enter the Church, he enrolled to study theology. However, during his two years at the University of Caen, Laplace discovered his mathematical talents and his love of the subject. Credit for this must go largely to two teachers of mathematics at Caen, C Gadbled and P Le Canu of whom little is known except that they realised Laplace's great mathematical potential.

Once he knew that mathematics was to be his subject, Laplace left Caen without taking his degree, and went to Paris. He took with him a letter of introduction to d'Alembert from Le Canu, his teacher at Caen. Although Laplace was only 19 years old when he arrived in Paris he quickly impressed d'Alembert. Not only did d'Alembert begin to direct Laplace's mathematical studies, he also tried to find him a position to earn enough money to support himself in Paris. Finding a position for such a talented young man did not prove hard, and Laplace was soon appointed as professor of mathematics at the École Militaire. Gillespie writes in [1]:-

Imparting geometry, trigonometry, elementary analysis, and statics to adolescent cadets of good family, average attainment, and no commitment to the subjects afforded little stimulus, but the post did permit Laplace to stay in Paris.

He began producing a steady stream of remarkable mathematical papers, the first presented to the Académie des Sciences in Paris on 28 March 1770. This first paper, read to the Society but not published, was on maxima and minima of curves where he improved on methods given by Lagrange. His next paper for the Academy followed soon afterwards, and on 18 July 1770 he read a paper on difference equations.

Laplace's first paper which was to appear in print was one on the integral calculus which he translated into Latin and published at Leipzig in the *Nova acta eruditorum* in 1771. Six years later Laplace republished an improved version, apologising for the 1771 paper and blaming errors contained in it on the printer. Laplace also translated the paper on maxima and minima into Latin and published it in the *Nova acta eruditorum* in 1771. Laplace sent another paper *Recherches sur le calcul intégral aux différences infiniment petites, et aux différences finies* to the *Mélanges de Turin*. This paper contained equations which Laplace stated were important in mechanics and physical astronomy.

The year 1771 marks Laplace's first attempt to gain election to the Académie des Sciences but Vandermonde was preferred. Laplace tried to gain admission again in 1772 but this time Cousin was elected. Despite being only 23 (and Cousin 33) Laplace felt very angry at being passed over in favour of a mathematician who was so

clearly markedly inferior to him. D'Alembert also must have been disappointed for, on 1 January 1773, he wrote to Lagrange, the Director of Mathematics at the Berlin Academy of Science, asking him whether it might be possible to have Laplace elected to the Berlin Academy and for a position to be found for Laplace in Berlin.

Before Lagrange could act on d'Alembert's request, another chance for Laplace to gain admission to the Paris Académie arose. On 31 March 1773 he was elected an adjoint in the Académie des Sciences. By the time of his election he had read 13 papers to the Académie in less than three years. Condorcet, who was permanent secretary to the Académie, remarked on this great number of quality papers on a wide range of topics.

We have already mentioned some of Laplace's early work. Not only had he made major contributions to difference equations and differential equations but he had examined applications to mathematical astronomy and to the theory of probability, two major topics which he would work on throughout his life. His work on mathematical astronomy before his election to the Academy included work on the inclination of planetary orbits, a study of how planets were perturbed by their moons, and in a paper read to the Académie on 27 November 1771 he made a study of the motions of the planets which would be the first step towards his later masterpiece on the stability of the solar system.

Laplace's reputation steadily increased during the 1770s. It was the period in which he [1]:-

... established his style, reputation, philosophical position, certain mathematical techniques, and a programme of research in two areas, probability and celestial mechanics, in which he worked mathematically for the rest of his life.

The 1780s were the period in which Laplace produced the depth of results which have made him one of the most important and influential scientists that the world has seen. It was not achieved, however, with good relationships with his colleagues. Although d'Alembert had been proud to have considered Laplace as his protégé, he certainly began to feel that Laplace was rapidly making much of his own life's work obsolete and this did nothing to improve relations. Laplace tried to ease the pain for d'Alembert by stressing the importance of d'Alembert's work since he undoubtedly felt well disposed towards d'Alembert for the help and support he had given.

It does appear that Laplace was not modest about his abilities and achievements, and he probably failed to recognise the effect of his attitude on his colleagues. Lexell visited the Académie des Sciences in Paris in 1780-81 and reported that Laplace let it be known widely that he considered himself the best mathematician in France. The effect on his colleagues would have been only mildly eased by the fact that Laplace was right! Laplace had a wide knowledge of all sciences and dominated all discussions in the Académie. As Lexell wrote:-

... in the Academy he wanted to pronounce on everything.

It was while Lexell was in Paris that Laplace made an excursion into a new area of science [2]:-

Applying quantitative methods to a comparison of living and nonliving systems, Laplace and the chemist Antoine Lavoisier in 1780, with the aid of an ice calorimeter that they had invented, showed respiration to be a form of combustion.

Although Laplace soon returned to his study of mathematical astronomy, this work with Lavoisier marked the beginning of a third important area of research for Laplace, namely his work in physics particularly on the theory of heat which he worked on towards the end of his career.

In 1784 Laplace was appointed as examiner at the Royal Artillery Corps, and in this role in 1785, he examined and passed the 16 year old Napoleon Bonaparte. In fact this position gave Laplace much work in writing reports on the cadets that he examined but the rewards were that he became well known to the ministers of the government and others in positions of power in France.

Laplace served on many of the committees of the Académie des Sciences, for example Lagrange wrote to him in 1782 saying that work on his *Traité de mécanique analytique* was almost complete and a committee of the Académie des Sciences comprising of Laplace, Cousin, Legendre and Condorcet was set up to decide on publication. Laplace served on a committee set up to investigate the largest hospital in Paris and he used his expertise in probability to compare mortality rates at the hospital with those of other hospitals in France and elsewhere.

Laplace was promoted to a senior position in the Académie des Sciences in 1785. Two years later Lagrange left Berlin to join Laplace as a member of the Académie des Sciences in Paris. Thus the two great mathematical geniuses came together in Paris and, despite a rivalry between them, each was to benefit greatly from the ideas flowing from the other. Laplace married on 15 May 1788. His wife, Marie-Charlotte de Courty de Romanges, was 20 years younger than the 39 year old Laplace. They had two children, their son Charles-Emile who was born in 1789 went on to a military career.

Laplace was made a member of the committee of the Académie des Sciences to standardise weights and measures in May 1790. This committee worked on the metric system and advocated a decimal base. In 1793 the Reign of Terror commenced and the Académie des Sciences, along with the other learned societies, was suppressed on 8 August. The weights and measures commission was the only one allowed to continue but soon Laplace, together with Lavoisier, Borda, Coulomb, Brisson and Delambre were thrown off the commission since all those on the committee had to be worthy:-

... by their Republican virtues and hatred of kings.

Before the 1793 Reign of Terror Laplace together with his wife and two children left Paris and lived 50 km southeast of Paris. He did not return to Paris until after July 1794. Although Laplace managed to avoid the fate of some of his colleagues during the Revolution, such as Lavoisier who was guillotined in May 1794 while Laplace was out of Paris, he did have some difficult times. He was consulted, together with Lagrange and Laland, over the new calendar for the Revolution. Laplace knew well that the proposed scheme did not really work because the length of the proposed year did not fit with the astronomical data. However he was wise enough not to try to overrule political dogma with scientific facts. He also conformed, perhaps more happily, to the decisions regarding the metric division of angles into 100 subdivisions.

In 1795 the École Normale was founded with the aim of training school teachers and Laplace taught courses there including one on probability which he gave in 1795. The École Normale survived for only four months for the 1200 pupils, who were training to become school teachers, found the level of teaching well beyond them. This is entirely understandable. Later Laplace wrote up the lectures of his course at the École Normale as *Essai philosophique sur les probabilités* published in 1814. A review of the *Essai* states:-

... after a general introduction concerning the principles of probability theory, one finds a discussion of a host of applications, including those to games of chance, natural philosophy, the moral sciences, testimony, judicial decisions and mortality.

In 1795 the Académie des Sciences was reopened as the Institut National des Sciences et des Arts. Also in 1795 the Bureau des Longitudes was founded with Lagrange and Laplace as the mathematicians among its founding members and Laplace went on to lead the Bureau and the Paris Observatory. However although some considered he did a fine job in these posts others criticised him for being too theoretical. Delambre wrote some years later:-

... never should one put a geometer at the head of an observatory; he will neglect all the observations except those needed for his formulas.

Delambre also wrote concerning Laplace's leadership of the Bureau des Longitudes:-

One can reproach [Laplace] with the fact that in more than 20 years of existence the Bureau des Longitudes has not determined the position of a single star, or undertaken the preparation of the smallest catalogue.

Laplace presented his famous nebular hypothesis in 1796 in *Exposition du systeme du monde*, which viewed the solar system as originating from the contracting and cooling of a large, flattened, and slowly rotating cloud of incandescent gas. The *Exposition* consisted of five books: the first was on the apparent motions of the celestial bodies, the motion of the sea, and also atmospheric refraction; the second was on the actual motion of the celestial bodies; the third was on force and momentum; the fourth was on the theory of universal gravitation and included an account of the motion of the sea and the shape of the Earth; the final book gave an historical account of astronomy and included his famous nebular hypothesis. Laplace states his philosophy of science in the *Exposition* as follows:-

If man were restricted to collecting facts the sciences were only a sterile nomenclature and he would never have known the great laws of nature. It is in comparing the phenomena with each other, in seeking to grasp their relationships, that he is led to discover these laws...

In view of modern theories of impacts of comets on the Earth it is particularly interesting to see Laplace's remarkably modern view of this:-

... the small probability of collision of the Earth and a comet can become very great in adding over a long sequence of centuries. It is easy to picture the effects of this impact on the Earth. The axis and the motion of rotation have changed, the seas abandoning their old position..., a large part of men and animals drowned in this universal deluge, or destroyed by the violent tremor imparted to the terrestrial globe.

Exposition du systeme du monde was written as a non-mathematical introduction to Laplace's most important work *Traité de Mécanique Céleste* whose first volume appeared three years later. Laplace had already discovered the invariability of planetary mean motions. In 1786 he had proved that the eccentricities and inclinations of planetary orbits to each other always remain small, constant, and self-correcting. These and many other of his earlier results formed the basis for his great work the *Traité de Mécanique Céleste* published in 5 volumes, the first two in 1799.

The first volume of the *Mécanique Céleste* is divided into two books, the first on general laws of equilibrium and motion of solids and also fluids, while the second book is on the law of universal gravitation and the motions of the centres of gravity of the bodies in the solar system. The main mathematical approach here is the setting up of differential equations and solving them to describe the resulting motions. The second volume deals with mechanics applied to a study of the planets. In it Laplace included a study of the shape of the Earth which included a discussion of data obtained from several different expeditions, and Laplace applied his theory of errors to the results. Another topic studied here by Laplace was the theory of the tides but Airy, giving his own results nearly 50 years later, wrote:-

It would be useless to offer this theory in the same shape in which Laplace has given it; for that part of the Mécanique Céleste which contains the theory of tides is perhaps on the whole more obscure than any other part...

In the *Mécanique Céleste* Laplace's equation appears but although we now name this equation after Laplace, it was in fact known before the time of Laplace. The Legendre functions also appear here and were known for many years as the Laplace coefficients. The *Mécanique Céleste* does not attribute many of the ideas to the work of others but Laplace was heavily influenced by Lagrange and by Legendre and used methods which they had developed with few references to the originators of the ideas.

Under Napoleon Laplace was a member, then chancellor, of the Senate, and received the Legion of Honour in 1805. However Napoleon, in his memoirs written on St Hélène, says he removed Laplace from the office of Minister of the Interior, which he held in 1799, after only six weeks:-

... because he brought the spirit of the infinitely small into the government.

Laplace became Count of the Empire in 1806 and he was named a marquis in 1817 after the restoration of the Bourbons.

The first edition of Laplace's *Théorie Analytique des Probabilités* was published in 1812. This first edition was dedicated to Napoleon-le-Grand but, for obvious reason, the dedication was removed in later editions! The work consisted of two books and a second edition two years later saw an increase in the material by about an extra 30 per cent.

The first book studies generating functions and also approximations to various expressions occurring in probability theory. The second book contains Laplace's definition of probability, Bayes's rule (so named by Poincaré many years later), and remarks on moral and mathematical expectation. The book continues with methods of finding probabilities of compound events when the probabilities of their simple components are known, then a discussion of the method of least squares, Buffon's needle problem, and inverse probability. Applications to mortality, life expectancy and the length of marriages are given and finally Laplace looks at moral expectation and probability in legal matters.

Later editions of the *Théorie Analytique des Probabilités* also contains supplements which consider applications of probability to: errors in observations; the determination of the masses of Jupiter, Saturn and Uranus; triangulation methods in surveying; and problems of geodesy in particular the determination of the meridian of France. Much of this work was done by Laplace between 1817 and 1819 and appears in the 1820 edition of the *Théorie Analytique*. A rather less impressive fourth supplement, which returns to the first topic of generating functions, appeared with the 1825 edition. This final supplement was presented to the Institute by Laplace, who was 76 years old by this time, and by his son.

We mentioned briefly above Laplace's first work on physics in 1780 which was outside the area of mechanics in which he contributed so much. Around 1804 Laplace seems to have developed an approach to physics which would be highly influential for some years. This is best explained by Laplace himself:-

... I have sought to establish that the phenomena of nature can be reduced in the last analysis to actions at a distance between molecule and molecule, and that the consideration of these actions must serve as the basis of the mathematical theory of these phenomena.

This approach to physics, attempting to explain everything from the forces acting locally between molecules, already was used by him in the fourth volume of the *Mécanique Céleste* which appeared in 1805. This volume contains a study of pressure and density, astronomical refraction, barometric pressure and the transmission of gravity based on this new philosophy of physics. It is worth remarking that it was a new approach, not because theories of molecules were new, but rather because it was applied to a much wider range of problems than any previous theory and, typically of Laplace, it was much more mathematical than any previous theories.

Laplace's desire to take a leading role in physics led him to become a founder member of the Société d'Arcueil in around 1805. Together with the chemist Berthollet, he set up the Society which operated out of their homes in Arcueil which was south of Paris. Among the mathematicians who were members of this active group of scientists were Biot and Poisson. The group strongly advocated a mathematical approach to science with Laplace playing the leading role. This marks the height of Laplace's influence, dominant also in the Institute and having a powerful influence on the École Polytechnique and the courses that the students studied there.

After the publication of the fourth volume of the *Mécanique Céleste*, Laplace continued to apply his ideas of physics to other problems such as capillary action (1806-07), double refraction (1809), the velocity of sound (1816), the theory of heat, in particular the shape and rotation of the cooling Earth (1817-1820), and elastic fluids (1821). However during this period his dominant position in French science came to an end and others with different physical theories began to grow in importance.

The Société d'Arcueil, after a few years of high activity, began to become less active with the meetings becoming less regular around 1812. The meetings ended completely the following year. Arago, who had been a staunch member of the Society, began to favour the wave theory of light as proposed by Fresnel around 1815 which was directly opposed to the corpuscular theory which Laplace supported and developed. Many of Laplace's other physical theories were attacked, for instance his caloric theory of heat was at odds with the work of Petit and of Fourier. However, Laplace did not concede that his physical theories were wrong and kept his belief in fluids of heat and light, writing papers on these topics when over 70 years of age.

At the time that his influence was decreasing, personal tragedy struck Laplace. His only daughter, Sophie-Suzanne, had married the Marquis de Portes and she died in childbirth in 1813. The child, however, survived and it is through her that there are descendants of Laplace. Laplace's son, Charles-Emile, lived to the age of 85 but had no children.

Laplace had always changed his views with the changing political events of the time, modifying his opinions to fit in with the frequent political changes which were typical of this period. This way of behaving added to his success in the 1790s and 1800s but certainly did nothing for his personal relations with his colleagues who saw his changes of views as merely attempts to win favour. In 1814 Laplace supported the restoration of the Bourbon monarchy and cast his vote in the Senate against Napoleon. The Hundred Days were an embarrassment to him the following year and he conveniently left Paris for the critical period. After this he remained a supporter of the Bourbon monarchy and became unpopular in political circles. When he refused to sign the document of the French Academy of Sciences supporting freedom of the press in 1826, he lost the remaining friends he had in politics.

On the morning of Monday 5 March 1827 Laplace died. Few events would cause the Academy to cancel a meeting but they did on that day as a mark of respect for one of the greatest scientists of all time. Surprisingly there was no quick decision to fill the place left vacant on his death and the decision of the French Academy of Sciences in October 1827 not to fill the vacant place for another 6 months did not result in an appointment at that stage, some further months elapsing before Puissant was elected as Laplace's successor.

Article by: J J O'Connor and E F Robertson

January 1999