

Noël Bernard: ‘The greatest hope of French botany’

Nora De Angelli commemorates a man whose astonishingly quick mind was lost too soon to the world of orchids

Noël Bernard made fundamental discoveries about orchid seed germination and even used his lab experience to save his premature child's life.

DURING HIS SHORT but productive career, Noël Bernard (1874–1911) shed much light on the nature of the endophytic fungi found in orchids and their importance to their survival. His major discovery was the symbiotic germination of orchid seeds. This is where a soil fungus provides water, mineral nutrients and carbon to the seedling, compensating for the lack of endosperm (orchid seeds have minor food reserves, such as sugars and oil droplets, but they cannot use them) typical of the family *Orchidaceae* (Bernard 1899, Rasmussen 1995).

A precocious pupil

Noël Léon Bernard was born in Paris, France, on 13 March 1874. His father, François Bernard, was a dealer in textiles and his mother, Marie-Marguerite, was a milliner. His father died at 51, when Noël was only five years old, leaving his dependents short of money. Nevertheless, his mother worked hard and also borrowed money to support her son's studies. To bring in extra money after his father died, Bernard worked in his spare time as a tutor for wealthy and sometimes royal families, including that of Princess Marthe Bibesco (1886–1973), the Romanian-French writer.

A brilliant student, between 1895 and 1897 Bernard successively obtained a series of Bachelor of Science honours degrees in mathematics, physics and natural sciences (biology and geology). An outstanding student, he was also an admirer of the work and ideas of Charles Darwin (1809–1882). He was considered to be a clever, clear-thinking man, enthusiastic and charming, but with a direct »



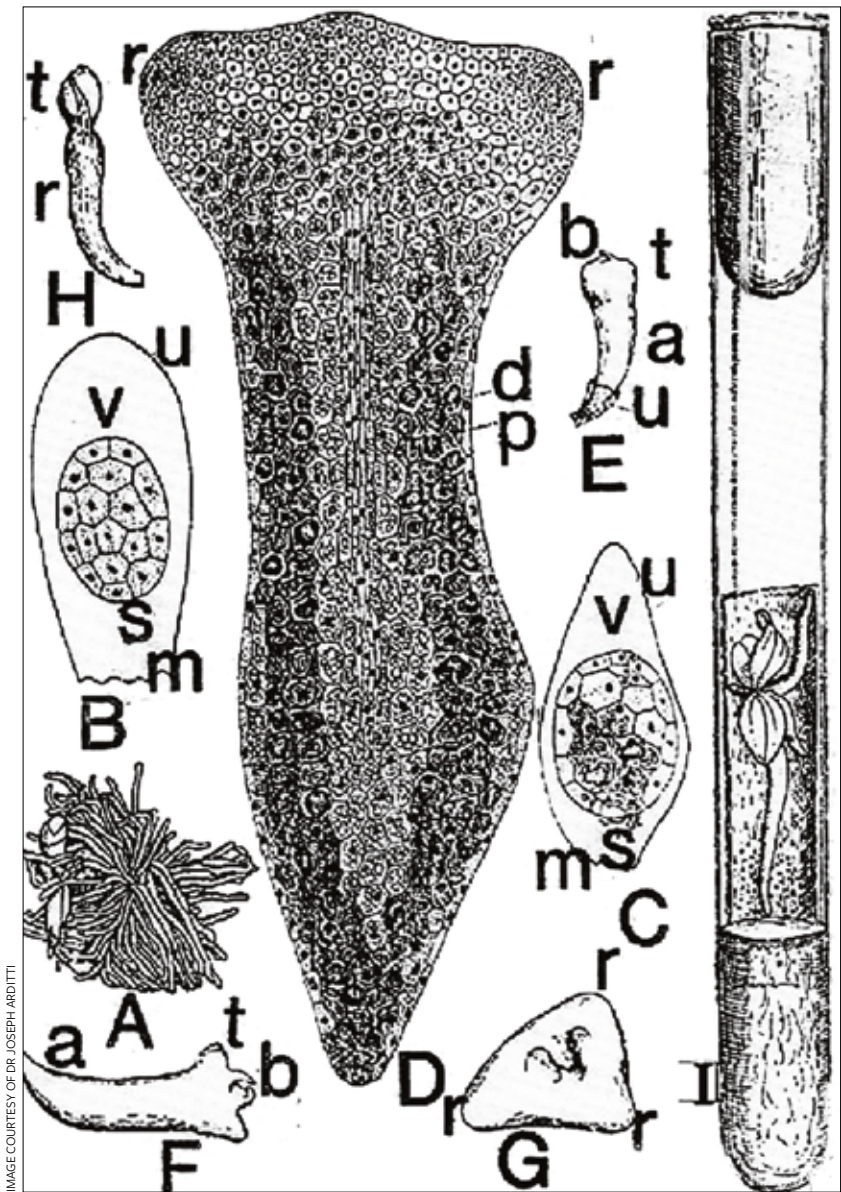
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Fig. 1. *Neottia nidus-avis*. A mature plant; B inflorescence and flower detail; C tall, dead infructescence; D a seed capsule before dehiscence (left) and dehiscent (right); E underground, tangled, bird's-nest-like rhizome.

A figure showing the germination of *Neottia nidus-avis* from Bernard's paper titled 'Études sur la tuberisation'. The process led Bernard to conclude that in nature colonization by a mycorrhizal fungus is required for orchid seed germination.



Major figures in Bernard's life included (below, left to right) Émile Duclaux, Joseph Magrou, Melchior Treub and Émile Roux.



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and frank way of speaking that sometimes antagonized his superiors (Selosse *et al.* 2011).

At the end of 1898 Bernard started a doctoral thesis on orchids under Professor Julien Costantin (1857–1936), a member of the French Academy of Science, in the Botany Department of the École Normale Supérieure and the École Polytechnique. In parallel, during 1899–1900, he took courses in microbiology at the Pasteur Institute taught by some of the greatest scientists of the time, Émile Duclaux (1840–1904), Pierre Paul Émile Roux (1853–1933) and Ilya Ilyich Mechnikov (1845–1916). These courses gave him a good grounding in the techniques he needed for his research on orchid-fungus symbiosis and influenced his future research (Yam *et al.* 2002).

Germination revelation

On the 3 May 1899, at the age of 25 and still studying for his doctorate, while walking in the Fontainebleau Forest near Melun, where he was doing his military national service, he discovered a dead, rotting infructescence of the achlorophyllous *Neottia nidus-avis* (bird's-nest orchid) (see Fig. 1).

Understanding the importance of his discovery, on the evening of the find, Bernard wrote two (nearly identical) letters to his cousin, Joseph Émile Magrou (1883–1951), head of the Phytopathology and Mycology Department at the Institute Pasteur, and to his uncle, Joseph Bernard (Boullard 1985). He described in detail the *Neottia nidus-avis* infructescence from the previous year, which was 'accidentally buried in the soil, under a layer of dead leaves. In the spring, the seeds, still inside the fruit, had not been released, but started to germinate' (Bernard 1899).

Under the microscope Bernard saw the underground orchid seedlings that 'no botanist's eye ever examined'. He noted that all germinating seeds contained fungi – 'some layers of cells are almost full with a tight clump of mycelial

filaments' (Jaquet 2007). His genius came into play when he concluded that 'mycorrhizae are indispensable for the plant [seeds] during the germination period [and] *Neottia nidus-avis* plants are associated with their fungi during all stages of development' (Bernard 1899). The observation that the fungal mycelial filaments were associated with all the seeds, led him to conclude that the fungus was providing nutrition, a phenomenon which inspired him to propose a mechanism for orchid seed germination.

To better describe the young plantlets during the first stages of germination he initially used the term 'spherules', which was shortly replaced by the term 'protocorm'. The term protocorm, which at present is mostly associated with orchids, was originally coined as 'protocorme' by Dutch botanist Melchior Treub (1851–1910), director of Bogor Botanical Gardens in Java, Dutch East Indies, today's Indonesia (Treub 1890).

In fact, germination had started because a *Sebacinales* species of soil fungus had colonized the seeds (Selosse *et al.* 2002). It was common knowledge at that time that orchids were generally infected by mycorrhizal fungi, but Bernard's 'stroke of brilliance', as Jaquet (2007) put it, was to establish that the relationship was absolutely necessary for the survival of orchids (Bernard 1900). Bernard published his observations and conclusions on 15 May 1899 in *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences*, the weekly reports of the meetings of the academy, less than two weeks after the field discovery (Bernard 1899).

Dr Bernard investigates

Not only did he continue his work on orchid seed germination, but his thesis had also proposed the theory that tuber formation, which he called 'tuberculisat[i]on', in *Ophrys* was due to the symbiotic fungal infection. He suggested that since this chronic infection was always present, the tuberous roots, characteristic of many orchids, were actually a consequence of fungal symbiosis in plants (Bernard 1900, 1901, 1902a, 1902b, 1909a, 1909b).

He defended his thesis on tuberisation in plants in November 1901 (Bernard 1902a) and in 1902 moved to Caen as a lecturer. Mentioning the clarity of Bernard's ideas and his elegant writing, his former thesis supervisor, Jean Costantin, who had been elected to the French Academy of Science, wrote 'his works are all signed with a touch of beauty'.

He went on to isolate several new species of

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'A clever, clear-thinking man, enthusiastic and charming, but with a way that sometimes antagonized his superiors'

fungi from more than 20 different orchid species. He then inoculated sterilized orchid seeds with the fungi and, in 1904, performed symbiotic germination under controlled laboratory conditions. Moreover, he concluded that orchid fungi were likely to be very diverse, and not compatible from one orchid species to another (Bernard 1902b, 1904b, 1905, 1906). Although the achievement of successfully germinating orchid seeds asymbiotically (in the absence of the fungus) was later attributed to investigators such as Lewis Knudson (1884–1958), Bernard became the first to accomplish this feat in 1908 (Bernard 1908, 1909b).

He was also the first to introduce *Rhizoctonia* (family *Ceratobasidiaceae*) as the name for the orchid symbiotic fungi he isolated. In 1908 he deposited two strains at the Centraalbureau voor Schimmelcultures in Utrecht, the Netherlands: CBS 125.08 (*Rhizoctonia lanuginosa* taken from a mycorrhizal root of *Odontoglossum* sp.) and CBS 126.08 (*Rhizoctonia solani*, from *Vanda tricolor*, originally called *Rhizoctonia mucoroides*, which to this day is still available for distribution) (Selosse *et al.* 2011).

Husband, father, professor

In 1907 Bernard married Marie-Louise Martin (1878–1946), a mathematician from the Ecole Normale Supérieure de Fontenay-aux-Roses. He was 33 and she was 29. They settled in the countryside in Mathieu, Normandy, leading a ‘remote and very free lifestyle [...] as did Curie or Darwin’ with Bernard cycling every morning of the year to his laboratory (Boullard 1985, cited in Selosse *et al.* 2011).

On 30 April 1908 the pregnant Marie-Louise went cycling, fell and their son Francis Bernard (1908–1990) was prematurely born. Bernard kept the tiny (1.5kg) baby alive by feeding him a mixture of malt, water and orange or lemon juice and placing him in an incubator, which may have been one of the incubators left over from Pasteur’s days and still in service (Yam & Arditti 2009). Francis Bernard survived and had his own, very distinguished career as a marine biologist and myrmecologist. He had two sons and four grandsons and died on 16 June 1990 (Arditti 2022).

During the same year, Bernard took charge of the course in botany at the Faculté des Sciences at Poitiers and in 1909 he was appointed as Professor of Botany. There, he made numerous major contributions to botany, orchids, potatoes and symbiosis. Two major works on orchid fungi were

published in 1909, one of which was Bernard’s definitive book-length review on orchid mycorrhiza, *L’évolution dans la symbiose, les orchidées et leurs champignons commensaux* (Bernard 1909b).

A premature passing

On 19 December 1910 Bernard received the Saintour Prize from the French Academy of Science for his research on orchids but by this time he was already gravely ill. Very weak, but fully conscious until his last hours, Noël Bernard lost his long battle with tuberculosis on 26 January 1911.

Professor Francis Bernard, Noël Bernard’s son, described his father as the ‘Mozart of plant biology’. This is because both the orchid scientist and the great composer had their peak of brilliance and creativity between the ages of 22 and 35 and they both died in their mid 30s, Mozart at 35 and Bernard at 36 (Arditti 2022).

As a lecturer and speaker, his wife, Marie-Louise Bernard, remembered him as having ‘a warm, deep voice, an elegant gesture, and a clever and softly ironical mind, masking [...] an infectious enthusiasm’ (Boullard 1985). In a late note published by his wife after his death, Bernard (1911) also reported on the fungicidal capacity of orchids: ‘even a relatively limited infection of the plant *Himantoglossum hircinum* is sufficient for the orchid’s tubers to acquire fungicidal capacity’. In Bernard’s eyes, the induced fungicidal capacity killed the fungus within the plant in a controlled manner, allowing it to survive in soil during the winter and to recolonize the plant the following spring. Antifungal compounds from orchids, »



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The Institut Botanique at Caen Jardin des Plantes (right) and the Noël Bernard Glass-house built there (below right).

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Francis Bernard (left) who owed his life to the scientific expertise of his father, Noël.

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The village church at Mathieu, Calvados (left) where Bernard settled with his wife after their marriage.



× Vandacostylis Bernardii Bultel.
2/4 de grandeur naturelle.

ARCHIVES DU MUSÉUM, 1935, 4^e Série, Tome XII

(A. GONZALEZ)

Source : M.P.H., Paris

An illustration of
x *Rhynchanthe*
(x *Vandacostylis*)
bernardii (above)
that appeared in
1935 in the
Archives du
Muséum d'Histoire
Naturelle, Paris.

A photograph of
the same plant
in the same
publication
(right).

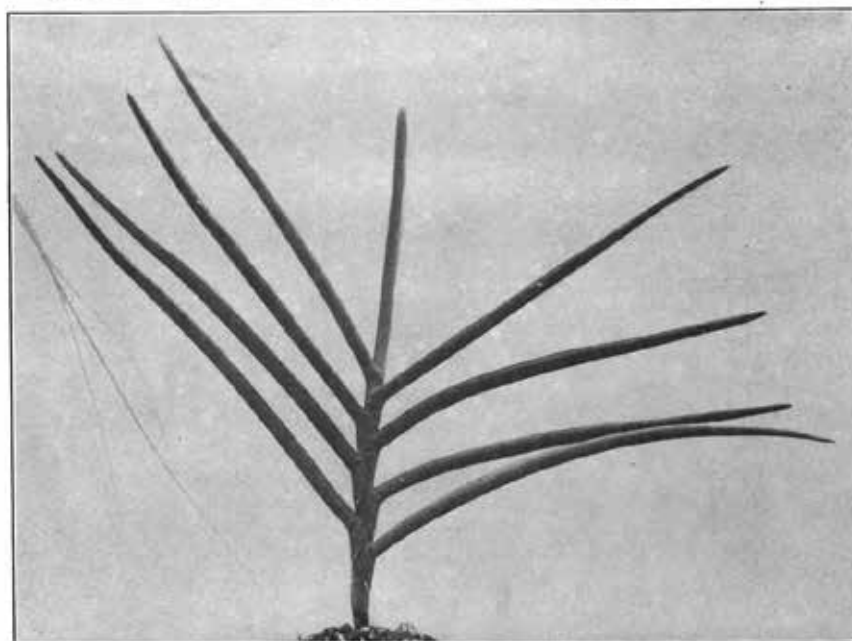


Fig. 1. — × Vandacostylis Bernardii. — Vue d'ensemble d'une plante. Environ 2/5 de la grandeur naturelle.

known as phytoalexins, such as hircinol, loroglossol and orchinol, were later discovered as a result of his observations (Selosse *et al.* 2011).

A long legacy

Bernard's unpublished works and notes were assembled after his death to produce two textbooks, *L'évolution des Plantes* (Bernard 1916) and *Principes de Biologie Végétale* (Bernard 1921), by his wife Marie-Noël Bernard, who also completed some other notes that Bernard was preparing before his death (Selosse *et al.* 2011).

In 1935, Gaston Bultel, head gardener and orchid grower of the Rothschild family, dedicated a new intergeneric hybrid orchid to him, *Rhynchanthe* (*Vandachostylis*) *bernardii* (*Vanda teres* × *Rhynchostylis retusa*) which also has the grex name Noël Bernard (Selosse *et al.* 2011). The grex name Noël Bernard has also been given to *Paphiopedilum primulinum* × *P. acmodontum*.

According to Arditti (2022), Bernard's discovery of orchid mycorrhiza is one of the five most important orchid discoveries, the other four being the early writings by Theophrastus on orchids in Europe, the establishment of the family *Orchidaceae* by Lindley, Lewis Knudson's method for asymbiotic seed germination, and Gavino Rotor's first orchid micropropagation.

In a letter to Joseph Magrou, the French physicist Jean Perrin (1870–1942), winner of the 1926 Nobel Prize, gives us a clear glimpse into the rich potential of Noël Bernard: 'I recently saw Jacques Loeb, a physiologist at the Rockefeller Institute. [...] We spoke a lot about Noël, whom he admires a lot. I told him that Bernard was probably the greatest hope of French botany and that his death had perhaps been a bigger social loss than that of [Marie] Curie or [Henri] Poincaré'. ○

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