In 1987 the italian marine researcher Fernando "Nando" Boero published a paper about a new marine jellyfish discovered in California and named "Phialella zappai" in honor to Frank Zappa, his favourite rocker. In 1988 Zappa decided to dedicate to Fernando the concert on 8th June 1988 at Genoa, and in particular the song "Lonesome Cowboy Nando", a variation of the most famous "Lonesome Cowboy Burt":
Frank Zappa - Lonesome Cowboy Nando

Nando has now written the first review of my book. The review will be published in *Marine Ecology*.

Nathanael Pringsheim: a forgotten scientist who knew how to look

Andreas Deutsch, *Archetypes of Sex: Unmasking Algae's Innocence — The Nathanael Pringsheim Revolution* (2026).

I must begin this review with a confession: before reading Andreas Deutsch's book, I had never heard of Nathanael Pringsheim. This is rather surprising, considering that he made fundamental contributions to our understanding of fertilization, sexual reproduction, and the alternation of generations. He was an influential scientist in his time, yet his name has largely disappeared from the general history of biology. I suspect that many contemporary biologists, including those who study reproduction and life cycles, would be as unfamiliar with him as I was, before reading this book.

Deutsch restores Pringsheim to the place he deserves in the history of biological discoveries. But it also raises a broader question: why do some scientists become permanent landmarks in the history of science, while others, whose contributions were no less fundamental, gradually disappear from collective memory?

Pringsheim lived in the nineteenth century, when the microscope was revealing an unsuspected world of biological processes. The existence of males and females, and their involvement in reproduction, had been recognized since antiquity. What actually happened during fertilization, however, remained largely inaccessible to direct observation. The discovery of spermatozoa had not immediately resolved the problem of their function, and the cellular mechanisms of reproduction were still poorly understood.

In 1855, studying the alga *Vaucheria*, Pringsheim directly observed a crucial event in sexual reproduction. Deutsch describes this as the first direct observation of fertilization in a living organism. The claim is remarkable, although it requires careful historical interpretation. Sexual reproduction in algae had already been investigated by Gustave Thuret and others, while fertilization in animals had been studied through observations and experiments on eggs and sperm. Pringsheim's particular achievement lay in observing the entry of a spermatozooid into the egg in the living alga itself.

This distinction is important. In mammals, fertilization occurs within the reproductive tract, beyond the reach of direct microscopic observation at that time. In many marine animals, eggs and sperm can be collected and their interactions observed outside the parent organism. *Vaucheria*, by contrast, offered an opportunity to observe reproductive structures and processes in the living organism. Its biology made something visible that other organisms had concealed.

Pringsheim did not discover fertilization because algae were biologically simple. He could observe it because their particular organization made the process accessible.

His investigations also contributed to our understanding of the alternation of generations. The phenomenon had first been discovered in animals by Adelbert von Chamisso, who described the remarkable alternation between solitary and aggregate forms in salps in 1819. Japetus Steenstrup

subsequently recognized its occurrence in other animal groups, including cnidarians, and developed a more general interpretation of the phenomenon. Wilhelm Hofmeister established the significance of alternation of generations in land plants. Pringsheim extended these investigations to algae, including *Oedogonium* and *Coleochaete*, revealing reproductive sequences that could not be understood by examining a single phase of an organism's existence. These discoveries shared a fundamental methodological insight: only by following organisms through their entire life cycles could apparently unrelated forms be recognized as successive stages of the same biological history. He later developed a theoretical interpretation of the relationships between alternating generations, contributing to a debate that would become central to the evolutionary understanding of plant life cycles. Not all the phenomena then described as alternation of generations correspond precisely to the distinctions established later through cytology and the recognition of haploid and diploid phases. Nevertheless, Pringsheim's observations helped demonstrate that reproductive cycles were far more diverse than the familiar succession of parents and offspring might suggest.

The lesson is fundamental: to understand an organism, it is often necessary to follow its entire life cycle. A single form, however accurately described, may provide only a fragment of its biological identity.

The subtitle of Deutsch's book, *Unmasking Algae's Innocence*, is particularly revealing. It recalls the cultural resistance encountered by the recognition of sexuality in plants. Linnaeus's sexual system of classification, with its references to marriages and reproductive arrangements, scandalized some of his contemporaries. Johann Georg Siegesbeck objected to what he perceived as the indecent implications of botanical sexuality. Even Goethe expressed discomfort with the language used to describe plant reproduction, imagining innocent readers whose moral sensibilities might be offended by the multiple marriages and apparent promiscuity attributed to plants.

The episode is amusing, but its implications are serious. Human moral categories were projected onto the reproductive biology of organisms whose sexual processes had little to do with human social conventions. The innocence of plants was not a biological characteristic. It was a cultural assumption, sustained in part by ignorance of their reproductive processes.

Algae, apparently even further removed from the familiar sexuality of animals, offered an additional challenge to that assumption. Their reproductive diversity revealed that sexuality could not be adequately understood through the model provided by humans and other familiar animals. Indeed, the plural *Archetypes* in Deutsch's title is appropriate: there is no single reproductive arrangement that represents the extraordinary diversity of sexual processes and life cycles. Another fascinating aspect of the book concerns Pringsheim's involvement in the development of scientific institutions. He proposed establishing a marine biological station on Helgoland, recognizing the importance of permanent facilities for studying marine organisms. The proposal encountered opposition from Anton Dohrn, founder of the Zoological Station in Naples, who feared that another station might divert financial resources from his own institution. Pringsheim's efforts nevertheless contributed to the establishment of the Biologische Anstalt Helgoland in 1892, an institution that remains a major centre of marine research today. His contribution deserves lasting recognition. Indeed, a museum on Helgoland once bore his name. Why not honour him again by naming the station's laboratories after him?

The episode illustrates a less celebrated dimension of scientific progress. Research requires institutions, equipment, funding, and political support. Scientists who share intellectual goals may nevertheless become competitors when the resources needed to pursue them are limited. The history of marine biology is inseparable from the history of its research stations, and the relationship between scientific cooperation and institutional competition has never been straightforward.

But why has Pringsheim been forgotten?

There is, of course, a general explanation. Science preserves discoveries more effectively than it preserves the memory of those who made them. Concepts become incorporated into common knowledge, while the observations, controversies, and individuals from which they originated gradually disappear from view. Even citations are imperfect instruments of remembrance. Scientists

may continue to be cited long after their original publications have ceased to be read, with references inherited from one paper to another.

Scientific knowledge accumulates, but the memory of how that knowledge was acquired does not necessarily accumulate with it.

There may, however, be another explanation for Pringsheim's relative obscurity. The conventional history of evolutionary biology has been constructed predominantly around zoologists and zoological problems. Lamarck, Darwin, Wallace, and Weismann occupy central positions in its early development. The genetic tradition subsequently acquired much of its experimental authority through animal organisms, particularly *Drosophila*, while evolutionary developmental biology has relied heavily on animal models.

Botany certainly made fundamental contributions. Mendel's experiments on peas established principles that would become the foundations of genetics. Hugo de Vries played a prominent role in the development of evolutionary thought, and G. Ledyard Stebbins was among the architects of the Modern Synthesis. Yet the different visibility of botanical and zoological contributions is worth considering.

There is a suggestive contrast between the titles of two major evolutionary works. Darwin wrote *On the Origin of Species*, announcing a theory intended to explain a general biological phenomenon. Stebbins wrote *Variation and Evolution in Plants*, explicitly identifying the organisms to which his investigation was devoted. The contrast does not establish a general rule, but it invites a question: have zoologists been more successful in presenting their discoveries as general biology, while botanists have more often remained identified with the particular organisms they studied?

If so, Pringsheim's fate may be part of a broader pattern. His discoveries concerned algae, but their significance extended far beyond phycology. Fertilization, sexual differentiation, reproductive cycles, and the relationships between generations are fundamental problems of biology, not merely botanical specialities.

The choice of organisms also influences the theories that scientists construct. A theory developed mainly from familiar animals may fail to accommodate reproductive strategies that are common elsewhere. The extraordinary diversity of algal life cycles challenges the assumption that the reproductive patterns of a restricted selection of organisms can represent the diversity of life. Similarly, among animals, the profound transformations of life cycles found in hydrozoans illustrate evolutionary possibilities that are easily overlooked when developmental theory concentrates on a few conventional models.

Biological theories must be tested against biodiversity, not merely against the organisms from which those theories were originally derived.

There is a further historical paradox. Darwin's theory of natural selection was grounded in ecological relationships, in what he called the *economy of nature*. Organisms survive and reproduce through their interactions with other organisms and with their environment. Ecology and evolution were therefore inseparable in the original formulation of evolutionary theory.

Yet the subsequent histories of the two disciplines progressively diverged. The Modern Synthesis was constructed primarily through genetics, systematics, and palaeontology, with relatively limited contributions from community ecology. Ecology, meanwhile, developed a theoretical tradition increasingly associated with mathematical modelling and the search for predictive relationships. The historical and organismal dimensions of Darwin's original approach became less prominent in both fields.

Darwin himself recognized the limitations of purely theoretical calculation. After estimating the potential rate of increase of elephant populations, he observed that actual records of population growth provided better evidence than mere theoretical calculations. This was not a rejection of mathematics, which Darwin also employed, but a recognition that calculations must ultimately be confronted with the behaviour of organisms in nature.

And this brings us to what may be the most important lesson of Pringsheim's scientific life.

Pringsheim looked.

Of course, he used a microscope. He extended the resolving power of his eyes far beyond its natural limits. But he was looking at living organisms. He observed their structures, followed their development, watched their reproductive processes, and reconstructed their life cycles. His discoveries emerged from the ability to recognize the biological significance of what he saw.

This may sound obvious, but it is becoming less obvious in contemporary biology.

Today, a growing proportion of biological research is conducted through representations of organisms rather than through direct observation of the organisms themselves. Biodiversity is increasingly investigated by comparing DNA sequences, analysing molecular signatures, processing large datasets, and constructing mathematical models. These approaches have transformed biology and revealed processes that could never have been discovered through direct observation alone. Their importance is beyond question.

But a DNA sequence is not an organism, and a mathematical model is not an ecosystem. Both are powerful sources of information, yet neither can replace the biological knowledge needed to understand the entities and processes they represent.

The risk is not that modern instruments are too sophisticated. Pringsheim himself depended on an instrument that revolutionized biological research. The risk is that instruments may come to replace observation rather than extend it, and that producing increasingly detailed representations of life may be mistaken for understanding life itself.

The microscope did not discover fertilization. Pringsheim did. His instrument enabled him to see, but it was his ability to observe, compare, interpret, and ask biological questions that transformed what he saw into scientific knowledge.

Deutsch is himself a mathematical biologist, which makes his reconstruction of Pringsheim's achievements particularly interesting. His book celebrates a scientific tradition in which general principles emerged from close familiarity with organisms, rather than from the application of abstract models to biological data.

The book is not without occasional historical inaccuracies. Its broader account of evolutionary thought does not always clearly distinguish Weismann's original neo-Darwinism, based on the separation of germ line and soma and the rejection of the inheritance of acquired characteristics, from the later Modern Synthesis, which integrated Mendelian genetics with evolutionary theory. Such distinctions are important in a work concerned with the history of biological ideas. They do not, however, detract substantially from the value of Deutsch's reconstruction of Pringsheim's scientific achievements and intellectual world.

I began by admitting that I had never heard of Nathanael Pringsheim. By the end of the book, the surprising fact was no longer that Deutsch had devoted so much attention to him, but that a scientist of such importance had become so unfamiliar.

Deutsch deserves credit for bringing him back into view. But perhaps the value of this rediscovery extends beyond the restoration of a forgotten name. Pringsheim reminds us that some of the most important advances in biology arose from studying organisms that others had overlooked, and from recognizing processes that existing theories had failed to anticipate.

We have developed extraordinary instruments for investigating life. We should not forget how to look at it.