

Introduction

Marine biology studies

Anders Sandøe Ørsted was born in Rudkøbing in Southern Denmark on 21 June 1816 to the grocer Jacob Albert Ørsted (1780–1829) and his wife Petronelle Catherine Bang (1781–1845). Today, Ørsted's name is usually spelled Ørsted; however, in his time the German and Swedish letter Ö was generally used. In 1820, he went to live in the house of his uncle with the same name, Anders Sandøe Ørsted (1778–1869), who took care of him as if he were his own child.

In 1835 he graduated from Borgerdydskolen in Copenhagen. In 1836 he passed the *Examen philosophicum*, the exam that all Danish university students from 1675 until 1971 had to pass before they could go on to actual academic studies. He then, in 1837, became a natural history teacher at Borgerdydskolen, and in 1839 at the Metropolitan School. At the beginning of the 1840s, he developed a lively career in zoology. He won the University's Gold Medal in 1841 for an article on Denmark's annelids. In 1843 and 1844 he published some works on Greenland's annelids and flatworms, which among other things enriched the knowledge of Nordic fauna very considerably, constituting a turning point in flatworm research. On 29 April 1844 he defended his master's dissertation, which carried the title *De Regionibus Marinis*. In 1845 he began a journey of more

than three years to the Caribbean (Danish West Indies and Jamaica) and Central America (Nicaragua and Costa Rica) with zoological studies in mind. For this purpose, he applied to the Royal Danish Academy of Sciences for funds to produce equipment with which he could collect animals down to a depth of 1,000 fathoms. He also brought home rich collections and many color drawings of marine invertebrates made shortly after they had been caught. These collections were processed only in small part by himself, and although his debut as a zoologist was quite successful, he soon abandoned zoological studies, and after 1850 barely continued them. The annelids he had collected were turned over to Adolf Eduard Grube (1812–1880) in Königsberg.

Ørsted set out as a zoologist but returned home as a botanist after his encounters with Central America's lush tropical vegetation, becoming professor ordinarius of botany in Copenhagen from 1862 until his death. Primarily, he worked with Central American plants and mycology during this period. He died of dysentery on 3 September 1872 (Warming 1881; 1905; Meisen 1932; Spärck 1933; 1962; Dahl 1941; Wolff 1967; 1979; Sandbeck 2007; Hansson 2011).

Two important biographies of Ørsted exist. Johannes Eugenius Bülow Warming (1841–1924) was a student of Ørsted's and wrote a detailed biography of him in 1905. Christensen (1924–1926) gave a detailed review of Ørsted's work which made important comments on several of his publications and included a biography.

De Regionibus Marinis

Anders Sandøe Ørsted strove for a synoptic view in his studies of the natural conditions of the sea, taking his point of departure in the Øresund – a small strait between Denmark and Sweden. His dissertation is pioneering work as it marks the beginning of benthic ecology. Distributional patterns of the living organisms were connected to environmental factors like geological background and sediment types, and hydrographical factors such as depth, current and light (Warming 1905; Wolff 1967; 1979).

Ørsted defended his thesis *De Regionibus Marinis* for the award of the master's degree at a disputation in Copenhagen on 29 April 1844. The respondent was the military surgeon and botanist Emil Petit (1817–1893). Zoologists and medical doctors shared the same basic training until the twentieth century. The branch of science we now call botany was also often referred to as '*Materia medica*' in the 19th century. The opponent must therefore have been well qualified for his role as Ørsted's thesis covered zoology, botany and chemistry. As Ørsted did not have an "Embedseksamen" (equivalent to a Bachelor of Science), he requested dispensation to defend his thesis. This was granted on the grounds that Ørsted had won two gold medals and had published several scientific articles that had been recognized. Two other people requested similar exemptions in the same year, which were also granted. These three exemptions were attacked in the newspaper *Fædrelandet*, but Ørsted

was attacked much more strongly than the other two. The reason behind this was that there was an indirect attempt to damage Ørsted's uncle (of the same name), who was the Danish Prime Minister. Ørsted himself did not take part in this polemic, but it later had negative consequences for him (Christensen 1924–1926).

Ørsted was influenced to conduct this study by a number of earlier scientists. He makes several references to the chemist and geologist in Copenhagen, Johan Georg Forchhammer (1794–1865). He must have been a mentor for Ørsted and introduced him to several aspects of geology. Ørsted refers to Forchhammer in the most respectful way but dares to express some deviating opinions based on his own observations.

In the geological chapter, Ørsted also mentions the Cimbrian flood, also called the Cymbrian flood by others, as a causative factor behind geological structures in the Sound. According to Roman authors, the Cimbrians were a people living in Jutland but forced to migrate by severe flooding in the period 120–114 BC. They went south and, together with other German tribes, the Ambrones and the Teutons, they came into conflict with the Romans between 113–101 BC during what became known as the Cimbrian Wars (Roller 2014). C.G.J. Petersen discovered a little horse mussel in Kattégat, which he misidentified as *Modiolus adriaticus* Lamarck, 1819. In fact, that species dispersed from the south during the warm Stone Age period and survived in the Skagerrak-Kattégat area where it evolved into

an endemic species that was later described under the name *Modiolus cimbricus* Ockelmann & Cedhagen, 2019 in order to commemorate the Cimbrian tribe. In fact, the Ice Age with its glacifluvial remains was not discovered and understood until a few years after Ørsted's death, when the Swedish geologist and zoologist Otto Martin Torell (1828–1900) found ice grooves and an erratic block of Kinne diabase outside Berlin (Frängsmyr 1976; Nejle 1998).

Ørsted also refers to the book *Principles of Geology* (1837) by Charles Lyell (1797–1875). This is a book of particular importance. Previously, geological processes were usually interpreted in the light of the Bible, and often believed to be catastrophic processes (e.g., Swedenborg 1719; Linnaeus 1747; Cuvier 1839). On the contrary, Lyell argued that catastrophes in geology are rare events, and that the world we see around us is primarily the result of the same, often slow, geological processes that we experience today, but over enormously long periods of time. Lyell travelled extensively and gave numerous examples of observations and conclusions based on these journeys. In addition to being a book on geology, it could also be called a handbook of modern scientific reasoning and inference – observe and make conclusions. Captain Robert FitzRoy (1805–1865) gave this book to the young Charles Darwin (1809–1882) when they embarked on their five-year expedition on the HMS Beagle. This book was eye-opening for Darwin, in forming his formulation of the theory of evolution. It probably had the same enlightening effect on Ørsted.

Among botanists, he mentioned the early authors Joseph Pitton de Tournefort (1656–1708) and Carolus Linnaeus (1707–1778) as doing pioneering work in plant systematics and geography. Ørsted respected Alexander von Humboldt (1769–1859) who did extensive research on quantitative plant geography that laid the foundation for the research field of biogeography. This field of science was solidly established by his publications “Essai sur la géographie des plantes” and “Tableau physique des régions équinoxiales” (von Humboldt & Bonpland 1805; 1807). Other scientists of importance for him were Göran Wahlenberg (1780–1851), Robert Brown (1773–1858) and Augustin Pyramus de Candolle (1778–1841), the last of whom coined the term ‘taxonomy’. It is surprising that he did not refer to Jean Vincent Félix Lamouroux (1779–1825) who in 1813 had recognized the green, brown and red algae. They form the basis for Ørsted’s division of the sea into regions (zones). Frederik Michael Liebmann (1813–1856) and Hans Christian Lyngbye (1782–1837) as well as Jacob Georg Agardh (1813–1901) gained some understanding of such a zonation for the algae, and it is also this vegetation that forms the basis for Ørsted’s division (Agardh 1835).

Joachim Frederik Schouw (1789–1852) was a professor of botany at University of Copenhagen and a teacher of Ørsted’s. He was a pioneer in plant geography and the author of one of the very earliest books in this field – *Grundtræk til en almindelig Plantegeographie* [Fundamentals of a general Phytogeography] in 1822. Ørsted cited his book and gave him credit as one of the founders of this research