How did Mendel arrive at his discoveries?

Appendix to the news item, published on 11th July 2022 on KeyGene.com: post containing more details

This year marks the 200th anniversary of the birth of the founder of genetics, Gregor Mendel (1822-1884). Genetics occupies a central position in biology today, and Gregor Mendel is as famous as Charles Darwin. However, in the 19th century, this friar from Brünn (now Brno in the Czech Republic) was the only one who correctly understood the inheritance of traits. Since his notes no longer exist, how he achieved this is one of the greatest mysteries in the history of biology. Recently several relevant text fragments from Mendel's time were found that throw new light on Mendel's work, as is discussed in an article in the July issue of the scientific journal *Nature Genetics* titled: "How did Mendel arrive at his discoveries?"

The three authors are Peter van Dijk, a plant geneticist at the research company KeyGene, Noel Ellis, a plant geneticist associated with the John Innes Institute, and Adrienne Jessop, a retired yeast geneticist from the University of Glasgow. The first two authors have, since 2016, published six scholarly articles about Mendel's life and work. The last author has written an essay about "Mendel in and after his time".

Mendel published the results of his pea crosses in 1866 in a brilliant paper titled Experiments on Plant Hybrids. This paper is written with exceptional clarity and is surprisingly modern in its form. It is so instructive that the pea crosses described are still used to introduce genetics at school. The superiority of this work to everything else on the subject from that time it creates a similar problem to, for example, Vermeer's paintings, or Shakespeare's writings. Very little is known about these geniuses, and their work is outstanding, yet their work does not inform us how it was created.

No relevant documents were known from the 10 years in which Mendel performed his pea research (1854-1863). It was thought that Mendel had developed a genetic theory in advance that he wanted to test with his pea crosses, but evidence for this was lacking. The authors have found several historical sources about Mendel and his immediate environment from digitized historical newspapers, proceedings, and yearbooks. These texts about Mendel often contained only a single relevant line. Like archaeologists reconstructing a pot from a few pottery fragments, the authors have reconstructed Mendel's working method from these few snippets of text.

Most importantly, a short newspaper article from 1861 was found that showed that Mendel's aim was to improve vegetables, like pea, bean, and cucumber. Another local newspaper responded by stating that the economic effect of Mendel's work had been exaggerated but wholeheartedly 'supported Mendel's efforts to approach the truth in a practical manner'. Approaching the truth means solving a scientific problem, and therefore the authors conclude that Mendel's interest in the study of inheritance arose from his vegetable breeding program.

The authors note that the 22 pea varieties which Mendel used for crosses showed a great deal of variation in seed color (yellow or green) and seed shape (round or wrinkled), and therefore, Mendel's breeding crosses inadvertently often included variation in these traits. They consider it very plausible that Mendel noticed recurring seed color and shape ratios and became intrigued by it. Consequently, he later set out a research program for other traits, such as flower color, plant height, and pod shape.

Essential factors, they argue, were also Mendel's character and education. Mendel had studied physics at university in Vienna and had a great interest in numbers, which is also reflected in the fact that he was an enthusiastic meteorologist. As Louis Pasteur once said: "In the fields of observation, chances favors only the prepared mind". Mendel's mind was clearly prepared to observe recurring numerical ratios of traits in the offspring, which were, after 1900, coined "Mendel's laws".

The authors further point out that, relative to the laws, Mendel's ideas about the reproductive cells (pollen grains and egg cells) have been neglected until now. These were entirely new for their time. The paper provides evidence that Mendel was strongly influenced in this by his friend Johann Nave, who died of tuberculosis shortly before Mendel presented his results. Because of his early death Nave's name never made it into the history of biology. His science books were donated to the local Natural Science Society after his death. Their titles show that Nave (and thus Mendel) was aware of the latest developments in cell biology at the time. Mendel explained the observed ratios in his crosses by proposing properties of pollen grains and egg cells and about their union; it was not until decades later that these proposals were confirmed.

Mendel published his results in the proceedings of the local natural science society. Mendel sent one of the 40 reprints to the then-famous botany professor Carl Nägeli in Munich. Unfortunately, Nägeli did not understand or believe Mendel's results. It was not until 1900, 16 years after Mendel's death, that his paper was rediscovered by three scientists: the Dutchman Hugo de Vries, the German Carl Correns, and the Austrian Erich von Tschermak. All three claimed that they had rediscovered Mendel's work only after they had completed their own experiments, although this is now questioned.

Isaac Newton wrote in a letter to Robert Hooke, 'If I have seen further it is by standing on the shoulders of giants'. Mendel's case, however, was different, according to Gavin DeBeer (1964), because he had no precursors. On the 200th anniversary of Mendel's birth, the paper of van Dijk *et al.* in *Nature Genetics* provides insight into how Mendel arrived at his discoveries by standing on the firm ground of careful work and clear thinking.

Sir Gavin de Beer D.Sc. F.S.A. F.R.S. (1964) Other men's shoulders, Annals of Science, 20:4, 303-322