

Mendel and the *Origin of Species*

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Gregor Johann Mendel, the monk who is credited for unlocking the secrets of genetics, is an enigmatic figure in the history of biology. Moreover, Mendel's interest in Darwin and evolution, while well documented, is open for reinterpretation.

Most of the information about Mendel comes from his biographer Hugo Iltis (6), who first read about Mendel while a schoolboy in Brunn. (Iltis' interest is likely local pride; Mendel performed his experiments at a monastery outside Brunn.) Iltis' biography contains many questionable extrapolations. Mendel's interest in Darwin also was explored by Gavin de Beer (3). De Beer was the first to study Mendel's margin notes in the *Origin of Species* by Charles Darwin, but he referred to Iltis for some basic information regarding Mendel's interest in Darwin and evolution. The most active worker of Mendel history today is Vítězslav Orel of the Mendel Museum at the monastery in Brunn. Orel's work on Mendel's interest in evolution is critical of de Beers' comments concerning Mendel's not declaring his support of Darwinian evolution (9).

Thus, the purpose of this paper is to examine Mendel's interest in evolution and Darwin, and to determine the influence Darwin may have had on Mendel's work.

Important to the scenario is when and why Mendel started his research on garden peas. Iltis (6) has refuted the idea that Mendel, being a priest, was opposed to evolution and started his research to disprove it. The chronology of Mendel's research shows that Mendel started his work in 1856, three years before Darwin's *Origin of Species* was published. Mendel in a letter to Carl Nägeli stated his experiments took place during 1856 to 1863. Therefore, Darwin could not have been the initial reason for Mendel's research.

A clue to why Mendel started his research may be found upon reading Mendel's paper, *Experiments on Plant Hybridization* (7). In Mendel's paper one finds the names Gärtner and Kölreuter often being cited. Gärtner wrote a comprehensive monograph in 1849 entitled *Versuche und Beobachtungen über die Bastarderzeugung im Pflanzenreich*. His experimental design was similar to Mendel's in that he performed hundreds of crosses but observed the effects of crosses not on one or two characteristics but several characters in many species (5). Mendel cited Gärtner eighteen times in his paper (7). Kölreuter was a forerunner of Gärtner, having published his major work on hybridization in 1761. Kölreuter studied the hybridization of different varieties of tobacco. Mendel cited Kölreuter six times (7). It is clear that what interested Mendel was the action of hybridization and how it related to species formation. Not only did Mendel often cite Gärtner and Kölreuter but also Darwin cited the two botanists several times in the *Origin of Species*.

The period from 1863 to 1865 when Mendel had completed his experiments, reviewed his data, and read his paper, appears to be the time when Darwin had his greatest influence on Mendel's work. It was at this time that Mendel obtained his

copy of the *Origin of Species*. Mendel owned the second German translation published in 1863 under the name *Über die Entstehung der Arten im Thier und Pflanzenreich* (2). The second German edition was based on the third English edition published in 1861 (1). The fact Mendel read the text is established by the 33 pages that Mendel marked (9). It was Mendel's habit to write page numbers down in the back cover and to mark some pages. A list of the pages marked by Mendel was published by de Beer (3).

A review of Mendel's marginalia will reveal an interest in several points. First, Mendel cited three pages where Darwin defined creation and evolution. On page one of the *Origin of Species*' Historical Sketch, Darwin wrote "the great majority of naturalists believe that species are immutable productions, and have been separately created. . . few naturalists, on the other hand, believe that species undergo modification, and that existing forms have descended by true generation from preexisting forms." On page 6, still in the Historical Sketch, Darwin said that "by the word 'creation' the zoologist means a process he knows not what." Mendel also marked page 16, where he read, "the view which most naturalists entertain. . . that every species have been independently created is erroneous." It is perfectly logical that a priest would be interested in such comments. It is possible he discussed evolution with Klacel, another priest at the monastery who was interested in natural philosophy (6).

Mendel also noted pages that included comments relating to his experimental design. On page 76, Darwin calculated the doubling time of some plants and animals. While Mendel was not necessarily concerned with rates of increase, he was interested in statistics and the application of mathematics to biological problems.

Mendel was also concerned with Darwin's comments about hybridization research. Page 43, one of the page numbers Mendel wrote on the back cover of the book, includes a discussion about the skill of gardeners. Darwin commented, "I have seen great surprize expressed in horticultural works at the wonderful skill of gardeners, in having produced such splendid results from such poor materials." Mendel also noted page 111, where Darwin examined the flower and pollination of the pea family.

Many of the pages that Mendel marked concerned Darwin's view about varieties and how they related to species. Darwin's view was that "species are only strongly marked and permanent varieties." This theme was discussed in detail in several pages Mendel marked. On page 63, Darwin asserted, "Certainly no clear line of demarcation has as yet been drawn between species and subspecies. . . between subspecies and well marked varieties or between lesser varieties and individual differences. These differences blend into each other in an insensible series." Moreover, Darwin stated that the individual differences are only slightly effected by climate and food. On page 57, recorded by Mendel in the back cover, Darwin wrote that "individual differences, are highly important for us, for they are often inherited." Mendel also noted page 63, where Darwin carried this argument further: "I look at individual differences . . . as being the first step toward such slight varieties . . . And I look at varieties which are in any degree more distinct and permanent, as steps leading to more strongly marked and permanent varieties; and these latter, as leading to subspecies and to species." Mendel could appreciate the relevance of his work on hybrids and how variation would be involved in Darwin's view on the origin of species. What Mendel did was to quantify how this variation moved from generation to generation.

Likely the greatest surprise in the pages Mendel marked are the passages that indicate Darwin knew, in general terms, Mendel's conclusions. Mendel discovered the specifics about heredity because he worked with single characters. Darwin and Gärtner worked on groups of characters. Therefore, it was more difficult to spot the specific ratios Mendel described.

Mendel marked pages 287 and 303, where Darwin correctly noted that some characteristics of the parent are dominant in the first generation. Darwin wrote that some individuals "have a remarkable power of impressing their likeness on their hybrid offspring." Clearly Darwin had noted that some traits were dominant, but his concern was in hybrids between different species and not individual genes. Darwin also knew that characters reappeared from generation to generation. Mendel likely read with interest page 302, because he marked the passage where Darwin dealt with the difference between the first and second generation from a hybrid cross. Darwin wrote, "The slight degree of variability in hybrids from the first cross or in the first generation, in contrast with their extreme variability in the succeeding generations is a curious fact and deserves attention." Darwin had put his finger on one of Mendel's important contributions. Namely, individuals in the first generation of a cross are more similar to each other because of heterozygous genes. When individuals from the first generation are crossed a second time, one gets more variability. Mendel demonstrated that fact in a quantitative manner, but Darwin already knew about increased variability in subsequent generations in a qualitative sense five years earlier.

How did Mendel view these comments in the *Origin*? It is my opinion that the previous works depicting Mendel as a critical evaluator of evolution are wrong. I do not see Mendel as a forceful individual. We must recall that Mendel failed his high school examination. We also must take with a grain of salt Ilitis' comments that Mendel was a richer person for this experience (6). Mendel may have been a good teacher, but such a rebuke would not likely increase one's confidence as a scientist or researcher.

It is easy to envision Mendel as the active scientist because we are looking at Mendel's actions as he read the *Origin of Species* and wrote his paper. But this description of Mendel should not be extrapolated into thinking of him as the dominant individual. I see Mendel as reading the *Origin of Species* and finding his basic conclusions already in Darwin's work. With the *Origin of Species* in mind, Mendel wrote his paper incorporating Darwin's philosophy. This action of trying to make one's research relevant with current trends in biology is still common today.

Evidence for this thesis occurs throughout Mendel's paper (7). In the introductory remarks Mendel states that his procedure of studying hybridization is "the only right way by which we can finally reach the solution of a question, the importance of which, cannot be overestimated in connection with the history of the evolution of organic forms." Later Mendel states, "For the history of the evolution of plants this circumstance is of special importance, since constant hybrids acquire the status of new species." Clearly, Mendel was placing his work within the mainstream of evolution.

Moreover, Darwin's influence on Mendel is also seen in Mendel's discussion about varieties and species. Mendel wrote, "It has so far been found to be just as impossible to draw a sharp line between the hybrids of species and varieties themselves as between species and varieties themselves." This is very similar to what Darwin wrote on page 63, "Certainly no clear line of demarcation has as yet been drawn between species and subspecies . . . and varieties."

The contention that Mendel was trying to fit his work into evolution and not trying to answer problems of heredity is supported in a paper by Robert Olby (8). Olby discusses the likelihood that Mendel did not realize he had discovered the basic principles of genetics but was only concerned with how hybrids related to species formation. This, as Olby points out, allows one to understand why no one recognized the genetic importance of Mendel's work. Since Mendel's basic conclusions about dominant and recessive traits, F_1 constancy and F_2 variability were already known; therefore, Mendel discovered nothing new. Olby maintains that Mendel's work became important when 20th century biologists read 35 years of advances into it.

Itlis (6) claimed in his biography of Mendel that Mendel agreed with natural selection, but felt something was missing. Itlis even quoted a close friend of Mendel who said the name Darwin never crossed Mendel's lips. Itlis further quoted a colleague of Mendel who claimed Mendel said, "My time will come." Doubt has to be thrown on these recollections made years after Mendel's death. The former comment about never mentioning Darwin is in error because in his letters to Nägeli, Mendel mentioned Darwin by name (9). The latter quotation, "My time will come," could have been made after Mendel read Darwin's book *Variation in Animals and Plants under Domestication*. Mendel received that text at least three years after he wrote his paper on hybridization. The book, *Variation in Animals and Plants under Domestication*, contains five notes by Mendel but is mostly uncut (9). In *Variation*, Darwin took a wrong turn with regard to how traits moved from generation to generation.

The fact that Mendel was an evolutionist is further substantiated in his letters to Nägeli. In 1877, Mendel wrote, "If such be the real state of affairs, spontaneous hybridization in *Hieracium* must be ascribed to temporary disturbances which if frequently repeated or persistent must even lead to the disappearance of the species in question, whereas one of another more favourably organized hybrid offspring better adapted to extant telluric and cosmic conditions might succeed in maintaining itself in the struggle for existence and might thus persist for long periods of time, until at length overtaken by the same fate" (6). In another letter Mendel wrote, "When several are competing i.e. pollen grains, we can probably assume that only the strongest ones succeed in effecting fertilization" (9).

Summary

It is established from Mendel's copy of the *Origin of Species*, his paper *Experiments on Plant Hybridization*, and his letters to Nägeli that Mendel was not opposed to evolution, but a supporter of it. The timetable of events indicated that Mendel started his research in 1856 and continued it until 1863. During 1863-1865, while he was summarizing his research, Mendel received his copy of the *Origin of Species*. The pages he marked indicate his interest in varieties as they relate to species and also contain in qualitative terms his conclusions about dominant versus recessive traits and what happens in the F_1 and F_2 generations.

With this verification of his work by Darwin, Mendel wrote his paper placing it into the mainstream of evolution as it was studied in the 1860s. Mendel was possibly not the "priest who held the key to evolution" as Loren Eiseley (4) claimed, not an individual who was skeptical about evolution as Itlis claimed (6), but rather was converted to evolution and wrote his paper as a supporter of Darwinism, trying to demonstrate the importance of his research to the current trends in biology.

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