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Research · August 2015

DOI: 10.13140/RG.2.1.1242.8000

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Medina, M.N.D. (2011). The monk in the garden: The lost and found of Gregor Mendel by Robin Marantz Henig. A book review. *College Research Journal, 1*(1), 48-55.

THE LIFE OF GREGOR MENDEL

Based on the book 'The Monk in the Garden: The Lost and Found of Gregor Mendel' by Robin Marantz Henig

Gregor Johann Mendel was born in Heizendorf, North of Moravia. His father Anton was a farmer who was crippled by a falling tree but forced to work because young Johann was sick and in bed. Often, his father would say "*He is a disappointment for me*" referring to young Johann. It was hard for Johann to look at his father forcing his crippled body to work in the farm and yet he could not do anything to help him – but watch. Johann did not have a good relationship with his father Anton. The reason why Johann only spoke to his mother Rosine was because his mother was polite and sweet natured, and likewise to his younger sister Theresia who had the same temperament as his mother. He did not even talk to his older sister Veronika who was very antagonistic towards him. At the age of eleven he was sent away from his family to finish his elementary and high school education at Gymnasium in Troppau. His parents never sent him money for his school fees because they saved their money to buy the land from their feudal lord. However, his younger sister provided him some finances for which he was greatly indebted for his entire life. He graduated at the Gymnasium and moved on to the Philosophical Institute, a two-year program for all high achieving students from the high school education before they could pursue to university. Without money life was even more difficult for Johann. He felt very cold and hungry at night, but he survived because of his sister Theresia's support. Because he was indebted to his sister Theresia he took responsibility of helping two of his nephews (sons of Theresia) on their education and who became physicians later.

Back at Heizendorf, he continued his struggle with his illness which made him helpless and tearing his heart as he watched his crippled father, struggled to hoop the fields. At the age of 19, he was again bed-ridden for a year for an unknown disease. It was clear for young Johann that he was never meant to be a farmer as his father wanted him to be. A year after he recovered from his disability, he received a letter from his former professor at Gymnasium Father Friedrich Fraz recommending him to go for priesthood. He was recommended by Franz because Johann was once his talented student at the Gymnasium in physics and natural science. Readily, Johann grabbed the opportunity to enter priesthood at St. Thomas monastery and changed his christened name Johann to ***Gregor***. St. Thomas monastery in Gregor's time was always cold. It was built in 1322 for the purpose of protecting the Cistercian sisters (an order dating back to the 11th century) and a subset of Benedictines that wear white instead of black. Nearly five hundred years since the time of the Cisterian sisters, the Augustinian monks took over the building. But in 1793 Emperor Josef II, (who was known as the good emperor) evicted the priests and utilized the building for his residence and government offices, forcing the priests to go down to the city.

But by early 1800's, the friars went back to the monastery during the decline of Austro-Hungarian Empire. Gregor arrived at St. Thomas in 1843 during the abbacy of Cyrill Napp who was a friend of Friedrich Franz who recommended him. Because Abbot Napp was also fond of scientific discoveries, they became friends in a short time. While being an abbot of St. Thomas, Abbot Napp was also the president of the Agricultural Society in Brunn, which was a prominent scientific community in his time. Unlike with other catholic orders who really focused on

spirituality, Augustinians in Brunn was a liberal catholic order who participated in education and research guided by the credo "***per scientiam ad sapientiam***" which means "*from knowledge to wisdom over prayer*". The monastery itself was more of a college dormitory rather than a house of God. Because of his persistence to acquire scientific knowledge, Gregor became interested in animal and plant breeding experiments. He bred several species of animals like sheep, mice and several species of plants, particularly the *Pisum* species (common garden peas). Abbot Napp saw this enthusiasm with young Gregor, so he decided to build a glasshouse (greenhouse) for him to further pursue his plant breeding experiments. But bishop Schaffgotsch heard that monks at St. Thomas were doing breeding experiments especially animals, "So inappropriate for a priest to see sex", the bishop said. So he went to the monastery once and for all to stop the monks' experimental endeavors. But Mendel was clever enough to make an agreement with the bishop to stop animal breeding experiments but continue his plant experiments. With the bishop convinced of their agreement, the priest continued his plant experiment. For Mendel "The bishop did not know that plants also have sex", he said to himself. Gregor was ordained on August 6, 1847 at the age of twenty five after which he was again bedridden for a month.

One of his best friends at the monastery was Matous Klacel (Klah-tzell in German) who was in-charge of the monastery experimental garden. Backed-up by Klacel who was then a natural philosopher made a proposal to the government that priests especially from St. Thomas would be given the chance to teach at the university. It was a long process but they gained their advocacy on the condition that priests should get a qualifying examination with the scientific community. Young Gregor took his first certification to teach high school science at the University of Vienna after passing three types of exams (written, oral, and practical examination). Gregor got a "satisfactory" though not impressive grade with meteorology, geology result was "arid, obscure, hazy" as described by Professor Kner, and got a worse result with his two take – home essays. Because of severe case of test and interview anxiety, he was like a five yearold child reciting ABC in front of his six intellectual jurors during interview. One of the questions during the interview was, "What are the uses of mammals to humans?"
Gregor answered, "A cat is a useful animal because it exterminates mice, and because its soft and beautiful fur can be dressed by furriers. A civet, whose anal gland secretes an aromatic substance, is an article of commerce. The elephant is a splendid beast of burden". With these answers, Gregor failed his first qualification. One of the recommendations for Gregor was to take a two-year bridging program to prepare him for the next try-out.

Because he found favor in the eyes of Abbot Napp, he was sent to Vienna to study at Royal Imperial University. Because he was one month behind his classmates, he took the challenge with passion and sincerity to learn precious ideas from professors like Franz Unger who taught him hybridization (but his questions of what, how and why in genetic inheritance was never clear at this time). One of the prominent student organizations at the university was the circle of physicists known as "Eleves" (in French for students) which consists of twelve exceptional physics students under the advisory of Christian Doppler (discovered Doppler Effect). Gregor was not included in the circle, but because of his enthusiasm Doppler decided to take Gregor on-board as eleves thirteen. Although Doppler died at early age of 49, he was replaced by a great physicist Andreas Von Ettinghausen who became Gregor's influential teacher. Ettinghausen discovered the principle of combination which later became the basis of Gregor's theory of inheritance. After completing his bridging program at Royal Imperial University, he took the second challenge for teacher qualification. After his hard work in pursuit of scientific knowledge at the university, he felt more confident of passing the second examination to obtain his ever dreamed teacher certification. Attacked with another severe test anxiety, he was only half-way on his oral examination, when he decided to give-up. However, he did not fail not

because he did not know biology, but because he had something more to give to the panel of examiners. Mendel argued to one of the examiners Eduard Fenzl who was a *Spermist* (pre-formed embryo at the male reproductive organ) that he believed that an offspring is a product of contribution of gametes from each of the parents. He stood him in his belief and would rather *fail than capitulate*. Johann never got his dreamed teacher certification.

Back in St. Thomas monastery, the garden was his only place of refuge, his comfort after all his life's struggles especially from failing to obtain his ever dreamed certification. He continued with his breeding experiments with *Pisum* species which sometimes he called as 'children' while working part-time as weather watcher and a teacher at Realschule (Gymnasium) in the city of Brunn for 20 years until his death. Because of his persistence of acquiring scientific knowledge, he engaged himself in reading hybridization experiments of Josef Kolreuter and Karl Gartner. It was Kolreuter who conducted the first hybridization experiment with related members of tobacco family, *Nicotiana rustica* and *Nicotiana paniculata*. Garther was well-known for his 10,000 hybridization experiments yielding some 250 hybrid plants. But none of the two great scientists gave Mendel the answer as to how the hybrids acquired characteristics from the parents? In fact, these two scientists were great believers of 'blending theory', which theorized that offspring showed a combination of traits and thus roughly midway between the two parents, which Mendel doubted.

The baseline generation of his breeding experiments which he called as P generation (parent generation; pure breeds) manifested seven traits in peas that never blended (seed shape, seed color, seed coat, shape of ripe pea pod, color of unripe pod, location of the flowers, and height); these traits were always inherited separately and intact. This observation was in contrast with what scientists in his time had been saying with inheritance. If an offspring is a product of blending, then such *Pisum* specie should look different and not similar with the parents. To test his theory that traits are intact when passed form parents to offspring, he then designed his F2 (second filial generation) experiment which is a cross between dominant trait with a recessive one. To his amazement he found out that in a particular trait (i.e. seed color) in every 4 seeds, 3 are yellow and 1 green, and he found similar findings to all of his seven identified traits having a ratio of 3:1. After obtaining such findings, he concluded that recessive traits (which in his time considered a curse from God) were not 'diluted' or 'swamped' (according to Darwin) or 'blended' (according to Kolreuter, Unger his teacher in Vienna, Nageli a botanist from Munich, and Gartner) but instead it showed up given the right pair of allele. To calcify his theory about inheritance, he conducted the ultimate test of his experiment, the backcross. This is the cross between pure dominant traits (*Merkmale* in German for 'traits'), and the cross between pure recessive units ('*Units*' later changed to Genes) and heterozygous, *Merkmale* contained dominant and recessive alleles. After the backcrosses, he found out that the cross between pure dominant would result to pure dominants, and the cross between pure recessives would result into pure recessives and the cross between heterozygous would produce his 3:1 ratio (3 dominant: 1 recessive). Consequently, he revised his earlier ratio of 3:1 to 1:2:1. The 3:1 ratio would show the physical manifestation of the units (genes). This is now the basis for the 'phenotype' which is the physical manifestation of genes masking the recessive expression when paired with dominant genes and 'genotype' which is the actual genetic expression of alleles. Charles Naudin, a French botanist, conducted almost the same experiment with that of Mendel but never came up with deeper understanding about inheritance. Naudin produced hybrids but he never established a baseline generation as a standpoint of his argument towards the passing of traits. He just bred plant species and noted the results. It was very difficult to deduce his explanation. On the other hand, Charles Darwin, a very influential naturalist because of the publicity of his theory of natural selection regarding the 'Origin of species', conducted the same experiment with Mendel but never understood the concept of inheritance. Instead Darwin

created his own blending theory and believed in the 'spontaneous generation' by Louis Pasteur to ultimately support his theory of evolution. If had Darwin supported his breeding experiments with mathematical explanations like Mendel did, he would have a better understanding towards his theory of inheritance (unluckily, Darwin was not very good in mathematics unlike Mendel). What if Mendel and Darwin had the chance to talk to each other? Would they produce a better theory of evolution following the principles of genetic inheritance? How wonderful it would have been. There was a time when these two giants almost met at the London Exhibition but Darwin needed to stay at home at Down to nurse his sick child Leonard after the death of his 3 children from Emma, his wife who had been a cousin. After completing his pea experiments, he started writing his forty-pages manuscript. On February 8 (Friday) 1865, he presented his experiments at the Brunn Society for the Study of Natural Sciences to an audience of 40 people. Most of the faces were familiar to Mendel; there was Alex Makowsky a noted botanist, and his teacher at Realschule, as well as the chemist Franz Czermak, the physician Jacod Kalmus, and his fellow monk Antonin Alt. noticeably absent was Johann Nave, his closest friend who died a year before and who like Mendel had a buring passion for natural sciences particularly in studying algae. These two exchanged ideas, had been alive during Mendel's presentation, he will could have readily understood Mendel' scientific presentation. Gregor took a deep breath and started reading his paper filled with mathematical ratios showing the principles of his first finding, the 3:1 ratios among his pea traits. Since there were no questions, the meeting adjourned. After four weeks, Mendel intended to explain his 1:2:1 ratio which was a modification of his 3:1 ratio and his ideas on dominant and recessive traits. Again the response was courteous but quiet. Nobody asked a single question, because no one understood the significance of what Mendel had discovered. They felt, they had just spent two boring evenings listening to a priest describing his gardening work.

Struggling to gain legitimation, Mendel decided to distribute his work to twelve respected scientists in Europe. The first copy went to Kerner von Marilaun, the botanist from Innsbruck who attended Ungers' plant physiology class the same time with Mendel. Another copy went to Charles Darwin, who – probably never read Mendel's work – because he was also conducting his breeding experiments with snapdragons. Later in 1868 he published his work called prepotency" of a character trait which was basically a blending theory, three years after Mendel's presentation. A third reprint went to Martinus Beijerink, a well-known Dutch biologist who had a controversy with Dmitry Ivanovsky over the re-discovery of virus. Martinus sent the reprints to Hugo de Vries a Dutch botanist because he believed that Hugo would benefit more from the manuscript. A fourth reprint arrived at Max Planck Institute in Tubingen, Germany and went to the hands of Theodor Boveri, the co-developer of chromosome theory of the cell. A fifth reprint went to the library of the Institute of Botany at Graz University where Unger (his former plant physiology teacher) probably donated the paper to the Institute. Unger did not pay attention to Mendel's work for he was a strong supporter of Darwin and he considered Mendel's work as anti-Darwinian. Another copy went to M. J. Schleiden, who together with T. Schwann discovered the cell theory and the author of scientific botany. Schleiden, who had a boundless faith in mathematics, respected Mendel's methodology than any other scientist during that time.

Five more reprints were discovered for the last forty years (until the year 2000). Two of the reprints were sold at auction in England; one copy left at the monastery library in Brno, and another copy was found at the National Institute of Genetics in Mishima, Japan. The last reprint ended up at the desk of Professor Karl von Nageli at the University of Munich, who was the last hope of Mendel to believe in his experimental works. This was a special copy made by Mendel for Nageli for he included a letter summarizing his eight years of *Pisum* experiments hoping that the old Nageli would understand his works. After Mendel sent out the reprints, his experimental work was done. All he could do was to wait for a reply. The year was 1867.

In February of 1867, Mendel's silent waiting ended when he received the first reply, from Professor Nageli – actually the only one who replied to Mendel. With his excitement, he opened the letter in handwritten since the typewriter was discovered after seven years in 1874, as expected Professor Nageli did not understand his experiments. He sent another letter to Nageli with the concrete details of his experiments, but he never received any reply from Professor Nageli in the whole year of 1867. So Mendel wrote another letter to Nageli - to offer himself as unpaid research assistant to him as he worked out with *Hieracium*, his favorite angiosperm but very difficult to hybridize because of its minute flower. Nageli responded and sent him some of the seeds of *Hieracium* for cultivation and hybridization, and ultimately proved his theory using the said plant. In 1868, Mendel's election as abbot of the monastery, greatly affected his scientific pursuit. Because of his additional obligations - his chance of proving his experiment to the only person who listened to him, Nageli proved to be difficult.

Mendel struggled to prove his experiment with a very notorious plant *Hieracium*. He had to use the microscope in order to view its pistil and stamen. The constant use of the microscope affected his health condition; blurring eyesight, back pains, headaches. Eventually, because of his deteriorating health coupled with the administrative functions in the monastery, involvement in local school authority, banking authority and scientific society, Mendel had to give-up the *Hieracium* experiments. If he could not complete the *Hieracium* experiments and proved his theory of inheritance, then his *Pisum* experiments must be wrong. In the 9th of November 1870, an unexpected "tornado" wrecked Brno including the monastery's glasshouse wiping out all his *Pisum* "children" and *Hieracium* plants. Most of the monks at the monastery did not like Mendel for his stubbornness against the government's policy to tax the church. He was against it because it was unconstitutional. With no one in the monastery to help him on his advocacy, Mendel singlehandedly fought the government by writing letters until the last years of his life.

On the early morning of January 6, 1884 Gregor Mendel died at the age of sixty three. Josef, his manservant, and housekeeper Frau Doupovec, and his three nephews, Johann, Alois, and Ferdinand Schindler, sons of Theresia his beloved sister were with him when he met his maker. It is indeed a humbling experience for me to rewrite the life story of the man who revolutionized the science of Genetics. Thanks to Robin Marantz Henig for writing the life story of Mendel, my inspiration being a science teacher and researcher. His life story is indeed worth sharing.