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Editorial

EMERGENCE OF MENDELISM : PAGES FROM HISTORY

It is a common knowledge that Gregor Mendel (1822-1884) performed his experiments on ordinary garden pea in a monastery at Brunn in Moravia, Czechoslovakia during the period 1856-1863. He presented his observations to the Brunn Society of Natural Sciences in 1865, and published his results in the Proceedings of the Brunn Society of Natural Sciences in 1866. The research phase of his career was not long; it effectively ended in 1868 when he was elected abbot of the monastery. The demands of his new responsibilities, especially in the face of a tax dispute raised against the monastery, did not allow him to continue his genetic studies in plants. In 1884, Gregor Johann Mendel died of a kidney disorder.

On the basis of rather simple, but precisely performed breeding experiments and quantitative analytic reasoning, Mendel proposed that discrete, particulate units of heredity exit, and explained how they are transmitted from one generation to the next generation. This was truly outstanding scientific achievement. However, Mendel's observations remained by and large unappreciated, and his paper was poorly disseminated among scientists till 1900 when, well after his death, at least three biologists - Hugo DeVries, Karl Correns and Eric Von Tschermak - independently discovered the significance of Mendel's observations, which are now considered the foundation of modern genetics. The delayed recognition of Mendel's work has no simple explanation, but an analysis of the historical facts might help.

Mendel was not the first to make an attempt to understand the principles of inheritance using breeding experiments. Joseph Gottlieb Kolreuter (1733-1806), a German botanist, performed crossbreeding experiments with tobacco plants. He observed that a new hybrid form resulted from crossbreeding of two groups, and on repeated backcrosses, one of the parental forms sometimes reappeared. He also observed segregation of traits in his breeding experiments with carnations. Kolreuter did not however realize the significance of his observations, because he believed in *special creation* and *fixity of species*. Similarly, Karl Friedrich Gaertner (1772 -1850) performed breeding experiments with peas and obtained results not unlike those of Mendel. Gaertner, however, did not analyse the individual traits. Mendel, on the other hand, worked with seven visible features (unit characters) of garden peas, and each of these features was represented by two highly contrasting traits. Unlike his predecessors, Mendel used a valid experimental model, an elegant study design, sound methodology, and quantitative analysis: all these are essential for good experimental biology. His approach to experimental genetics was very different from that of other scientists of his time. As a result, his work, the work of a monk, was treated as if it did not belong to the world of science.

Furthermore, Mendel's work was marginalized because of newly found interest in the theory of natural selection of Darwin and Wallace, in which *why* certain phenotypes survive preferentially was considered *more important* than *how* phenotypic variations are transmitted. It is the latter question which Mendel's study addressed at a time when it was not considered important.

There was an even more serious conceptual problem which hampered Mendel's idea in his lifetime. Some contemporary biologists were indeed intrigued by the underlying mechanism of natural variation. As Darwin and Wallace believed, the predominant concept in this regard was the *blending theory of inheritance*, that the 'hereditary fluid' from two parents meet together and blends, forming an inseparable mixture giving rise to *continuous variation*. On the contrary, Mendel presented, based on his observations, that hereditary transmission occurred through particulate, discrete units or factors, which resulted in *discontinuous variations*. Given the overpowering influence of Darwin's theory, Mendel's thesis did not fit well with the contemporary biologists' belief about natural variation.

Mendel's theory was further marginalized because of a lack of any cytological basis for his observation. During the period from 1865 to 1900, it became progressively evident that Weissmann's *germplasm* houses the genetic material which contains the information for heredity and development. In 1879, Walter Flemming discovered chromosomes in nuclei of salamander cells. Against this background, Mendel's theory returned with a bang in 1900. This was a paradigm shift when new observations, new data, new tools and new minds converged at a point which went beyond the existing rules and paradigm. In 1902, Walter Sutton and Theodor Boveri independently discovered the behaviour of chromosomes during meiosis, which corroborated Mendel's principles of segregation and independent assortment.

However, all these explanations do not fully solve the mystery as to why at least some contemporary biologists failed to appreciate the significance of Mendel's observations, which in Kuhn's terminology constitute a *small revolution* when a limited group of scientists in a specific subspeciality starts finding anomaly in existing rules and paradigm in view of newly observed data. An additional reason could be that people who mattered in genetics at Mendel's time and place did not promote his findings, for whatever reasons. In 1866, Mendel sought the help of the famous Swiss biologist Karl Von Nageli (1817–1891), who himself was engaged in plant breeding experiments. Von

Nageli, however, was not impressed with Mendel's theory and suggested that Mendel should grow some more peas. Mendel had already recorded observations on some 13000 hand-bred specimens of pea plants. Mendel sent him 140 packets of pea seeds to grow them at the Botanical Gardens in Munich. Von Nageli never planted the seeds and did not refer to Mendel's findings in his major treatise (*Mechanisch- physiologische Theorie der Abstam-munglehre*) published in 1884. Because of concentration of power in the hand of a few self-opinionated scientists, their tubular vision about progress in science, conceptual inertia and other diverse psychological blocks, such dismissal of a potentially great idea has not been a rare phenomenon in the history of science.

Above everything else, Mendel is remembered for his exemplary unbiased experimentation and meticulous analysis of observed data with a clear, free mind. Besides being the gold standard of research methodology in biological sciences, Mendel laid the foundation stones for two branches of modern biology: *genetics and biometry.*

Four postulates form the basic tenets of Mendelian genetics. First, genetic characters are controlled by unit factors present in pairs in individual organism. Second, presentation of a single character in a single individual is determined by relative dominance and recessiveness of unit factors in pair. Third, the paired unit factors segregate randomly during gamete formation. Finally, segregating pairs of unit factors assort independently of each other during gamete formation. Clearly, independent assortment of genetic material forms the basis of wide spectrum of genetic variation, which appears to be important in the process of organic evolution in all organisms. Thus, Mendelian genetics replaced the Darwin's *blending theory of inheritance through continuous variation.*

Furthermore, Mendel's method of handling data was the beginning of statistical analysis in biological sciences, which stimulated a new generation of scientists like Karl Pearson and Ronald Fisher. Somewhere, between 1892 and 1900, Karl Pearson coined the term *biometry*, which literally means biological measurement, to define analysis and interpretation of data with a view toward objective evaluation of the reliability of the conclusions based on scientific data. In 1901, Karl Pearson published this term in the inaugural issue of his journal *Biometrika.*

IJPP is proud to analyse the circumstances which delayed the recognition of Mendel's monumental contribution by more than thirty years. Now that the human genome has been completely mapped, it is easy to appreciate what a revolution Mendel initiated.