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FORUM
Contested memory: debates over the nature of Mendel's paradigm

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Observation and analysis of phenomena penetrate into the depths of Nature, and one cannot know how far this will lead in the course of time.
I. Kant in "Critique of pure reason" (STERN and SHERWOOD 1966, p.VI).

Mendel remembered in Brno in the 1960s

In 1962 Curt Stern visited Brno to speak with J. Křiženecký (1896–1964) about Mendel's scientific achievements. The topic was to be re-considered within the context of the origin and development of genetics on the occasion of the one-hundredth anniversary in 1965 of the publication of Mendel's discovery. Already before World War II, Stern, a geneticist from Berlin and later a professor of human genetics in USA, had been in contact with Křiženecký, a teacher of animal breeding in Brno, who in the 1930s strove to establish an institute for the teaching of genetics there. The project was not realised due to the economic crisis and, later, the closing of Czech universities after the Nazi occupation in 1939 of what was then Czechoslovakia. In 1948, a renewed project was again stopped – this time after the communists' putsch in the country when genetics, known as "the reactionary science", had to give way for lysenkoism. At that time Křiženecký was teaching his students that the question of inheritance of acquired traits – the basis of lysenkoism – had been elucidated and rejected by geneticists already twenty years earlier (PLESNÍK and OREL 1949–1950). I belonged to his enthusiastic students, when he became stigmatized as a representative of "reactionary genetics" and dismissed from his university teaching. In 1958 he was even arrested (OREL 1992).

When Křiženecký returned from prison, I welcomed the renewed contact with him, and he enthusiastically informed me about the "International Mendel Memorial Symposium" to be held in Brno in 1965 (SOSNA 1966). It was to be a milestone in the development of genetics in our country. The visit of professor Stern fuelled Křiženecký's enthusiasm for gathering documents to prepare a rehabilitation of Mendel from accusations about falsification of his experimental data and for the elevation of genetics from its subordination to political ideology. Křiženecký immediately began working on his book, "Fundamenta genetica", containing the revised edition of Mendel's *Pisum* paper, plus a collection of 27 original papers published during the era of the rediscovery of Mendel's work (KŘIŽENECKÝ 1965a). In his commentary, Křiženecký briefly explained how the external characteristics of peas corresponded to certain internal qualities in cells, called "Elementen", existing in pairs, being separated during gametogenesis, and one member of each pair becoming incorporated into each of the two germ cells (KŘIŽENECKÝ 1965b).

Stern was convinced that Mendel's scientific achievements were not well enough known to geneticists. He compared the investigation of Mendel's research to the explanation of the slow growth of human genetics in the USA due not only to the difficulties which the long life span of man introduces but also "to the dampening effect on bona fide research which resulted from class prejudice within the eugenic movement" (STERN 1966). In his book, "The origin of genetics: a Mendel source book," Stern published the revised English translation of Mendel's papers on hybridizations, the first English translation of Mendel's letters to C. Nägeli, and five of the most important papers published after 1900, with the aim to spread a better understanding of the pioneer knowledge of heredity (STERN and SHERWOOD 1966). The geneticist A. H. Sturtevant stressed that Mendel's letters to C. Nägeli illustrates how actively Mendel was engaged in genetic studies on several other plant forms, "proving his approach to the investigation of ever more complex problems" (STURTEVANT 1965).

It was a paradox of the time that Křiženecký, after being released from prison, became entrusted in 1963 with the establishment of a new department for the study of the history of genetics in the Moravian museum in Brno. His first task was the renovation of the Mendel museum. It had been opened in 1922 in the Augustinian monastery on the occasion of the hundredth anniversary of the birth of Mendel and it had been closed down in 1950. The following year, 1964, Křiženecký invited me to cooperate in the realization of the project. Towards the end of 1964 Křiženecký suddenly died, and in carrying through his plans I had the honour of inviting the participants of the Mendel Memorial Symposium to the newly-opened Mendel museum adjoining the experimental garden where Mendel had performed his hybridization experiments (OREL 1966). The visitors were also informed about the continuing documentation and historical investigations of Mendel's life and scientific activities, which were taking place within the new department named the Mendelianum.

At the opening ceremony of the Mendel symposium a recorded message of the Nobel prize winner, professor M. J. Muller, was read with the following conclusion: "The science that we at present term genetics, that had its first clear start in the brilliant work of Gregor Mendel, contains the main clue to the means by which life arose out of the non-living material, to the nature of the threads that have woven evolution, and to the way that must follow up when he transcends himself" (MULLER 1966). Also remarkable was the presentation, titled "Gregor Mendel," by the Russian geneticist, N. W. Timofeev-Ressowsky who had not been allowed to leave the USSR to attend the meeting (TIMOFEEV-RESSOWSKY 1966). The author had previously been arrested and held in a Gulag-camp. According to him, "Mendel passed ahead of his time; he became the pioneer in introducing strict mathematical thought in biology and founded the basis for the fast and gracious development of genetics in our century; and we may state now that genetics together with evolution theory, grounded on the principle of selection, is the basis upon which the 'biological thought' is to be formed, and which imparts the powerful stimulus to the development of all the fields of modern biology." The participants of the symposium combined an interest in the development of genetics growing out of Mendel's discovery with a vision for the future based on new methodologies. Professor Stern in his lecture "Mendel and human genetics" encouraged further developments of human genetics along this trend. Referring to the first Mendel biographer H. ILTIS (1924), STERN (1965, 1966) stated that Mendel had also "shown persistently great interest in hereditary phenomena in man" and was "the first who, on the basis of his particulate theory of inheritance, attacked a problem not only of the genetics of individuals and their progeny, but also of a whole population".

Since 1966, using newly found documents and information, the staff of the Mendelianum has continued their investigations of Mendel's achievements and the early development of genetics, in cooperation with geneticists and historians of science. Their priority has been to explain the questions posed by R. A. Fisher in 1936: "What did Mendel discover? How did he discover it? And what did he think he had discovered?" (FISHER 1936). The results have been published annually in the series of the Moravian museum, "Folia Mendeliana," under my editorship until 1991. Looking back, a brief summary can be given of how Mendel's discovery has become perceived after 1965.

Mendel's discovery

In 1806 the newly organized "Moravian Society for the Furtherance of Agriculture, Natural Sciences and Knowledge of the Country" presented a programme in Brno for scientific and economic advancement with special attention to the "most useful auxiliary science, above all to mathematics and chemistry, without which it is impossible to achieve any progress." Newly named professors of agriculture and natural history in Olomouc and Brno initiated a unique communication between sheep breeders and naturalists that lead to the formulation in 1818 of empirical laws of inheritance (OREL and WOOD 1998). Four years later Johann Mendel, the only son of an industrious peasant farmer, was born. The village parish priest, J. Schreiber (1769–1850), influenced by the surviving ideas of the famous Moravian educationist John Amos Comenius (1592–1670), included in his teaching of religion to village pupils the basic knowledge of natural history to be applied towards the improvement of agriculture, and, in particular, to pomology and bee keeping. Later in Brno his pupil J. Mendel became the acknowledged expert in these fields. With the encouragement of Schreiber and the village teacher, Mendel went on to study for six years at the gymnasium in Opava, 25 km from his home, with excellent results.

Upon graduation from the gymnasium, Mendel's first concern was to secure the necessary means to continue his studies at the more distant Philosophy Lyceum at Olomouc University. His parents were not able to meet all the expenses necessary for the continuation of Mendel's studies, and only his ability to overcome material problems enabled him to continue further study. With the self-sacrificing support of his family, he managed two years of study at Olomouc, where great attention was paid to mathematics and physics, the subjects of importance for his future career. The physics teacher, F. Franz, recognised Mendel's deep interest in physics and recommended F. C. Napp (1792–1867), the abbot of the Augustinian monastery in Brno, to accept Mendel into the monastery. Since 1807 the Augustinians in Brno had been entrusted with the teaching of mathematics and liberal studies in the newly established Philosophical Institute in Brno. In 1824, having been elected abbot, Napp used his broad knowledge and organizational skill to fulfil this duty at the highest level, looking for talented young monks who would be able to study various branches of science and be prepared for the teaching profession and for spreading the latest scientific knowledge. As a member of the provincial Diet, a member of the committee of the Agricultural Society, president of the Pomological Association, and a member of the Sheep Breeder's Association, Napp paid attention to agricultural literature and the associated natural science, and supported research toward applying this knowledge in practice (Orel 1975).

In October 1843 the 21 year old Johann Mendel, having received his order's name Gregor, entered noviciate training supervised by A. Keller (1783–1853), an acknowledged member of the Pomological Association of which Napp was the president. While studying the classical subjects prescribed for the probationary year, Mendel also occupied himself with studies of natural science, for which, he later wrote in his autobiography, he had a special liking, the more so when he become more familiar with it.

He performed his studies in a cultural and scientific environment in Moravia whose advances in animal and plant breeding since the 1820s had come from the close cooperation of breeders with teachers of agricultural science and natural history. J. K. Nestler (1783–1841), a professor at the Olomouc University, was primarily interested in sheep breeding for wool production (Orel 1978), while F. Diebl (1770–1859), a professor at the Brno Philosophical Institute, paid most of his attention to plant production, stressing the importance of creating more productive new plant varieties (Orel and Czihak 2000). In 1829 the publication of Nestler's lectures on scientific animal and plant breeding initiated a discussion among sheep breeders on the process of the transmission of parental traits to the progeny. At the same time Diebl explained that botanists in their classification of cultivated plants should consider the constant traits that are inherited, and which under special conditions are not seen but may reappear in later generations. According to him, plant physiology permits that such traits may arise through artificial fertilization through a force, still unknown to breeders, that plant breeders can investigate scientifically with the goal of creating new, more productive varieties.

Advances in breeding practices in the 1830s brought to light new theoretical questions. In 1836, when Nestler was asked to define the most important problem for the improvement of methods in sheep breeding for wool production, he recommended the investigation of heredity as a separate issue from "generation", the enigmatic process of reproduction and development. Abbot Napp maintained that inheritance of traits from producers to the produced is based on the mutual elective affinity of paired animals and that therefore each ewe and ram should be chosen according to their corresponding internal and external organisation, and that this process deserves to be the subject of physiological study. The next year, returning to the discussion of selection and heredity, E. Bartenstein (1769–1838), chairman of the breeder's association, proclaimed that in the last 24 years of the existence of the association "the genius of truth and of higher education floated above the heads of the participants" (Bartenstein et al. 1837). He had expected that an elucidation of the problem would have been achieved during this time. According to Napp, the discussion, dealing mostly with the breeding operations, had deviated from the theoretical theme, and that the main question should be "what is inherited and how?" In summarizing the discussion Nestler indicated how nature produces – "through forces beyond the hand of man" – natural species with undoubted constancy, and how man can modify the deviations in organic bodies "with increasing or disappearing inheritance." Considering the potential for tracing patterns of transmission of traits from generation to generation from the pedigree registers of sheep breeding, Nestler used the terms "developmental history", in original German *Entwicklugsgeschichte*, and "hereditary history", *Vererbungsgeschichte* (Wood and Orel 2005).

The creative communication in Brno between breeders and naturalists was appreciated by a senior member of the Agricultural society, J. Waniek, who said in 1842: "Differences of opinion, freely expressed in the meetings, stimulated experiments that open the way for new reflection, experimentation and progress which, according to natural laws, cannot be stopped" (Waniek 1845). However, after the revolutionary year of 1848, the Natural Science Section within the reorganized Agriculture Society, was changed in 1861 into the independent Natural Science Society. The aim of its members was to cultivate only "pure science" (Orel 1970). At the newly built Technical Institute, J. Helcelet (1812–1876), a medical graduate and professor of natural science, was not interested in the problems of breeders. The contacts between breeders and naturalist became interrupted, and the physiological basis of heredity was left undiscussed.

While studying theology in 1846 Mendel attended Diebl's lectures in agricultural science and pomology and passed three examinations with distinction. In the revolutionary year 1848 he, together with five other friars, signed the courageous petition of M. Klácel (1808–1882), addressed to the imperial constitutional parliament, asking for members of religious orders to be given more freedom to teach and study sciences

(Orel and Fantini 1983). In 1849 Mendel welcomed the offer of abbot Napp to take the post of extra teacher at the gymnasium in the town of Znojmo. In 1851 to 1853 he studied natural science at Vienna University, paying utmost attention to experimental physics and plant physiology. He returned to Brno with the idea of plant hybridization experiments in his mind. When Mendel explained "the general application of the law of formation and development of hybrids" in his lectures to the members of the Natural Science Society in 1865, the listeners did not understand that he addressed the research question that had arisen from the discussion between local breeders and naturalists thirty years ago. The relevance of his research to the breeders' needs was not to be appreciated until 35 years later.

After 1900, the naturalists and agricultural experts in Brno accepted "the rediscovery" of Mendel's experiments by foreign naturalists, and the generalizations of the genetic laws ascribed to Mendel appeared in the literature. The relationship of heredity to evolution remained controversial for a long time, as did the achievements of Mendel and Darwin. A remarkable summary of the situation was presented in the lecture by N. W. Timofeeff-Ressovsky in Brno in 1965: "Mendel is honoured mainly for the famous Mendelian laws, or rules of heredity – 'dominance,' 'segregation,' and 'free combination.' Moreover, Mendel's investigations, just as Darwin's work, are often seen as something 'new', 'breaking all the traditions' and 'entirely neglecting' the previous advances of science. It is characteristic of both C. Darwin and G. Mendel that they created, for the first time, the possibility of true scientific theorizing, free of teleological philosophy, in the two main fields of biology – evolution and heredity" (Sosna 1966).

Mendelism as a new paradigm

Historical investigations give us an explanation of the origin and essence of Mendel's discovery. Scientific breeding during the early nineteenth century created a background to his research (Wood and Orel 2001, 2005). Arising from his initial theoretical framework, Mendel proved, in his sequence of hypotheses and experiments, that material units govern the transfer of parental traits to offspring through the germ and pollen cells (Hartl and Orel 1992; Orel and Hartl 1994; Orel and Czihak 2001).

This explanation can be compared to the interpretation of Mendel's discovery by philosophers and sociologists of science. Based on the history of the physical sciences in Europe from 1620 to 1920 and from chemistry after the mid-nineteenth century, T. Kuhn (1922–1996) introduced in 1962 the idea of drastic paradigmatic thresholds in the growth of scientific knowledge. Revolutionary geniuses, such as Newton and Einstein, could be seen as the originators of new paradigms (Kuhn 1962).

This interpretative "structure" became in itself a new paradigm for further research, and a new research program, known as the "sociology of scientific knowledge", and an interdisciplinary field of "science and technology studies" or "science studies" became introduced. According to Kuhn's pupil, S. Fuller, most branches of physics in earlier times were paradigm based, while most branches of biology were not. "The strict historian would place the origins of paradigm-driven biology no earlier than the 1930s, down to the so-called neo-Darwinian synthesis" (Fuller 2000, p. 76). Fuller (p. 89) mentions that Gregor Mendel became retrospectively "canonized" as the "father of modern genetics", 40 years after the publication of his paper.

However, a correct appreciation of Mendel's discovery, made possible after 1965, allows us to place the "canonized father of genetics" along with Darwin as the originators of paradigm-driven biology. I am sure that Curt Stern, even today, would have been pleased to repeat his dictum from 1965:

> *"Mendel's paper of 1866 can be read as a self-contained document illustrating the power of the human intellect to probe into the depths of Nature and it can be read as a prelude to a hundred years of future penetration."*
>
> (Stern and Sherwood 1966, p. VI)

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