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by Australia. The authorities considered plant and animal breeding to be the most promising instruments for improving and diversifying Moravian agriculture. The dynamic abbot Cyril Napp, concerned about the dependence of his monastery on the productivity of its many farms, encouraged Mendel, who wanted to explore the nature and results of hybridization both for practical and for theoretical reasons. An experimental approach, such as Mendel had learned in his physics courses in Vienna, might yield results that would guide the practical breeder and clarify the nature and origin of species for the naturalist.

The origin of species was discussed in central Europe long before *Darwin's theory reached there in connection with the question whether hybridization yielded offspring able to reproduce their like with the constancy of species. If so, as Carl *Linnaeus had suggested, might not the majority of species have arisen by hybridization between a much smaller number of created forms? The possibility had its attractions to a scientifically minded member of the Roman Catholic church.

Mendel planned a systematic investigation to answer this question. Treating the organism as composed of a number of independent hereditary traits, he designed a series of experiments to substantiate their independence and reveal the patterns governing their combinations. After testing thirty-four varieties of the edible pea for constancy of type (1854–1856), he embarked on his now famous hybridizations (1856–1863). To achieve statistically significant results he grew large numbers of plants. To avoid problems in the sorting of the progeny he studied only clearly distinguishable traits. One expression of each of the traits *dominated* in the hybrid so that another expression (the *recessive* trait) did not reappear until the following generation. The progeny of these hybrids showed the dominant characters three times as often as the recessive. The next generation revealed that the dominants consisted of one pure form for every two hybrids. Hence the ratio of pure dominants:hybrids:pure recessives was 1:2:1, like the coefficient in the expansion of the binomial equation $(A + a)^2 = A^2 + 2Aa + a^2$.

Mendel knew that in fertilization one pollen cell fertilizes one egg cell. Hence if these cells in the hybrid were of two kinds represented by the letters *A* and *a*, self- fertilizations would yield all combinations of germs cells for *a* and for *A*, for example: $AA + Aa + aA + aa$ $[A + 2Aa + a]$.

Therefore he postulated that the differing potentials—*A* and *a*—brought together in the hybrid, separated in the formation of the germ cells. This is Mendel's principle of the *purity of the germ cells*, and it accounted for the reversion of hybrid offspring to their originating species. He accounted for the variability that followed from hybridization by the possibilities for recombination between differing germ cells. He thought that some hybrids did not separate, but remained constant in their progeny. But his subjection of some so-called constant hybrids to the test of experiment showed that they followed the same sort of segregation as the edible pea.

Mendel continued these researches until his duties as abbot became too heavy. He announced his results in three lectures to the Brünn Society of Naturalists, two papers on hybridization in *Pisum* and one on *Hieracium* in their *Proceedings*, and described his work in correspondence with the famous botanist Carl Wilhelm von Naegeli. Not until 1900, however, were his papers discovered and his work repeated. Then the science that would become *genetics was born.

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ROBERT OLBY

MENDELEEV, Dmitrii Ivanovich (1834–1907), chemist, formulator of the periodic system of chemical elements.

Growing up in Tobol'sk, Siberia, Mendeleev had a typical childhood in the backwaters of the Russian empire. His mother determined that a child with his good grades should attend university. Having failed to matriculate at Moscow University, Russia's oldest educational institution, he was sent on to St. Petersburg, where he enrolled in the Chief Pedagogical Institute, the same place at which his father had trained. The Institute shared a faculty with the more prestigious St. Petersburg University, and there Mendeleev began to study the natural sciences, especially *chemistry, under Aleksandr A. Voskresenskii. In 1858, he was granted permission to study abroad for two years. After some deliberation, Mendeleev settled in Heidelberg. Rather than working with Robert Bunsen, as he had intended, Mendeleev established a laboratory in his apartment and began to study the capillarity of organic solutions. He served as the social center for the several Russian chemists in Heidelberg. In September 1860, he traveled with three Russian companions to the chemical congress at Karlsruhe, which proved seminal in standardizing various chemical conventions, including

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the crucial revival of Avogadro's hypothesis for the determination of consistent atomic weight values. In February 1861, a few days before Czar Alexander II abolished serfdom, Mendeleev returned to St. Petersburg to try to establish a career in the capital during the turbulent years of Imperial reform.

At first, these efforts proved abortive. While seeking a permanent position, Mendeleev wrote a textbook, *Organic Chemistry* (1861), which won him the Demidov Prize of the Petersburg Academy of Sciences. In 1864, Mendeleev obtained a position at the St. Petersburg Technological Institute. During the 1860s, he was one of the principal architects of the Russian Chemical Society, one of the first truly organized scientific societies in Russia. In 1867, he succeeded Voskresenskii at St. Petersburg University, and he began to teach inorganic chemistry. While preparing a textbook for this course, *The Principles of Chemistry* (first edition, 1869–1871), Mendeleev made his most important chemical discovery.

Today, Mendeleev's name is most closely identified with his formulation of the periodic system of chemical elements, an ordering of the sixty-three then-known elements by order of increasing atomic weight. Although seven other chemists formulated similar periodic classifications before Mendeleev in the 1860s, his generally recognized priority stems from his novel prediction of three elements to fill empty spaces in the *periodic table. These elements, eventually named gallium, germanium, and scandium, were discovered by other European chemists from 1876 to the mid-1880s, and Mendeleev's detailed forecasting of their chemical properties, from atomic weight to specific gravity, earned him an international reputation. The periodic system, originally conceived as a convenient pedagogical classification, is today almost universally employed as a teaching tool throughout the world.

Mendeleev did not pursue work on the periodic system after finalizing his predictions in 1871. Although he continued to teach inorganic chemistry, he began large-scale experimental research into the laws of gas expansion in an attempt to locate the substance of the luminiferous *ether. This effort, financed by the Russian Technical Society, collapsed in 1881, a few months after Mendeleev failed by one vote to win election to the Imperial Academy of Sciences. This event, which sparked a lively public debate about the role of ethnic Russians in Imperial institutions, along with Mendeleev's public attacks on spiritualists in St. Petersburg in 1876, helped forge a new public role for the natural scientist in Russian culture.

After his rebuff at the Academy of Sciences, Mendeleev retreated to his pedagogical duties while continuing to consult for the Ministry of Finances on oil exploitation in Baku and conducting research on chemical solutions. In 1890, during a dispute about a petition for students' rights at the University, Mendeleev resigned from his post at St. Petersburg University, and soon moved to the Navy, where he developed a form of smokeless gunpowder. In 1893 Mendeleev was appointed first director of the Chief Bureau of Weights and Measures and in 1899 he initiated and oversaw the partial introduction of the metric system into the Russian empire. In the final years of his life, he maintained his role as a public intellectual while reviving his ether speculations of the 1870s in a theoretical chemical work. He died as the most highly decorated chemist in Russian history.

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MICHAEL D. GORDIN

MENTAL SCIENCES. The various dimensions of consciousness have long been the subjects of speculation and observation. The modern word "psychology" dates from the seventeenth century, but Greek doctors and philosophers established a framework that guided Western thinking on the subject. Plato and the Hippocratics believed that the soul and hence mental activity resided in the brain, whereas Aristotle located these functions in the heart. Galen, the most influential doctor of antiquity, sided with Hippocrates and Plato, and medieval physicians placed the important mental functions of reason, memory, and imagination along with sensation in the ventricles of the brain.

René *Descartes created a framework for a scientific physiology but at the expense of human psychology. His strict dualism, in which animals were merely complicated machines, potentially understandable in material terms, and human beings similar machines, with soul added, was a neat but awkward solution to long-standing problems. If animals were machines, then sensation, movement, and the apparent expression of emotions, for example in response to painful stimuli, should be explicable mechanically. Consciousness, free will, language, reason, and other "higher" aspects of mental life were functions of the soul (or mind, the French word being the same for both) and hence