

Adrain shares with his contemporary Nathaniel Bowditch the honor of being the first creative mathematician in America. Like Bowditch, he was an ardent student of Laplace, and his paper on errors is in the spirit of Laplace.

Adrain became a member of the American Philosophical Society in 1812, and six years later he published in its *Transactions* a paper on the figure of the earth, in which he found $1/319$ as its ellipticity (Laplace had $1/336$; the modern value is $1/297$). In the same issue of the *Transactions* he also published a paper on the mean diameter of the earth. Both papers were inspired by Laplace.

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II. SECONDARY LITERATURE. The most easily available source of information on Adrain is J. L. Coolidge, "Robert Adrain and the Beginnings of American Mathematics," in *American Mathematical Monthly*, **33** (1926), 61–76, with an analysis of Adrain's mathematical work. On his theory of errors, see also O. R. Sein, "R. Adrain's Works in the Theory of Errors and Its Applications," in *Istoriko-matematicheskie issledovaniya*, **16** (1965), 325–336 (in Russian). An early source is an article in *United States Magazine and Democratic Review*, **14** (1844), 646–652, supposedly written by Adrain's son Garnett. See also G. E. Pettengill, in *Historical Review of Berks County (Penn.)*, **8** (1943), 111–114; and D. E. Smith, in *Dictionary of American Biography*, **1** (1928), 109–110.

Coolidge mentions the existence of manuscript material of Adrain's on which M. J. Babb of Princeton was working. These papers seem to have been lost after Babb's death in 1945. The library of the American Philosophical Society has some letters by and concerning Adrain to John Vaughan in Philadelphia, and a letter written to Adrain by M. Roche in 1831.

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ADRIAANSON, ADRIAAN. See *Metius, Adriaan*.

AEGIDIUS. See *Giles of Rome*.

AEPINUS, FRANZ ULRICH THEODOSIUS (b. Rostock, Germany, 13 December 1724; d. Dorpat, Russia [now Tartu, Estonian Soviet Socialist Republic], 10 August 1802), *mathematics, electricity, magnetism*.

Aepinus came from a family long distinguished for its learning. His great-grandfather, who had translated the family name, Hoeck, into Greek, had been an important evangelical theologian. His father held the chair of theology and his elder brother that of oratory at the University of Rostock. Aepinus studied medicine and mathematics at Jena, particularly under the guidance of G. E. Hamberger, and at Rostock, where he took his M.A. in 1747 with a dissertation on the paths of falling bodies. Until 1755 he taught mathematics at Rostock, as a junior lecturer, and published only on mathematical subjects: the properties of algebraic equations, the integration of partial differential equations, the concept of negative numbers. In 1751–1752 one of his auditors was J. C. Wilcke, who had come to Rostock to study under Franz's brother. With Franz's encouragement and instruction, Wilcke concentrated on physics and mathematics, and soon decided against the clerical career for which his father had intended him. A few years later Wilcke played an equally important role in reorienting his mentor's professional career.

In the spring of 1755 Aepinus became director of the observatory in Berlin and a member of the Academy of Sciences there. These appointments were apparently merely a device for establishing Aepinus, who had begun to acquire a reputation, in Frederick's capital: he was neither especially interested nor experienced in astronomy, and his closest published approach to the subject during his Berlin sojourn was a mathematical analysis of a micrometer adapted to a quadrant circle. His main preoccupation at the time was the study of the tourmaline, to which he was introduced by Wilcke, who had followed him to Berlin. Aepinus' first researches on the thermoelectric properties of this stone, which was then of extreme rarity, were fundamental. He recognized the electrical nature of the attractive power of a warmed tourmaline and attempted, not altogether successfully, to reduce its apparent capriciousness to rule. He was particularly struck by the formal similarity between the tourmaline and the magnet in regard to polarity, which inspired him to reconsider the possibility, then occasionally discussed, that electricity and magnetism were basically analogous. This thought became the

theme for his masterwork, *Tentamen theoriae electricitatis et magnetismi* (1759).

In experimenting on the tourmaline Aepinus was often assisted by Wilcke, who was then preparing a dissertation on electricity. Their closeness made it natural for Wilcke to bring to Aepinus' attention certain phenomena he had discovered that apparently conflicted with Franklin's principles. In seeking an explanation, Aepinus came to the anti-Franklinian idea of a Leyden jar without the glass. The success of this air condenser eventually helped to persuade many to abandon Franklin's special assumptions about electrical atmospheres and the electricity of glass, and to prepare the ground for more general views of the kind Aepinus urged in his *Tentamen*.

In October 1756 Aepinus asked to be relieved of his positions in Berlin in order to accept the directorship of the observatory and the professorship of physics, vacant since the death of Richmann, at the Imperial Academy of St. Petersburg. Euler, with whom he boarded in Berlin, warmly recommended him for the job and interceded with Frederick to procure his release, which occurred in the spring of 1757. The Petersburg academicians expected that Aepinus, as befitted Richmann's successor, would continue to work on electricity. They were not disappointed. Late in 1758 Aepinus completed the lengthy *Tentamen*, which the Academy rushed into print before its author could finish his polishing.

The *Tentamen* is one of the most original and important books in the history of electricity. It is the first reasoned, fruitful exposition of electrical phenomena based on action-at-a-distance. Aepinus emphatically rejects the current notion of electrical atmospheres. Not that he believes that bodies act where they are not: he merely takes literally Newton's precepts about natural philosophy, and deduces the phenomena from certain assumed forces, without inquiring into the manner in which the forces themselves might be effected. Three such forces, according to him, create all the appearances of electricity: a repulsion between the particles of the electric fluid, an attraction between them and the corpuscles of common matter, and a repulsion between the corpuscles. This last is necessary to prevent unelectrified bodies—bodies with their normal complement of electrical fluid—from attracting one another. Aepinus observes that although such a repulsion might appear to conflict with universal gravitation there is no reason not to suppose several types of forces between matter corpuscles, and in fact the phenomena require it. As for the law of force, it is proportional to the excess or deficiency of fluid, and the same for all pairs of particles and corpuscles. Aepinus does not pretend

to know its precise form. Analogy, he thinks, favors the inverse square, which he uses in one numerical application; but generally he leaves the matter open, the great unanswered question in electrical theory.

Aepinus does not need the precise law, however, to explain the phenomena qualitatively. He is particularly successful with induction effects, which had puzzled philosophers since Canton's experiments of 1752; his explanations, with appropriate terminological changes, are essentially those used in elementary electrostatics today. Although his exposition is not quantitative, it is mathematical, with symbols used to indicate the excess or deficiency of fluid and the associated forces. Assuming that the forces decrease with distance, he is able to anticipate the direction of electrical interactions. In this way he predicts apparently paradoxical phenomena, e.g., that if two bodies with like charges of greatly different strengths are pushed together, their repulsion will at some point change to attraction. The magnetic theory of the *Tentamen* operates on the same principles, except that the magnetic fluid can freely penetrate all substances but iron, in which it is so tightly held that it can neither increase nor decrease. A piece of iron is thus to the magnetic fluid what a perfect insulator would be to the electric. All magnetic phenomena depend on the displacement of the magnetic fluid within iron. Aepinus' analysis of magnetization is exactly analogous to his treatment of electrical induction; it is adequate to all problems he considers except the formation of two magnets by the halving of one. Most notably it leads him to improve on Canton's and Michell's method of preparing artificial magnets, and on the usual disposition of armatures.

In 1760 or 1761 Aepinus became instructor to the Corps of Imperial Cadets, a position that left him too little time to fulfill his duties at the academy. The observatory was seldom used, and the equipment in the physics laboratory deteriorated. These circumstances gave Lomonosov the opportunity for a furious attack on Aepinus, whose haughtiness toward Russian scientists and quick preferment at court had already irritated him. Despite such unfavorable conditions, Aepinus continued for a few years to produce papers on various mathematical and physical subjects. He published the most important and coherent of these, several dissertations on the tourmaline, along with some criticism and corrections of his earlier work, as *Recueil des différents mémoires sur la tourmaline* (1762). Among the more occasional pieces, perhaps the most interesting are a masterful discussion of the mercurial phosphorus and a critical examination of Mayer's theory of magnetism, both of which appeared in the *Novi commentarii* of the Petersburg Academy

for 1766–1767. About that time Aepinus' scientific activity ceased almost entirely. He became preceptor to the crown prince, a member of the prestigious Order of St. Anne, an educational reformer, a diplomat, a courtier, and finally a privy councillor. In 1798, after forty years in Russia, he resigned his offices and retired to Dorpat.

Except for his work on the tourmaline, which established a new subject, it is difficult to assess Aepinus' immediate influence. He had no distinguished students besides Wilcke. His contributions to mathematics, astronomy, and optics were competent but not outstanding. The *Tentamen* was at first not widely read. It was not easy to find (Beccaria had not seen a copy as late as 1772), and it was not easy to read (it demanded greater mathematical facility than most physicists then possessed). Although it was known and praised by Volta, Cavendish, and Coulomb, those physicists appear largely to have developed their own views before they came across it. But, less directly, the *Tentamen* was of great importance. Most of its content became easily available in 1780 in the excellent nonmathematical epitome composed by R. J. Haüy, who managed to preserve the spirit and clarity of the original. A much less adequate notice appeared in Priestley's *History*. Through such means the message of the *Tentamen* became widely diffused. Those who returned to the original then discovered in it a model for the application of mathematics to electricity and magnetism, and a store of apposite experiments. As one can see from P. T. Riess's *Die Lehre von der Reibungselektricität* (1853), the *Tentamen* remained an important source until the middle of the nineteenth century.

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by Wilcke, are preserved in the library of the Swedish Academy of Sciences; other manuscripts may exist in the Soviet Union.

II. SECONDARY LITERATURE. Biographical information about Aepinus is sparse and scattered. The older, standard biographical entries are summarized and slightly expanded in W. Lorey's notice in *Allgemeine deutsche Biographie* and in H. Pupke, "Franz Ulrich Theodosius Aepinus," in *Naturwissenschaften*, 37 (1950), 49–52. For other data, see Euler's correspondence, particularly A. P. Youschkevitch and E. Winter, eds., *Die Berliner und die Petersburger Akademie der Wissenschaften im Briefwechsel Leonhard Eulers. I. Der Briefwechsel L. Eulers mit G. F. Müller* (Berlin, 1959); A. A. Morosow, *Michail Wassilyewitsch Lomonossow 1711–1765* (Berlin, 1954); and E. Winter, ed., *Die Registres der Berliner Akademie der Wissenschaften 1746–1766* (Berlin, 1957).

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AËTIUS OF AMIDA (*b.* Amida, Mesopotamia [now Diyarbakir, Turkey], *fl. ca.* A.D. 540), *medicine*.

Aëtius had the title *comes obsequii*, which indicates that he had a relatively high rank, possibly of a military nature, at court. Since this title seems not to have been introduced until the reign of Justinian I, Aëtius cannot have lived before the sixth century. It is sometimes supposed that he was physician in ordinary at the Byzantine court, and this is occasionally stated as a fact both in books dealing with antiquity and in books on medical history. In any case, Aëtius lived after Oribasius, for the latter's medical encyclopedia is one of his main sources. Several times in his work Aëtius speaks of a sojourn in Alexandria. It cannot be proved that he was a Christian, for he does no more than mention Christian institutions and customs several times. In any event, he ought not to be confused with the physician and Arian Christian Aëtius who lived in the fourth century and is mentioned in Philostorgios' church history, as well as in Gregory of Nyssa's *Contra Eunomium*.

Aëtius wrote a large medical encyclopedia that is called either *Sixteen Medical Books* or *Tetrabibloi* (i.e., four volumes, each containing four parts or books). This form of medical encyclopedia, typical of late antiquity and the Byzantine period, corresponds to that of the known encyclopedias of Oribasius and Paul of Aegina. They are all collections of more or