

## Thomas Johann Seebeck (1770–1831)

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**Abstract.** Thomas Johann Seebeck, an Estonian-German physicist, chemist and physician was born in 1770 in Tallinn, Estonia. Educated in Tallinn, Berlin and Göttingen, he lived and worked in Jena, Bayreuth, Nuremberg and Berlin, where he died in 1831. In this article, his main scientific achievements in optics and electricity are briefly described, his life story is summarized and the genealogy of his ancestors is given.

**Key words:** thermoelectricity, photoelasticity, semiconductors, colour photography.

In the history of science, the physicist and chemist Dr. Med. Thomas Johann Seebeck is usually referred to as the discoverer of one of the basic thermoelectric effects, the *Seebeck effect*. Seebeck reported for the first time on his observation that a magnetic compass needle is deflected when the junctions in a closed loop of two dissimilar metals or semiconductors are at different temperatures, at a session of the Berlin Academy of Sciences on December 14, 1820 [1]. Seebeck called the effect *thermomagnetism*. Professor Hans Christian Oersted from Copenhagen, who on April 21, 1820 first observed the magnetic effects of an electric current [2], proposed a clear explanation of the phenomenon discovered. He coined also the term *thermoelectricity*. A single thermoelement or a *thermocouple* can be used as a sensor element in relatively fast-responding and exact thermometers at temperatures from  $-270$  to  $+2500^{\circ}\text{C}$ . More complex devices with a number of thermocouples connected in series are called *thermopiles* or *thermobatteries*. Since the 1960s, various types of thermoelectric generators, containing an array of thermocouples, utilizing heat, released by the decay of a radioactive material, have been exploited in remote spacecrafts, where solar cells are not viable any more.

It is less known that Seebeck discovered the *piezooptic effect* or *photoelasticity* in 1813 [3,4]. Due to this effect, mechanical stress applied on amorphous

transparent materials like glass or plastics makes them birefringent similar to crystals. In such materials, illumination with polarized light creates interference fringes (*entoptische Farbenfiguren*, as called by Seebeck), which are directly related to the stress field in the specimen. Seebeck discovered this effect by investigating tempered glass plates and blocks. Using plastic models one can determine experimentally distributions of mechanical stresses in real machine parts and structures. The method of photoelasticity is also widely used to determine residual stresses in glass articles. Later the English physicist David Brewster rediscovered the same effect. The French Institute recognized achievements of both physicists and decided to divide the physics award for excellent research work, printed within the period from Oct. 1, 1813 to Oct. 1, 1815 in equal parts between Seebeck and Brewster. Seebeck's earlier research in optics are partly documented in Goethe's most comprehensive work on natural sciences *Zur Farbenlehre*, the first edition of which was printed during 1806–1810 [5].

It is remarkable that Seebeck's name is on the top of semiconductor research chronology as well. Namely, at the beginning of the 1820s, Seebeck, performing his famous thermoelectrical experiments, observed that some materials, today known as semiconductors, exhibited much stronger "thermomagnetism" in contact with copper than many of the tested metals. He announced in [1] that Bismuth-like behaviour revealed the following natural minerals: *Bleiglanz* (Galena, PbS), *Schwefelkies* (Pyrite, FeS<sub>2</sub>), *Kupferkies* (Chalcopyrite, CuFeS<sub>2</sub>), *Arsenikkies* (Arsenopyrite, AsFeS), *Kupfernickel* (Nickeline, NiAs), *weisser Speiskobalt* (white Skutterudite, (Co,Ni) As<sub>3-x</sub>). Antimony-like behaviour showed *Kupferglas* (Chalcocite, Cu<sub>2</sub>S), *Buntkupfererz* (Bornite, Cu<sub>5</sub>FeS<sub>4</sub>) and *blättriger Magnetkies* (Pyrrhotite, Fe<sub>1-x</sub>S). It was about ten years before Faraday's observation in 1833 that electrical resistance of silver sulphide Ag<sub>2</sub>S decreases at higher temperatures [6].

And last, but not least, it is noteworthy that Seebeck contributed to the development of photography as well. He was probably the first to record the solar spectrum in natural colours in silver chloride AgCl in 1810, well before the beginning of colour photography. T. J. Seebeck, A. Niepce de Saint-Victor, E. Becquerel and A. Poitevin have been recognized as the forerunners of the interference colour photography [7], giving impact to the invention of holography [8].

Thomas Johann Seebeck was born on April 9, 1770, in the Hanseatic town of Tallinn (then Reval). His father Johann Christoph Seebeck, a wealthy merchant, had also been born in Tallinn in 1729. He became a citizen of Tallinn in January 1769 and married a merchant's daughter Gerdrutha Lohmann. In May 8(19), 1769 he purchased a real estate at the Great Market, today Raekoja plats 4/Dunkri 2. In the house, faced to the market place, the future scientist was born and grew up. Alderman of Great Guild Johann Christoph Seebeck died in 1786, when his children Thomas Johann and two years younger Christoph were still teenagers. Since their mother had died already eleven years ago, the Bar of Conscience appointed father's property under guardianship of merchants Adolf

Ohm and Ernst August Mayer. Brothers were taken in care by their patronal grandmother Anna Gerdrutha Seebeck (née Schrewe) and aunt Catharina Margaretha Wilcke. In 1796 Christoph died and Thomas Johann Seebeck became the legitimate heir of his father's property in Tallinn. Due to unknown circumstances the reception of inheritance was delayed until 1819. Thomas Johann, residing permanently in Germany, sold in December 1827 his legacy at Town Hall square to a Russian merchant Moisei Proklow.

In 1788 Seebeck graduated from the Reval Imperial Grammar School, now Tallinn Gustav Adolf Grammar School, founded in 1631. After graduation he went to Berlin and then to Göttingen University to study medicine. In 1792, Seebeck passed his final examinations in medicine and practical surgery with excellent marks. He settled in Bayreuth and concentrated on physics. His father's inheritance allowed him to live as an independent scholar, not practising medicine.

In 1795 he married Juliane Amalie Ulrike Boye in Bayreuth and their first daughter was born. In March 1802, Seebeck took a medical doctorate degree in Göttingen and in summer the family moved to Jena. Seebeck found himself here in a very stimulating intellectual atmosphere. He was acquainted with the *Jenaer Romantikerkreis*: natural philosophers Schelling and Oken, leaders of pre-romanticism in Jena brothers Schlegel, a "romantic physicist" and co-founder of electrochemistry Ritter, and many other outstanding personalities. At that time, Seebeck's long-lasting friendship with the philosopher Hegel and the writer Goethe began. The latter spent much time studying different natural sciences. Seebeck became Goethe's closest adviser and collaborator in experimental optics and chromatics. Goethe's diary reveals that during the last two years before Seebeck's return to Bayreuth in summer 1810, they had met in Weimar or Jena at least 55 times [<sup>9</sup>], performing together experiments or writing and editing Goethe's book *Zur Farbenlehre*. During Seebeck's Bayreuth and Nuremberg years, his correspondence with Goethe became less frequent and practically stopped, when in 1818 Seebeck was elected corresponding member of the Prussian (Berlin) Academy of Sciences and moved from Nuremberg to Berlin. On January 1, 1819, Seebeck became an academician of the Berlin Academy.

In July 1820, Oersted [<sup>2</sup>] first reported the existence of electromagnetism. Accidentally, using a voltaic battery, he discovered that an electric current could influence an adjacent magnetic compass needle. Seebeck, hearing about that at the beginning of August, decided to give up his studies on optics in favour of electricity and magnetism. By the way, Seebeck's enthusiasm for new scientific discoveries was rather characteristic of him. This time his road to major success was fast. On August 16, 1821, at a session of the Berlin Academy, he made his first report on "*thermomagnetism*" of a galvanic circuit. Next *Vorlesungen* followed on October 18 and 25, 1821, and on February 22, 1822 [<sup>1</sup>].

In 1823 Seebeck felt ill and his work ability was on the decline. Many scientifically important results had to remain recorded in his notes or manuscripts. The best he could do was to give a talk at the Academy. Seebeck died in Berlin on December 10, 1831.

Only a month earlier, on November 14, the Rector of the Berlin university, philosopher Hegel, died as a victim of a cholera epidemic. Next year, on March 22, Goethe died in Weimar.

Seebeck had eight grown-up children – six daughters and two sons. Both sons and two daughters have left their footprints in the German history of culture.

Karl Julius *Moritz* Seebeck, born in Jena on January 8, 1805, was a philologist, scholar of antiquity, and an educationalist. Moritz Seebeck became one of the most famous curators (1851–1877) of the University of Jena [<sup>10</sup>]. He died in 1884.

Ludwig Friedrich Wilhelm *August* Seebeck was also born in Jena on December 27, 1805. He was professor of physics and an academician of the Berlin Academy of Sciences. His main field of research was acoustics. August Seebeck was director of the Technical School (*Technische Bildungsanstalt*) in Dresden, now Dresden University of Technology, for seven years (1842–1849), when, still a young man, he died of smallpox [<sup>11</sup>].

Seebeck's daughter *Adeline* Seebeck (1799–1874) was a translator and writer under pseudonym *Anileda*. Another daughter, *Sidonie* Seebeck-Passow (1801–1886) is known due to recollections from her childhood in Jena, Bayreuth and Nuremberg [<sup>12</sup>].

Finally, let us try to search out the origins of Seebeck's family. Most probably the roots of his male line of ancestors are in Sweden. His first known forefather was Klaus Seebeck, who at the beginning of the 1600s served the Swedish King as a commandant or commander in fort Jamo (Jama/Jam/Jamburg in 1703–1922/now Kingissepp) in Ingermanland, on the eastern borderline of the past Swedish administrative area. Among descendants of Klaus Seebeck were many aldermen of the Great Guild and members of the Town Council in Tallinn. His female line of ancestors also originates from the 16–17th centuries. Gerdrutha Seebeck's ancestors Lohmanns of paternal line and von Glehns of mother line had moved to Estonia from Schleswig-Holstein in the northern part of Germany. Among Seebeck's mother line ancestors were many respectful persons, known from the history of Tallinn. For example, Johann(I) Burchart and his son Johann(II) Burchart, impoverished descendants of an Hungarian nobleman's family, originated in Tallinn a dynasty of chemists, all by name Johann, who were running a famous chemist's shop at Town Hall square during ten generations up to 1891. Seebeck's grandmother of the third generation, Elisabeth von Drenteln (née Buchau), widow of the town councillor Hermann von Drenteln, sold her husband's summer manor in Kadriorg to Peter the Great, Emperor of Russia, who reconstructed the manor house. Later on, tsar Peter built there a beautiful palace and arranged a regular park around it. And, last but not least, Nikolai von Glehn, founder of the settlement Nõmme, close to Tallinn University of Technology, was also a remote relative of Seebeck.

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## APPENDIX

### ANCESTORS OF THOMAS JOHANN SEEBECK

#### Klaus Seebeck

#### Anna von Schmaßen

At the beginning of the 1600's in service of the Swedish King  
as a commandant of the fort Jam/Jamo/Jama in Ingermanland



#### Kristoffer Seebeck

#### Meta Wulff

In service of the Swedish King as a quartermaster with Armfeldt's  
Regiment in Ingermanland(?)



#### Bernhard Kristoffer Seebeck (1663–1697)

#### Anna Oom (Ohm)

\*13.12.1663, Viljandi(?)

\*02.02.1667

†12.03.1697, Viljandi/Fellin

†20.11.1702

Was a merchant in Viljandi, Tallinn/Reval, and Rakvere/Wesenberg  
1693 was a member of the Brotherhood of Blackheads in Tallinn

28.08.1694, St. Olaus'/Oleviste Church in Tallinn

#### Thomas Seebeck (1697–1748)

#### Anna Gerdrutha Schrewe (Schreve)

\*21.01.1697, Viljandi

\*27.03.1707, Tallinn

†07.09.1748, Tallinn/Reval

†25.06.1789, Tallinn

20.02.1720 became a member of the Brotherhood of Blackheads

17.04.1724 became a citizen of Tallinn

19.03.1725 was elected an alderman of the Great Guild in Tallinn

05.12.1742 was elected a member of the Town Council of Tallinn

05.05.1724, Tallinn

**Johann Christoph Seebeck (1729–1786)**

\*1729, Tallinn

†29.10.1786, Tallinn

13.01.1769 became a citizen of Tallinn

08.05.1769 purchased a dwelling house in Tallinn, Town Hall square 4

1782 was an alderman of the Great Guild in Tallinn

☉ 29.01.1769, Tallinn

**Gerdrutha Lohmann**

\*

†04.03.1775, Tallinn

**Christoph Seebeck**

\*17.01.1772, Tallinn, †19.11.1796, Tallinn

**Thomas Johann Seebeck (1770–1831)**

\*29.03.(09.04.)1770, Tallinn

†10.12.1831, Berlin

1788 graduated from Reval Imperial Grammar School in Reval

20.07.1802 received degree of Dr. Med. from the Göttingen University

01.01.1819 elected as a member of the Academy of Sciences in Berlin

1820, autumn discovered “thermomagnetism” (i.e. the Seebeck effect)

☉ 1795, March, Bayreuth

**Juliane Amalie Ulrike Boye**

\*02.1774, Bayreuth(?)

†

**REFERENCES**

1. Seebeck, T. J. Magnetische Polarisation der Metalle und Erze durch Temperatur-Differenz. *Abh. Akad. Wiss. Berlin 1820–21*, 1822, 289–346.
2. Oersted, H. C. *Experimenta circa effectum conflictus electrici in acum magneticam*. Typis Schultzianis, Hafniae, Copenhagen, 1820.
3. Seebeck, T. J. Einige neue Versuche und Beobachtungen über Spiegelung und Brechung des Lichtes. *J. für Chemie Physik*, 1813, **7**, 259–298, 382–384.
4. Seebeck, T. J. Von den entoptischen Farbenfiguren und Bedingungen ihrer Bildung in Gläsern. *J. für Chemie Physik*, 1814, **12**, 1–17.
5. Goethe, J. W. *Zur Farbenlehre*. Cotta, Tübingen, 1810.
6. Faraday, M. On a new law of electric conduction. On conducting power generally. *Philos. Trans. Royal Soc.*, 1833, **123**, 507–522.
7. Lippmann, G. Colour photography, Nobel lecture, December 14, 1908. In *Nobel Lectures, Physics 1901–1921*. Elsevier, Amsterdam, 1967.
8. Gabor, D. Holography, 1948–1971, Nobel lecture, December 11, 1971. In *Nobel Lectures, Physics 1971–1980* (Lundqvist, S., ed.). World Scientific, Singapore, 1992.
9. Nielsen, K. Another kind of light: The work of T. J. Seebeck and his collaboration with Goethe. *Historical Studies in the Physical and Biological Sciences*, 1989, **20:1**, 107–178, (Part 1); 1991, **21:2**, 317–397, (Part 2).
10. Gerber, S. *Universitätsverwaltung und Wissenschaftsorganisation im 19. Jahrhundert. Der Jenaer Pädagoge und Universitätskurator Moritz Seebeck*. Verlag Böhlau, Köln, 2004.
11. Voss, W. August Seebeck – der erste Physikprofessor der Technischen Bildungsanstalt. *Universitäts Journal*, 2001, **11**, No. 8, 8.
12. Passow, S. Erinnerungen an den Kinderjahren. *Jahrbuch der Jean-Paul Gesellschaft*, 1976, 136–154.

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Tuntud eesti-saksa füüsik, keemik ja arst Thomas Johann Seebeck sündis Tallinnas (tollal Reval) 1770. a. Ta õppis Tallinnas, Berliinis ja Göttingenis ning seejärel elas ja töötas Jenas, Bayreuthis, Nürnbergis ning Berliinis, kus ta suri 1831. a. Artiklis on antud lühiülevaade tema elukäigust ja olulisematest teaduslikest saavutustest optika- ning elektrinähtuste vallas. Artiklis on toodud fakte Seebecki suguvõsa kohta ja lisatud on ka tema kõukude tabel.