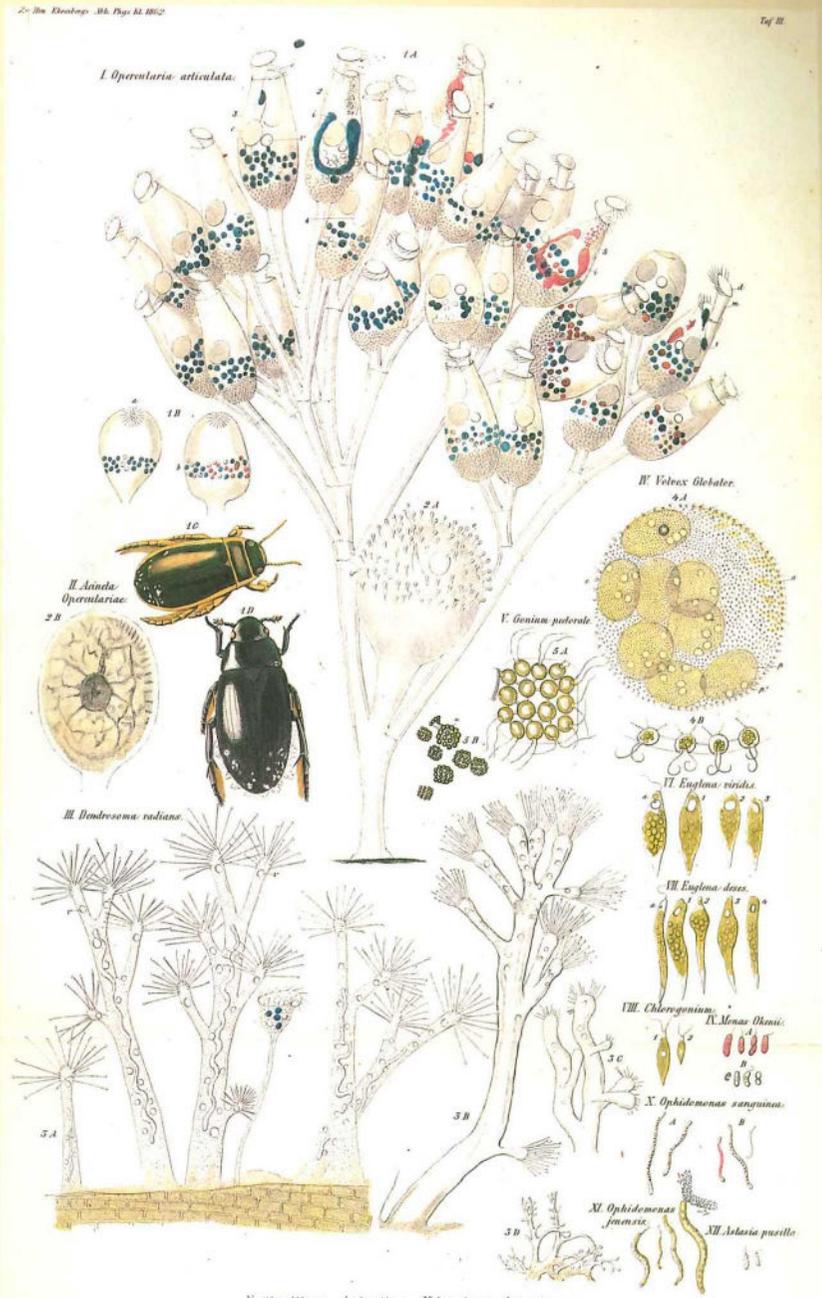


175 YEARS OF PROTOZOOLOGY IN GERMANY

Front cover from: C. G. EHRENBURG: Über die seit 27 Jahren noch wohl erhaltenen Organisations-Präparate des mikroskopischen Lebens. Abhandlungen der Königl. Akademie der Wissenschaften, 41-74, 1862, Berlin. Tafel III: Vorticellinen, Acinetinen, Volvocinen, Astasiaeen und Monadinen



Vorticellinen, Acinetinen, Volvocinen, Astasiaeen.



IX INTERNATIONAL CONGRESS OF PROTOZOOLOGY



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PREFACE

The *IX International Congress of Protozoology* held in Berlin offers an opportunity to give an insight into the development of protozoology in Germany, where Berlin was a centre of research in this field.

The concept of the exhibition comprising the period from the birth of this science up to the year 1950 is focussed on three aspects:

- the role of the outstanding scientists in this field
- the concepts that were important for the understanding of unicellular organisms
- the establishment of protozoology in Germany as a special discipline of zoology



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THE BEGINNINGS: ANIMALCULA

ANTONI VAN LEEUWENHOEK (1632-1723)

Because of their size protozoa remained hidden to the human eye for a long time. Only the invention of the microscope at the end of the 16th century cleared the path for them to be discovered and investigated. Though its inventor was not a German, his contribution as the actual founder of this field of science should not be overlooked in this exhibition.

It was ANTONI VAN LEEUWENHOEK, a merchant from Delft, who in 1674 was the first to observe small animals in water drops from an inland lake which he called "dierkens, beesjes", in Latin "animalcula". Inspired by HOOKE's writings ("Micrographia", 1665) VAN LEEUWENHOEK, who was not a learned man, took up the polishing of lenses and the production of simple microscopes in his spare-time.

His microscopes reaching a magnification up to 270x consisted of a single magnifying lens and a needle for suspending the specimen. VAN LEEUWENHOEK painstakingly described and sometimes drew his objects and put his observations into letters that he sent to the Royal Society in London. 200 of his letters have been preserved. In 1680 he was elected Fellow of the Royal Society.

VAN LEEUWENHOEK reported on numerous free-living protists such as *Vorticella*, *Stylonychia*, *Carchesium*, *Volvox*, *Coleps*. He was also the first to detect the oocyst of the coccidium *Eimeria stiedai* in the bile duct of rabbits.

With his discoveries VAN LEEUWENHOEK was the first to scientifically observe and investigate the protozoa. In the following period the number of naturalists devoted to the study of "animalcula" increased.

PROTOZOA: NAME - DESCRIPTION - CLASSIFICATION

GEORG AUGUST GOLDFUSS (1782-1848)

The first period of research in protozoology was characterized by simply recording observations. Later on, in the 18th century efforts were made to classify the "animalcula" or "infusoria", as they were also called at this time.

At the beginning of the 19th century the mineralogist and palaeontologist GEORG AUGUST GOLDFUSS coined the term "protozoa" (1817/1818). In his essay "Über die Entwicklungsstufen des Thieres" published in 1817 and reflecting the thoughts of German "Naturphilosophie" this term appears for the first time.

The animal kingdom is represented in the shape of an egg enclosing a scale leading from the most primitive to the most highly developed animal. The protozoa are placed at the base of the scale. Like many naturalists of his time GOLDFUSS considered the protozoa to be analogous to the germs emerging from the "Urschleim" and the semen of the animals. In 1818 he included the protozoa into the system of the zoophyta as the first class and named them "Urthiere", Protozoa.

GOLDFUSS studied medicine and natural history at the Universities of Berlin and Erlangen. He became a private tutor and, later on, a lecturer in Erlangen in 1810. In 1818 he was appointed to a professorship of zoology and mineralogy at the University of Bonn.

FRIEDRICH RITTER VON STEIN (1818-1885)

In the course of the 17th and the 18th century the number of microscopically studied infusoria (a term introduced in 1764 by WRISBERG and replacing the word "animalcula") had increased considerably. Naturalists attempted to integrate the small organisms in the zoological nomenclature.

In the German speaking countries FRIEDRICH RITTER VON STEIN contributed much to the description and classification of the ciliates by his monograph "Der Organismus der Infusionsthier" (1859-1883, three volumes). On the basis of the structural diversification and the distribution of the external ciliary organelles, he classified the ciliates into four major groups: Holotricha, Heterotricha, Hypotricha, and Peritricha.

VON STEIN was the author of the so-called acineta theory, a short-lived conception erroneously assuming suctorians to be the larval stages of vorticellid peritrichs.

VON STEIN studied medicine in Berlin, for the most part with JOHANNES MÜLLER. In 1845 he qualified as university lecturer. In 1850 he became a professor at the academy of forestry in Tharandt near Dresden, and in 1855 he joined the German University in Prague as a professor.

CHRISTIAN GOTTFRIED EHRENBERG (1795-1876)

EHRENBERG was a microscopist and micropalaeontologist of high reputation. Observations on protists made during feeding experiments had led him to adopt the view that the organization of these microorganisms was analogous to that of higher animals. He ascribed to the infusoria a digestive tract, a vascular system, salivary glands, testes, seminal vesicles, and ovaries.

This interpretation, however, provoked some opposition. In contrast to EHRENBERG the French scientist DUJARDIN (1801-1860) perceived the simple structure of the protists and called their ground substance "sarcode", thereby clearing the road for a protoplasma concept of the cell.

All his life EHRENBERG stuck to his ideas. His sumptuous monograph "Die Infusionsthierchen als vollkommene Organismen" (1838) in which he described numerous species unknown until then aroused a great interest in unicellular organisms. The contradiction between his interpretations and the findings of cytologists stimulated intensive microscopical investigations and caused a disparity of views which divided the specialists into two groups. The complex structure of the ciliates in particular apparently contradicted the sarcode theory.

EHRENBERG was born in Delitzsch near Leipzig in 1795. He studied theology and medicine in Leipzig and Berlin. In 1827 he became assistant professor, in 1839 full professor of the theory and history of medicine at the University of Berlin.

THE WAY TO MODERN PROTOZOOLOGY

THEODOR VON SIEBOLD (1804-1885)

On the basis of the cell theory formulated by SCHWANN and SCHLEIDEN in 1838/39 THEODOR VON SIEBOLD, who had studied with HAECKEL, elaborated a scientific definition of the protozoa in his textbook on comparative anatomy of invertebrate animals (1848).

He defined them as unicellular animals thus separating them clearly from the metazoa. Although it was not immediately accepted, this definition eventually established a close relationship between cytology and protozoology. Now studies on protists also aimed at gaining information on the cell in general.

VON SIEBOLD studied medicine in Berlin and Göttingen. He became a professor of zoology, comparative anatomy and veterinary medicine in Erlangen in 1840. He was appointed professor in Freiburg in 1845, professor of physiology in Breslau in 1850, and professor of physiology, comparative anatomy, and zoology in Munich in 1853.

ERNST HAECKEL (1834-1919)

Influenced by his teacher JOHANNES MÜLLER, ERNST HAECKEL was devoted to the study of marine protozoa. The radiolarians fascinated him in particular. He wrote an impressively illustrated monograph (1862, 1867, 1888) describing thousands of radiolarians.

Convinced by DARWIN's thoughts HAECKEL tried to support the theory of evolution in his systematics of the radiolaria. According to HAECKEL organisms which could be traced back to one ancestral form should be referred to as a phylum. He objected to previous schemes of classification dividing the unicellular organisms into plant and animal protists. Consequently, additionally to the kingdoms metazoa and metaphyta he established a further kingdom named "protista" comprising all unicellular organisms which could not clearly be placed into the plant or animal kingdom. Immediately after publication HAECKEL's three-fold scheme met disagreement. The theory of one single protist kingdom was not adopted until the 1950s.

ERNST HAECKEL was born in Potsdam in 1834. He studied medicine in Würzburg, Vienna and Berlin. He became a lecturer in zoology at Jena in 1861, associate professor in 1862, and full professor of zoology in 1865 at the first professorial chair of zoology in Germany.

JOHANNES MÜLLER (1801-1859)

During the last ten years of his life the outstanding physiologist and comparative anatomist JOHANNES MÜLLER was concerned with studies of the marine fauna. In the years 1849-1853 he regularly travelled to the French Riviera where he studied radiolarians and foraminiferans. His last book was a monograph on *Thalassicolla* of the Mediterranean (1858) which he placed correctly to the rhizopods. The establishment of the taxon Radiolaria is also his achievement.

MÜLLER paved the way for modern physiology in medicine and biology. His protistological studies, however, were mainly devoted to the morphology and development of unicellular organisms.

JOHANNES MÜLLER was born in Koblenz in 1801. He studied medicine in Berlin and Bonn, where he taught from 1824 until 1833 when he accepted the professorial chair of physiology at the University of Berlin.

MAX SCHULTZE (1825-1874)

The modern definition of the cell traces back to MAX SCHULTZE, professor of anatomy at the university of Bonn since 1859 who is reputed to be the founder of the protoplasma theory of the cell. His investigations on living protoplasma were made on monothalamian and polythalamian Foraminifera for the most part. SCHULTZE confirmed DUJARDIN's sarcode theory and proved the identity of sarcode and protoplasma. His results diametrically opposed EHRENBERG's understanding of infusorian organization, which was the prevailing concept at that time.

MAX SCHULTZE was born in Freiburg in 1825. He was educated at the universities of Greifswald and Berlin. After his studies he worked at the department of anatomy of the university of Greifswald, later on as an assistant professor of anatomy at the university of Halle and as a professor of anatomy at Bonn university from 1858.

FOUNDERS OF MODERN PROTOZOOLOGY

OTTO BÜTSCHLI (1848-1920)

OTTO BÜTSCHLI cleared the path to modern protozoology. His extensive monograph on the division, fertilization and conjugation of the infusoria (1876) makes him a founder of modern protozoology and cytology.

His most significant work is the compendium on the protozoa (three volumes) in "BRONN's Klassen und Ordnungen des Thier-Reichs" (1880-1889). It can be considered as the first protozoological textbook. In it he summarized all that was known at his time about protozoa as well as the history of the observation of protozoa. Moreover, based on the unicellular model he manifested a general classification of all groups of protozoa which was recognized until the middle of the 20th century.

Thus a comprehensive taxonomic framework for the classification of numerous newly discovered species including the parasitic protozoa, whose classification had until then caused difficulties, was established. BÜTSCHLI's work had a tremendous influence on the following generations of protozoologists.

OTTO BÜTSCHLI was born in Frankfurt/Main in 1848. He studied mineralogy, chemistry, and palaeontology in Karlsruhe, zoology in Heidelberg and became an assistant and assistant professor in Leipzig, Kiel and Karlsruhe. In 1878 he was appointed professor of zoology and palaeontology in Heidelberg.

RICHARD HERTWIG (1850-1937)

All his life HERTWIG was fascinated by protists, especially by radiolarians, ciliates, and the heliozoon *Actinosphaerium* whose life cycle he elucidated.

HERTWIG went beyond the domain of morphology which had dominated protozoology until the end of the 19th century by systematically choosing protists as objects for cytological research. He considered experiments with protists to be an adequate approach to investigate basic cytological principles.

By HERTWIG's influence, protozoology and cytology became even more closely associated with one another. At the university of Munich he created a department of protozoology. Numerous outstanding future protozoologists as FRANZ DOFLEIN, RICHARD GOLDSCHMIDT, VIKTOR JOLLOS, STANISLAUS VON PROWAZEK, EDUARD REICHENOW, MAX HARTMANN came here to take their doctorates or to work with him.

The works of BÜTSCHLI along with HERTWIG's school of protozoology furnished the basis for the establishment of protozoology as a distinct field of research at the beginning of the 20th century.

RICHARD HERTWIG was born in Friedberg (Hessen) in 1850. Trained at the universities of Jena (with ERNST HAECKEL), Zürich, and Bonn he became a lecturer in Jena in 1875, professor of zoology at Königsberg/East Prussia in 1881, professor at Bonn in 1883, and was appointed to the professorial chair of zoology at the University of Munich.

FRITZ RICHARD SCHAUDINN (1877-1906)

Through his investigations of the coccidia SCHAUDINN provided the basis for research on parasitic protozoa causing infectious diseases. The discovery of the heterogenesis in Foraminifera (1903), the elucidation of the complete life cycle of the coccidium *Monocystis* effected in collaboration with MICHAEL SIEDLECKI (1897) as well as a publication on the rhizopod *Trichosphaerium sieboldi* (1899) and on *Coccidium schubergi* (1900) range among his most important achievements. His studies on the coccidia provided clues that aided in the comprehension of the pathogenic agent of malaria. SCHAUDINN was also the first to differentiate between *Entamoeba histolytica*, the cause of amoebic dysentery, and its harmless counterpart *Entamoeba coli*.

In 1902 he founded the first professional journal of protozoology in the world, the "Archiv für Protistenkunde", in order to create a forum open to the different fields of protistological research.

SCHAUDINN was born in Röseningken (East Prussia) in 1871. He studied philology and natural sciences in Berlin. In 1898 he qualified as assistant professor at the university of Berlin. In 1901 the Imperial Health Service, Berlin, appointed him director of the protozoology laboratory of the Zoological Station in Rovigno (Jugoslavia). He returned to Berlin in 1905. In 1906 he took charge of the newly established department of protozoology at the Bernhard-Nocht-Institute of Tropical Diseases in Hamburg.

FRANZ EILHARD SCHULZE (1840-1917)

FRANZ EILHARD SCHULZE, a student of MAX SCHULTZE, was an all-round zoologist. He carried out several studies on rhizopods contrived as an evaluation of the North Sea expedition of the "Pommerania". His illustration of a dividing amoeba became familiar to most zoologists/protozoologists since it was published in numerous textbooks.

Although protozoology was not his primary interest, it was he who led SCHAUDINN, who was then one of his students, to become interested in protists.

FRANZ EILHARD SCHULZE, born in Eldena near Greifswald in 1840, studied medicine in Rostock and Bonn. He became professor of comparative anatomy in Rostock and Graz until he was appointed head of the newly established Department of Zoology of the University of Berlin in 1884.

ALFRED KAHL (1877-1946)

ALFRED KAHL was not a trained protozoologist. Teaching at an elementary school in Hamburg he took on microscopical studies in his spare-time. His daughter's studies - she had participated in a protozoology class at the Bernhard-Nocht-Institute, Hamburg - woke his interest in unicellular organisms, in particular in the ciliates.

KAHL described, drew, and catalogued thousands of species. His taxonomic keys are of lasting value. The Kahlian scheme of classification which was based essentially on BÜTSCHLI and STEIN remained the dominant scheme of ciliate nomenclature for the years 1930-1950. KAHL's best known work is contained in Dahl, F. (ed.): Die Tierwelt Deutschlands, 1930-1935.

MAX HARTMANN (1876-1962)

The period of National Socialism and World War II caused a loss of outstanding scientists who were forced to emigrate for religious or political reasons. Reconstruction of protozoology started in the 1950s and lasted until the 1970s.

Protozoological research was resumed at the Max-Planck-Institute of Biology in Tübingen where MAX HARTMANN headed the Department of Protozoology. It was he who played a major part in the revival of protozoology. He was keenly interested in the significance of sexuality in protozoa and elaborated the theory of relative sexuality. His physiological studies inspired new scientific approaches reaching into the emerging field of biochemistry.

HARTMANN was born in Lauterecken (Rhenish Palatinate) in 1876. He studied biology at the school of forestry at Aschaffenburg, and zoology with HERTWIG in Munich. In 1903 he qualified as university lecturer at Gießen. From 1905 he worked at the Institute of Infectious Diseases in Berlin, where he became head of the Department of Protozoology in 1911. In 1914 he was appointed chief of the Protozoology Department at the Kaiser-Wilhelm-Institute in Berlin-Dahlem. In 1921 he was appointed professor of zoology and general biology at the University of Berlin. After the war HARTMANN was appointed titular professor at the University of Tübingen.

PROTOZOOLOGY - A SPECIALIST DISCIPLINE

Along with the establishment of the German colonies, a vivid interest in pathogenic protozoa of man and animals came up. This political background initiated the development of medical protozoology and caused the foundation of several protozoological research institutions:

- The Laboratory of Protozoological Research at the Imperial Health Service in Berlin (senior scientists: SCHAUDINN, REICHENOW) in 1904
- The Department of Protozoology at the Bernhard-Nocht-Institute of Tropical Diseases in Hamburg (first director: SCHAUDINN) in 1906
- The Department of Protozoology at the Kaiser-Wilhelm-Institute of Biology in Berlin-Dahlem (head of department: HARTMANN) in 1914.

Protozoological research was also done at the Prussian Institute of Infectious Diseases, Berlin. Berlin and Hamburg became the centres of protistological research in Germany.

DIVERSIFICATION OF PROTOZOOLOGY

Since the beginning of the 20th century protozoology has diversified into several subdisciplines.

In the field of medical protozoology (human and veterinary medicine) such famous protozoologists as SCHAUDINN, DOFLEIN, VON PROWAZEK, NÖLLER, and REICHENOW worked on problems of parasitological life cycle, transmission, and propagation along with prophylaxis and chemotherapy against parasitic protozoa.

Investigations on free-living as well as on parasitic protozoa soon exceeded the fields of morphology and taxonomy. New domains of research opened: protistan cytology, genetics and sexuality, physiology, and ecology.

BOOKS

The publishing of special textbooks points to the rise of protozoology as a distinct scientific discipline. The first general textbook of protozoology was written by OTTO BÜTSCHLI (1880-1889). Later on, FRANZ DOFLEIN published "Die Protozoen als Parasiten und Krankheitserreger nach biologischen Gesichtspunkten dargestellt" in 1901. This book turned out to be one of the most successful protozoological textbooks and was reprinted several times, with EDUARD REICHENOW being DOFLEIN's co-author.

The first practical handbook of protozoology, "Praktikum der Protozoologie" by MAX HARTMANN, appeared in 1907. It became widely distributed and was reissued several times, the 5th edition from 1928 being the most popular one. Additionally to general textbooks, several monographies were published.

CHEMOTHERAPEUTICS

The German chemical industry contributed to the development of therapeutics against malaria, sleeping-sickness and amoebic dysentery. The first effective drug against sleeping sickness was developed in the laboratories of the Farbwerke Elberfeld (BAYER). It was sold as "Germanin[®]" beginning in 1923.

The antimalarial drug "Atebrin[®]" was produced since 1932; chloroquine was synthesized in 1934, and was introduced in the pharmaceutical market by the name of "Resochin[®]" in 1950.

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