WARBURG, OTTO HEINRICH (b. Freiburg im Breisgau, Germany, 8 October 1883; d. Berlin, Germany, 1 August 1970), *cell physiology, organic chemistry, oncology.*

Warburg, son of the physicist Emil Gabriel Warburg, studied physics and chemistry at the Albert-Ludwigs-University of his hometown (1900–02). In 1903 he continued his studies under Emil Hermann Fischer at the Friedrich-Wilhelms-University of Berlin, where he received his PhD with a thesis *Über Derivate des Glycocolls, Alanins und Leucins. Über l-Brom-propionsäure und das l-Alanylglycin* (1906). He decided to continue with medical studies at the Ludwig-Maximilians University in Munich and the Ruprecht-Karls-University of Heidelberg (1907–11). In 1908, under the influence of Jacques Loeb, he turned toward the analysis of biological oxidation processes. Warburg not only pursued experimental studies similar to Loeb's on the physiology of developmental processes, but also quantitative analyses of biochemical reactions, as described in 'Beobachtungen über die Oxydationsprozesse im Seeigelei' (1908). Warburg graduated MD from Heidelberg University in 1911 with a thesis *Über die Oxydation in lebenden Zellen nach Versuchen am Seeigelei.* The eggs of the sea urchin remained Warburg's central experimental model until 1914, because he saw that the formative processes underlay rapid changes, ideal for the study of oxidative processes in embryonic tissue.

Warburg conducted most of his experimental investigations at the Zoological Station of Naples, where he used to stay for many months during his university studies. Additional residences in the laboratories of Joseph Barcroft in Cambridge and Paul Ehrlich in Frankfurt am Main followed. In 1912 Warburg received his 'venia legendi' for physiology from the University of Heidelberg and volunteered as a

cavalry officer at the beginning of World War I. After two years he was recalled from the battlefields to take on the directorship of the division for physiology at the Kaiser-Wilhelm-Institute for Biology. In selecting his staff, Warburg laid strong emphasis on precision engineers who provided him with specific technology for his experimental system. As a consequence of his achievements, Warburg was made a permanent member of the Kaiser-Wilhelm-Institute in 1921. Hans Krebs, who was Warburg's most prominent pupil, and many other scientists held his laboratory in high esteem, because its novices were trained in a wide variety of methods, ranging from chemical physiology and tissue culture to analytical chemistry.

Warburg's work was significantly funded by the Rockefeller Foundation, which perceived his research on tumor metabolism as exceedingly forward-looking. In 1923 he received a fellowship of the Rockefeller Foundation as 'an exceptionally promising scientist'. According to his own recollection, it was through the invitation of Johns Hopkins University in Baltimore, where he delivered the Herder Lecture under the title *Das Enzym-Problem und die biologische Oxydation* (1929), that officials of the Rockefeller Foundation remained aware of his research. Only with external funding was he able to direct his laboratory through the economic crisis of the Weimar Republic. Eventually, in 1930, Warburg founded the new Kaiser-Wilhelm-Institute for cell physiology, which provided access to made-to-measure experimental equipment of the highest standards. His discovery of the nature of respiratory fermentation was awarded with the Nobel Prize for Physiology or Medicine (1931).

During the Nazi regime, Warburg had been expelled as institute director because the Ministry of Education was told about his Jewish family origins. However, in 1942 he was reinstated as director for cancer research in what was now called a defense institute ('Wehrinstitut'), directly related to the High Command of the German Army. After World War II, Warburg worked in the United States before returning to his home country, where he was engaged with the reshaping of the former institute. It was reunited with the Max-Planck-Society in 1953. Until his death, Warburg continued to publish on the biochemical paradigm of cellular metabolism and tumor growth.

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Frank W. Stahnisch