

# Otto Warburg

The Nobel Prize in Physiology or Medicine 1931

## Biography

**Otto Heinrich Warburg** was born on October 8, 1883, in Freiburg, Baden. His father, the physicist Emil Warburg, was President of the Physikalische Reichsanstalt, Wirklicher Geheimer Oberregierungsrat. Otto studied chemistry under the great [Emil Fischer](#), and gained the degree, Doctor of Chemistry (Berlin), in 1906. He then studied under von Krehl and obtained the degree, Doctor of Medicine (Heidelberg), in 1911. He served in the Prussian Horse Guards during World War I. In 1918 he was appointed Professor at the Kaiser Wilhelm Institute for Biology, Berlin-Dahlem. Since 1931 he is Director of the Kaiser Wilhelm Institute for Cell Physiology, there, a donation of the Rockefeller Foundation to the Kaiser Wilhelm Gesellschaft, founded the previous year.

Warburg's early researches with Fischer were in the polypeptide field. At Heidelberg he worked on the process of oxidation. His special interest in the investigation of vital processes by physical and chemical methods led to attempts to relate these processes to phenomena of the inorganic world. His methods involved detailed studies on the assimilation of carbon dioxide in plants, the metabolism of tumors, and the chemical constituent of the oxygen transferring respiratory ferment. Warburg was never a teacher, and he has always been grateful for his opportunities to devote his whole time to scientific research. His later researches at the Kaiser Wilhelm Institute have led to the discovery that the flavins and the nicotinamide were the active groups of the hydrogen-transferring enzymes. This, together with the iron-oxygenase discovered earlier, has given a complete account of the oxidations and reductions in the living world. **For his discovery of the nature and mode of action of the respiratory enzyme, the Nobel Prize has been awarded to him in 1931. This discovery has opened up new ways in the fields of cellular metabolism and cellular respiration. He has shown, among other things, that cancerous cells can live and develop, even in the absence of oxygen.**

In addition to many publications of a minor nature, Warburg is the author of *Stoffwechsel der Tumoren* (1926), *Katalytische Wirkungen der lebendigen Substanz* (1928), *Schwermetalle als Wirkungsgruppen von Fermenten* (1946), *Wasserstoffübertragende Fermente* (1948), *Mechanism of Photosynthesis* (1951), *Entstehung der Krebszellen* (1955), and *Weiterentwicklung der zellphysiologischen Methoden* (1962). In the last years he added to the problems of his Institute: chemotherapeutics of cancer, and the mechanism of X-ray's action. In photosynthesis he discovered with Dean Burk the I-quantum reaction that splits the CO<sub>2</sub>, activated by the respiration.

Otto Warburg is a Foreign Member of the Royal Society, London (1934) and a member of the Academies of Berlin, Halle, Copenhagen, Rome, and India. He has gained l'Ordre pour le Mérite, the Great Cross, and the Star and Shoulder Ribbon of the Bundesrepublik. In 1965 he was made doctor honoris causa at Oxford University.

He is unmarried and has always been interested in equine sport as a pastime.

From [Nobel Lectures](#), Physiology or Medicine 1922-1941, Elsevier Publishing Company, Amsterdam, 1965

# The Prime Cause and Prevention of Disease

**Dr. Otto Warburg's Address to Nobel Laureates,  
June 30, 1966 at Lindau, Lake Constance, Germany**

**O. Warburg won the Nobel Prize in Medicine in 1931 for his  
discovery  
of the oxygen transferring enzyme of cell respiration**

## **Editor's Note:**

What follows below is even more interesting when tied in to what Dr. Hidemitsu Hayashi, M.D. Director, Water Institute of Japan, has stated: "When taken internally, the effects of reduced ionic mineralized water are immediate. Ionized Water inhibits excessive fermentation in the digestive tract by reducing indirectly metabolites such as hydrogen sulfide, ammonia, histamines, indoles, phenols and scatoles, resulting in a cleaner stool within days after reduced ionic mineralized water is taken on a regular basis." In 1965, just before Dr. Otto made the following speech the Ministry of Welfare of Japan announced that reduced water obtained from electrolysis or ionic mineralization can prevent abnormal fermentation of intestinal microbes.

## **Cause and Prevention of Disease**

"There are prime and secondary causes of diseases. For example, the prime cause of the plague is the plague bacillus, but secondary causes of the plague are filth, rats, and the fleas that transfer the plague bacillus from rats to man. By the prime cause of a disease, I mean one that is found in every case of the disease.

Cancer, above all other diseases, has countless secondary causes. Almost anything can cause cancer. But, even for cancer, there is only one prime cause. **The prime cause of cancer is the replacement of the respiration of oxygen ... in normal body cells by fermentation of sugar.**

All normal body cells meet their energy needs by respiration of oxygen, whereas cancer cells meet their energy needs in great part by fermentation. All normal body cells are thus obligate aerobes, whereas all cancer cells are partial anaerobes. From the standpoint of the physics and chemistry of life this difference between normal and cancer cells is so great that one can scarcely picture a greater difference. Oxygen gas, the donor of energy in plants and animals, is dethroned in the cancer cells and replaced by the energy yielding reaction of the lowest living forms, namely the fermentation of sugar.

**In every case**, during the cancer development, the oxygen respiration always falls,

fermentation appears, and the highly differentiated cells are transformed into fermenting anaerobes, which have lost all their body functions and retain only the now useless property of growth and replication. Thus, when respiration disappears, **life does not disappear, but the meaning of life disappears, and what remains are growing machines that destroy the body in which they grow.**

... To prevent cancer it is therefore proposed first to keep the speed of the blood stream so high that the venous blood still contains sufficient oxygen; second, to keep high the concentration of hemoglobin in the blood; third, to add always to the food, even of healthy people, the active groups of the respiratory enzymes; and to increase the doses of these groups, if a precancerous state has already developed. If at the same time exogenous carcinogens are excluded rigorously, then much of the endogenous cancer may be prevented today.

**These proposals are in no way utopian. On the contrary, they may be realized by everybody, everywhere, at any hour. Unlike the prevention of many other diseases, the prevention of cancer requires no government help, and not much money.**

Many experts agree that one could prevent about 80% of all cancers in man, if one could keep away the known carcinogens from the normal body cells. But how can the remaining 20%, the so-called spontaneous cancers, be prevented? **It is indisputable that all cancer could be prevented if the respiration of body cells were kept intact.**

**Nobody today can say that one does not know what the prime cause of cancer is. On the contrary, there is no disease whose prime cause is better known, so that today ignorance is no longer an excuse for avoiding measures for prevention. That the prevention of cancer will come there is no doubt. But how long prevention will be avoided depends on how long the prophets of agnosticism will succeed in inhibiting the application of scientific knowledge in the cancer field. In the meantime, millions of men and women must die of cancer unnecessarily.**

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Excerpts from Follow-Up Lecture by Otto Warburg, Director, Max Planck-Institute for Cell Physiology, Berlin-Dahlem  
English Edition by Dean Burk, National Cancer Institute, Bethesda, Maryland, USA

If a lowered oxygen pressure during cell growth may cause cancer, or, more generally, if any inhibition of respiration during growth may cause cancer, then a next problem is to show why reduced respiration induces cancer. Since we already know that with a lowering of respiration fermentation results, we can re-express our question: Why does cancer result if oxygen-respiration is replaced by fermentation?

The reverse process, the dedifferentiation of life, takes place today in greatest amount before our eyes in cancer development, which is another expression for dedifferentiation. To be sure, cancer development takes place even in the presence of free oxygen gas in the atmosphere, but this oxygen may not penetrate in sufficient quantity into the growing body cells, or the respiratory apo-enzymes of the growing body cells may not be saturated with the active groups. In any case,

**during the cancer development the oxygen - respiration always falls, fermentation appears, and the highly differentiated cells are transformed to fermenting anaerobes, which have lost all their body functions and retain only the now useless property of growth. Thus, when respiration disappears, life does not disappear, but the meaning of life disappears, and what remains are growing machines that destroy the body in which they grow.**

But why oxygen differentiates and why lack of oxygen dedifferentiates? Nobody would dispute that the development of plants and animals and man from unicellular anaerobes is the most improbable process of all processes in the world... But according to the thermodynamics of Boltzmann, improbable processes require work to take place. It requires work to produce temperature differences in a uniformly temperatured gas; whereas the equalization of such temperature differences is a spontaneous process that does not require work. It is the oxygen - respiration that provides in life this work, and dedifferentiation begins at once when respiration is inhibited in any way. In the language of thermodynamics, differentiation represents a forced steady state, whereas dedifferentiation - that is, cancer - is the true equilibrium state. Or, illustrated by a picture: the differentiated body cell is like a ball on an inclined plane, which, would roll down except for the work of oxygen-respiration always preventing this. If oxygen respiration is inhibited, the ball rolls down the plane to the level of dedifferentiation.

### **In Summary:**

- Impairment of respiration is more frequent than impairment of fermentation because respiration is more complicated than fermentation.
- The impaired respiration can be easily replaced by fermentation, because both processes have a common catalyst, the nicotinamide.
- The consequence of the replacement of respiration by fermentation is mostly glycolysis, with death of the cells by lack of energy. Only if the energy of fermentation is equivalent to the lost energy of respiration, is the consequence anaerobiosis. Glycolysis means death by fermentation, anaerobiosis means life by fermentation.
- Cancer arises, because respiration, but not fermentation, can maintain and create the high differentiation of body cells.

The physicist MANFRED VON ARDENNE ... recently discovered that **cancer cells owing to their fermentation, are more acid - inside and on their surface - than normal cells ...**