Otto Warburg (1883-1970)[1] obtained his doctorate of chemistry in 1906 which was followed by a medical degree in 1911. He was awarded the Nobel Prize for medicine and physiology in 1931. Much of his work involved photosynthesis, metabolism of cancer cells and the chemistry of enzymes involved in energy transfer within cells. An extensive biography was written by Hans Kreb, a colleague who was a co-discoverer of the Krebs cycle.[2]

In 1966, Warburg delivered a lecture to Nobel Laureates at Lake Constance, Germany where he stated:[3]

> The prime cause of cancer is the replacement of the respiration of oxygen (oxidation of sugar) 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.

During exercise, glucose is converted to lactic acid when limited amounts of oxygen is available.

Warburg observed tumour cells convert glucose to lactate even when oxygen is present. Warburg termed this aerobic glycolysis and has become known as the Warburg effect.[4] One molecule of glucose normally produces 32 molecules of ATP where as glycolysis only produces 2 ATP molecules.[5] This is a large depletion in the amount of energy available to cells.

ATP (Adenosine triphosphate) is found in all cells and delivers energy required for cellular processes. ATP powers all reactions within cells so it is a vital component of life.

Thomas Seyfried, professor of biology at Boston College, has cited the Warburg effect as underpinning his research into ketogenic diets in treating cancer. Similar,popular commentators such as Joseph Mercola and Ty Bollinger, have cited the Warburg effect in their justification of ketogenic diets.

Whilst the conversion of glucose to ATP is a target for cancer research because glucose restriction (as in ketogenic diets) induces apoptosis (cell death) in rodent cancer cells, it also kills normal human cells. However, depletion of glutamine, another major nutrient consumed by cancer cells, induced apoptosis in the cancerous cells but not normal, healthy cells.[6] Glutamine is a non-essential amino acid meaning that it can be produced by our bodies. High glutamine foods include cheese; fish; soy; nuts; beef and chicken.[7] Glutamine is more common in animal-based foods.

Also note that calorie-restricted and ketogenic diets are not the same. Ketogenic diets are carbohydrate-restricted diets where fat becomes the primary source of energy instead of glucose. The end products of a ketogenic diet are three ketone compounds which includes acetone – nail polish remover. A calorie-restricted diet restricts the amount of energy that is consumed which is difficult to maintain. A diet may be both ketogenic and calorie-restricted.

The book *The China Study*[8] presents evidence that whole-food, plant-based diets reduce the risk of cancers.

A number of posts listed below evaluate the value of ketogenic diets.

Related articles

The Keto diet slays the opposition? – not true
The Evidence Against Eric Westman and William Yancy
CSIRO Low-Carb Diet

Footnotes

1. Image from Elsevier Publishing Company (2019) *Otto Warburg – Biographical. NobelPrize.org*. [online]. Available from: https://www.nobelprize.org/prizes/medicine/1931/warburg/biographical/ (Accessed 18 January 2019).
2. Kebs, H. A. (1972) *Otto Heinrich Warburg, 1883-1970*. 71.
3. Warburg, O. (1966) *Prime Cause and Prevention of Cancer*
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7. U.S. Department of Agriculture (n.d.) *USDA Food Composition Databases* [online]. Available from: https://ndb.nal.usda.gov/ndb/foods.
8. Campbell, T. C. & Campbell, T. M. (2016) *The China Study*. Revised and Expanded Edition. Dallas, Texas: BenBella Books.

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