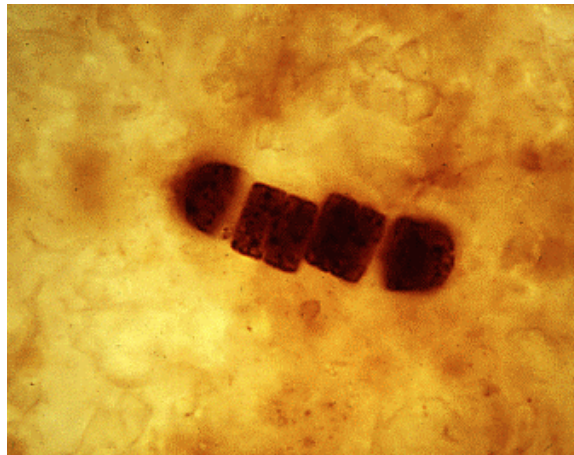


Multi-cellular Organisms, Tyranny Over Uni-Cellular Organisms and Cancer

To understand cancer we need to look back in time -- way back

The [oldest known forms of life on the planet](#) were tiny single cell organisms like bacteria or blue-green algae that evolved about 3.5 billion years ago.

A Cluster of Ancient Fossilized Bacteria



[University of California Museum of Paleontology](#)

For almost 3 billion years mostly single cell organisms appear to have populated the world. Then about 600 million years ago, in what is known as the Cambrian Explosion, an enormous variety of multi-cellular organisms evolved in full force. Multi-cellular organisms evolved from single cell organisms.

Fossilized Worms from Cambrian Period



[The Virtual Fossil Museum](#)

The emergence of multi-cellular organisms required the evolution of mechanisms to control the function, organization, and replication of the single cells that comprised the organism. A dichotomy developed between the reproductive or [germ cells](#) and the [somatic cells](#) that comprised the bulk of the multi-cellular organism. Specialized sex organs evolved that were responsible for reproduction.

Multi-cellular organisms were subjected to natural selection and competed for survival. As multi-cellular organisms became more complex, control over cell proliferation, specialization, location, and tissue organization became increasingly critical to the survival of multi-cellular organisms. In a sense, the individual cells that form multi-cellular organisms became subservient slaves to the greater needs of the whole organism.

Each additional level of evolutionary sophistication in the complexity and function of multi-cellular organisms required additional layers of regulatory complexity. The evolution of new specialized cell types required the co-evolution of regulatory mechanisms to control and restrain the new cell types. The evolutionary journey from the earliest of multi-cellular organisms to man took at least 600 million years. During this time a fantastically complex web of regulatory mechanisms evolved to control, coordinate and restrain the individual cells that comprised multi-cellular organisms.

Complexity can endow an organism with increased robustness and enable it to adapt to environmental challenges and stresses. However, there is a downside to complexity, more can break. As systems become more complex with an increased number of interacting components, seemingly minor errors and events can interact to produce catastrophic results. In addition, [redundant layers of regulatory control can enable defective regulatory genes to accumulate within the gene pool](#). In multi-cellular organisms the catastrophe can be a breakdown of the control over the single cell components leading to cancer.

Cancer occurs when single cells escape the tyranny of the multi-cellular organism and begin to evolve within the host.

A single cell organism only “cares” about its own self-interests

The structure and behavior of single cell organisms is geared to promote the survival of the cell and its capacity to reproduce. Stated in metaphorical language, a single cell organism only “cares” about its own self-interests. Surprisingly, single cell organisms like bacteria can engage in cooperative social behavior. Bacteria can form structured colonies, communicate with other bacteria using chemical signals, and respond by altering gene expression and cell behavior. But when this occurs the single cell organism is still just “looking out” for its own self-interest. Cancer cells are single cell organisms and behave in the same selfish manner. The problem is they do it inside the host of the human body. Cancer cells are like parasites.

Single cell organisms dominate the earth

A cell is the smallest unit of life that can reproduce. It contains all the information and machinery needed to replicate. Viruses are smaller, but must use the machinery of a cell in order to multiply. Although invisible to the naked eye, [single cell organisms dominate the earth](#). It is estimated that there are about 5×10^{30} single cell organisms on the planet. That

is the number 5 followed by thirty zeroes. If each uni-cellular organism were a penny, the stack of coins would extend past the edge of the present observable universe.

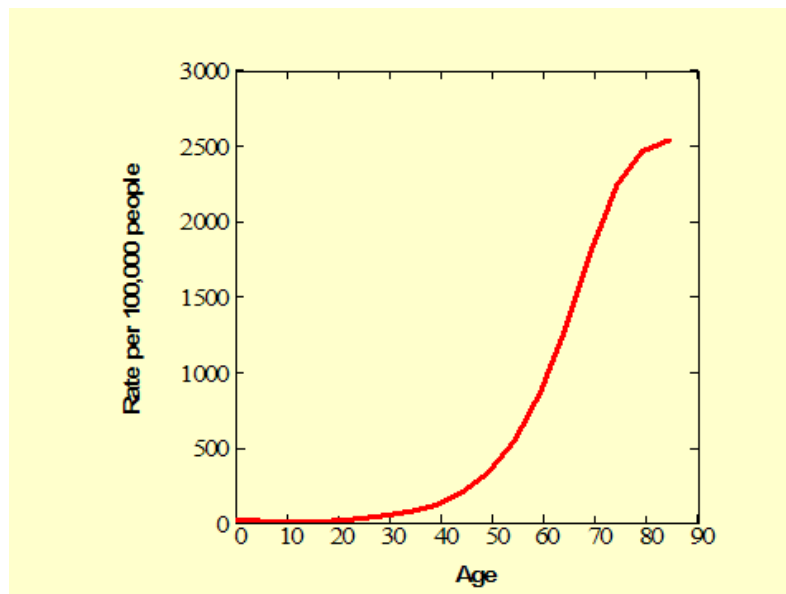
Exponential Growth

You might think that it would take a long time for 5×10^{30} cells to grow. But this is not the case. Under ideal nutrient and growth conditions some single cell organisms reproduce about every 15 minutes. But lets assume it takes twenty-four hours for a cell to divide and that no cells die. It would take just 102 days for one cell to give rise to 5×10^{30} cells. The growth is **exponential**. In reality cells could never continue to double like that. The food and space would run out. Cell death does occur. However, single cell organisms can and do undergo exponential growth for short periods of time before conditions become growth limiting. A single cell organism that divides once a day, in one month can give rises to tens of millions of progeny. Cancer cells can do the same.

Cancer and age

Mechanisms evolved over eons of time that limit the occurrence of cancer in individuals before and during the age of sexual reproduction. Individuals that develop cancer prior to having kids can't pass on their genes. These genes were therefore selected against during human evolution. However, genes and mutations that increase the risk of cancer after the age of sexual reproduction are not subject to strong negative selective pressures. This reflects a general property of evolution. Evolution discriminates in favor of the young, but does little to select for fitness of the old. This explains in part the striking increase in cancer that occurs after the age of 40 as shown in the graph below (data from NCI):

Cancer Incidence Different Ages (Male and Female)



Cancer reflects the tension between two evolutionary forces, those that act at the level of uni-cellular organisms and those that acted over hundreds of millions of years at the level of the multi-cellular organism.

Cancer results from evolution of cells inside the body.