



## About the IGB

[ABOUT THE IGB](#)[WHAT IS GENOMICS](#)[CARL R. WOESE](#)[JOIN THE IGB](#)[ANNUAL REPORT](#)

In 1977, Carl Woese overturned one of the major dogmas of biology. Until that time, biologists had taken for granted that all life on Earth belonged to one of two primary lineages, the eukaryotes (which include animals, plants, fungi and certain unicellular organisms such as paramecium) and the prokaryotes (all remaining microscopic organisms). Woese discovered that there were actually three primary lineages.



Carl R. Woese / Jason Lindsey

Within what had previously been called prokaryotes, there exist two distinct groups of organisms no more related to one another than they were to eukaryotes. Because of Woese's work, it is now widely agreed that there are three primary divisions of living systems – the Eukarya, Bacteria, and Archaea, a classification scheme that Woese proposed in 1990.

The new group of organisms – the Archaea – was initially thought to exist only in extreme environments, niches devoid of oxygen and whose temperatures can be near or above the normal boiling point of water. Microbiologists later realized that Archaea are a large and diverse group of organisms that are widely distributed in nature and are common in much less extreme habitats, such as soils and oceans. As such, they are significant contributors to the global carbon and nitrogen cycles.



# Illinois Alumni News

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## U.I. Biologists Make News

A faculty-student research team in the School of Life Sciences has found evidence that certain microscopic organisms thought to be ordinary bacteria actually are a separate, "third form of life."

Biologists heretofore have recognized two lines of descent from the still undefined first life on earth—the lower forms, bacteria, and the higher forms, animals and plants. An ongoing study at the University now has identified methanogens, or methane-producing organisms, as distinct from these two and quite likely the oldest of them all.

The subject organisms abound in places such as marshes, sewage treatment plants, the digestive systems of ruminants and even in hot springs.

Despite their ubiquity, they've been hard to study because to them oxygen is a poison. Exposed to the air, they die, and the research currently attracting attention in the world scientific community went forward only after U. I. microbiologists developed

teaching and research was disrupted by visits and telephone calls from newspaper and magazine reporters and radio and television newsmen and newswomen with their recorders and camera crews.

As stated in an abstract accompanying their report, here is what the researchers had done and what they had found:

"The 16S ribosomal RNAs from ten species of methanogenic bacteria have been characterized in terms of the oligonucleotides produced by T1 ribonuclease digestion. A comparative analysis of these data reveals the methanogens to constitute a distinct phylogenetic group which contains two major divisions. By this criterion these organisms bear only slight resemblance to typical bacteria."

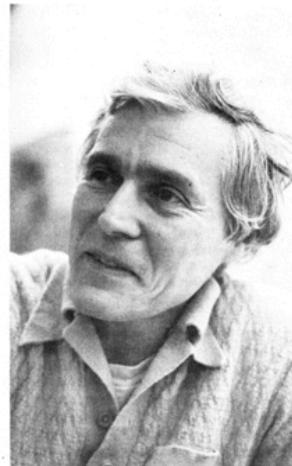
### Rewriting the Textbooks?

Put in nonscientific terms and expanded, here's what that means:

Make a three-way comparison of cell components from the higher forms, from an assortment of methanogens and from other lower forms, or bacteria. Assess each of them on, say, 25 characteristics.

If the methanogens are found to be similar to each other in 20 respects and to the other lower forms and the higher forms in only a few, then the methanogens can be considered as in a different family from each of the others.

That's just what the research indicates. The methane-producing organisms are as different from bacteria as they are from plants and animals, and thus constitute a third evolutionary stem. As Newsweek magazine said in what may not be overstatement, "All the biology texts in the world



In the spotlight: Carl Woese, above, and Ralph Wolfe, at the left.

U. of I. researchers, using ribosomal RNA as the basis for classification, "have shown not only that methanogens are a coherent phylogenetic grouping, but that they are quite distinct from other bacteria as well." Continuing, the investigators wrote:

"It would appear that methanogens ultimately may have to be classified as a systematic group distinct from other bacteria . . . Although it cannot be unequivocally concluded that methanogens represent the most ancient divergence yet

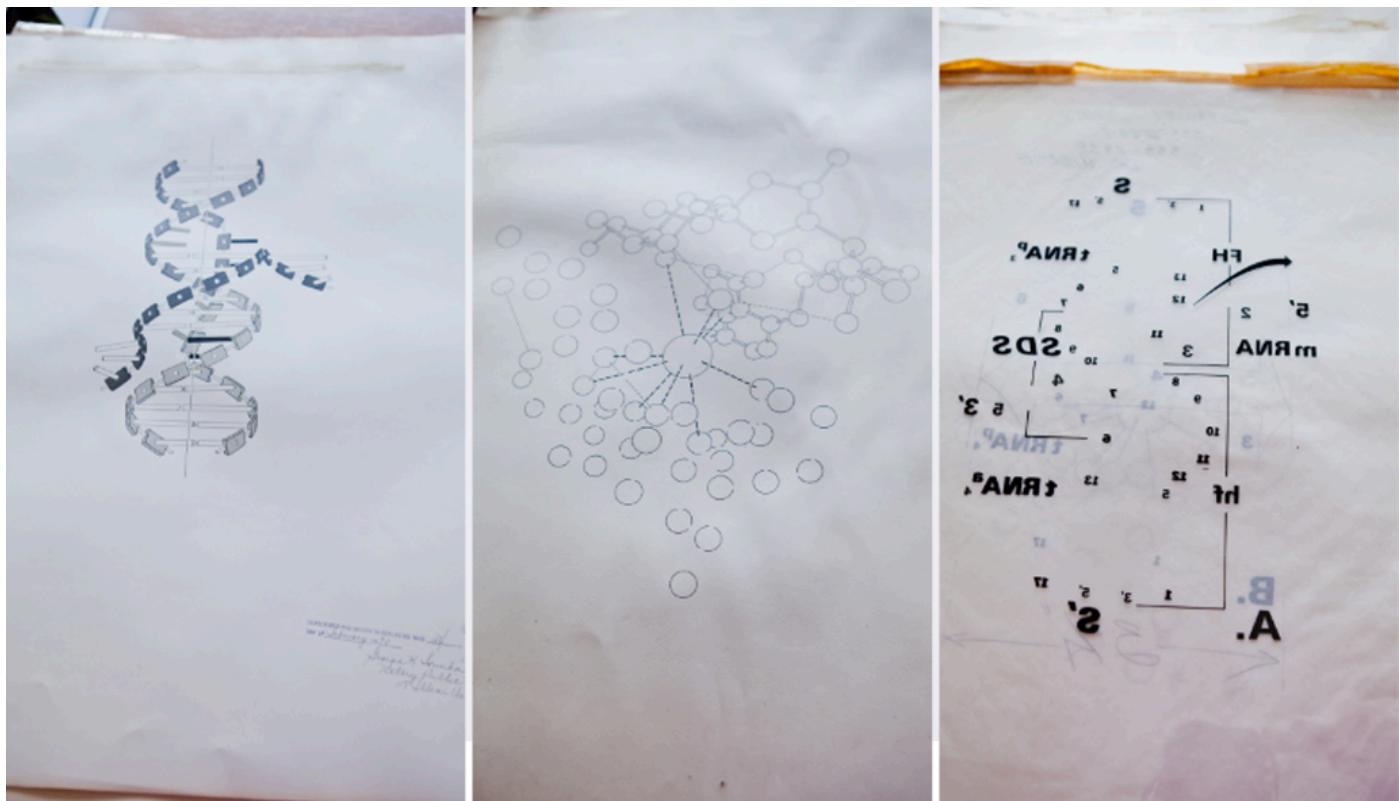
than 15 years, is primarily interested in their biochemistry. For the past decade he and Marvin P. Bryant, U. of I. professor of microbiology and of dairy science, have collaborated in studying the enzymology of how carbon dioxide is reduced to methane.

They learned to mass-culture the methanogens so they could be used as experimental tools and, Wolfe relates, "We discovered some new vitamins and coenzymes you don't find in the cells, and there were other differences."



The December 1977 edition of Illinois Alumni News highlights the discovery and publication "Phylogenetic structure of the prokaryotic domain: The primary kingdoms" / University Archives

The method Woese used to identify this "third form of life," which involved comparing the sequences of a particular molecule central to cellular function, called ribosomal RNA, has become the standard approach used to identify and classify all organisms. These techniques have also revolutionized ecology, because it is now possible to survey an ecosystem by collecting ribosomal DNA from the environment, thus sidestepping the often impossible task of culturing the organisms that are there. These microorganisms and the revolutionary methods that Woese introduced into science can offer insights into the nature and evolution of cells.



Materials from the Woese lab, circa 1970 / University Archives

In 1996, Woese and colleagues (University of Illinois professor Gary Olsen and researchers from the Institute for Genomic Research) published in the journal *Science* the first complete genome structure of an archaeon, *Methanococcus jannaschii*. Based on this work, they concluded that the Archaea are more closely related to humans than to bacteria. “The Archaea are related to us, to the eukaryotes; they are descendants of the microorganisms that gave rise to the eukaryotic cell billions of years ago,” Woese said at the time.

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Woese's experimental discoveries were made in the context of his search for a deep understanding of the process of evolution. As early as the 1970's Woese was thinking about what sort of theory of evolution one would need in the era before genes as we know them had emerged. At such a time, the standard population genetics theory of evolution would not be applicable. Woese articulated early clear proposals about the nature of what has come to be known as the last universal common ancestor, concluding for a variety of reasons that the universal ancestor was not a single organism, but rather groupings of loosely structured cells that existed together during a time when genetic mutation rates were high and the transfer of genes between cells occurred more frequently than in the present day. The most detailed version of these proposals was put forward on the basis of Woese's work here at IGB (with University of Illinois professor Nigel Goldenfeld). These groups of primitive cells, called progenotes, evolved together and eventually formed the three ancestral lineages.

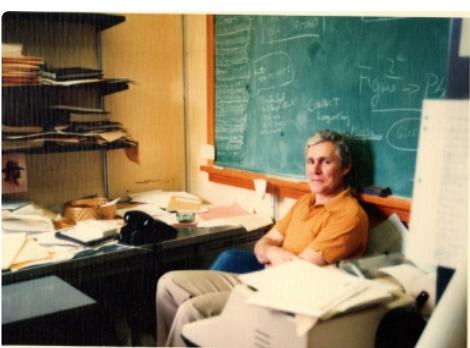
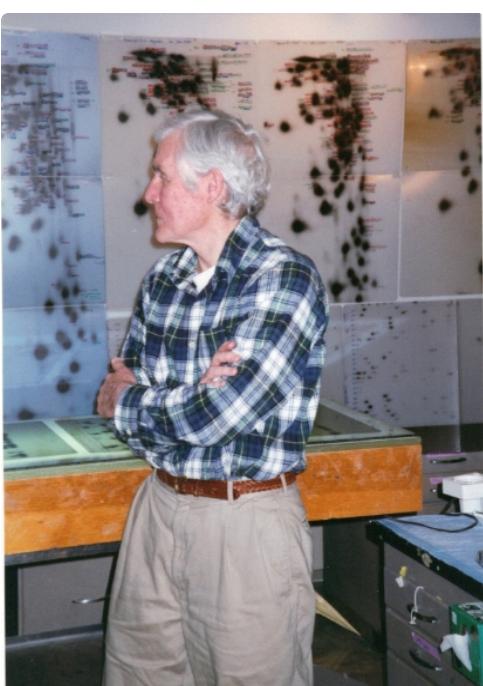
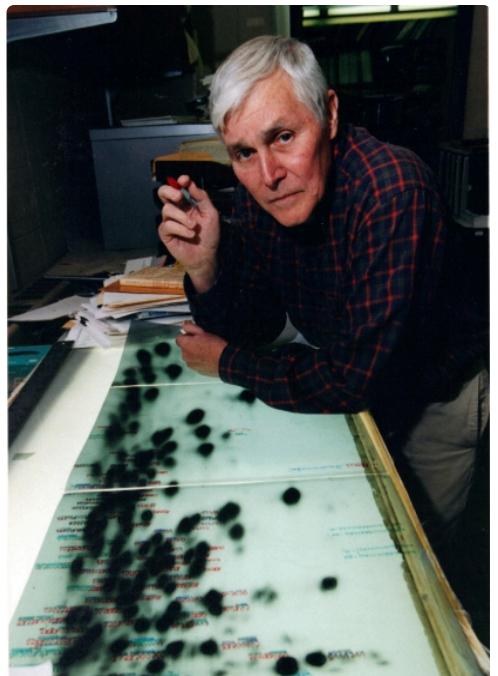
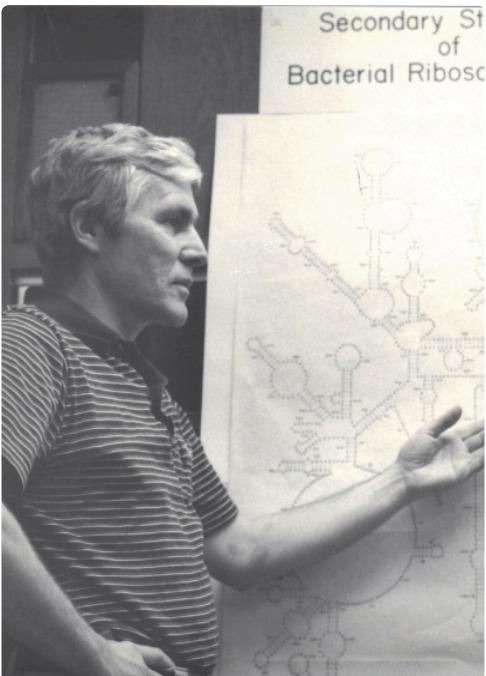
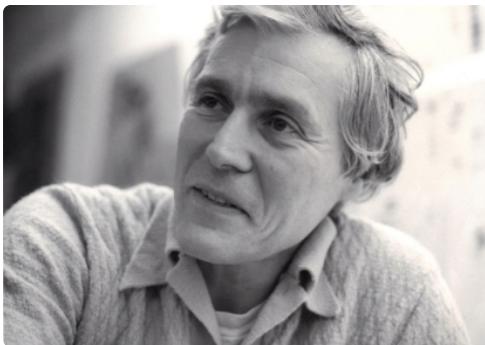
"Carl's work, in my view, ranks along with the theory of superconductivity as the most important scientific work ever done on this campus – or indeed anywhere else," says Dr. Nigel Goldenfeld, leader of the IGB Biocomplexity research theme and long-time colleague of Dr. Woese. "It remains one of the 20th century's landmark achievements in biology, and a rock solid foundation for our growing understanding of the evolution of life."

Woese passed away in December of 2012 at the age of 84.

*Carl Woese was a professor of microbiology at the University of Illinois Urbana-Champaign and a faculty member of the Carl R. Woese Institute for Genomic Biology. He was awarded the John D. and Catherine T. MacArthur Foundation "genius" award in 1984, and the National Academy of Sciences elected him to membership in 1988. In 1992 the Dutch Royal Academy of Science gave him the highest honor bestowed upon any microbiologist, the Leeuwenhoek Medal, awarded only once every 10 years. He was given the National Medal of Science in 2000 "for his brilliant and original insights, through molecular studies of RNA sequences, to explore the history of life on Earth." In 2003 the Royal Swedish Academy of Sciences awarded Woese the Crafoord Prize in Biosciences for his discovery of the third domain of life. The Crafoord award honors scientists whose work does not fall into any of the categories covered by Nobel Prizes. The Royal Society, the world's oldest continuously active scientific organization, elected Woese as a foreign member in 2006. He held the Stanley O. Ikenberry Endowed Chair and served as Center for Advanced Study Professor of Microbiology.*

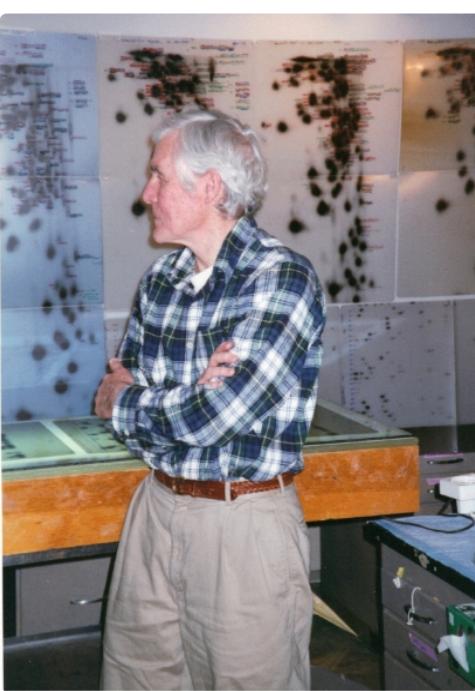
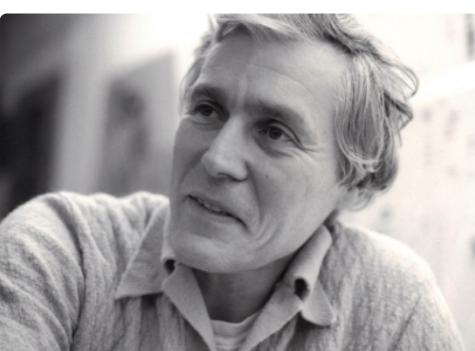
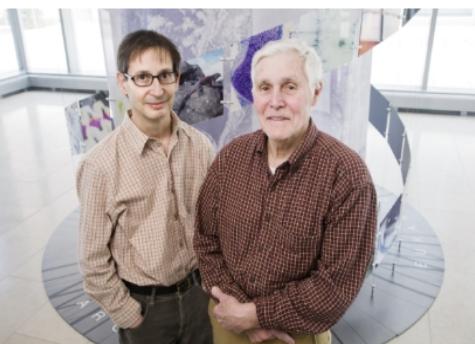
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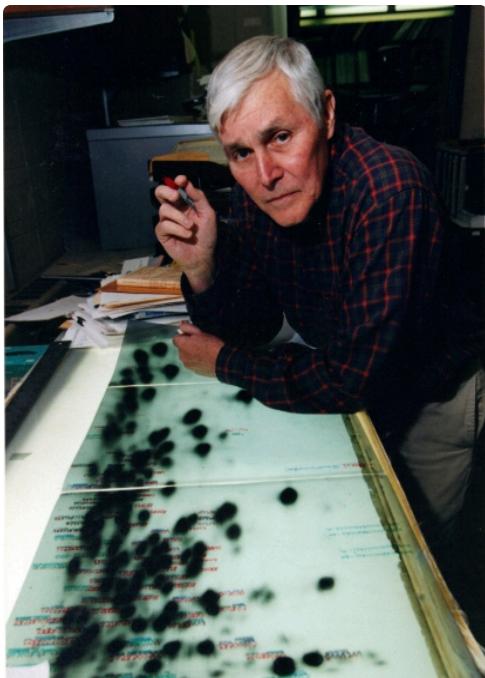
## Gallery



This Royal highness, the Archackönig, requests the honor of your presence at a revolutionary performance of the 3,400,000,105<sup>th</sup> annual Archaemasters Tournament. The festivities will commence 3pm, July 14 celebrating the anniversary of the storming of the putt-putt course by an angry mob of Frenchmen. Seeded players:  
 Archackönig Wöse XVI  
 Archackönigin Gabriella the Pure  
 Grand Monk Bruno Passapasta Risatti  
 Archaechimpignon (1983) Pandemonium Wells  
 Archaechimpignon (1981-82) Jacques le Driver Jones  
 Archaechimpignon (1980) Beauregard Whitman  
 Archæcountessa Paula Schwannenwittenpsychohypnolayin'non  
 Archæduke Okie Nagle  
 thebeachonfleuge  
 Archæprincess Sandorra Beaujolais  
 Archæpeasant Will the doormat Weisburg  
 Archæjester Charles Bush-league Vossbrink  
 Archæ-NoShow Raoul Aarrghh Canner  
 Archæprophet Josannah Brineshrimp Escalante  
 Archæchoke Canette Nulle  
 Location: Putt-putt course near Prospect/Bradley intersection  
 Entry fee: \$3.00 Reception follows at the palace (Versailles)  
 Putt-putt belongs to the Archaes!



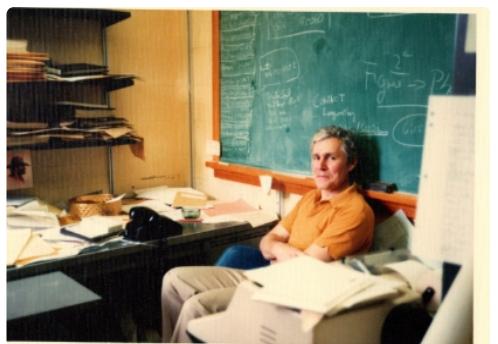
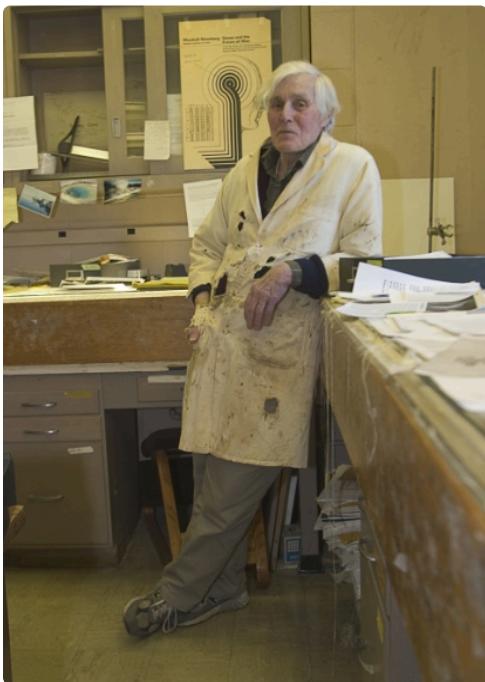
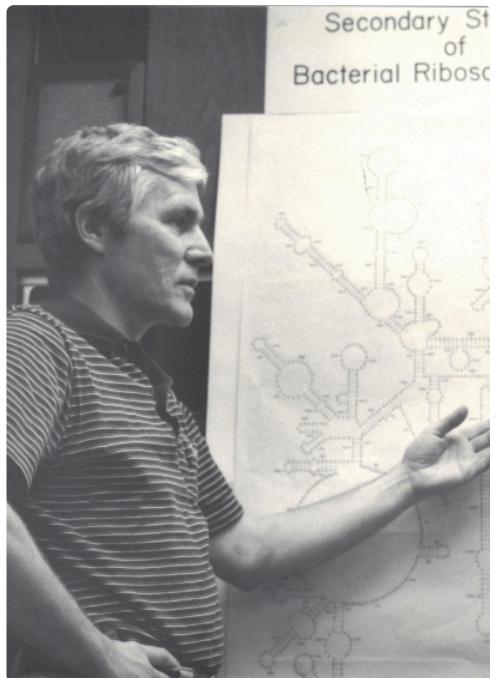


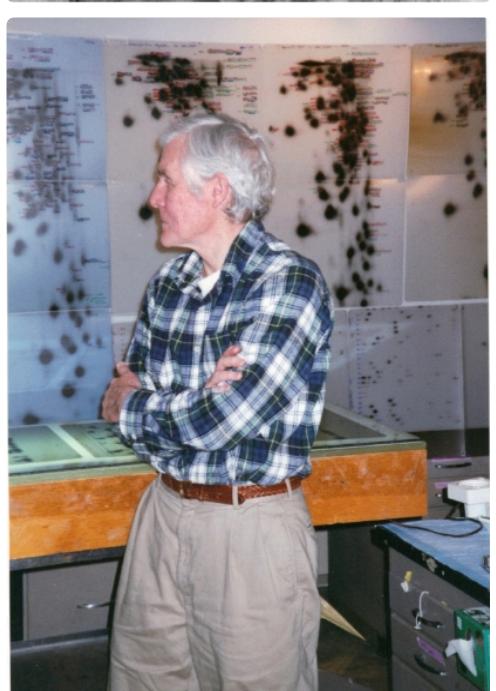
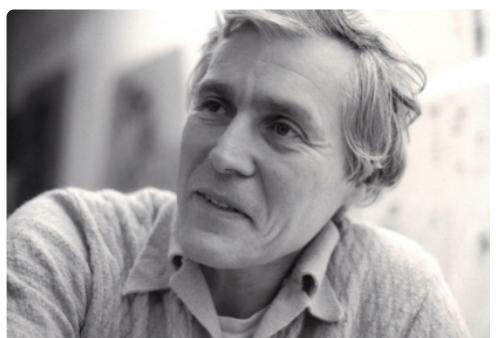
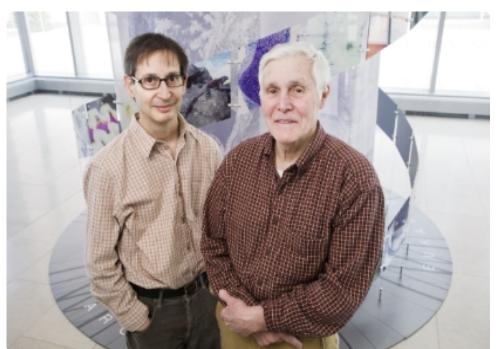
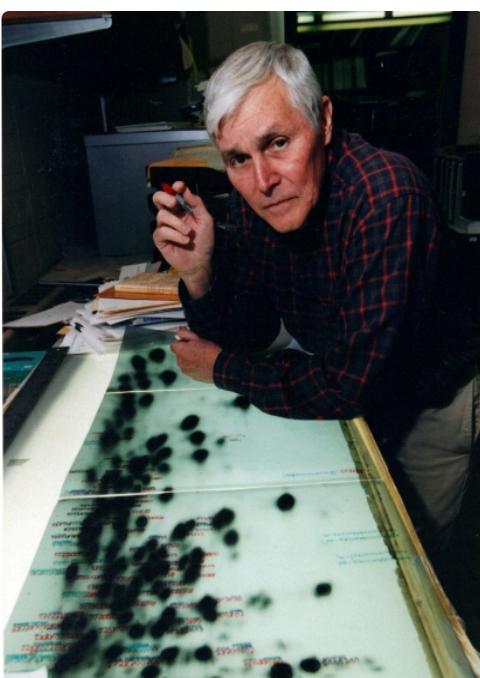
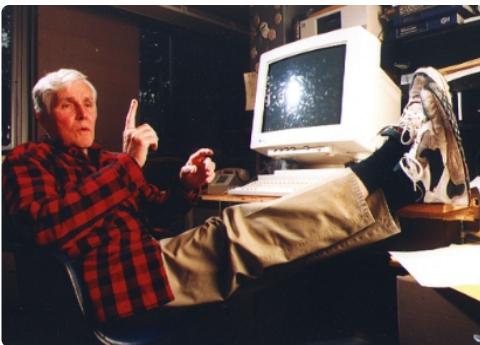
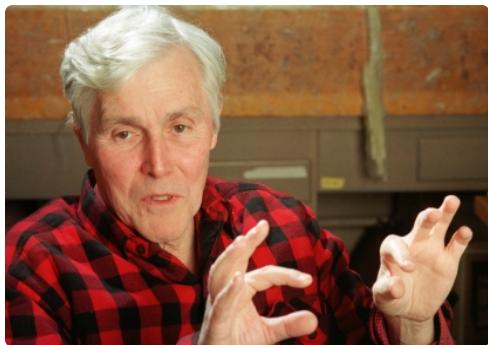


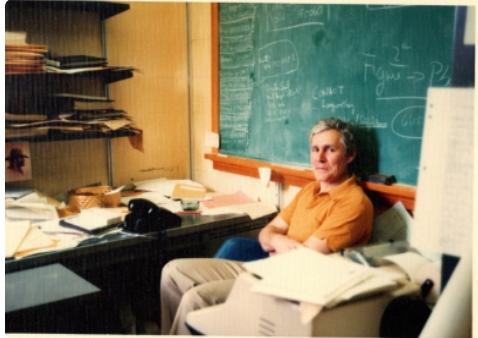
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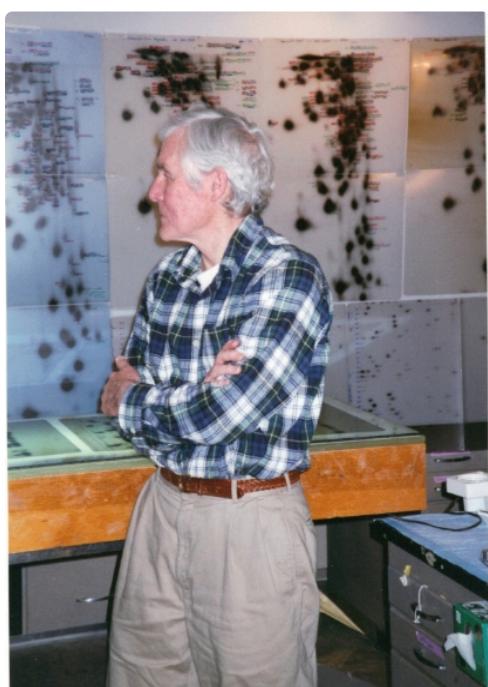
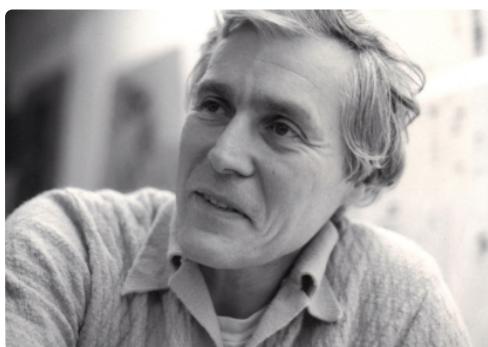
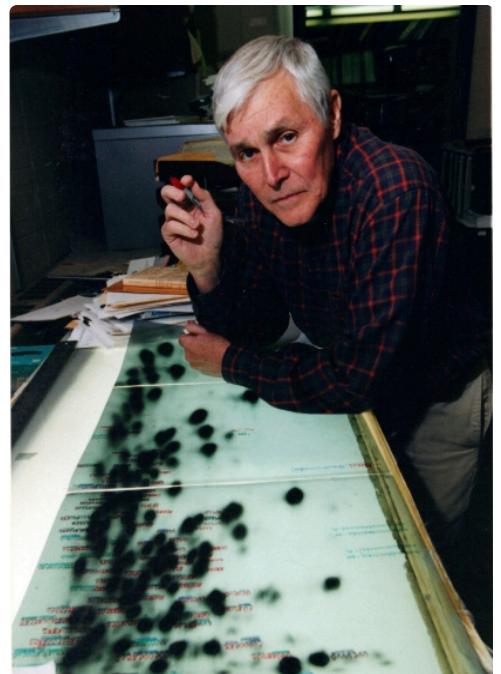
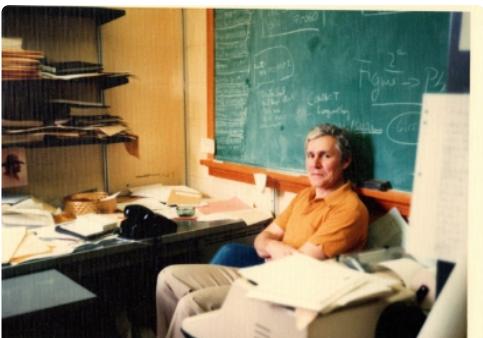
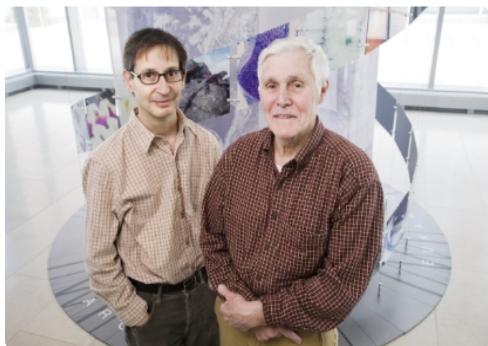


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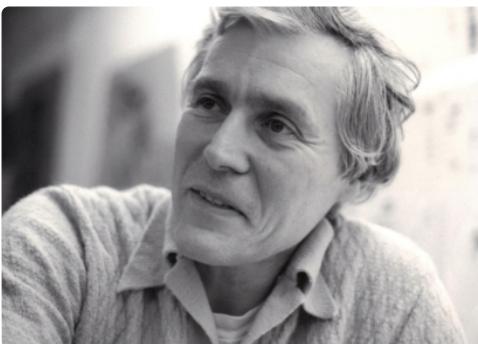
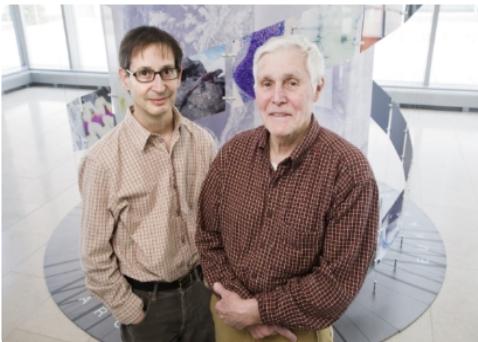
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## Carl R. Woese Institute for Genomic Biology



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Phone: 217-244-2999

Email: info-igb@illinois.edu

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