

# Growing up in Allentown



**1922-1939**

Lloyd was born in Allentown, Pennsylvania on January 17 1922. He was the youngest of three siblings with two older sisters named Rose and Doris. His father left school after eighth grade and became a railroad clerk in Bethlehem. His mother worked there also after she had graduated from high school. Lloyd attended a two-room, six-grade schoolhouse. Mrs. Kistler was his teacher for the first three grades. He then moved across the hall to Mr. Kistler's class for the next three grades. Middle school and high school were different. Middle school was several miles by bus but the high school was a short walk away. Lloyd began his experimental career in high school. He obtained permission to conduct experiments in both physics and chemistry instead of attending study period. During his senior year he did a series of chemistry experiments on making dyes and applying them to different kinds of cloth. The binding of the dyes to the cloth formed the basis for his later work on binding of chemicals to taste receptor membranes.

# Muhlenberg College



**1939-1942**

Lloyd attended Muhlenberg College in Allentown. Muhlenberg College was founded in 1848 and is named after Henry Melchior Muhlenberg the "patriarch" of the Lutheran Church of America. Lloyd bicycled to college from home and was a physics major. In recognition of Lloyd's achievements the college gave him an honoray doctor of law degree in 1969.

# Johns Hopkins University

**1942-1945**

At the request of a former physics professor at Muhlenberg college Lloyd accepted a junior instructorship as a graduate student in the physics deptment at Johns Hopkins University in Baltimore. He received an M.S. in physics after a year and was then recruited to join the Naval Laboratory a floor beneath the physics department, where he did research to develop proximity fuses for the war effort. The fuses were tested for their radiation patterns by four women, of of whom was Mary Lou Hackethal a graduate of Goucher college. Lloyd was to marry Mary Lou in 1950.

# Johnson Foundation for Medical Physics, University of Pennsylvania

**1945**

After World War II Lloyd was encouraged to enter the then new field of biophysics and he joined the Johnson Foundation. The director, Detlev Bronk, had studied with Lord Adrian (Nobel Prize, 1932). In discussions with Bronk Lloyd had expressed his desire to study the interactions of ions and molecules with taste and olfactory receptors. Bronk then suggested that Lloyd should study with Adrian in Cambridge England. Unfortunately Lloyd did not have the resources to move to England. This problem was solved when Bronk left to become president of Johns Hopkins and Lloyd moved back to Johns Hopkins as well.



Detlev Bronk

# Ph.D. Johns Hopkins University



H.K. Hartline

Vincent Dethier

**1951**

Keffer Hartline (Nobel Prize 1967) was to become chair of a new department of biophysics at Hopkins. Moreover, Vincent Dethier in biology and Elliot Stellar in psychology were interested in the chemical senses and encouraged the choice of Lloyd dissertation research on the taste receptors of the rat. Lloyd learned to dissect the chorda tympani in Carl Pfaffmann's laboratory at Brown University. Once he was able to obtain good quality recordings he wanted to be able to quantify the results. Lloyd decided to average the whole nerve responses electronically by using an RC (resistance-capacitance) network and a half-wave rectifier vacuum tube. This innovative method of quantifying taste data, known as the integrated response, is still used extensively in taste research.

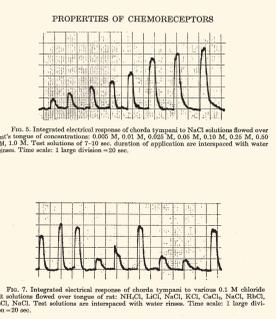


Fig. 8. Integrated electrical responses of chorda tympani to NaCl solutions...  
Fig. 7. Integrated electrical responses of chorda tympani to various 0.1 M chloride salt solutions...

# Taste Equation

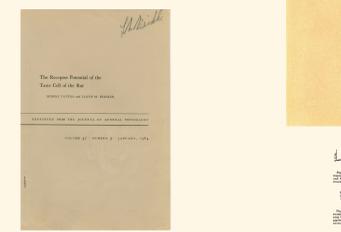
**1954**

Lloyd accepted a position at Florida State University in 1950 and set up his laboratory. He was to remain there for the rest of his professional career. In 1953 Lloyd was asked to present a seminar and he decided to talk about a mathematical expression describing the relationship between the magnitude of the taste response as a function of stimulus concentration based on the law of mass action.

$$\frac{c}{R} = \frac{c}{R_m} + \frac{1}{K R_m}$$

He called this the fundamental taste equation and used it to estimate the binding strength between tastants and the taste receptors.

# First Intracellular Recordings from Taste Cells



**1954**

Lloyd was always innovative and as soon as the microelectrode technique was developed he used it to record the first intracellular measurements of taste cell receptor potentials. He was fortunate to have skilled Japanese postdocs in his lab as the technique of manipulating a fine tipped glass microelectrode through the taste pore was very demanding, requiring much patience and dedication. The important conclusion from this work demonstrated that taste cells respond to more than one taste quality, a fact that has been confirmed by others using more advanced intracellular recording techniques. In addition this work resulted in a long tradition of collaboration with Japanese scientists.

# Lloyd M. Beidler - his life and contributions to the science of taste and smell

# International Symposium on Olfaction and Taste



Lloyd and Carl Pfaffmann first ISOT 1962, Stockholm



Pfaffmann, Lloyd, Zotterman, Lord Adrian, ISOT III 1968, New York



Lloyd and Carl Pfaffmann, ISOT VII 1980, Noordwijkerhout



Lloyd and M. Sato ISOT XI 1992, Sporo

In 1959, Walter Rosenblith sponsored a symposium on sensory communication at MIT. Carl Pfaffmann, Yngve Zotterman and Lloyd all attended this meeting and they decided to hold an international meeting on the chemical senses. Yngve Zotterman agreed to organize the first of these which took place in Sweden. Since then one of these international meetings has taken place every three years and now alternates among the United States, Europe and Japan.

# SeattleWorld's Fair

**1962**

An International World's Fair was held in Seattle in 1962. It was decided that the U.S. exhibit would center on science and technology. Lloyd was appointed Science Coordinator of the U.S. Science Exhibits. Using his expertise in sensory biology and his contacts with the scientific community he organized a series of exhibits that were based on animal behavior. For example each day one of the demonstrators dissected the optic nerve of a horseshoe crab and record the electrical activity in reponse to light stimulation and displayed the activity on a large oscilloscope and audio amplifier. Other exhibits included a working display of pigeons to demonstrate color vision and many others that resulted in an excellent series of animal exhibits.

# Psychobiology Program

**1964**



Lloyd and Dan Kenshalo

In 1964 the National Science Foundation initiated its Centers of Excellence Program. The Florida State University vice president appointed a committee and decided that Lloyd and Dan Kenshalo should apply to fund a psychobiology program. This was funded and resulted in additional faculty positions as well as new core equipment including a mini-computer and a scanning electron microscope. More important for the students at that time was the visit of many outstanding sensory biologists who presented their work, as well as visiting the labs, and a social evening after their presentation. This program was therefore very important to the students and postdocs in the labs. It continues to this day although it is now the Neuroscience Program

# Turnover of taste cells

**1965**



Because taste cells are exposed to hundreds of different chemicals at various concentrations, pH and varied temperatures, Lloyd had an idea that the taste bud cells must turnover. Using first colchicine and later the then new technique of autoradiography Lloyd demonstrated that taste cells had an average life span of about 10 days. This finding of the dynamic property of taste buds raised interesting questions about the relationship of the innervation to the taste cells and the possibility that taste cells may change response specificity during their brief life cycle.

# Taste Modifiers

**1968**



Miracle fruit



Kenzo Kurihara

Lloyd had learned about a red fruit that grew in West Africa that was supposed to produce sweetness when eaten before sour food. Lloyd cultivated some of these plants in the greenhouse at Florida State, and began the process of extracting the active ingredient. In 1967 Kenzo Kurihara, a protein chemist, joined the lab and Lloyd set him to work on the problem. The active ingredient was a protein and a paper describing its properties was published in *Science*. Although attempts were made to use it commercially these were not successful. At that time the discovery of sweet receptor proteins in the taste cells was 30 years away and the interaction of the miracle fruit protein with this receptor awaits investigation.

**In Summary** Lloyd received many honors including being elected to the National Academy of Sciences in 1974, and the American Academy of Arts and Sciences in 1975. He held the Robert O. Lawton Distinguished Professorship. Among close colleagues and associates, Don Tucker, Jim Smith and Pasquale Graziadei are the most notable. He trained many students including, Robert Bradley, John Caprio, Fay Ferrel, Irving Fishman, Gunter Gross, Clarence Hardiman, Scott Herness, Inglis Miller, Charlotte Mistretta, Wayne Silver, and Walter Zawalich. His postdocs include, Toshihide Kikuchi, Don Mathews, David Moulton, Max Mozell, Mohessen Nejad, Robert O'Connell, Toshihide Sato and Norio Suzuki. One of Lloyd's characteristics was to let his students persue their own interests, as long as it was related to the chemical senses. He rarely put his name on his student's papers. He would also have the knack of applying work in an unrelated field to taste research and would ask his students after a seminar how the information related to taste. Most of the work in Lloyd's lab related to the peripheral taste system, he rarely paid any attention to central processing. As he states in his first publication when he started "the science of taste was still in its infancy", with very few labs working in the chemical senses. When he retired in 1992 there were many laboratories and a national association devoted to the chemical senses. He was one of the major movers in the growth of the field and all members of AChemS owe much to his drive, foresight and enthusiasm.

