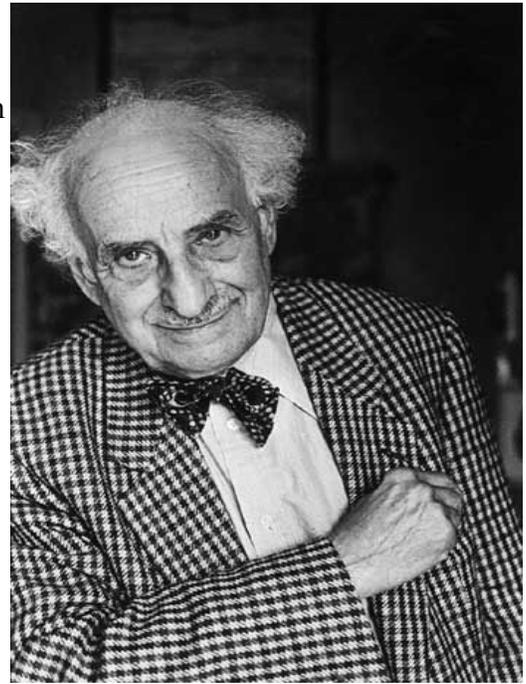


## Hans Freudenthal

German-born Dutch mathematician and mathematical historian **Hans Freudenthal** (September 17, 1905 – October 13, 1990) made important contributions in topology, geometry and Lie groups. Later in his career he directed his abundant talents to the history of mathematics, in particular the history of geometry. Besides wishing to communicate with human beings, he also sought means to communicate with alien civilizations in far off galaxies, by designing a language, *Lingua Cosmica*, or *Lincos* for short, for cosmic interaction.



Lincos isn't a spoken language, but a collection of mathematical and logical symbols. Unlike encryption, in which it is a mistake to send encrypted messages with predictable beginnings, as did the Germans with their Enigma code, Freudenthal maintained that in anti-encryption: "In the beginning communicate facts which may be supposed to be known to the receiver."

Freudenthal was born to a Jewish family in Luckenwalde, Germany. He developed an early interest in mathematics and science, but he also read widely in the classics of literature and poetry. In 1923 he entered the University of Berlin to study mathematics and physics. Seven years later Freudenthal became an assistant to Dutch mathematician and logician L.E.J. Brouwer and spent the rest of his career in The Netherlands. That same year, he married Dutch teacher Suus Lutter. In 1931 he received his doctorate for a thesis on the theory of ends on a class of topological spaces, which are nowadays called locally finite graphs, supervised by Heinz Hopf. Usually ends are defined as equivalence classes of rays.

Soon after arriving in The Netherlands, Freudenthal became a lecturer at the Mathematical Institute of the University of Amsterdam. Because he had left Germany, he was not immediately affected by the infamous Nazi legislation that denied German Jews their jobs. However, in 1940, Germany invaded The Netherlands and deported 70,000 Jewish citizens to concentration camps. Freudenthal lost his position and went into hiding with his family. During the ensuing difficult years, he turned his attention to his literary matters, winning a prize for a novel he wrote in 1944. Because he was a Jew he could not reveal his identity, so a friend, at considerable risk to himself, posed as the prizewinner, participating in the interviews, dinners and speeches in Freudenthal's stead.

In 1945 Amsterdam was liberated by Canadian troops and Freudenthal resumed his duties at the university. The next year, he was appointed to the chair of pure and applied mathematics at the University of Utrecht, where he remained until his retirement in 1975. As a teacher he was a remarkable storyteller and he won worldwide recognition for championing his "realistic mathematics" education program. It is based on problems suggested by day-to-day experiences rather than on abstract mathematical rules. He almost single-handedly prevented the so-called "New Math," developed in the United States in the 1960's, from being adopted in The Netherlands. His educational motto was, "you learn mathematics best by reinventing it." He advocated grounding the curriculum in the real world activities, which he also called "Mathematics in Context." This meant getting away from repetitive drills, sequential content, and from solving problems "in a vacuum." He was certain that students assigned practical problems chosen from daily life would gradually developed an understanding of mathematics and as they solved them. He criticized the practice of initially giving geometry students a collection of definitions before they are ready to understand where they came from. Freudenthal claimed that most definitions are not preconceived but are made only as the culmination of an organizing activity, and that students should not be denied this privilege.

In 1971 Freudenthal set up an Institute for the Development of Mathematics Education, now known simply as the Freudenthal Institute, which continues to be one of the driving forces in renewing mathematics education, both in The Netherlands and abroad. Dutch educators define mathematics as “mathematizing” – the activity of structuring, modeling, and interpreting one’s “lived world” mathematically. The main function of teachers is not to be problem solvers, but rather educational designers, who cater to a wide range of educational needs, observe, invent questions, design problems with accompanying tips and explanations, think of ideas, talk with students, encourage students to reflect on their own activities, and so forth.

The history of education is filled with noble educational experiments that at the beginning made some sense and held out promise of success, only later to fall on hard times, and be blamed for all the terrible things happening in the world. Many younger readers may have no acquaintance with the so-called “New Math” of the 1960’s, which was a reaction to the alleged failures of the educational system in place at the time the United States and the U.S.S.R. entered into a “cold” war. The mathematics and science being taught was out-of-date, and instruction depended more on rote memorization than understanding. The proponents of the New Math came up with the idea that mathematics should be taught in such a way that students knew why things worked. The reform got carried away in the attempt to replace rote learning with rigorous learning. Thus in the schools that adopted the “New Math” approach, there was a swing of almost 180 degrees in approach and for about a decade, students were taught the “x, y, z’s” of mathematics before they knew their “a, b, c’s.”

In the last century considerable interest developed in devising means to communicate with extraterrestrial intelligence. Between 1957 and 1960, Freudenthal developed his “cosmic language,” *Lincos*. Rather than rely on pictures for communication, he constructed a complex mathematical

language that could be transmitted via radio signals. His only assumption was an alien ability to reason as humans do, and as such aliens would have developed a mathematical system. Assuming so little, it is necessary to communicate a great deal about human language itself before being able to communicate any really interesting information. Among the first lessons that are to be covered in any interstellar tutorial are the principles of arithmetic. For instance, to convey the operation of arithmetic, certain radio pulses would be used to represent numbers and other kinds to represent the operations and equality.

Aboard the Voyager spacecrafts I and II are phonograph records – 12-inch gold-plated copper disks containing sounds and images selected to portray the diversity of life and culture of Earth for any extraterrestrials who happen to capture the spacecrafts. This casting into the cosmic sea of such a sophisticated bottle containing a message is an optimistic gesture that sometime, long after those who launched it are dead, somewhere in interstellar space some intelligent life will intercept the spacecraft and understand the message. Carl Sagan headed a committee that selected the contents of the record for NASA. Among the pictures electronically placed on the phonograph records are: The Sun, Mercury, Mars, Jupiter, Earth, DNA structure, human sex organs, diagram of conception, fetus diagram, diagram of family ages, seashells, snowflakes, Great Wall of China, Taj Mahal, Sydney Opera House, X-ray of hand, Golden Gate Bridge, Airplane in flight, astronaut in space, sunset with birds, and a string quartet.

Among the sounds contained on the record are: music of the spheres, wind, rain, surf, fire, speech, volcanoes, earthquake, thunder, crickets, frog, kiss, birds, heartbeat, and laughter. The musical selections include: Bach's Brandenburg Concerto No. 2 in F, Australian Aborigine songs, "Johnny B. Goode" performed by Chuck Berry, Mozart's The Magic Flute, "Melancholy Blues," performed by Louis Armstrong, Stravinsky's Rite of Spring, Beethoven's Fifth Symphony, and Navajo Indians' Night Chant. The record also includes greetings to the Universe in 55 different languages, and messages from

President Jimmy Carter and Secretary General of the United Nations, Kurt Waldheim. In 1990, the Voyager spacecraft left Pluto and the solar system behind as empty space was entered. It will be 40,000 years before the craft makes any close approach to another planetary system. As Voyager was leaving this world, so was Freudenthal, who died on October 13, 1990. He was discovered sitting on a park bench in Utrecht by children playing there.

**Quotation of the Day:** “One can learn more from a single paradigmatic instance than from a hundred irrelevant ones... Such an opportunity should be taken advantage of.” – Hans Freudenthal