

THE MAN WHO TURNED PAPER INTO PIXELS

HOW OUR DIGITAL WORLD WAS BORN
...AND HOW IT WORKS

CLAUDE SHANNON

of proper encoding of the information. In telegraphy, for example, the messages to be transmitted consist of sequences of letters. These sequences, however, are not completely random. In general, they form sentences and have the statistical structure of, say, English. The letter E occurs more frequently than Q, the sequence TH more frequently than XP, etc. The existence of this structure allows one to make a saving in time for





Graduate Student Wins Noble Prize In Math Research

Claude Shannon Wins \$500
Given In Memory Of
Alfred Noble

Claude E. Shannon, graduate student in the department of Mathematics and former research assistant in the department of Electrical Engineering at the Institute, was announced as the winner of the Alfred Noble Prize, coveted award for young American engineers.

Shannon, a native of Gaylord, Mich., and a graduate of the University of Michigan in the class of 1936, has been awarded the prize on the basis of his article which appeared in the journal, *Electrical Engineering*, last summer, and which reported the results of his three years' study in intricate mathematical analysis in connection with the Institute's Differential Analyzer.

Noble Was American Engineer

Not to be confused with the Nobel Prizes, which honor the Scandinavian scientist, Alfred B. Nobel, the Noble Prize honors the late Alfred Noble, prominent American civil engineer who, among other achievements, had a prominent part in engineering the Panama Canal. First awarded in 1931, this distinguished prize, which carries a stipend of \$500, is given to a member, not over 30 years old, of one of five contributing societies on the basis of a technical paper published in an official publication of one of these societies.

Shannon came to the Institute after

(Continued on Page 4)



A SYMBOLIC ANALYSIS
OF
RELAY AND SWITCHING CIRCUITS

by

Claude Elwood Shannon
B.S., University of Michigan
1936

Submitted in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
from the
Massachusetts Institute of Technology
1940

Signature of Author Claude E. Shannon

Department of Electrical Engineering, August 10, 1937

Signature of Professor
In Charge of Research Frank L. Hitchcock

Signature of Chairman of Department
Committee on Graduate Students Edward S. Moore

AN ALGEBRA FOR THEORETICAL GENETICS

By
 Claude Elwood Shannon
 B.S., University of Michigan
 1936

Submitted in Partial Fulfillment of the
 Requirements for the Degree of
 Doctor of Philosophy

From The
 Massachusetts Institute of Technology
 1940

Signature of Author..... *Claude E. Shannon*
 Department of Mathematics, April 15, 1940
 Signature of Professor
 In Charge of Research. *Frank L. Hitchcock*
 Signature of Chairman of Department
 Committee on Graduate Students.... *H. B. Phillips*



Theorem XII. Under random intermating of the

population $\lambda_{k\ell m}^{hij}$ the nth offspring generation is given by:

$$\mu_{k\ell m}^{hij} = [p_{00}^{n-1} (p_{00} \lambda_{\dots}^{hij} + p_{01} \lambda_{\dots}^{hi\cdot} + p_{10} \lambda_{\dots}^{h\cdot j} + p_{11} \lambda_{\dots}^{h\cdot\cdot j})$$

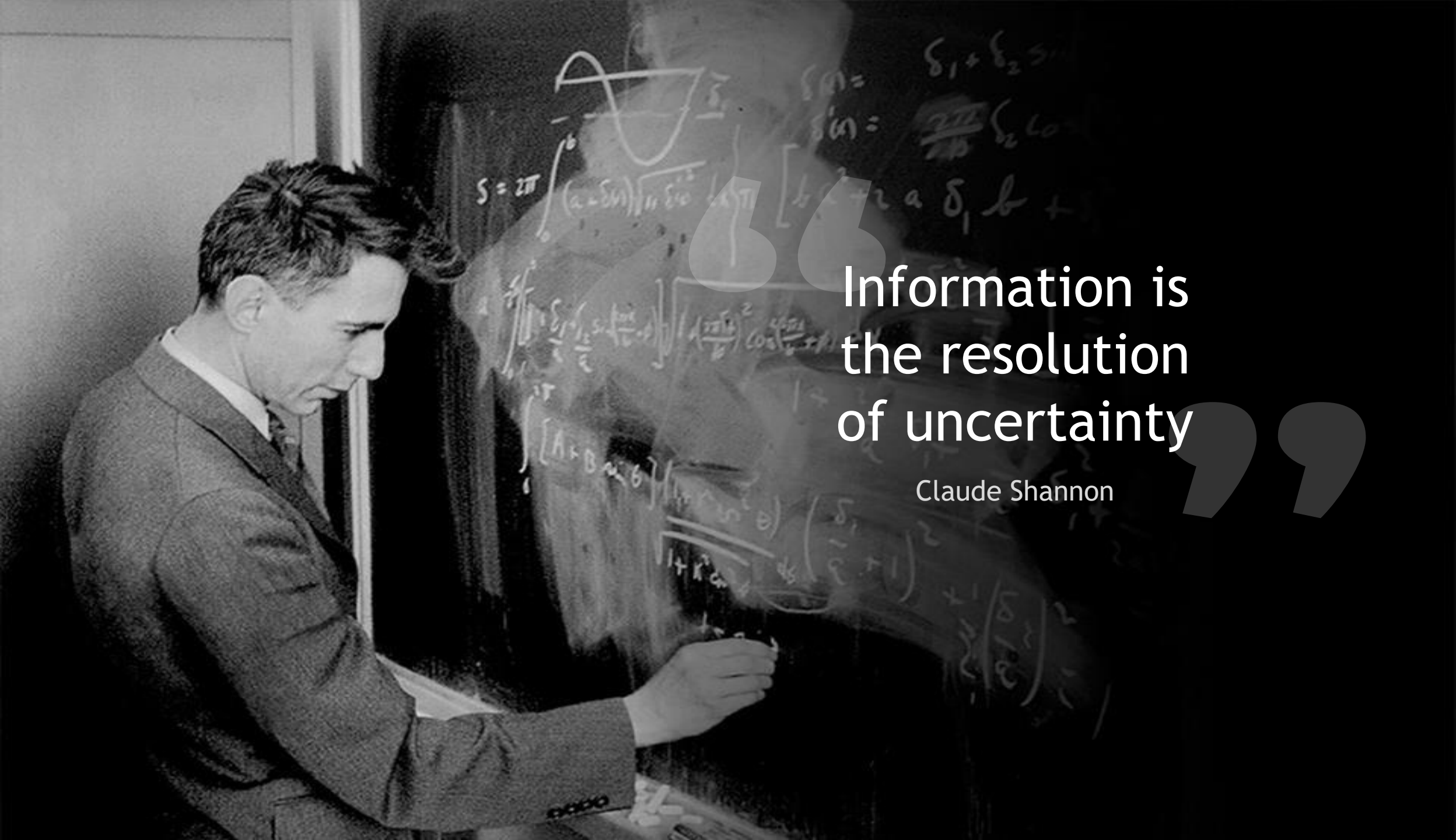
$$+ ((p_{00} + p_{01})^{n-1} - p_{00}^{n-1}) \{ (p_{00} + p_{01}) \lambda_{\dots}^{hi\cdot} + (p_{10} + p_{11}) \lambda_{\dots}^{h\cdot\cdot j} \} \lambda_{\dots}^{h\cdot j}$$

$$+ ((p_{00} + p_{10})^{n-1} - p_{00}^{n-1}) \{ (p_{00} + p_{10}) \lambda_{\dots}^{h\cdot j} + (p_{10} + p_{11}) \lambda_{\dots}^{h\cdot\cdot j} \} \lambda_{\dots}^{h\cdot\cdot}$$

$$+ ((p_{00} + p_{11})^{n-1} - p_{00}^{n-1}) \{ (p_{00} + p_{11}) \lambda_{\dots}^{h\cdot\cdot j} + (p_{01} + p_{10}) \lambda_{\dots}^{h\cdot\cdot\cdot} \} \lambda_{\dots}^{h\cdot\cdot}$$

$$+ (1 + 2 p_{00}^{n-1} - (p_{00} + p_{01})^{n-1} - (p_{10} + p_{00})^{n-1} - (p_{00} + p_{11})^{n-1}) \lambda_{\dots}^{h\cdot\cdot} \lambda_{\dots}^{h\cdot\cdot} \lambda_{\dots}^{h\cdot\cdot}$$

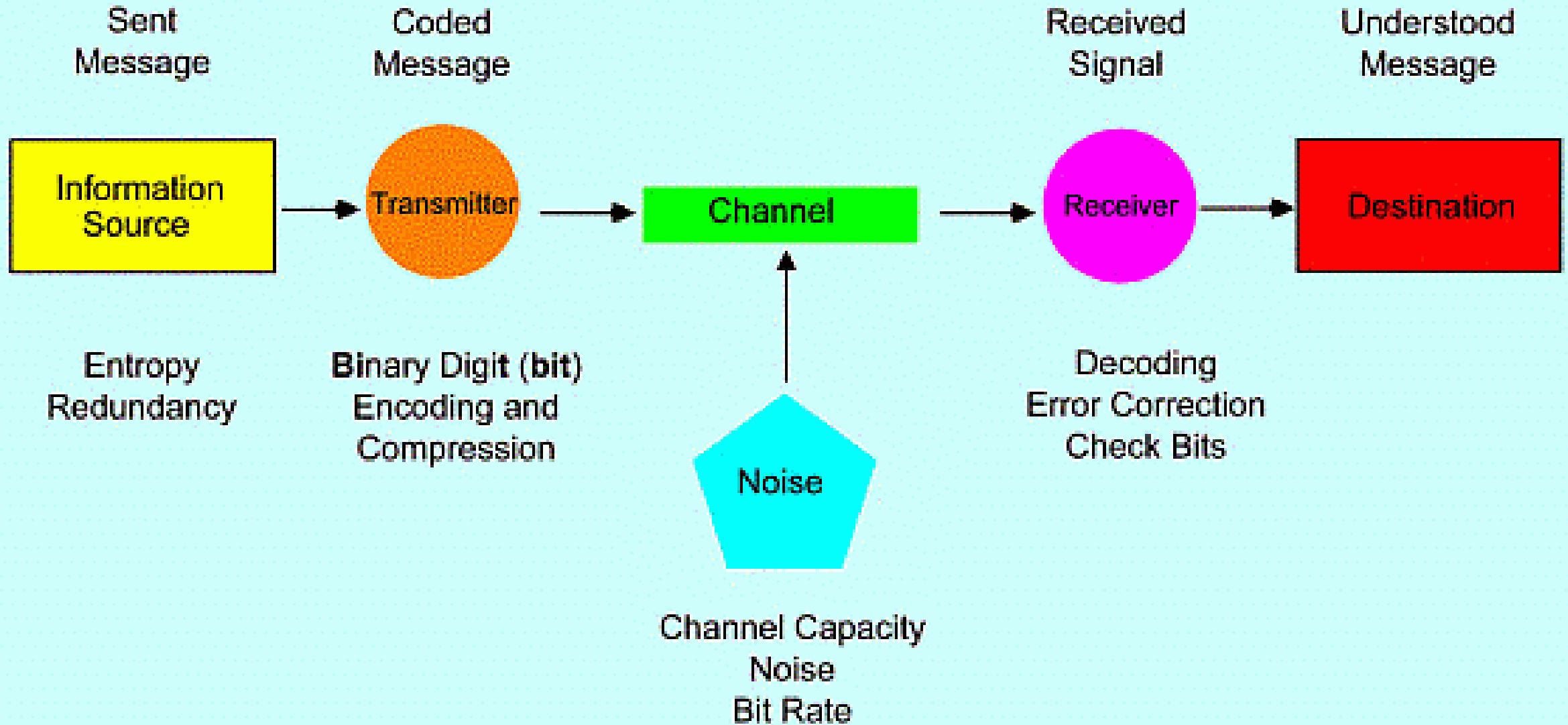
[same expression with h, i, j replaced by k, l, m]



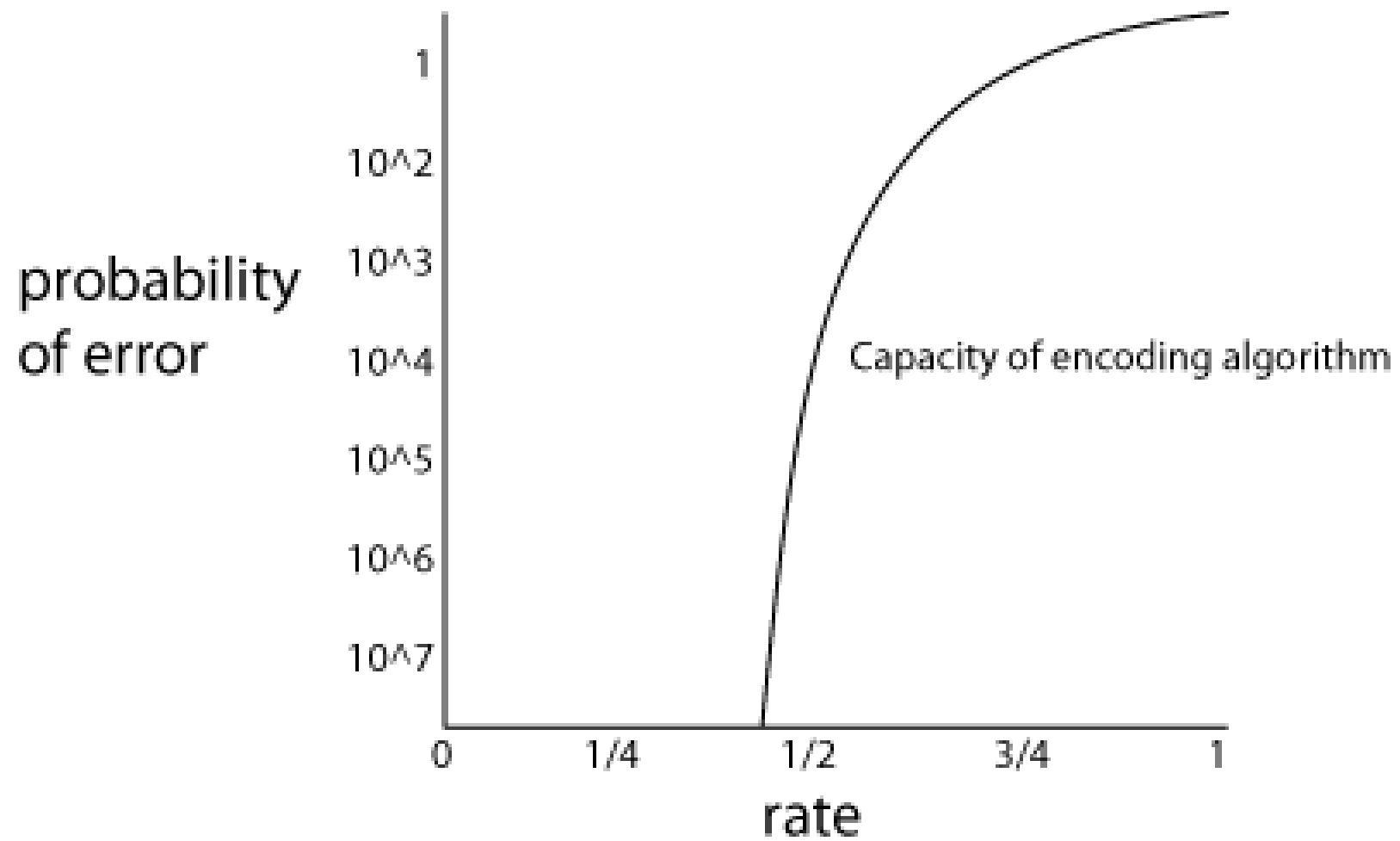
Information is
the resolution
of uncertainty

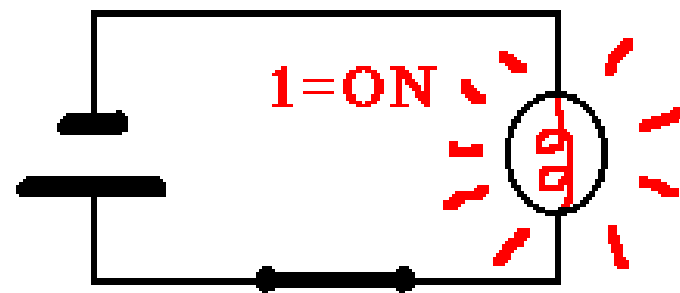
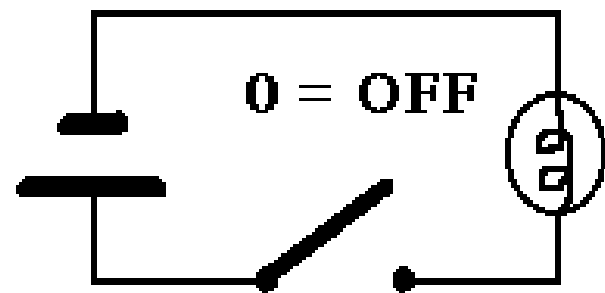
Claude Shannon

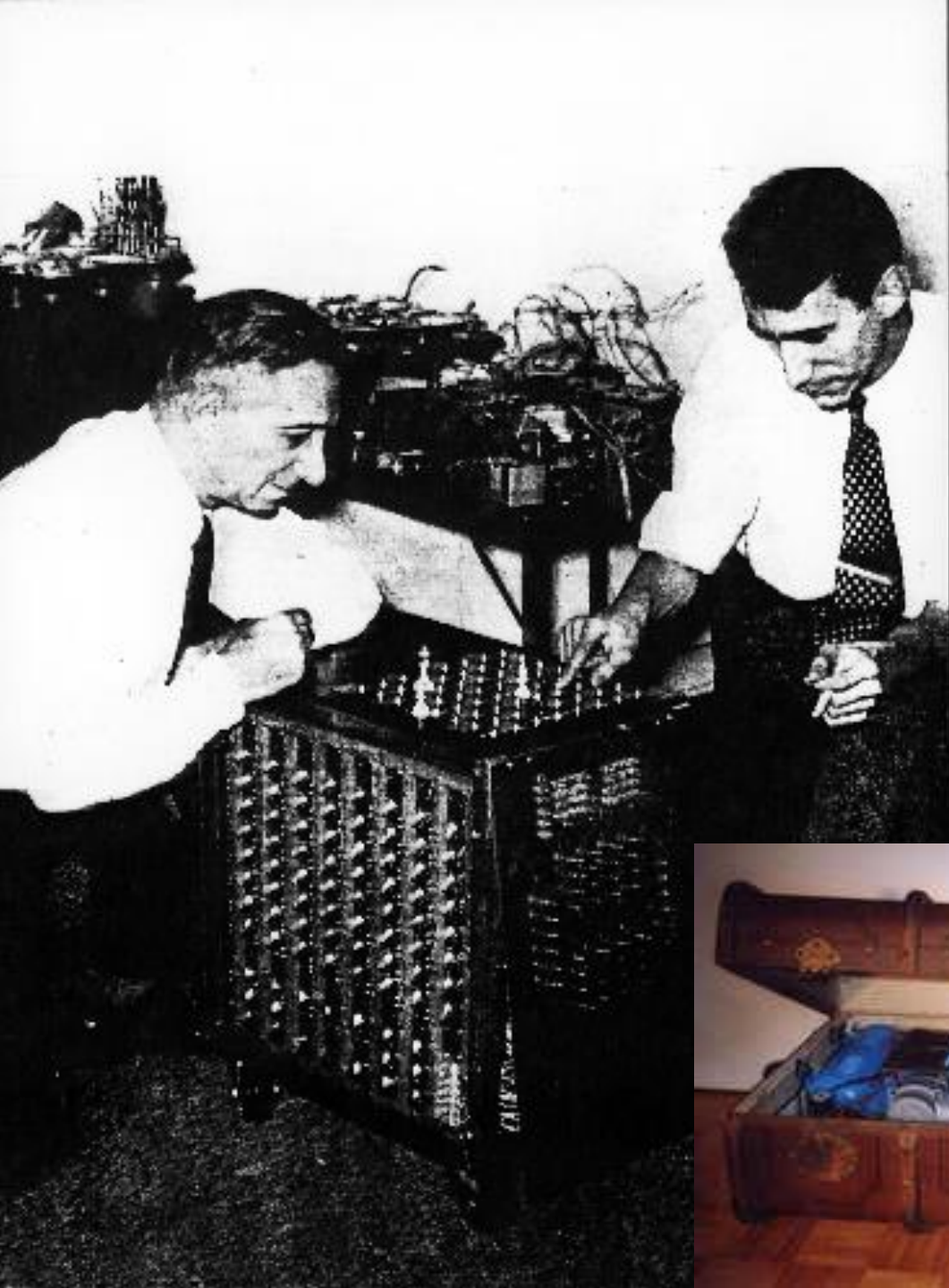
Shannon's Model of a Communication System



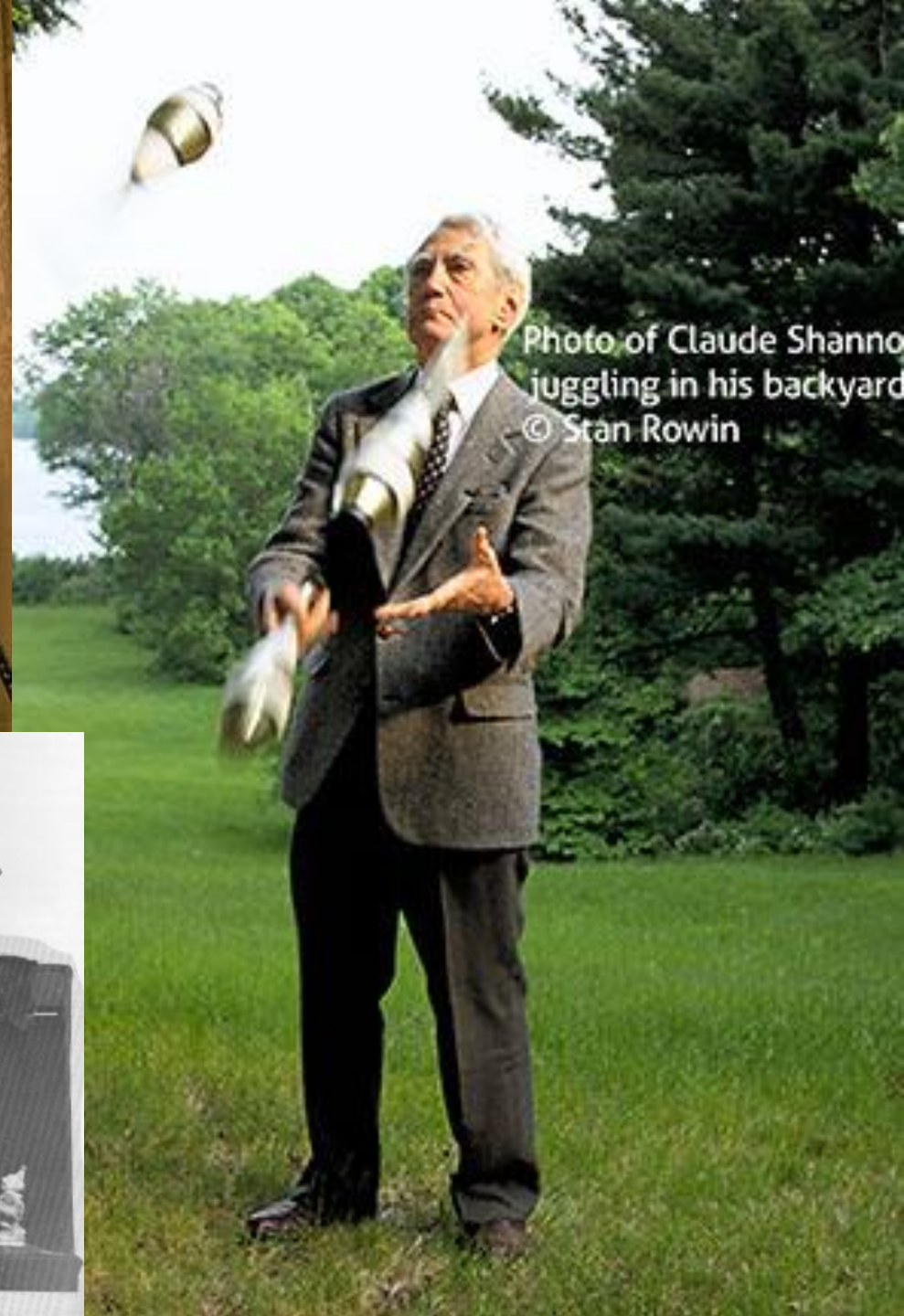
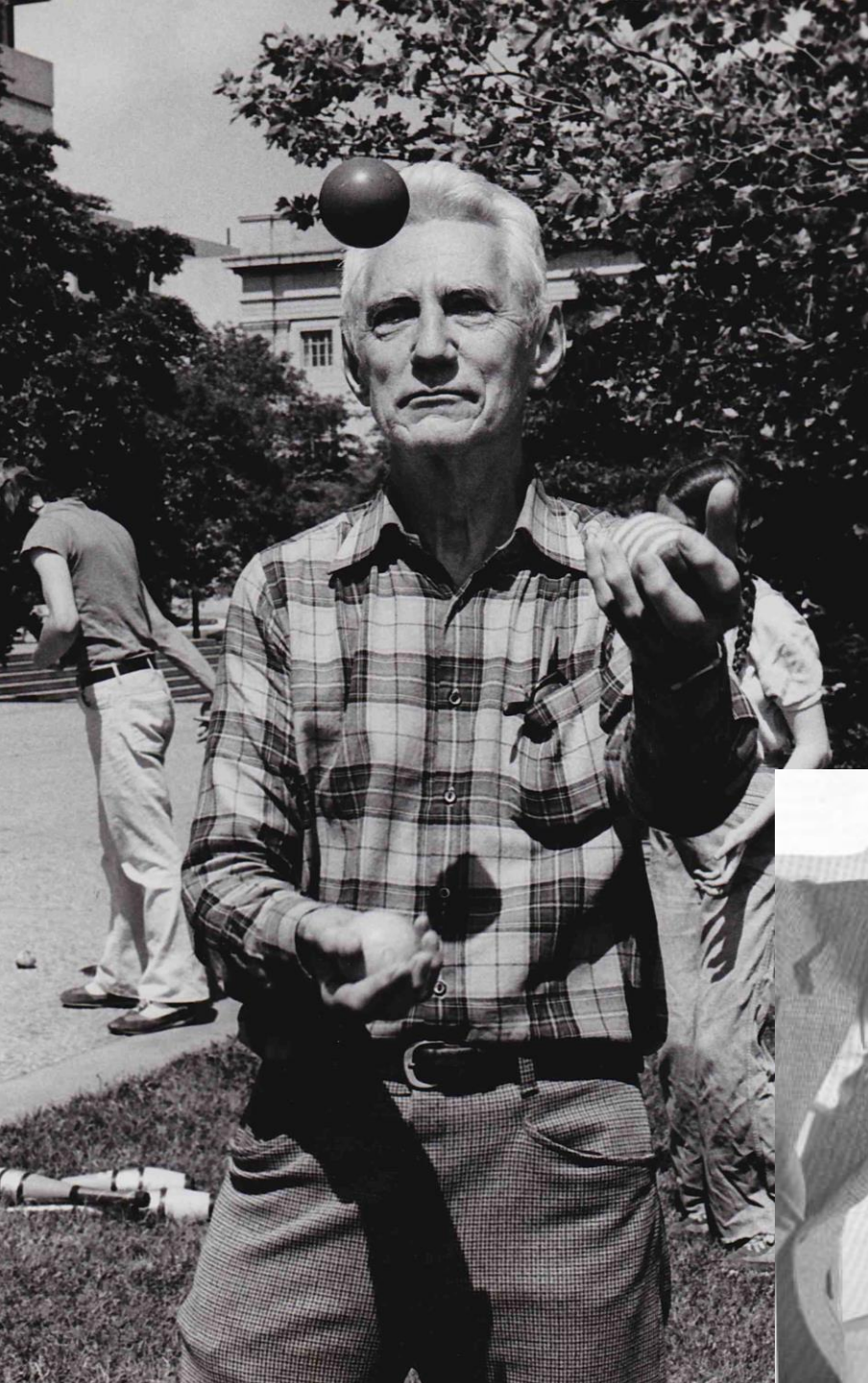
$$H = - \sum p(x) \log p(x)$$











We know the past but cannot control it. We control the future but cannot know it.



— *Claude Shannon* —