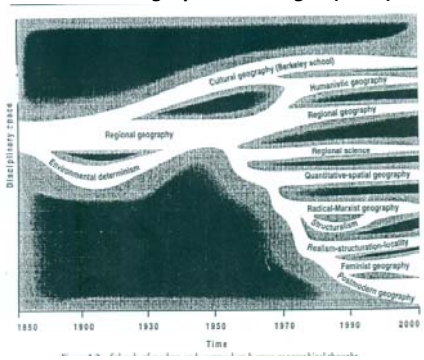
The Quantitative Revolution

was an episode in the history of American geography, occurring roughly between 1950-70, during which the primacy of descriptive regional geography was successfully challenged by a younger generation of geographers who sought a more scientific brand of geography.

From Richard Peet,
***Modern Geographical Thought* (1998)**



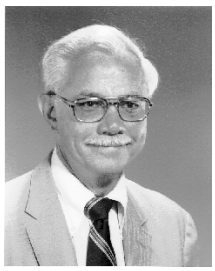
Causes of "The Quantitative Revolution"

- Technical expertise and spatial perspectives gained during World War II.
- The rise in positivism and spatial analysis in the social sciences.
- Advances in computational technology.
- Discontent of geographers, especially younger members of the discipline, concerning the nature (and "The Nature . . .) of geography.
- The resistance of "The Old Guard" to change.
- The demise of geography at Harvard.

"War is God's way of teaching Americans geography."
-- Ambrose Bierce

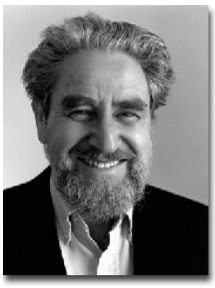
"World War II was the best thing that has happened to geography since the birth of Strabo."
-- Kirk H. Stone

William L. Garrison
(1924 -)



- Pivotal figure in "the quantitative revolution" that transformed American geography after 1950.
- Trained in advanced statistics during WWII. Focused on transportation and logistics.
- Received Ph.D. in Geography from Northwestern in 1950.
- One of the first geographers to use computers, applying advanced quantitative analysis to transportation issues.
- Taught (at U. of Washington) the first geography graduate seminar in quantitative methods.
- Enrollees became a "Who's Who in American Geography."

Zvi Grilches
(1930-1999)



- Holocaust survivor who became a leading international expert on the economic impact of the spatial diffusion of technological innovation.
- Emigrated to the U.S. after World War II and studied sociology.
- His doctoral dissertation (U. of Chicago, 1957) on the diffusion of hybrid corn in the U.S. is considered a classic in many fields, including cultural geography.
- Numerous publications, principally in Rural Sociology and other journals in the field of sociology.

The Corn Belt

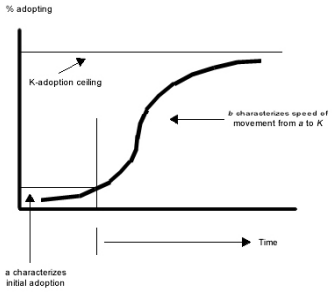
- A region in the Midwest where corn has been the dominant crop since the 1850s, replacing tall natural prairie grasses
- Since 1950, almost entirely hybrid corn.
- Most ends up as feed for livestock, especially hogs and chickens.
- Growing use for ethanol
- U.S. produces about 40%
- Of world corn crop.
- Increasingly complemented by soy beans.

Hybrid Corn (center) vs. Earlier Varieties

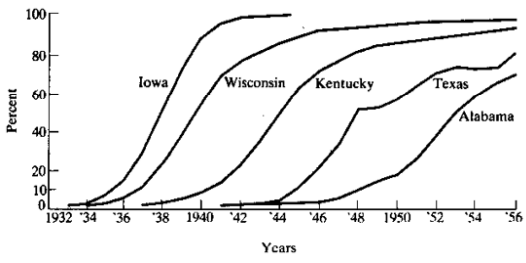
Inspecting ears of hybrid seed corn, Reinbeck, Iowa, Sept. 1939.
Photo by Arthur Rothstein for the FSA.

Corn Harvesting in the Midwest

The S-shaped adoption curve



Diffusion of hybrid corn in several states



Hybrid corn field

1508 Woodcut showing a "calculating table" (a type of abacus) in use in Europe.

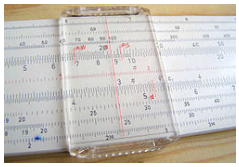
Abacus

(the one below is from China)

- **The abacus (also known by other names) is an ancient device used to perform a variety of arithmetic processes.**
- **Takes a variety of forms, most consisting of a rectangular wooden frame containing a series of parallel axles, each holding a number of counters having specific values whose movement on the axles corresponds to a desired mathematical process.**
- **Originated in Mesopotamia as early as 2700 BC.**
- **The plural is *abaci*. A user is an *abacist*.**

Abaci

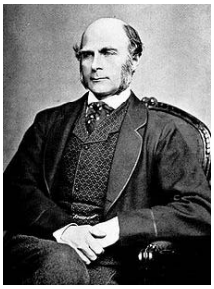
Slide Rule



- **A hand-held device (about 10 inches long) used to perform multiplication, division, roots, logarithms and trigonometry.**
- **A prototype was invented in England around 1620.**
- **Operated by sliding adjoined rulers (containing finely printed logarithmic scales, as at bottom left) relative to each other to perform the desired numerical operation.**
- **Was the principal tool for science and engineering until about 1974, when it was made obsolete by the first electronic calculators.**

Sir Francis Galton

(1822-1911)



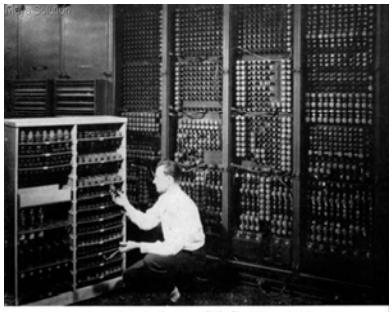
- **English polymath noteworthy for contributions to geography, meteorology and statistics.**
- **In an age before electronic calculators, he invented the concept of statistical correlation, and championed the concept of regression from the mean.**
- **Travelled widely in Europe, the Middle West, and Africa.**
- **Led a 2-year (1850-52) expedition to produce the first maps of what is now Namibia.**
- **Wrote "The Art of Travel," a handbook of practical advice for travelers of his time. The volume is still in print.**

Mechanical Calculator from the 1950s-1960s

MADAS 20BZS circa 1950s-1960s

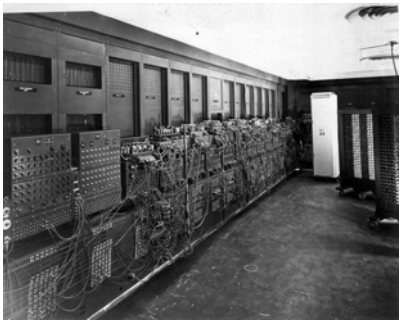
The Texas Instruments TI-30 Hand-held Calculator (1976)

Early computers, like the ENIAC (1946), were HUGE
(ENIAC = Electronic Numerical Integrator and Computer)

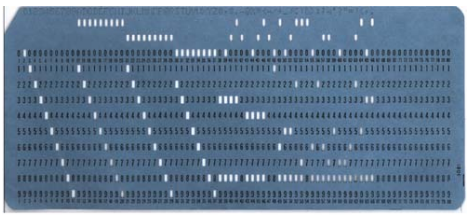


Replacing a bad tube meant checking among ENIAC's 19,000 possibilities.

Many early computers took up whole floors, yet had less capability than a modern hand-held device.



In the early days of computing, computers were computers, not word processors and multi-taskers. Decks of "punch cards" (example below) were used to tell a computer what to and to provide it with raw data to do it.



In time, programming was developed to provide instructions to a computer. This took the form of an artificial language (example at left), such as FORTRAN, COBOL, and C.

The concept of a "computer language" led to an interesting philosophical question as regards graduate training in geography":

Is talking to a computer like talking to, say, a Spaniard or German in her/his native language? If so, then a graduate student in geography might ask, "Can I satisfy my [foreign] language requirement (common for graduate students at the time) by learning FORTRAN?"

How does an academic discipline progress (as by adopting new concepts, methodologies and techniques) if its "gatekeepers" – i.e., those who control publication, promotion and tenure -- are opposed to new ways of doing things?

Thomas S. Kuhn

(1922-1996)

- American historian/philosopher of science.
- Wrote the highly influential and controversial book *The Structure of Scientific Revolutions* (1962).
- Argued against the "normal science" viewpoint that disciplinary progress is a slow, incremental accumulation of knowledge.
- Argued instead that "normal science" leads to a "crisis phase" when the existing paradigm (mode of explanation) proves unsatisfactory.
- The result is a period of upheaval followed by a "paradigm shift" that involves adoption of a more satisfactory mode of explanation.

Sequence of events in a scientific revolution, according to Kuhn

- Preparadigm period: Various schools of thought, often associated with noteworthy individuals, vie for disciplinary dominance.
- Professionalization: Responding to a need to define what a discipline is all about, one paradigm comes to the fore. (Happened in geography when a university degree became necessary to become a high school geography teacher.)
- A period of normal science ensues.
- A crisis phase develops when the existing paradigm proves increasingly unable to solve problems or operate satisfactorily.
- A revolutionary phase, characterized by a paradigm shift occurs when new exemplars prove superior to old ones. The new way of doing things often captures the allegiance of young practitioners. The revised science may adopt the new paradigm or exist as a contested discipline.

Fred Schaefer (1904-1953)

- German-born and German-educated geographer who, in later life, taught at the University of Iowa.
- A student of economic geography and population statistics.
- A major figure in American geography's "quantitative revolution."
- Famous for his article "Exceptionalism in Geography: A Methodological Examination," Annals of the Association of American Geographers, Vol. 43 (1953): 226-49.
- The article is a direct challenge to the Harsthorne's The Nature of Geography, in particular its idiographic approach to the subject.
- Calls for a more scientific approach to geography, based on a search for generalizations and laws.
- A rallying call for the younger generation intent on transforming geography into a true social science.

Philosophies of Geography

Positivism

(a.k.a. Logical Positivism, Modernism, Scientism . . .)

Philosophy: The goal of geography should be to generate laws that explain and predict events and patterns in the real world. True understanding of the world is gained through verifiable experience in the form of data that are collected, analyzed, and reported in an objective manner (that is, free of investigator bias).

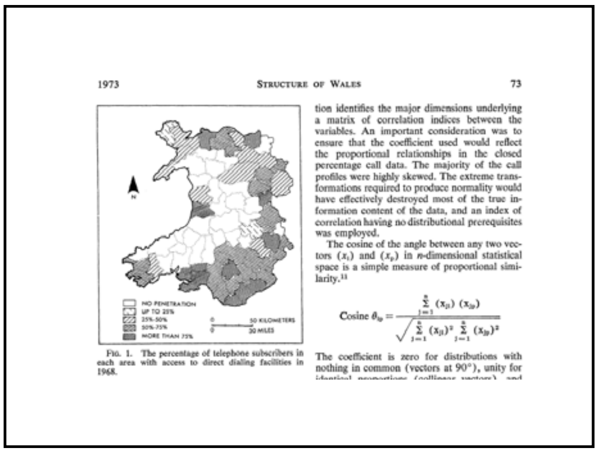
Epistemology: The scientific method. That is, a method of research in which a problem is identified, stated in the form of a hypothesis, relevant data are gathered and analyzed in an unbiased way, leading to acceptance or rejection of the hypothesis.

Paradigm: A scientific experiment.

THE FORMAL AND FUNCTIONAL STRUCTURE OF WALES

DAVID CLARK

ABSTRACT. A central postulate of field theory, that formal activities and functional linkages describe similar and interdependent patterns in space, is empirically examined in a study of telecommunications in Wales. The structure of Wales is defined by a set of telephone subscriber variables and by the major patterns of long distance telephone calls. The Welsh system is composed predominantly of a set of central place, resort, and coastal industrial activities. A second level of organization is produced by agricultural and mining communities. The formal and functional dimensions give rise to similar but not identical patterns of regions. KEY WORDS: *Field theory, Spatial systems, Telecommunications, Wales.*



1973 STRUCTURE OF WALES 73

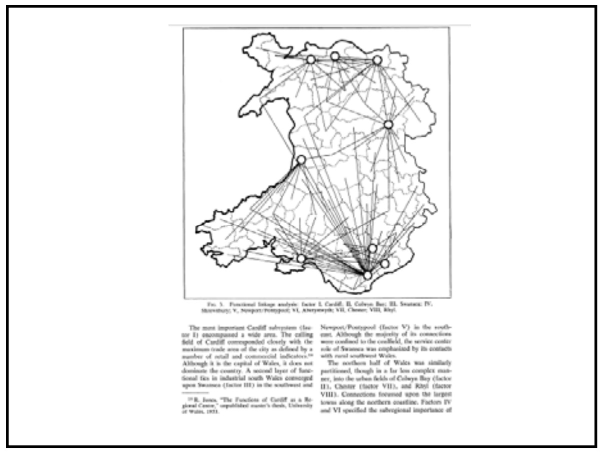
FIG. 1. The percentage of telephone subscribers in each area with access to direct dialing facilities in 1968.

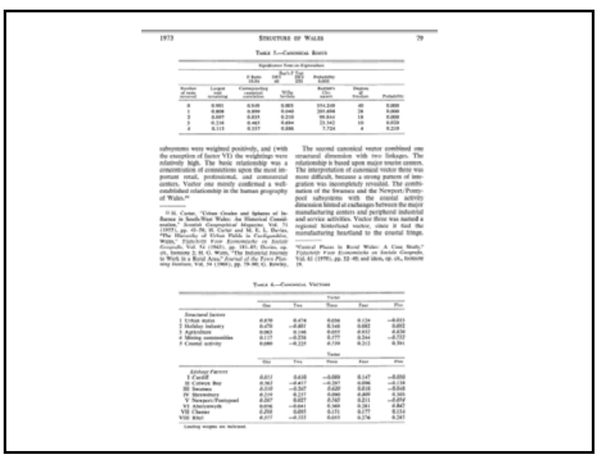
tion identifies the major dimensions underlying a matrix of correlation indices between the variables. An important consideration was to ensure that the coefficient used would reflect the proportional relationships in the closed percentage call data. The majority of the call profiles were highly skewed. The extreme transformations required to produce normality would have effectively destroyed most of the true information content of the data, and an index of correlation having no distributional prerequisites was employed.

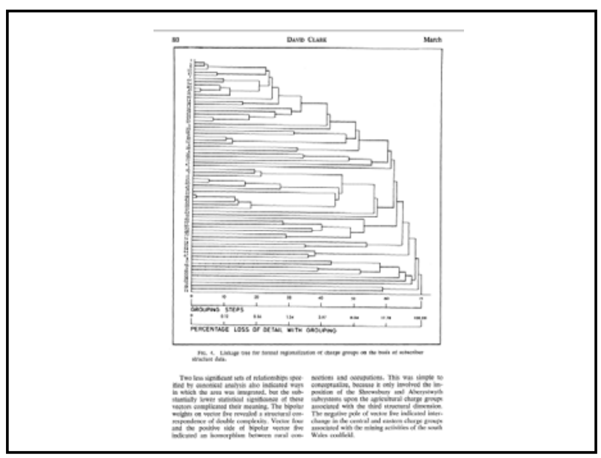
The cosine of the angle between any two vectors (x_i) and (x_p) in n-dimensional statistical space is a simple measure of proportional similarity.[11]

$$\text{Cosine } \theta_{ip} = \frac{\sum_{j=1}^{n} (x_{ji})(x_{jp})}{\sqrt{\sum_{j=1}^{n} (x_{ji})^2 \sum_{j=1}^{n} (x_{jp})^2}}$$

The coefficient is zero for distributions with nothing in common (vectors at 90°), unity for







Augean:
resembling the Augean stables in filth or degradation; difficult and unpleasant.

Augean stables:
In Greek mythology, the stables in which King Augeas kept 3,000 oxen, and which had not been cleaned for 30 years. Hercules diverted a river through them and cleaned them in a day.

"*. . . Quantitative Revolution* was a disastrous misnomer. . . It was not the numbers that were important, but a whole new way of looking at things geographic. [Namely, and as noted by Whitehead,] to see what is general in what is particular and what is permanent in what is transitory."

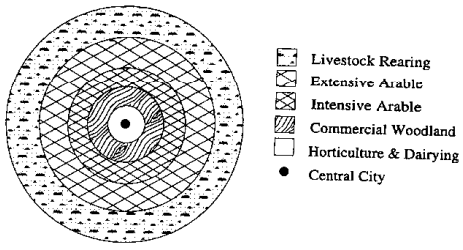
-- Peter Gould

Peter Gould, "Man Against His Environment: A Game Theoretic Framework."

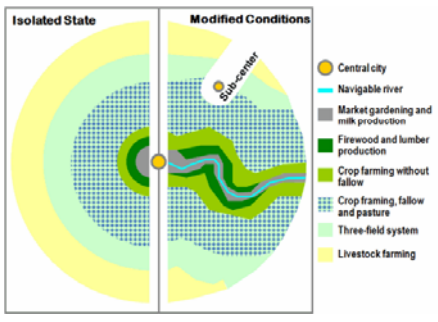
Johann Heinrich von Thunen
(1783-1850)

- German economist and land manager.
- Developed a theory to explain the geography and value of agricultural land use that surrounded a market town.
- Used concentric rings to visually portray his theory, presented in *The Isolated State* (1826).
- It took more than a century for geographers to appreciate his work, which is now a mainstay of many textbooks on introductory human and economic geography.

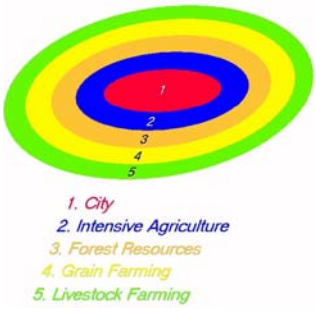
Von Thunen land use model



Von Thunen land use model

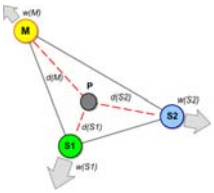


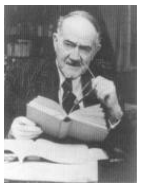
Von Thunen land use model



Alfred Weber
(1868-1958)

Theory/model for the Location of Industries





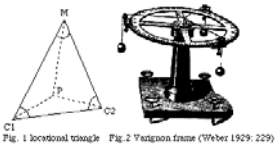
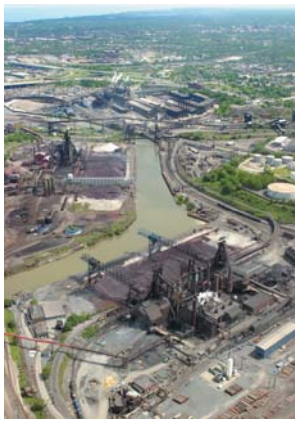


Fig. 1 locational triangle Fig. 2 Varignon frame (Weber 1929: 229)

Recipe for Making Steel
(art by Phil Gersmehl)

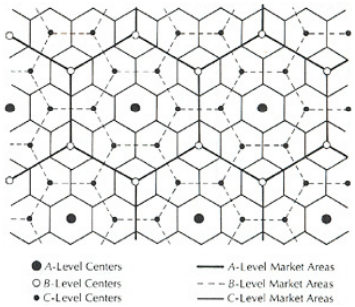


Heavy industry on the Cuyahoga River near Cleveland, Ohio

Walter Christaller
(1893-1969)

- German geographer who created central place theory (1933).
- Seeks to explain the sizes and distribution of cities within the context of the economic services they provide.
- Theory relies on threshold (the minimum population needed to support an economic activity) and range (the maximum distance consumers will travel to acquire a good).
- Hexagonal arrangement.

Idealized distribution of urban centers in Central Place Theory



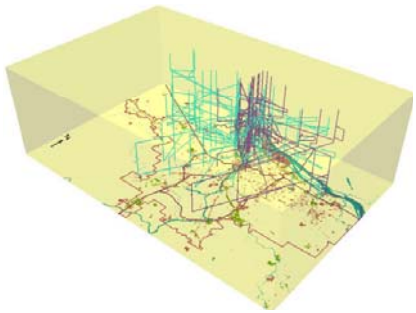
Torsten Hagerstrand
(1916-2004)

- Swedish geographer famous for his work on migration, cultural diffusion, and time geography.
- An early user of mathematical models to help predict the spread of people, ideas, and culture.
- Noted for spatial modeling based on Monte Carlo Simulation, and time-space data.
- One of the first quantitatively inclined geographers to address the limitations of quantitative techniques and models, particularly their focus on groups instead of individuals.

Monte Carlo Simulation

- A statistical technique designed to model a multi-step process based on the probabilities of certain events happening along the way.
- In the field of geography, it has been used to help predict how an innovation will spread through a population of potential adopters, taking into account the probability of diffusion between possessors and potentials adopters based on the distances between them and other factors.
- Invented in the 1940s by a group of physicists, and named in honor of the Monte Carlo Casino because the use of probabilities evoked the notion of gambling.

Time Space "aquarium" showing movement on a given day of African American (purple) and Asian (green) women in Portland, Oregon. Research by Mei-Po Kwan.

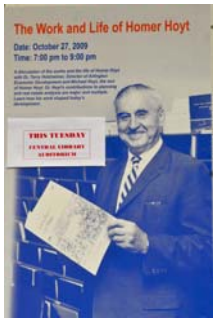


Ernest Burgess
(1886-1966)

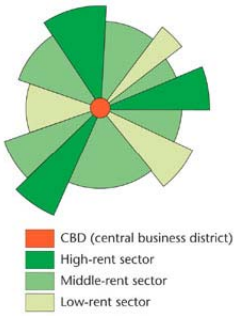
- Highly influential urban sociologist at the University of Chicago.
- Co-inventor in 1924 (with Robert Park) of the "Concentric Ring Model" of urban form, the first to explain the geography of urban social groups.
- Broadly based on the concentric land use model of von Thunen.

Concentric Zone Model of urban form by Ernest Burgess (1925)

Homer Hoyt
(1895-1984)



- Land economist and real estate consultant
- His 1933 doctoral dissertation, *One Hundred Years of Land values in Chicago,* led to his "Sector Model of Urban Form."
- Based on Chicago, the model refines the concentric ring model by accounting for the impact of transportation systems that radiated from the Central Business District.

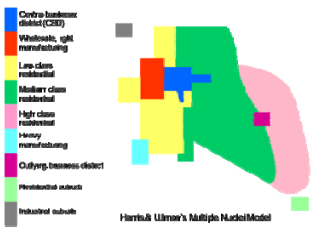


Homer Hoyt's Sector Model of Urban Form (1939)

Hoyt's Sector Model was influenced by the effects of road and rail systems that radiated outward from downtown Chicago

Chicago provided the real-world inspiration for the Burgess Model

Multiple Nuclei Model
of urban form by
Chauncy Harris and Edward Ullman (1945)

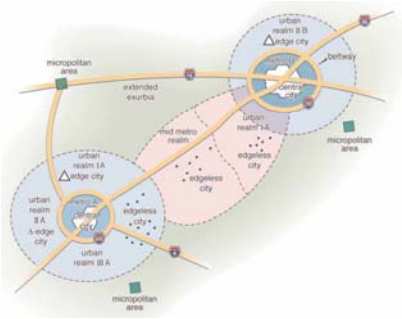


The Multiple-Nuclei Model of Urban Growth

- Proposed in 1945 by geographers Chauncy Harris and Edward Ullman in their book, *The Nature of Cities.*
- Viewed the previous models as simplistic and obsolete for not accounting for mass automobile ownership.
- Based on the notion that car ownership results in greater personal mobility, leading to the development of multiple centers of particular kinds of land use (e.g., shopping centers, office parks, heavy industries, housing developments).

Megapolitan Urban Model

by Robert Lang and Paul Knox (2009)



Criticisms of Quantification

- **Human behavior is much too complex to be adequately described by statistics and models.**
- **Specifically, they cannot give due consideration to the influences of culture, experience, preference, perception, and/or whimsy.**
- **Social statistics reflect characteristics of populations, not individuals.**
- **There is no guarantee that the scientific method, as applied to geography, is really scientific or objective due to researcher choice of variables and possible lack of ideal data.**