INTER-FACULTY MASTER PROGRAM on

COMPLEX SYSTEMS and NETWORKS

SCHOOL of MATHEMATICS
SCHOOL of BIOLOGY
SCHOOL of GEOLOGY
SCHOOL of ECONOMICS

ARISTOTLE UNIVERSITY of THESSALONIKI

Net Awareness 1: History

Ι. Αντωνίου, Δ. Κουγιουμτζης,
Φ. Κολυβα-Μαχαιρα, Γ. Μητακιδης,
Χ. Μπρατσας, Π. Μωυσιαδης,
Α. Παπαδοπουλου, Ν. Φαρμακης, Ν. Χασαναγκας

ΣΧΟΛΗ ΘΕΤΙΚΩΝ ΕΠΙΣΤΗΜΩΝ
Α.Π.Θ

05-12-2014

600 πΧ Ομφαλος Δελφων

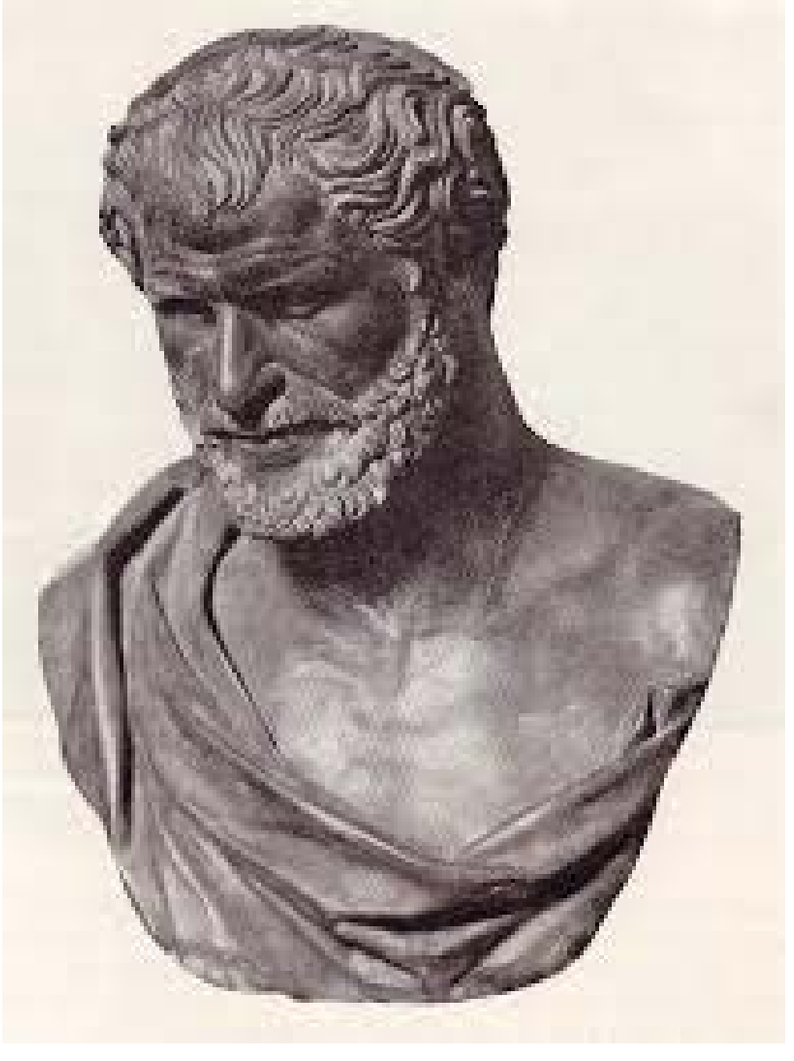
Δικτυο Ανθρωπινων Σχεσεων

Networks History

Ηρακλειτος 500 πΧ

Η δυνατότης αυτορρύθμισης μέσω αλληλεπιδράσεων που επάγουν αμοιβαίες σχέσεις είχε επισημανθεί από τον Ηράκλειτο, ο οποίος τονίζει ότι:

«ἕν τὸ σοφόν, ἐπίστασθαι γνώμην
ὅκη κυβερνᾶται πάντα διὰ πάντων»
[Απόσπ. 41].



«συνάψιες ὅλα καὶ οὐχ ὅλα,
συμφερόμενον διαφερόμενον,
συνᾷδον διᾷδον,
καὶ ἐκ πάντων ἓν καὶ ἐξ ἑνὸς πάντα»
[Απόσπ. 10].

Networks History

Parts-Whole Analysis-Synthesis, Modular Decomposition

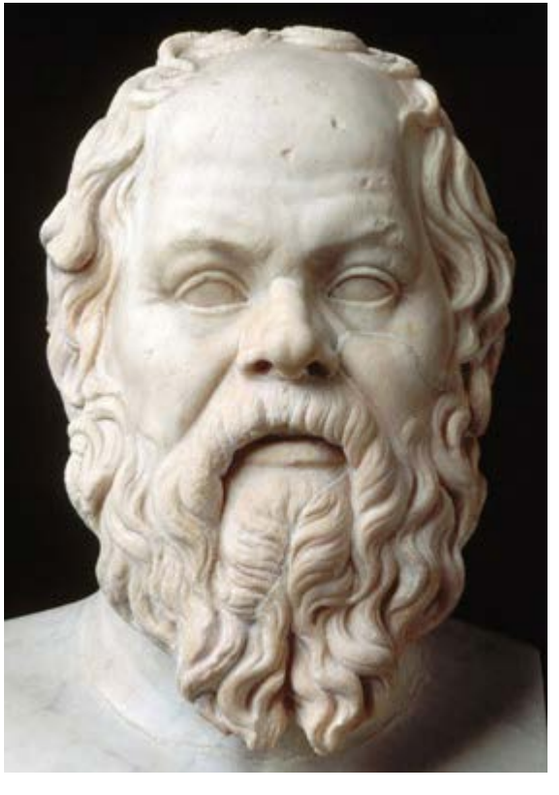
Πλατων 390 πΧ: Σωκρατης

εἰς μίαν τε ἰδέαν συνορῶντα ἄγειν τὰ πολλαχῇ διεσπαρμένα, ἵνα ἕκαστον ὁριζόμενος δῆλον ποιῇ περὶ οὗ ἂν ἀεὶ διδάσκειν ἐθέλῃ…

τὸ πάλιν κατ᾽ εἴδη δύνασθαι διατέμνειν κατ᾽ ἄρθρα ᾗ πέφυκεν, καὶ μὴ ἐπιχειρεῖν καταγνύναι μέρος μηδέν, κακοῦ μαγείρου τρόπῳ χρώμενον.

[Πλατων Φαιδρος 265δ,ε]

…First, the taking in of scattered particulars
under one Idea, so that by precise definition,
everyone understands what is being talked about
...Second, the analysis of the Idea into parts,
by dividing it at the joints, naturally,
not breaking any part as a bad carver might."
[Plato, Phaedrus, 265d,e]



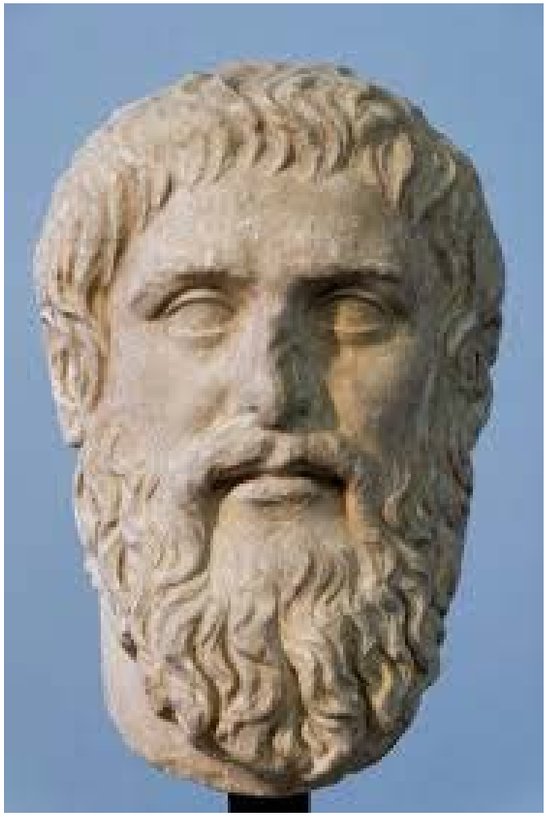
Networks History

System

Πλατων 390 πΧ

*“ἀνάγκη γὰρ τό γε τοσοῦτον φράζειν: πᾶν διάγραμμα ἀριθμοῦ τε **σύστημα***
*καὶ ἁρμονίας **σύστασιν** ἅπασαν τῆς τε τῶν ἄστρων περιφορᾶς τὴν ὁμολογίαν*
*οὖσαν **μίαν** ἁπάντων ἀναφανῆναι δεῖ τῷ κατὰ τρόπον μανθάνοντι, φανήσεται δέ, ἄν, ὃ λέγομεν,*
ὀρθῶς τις εἰς ἓν βλέπων μανθάνῃ
***δεσμὸς** γὰρ πεφυκὼς πάντων τούτων εἷς ἀναφανήσεται διανοουμένοις” [Πλατων Επανωμις 991ε]*

*“for it is necessary to explain it thus far: every diagram, and **system** of number,*
*and every **combination** of harmony, and the agreement of the revolution of the stars*
*must be made manifest as **one** through all to him who learns in the proper way, and will be made manifest if,*
as we say, a man learns aright by keeping his gaze on unity”
[Plato Epanomis 991e]

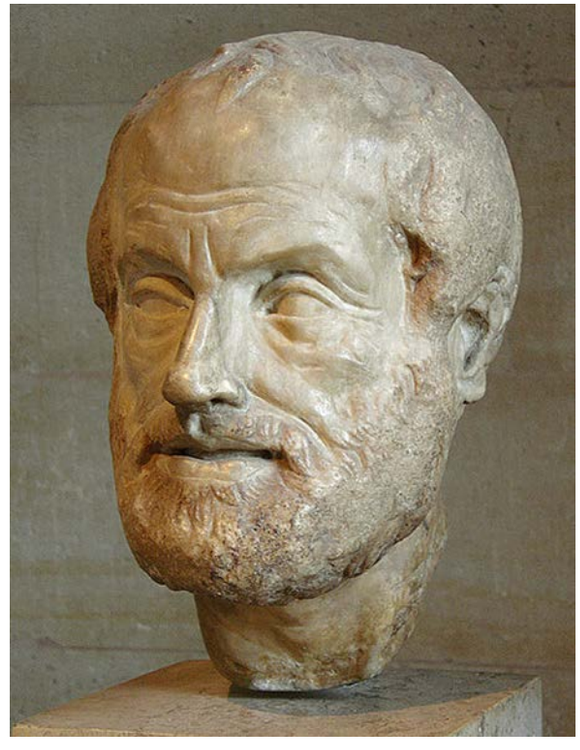


Nearness Affinity Eros Εγγυτης-Συγγενεια Ερως

Ο ἔρως ἔμφυτος ἀλλήλων τοῖς ἀνθρώποις
Και τῆς ἀρχαίας φύσεως συναγωγεὺς
καὶ ἐπιχειρῶν ποιῆσαι ἓν ἐκ δυοῖν
καὶ ἰάσασθαι τὴν φύσιν τὴν ἀνθρωπίνην
[Πλατων Συμπ. 191δ],

ὅμοιον ὁμοίῳ ἀεὶ πελάζει
[Πλατων Συμπ. 195β],

Networks History



Αριστοτελης 330 πΧ

τί αἴτιον τοῦ ἓν εἶναι;

πάντων γὰρ ὅσα πλείω μέρη ἔχει

καὶ μὴ ἔστιν οἷον σωρὸς τὸ πᾶν

ἀλλ' ἔστι τι τὸ ὅλον παρὰ τὰ μόρια, ἔστι τι αἴτιον, ἐπεὶ

καὶ ἐν τοῖς σώμασι τοῖς μὲν ἀφὴ αἰτία τοῦ ἓν εἶναι τοῖς

δὲ γλισχρότης ἤ τι πάθος ἕτερον τοιοῦτον.

ὁ δ' ὁρισμὸς λόγος ἐστὶν εἷς οὐ συνδέσμῳ καθάπερ ἡ Ἰλιὰς

ἀλλὰ τῷ ἑνὸς εἶναι. τί οὖν ἐστὶν ὃ ποιεῖ ἓν τὸν ἄνθρωπον, καὶ διὰ τί

ἓν ἀλλ' οὐ πολλά, οἷον τό τε ζῷον καὶ τὸ δίπουν, ἄλλως

τε δὴ καὶ εἰ ἔστιν, ὥσπερ φασί τινες, αὐτό τι ζῷον καὶ αὐτὸ δίπουν;

Αριστοτελης μετα τα Φυσικα 1045α 9-19.

Στα οντα που αποτελουνται απο πολλα μέρη και δεν ειναι ως ενας σωρος, υπάρχει κάποιο αιτιον. εις άλλα π. χ. από τα σώματα αιτια της ενοτητος ειναι ή επαφή , εις άλλα κάποια κολλητικη Ιδιότης η κάποια άλλη παρομοία Ιδιότης

the whole is more than the sum of its parts.

Networks History

Διαλογος Μενανδρου-Nagasena ~120 πΧ

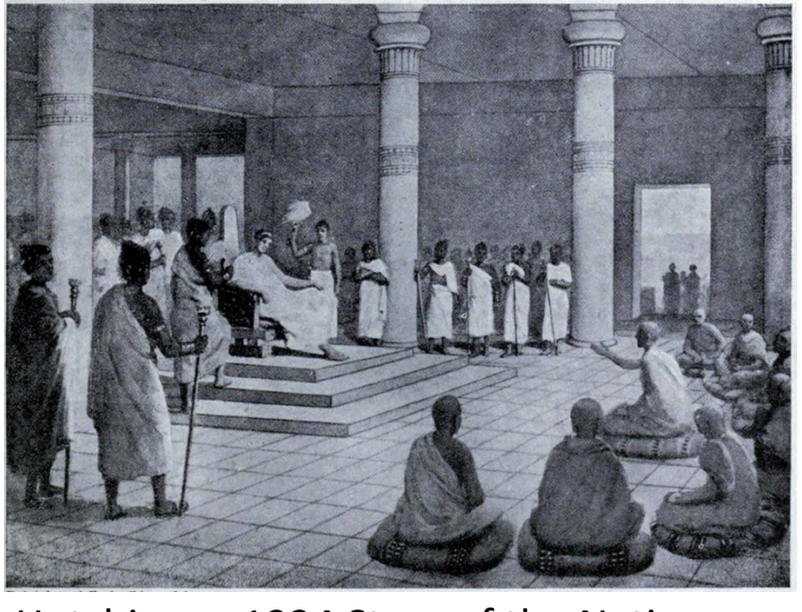
Nagasena:

«just as the King's chariot is neither its wheels nor its framework nor its axle nor its pole, nor its ropes,
neither is man his matter, form, impressions, ideas, instincts or consciousness,
nor the combination of these parts, nor does man exists outside them. . .»

King Milinda of Bactriana:

“It is all these things, the wheels and the framework and the axle and the pole and the ropes,
in their interdependence that give the denomination *chariot*"

The Questions of King Milinda (Milinda Panha)
Translations: Rhys T.W. 1890 and Horner I.B. 1969



Hutchinson 1934 Story of the Nations,
Hutchinson and Co., London.

Τετραδραχμα Βασιλεως Σωτηρος Μενανδρου ~130πΧ

The Chariot Story is quoted by BORGES J. L. 1962
in “Labyrinths, New Directions, New York

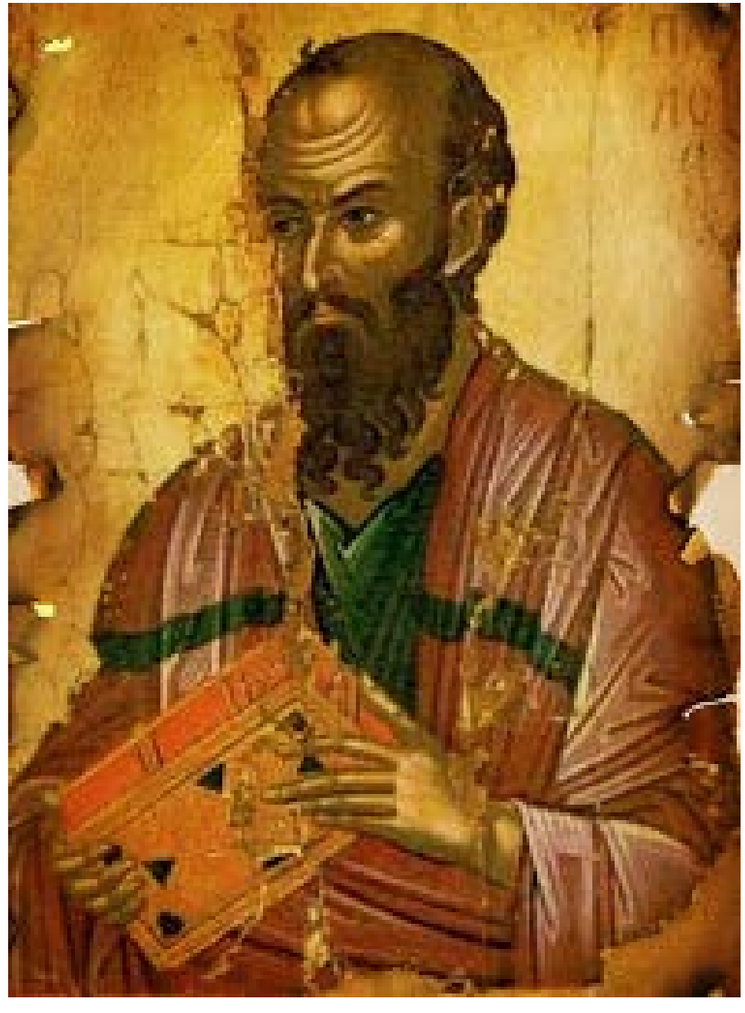
Networks History

Αποστολος Παυλος 60

ἵνα μὴ ᾖ σχίσμα ἐν τῷ σώματι

ἀλλὰ τὸ αὐτὸ ὑπὲρ ἀλλήλων μεριμνῶσιν τὰ μέλη

[Προς Κορινθιους Α 12: 25]



Μαρκος Αυρηλιος 180

επισημανε ότι τα πάντα, συμπεριλαμβανομένου του Κόσμου καθώς και του Θείου αλληλοπροσδιορίζονται μέσω συνδέσεων:

«Πάντα ἀλλήλοις ἐπιπέπλεκται καὶ ἡ σύνδεσις ἱερά,

καὶ σχεδόν τι οὐδὲν ἀλλότριον ἄλλο ἄλλῳ,

συγκατατέτακται γὰρ καὶ συγκοσμεῖ τὸν αὐτὸν κόσμον.

κόσμος τε γὰρ εἷς ἐξ ἁπάντων

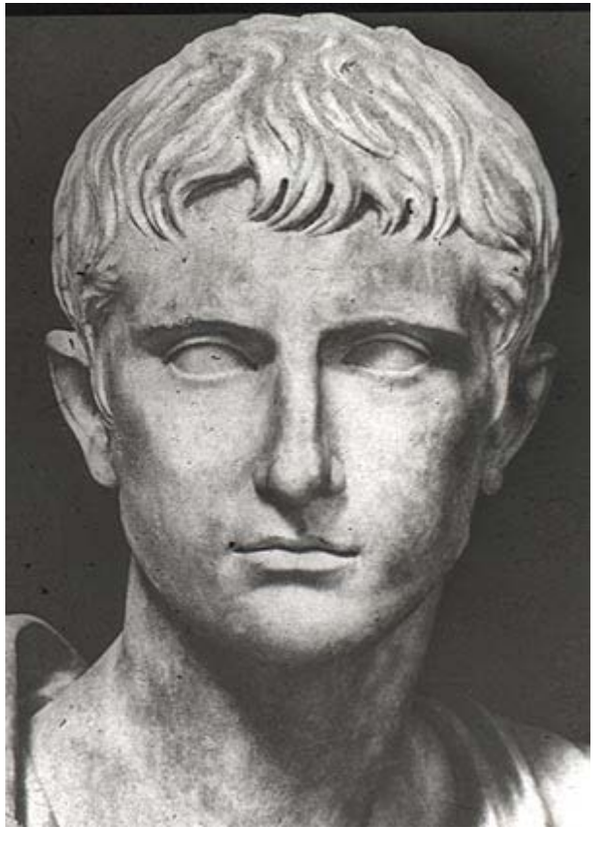
καὶ θεὸς εἷς δἰ ἁπάντων καὶ οὐσία μία καὶ νόμος εἷς,

λόγος κοινὸς πάντων τῶν νοερῶν ζῴων, καὶ ἀλήθεια μία,

εἴγε καὶ τελειότης μία τῶν ὁμογενῶν

καὶ τοῦ αὐτοῦ λόγου μετεχόντων ζῴων»

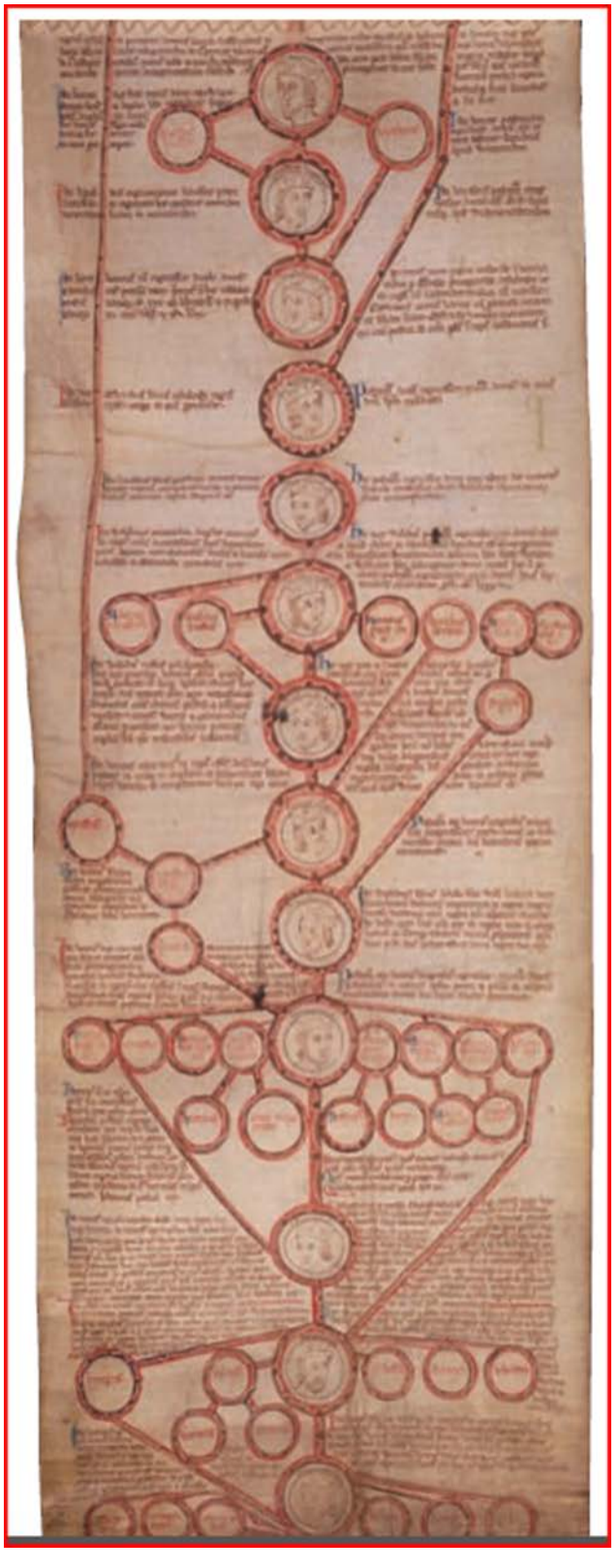
[Μάρκος Αυρήλιος, Τα εις Εαυτόν (7,9)].



Networks History

1272

A visually spare, elegant record of English history from Alfred the Great (871–99) to Henry III (1216–72), includes 23 roundel portraits of English kings



Rosenberg D. and Grafton A. 2010,
Cartographies of Time Princeton Architectural Press, New York.

Networks History

1585 Lorenz Faust

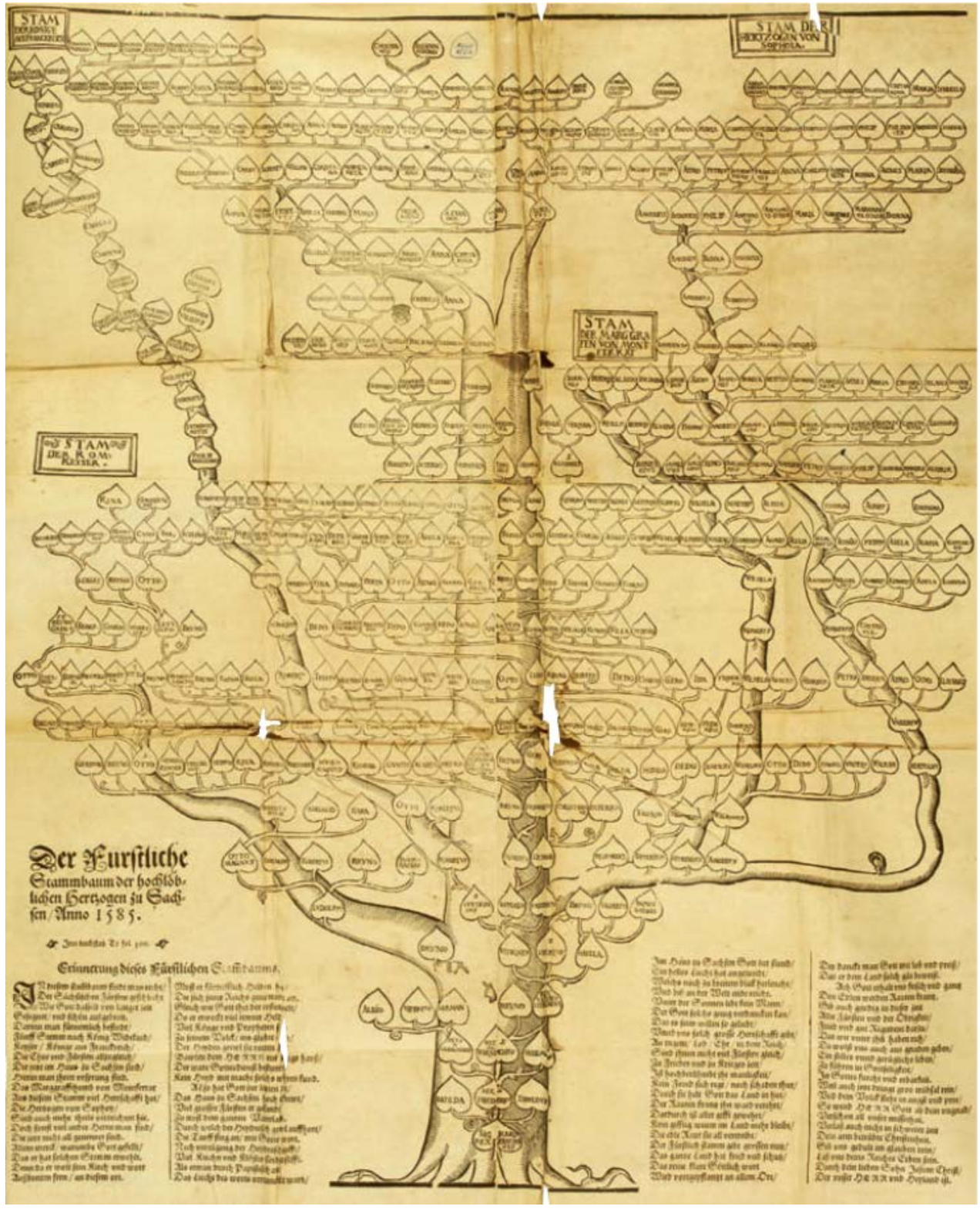
Anatomia statuae Danielis

Rosenberg D. and Grafton A. 2010,

Cartographies of Time

Princeton Architectural Press,

New York.



Networks History

Isaac Newton 1700

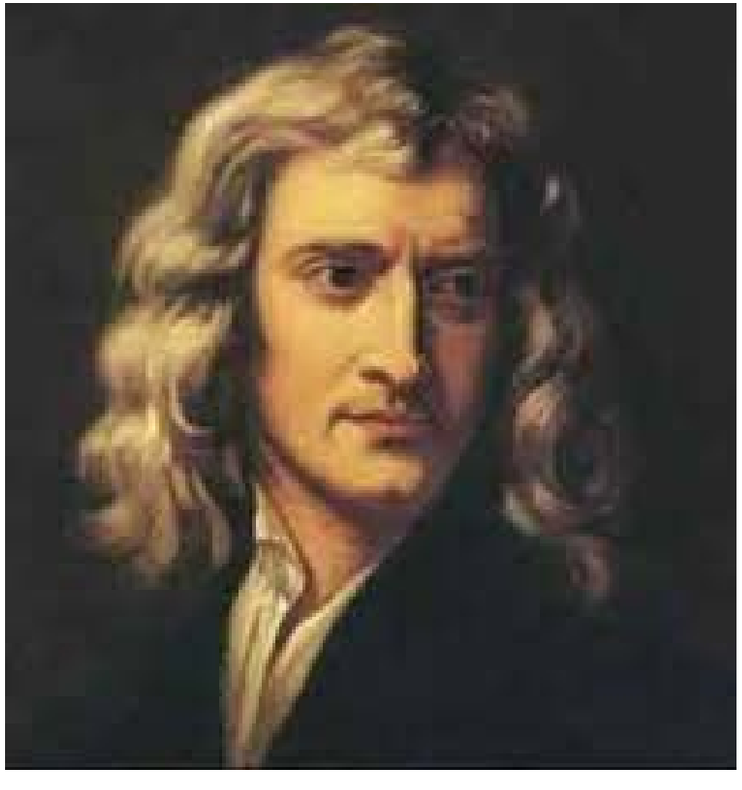
Το Σημασιολογικό Newton

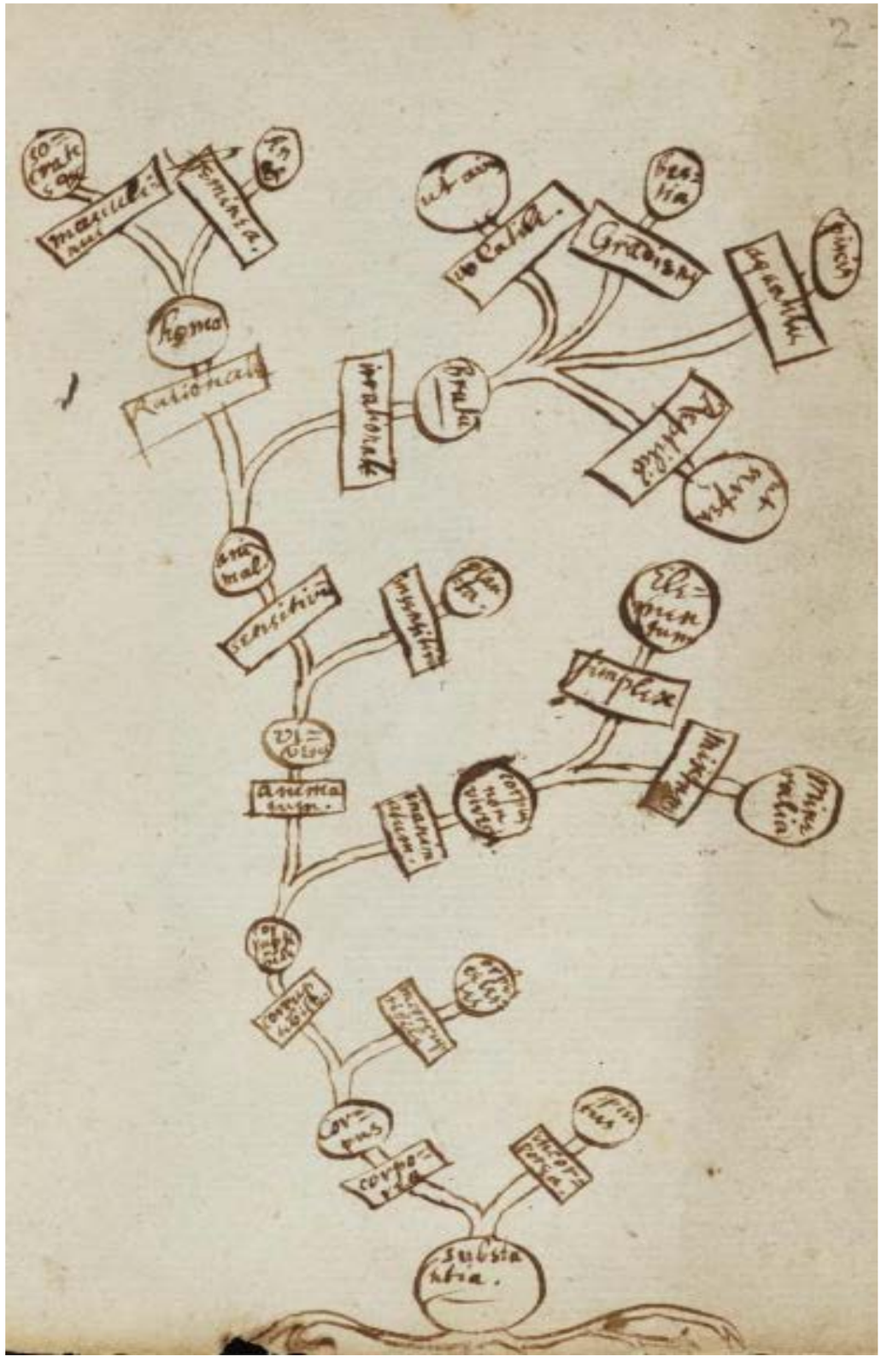
Ιδιόχειρες σημειώσεις του Newton

στο «Όργανον» του Αριστοτέλη

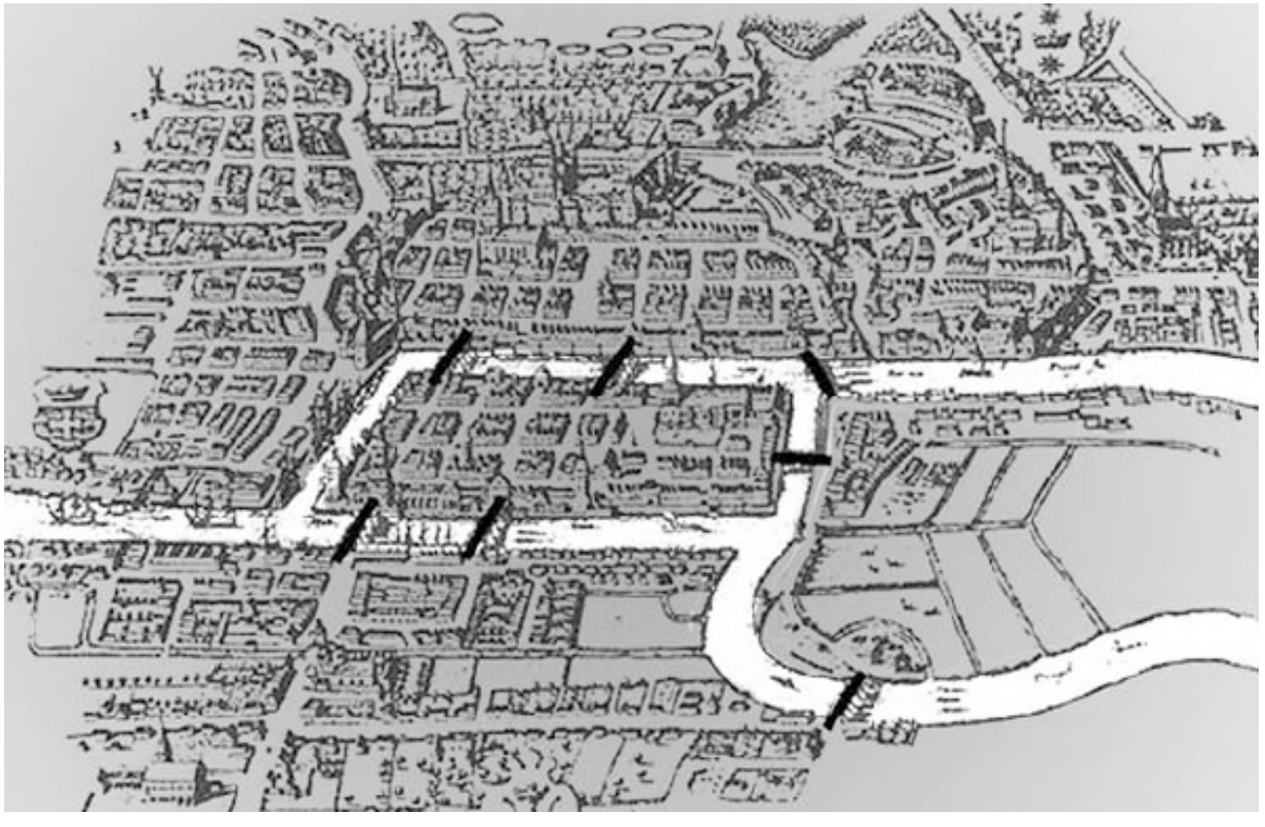
Trinity College, Πανεπιστημιο Cambridge,

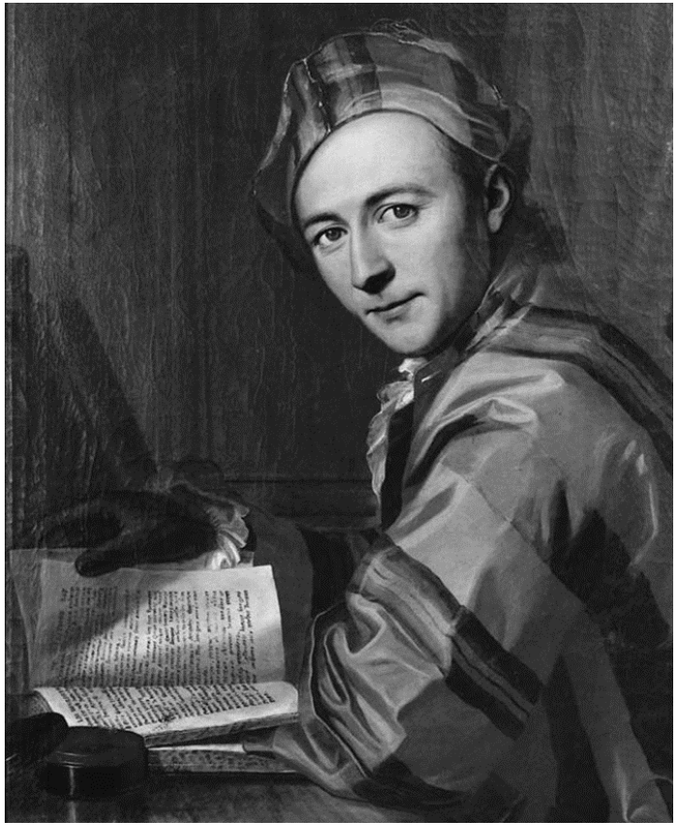
32TUhttp://cudl.lib.cam.ac.uk/view/MS-ADD-03996/5U32T





Euler L. 1736, The 7 Bridges of Konigsberg





Is there a path crossing all 7 bridges of Konigsberg exactly once each?”

Leonard Euler used graph theory to prove that there is no such path.

Solutio problematic ad Geometriam situs pertinentis, Comm. Academiae Petropolitanae, 8, 128-140.

Paths in GRAPHS

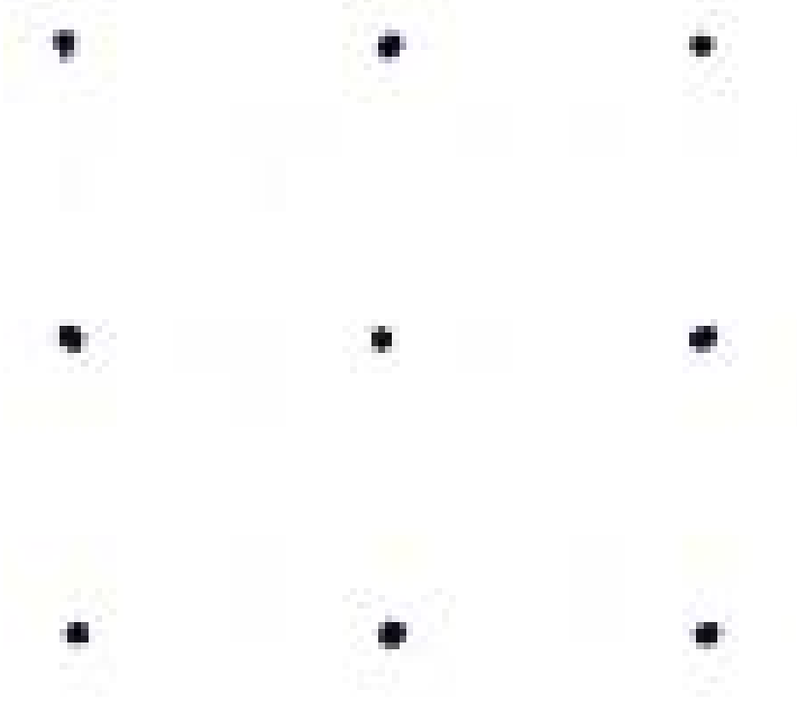
Graph Theory and Network Theory

The mathematical language for describing Interdependence.

Paths in GRAPHS

Μονοκονδυλιες (Strokes)

Συνδέστε τους 9 κομβους με Μονοκονδυλιά, αποτελούμενη από 4 μόνο ευθύγραμμα τμήματα



Paths in GRAPHS

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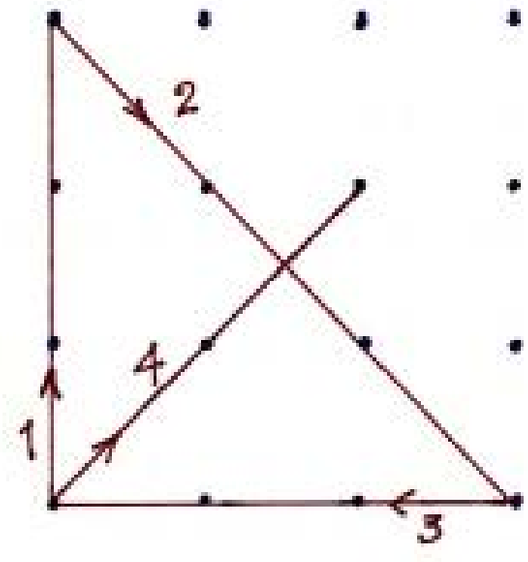
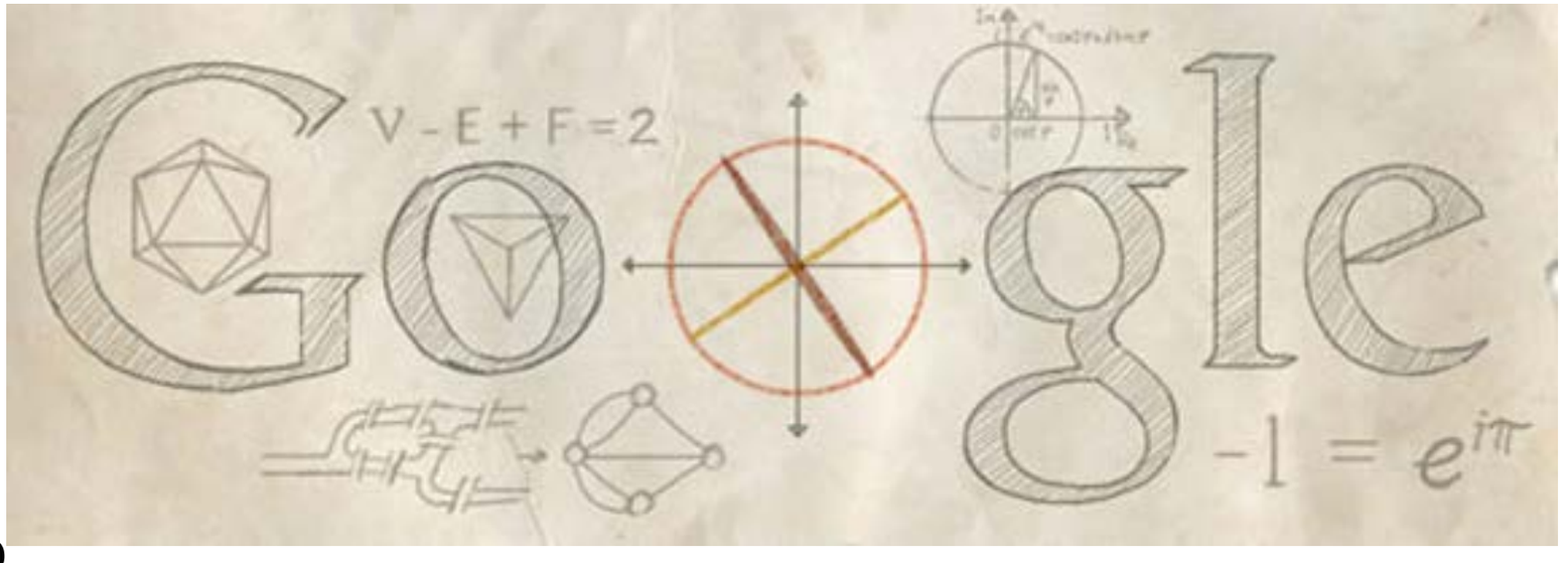


Graph Embedding (Ενσωματωση)

Euler L. 1752

Polyhedral Formula



Για κάθε Πολυεδρο

με Ε Ακμες, V κορυφες, F Εδρες:

$$V - \mathrm{E} + F = 2$$

The foundation of graph theory

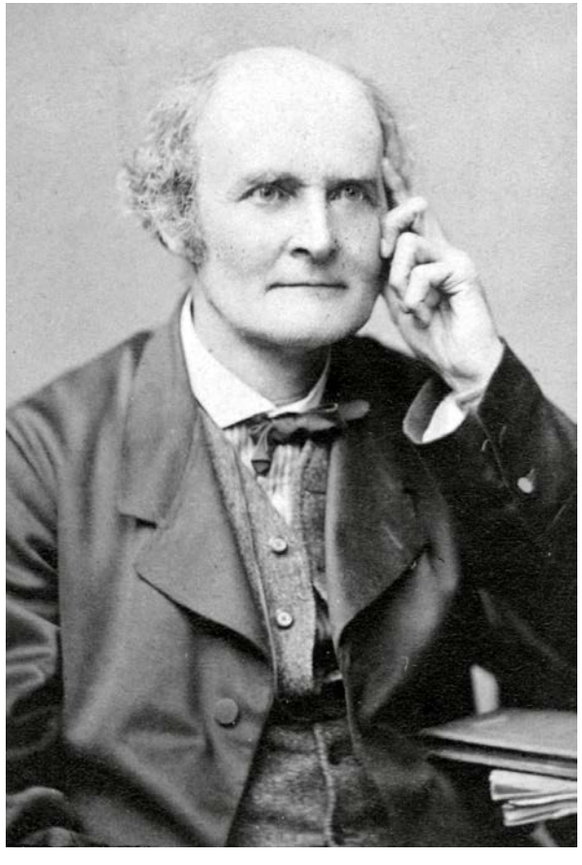
Αλ-Χημεια

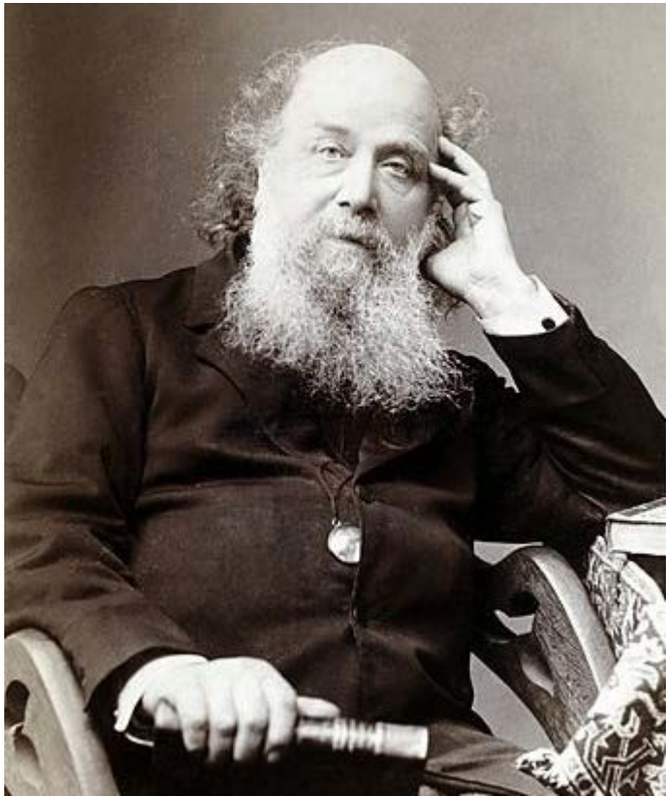
Chemical Affinity Networks

Alchemy…

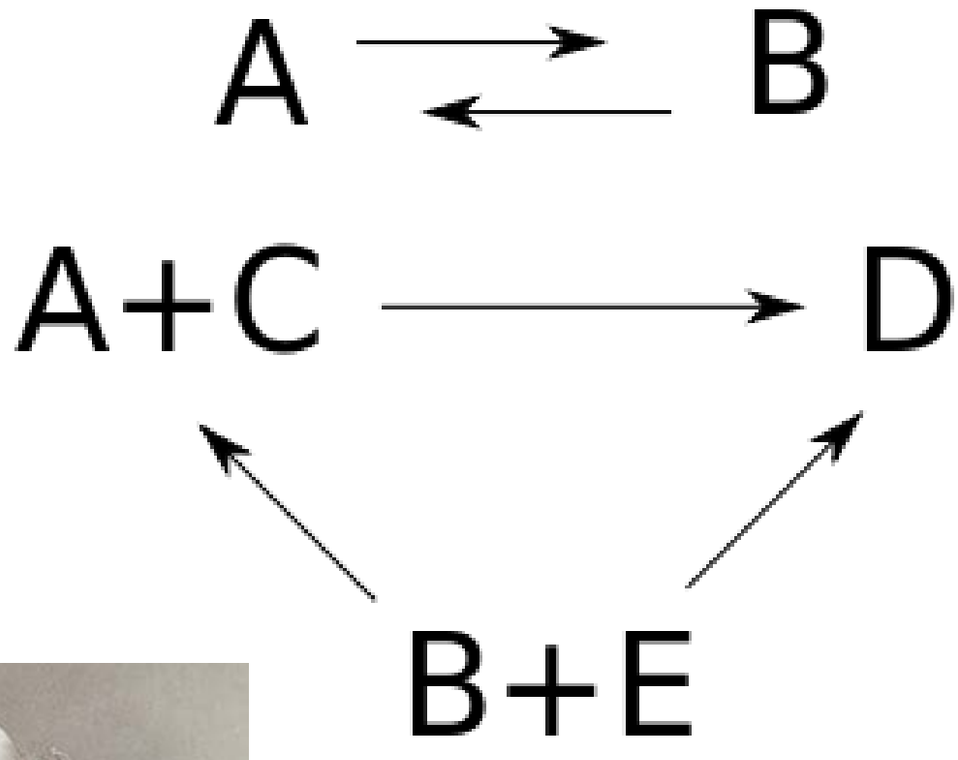
Newton…

Cayley A. 1875 Trees





Sylvester 1878 Graphs



1845 Kirchhoff G. Circuit Laws (current and voltage laws)

Kirchhoff G. 1845, Ueber den durchgang eines elektrischen stromes durch eine ebene, insbesondere durch eine kreisformige. Poggendroffs Ann. Physik Chemie 64(1), 497–514.

generalized circuit theory

information networks

Watanabe H. 1993, A basic theory of information network,

IEICE Transactions on Fundamentals; E76-A(3), 265–276.

Kirchhoff G. 1847, Ann Physik Chemie, 72:497–508.

English translation, IRE Trans Circuit Theory, CT5 (1958)4-7

1895 Henri Poincaré Topology

Algebraic Topology.

Topology ⟶ Algebra ⟶ Graphs

Poincaré, Henri, "Analysis situs",

Journal de l'École Polytechnique ser 2, 1 (1895) pp. 1–123

1900 Poincare Incidence Matrix

H. Poincare 1900,

Second complement de l'Analysis Situs,

Proc. London Math. Soc. 32, 277-308.

Extension of **Kirchhoff** Circuit Laws

Graphs as Abstract Geometry

Biggs N., Lloyd E. and Wilson R. 1977, Graph Theory 1736-1936, Clarendon Press, Oxford

1899 Henri Poincaré
Dynamical Systems
Topological Dynamics
Non-Integrability
Chaos

Solvay 2011

- Differential Equations as Dynamical Systems

  The value of the unknown variable as a function of the initial condition

  Previously the unknown variable was considered as

  a function of the the independent variable (time)
- Orbits, Phase Portrait,
- Stability, Periodicity, Recurrence
- Statistical Analysis of Dynamical Systems
- Analytic Non-Integrability of the 3-Body Problem (Chaos)

Συστημικη Ψυχολογια – Ψυχοθεραπεια

Moreno Jacob 1934

Freud 1912‘
Freud asked him what he was doing
“Well, Dr. Freud, I start where you leave off.
You meet people in the artificial setting of your office.
I meet them on the street and in their homes, in their natural surroundings.
You analyze their dreams. I give them the courage to dream again.
You analyze and tear them apart.
I let them act out their conflicting roles and help them to put the parts back together again”.
Mathematics, philosophy, medicine
interpersonal relations
Psychodrama
group psychotherapy
Sociometry Social Networks Analysis
quantitative evaluation of the role of an individual in a group or community
by analysis of the network of connections between them and others.

1934 *Who Shall Survive?*
earliest graphical depictions of social networks

Moreno Jacob 1934

Sociometry Social Networks Analysis

role of individuals

in a group or community

by analysis of the network of connections

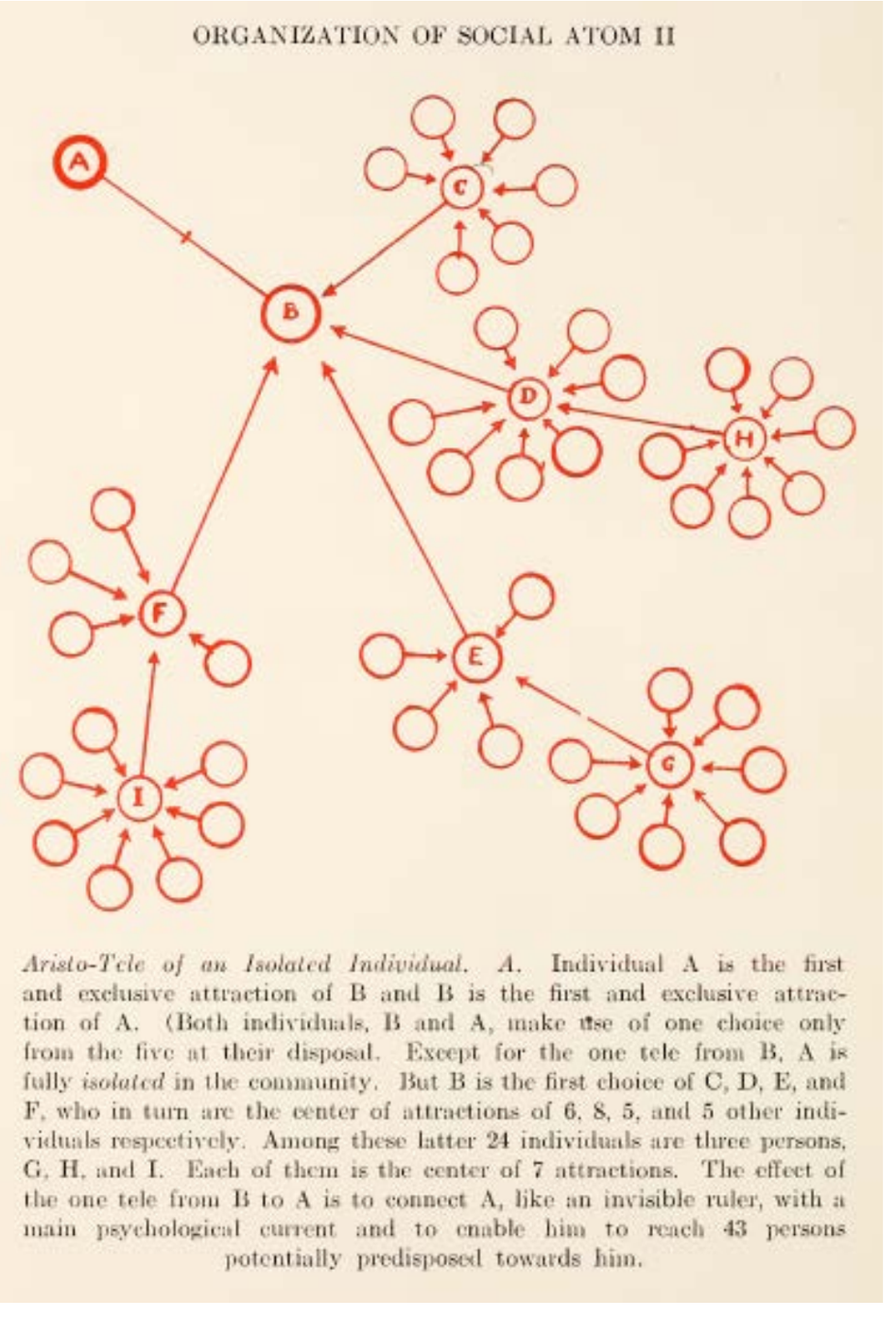
between them and others.

Communities in a Network

earliest social networks

1934 *Who Shall Survive?*

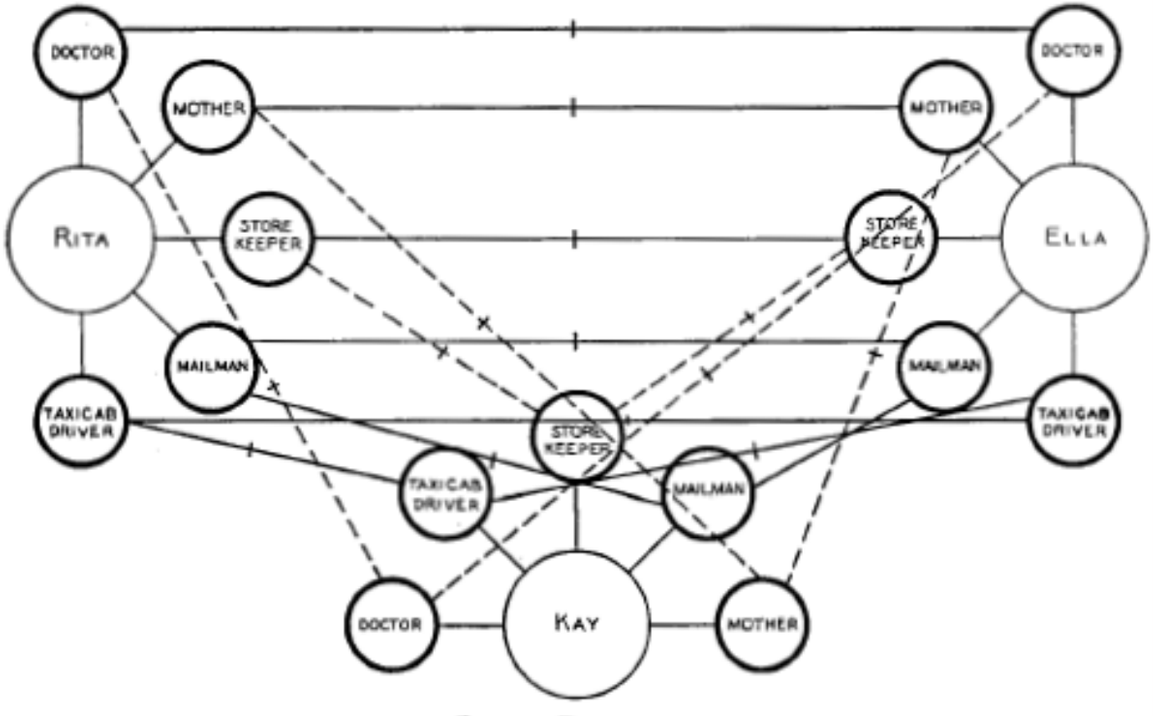
XIII. Psychological Currents 233
1. Psychological Geography, Maps I, II, III. 233
2. Sociometric Speculations 248
3. Psychological Currents 251
Sexual Currents. 252
Racial Currents. 253
Social Currents. 253
4. Networks 256
Proofs that Networks Exist. 256
Causes and Organization of Networks. 261
Technique of Determining Networks. 263
Function of Networks. 264



Aristo-Tele of an Isolated Individual. A. Individual A is the first and exclusive attraction of B and B is the first and exclusive attraction of A. (Both individuals, B and A, make use of one choice only from the five at their disposal. Except for the one tele from B, A is fully *isolated* in the community. But B is the first choice of C, D, E, and F, who in turn are the center of attractions of 6, 8, 5, and 5 other individuals respectively. Among these latter 24 individuals are three persons, G, H, and I. Each of them is the center of 7 attractions. The effect of the one tele from B to A is to connect A, like an invisible ruler, with a main psychological current and to enable him to reach 43 persons potentially predisposed towards him.

Moreno Jacob 1934 Sociometry Social Networks Analysis

Roles and Communities From Relations



ROLE DIAGRAM

KEY:

MUTUALLY ANTAGONISTIC
MUTUALLY COMPATIBLE

From J. L. Moreno, Ed., *Group Psychotherapy, A Symposium*, 1945.

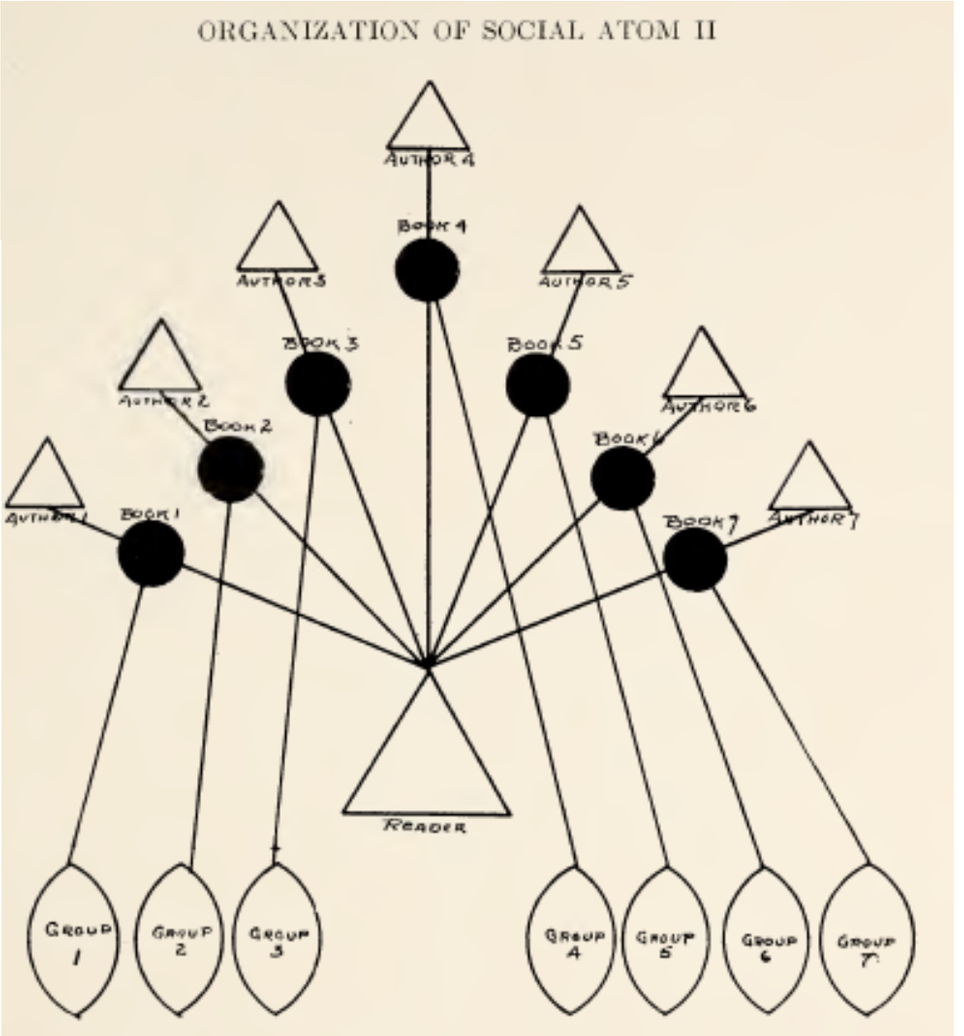


Figure 3 illustrates a final phase of this cultural atom. The subject-reader appears interlocked with Authors 1–7 through Books 1–7 and also to Reader-Groups 1–7 through Books 1–7. The cultural atom here visualized may be characteristic for this reader only and not for any of the other readers who belong to one of the Reader-Groups 1–7. No other reader may have read all seven of the books as is true of our Subject Reader.

The Role of Nodes in a Network

as a consequence of the Link Topology
is assessed by the Centrality Indices

Camille Jordan (1838-1922) for Trees

Jordan C. 1869, Sur les assemblages des lignes,
J. Reine Angew. Math. 70, 185–190

Permutations

Jordan Form of Matrices

Jordan Curve in the Complex Plane

Jordan Measure

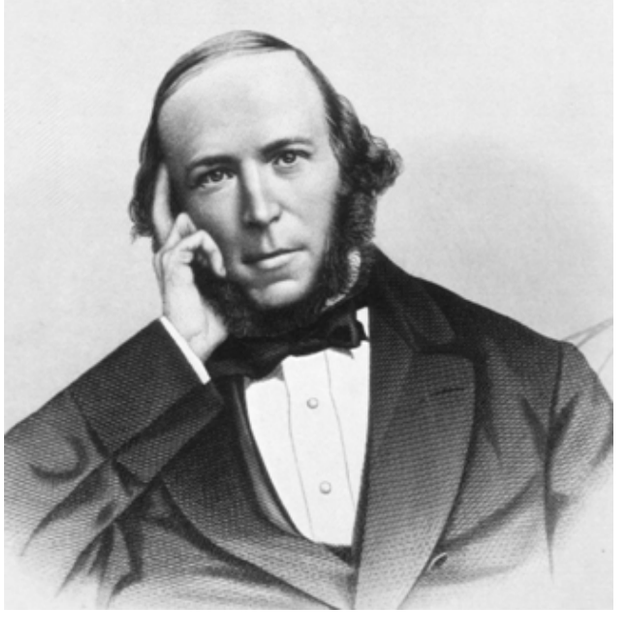
Herbert Spencer 1880

Interdependence as Evolutionary Integration

1) **Universality of natural law.** The laws of nature applied without exception,
   to the organic realm as much as to the inorganic,
   and to the human mind as much as to society.

2) **Evolution of Complexity.** All structures in the universe develop from a simple,
   undifferentiated, homogeneity to a complex, differentiated, heterogeneity,
   a process of greater integration of the differentiated parts.
   A universal law, applying to the stars and the galaxies
   as much as to biological organisms, and to human social organization
   as much as to the human mind.

3) **Individual and Social Evolution**
   Increase of social aggregates accompanied by
   increase of the complexity of structures and Interdependence
   Creation of specialized social roles and institutions



Spencer H. 1855-1880, A System of Synthetic Philosophy 10 volumes,
Williams and Norgate, London

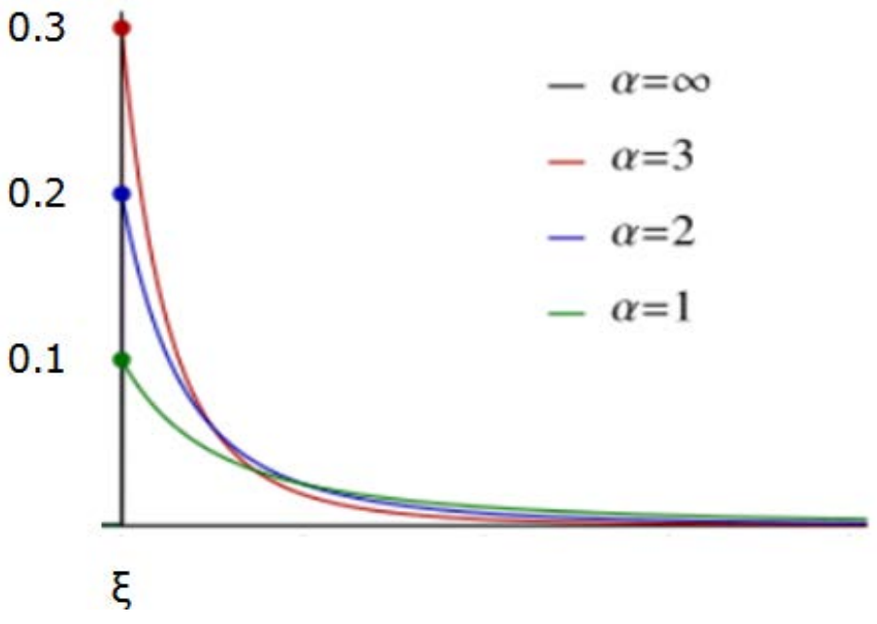
1902 Spencer was nominated for the Nobel Prize for literature.

Pareto 1897 Power Law Distribution

Pareto collected data and Observed that

80% of Italy's land was owned by 20% of the population

$$\rho(x) = \begin{cases} \dfrac{\alpha \xi^{\alpha}}{x^{\alpha+1}}, x \geq \xi \\ 0 \quad , x < \xi \end{cases}$$



Pareto Principle (80–20 rule)

- 80% of the Effects come from 20% of the Causes
- Οι πλειστες Πωλησεις γινονται προς λιγους Πελατες
- Οι πλειστες Εργασιες (Πωλησεις) γινονται από λιγα Στελεχη (Πωλητες)
- Τα πλειστα Προβληματα προκαλουνται από λιγους Πελατες

Pareto V. **1897**, Cours d'Economie Politique, Lausanne

Pareto V. **1906,** Manuale di Economia Politica, Milano, Societa Editrice Libraria.
English translation: Manual of political economy, by A.M. Kelley, 1971, ISBN 978-0-678-00881-2

Power Law Distribution in Real Observed Systems	
Mathematics	Fractals
	Square-cube law (ratio of surface area to volume)
Physics	The Stefan–Boltzmann Law of Heat Radiation
	The inverse-square Laws of Gravity and Electrostatics
	Van der Waals Molecular Forces
	Materials near Continuous Phase Transitions
Geology	Gutenberg–Richter law of earthquake magnitudes
	the sizes of craters on the moon
Astrophysics	the sizes of solar flares
	The initial mass function of stars
Biology	Animal Metabolism related to size
	Allometric laws relating animal shape or anatomy to size
	Activity patterns of neuronal populations
Ecosystems	the foraging pattern of various species
	the number of species per genus
	Forest Fires
Psychology	Stevens' Power Stimulus Perception Law (Psychophysics)
Linguistics	the frequencies of words in most languages
Sociology	the frequencies of family names
	the sizes of power outages and wars
	Numbers of religious adherents
	the severity of violent conflicts (wars and terrorism, Richardson)
	Populations of cities (Gibrat's law)
Economics	Pareto Principle (Discovery of Power law 1897)
	the size of financial returns
Publications	the frequency of publications by authors in a given field
WWW	the degree distribution of the webgraph

Pareto 1906 Collective Utility Interdependence Society as System

Pareto Improvement of an Allocation of Goods among a set of agents is a change to a different allocation that improves at least one agent without making any other agent worse.

Pareto Efficient Allocation or **Pareto Optimal Allocation** is an allocation that no further Pareto improvements are possible.

Pareto efficiency makes no statement about equality, or the overall well-being of a society.

Pareto Vilfredo **1906,** Manuale di Economia Politica, Milano, Societa Editrice Libraria.
English translation: Manual of political economy, by A.M. Kelley, 1971, ISBN 978-0-678-00881-2

Barr N. 2012, "3.2.2 The relevance of efficiency to different theories of society". Economics of the Welfare State (5th ed.). Oxford University Press.

Sen A. 1993, Markets and Freedom: Achievements and limitations of the market mechanism in promoting individual freedoms, Oxford Economic Papers 45 (4): 519–541

Grune-Yanoff T., Hansson S. 2009, editors, Preference Change. Approaches from Philosophy, Economics and Psychology, Springer, Dordrecht Heidelberg London New York

Pareto efficiency as a Decision Principle is also be applicable to the selection of alternatives in engineering and life sciences

1922 Bogdanov Alexander

Tectology Goal:

1) “the systematization of organized experience",
in Social, Biological and Physical Sciences
by considering them as systems of relations and
by seeking to identify the organizational principles
that underlie all systems:
"all things are organizational,
all **complexes** could only be understood
through their organizational character”.

2) any complex should correspond to its environment and adapt to it.

3) A stable and organized complex is greater than the sum of its parts.
Stability is the possibility of preserving the complex in the given Environment.

1922 *Tektologiya: Vseobschaya Organizatsionnaya Nauka*, Berlin and Petrograd-Moscow, 1922. English translation :
Essays in Tektology: The General Science of Organization, trans. George Gorelik, Seaside, CA, Intersystems Publications, 1980.

Precursor of Systems Theory

1950 Von Bertalanffy L.

System as a unifying Structural concept

An Outline for **General Systems Theory**,

British Journal for the Philosophy of Science, Vol 1, No. 2

1) there are general aspects, correspondances
and isomorphisms common to systems.
Such parallelisms or isomorphics appear, sometimes surprisingly,
in otherwise totally different systems.
General system theory is scientific exploration of “wholes” and “wholeness”…
Novel conceptions, models and mathematical fields have developed to deal with them, such as **dynamical system theory, cybernetics, automata theory, system analysis by set, net, graph theory.**
2) The problems arising in modem technology and society, comprising both the 'hardware' of computers, automation, self-regulating machinery and the 'software' of new theoretical developments and disciplines. Modem technology and society have become so complex that traditional ways and means are not sufficient any more... Approaches of a holistic or systems, and generalist or interdisciplinary nature became necessary. Systems of many levels ask for scientific control: ecosystems the disturbance of which results in pressing problems like pollution; formal organizations like a bureaucracy, educational institution or army; the grave problems appearing in socio-economic systems, in international relations, politics and deterrence…are essentially 'systems' problems, that is, problems of interrelations of a great number of variables.
3) systems philosophy, i.e. the reorientation of thought and world view ensuing from the introduction of system as a new scientific paradigm (in contrast to the analytic, mechanistic, oneway-casual paradigm of classical science). As every scientific theory of broader scope, general system theory has its 'metascientific' or Philosophical aspects.

Von Bertalanffy L. 1968, General System theory: Foundations, Development, Applications, George Braziller, New York

1949 Shannon-Kolmogorov

Information and Entropy (Average Information) as unifying concept

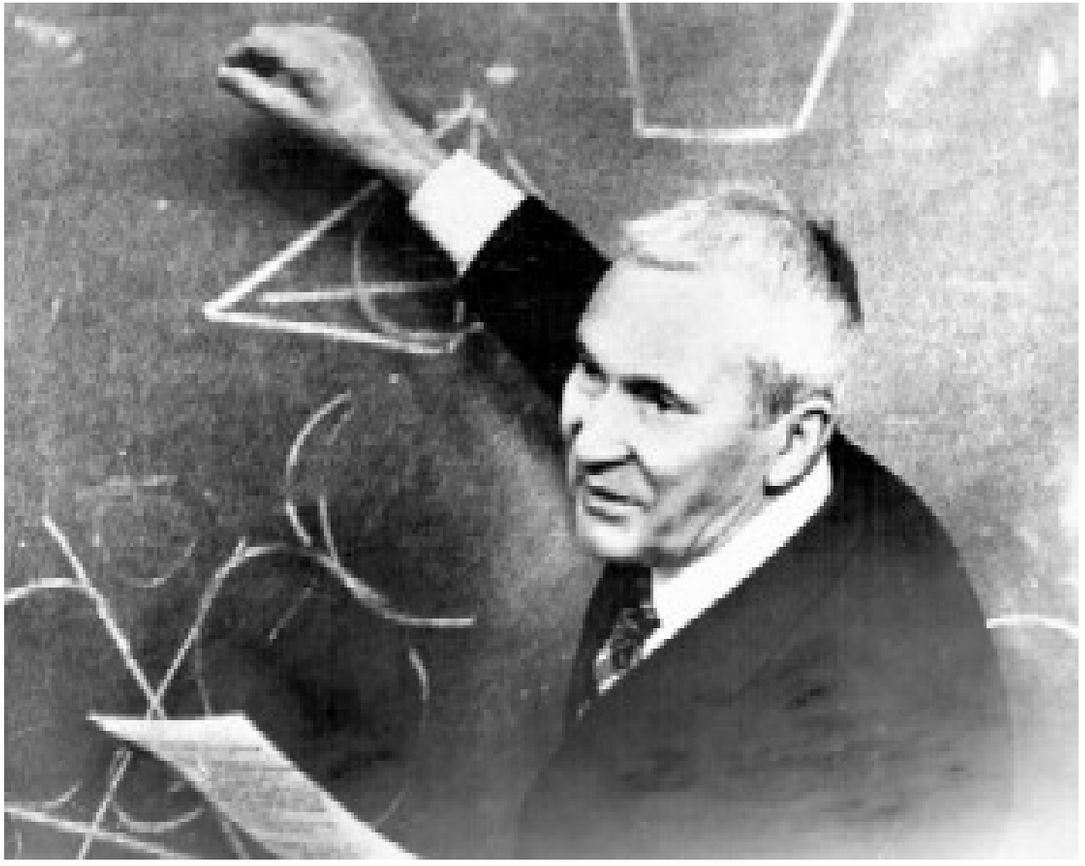
$\mathcal{I}$= $\mathcal{I}$[A,p] = $-\sum_{\nu} \mathrm{p}(A = \alpha_{\nu}) \log_2 p[A = \alpha_{\nu}] = -\sum_{\nu} \mathrm{p}_{\nu} \log_2 \mathrm{p}_{\nu}$

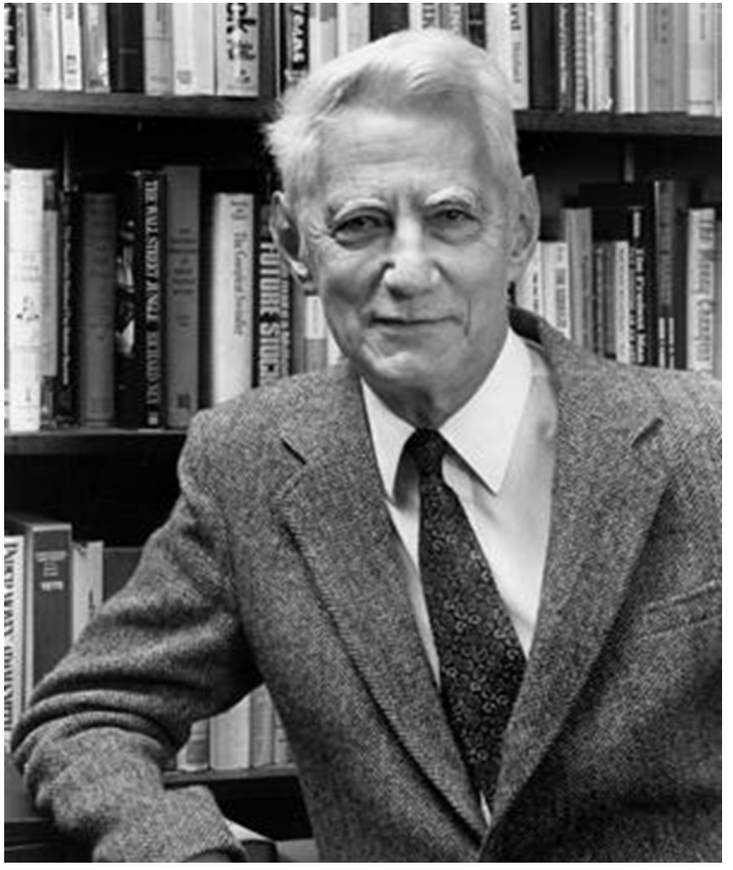
Assessing: Irreversible Processes, Complexity, Disorder, Uncertainty

Diversification-Precision, Inhomogeneity

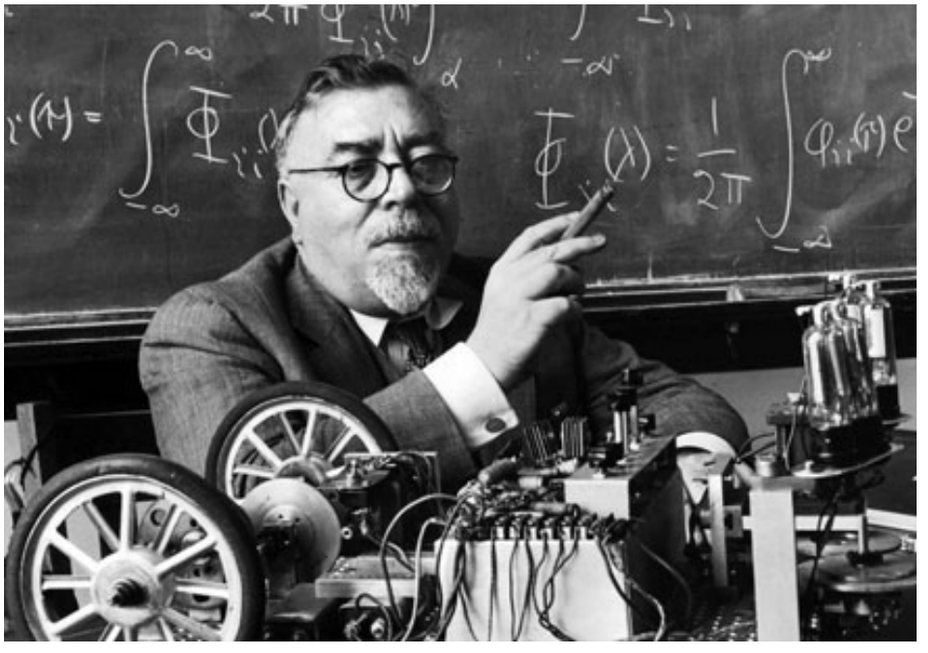
Binary Decisions

The basis of Digital Technology, Information society





1954 Wiener N. Cybernetics



a unifying Functional concept

System Regulation, Feedback Stabilization, Control

Τί δ' εν νηί, εί τω εξουσία είη ποιείν ό δοκεί,

νού τε καί αρετής κυβερνητικής εστερημένω,

καθοράς ά άν συμβαίη αυτώ τε καί τοίς συνναύταις

[Πλάτων, Αλκιβιάδης, 135A]

Cybernetics is "the science concerned with the study of systems of any nature which are capable of receiving, storing and processing information so as to use it for control."

[A. N. Kolmogorov]

Cybernetics is "the art of steersmanship: deals with all forms of behavior in so far as they are regular, or determinate, or reproducible: stands to the real machine (electronic, mechanical, neural, or economic) as much as geometry stands to real object in our terrestrial space; offers a method for the scientific treatment of the system in which complexity is outstanding and too important to be ignored." [W. Ross Ashby]

Cybernetics is "the science and art of the understanding of understanding."

[Rodney E. Donaldson, 1st president of the American Society for Cybernetics]

Cybernetics is "a way of thinking about ways of thinking of which it is one." [Larry Richards]

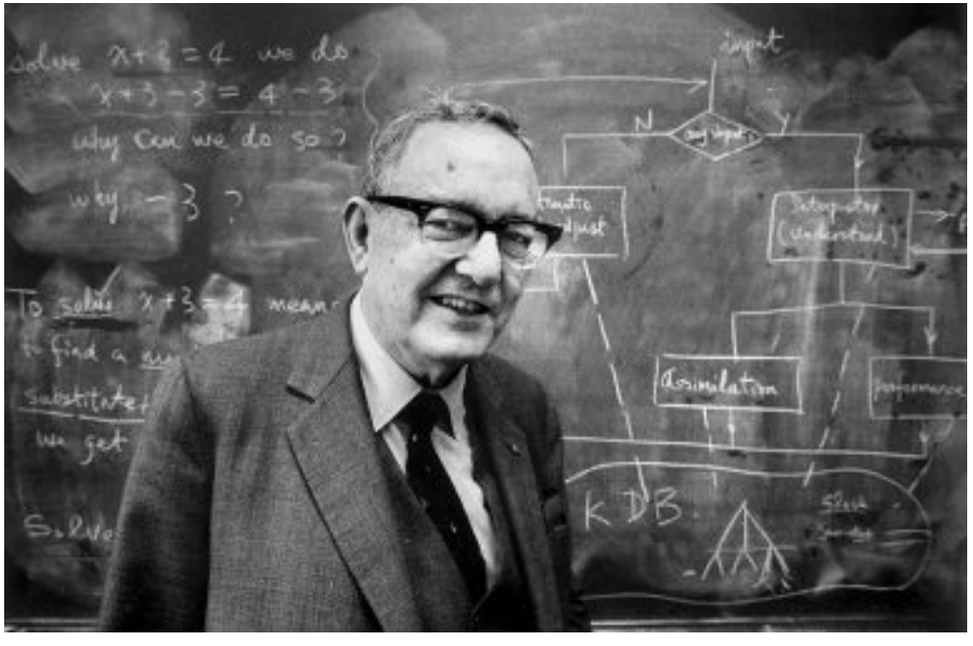
Cybernetics is "the art of interaction in dynamic networks." [Roy Ascott]

Wiener N. 1954, Cybernetics: or the Control and Communication in the Animal and the Machine, MIT Press, Cambridge, MA:.

1955 Simon H. Preferential Attachment, Power Law

Introduced the **Preferential Attachment** model

which has **Power Law** invariant distribution.



Specific Systems studied:

- words in prose samples
  by their frequency of occurrence
- scientists by number of papers published
- cities by population
- incomes by size
- biological genera by number of species.

Simon H. 1955, On a Class af Skew Distribution Functions, Biometrika Volume 42, Issue 3/4, 425-440

Answer to Mandelbrot:

Simon H. 1960, Some Further Notes on a Class of Skew Distribution Functions, Inform. and Control 3, 80-88

Simon Generalized Yule's Model of the growth of the number of species per genus in some higher taxon of biotic organisms

Yule, G. 1925, A Mathematical Theory of Evolution, based on the Conclusions of Dr. J. C. Willis, Philosophical Transactions of the Royal Society of London, Ser. B 213 (402–410): 21–87.

1955 Simon H. Bounded Rationality

How to Decide Under Uncertainty

Simon proposed the Bounded Rationality Concept
and Constructed Models for Decision Making
by individuals and Organizations in order to take into account the Several limitations to Decision Making, due to the available Information, the Complexity of the System, the Environment, the Mind.

Simon, H. 1955, A Behavioral Model of Rational Choice, Quarterly Journal of Economics, 69, 99–118.

Simon H. 1957, Models of Man , Wiley, New York

Simon H. 1969 “The Sciences of the Artificial”, MIT Press, Cambridge, Massachusetts.

Simon received the 1978 Nobel Prize in Economics "for his pioneering research into the decision-making process within economic organizations...and his contributions in a number of fields, including the methodology of science, applied mathematical statistics, operations analysis, economics, and business administration. His work is synthesized in a new theory of organizational decision-making”.

Klahr D., Kotovsky K. , editors 1989, “Complex Information Processing: The Impact of Herbert A. Simon. 21st Carnegie-Mellon Symposium on Cognition”, L. Erlbaum Associates, New York

Augier M. , James G. March J. 2004, editors, Models of a Man. Essays in Memory of Herbert A. Simon, MIT Press, Cambridge, Massachusetts

1965 Alexander Christopher

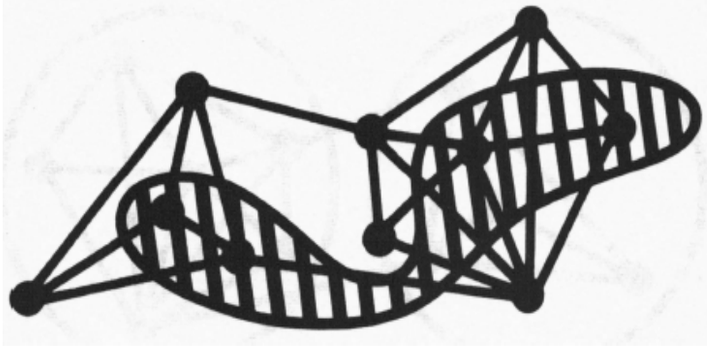
"Notes on the Synthesis of Form" (quotes Plato)

Architecture Parts-Whole

Natural Structural-Functional Units

Graph Modules using Entropy

Προδρομος της Ανακαλυψης Κοινοτητων



Community Detection (Clustering) noted in the 1970s:

R. Alba 1973 , A graph-theoretic definition of a sociometric clique, J. Math. Sociol. vol. 3, pp. 113-126

M. Girvan and M. E. J. Newman 2002, Community structure in social and biological networks, Proceedings of the National Academy of Sciences (USA) 99, 7821--7826

M. E. J. Newman 2006, Finding community structure in networks using the eigenvectors of matrices, Physical Review E 74, 036104

J. M. Hofman, C. H. Wiggins 2008, Bayesian Approach to Network Modularity, Phys. Rev. Letters PRL100, 258701. arxiv:0709.3512

M. A. Porter, J.-P. Onnela and P. J. Mucha 2009, Communities in Networks, Not. Amer. Math. Soc. 56: 1082–1097, 1164–1166. http://www.ams.org/notices/200909/rtx090901082p.pdf.

S. Fortunato 2010, Community Detection in Graphs, Physics Reports 486, 75-174

Η Αρμονικη Σχεση Μερων Μεταξυ τους και Μερων-Ολου

ως προυποθεση Ενοτητος της Γνωσης

Consilience of Evidence,

Commensurability of Theories

Wilson E. 1998, Consilience: the Unity of Knowledge, Knopf, New York.

Response to the Cultural difference between the 2 Cultures:

Humanities versus Physical Sciences

Snow C. 1959, The Two Cultures and the Scientific Revolution,
Cambridge University Press, New York.

Co-measurement is the Guiding Principle of Ilya Prigogine

who proposed a New Alliance establishing co-measurability between:

Humanities and Physical Sciences

Thermodynamics (Irreversible) and Dynamics (Reversible) ΧΑΟΣ

Thermodynamics (Disorder) and Life (Order) ΑΥΤΟ-ΟΡΓΑΝΩΣΗ

NETWORKS: the Common Language of Commensurable Knowledge

1970 Prigogine I.

Dissipative Structures Far From Thermodynamic Equilibrium

Bifurcations and Fluctuations

Self-Organization as a Mechanism for the Evolution of Complexity

Nobel Prize in Chemistry 1977 for his contributions to

"Non-equilibrium Thermodynamics, particularly the theory of Dissipative Structures"

Glansdorff P. , Prigogine I. 1970, Non-Equilibrium Stability Theory, Physica 46, 344-366.

P. Glansdorff and I. Prigogine 1971, Thermodynamic Theory of Structure, Stability and Fluctuations, Wiley, New York.

Prigogine I. 1978, Time, Structure, and Fluctuations, Nobel Lecture in Chemistry, Science 201 , 777-785.

Prigogine I. 1980, From Being to Becoming: Time and Complexity in the Physical Sciences, Freeman, New York.

Kondepudi D. , Prigogine I. 1998, Modern Thermodynamics, From Heat Engines to Dissipative Structures, Wiley

Prigogine I. 1999, The End of Certainty, Free Press, New York.

Prigogine I. 2000, The Networked Society, J. World-Systems Research 6, 892-898.

Prigogine I. 2003, Is Future given?, World Scientific, Singapore.

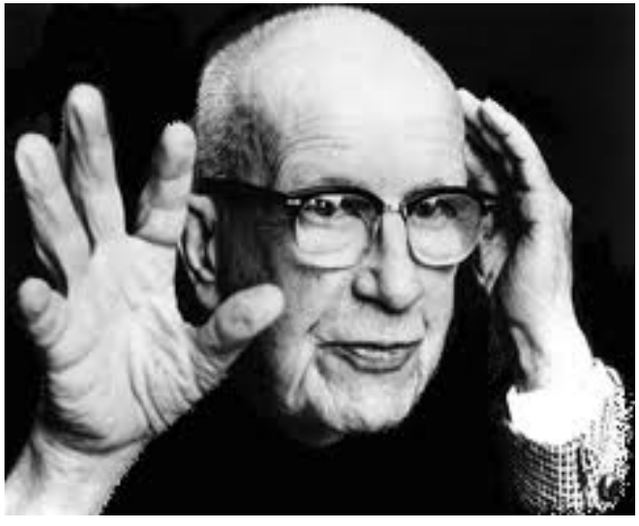
Prigogine's **Non-Equilibrium Thermodynamics** has also been formulated as **Network Dynamics**

G. Oster, A. Perelson, A. Katchalsky 1971, Network Thermodynamics, Nature 234, 393-381.

E. Lewis 1995, Network Thermodynamics Revisited, BioSystems 34, 47-63

D. C. Mikulecky 2001, Network thermodynamics and complexity: a transition to Relational Systems Theory, Computers and Chemistry 25, 369–391, 2001.

1975 Synergetics Backminister Fuller



the empirical study of systems in transformation,

with an emphasis on **total system behavior**

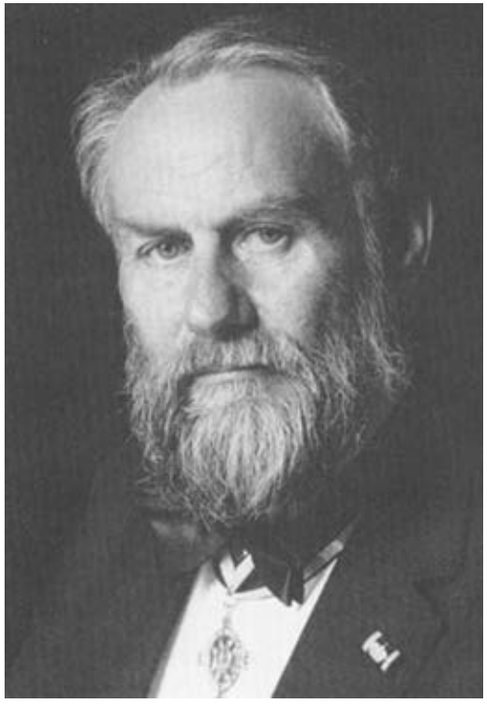
unpredicted by the behavior of any isolated components,

including humanity's role as both **participant** and **observer**.

Fuller B. , Applewhite E. : Synergetics: Explorations in the Geometry of Thinking

Vol. 1 in 1975 , Vol. 2 in 1979 Macmillan

Synergetics Hermann Haken



Deals with material or immaterial systems,

composed of, in general,of many individual parts

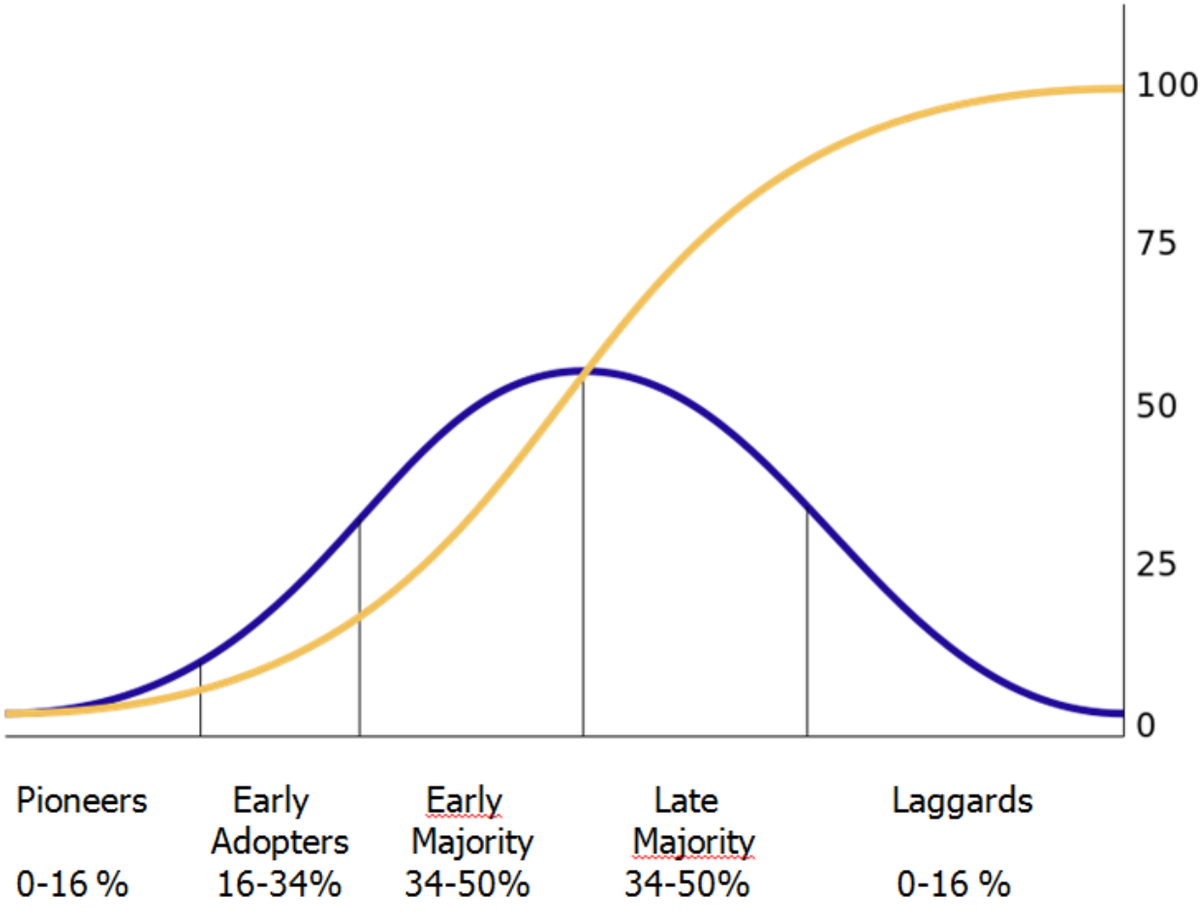
focusing on the spontaneous, i.e. self-organized emergence

of new qualities which may be structures, processes or functions.

H. Haken: "Synergetics, an Introduction: Nonequilibrium Phase Transitions and Self-Organization in Physics, Chemistry, and Biology",
1st edition 1976, 2d edition 1978, 3rd rev. enl. ed. 1983 New York, Springer-Verlag

Innovation Diffusion

Innovation Management



Rogers, E. 1962, Diffusion of Innovations. Free Press, London, NY, 5th ed. 2003

http://commons.wikimedia.org/wiki/File:Diffusion_of_ideas.svg#/media/File:Diffusion_of_ideas.svg

Sigmoid Curve: $\mathrm{X(t)} = \frac{KX_0}{X_0 + (K - X_0)e^{-rt}}$

The Solution of the Verhulst Logistic Equation: $\frac{\mathrm{dX}}{\mathrm{dt}} = r\left(1 - \frac{X}{K}\right)X, \qquad X(0) = X_0$

Verhulst P.F. 1838, Notice sur la loi que la population pursuit dans son accroissement. Corresp. Math. Phys. 10, 113-121

Pianka, E.R. 1970, On r and K selection. American Naturalist 104, 592-597

Opinion Diffusion on Graphs

Innovation Growth Knowledge Doubling Backminister Fuller 1982

Critical Path, second ed., St. Martin's Press, New York

Knowledge Doubling Curve”

until 1900 Knowledge doubled approximately every century.

By 1950 knowledge was doubling every 25 years.

Today: different knowledge fields grow with different rates.

Nanotechnology knowledge is doubling every 2 years

Clinical knowledge is doubling every 18 months.

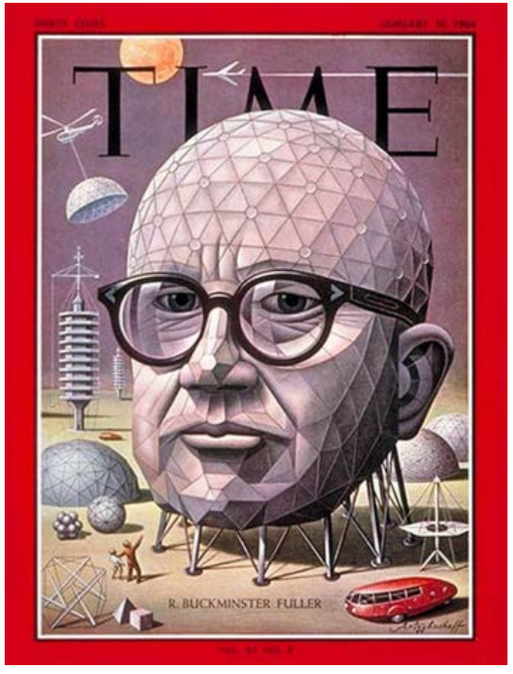
On average Knowledge is doubling every 13 months.

Forecasting IBM: the build out of the “internet of things”

will lead to the doubling of knowledge every 12 hours.

IBM 2006, The toxic terabyte: How data-dumping threatens business efficiency, IBM Global Technology Services
http://www-935.ibm.com/services/no/cio/leverage/levinfo_wp_gts_thetoxic.pdf (day accessed: 05-03-2015)

Backminister Fuller



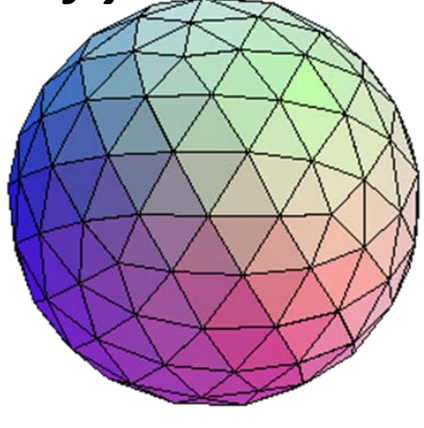
We are called to be architects of the future, not its victims.

When I am working on a problem, I never think about beauty
but when I have finished, if the solution is not beautiful,
I know it is wrong.

What usually happens in the educational process is that
the faculties are dulled, overloaded, stuffed and paralyzed so that
by the time most people are mature they have lost their innate capabilities.

There is nothing in a caterpillar that tells you it's going to be a butterfly.

Integrity is the essence of everything successful.

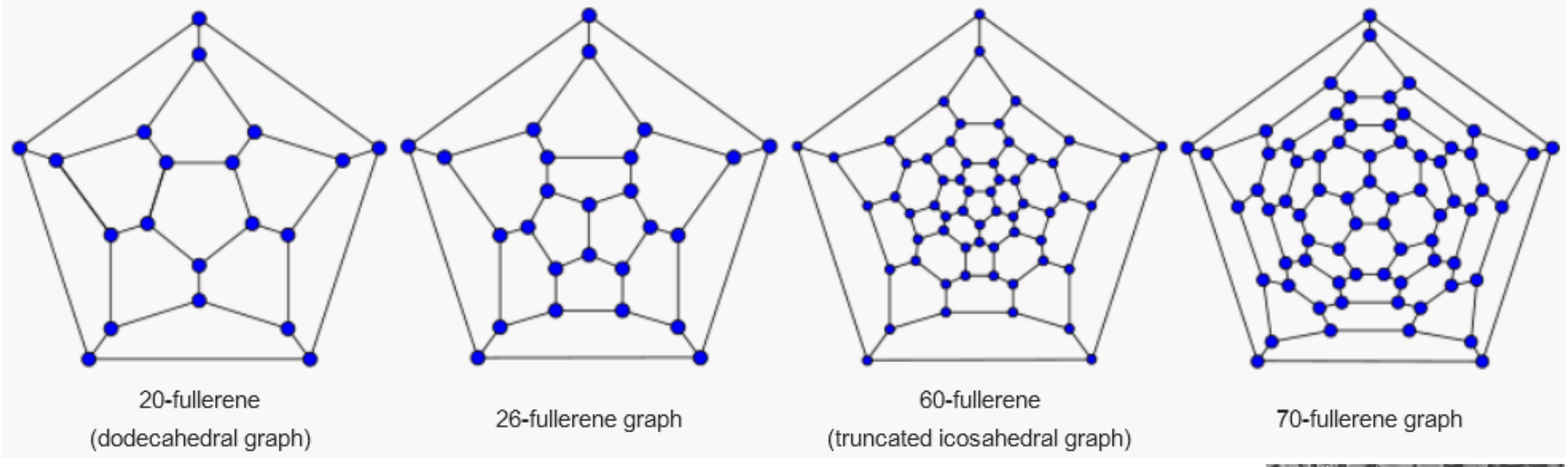


Geodesic Dooms (Thin shell Networks, Net Embedding)

Backminister Fuller

1985 From Geodesic Dooms to Fullerenes

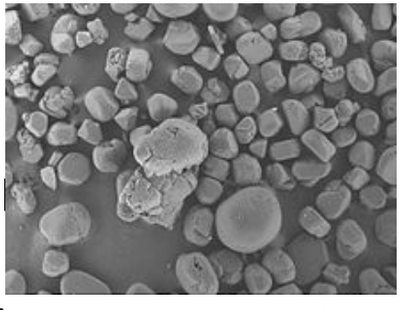
Fullerene Graphs http://en.wikipedia.org/wiki/Fullerene#cite_note-70



Fullerene Chemistry

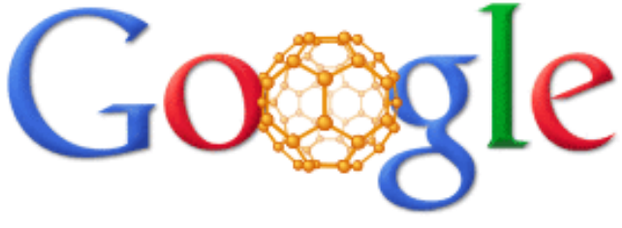
Fullerene Nanostructures

Fullerite Scanning Electron Microscope



4 September 2010 ,25th Anniversary of Buckyball, named after Buckminster Fuller. A structure is so strong it appears in architecture around the world, athletes also deemed it a sound shape for the football. Applications: display technology, medicine, security

http://www.google.com/doodles/25th-anniversary-of-buckyball



Regular Networks:

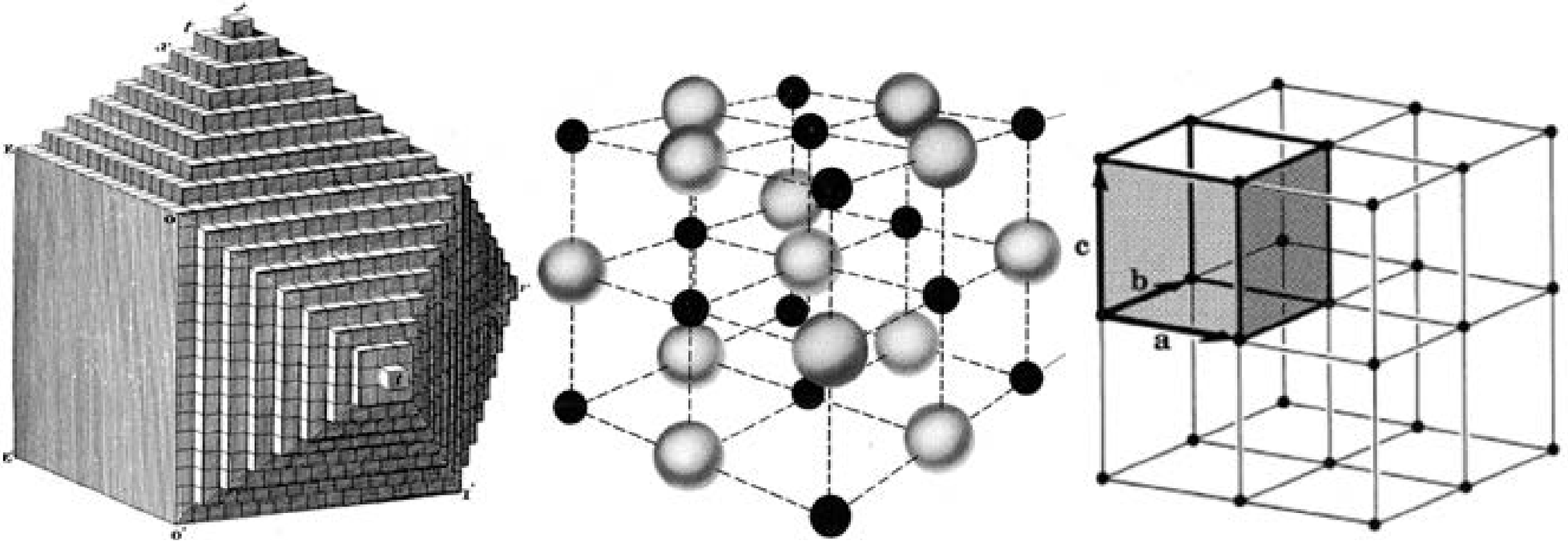
Planetary Motions, Musical instruments

Crystals: The simplest Graphs Constant Degree (6 NaCl)
Periodic Repetition of the Unit Cell

Ταξινομηση Barlow, Fedorov 1890 (32,7)

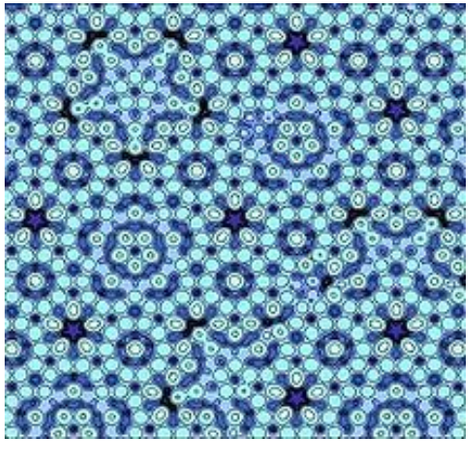
Το Αλας NaCl με Σταθερο Βαθμο 6

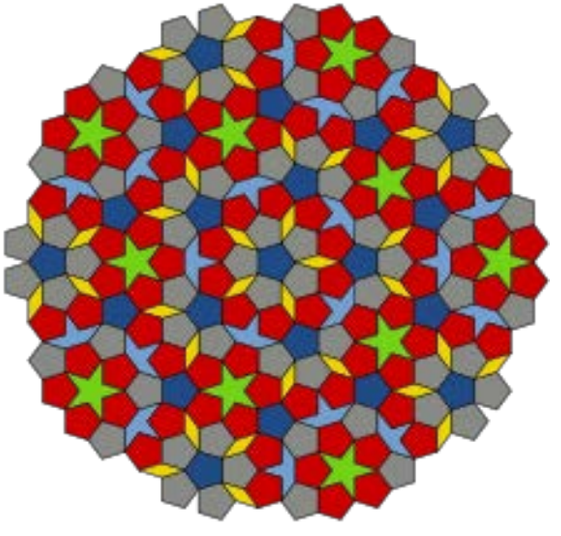
The archetype till 1950



Ωσει Κρυσταλλοι (Quasi Crystals): Απεριοδικα Δικτυα

Ag-Al quasicrystal

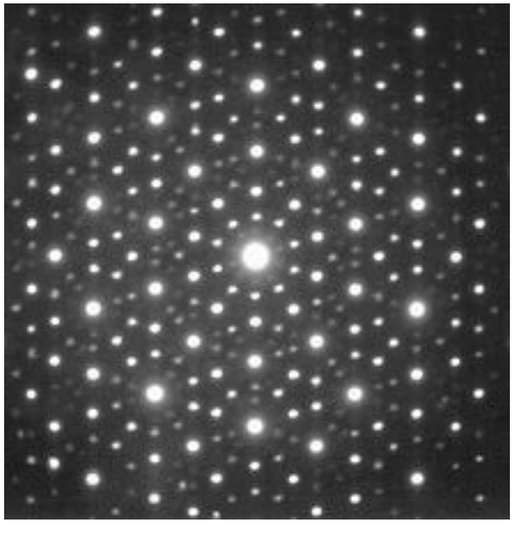




Penrose tiling

Dan Shechtman 1984
Nobel Prize in Chemistry 2011

Electron diffraction pattern
20εδρος quasicrystal Zn-Mg-Ho



1950 Neural Networks

McCulloch W. and Pitts W. 1943 Neural Nets perform Logical Operations

Rosenblatt F. 1958, The Perceptron

Memory
Learning
Distributed processing
Lashley K. (1930-1950) suggested that
memories were not localized to one part of the brain,
but were widely and distributed throughout the cerebral cortex.
Engrams are non-uniformly distributed across all cortical areas.

Hebb D.O. 1949 Learning Rule “cells that fire together, wire together” was based on Lashley’s work

1959 Random Networks

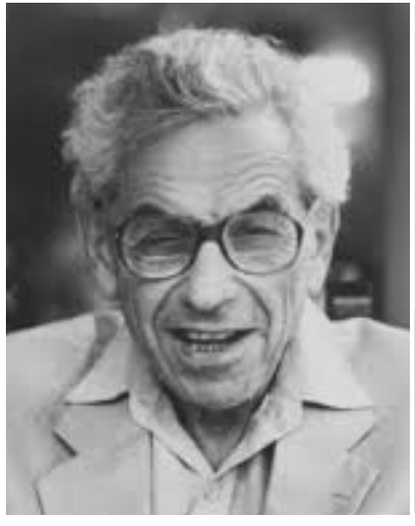
Radioactive Decay – Poisson Process, Poisson Music (Xenakis)

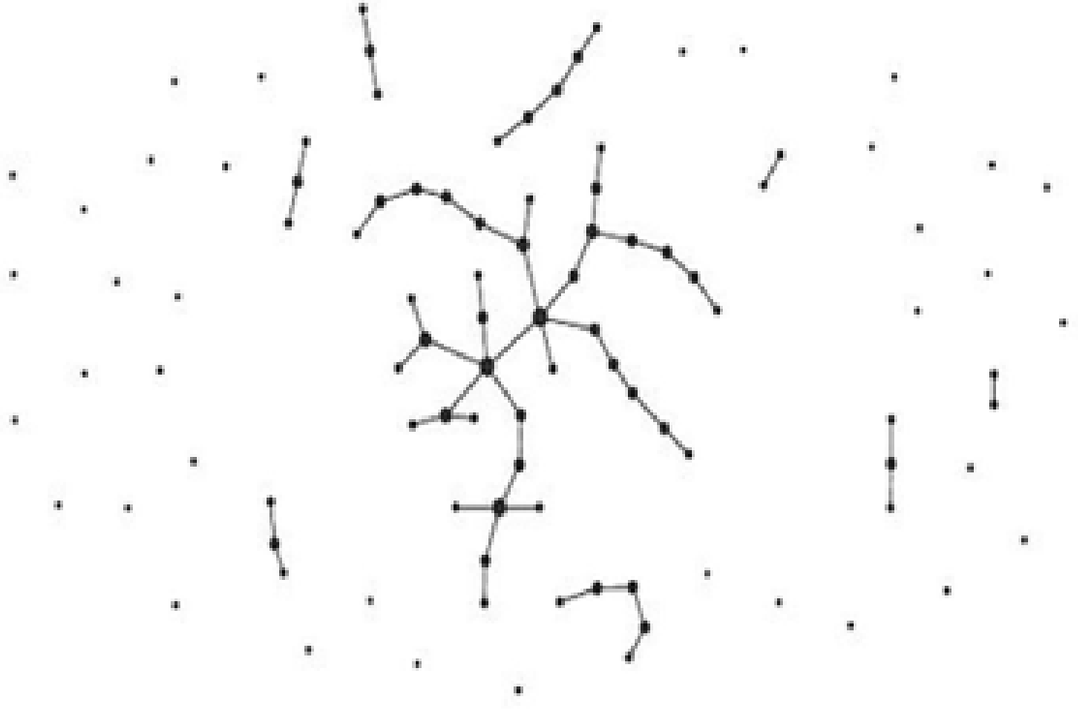
White Noise, Brownian Motion

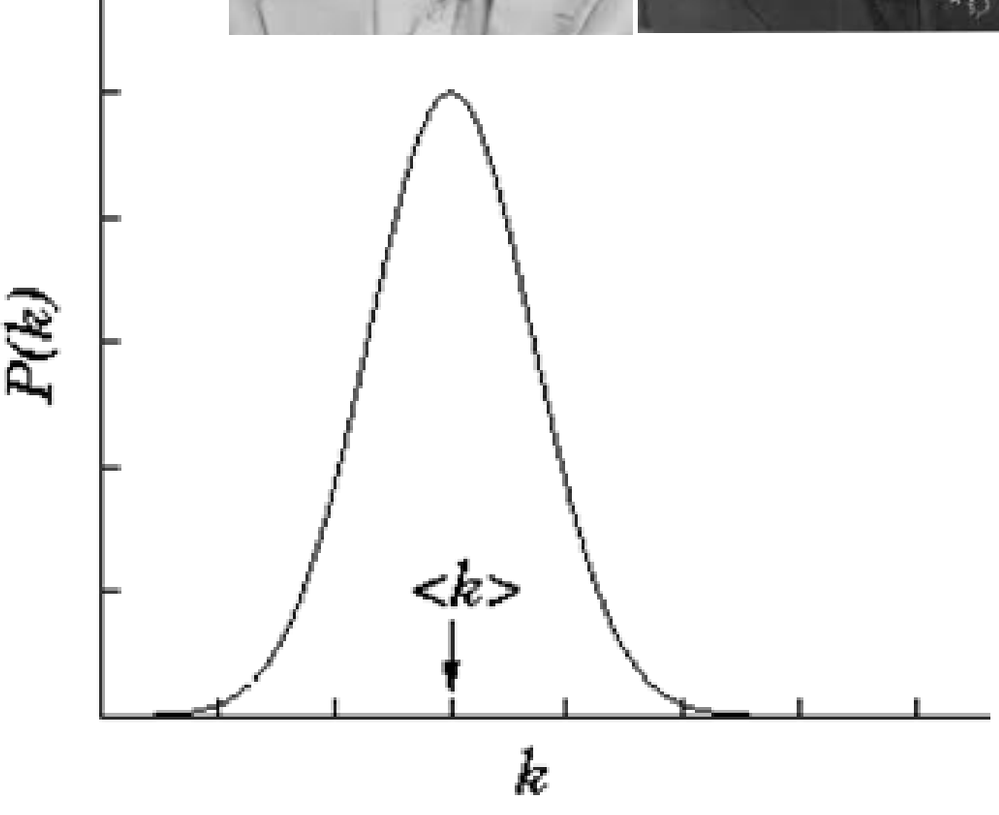
PSTN (Public Switched Telephone Network)

Random degree distribution. (Poisson)

Erdős P. , Alfréd Rényi







Τα Ζωντα Δικτυα

Εντασσονται στους κρυσταλλους και τα τυχαια?

Η Ζωη εκδηλωνεται ως Ταξη απο το Χαος

Prigogine I. 1980, From Being to Becoming, Freeman, New York.

Prigogine I. 2003, Is Future given?, World Scientific ,Singapore.

Prigogine I. 1999, The End of Certainty, Free Press, New York.

Τα Δικτυα της Ζωης δεν ειναι
«μονοτονοι» Προβλεψιμοι
Περιοδικοι Κρυσταλλοι
ουτε
«αδομητοι» Τυχαιοι σχηματισμοι
οπως τα Τηλεφωνικα Δικτυα του 1960

Η Ζωη Λειτουργει Μεταξυ
της Μονοτονης Δομης και
της Αδομητης Τυχαιοτητας

Πολυπλοκα Συστηματα κατά Prigogine 1980

Decomposability into Independent Components fails

Η Στρατηγικη Διαιρει και Βασιλευε καταρρεει

Indecomposability

Interdependence

Οι Αλληλοεξαρτησεις δεν Αιρονται

…1940
Θεωρια Συστηματων - Κυβερνητικη

Μηχανικη, Ηλεκτρομαγνητισμος, Κβαντικη Μηχανικη
Αναλογιες Μηχανικων-Κυματικων-Ηλεκτρικων Μεταβλητων
(Σχετικοτητα: Μαθηματικη περιγραφη που διασφαλιζει τις Συμμετριες)

Θερμοτητα 2^{ος} Νομος Εντροπια

Δυναμικη Πληθυσμων σε Οικοσυστηματα, Χημικη Κινητικη,
Διαδοση Νοσων στον Οργανισμο,
Διαδοση Επιδημιων στην Κοινωνια,
Εναλλαγες οικονομικων Μεγεθων,
Διαδοση Καινοτομιων

Ελεγχος με Αναδραση (Ετερονομη - Θερμοστατης)

1970-2000
Αυτο-Οργανωση,
Χαος
Πολυπλοκοτητα, Αλληλοεξαρτησεις

Θερμοδυναμικη Νομος Μακραν της Ισορροπιας

Αυτο-Οργανωση, Δομες Εκλυσης, Κυβερνητικη 2

Μελετη Συλλογικων Φαινομενων σε ολους τους Τομεις

Φυσικη, Βιολογια, Ψυχολογια, Οικονομια

Η Εντροπια ως βασικος Στατιστικος Δεικτης

2000-2010
Θεωρια Δικτυων

Τα Δικτυα αναδυονται ως Κοινο Πλαισιο Περιγραφης
των αλληλοεξαρτησεων
των Πολυπλοκων Συστηματων

Η **Δομη** των Πολυπλοκων Συστηματων
(Τα Συστηματα αναπαριστωνται ως Δικτυα και αντιστροφως
κάθε Δικτυο αποτελει Συστημα σχεσεων)

Δυναμικη Δικτυων:
Η **Λειτουργια-Εξελιξη** των Πολυπλοκων Συστηματων

Κατανεμημενη Λειτουργια-Επεξεργασια
Distributed Processing

Αναλυση Πραγματικων Συστηματων με Δικτυα
Ελεγχος της Θεωριας