

Number Systems, Technology, and Civilization

As far back as archaeological research takes us, we have been concerned as to the origins of civilization. The word itself is a subject of dispute. For our present purposes, we simply note that most civilizations we have come to recognize their association with the evolution of number systems. And along with number systems have come systems of writing, be their numerals or some form of hieroglyphics.

Here, we take up the question of the history of number systems and how they have shaped and at the same time reflect the various forms of civilization over time. Phi, Pi, and other mathematical relations have informed our understanding of the universe and are the building blocks of space exploration. What enriches our investigation is taking stock of the role of technology in improving our understanding of the history of numbers, and for which any number of puzzles remain unsolved. We do so through a stream of four consecutive sessions in which we develop characterizations of the history of numbers of the implications for our understanding of civilization.

1. **Origins of Number Systems.** Can animals count and if so, how do we know? Have oral traditions informed our sense of numbers, and how do they relate to the emerge of written languages? Why are numbers important – architectural and commercial value of number systems. Do we have any evidence of organized civilizations that have not relied on identifiable number systems. How have ancient number systems shaped early forms of civilization? What constitutes a civilization from both an historical and contemporary perspective: art, music, architecture, poetry, literature, language, cuisine, systems of beliefs, scientific prowess, and technological innovation. How do number systems facilitate social organization and representation across the spectrum of communication? Mohenjo Daro, Sumer, Babylon, Egypt, Hittites, Greeks, Romans, Chinese, Olmec, Maya, Aztec, Inca, Japan, Angkor Wat, Zimbabwe, Benin, Ethiopia, Spain, France, England, Russia, Germany.
2. **The Evolution of Number Systems and Mathematical Formulations.** On what basis have the earliest numbering systems emerged and where so? Is there symbolic significance in the base 60, or other systems as to the nature of civilization? Comparing hierarglyphic, Sumerian, Chinese, Roman, and Arabic number systems. The evolution of algebra, geometry, trigonometry, and calculus as measurement tools for the solution of specific problems. Sumerian, Egyptian, Babylonian, Indian, Chinese, Thales (626 BCE-548 BCE), Pythagoras (570 BCE-495 BCE) , Zeno (495 BCE-430 BCE), Democritus (460 BC-370 BCE), Euclid (350 BCE-250 BCE), Archimedes (287 BCE-212 BCE), Eratosthenes (276 BCE-194 BCE), Ptolemy (100 CE-170 CE), Diophantus (200-284), Brahmagupta (598-668) , Bhaskara (1114 -1185), Leonardo of Pisa (1170-1245), Qin Jiushao (1208-1261) , Nicole Oresme (1323-1382), Luca Pacioli(1445-1517) , John Napier (1550-1617), René Descartes (1596-1650), Blaise Pascal (1623-1662), Isaac Newton (1643-1727), Jacob Bernoulli (1655-1705), Daniel Bernoulli (1700-1782), Leonhard Euler (1707-1783), Carl Friedrich Gauss (1777-1855), George Boole, (1815-1864), Bernhard Riemann (1826-1866), Henri Poincaré ((1854-1912), L.E.J. Brouwer (1881-1966), John von Neumann (1903-1957), Oskar

Morgenstern (1902-1977), Kurt Gödel (1906-1978) , Alan Turing (1912-1954), Benoit Mandelbrot (1924-2010), John Nash (1928-2015), Andrew Wiles (1953-), Grigori Perelman (1966-).

3. **Various Technologies for Calculations.** Hand counting, the abacus, rings, rocks, and other mechanisms for counting. Fire (400,000 BCE), Neolithic Civilization (10,000-4,500 BCE), , The Lever (5,000 BCE), The Wheel (4200-4000 BCE), Calendar Systems (3100 BCE), Abacus (2,400 BCE), Windmills (644 BCE), Magnetism (600 BCE), Magnetic Compass (206 BCE), Paper Money (600), Gunpowder (800 CE), Rocketry (900), Mechanical Clocks (1340), Analog Calculators (1617), Electricity (1752), Printing (1440), Steam Engines (1698), Cotton Gin (1794), Smallpox vaccination (1798), Photography (1826), Railways (1827), Electric Vehicle (1832), Reaper (1834), Telegraphy (1843), Internal Combustion Engine (1860), Diesel Engine (1893), Telephone (1876), Internal Combustion Automobile (1886), Matrix Inversion (1887), Airplane (1903), FAX Machine (1924), Television (1927), Cable Television (1948), Dynamic Programming (1950's), Salk Polio Vaccine (1954), Microwave Oven (1967), Digital Mainframe Computer (1943), Nuclear Power (1945), the Transistor (1947), Supersonic flight (1947), Artificial Intelligence (1956), the Internet (1961), LED technology (1962), International Space Station (1969), the Personal Computer (1971), Black-Sholes Formula (1973), SMS Text Messaging (1984), CRISPR (1987), JPEG imagery (1992), Emoji (1997). the iPod (2001-2022), the iPhone (2007), the iPad (2010), COVID vaccines (2021)
4. **Extending the Frontiers of Knowledge through Numerical Complexity.** How the fixed and stochastic calculus have improved our understanding of dynamic processes from the solar system, the universe, and the mastery of energy. Unresolved mathematical problems continue to engage our inquiries and offer the promise of further advances in civilization. Remaining mathematical puzzles on the frontiers of knowledge, Incomplete and Complete Knowledge under Symmetric and Asymmetric Distributions, Decisions under Risk and Uncertainty, Global Warming, Environmental Sustainability, Extraterrestrial life, Life Expectancy, Visual, Written, Spoken, and Culinary Cultural Expression Within and Across Geopolitical Boundaries, Global Governance.

Selected Readings

- Acemoglu, Daron, and James A. Robinson (2012). *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*. (New York: Crown Publishers).
- Aczel, Amir D. (1999). *God's Equation: Einstein, Relativity, and the Expanding Universe* (New York: Four Walls Eight Windows Publishers).
- Aczel, Amir D. (1998). *Probability: Why There Must Be Intelligent Life in the Universe*. (New York: Harcourt Brace and Company).
- Aczel, Amir D. (1996). *Fermat's Last Theorem: Unlocking the Secret of an Ancient Mathematical Problem*. (New York: Four Walls Eight Windows Publishers).
- Albert, David Z. (1994, 1992). *Quantum Mechanics and Experience*. (Cambridge, Mass.: Harvard University Press).
- Baggott, Jim (1993, 1992). *The Meaning of Quantum Theory*. (New York: Oxford University Press).
- Berger, Peter and Thomas Luckmann (1967, 1966). *The Social Construction of Reality: A Treatise on the Sociology of Knowledge* (New York: Anchor Books).
- Boyer, Carl B. (1959, 1949). *The History of the Calculus and Its Conceptual Development*. (New York: Dover Publications).
- Calder, Nigel (1979). *Einstein's Universe: Relativity made Plain – The Amazing Achievement of Albert Einstein and What It Means Today*. (New York: The Viking Press)
- Chuyev, Yuri V., Yuri B. Mikhaylov (1975). *Forecasting in Military Affairs: A Soviet View*. (Washington, D.C.: U.S. Government Printing Office).
- Daly, Herman E. (1977). *Steady-State Economics*. (San Francisco: W.H. Freeman and Company).
- Diamond, Jared (2006, 2005). *Collapse: How Societies Choose to Fail or Succeed*. (New York: Penguin Books).
- Diamond, Jared (1999, 1997). *Guns, Germs, and Steel: The Fates of Human Societies*. (New York: W.W. Norton and Company).
- Dupuy, Colonel T.H., US Army Retired (1979). *Numbers, Predictions and War: Using History to Evaluate Combat Factors and Predict the Outcome of Battles*. (London: MacDonal and Jane's)
- Ellul, Jacques (1964). *The Technological Society*. (New York: Vintage Books.)
- Georgescu-Roegen, Nicholas (1976, 1971). *The Entropy Law and the Economic Process*. (Cambridge, Mass.: Harvard University Press).
- Held, David (1987). *Models of Democracy*. (Stanford, California: Stanford University Press).
- Hofstadter, Douglas R. (1980, 1979). *Gödel, Escher, Bach: An Eternal Golden Braid: A Metaphorical Fugue on Minds and Machines in the Spirit of Lewis Carroll*. (New York: Vintage Books).
- Hodges, Henry (1992, 1970). *Technology in the Ancient World*. (New York: Barnes and Noble Books).
- Hogben, Lancelot (1993, 1937). *Mathematics for the Millions: How to Master the Magic of Numbers*. (New York: W.W. Norton and Company).
- Ifrah, Georges (2000). *The Universal History of Numbers*. (New York: John Wiley and Sons).
- Keynes, John Maynard (2007, 1919). *The Economic Consequences of the Peace*, with an Introduction by Paul A. Volcker. (New York: Skyhorse Publishing).

- Kidwell, Peggy A., and Paul E. Ceruzzi (1994). *Landmarks in Digital Computing*. (Washington, D.C.: Smithsonian Publishing).
- Kipfer, Barbara Ann (2001, 1997). *The Order of Things: How Everything in the World is Organized into Hierarchies, Structures, and Pecking Orders*. (New York: Random House).
- Kline, Morris (1982, 1980). *Mathematics: The Loss of Certainty*. (New York: Oxford University Press).
- Klingaman, William K. and Nicholas P. Klingaman (2013). *The Year Without Summer: 1816 and the Volcano That Darkened the World and Changed History*. (New York: St. Martin's Press).
- Livio Mario (2003). *The Golden Ratio: The Story of Phi, the World's Most Astonishing Number* (New York: Broadway Books).
- Mangel, Marc, and Colin W. Clark (1988). *Dynamic Modeling in Behavioral Ecology*. (Princeton, N.J.: Princeton, New Jersey).
- McKenzie, A.E.E. (1973, 1960). *The Major Achievements of Science*. (New York: Touchstone Books).
- Meigs, Russell (1998, 1982). *Trees and Timber in the Ancient Mediterranean World*. (Oxford, U.K.: The Clarendon Press).
- Menninger, Karl (1992, 1969). *Number Words and Number Symbols: A Cultural History of Numbers*. (New York: Dover Books).
- Miller, John H. and Scott E. Page (2007). *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*. (Princeton, N.J.: Princeton University Press).
- Nettle, Daniel, and Suzanne Romaine (2000). *Vanishing Voices: The Extinction of the World's Languages* (New York: Oxford University Press).
- Ore Oystein (1988, 1976, 1948). *Number Theory and its History* (New York: Dover Books)
- Prigogine, Ilya (1997, 1996). *The End of Certainty: Tie, Chaos, and the New Laws of Nature*. (New York: The Free Press).
- Resnikoff, H.L. and R.O. Wells, Jr. (1984, 1973). *Mathematics in Civilization*. (New York: Dover Books).
- Routledge, Robert (1989). *Discoveries and Inventions of the 19th Century*. (New York: Crescent Books).
- Schumpeter, Joseph A. (1961, 1934, 1911). *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. (New York: Galaxy Books for Harvard University Press).
- Seife, Charles (2000). *Zero: The Biography of a Dangerous Idea*. (New York: Penguin Books).
- Shiller, Robert J. (2000). *Irrational Exuberance*. (Princeton, N.J.: Princeton University Press).
- Smiley, Jane (2000, 1997). *The Sagas of Icelanders: A Selection*, with an Introduction by Robert Kellogg (New York: Viking Penguin Books).
- Smith, Bruce D. (1998, 1995). *The Emergence of Agriculture*. (New York: W.H. Freeman for the Scientific American Library).
- Snow, C.P. (1969, 1959). *Two Cultures and a Second Look*. (New York: Cambridge University Press).
- Stewart, Ian (2008). *The Story of Mathematics: From Babylonian Numerals to Chaos Theory*. (London: Quercus Publishing).
- Swade, Doron (2000). *The Difference Engine: Charles Babbage and the Quest to Build the First Computer*. (New York: Penguin Books).

- Thompson, D'Arcy Wentworth (1991, 1942). *On Growth and Form: The Complete Revised Edition*. (New York: Dover Books).
- Weinberg, Steven (1992). *Dreams of a Final Theory: The Search for the Fundamental Laws of Nature*. (New York: Pantheon Books).
- Williams, Ann, and G.H. Martin, editors (1992, 1000). *The Domesday Book, A Complete Translation* (New York: Penguin Books).
- Young, W. Peyton (1999). *Individual Strategy and Social Structure: An Evolutionary Theory of Institutions*. (Princeton, N.J.: Princeton University Press).