



PHYSICS AND ASTRONOMY COLLOQUIUM

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“The Complexity, Simplicity, and Unity of Living Systems from Cells to Cities; A Physicist's Search for Unifying Theories of Biological and Social Structure and Dynamics”

Abstract

Despite its extraordinary complexity and diversity, many of Life's most fundamental and complex phenomena, whether cells or cities, scale with size in a surprisingly simple and universal fashion. For example, metabolic rate scales approximately as the $3/4$ -power of mass over 27 orders of magnitude from complex molecules to multicellular organisms.

Time-scales (such as lifespans and growth-rates) and sizes (such as genome lengths and RNA densities) scale with exponents which are typically simple multiples of $1/4$. These "universal" $1/4$ power scaling laws follow from dynamical and geometrical properties of space-filling, fractal-like, branching networks presumed optimised by natural selection. This leads to a quantitative, mechanistic framework that captures many essential features of diverse biological systems, including vasculature, growth, cancer, aging and death, sleep, cell size, and DNA nucleotide substitution rates. Cities and companies also scale: wages, profits, patents, crime, disease, pollution, road lengths scale similarly across the globe, reflecting underlying universal social network dynamics and principles of organization that transcend their individuality. Are cities and companies "just" large organisms? Why then do almost all cities persist, yet all companies die? Why does the pace of life continue to accelerate and how is this related to innovation and wealth creation that fuel socio-economic systems? Answers to such questions have potentially dramatic implications for growth, development and global sustainability.

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3:30 p.m.

Bob Wright Centre

Room A104