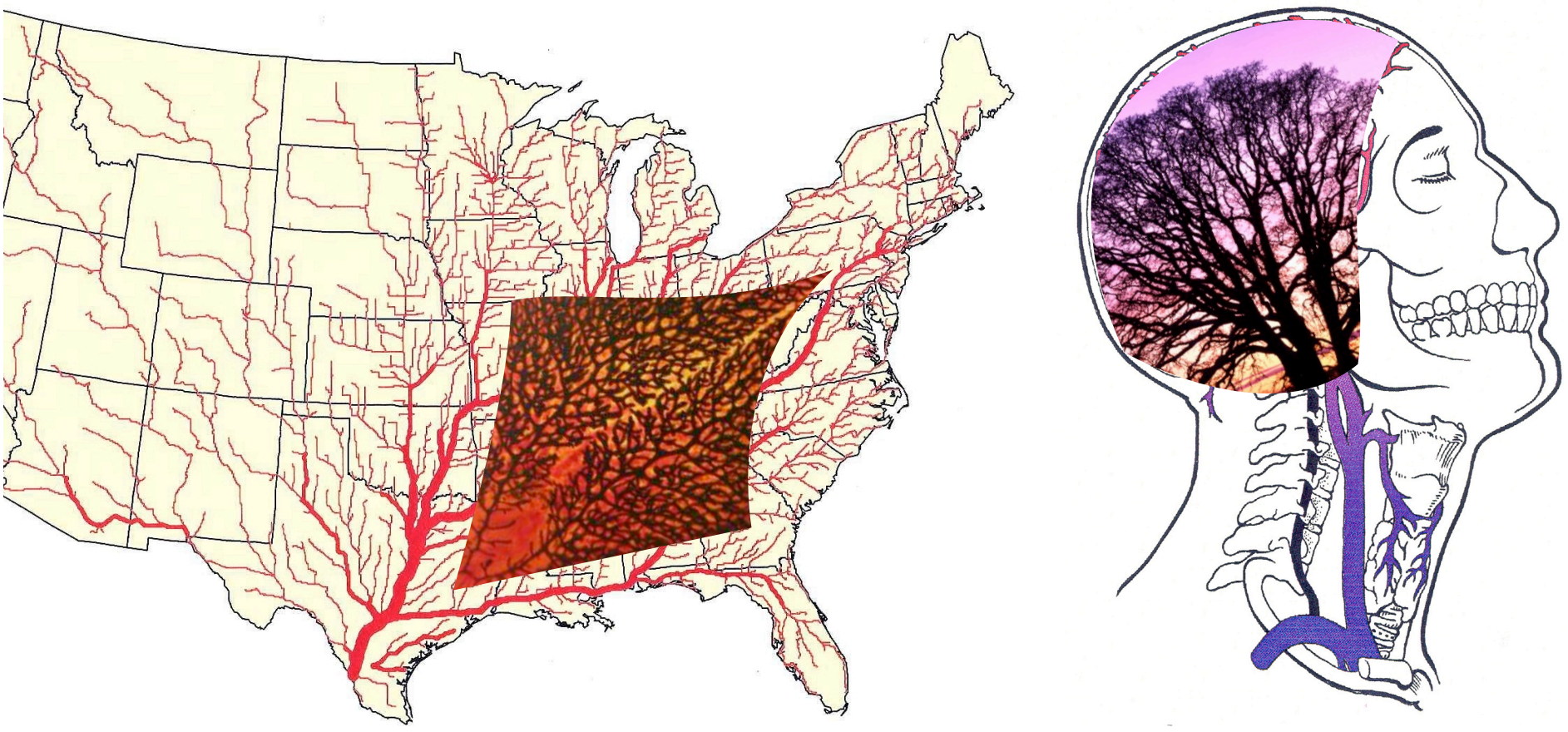
Boston University Physics Colloquium



The Complexity, Simplicity, and Unity of Living Systems from Cells to Cities:
A Physicist's Search for Quantitative, Unified Theories of Biological and Social Structure and Organization

Although Life is very likely the most complex phenomenon in the Universe, many of it's most fundamental and complex phenomena scale with size in a surprisingly simple fashion. For example, metabolic rate scales approximately as the 3/4-power of mass over 27 orders of magnitude from complex molecules up to the largest multicellular organisms. Similarly, time-scales (such as lifespans and growth-rates) and sizes (such as genome lengths, RNA densities, and tree heights) scale as power laws with exponents which are typically simple multiples of 1/4. The universality and simplicity of these relationships, together with emergent "universal" invariants, suggest that fundamental constraints underly much of the coarse-grained generic structure and organization of living systems. It will be shown how these 1/4 power scaling laws follow from underlying principles embedded in the dynamical and geometrical structure of space-filling, fractal-like, hierarchical branching networks, presumed optimized by natural selection. These ideas lead to a general quantitative, predictive theory that potentially captures the essential features of many diverse biological systems. Examples will include vascular systems, growth, cancer, aging and mortality, sleep, cell size, genome lengths, and DNA nucleotide substitution rates. These ideas will be extended to social organizations: to what extent are cities or corporations an extension of biology? Are they "just" very large organisms? Analogous scaling laws reflecting underlying social network structure point to general principles of organization common to all cities, but, counter to biological systems, the pace of social life systematically increases with size. This has dramatic implications for growth, development and particularly for sustainability: innovation and wealth creation that fuel social systems, if left unchecked, potentially sow the seeds for their inevitable collapse.

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April 21, 2009 (Tuesday) at 3:30pm (Refreshments at 3:15pm)
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Host: Lawrence Sulak