
Constructal Theory of Social Dynamics

Edited by

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Preface

Society is a “live” flow system, perhaps the most complex and puzzling we know. It is a jungle of flow systems—a vast multiscale system of systems—with organization, pattern, hierarchies, and usefulness (design). It is the most difficult to comprehend because we, the individuals who try to make sense of it, are inside the flow system. Difficult, because each of us is like an alveolus in the lung, an eddy in a turbulent river, or a leaf on a tree branch. From such a position of singularity, which is *identical* in rank to the positions of enormous numbers of individuals, it is a formidable task to see and describe the big picture—the lung, the river basin, and the forest.

Man’s great fortune has been the fact that Nature has shape, structure, configuration, pattern, rhythm, and similarity. From this stroke of luck, science was born and developed to the present day, where it is responsible for our physical and intellectual well-being. The puzzling architecture and history of society has many things in common with the architecture and evolution of other complex (but simpler) flow systems: blood vascularization, river basins and deltas, animal movement, turbulence, respiration, dendritic solidification, etc. Coincidences that occur in the billions are loud hints that a universal phenomenon is in play. Is there a single physics principle from which the phenomenon of configuration and rhythm can be *deduced* without recourse to empiricism?

In this book we show that there is such a principle, and it is based on the common observation that if a flow system (e.g., river basin, vascularized tissue, city traffic) is endowed with sufficient freedom to change its configuration, the system exhibits configurations that provide progressively better access routes for the currents that flow. Observations of this kind come in the billions, and they mean one thing: a time arrow is associated with the sequence of flow configurations that constitutes the existence—the survival—of the system. Existing drawings are replaced by easier-flowing drawings. This physics principle is the *constructal law* of the generation of configuration in Nature: “For a finite size flow system to persist in time (to survive) its configuration must evolve in such a way that it provides easier and easier access to the currents that flow through it.”

At Duke, where constructal theory began by accident in 1996 as a thermodynamics principle that unites physics with biology and engineering, we have stumbled upon another accident: scientists and sociologists view the generation of design in societies based on the same principle. Duke is a wonderful place not because of beautiful gardens and basketball, but because of *freedom*. Freedom

is good for all design, from the better-flowing river basins to the faster, cheaper, and safer flowing rivers of people and goods (our society with all its live tree flows), all the way to the design called “better science.”

Freedom brought the two of us together, a sociologist and an engineering scientist, and we were soon joined in this fertile discussion by our prominent colleagues Ed Tiryakian and Ken Land. Together we decided that the élan that constructal theory had generated in science is so contagious, and the theory itself so commonsense, concise, and useful, that it deserves to be discussed more broadly with colleagues throughout social sciences. We proposed this vision to the Human and Social Dynamics program of the National Science Foundation, which gave us an exploratory grant to “develop a community of scholars around the constructal theory of social dynamics.”

This book is the first of its kind in this new field. It is the first account of the ideas, results, and future plans that came out of putting scientists, sociologists, and engineers together. The chapters of this book are based on the contributions made by prominent invited speakers at the First International Workshop on the Constructal Theory of Social Dynamics, which was held on 4–5 April 2006 at Duke University. We wish to thank the authors for their contributions to the workshop and to this book:

Prof. Sylvie Lorente
 Prof. Heitor Reis
 Prof. Antonio Miguel
 Mr. Stephen Périn
 Prof. Edward Tiryakian
 Prof. John Staddon
 Prof. Anthony Oberschall
 Prof. Kenneth Land
 Prof. Carter Butts
 Ms. Miruna Petrescu-Prahova
 Ms. Lorien Jasny
 Dr. Franca Morroni
 Dr. John Angle
 Mr. Cyrus Amoozegar
 Mr. Jean-Christophe Danaës

The constructal theory of social dynamics developed in this book surprises even us with the breadth and freshness of the territory that it covers. Major threads of this emerging theory of social organization are as follows:

- The organized multiscale distribution of living settlements. The idea is to place the community–community access in geometric terms, and to optimize it everywhere, subject to space constraints. Allocation of territory to movement (people, goods, information) is the fundamental idea.
- The occurrence of multiscale structure inside a settlement. In a city, for example, we see a compounding of scales, and each flowing thing has its

own hierarchy of scales. One example is how small streets coexist with larger (fewer) streets, and how the latter sustain a single artery. There are macroscopic features that appear in the largest cities (finger-shaped growth, beltways) that may be attributed to the same global principle of maximization of access.

- Development, and the connection between “flowing” societies, advancement, and prosperity. There is an opportunity to exploit the constructal idea of the need to be free to change the flow configuration, and connect it with the Darwinian view that the living constructs that prosper are those that possess the greatest ability to change.
- Migration patterns on the globe, in space and in time. Where and when people settle may be random individually, but the society appears to be the result of global optimization.
- Globalization, and the problematic aspects of overcoming obstacles to efficient flows, e.g., investment funds from the public and private sectors.

In sum, this book is about the tearing down of fences that are presumed to exist between the most central fields of human thought. To tear down fences means the opposite of “to destroy.” It means *to construct* a far bigger tent that covers the designs (the bodies of knowledge) of historically separate fields.

Science is our knowledge of how nature works. Nature is *everything*, including engineering and society. Our knowledge is condensed in simple statements (thoughts, connections), which evolve in time by being replaced by simpler statements. We “know more” because of this evolution in time, not because brains become bigger and neurons smaller and more numerous. Our finite-size brains keep up with the steady inflow of new information through a process of simplification by replacement: in time, and stepwise, bulky catalogs of empirical information (e.g., measurements, observations, data, complex empirical models) are replaced by much simpler summarizing statements (e.g., concepts, formulas, constitutive relations, laws). A hierarchy of statements emerges along the way: it emerges naturally, because it is better than what existed before.

The simplest and most universal are the laws. The bulky and the laborious are being replaced by the compact and the fast. In time, science optimizes and organizes itself in the same way that a river basin evolves: toward configurations (links, connections, design) that provide faster access, or easier flowing.

The hierarchy that science exhibited at every stage in the history of its development is an expression of its never-ending struggle to optimize and redesign itself. Hierarchy means that measurements, ad hoc assumptions, and empirical models come in huge number, a “continuum” above which the compact statements (the laws) rise as needle-shaped peaks. Both are needed, the numerous and the singular. One class of flows (information links) sustains the other.

Civilization with all its constructs (science, religion, language, writing, etc.) is this never-ending physics of generation of new configurations, from the flow of mass, energy, and knowledge to the world migration of the special persons to whom ideas occur (the creative). Good ideas travel and persist. Better-flowing

configurations replace existing configurations. Empirical facts are extremely numerous, like the hill slopes of a river basin. The laws are the extremely few big rivers, the Seine and the Danube. This book is about the big river of all "live" flow systems, including social dynamics: the constructal law.

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