Theory of Physics Explains Human Patterns

June 12 2007

Why does a railway network look like a river? Why do the streets of old Rome look like a leaf? Because whether their shape is determined by the interactions of molecules or the choices made by individual humans, all of these systems of flow are governed by a relatively simple new principle of thermodynamics.

"Society, with all its layers and features of organization, is a flow system," say co-editors Adrian Bejan and Gilbert Merkx of Duke University. Consequently, these repeating patterns are no accident. "Coincidences that occur in the billions are loud hints that a universal phenomenon is in play."

That's the premise of an ambitious new collection of essays in the text "Constructal Theory of Social Dynamics," published June 13 by Springer Science+Business Media.

First described a decade ago by Bejan, a professor of mechanical engineering at Duke, the constructal theory is a deceptively simple explanation for why these branching patterns occur so frequently: for a flow system to persist in time, its configuration must change such that it provides easier access to its currents. Simply put, if something is flowing, it will branch in a fairly predictable pattern to reduce imperfections like friction, or in this case, bumping into pedestrians coming the other way. "Natural systems will always move toward faster access or easier flow," Bejan said.

We see the resulting branching pattern at all scales, from the alveoli of

the lungs, to the paths animals take to a watering hole, to the streams of a great river delta. Each of these structures has been honed by time to handle flow as efficiently as possible. Social scientists who are applying the theory to their fields suddenly see constructal patterns in everything from human migration patterns to a bowl of boiling rigatoni.

"What is new with constructal theory is that it unites geometry with dynamics in such a way that geometry is not assumed in advance but is the end result of a tendency in time," writes A. Hector Reis of Universidade de Évora in Portugal in his chapter on "flows of people."

For pedestrians pushing out of a football stadium or airplanes crossing the sky, there are predictable ways to make these social flows more efficient, said the book's co-author, sociologist Gilbert Merkx, Duke's vice provost for international affairs. Constructal theory fits well with network theory in sociology and helps explain why the large patterns persist even where there's free will and consciousness.

Although originally framed as a way to improve electronic heat-exchangers by borrowing from nature, Bejan's idea has spread to many other realms. For example, Bejan is currently branching out, as it were, on how constructal theory applies to the running, flying and swimming of animals and the distribution of city sizes -- a few large, many small -- all over the world.

The discussion of constructal theory's application to the social sciences grew out of a chance encounter between Bejan and Merkx at a faculty luncheon.

"In the course of conversation, I said 'so, Adrian, what do you do?' " Merkx recalled. "And as he described it, I realized that constructal theory sounded like what I'd observed in the social sciences."

They began to collaborate and won funding for two international conferences at Duke to explore the connections between social phenomena and constructal theory, out of which grew the book. "This is about tearing down the wall between the natural and social sciences," Merkx said.

The 355-page text features 18 essays by an international group of social scientists exploring the constructal underpinnings of everything from urban development and racial segregation to the development of written language.

Source: Duke University