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Vascular Design: Freedom, Evolution, Hierarchy

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Porous materials are usually thought of as amorphous mixtures of two or more things, solids, fluids, and voids. The research field started that way, and so did my own activity in it. Along the way, I was drawn to the part of nature (the physics) that was missing from the amorphous view: the structure, flow, configuration, drawing (design), purpose, and evolution.

The lecture is pictorial. It begins with defining the terms, because words have meaning: vascular, design, evolution, and prediction (theory). Next, vascular (tree shaped) architectures flow more easily than parallel channels with only one length scale (the wall to wall spacing). Transport across channels is facilitated when the spacing is such that the channel flow length matches the entrance (developing) length of the flow.

The tendency to evolve with freedom toward flow configurations that provide greater access is universal in nature, bio, and non-bio. This tendency is the Constructal Law, which empowers us to predict the evolution toward flow access, miniaturization, high density of heat transfer, and the scaling up (or down) of an existing design.

Vascular designs are icons of the design feature called hierarchy. Vasculatures occur naturally because they flow more easily than one-size designs. The movements in society are hierarchical, from city traffic to global air traffic, fuel consumption, and wealth. The future of evolutionary design everywhere points toward vascular, hierarchical flow architectures that will continue to morph with freedom and directionality.

To read more:

HEAT TRANSFER: Evolution, Design, and Performance, Wiley 2022.

FREEDOM AND EVOLUTION: Hierarchy in Nature, Society and Science, Springer 2020.

CONVECTION HEAT TRANSFER, 4th ed, Wiley, 2013.

Participation

In-Person

References

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