Detangling the vascular web

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Transport and distribution networks
How does nature build and maintain well functioning transport networks?
The brain

The brain Leaf Physarum

Penn Physics & Astronomy
The topology of vasculature

3d Networks with **restricted** degree

Topology and machine learning

Geometry carries information orthogonal to topology.

Geometry and topology are distinct phenotypes.

\( \sigma \) vein density
\( a \) mean distance between veins
\( A \) mean areole area
\( \rho \) areole density
\( d \) average vein diameter weighted by length of venation between junctions
Dynamics of growth

\[ \frac{dK_e}{dt} = a |F_e|^\sigma - b K_e + c \]
$C = \sum_{e} L_e K_e^{\gamma}$

Cost

Percolation penalty

$\hat{A} = \sum_{e} \frac{A_e}{A_{\text{tot}}}$
Functional archetypes

Tree archetype
- Low cost
- High percolation penalty
- Hierarchical

Decreasing $\sigma$

“Chickenwire” archetype
- High cost
- Low percolation penalty
- Uniform

(a) (b) (c)

EK, H. Ronellenfitsch, (in preparation)
The human vasculature