Modelling Elastin Self-Assembly

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HEART & STROKE FOUNDATION
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SickKids

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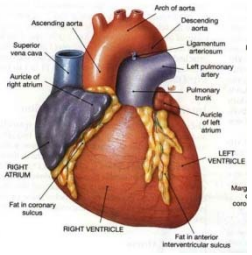
Elastin

- Elastic proteins imparting elasticity to tissues like skin, arteries, and lung parenchyma
- Found in many organisms
- Excellent potential to be used in novel biomaterials
  - Vascular grafts, artificial bladders using elastin
  - Military armor applications with spider silks



Tropoelastin

- Monomer form of elastin; self-assemble into fibre-like elastin
- DNA sequences typically have 34 to 36 exons, each corresponds to a hydrophobic or cross-linking domain in protein

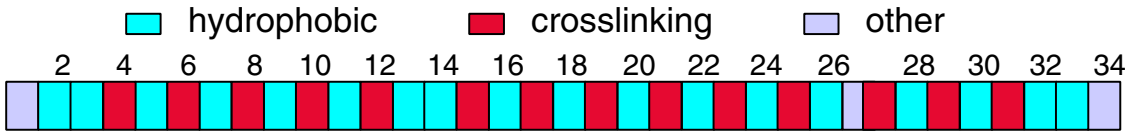


Figure 1. Exons of Human Tropoelastin

- Biomechanical tests on human elastin showed that change of tropoelastin domain configuration could affect physical properties of elastin

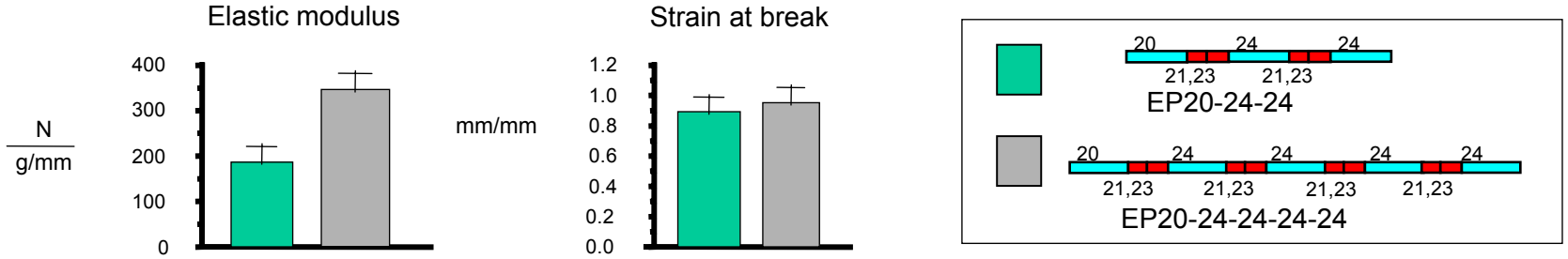


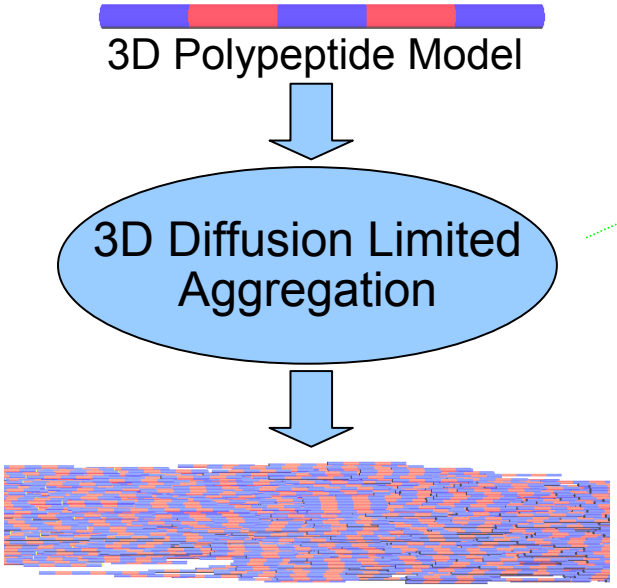
Figure 2. Comparisons of modulus and strain with different polypeptides based on human elastin

Motivation & Method

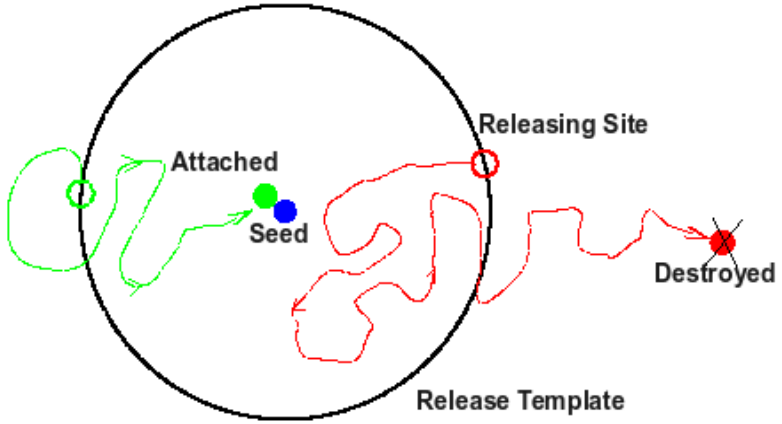
Motivation:

How does the domain architecture of tropoelastin influence the morphology and properties of the resultant elastin fibres?

Method:



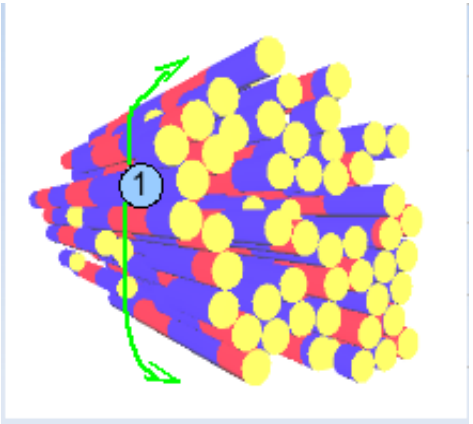
Generated 3D Aggregate



2D Diffusion Limited Aggregation

1. Plant a seed (blue) in the template center
2. Release particles from the template
3. Particles undergo Brownian motion, either attach to the seed or are destroyed
4. Repeat steps 2, and 3

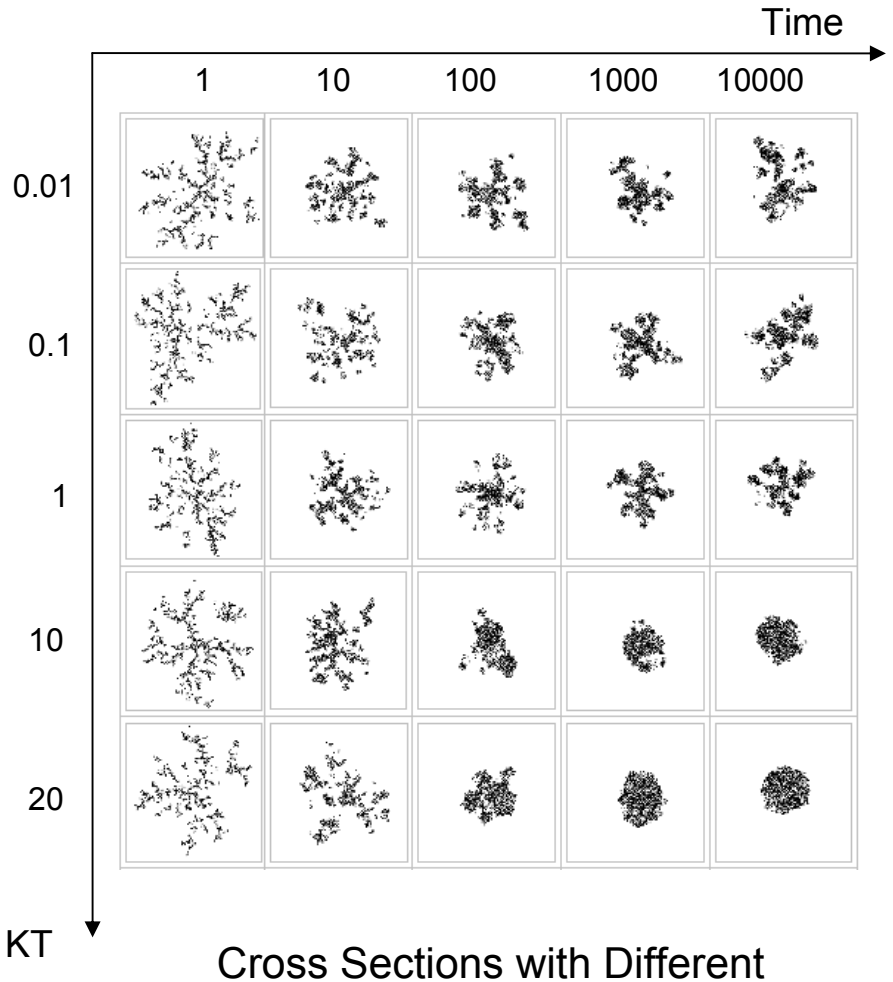
Surface Area Optimization



Surface Area Optimization

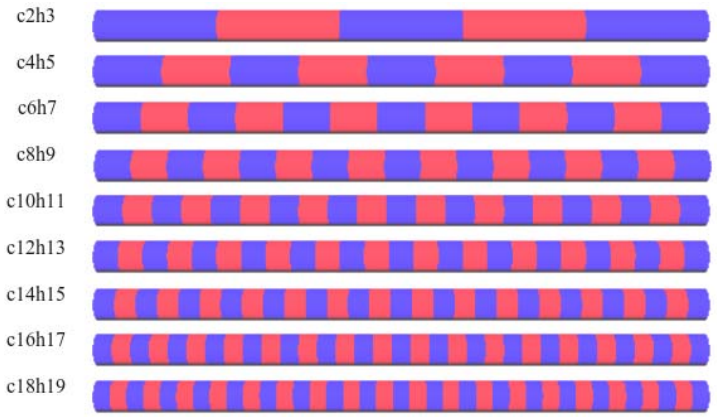
Particles spin around the aggregate to find positions minimizing the surface area of the aggregate. If a new position is as favourable or more favourable than the previous position, move to the new position. Otherwise, the movement of the particle is determined by probability, p, where,

$$p = \min\left\{1,\ e^{-\Delta E/KT}\right\}.$$

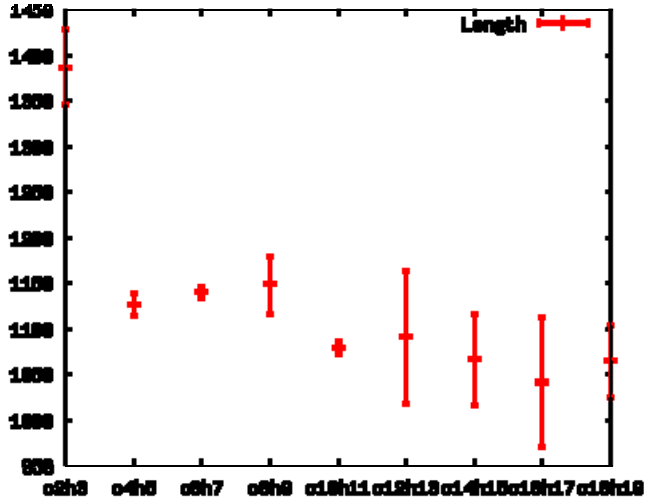


Cross Sections with Different KT Values and Time

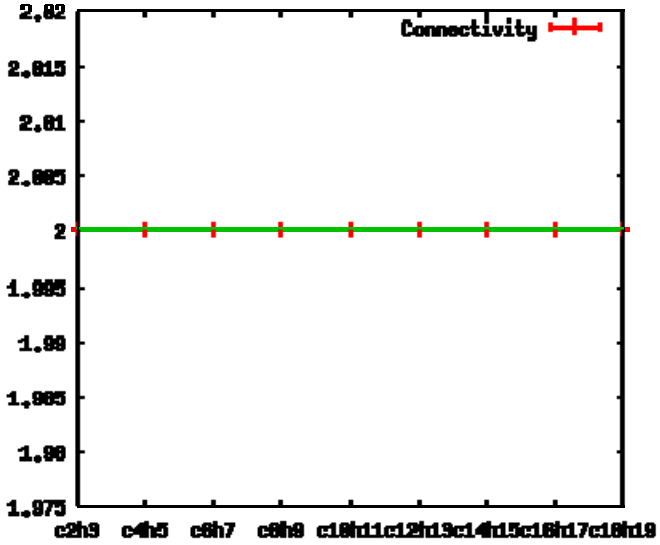
Number of Domains



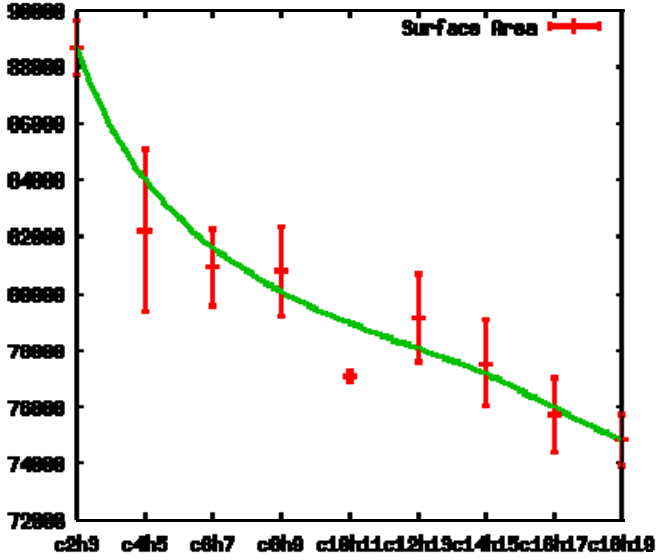
(A) Models with the same length mapped to different number of domains



(B) Aggregate Length



(C) Connectivity



(D) Surface Area