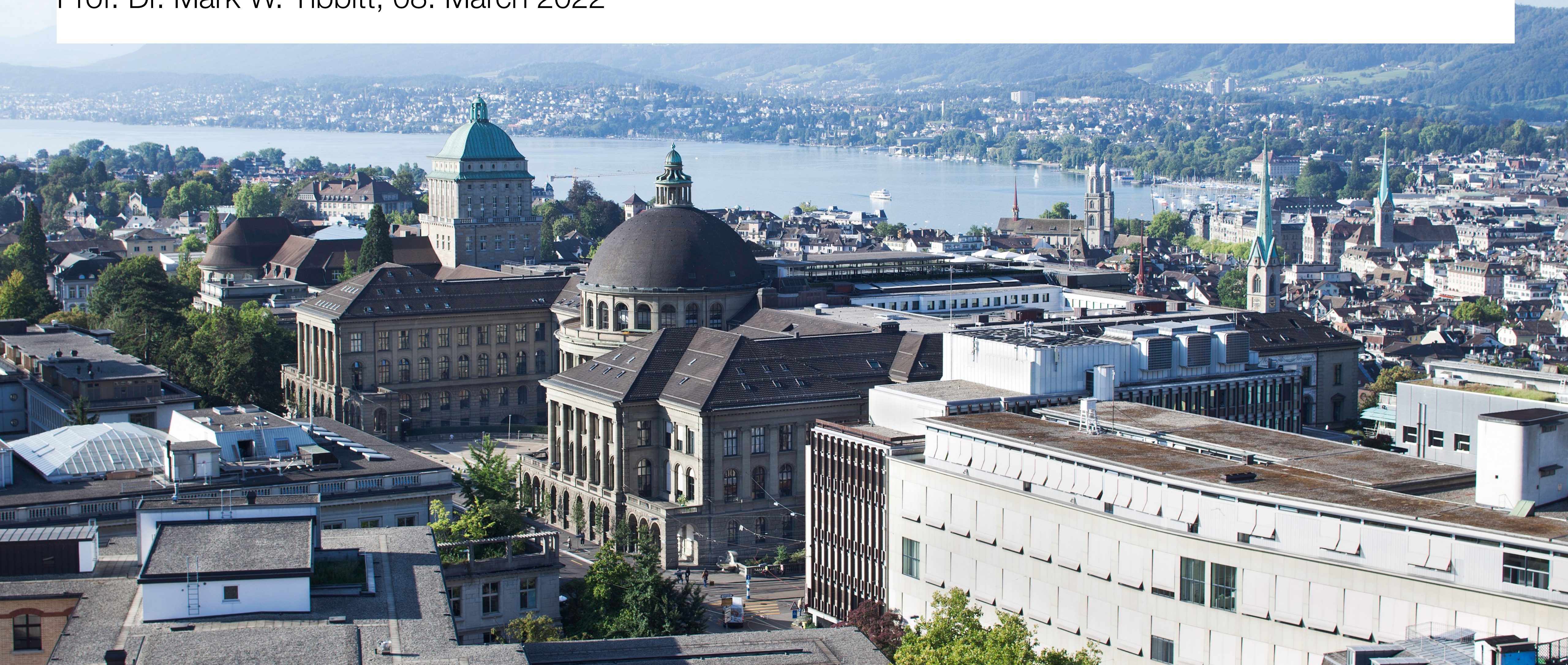


Lecture 5: Entropic elasticity – interactive exercise

Prof. Dr. Mark W. Tibbitt, 08. March 2022



History of rubber

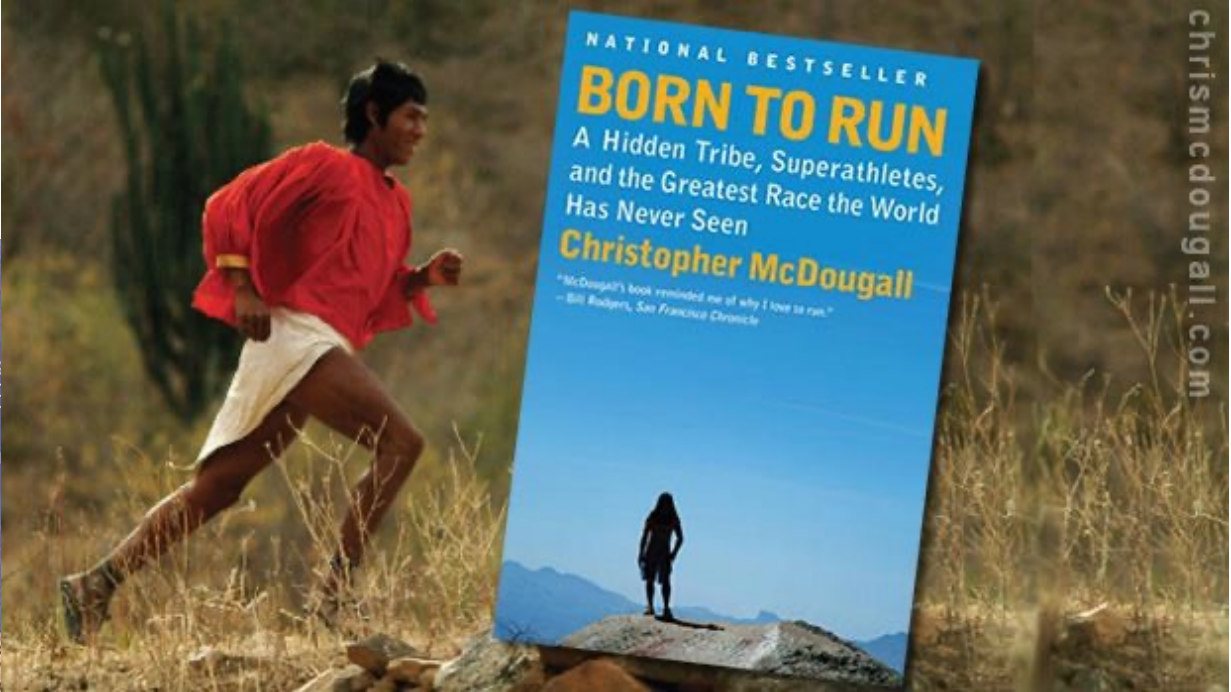
It all started in Mesoamerica!

Natural latex



Caoutchouc - 'weeping wood'

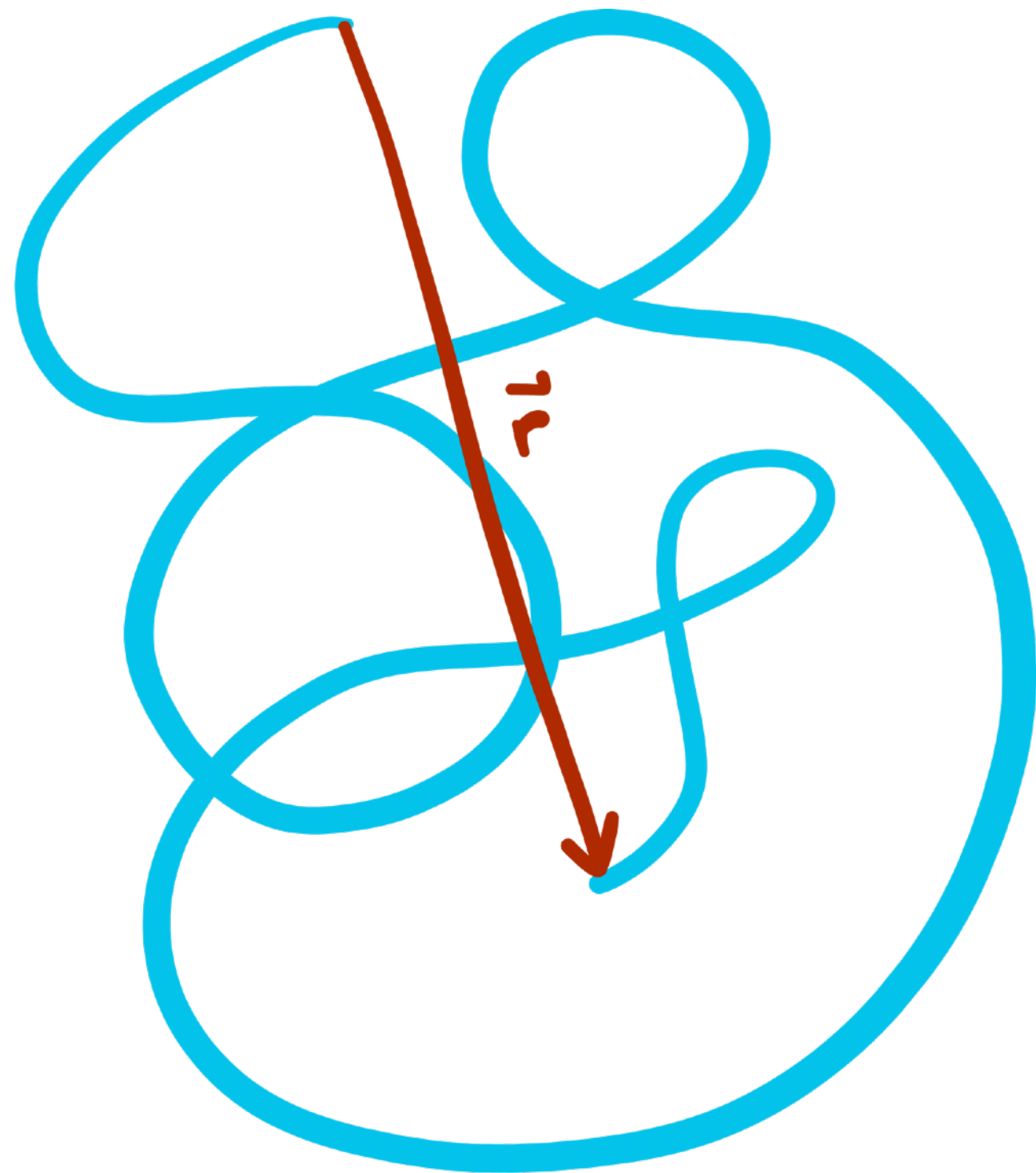
ca. 1600 BCE



1839 CE

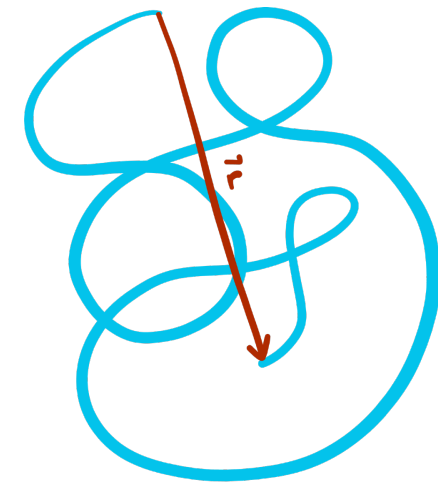


$$S(\vec{r}, N) = -\frac{3k_B T}{2N\ell^2} \vec{r}^2 + S(0, N)$$



$$\vec{f} = \frac{3k_B T}{N\ell^2} \vec{r}$$

$$\langle r^2 \rangle = N\ell^2$$

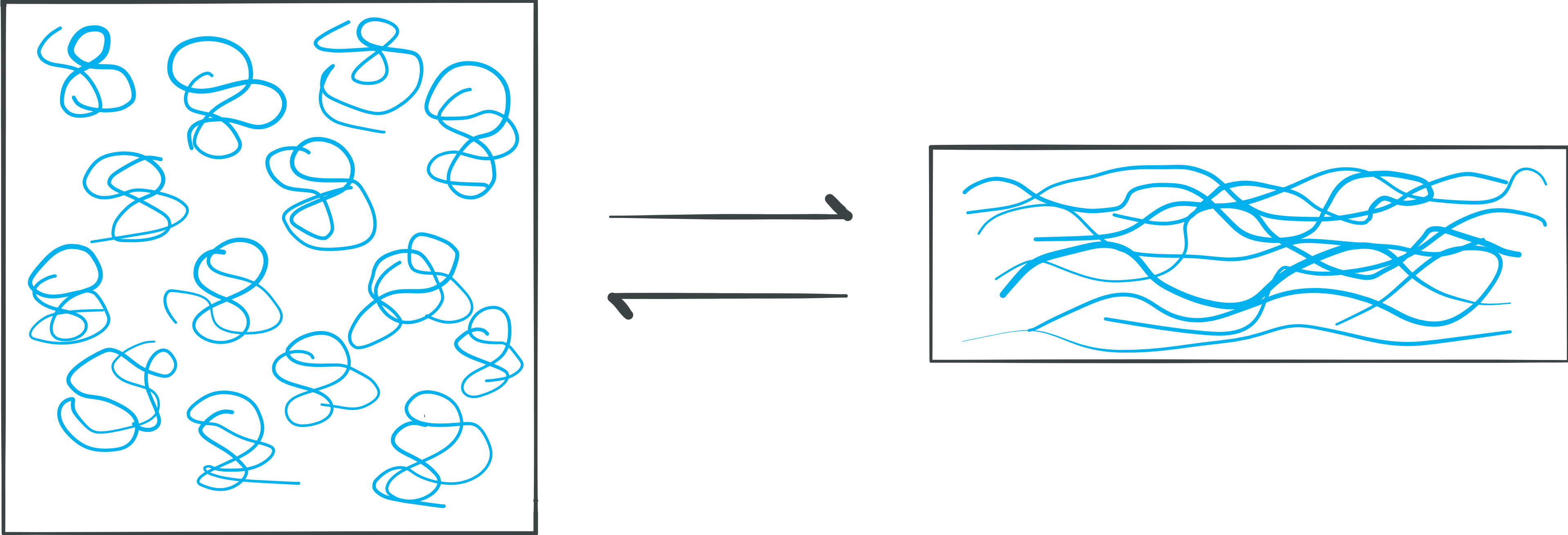


$$\vec{f} = \frac{3k_B T}{N\ell^2} \vec{r}$$

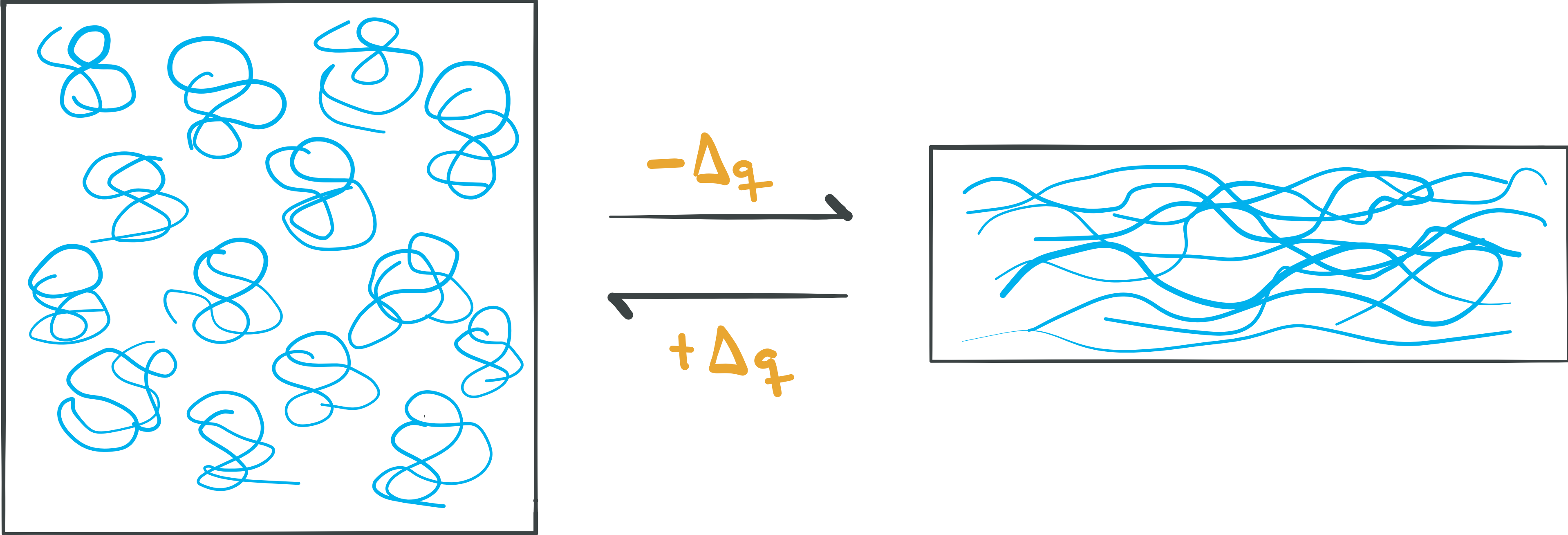
- What is origin and driving force of elasticity in a polymer chain?
- Can you make an analogy to a Hookean spring? If so, can you define a spring constant k ?
- How does the spring constant of the polymer chain change with temperature?
- How does the spring constant of the polymer chain change with degree of polymerization?
- How does the spring constant of the polymer chain change with monomer size?
- How is elasticity of polymeric materials different from metals and ceramics?
- What is the major assumption that we used to derive this equation for elasticity of a polymer chain?
- To see where this breaks down, consider extremely large deformations $r \sim L$. What would you expect to happen in this regime?

- Rubber band design: You are working at a rubber company and you are asked by your boss to design a rubber band with increased modulus (stretch less for the same applied force). Your boss does not want to change the material that the rubber bands are made of because she has all of the manufacturing equipment in place already. What would you suggest as the simplest way to alter the constituent polymers to make the bands stretch less?
- Rubber band stretching: What will happen to the surrounding temperature if you stretch a rubber band? That is, is stretching of a rubber band exothermic or endothermic? (Feel free to experiment.) Why does a rubber band contract when it is heated?

Rubber bands



Rubber bands



Heating a rubber band:

<https://www.youtube.com/watch?v=ovVO8NDdon4>

Rubber band thermodynamics:

<https://www.youtube.com/watch?v=d14w7SIPTd4>

Feynman, jiggling atoms [rubber bands, 12:08–14:50]

<https://www.youtube.com/watch?v=nYg6jzotiAc>