Programming Matter
Smart Surfaces, Molecular Machines, and Invisibility Cloaks

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Outline for the Evening

• Lauren Zarzar – Programming smart surfaces with hydrogels

• Nicholas Schade – Controlling the way matter interacts with light

• Adam Marblestone – Building tiny molecular machines using DNA
Outline for this Segment

• What it means to program matter
• Microscale / nanoscale
• A “smart” material: hydrogels
• How hydrogels can be used for smart surfaces
What is “Matter”?

- ANYTHING that occupies space is considered matter.
What does “Programming matter” mean?

• Since matter could be anything – have any property, take any form – we want to control it

• We can intentionally take matter and make it have desirable properties
What’s “nano”? “Micro”?

Developed for the NISE Network with funding from the National Science Foundation under Award Numbers 0532536 and 0940143. Any opinions, findings, and conclusions or recommendations expressed in this product are those of the authors and do not necessarily reflect the views of the Foundation.
What’s “nano”?

“Micro”?

If we say a nanometer is the size of a marble….
What’s “nano”?

“Micro”?

If we say a nanometer is the size of a marble....

Then a meter is the size of Earth.

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Demo
Demo

- Powder – sodium polyacrylate
- Can absorb hundreds of times its own weight
- It’s what makes diapers so absorbent!
Hydrogel

• We all know “gel”…. Like Jell-O, or hair gel
• “hydro” = water, “hydrogel” = gel that absorbs water
• Hydrogels are used in:

Contact lenses

Pills
Hydrogels are Polymers

- Polymers – long chains of molecules strung together (like a rope)

- Network polymer – polymer chains are interconnected (like a net)
Hydrogels as “Smart Materials”

• We can program hydrogels to respond to changes in the environment
• They can swell and shrink when you change:
  – Temperature
  – Acidity (pH)
  – Light
  – And more…
Responsive Hydrogels as “Muscles”

• This volume change of responsive hydrogels is kind of like the expansion and contraction of your muscles

• Used for *microscale surface actuators*

• Actuate = to put into motion
How Does this “Smart Surface” Work?

Microstructure “bones”

Microstructures bent by gel

10 micron

“Bone”

“Muscle”

Change in temp, pH, etc.

Actuating “Smart Surfaces”

- Good for all sorts of potential applications:
  - Self-cleaning surfaces (like the cilia in our respiratory tract)
  - “Smart” Surfaces that change color, transparency, reflectivity

Actuating Microposts

10 micron

Change in acidity causes posts to move

pH < 4.3

Change in acidity causes posts to move.
“Smart Surfaces”

• Good for all sorts of potential applications:
  – Self-cleaning surfaces (like the cilia in our respiratory tract)
  – “Smart” Surfaces that change color, transparency, reflectivity
Color Changing Surfaces

Inspired by animals like the octopus, squid, and cuttlefish, which can change color and pattern to camouflage themselves using chromatophores

[Image: Nearly colorless, Blue, Red]

Hidden Images

Contraction upon addition of acid
Real time

Optical signals, change in concentration
Smart Windows

“Smart” Surfaces which can sense temperature and help save energy by regulating lighting/shading

Cold outside, light enters house to warm it

Hot outside, surface shades the house by reflecting the light
Microscale Blinds

Change in transparency – “smart” windows?
In Summary…

• We can program matter to determine properties and functions on the micro/nanoscale

• Hydrogels are polymers which we can program to respond to temperature, pH, etc.

• Hydrogels can be used for “smart”, actuating surfaces