Examples

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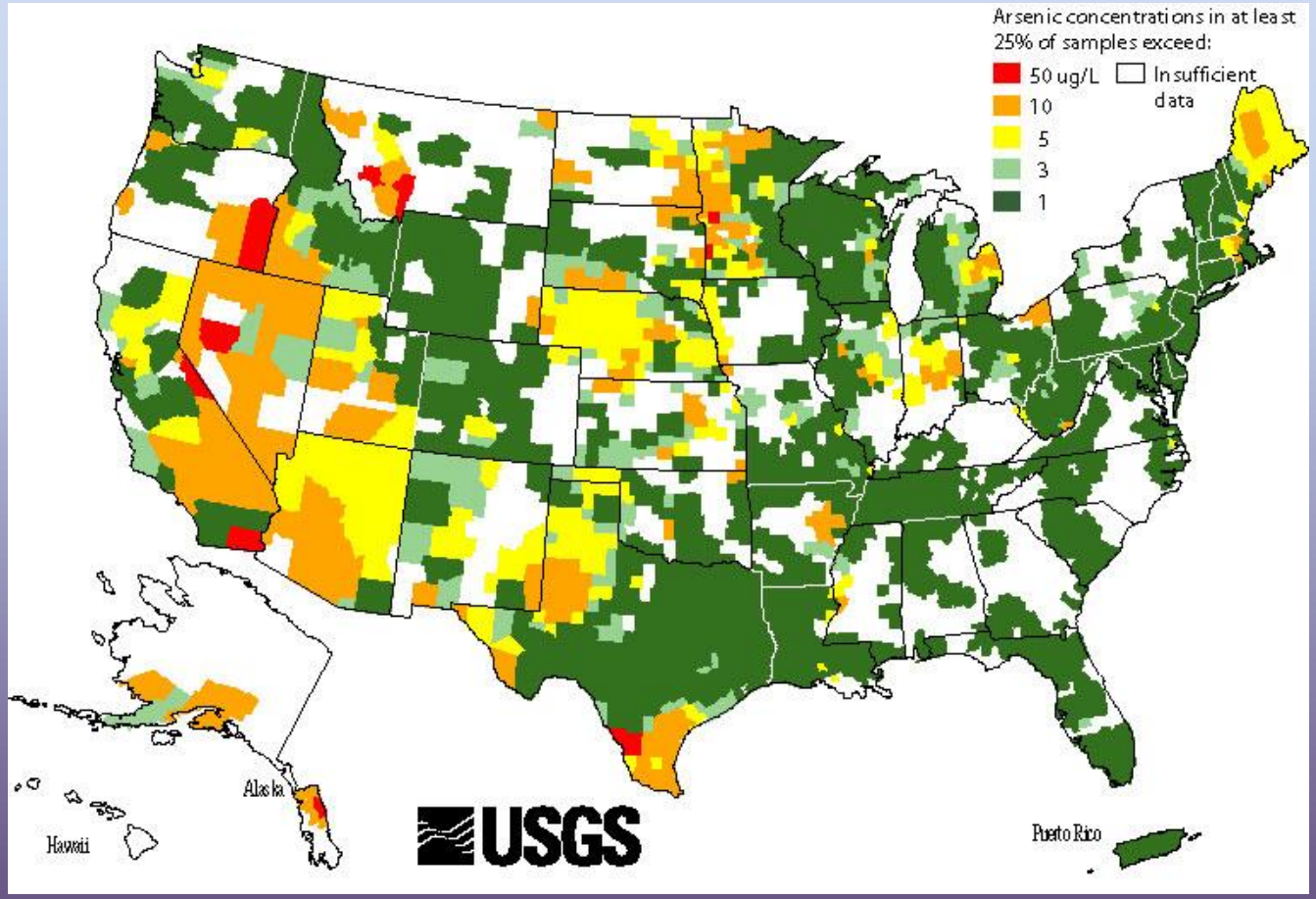
Examples

- Environmental
- Medical
- Household
- Electrical

Arsenic Contamination

Arsenic in drinking water is a large problem around the world, even in some parts of the US.



Arsenic Poisoning

- Numbness,
- Discoloration,
- Partial paralysis,
- Blindness,
- Nausea,
- Cancer (many kinds)

Arsenic Remediation

Reverse osmosis machines can remove much arsenic.

But, they are costly to run.

Not well suited to developing nations.

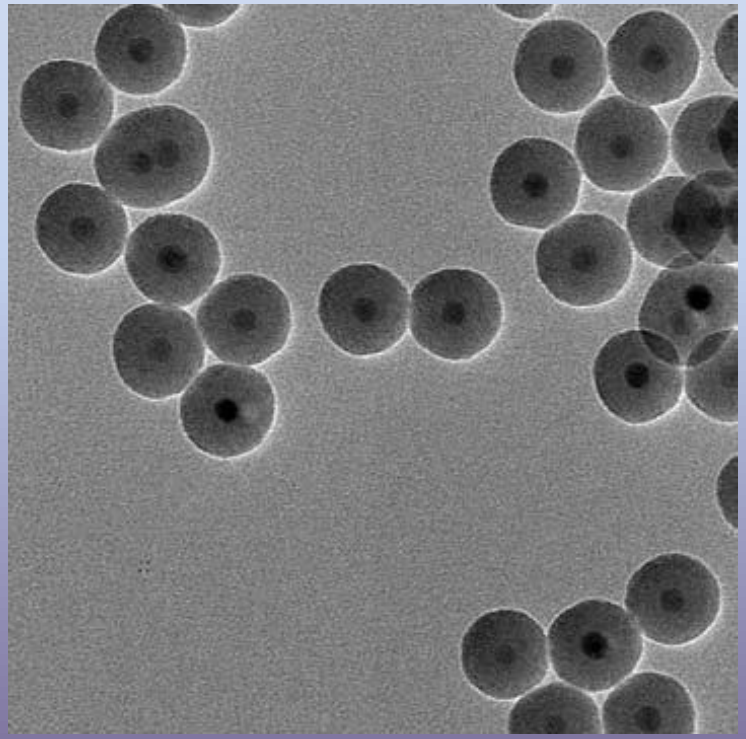
Arsenic likes to bind to Iron Oxide (rust). Soaking chunks of rusty metal in water can remove some arsenic.

But, slow and inefficient.

http://www.filtersforfamilies.org/

Alternative: “Nanorust”

Nanoparticles of Iron Oxide have MUCH greater surface area→ more effective. Then use magnets to pull particles out of water.



Coated Iron Oxide Nanoparticles

Artist’s Rendering of Nanoparticles in water

Artist’s Rendering of Nanoparticles Adsorbing Arsenic

Cheap Nanorust

To make this more useful in the developing world, the Rice U. researchers (Vicki Colvin) have developed ways to make nanorust out of simple materials:

Rusty metal

Oil (Olive, Linseed)

Vinegar

Lye

They used this technique successfully in 2006 in Guanajuato, Mexico.

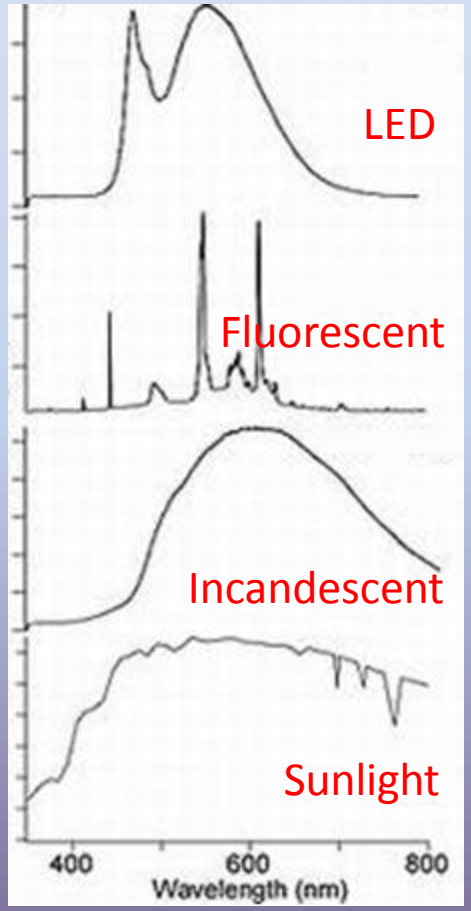
White Light LEDs

- Incandescent bulbs
  - Best color light, closest to Sun's spectrum
  - But not efficient

- Fluorescent bulbs
  - Harsher light
  - More efficient

- Light Emitting Diodes (LEDs)
  - Harsh light (too blue)
  - Most efficient

Spectrum



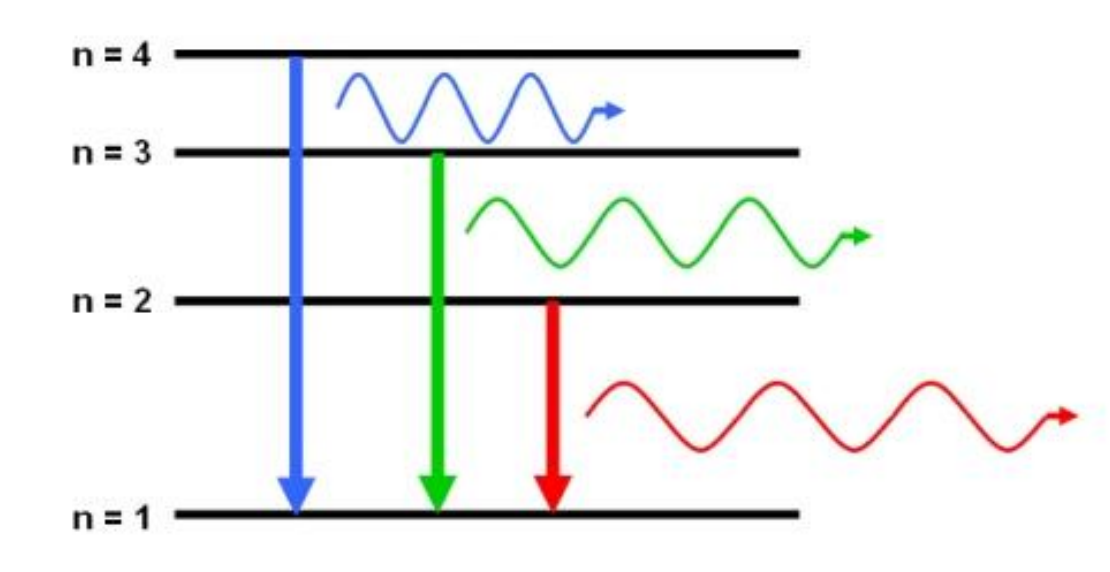
Blue → Red

How to get better light from an LED?

- Use Nanoparticles called “Quantum Dots”
  - Small (less than 20 nm) diameter spheres.
  - Coat an LED bulb with them and they give off nice white light.
- How does that work?

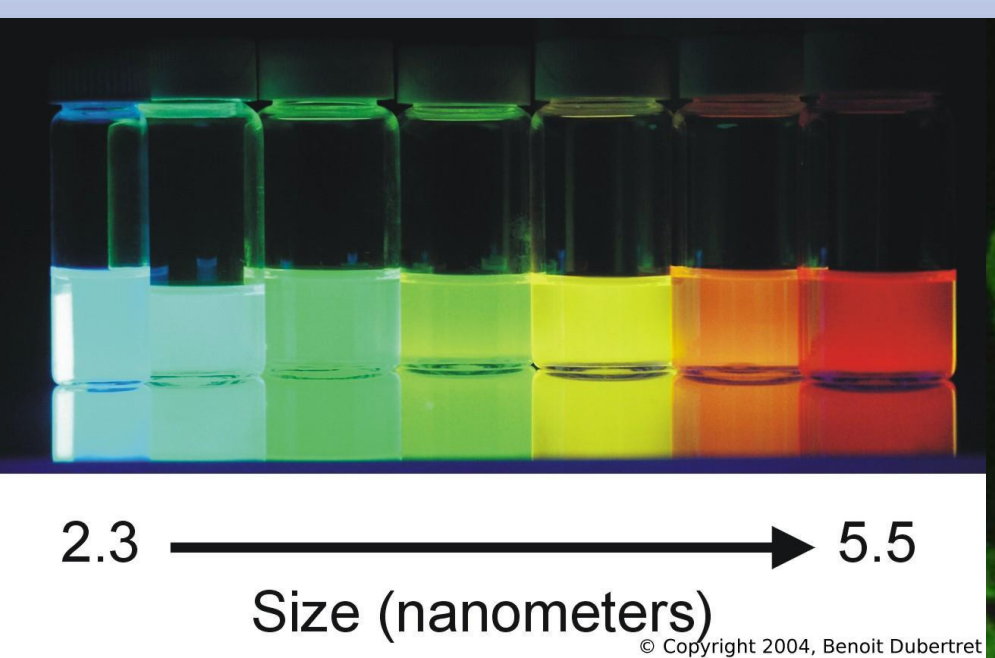
Quantization

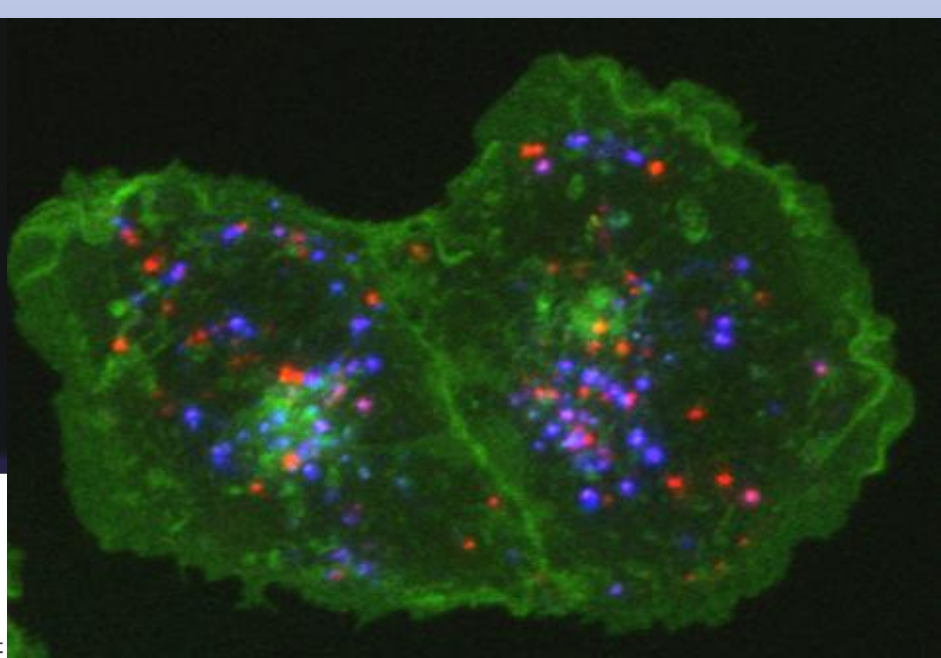
- Localizing a particle causes it to only be able to have certain discrete values of energy.
- Quantum jumps from a high to low energy level gives off light of a particular color.



Quantum Dots

- This has been used to make “quantum dots” that give off particular colors (red, green, blue).
  - Can be used to tag and track biomolecules.





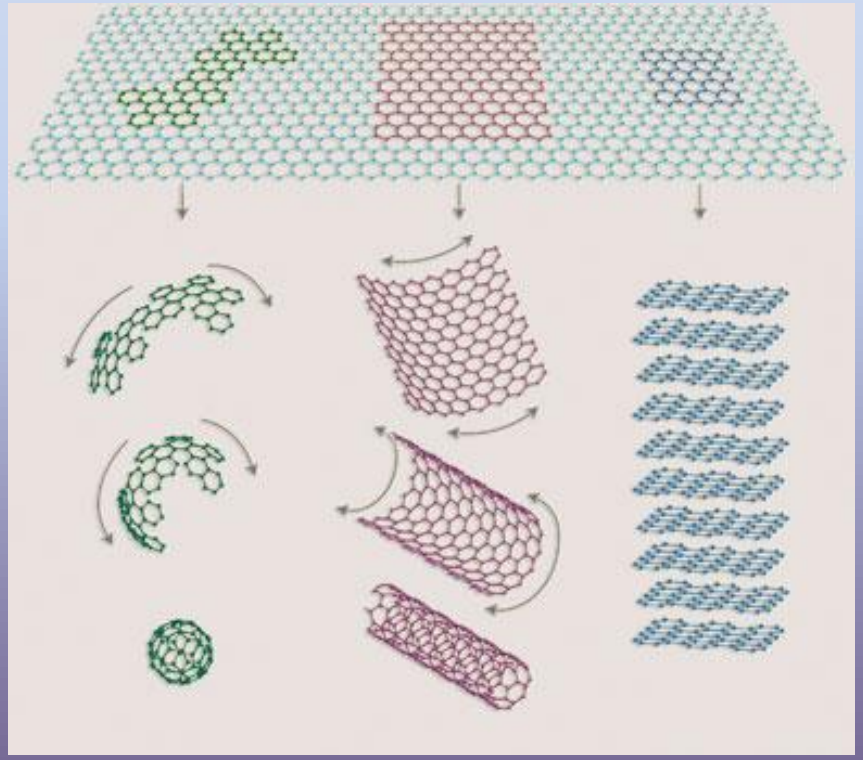
“Magic Sized” Quantum Dots

- Sandra Rosenthal (VU ’87) at Vanderbilt U. lead project which pushed the size of QDs to their lower limit, about 1.5 nm.
- Instead of discrete colors, the light given off is a nice warm white, closer to sunlight.
  - Energy comes from surfaces of QDs.
- Currently developing the technology.

Carbon Nanomaterials

- Carbon is one of the most abundant elements.
  - Biological molecules (us, life)
  - CO_2 gas
  - Fossil fuels
  - Diamonds
  - Graphite

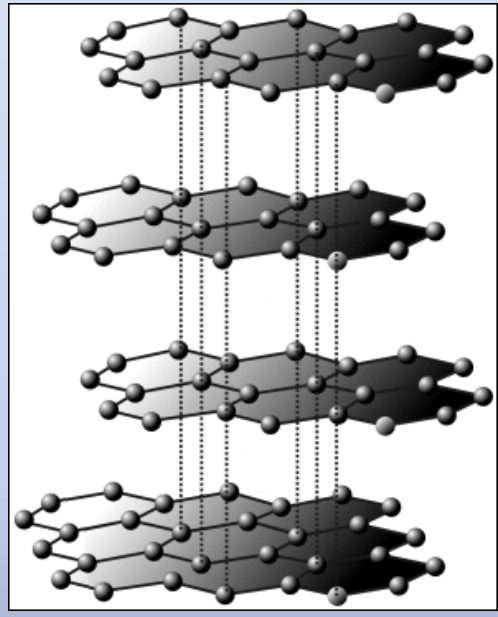
- New carbon forms have been discovered recently, all based on arrangements of sheets of carbon atoms.



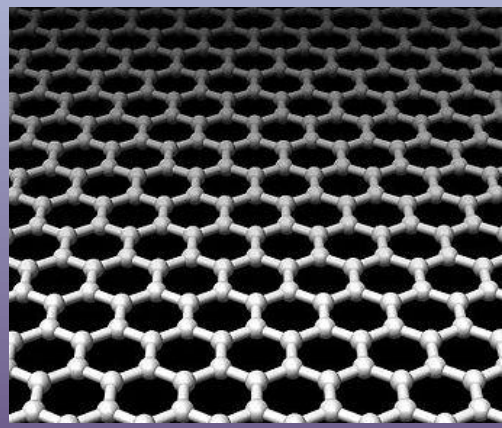
"Buckyballs" Carbon Nanotubes Graphite (pencil lead)

Graphite and Graphene

- Graphite: layers of carbon, loosely connected.
  - Scraping a pencil across paper easily scrapes off chunks, leaving marks.
  - Also used in electronics.



- Graphene: a single layer of carbon atoms.
  - Newly “discovered”.
  - Dramatically different and useful properties.
  - Commonly formed by mechanically peeling layers from graphite.
  - Currently one of the most expensive materials.



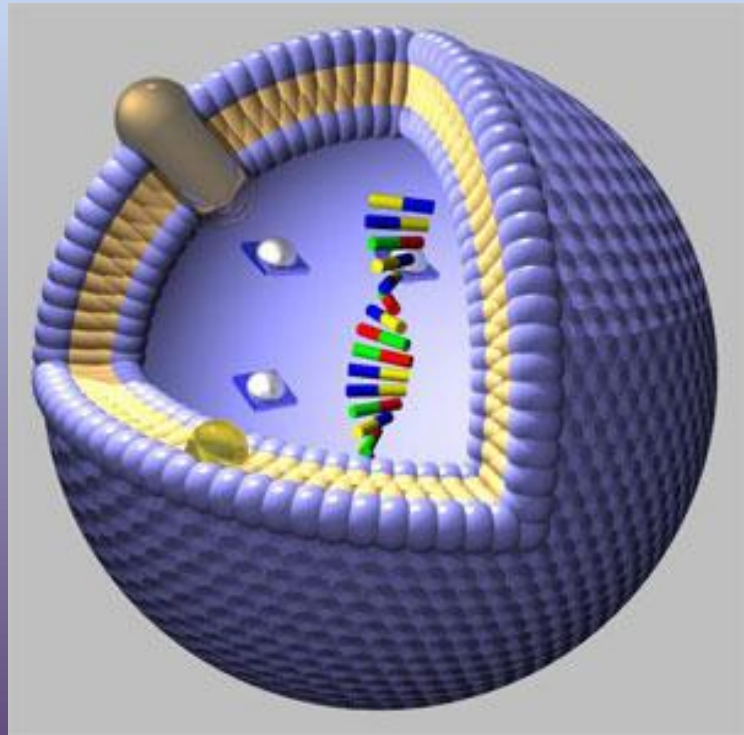
What's So Great about Graphene?

- High conductivity (like silver)
- Strongest material known
- Low noise (electrons don't run into anything)
- Nearly transparent (good for touchscreens, solar panels, etc).
- Useful for transistors (computer elements)
- Useful for biosensors (due to large surface area).

Nanocapsules

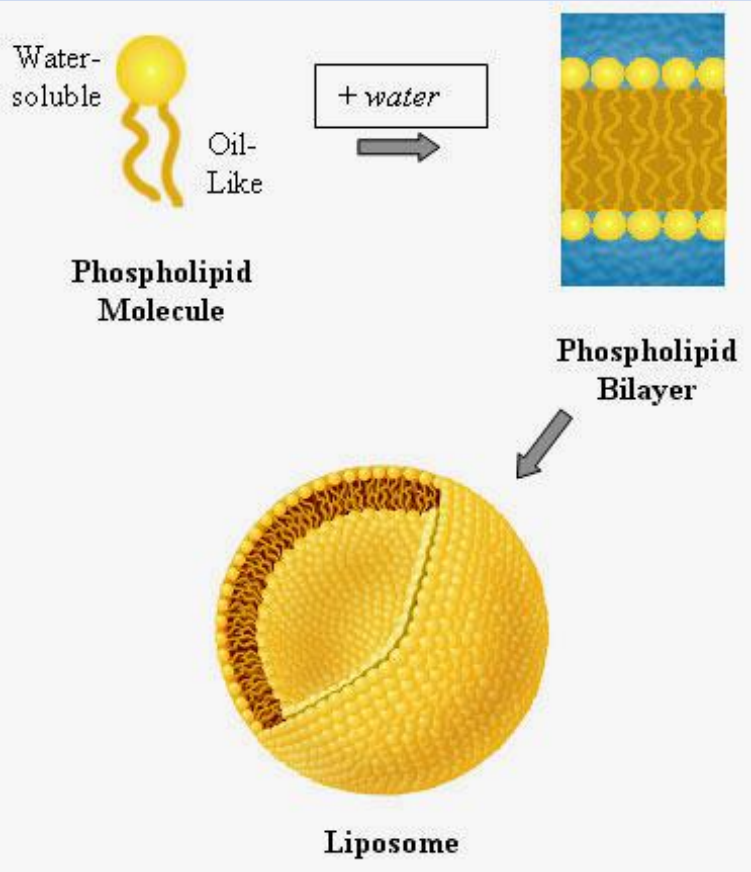
- The body uses little capsules, called “liposomes” to ferry material around.
- Shells are made out of the same material as cell walls, called “lipids.”

Because cells already use them, they are ideal for **drug delivery** applications.



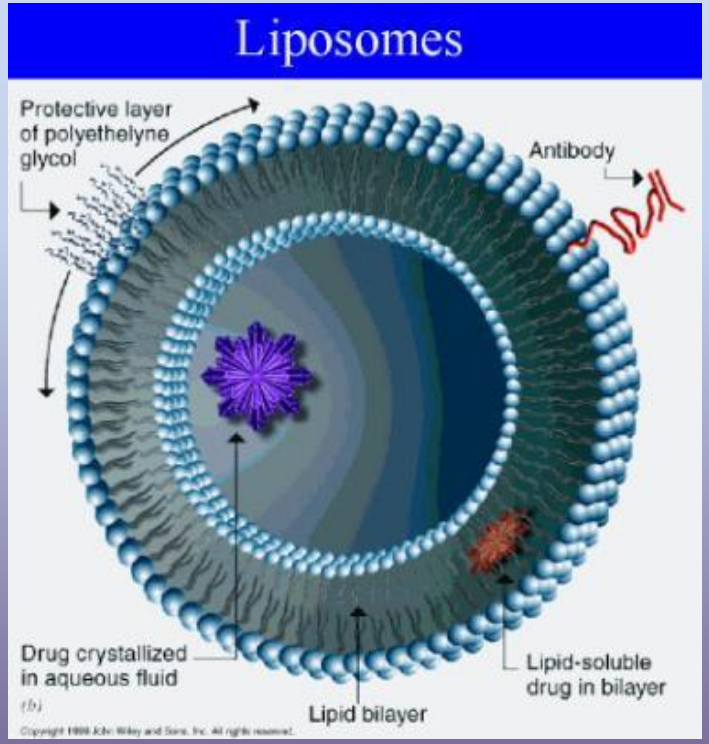
Making Liposomes

Kind of like making oil & vinegar salad dressing



http://www.encapsula.com/images/about_liposome_1.jpg

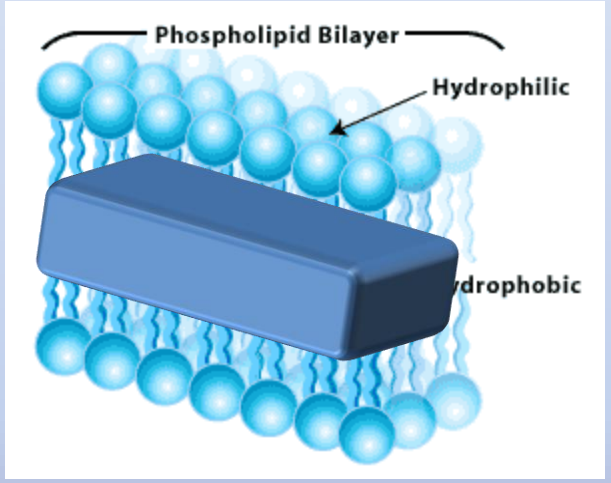
Can then "decorate" and load the capsule

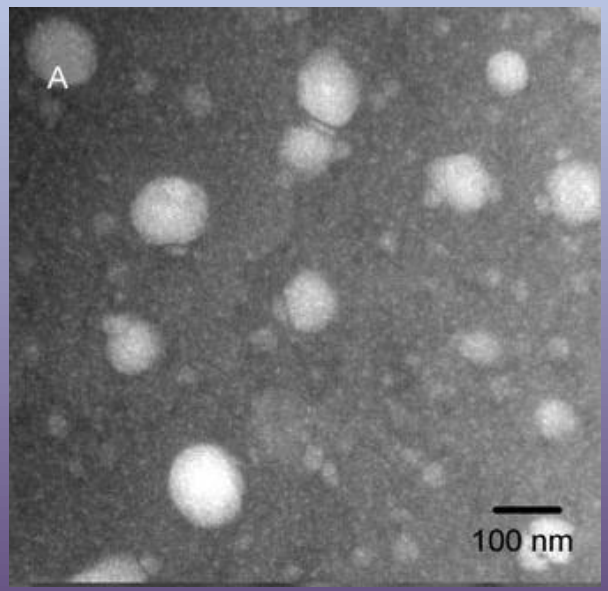


http://www.nanopharmaceuticals.org/Liposomes.html

Polymer Nanocapsules

- Can put molecules into the “hydrophobic” (water avoiding) inner part of the shell.
- Then zap molecules with UV light to join them together.
- Remove the liposome material and you have a polymer capsule with the same size as the liposome.



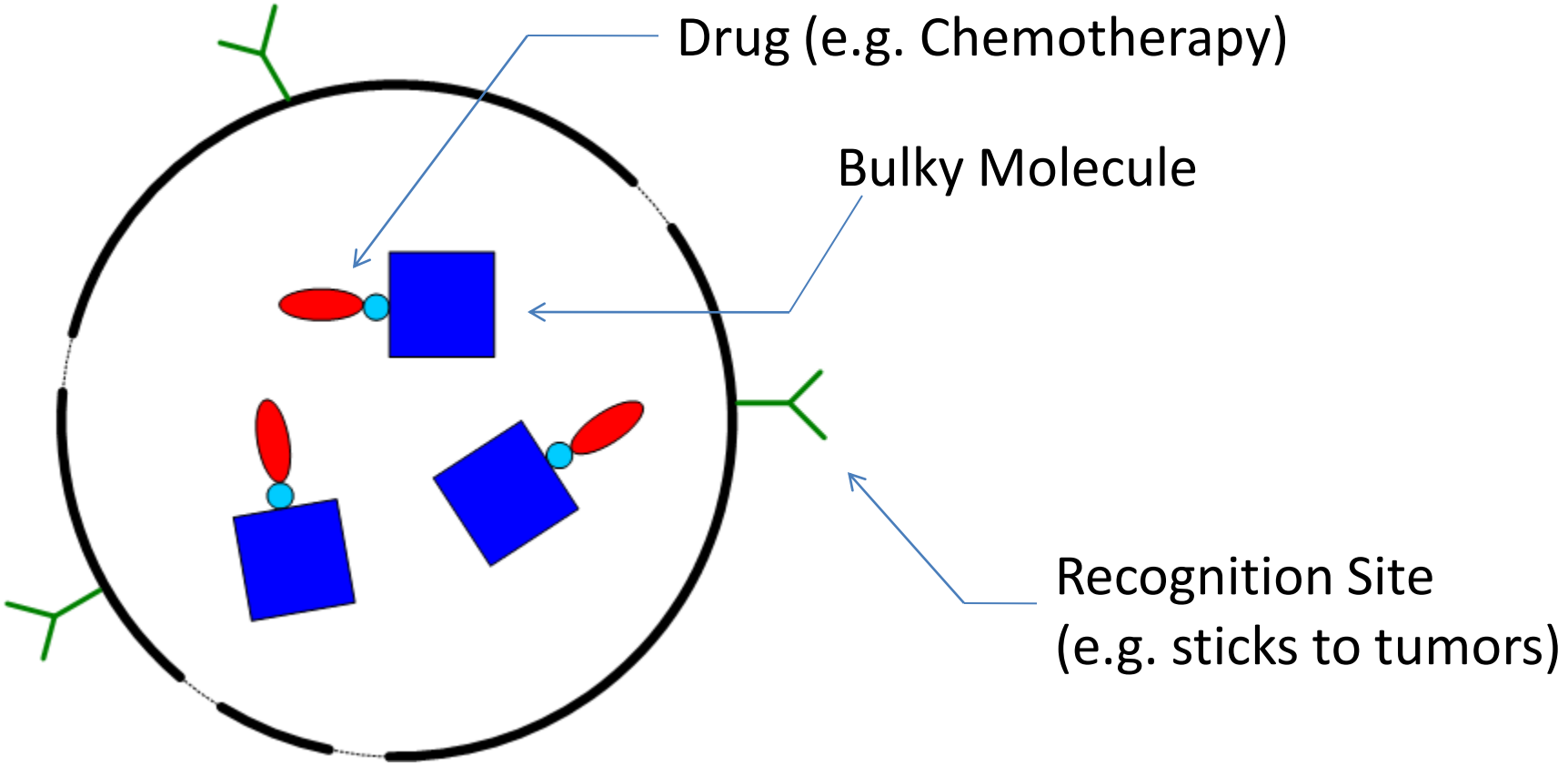


Nano-Wiffleballs

- Can add holes in the walls to create porous shells.
- Can trap large molecules and release small molecules.

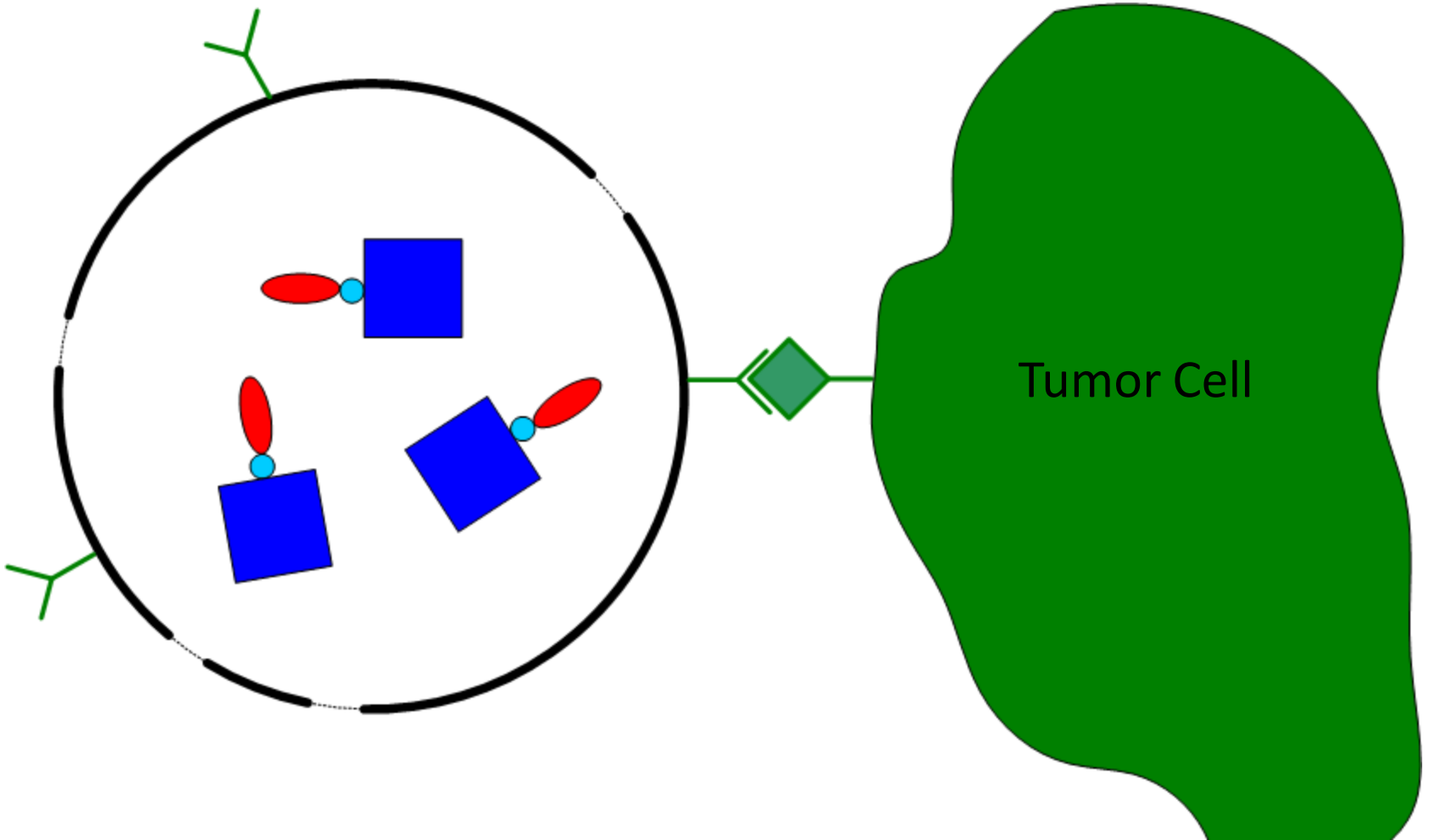
Drug Delivery

- Fill capsule with deactivated drug



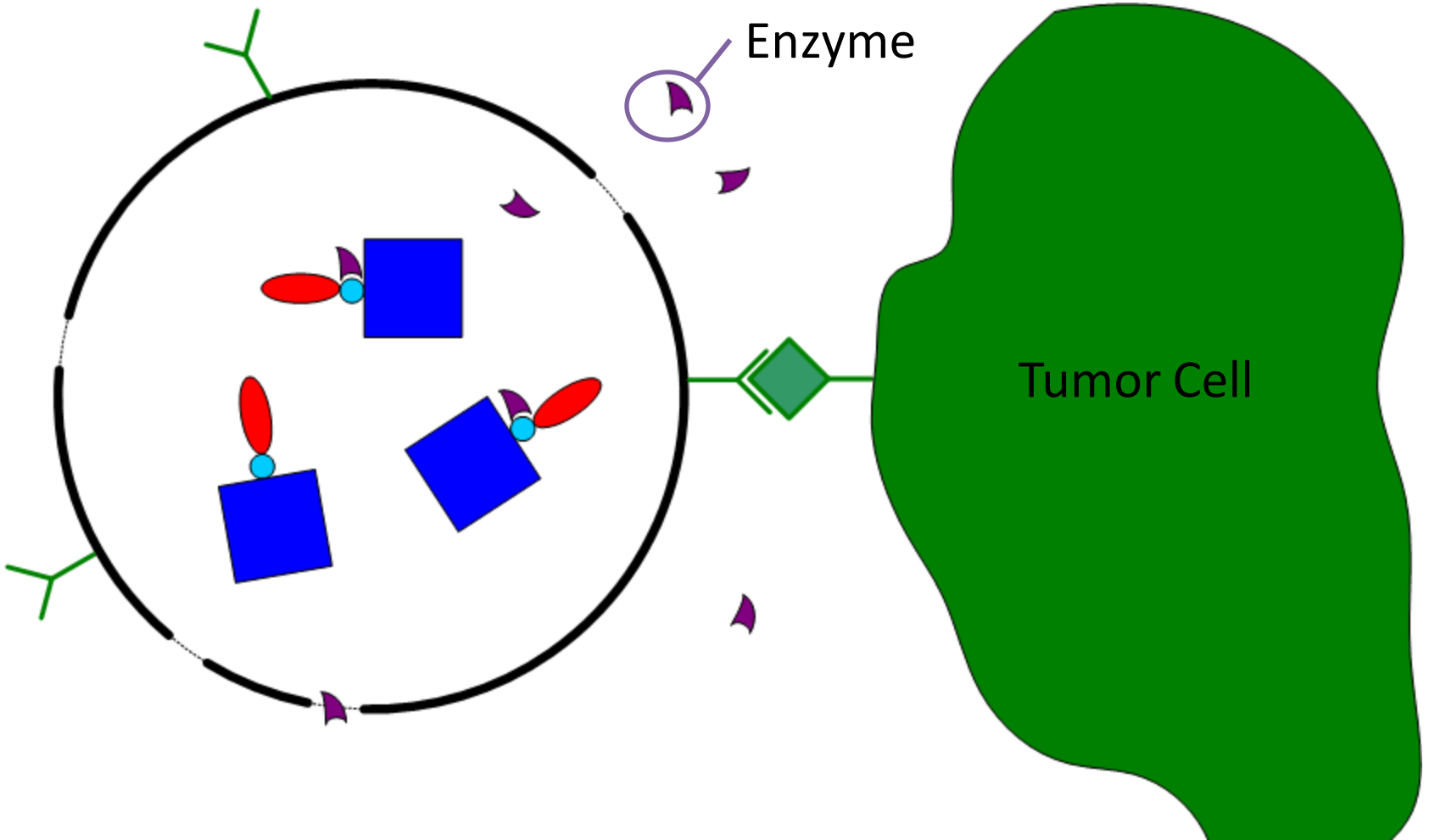
Drug Delivery

- Let it float around until it finds a target.



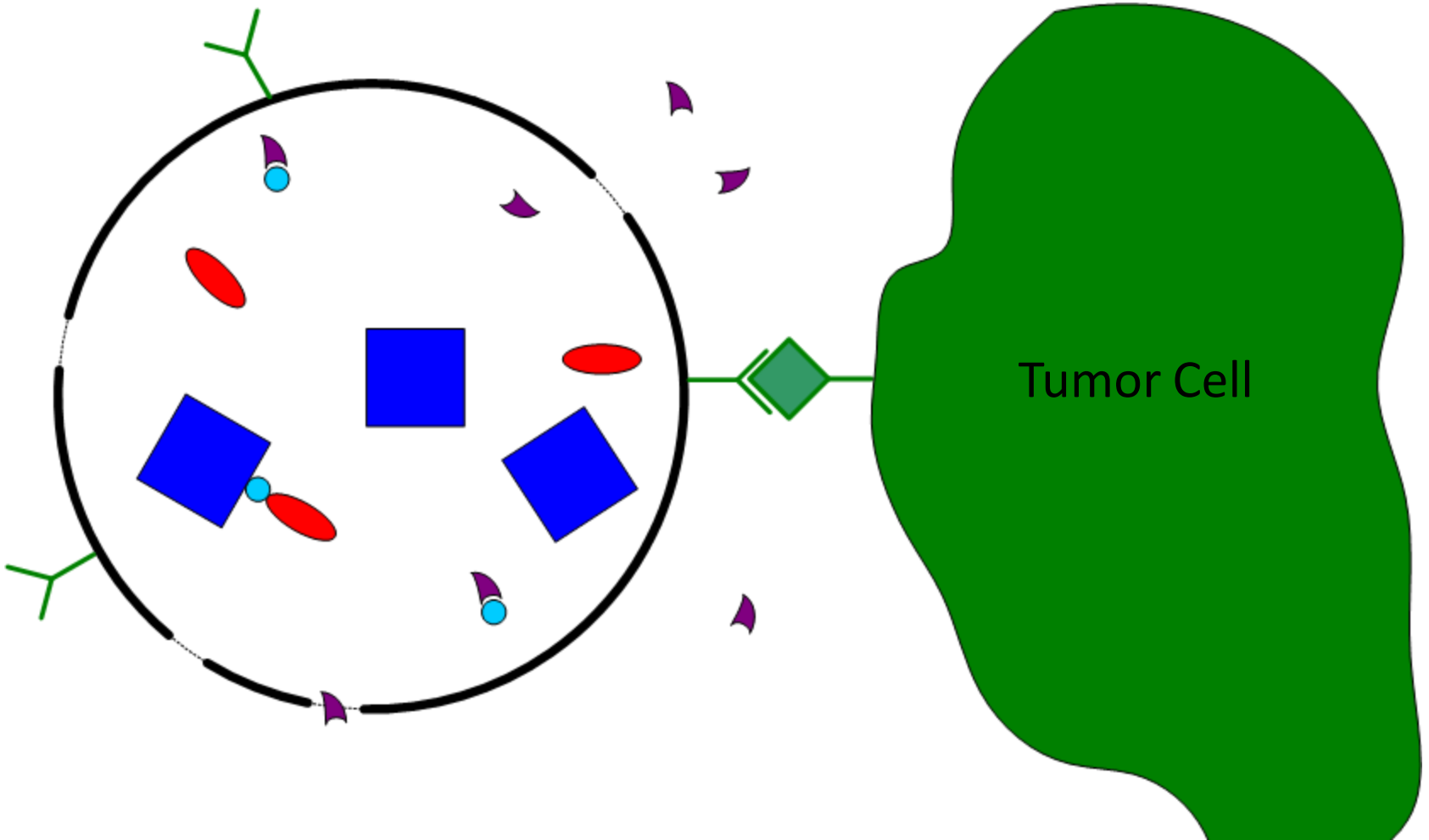
Drug Delivery

- Introduce an enzyme that breaks off bulky part.



Drug Delivery

- Drug is now free to escape the capsule…



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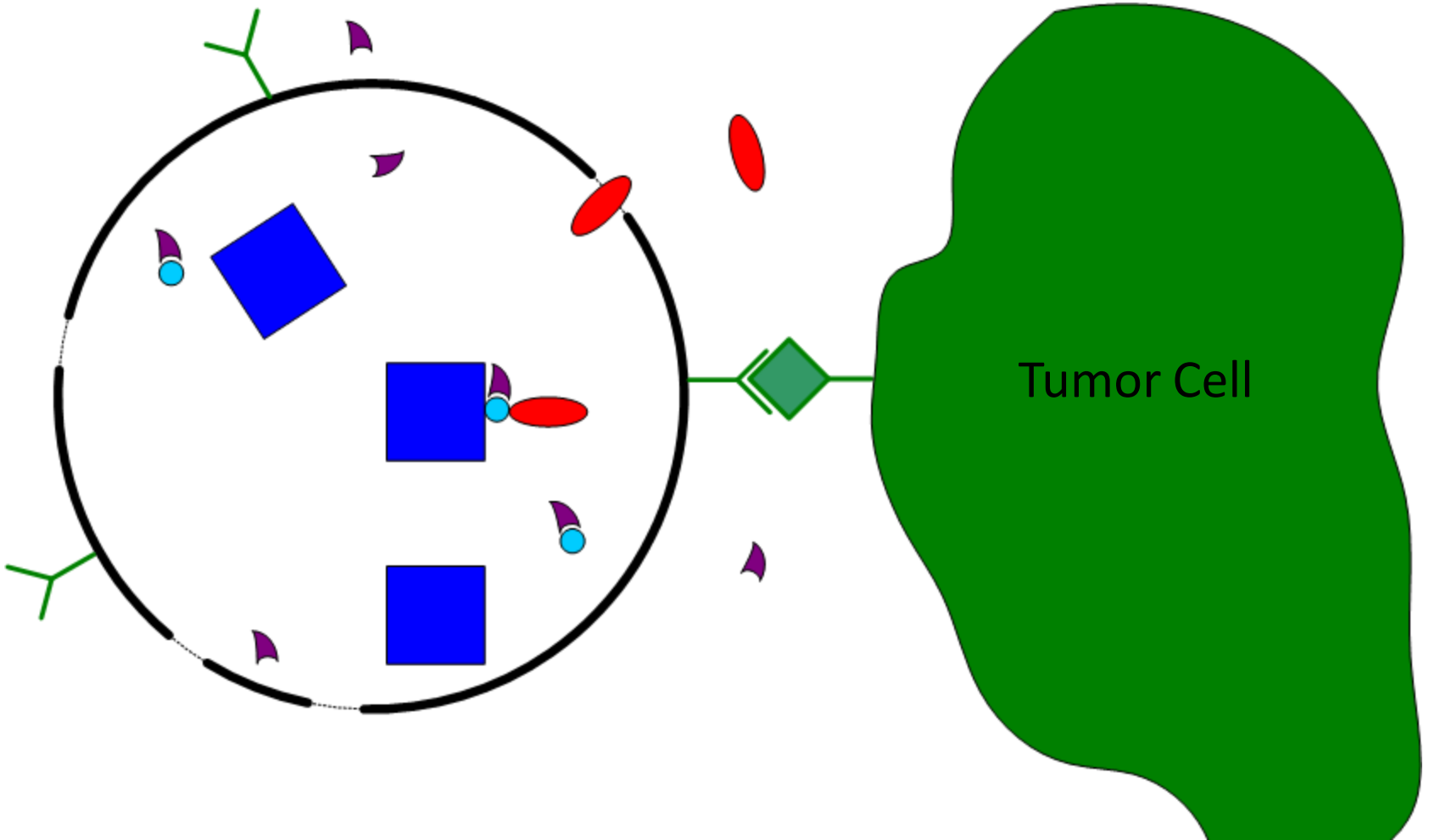
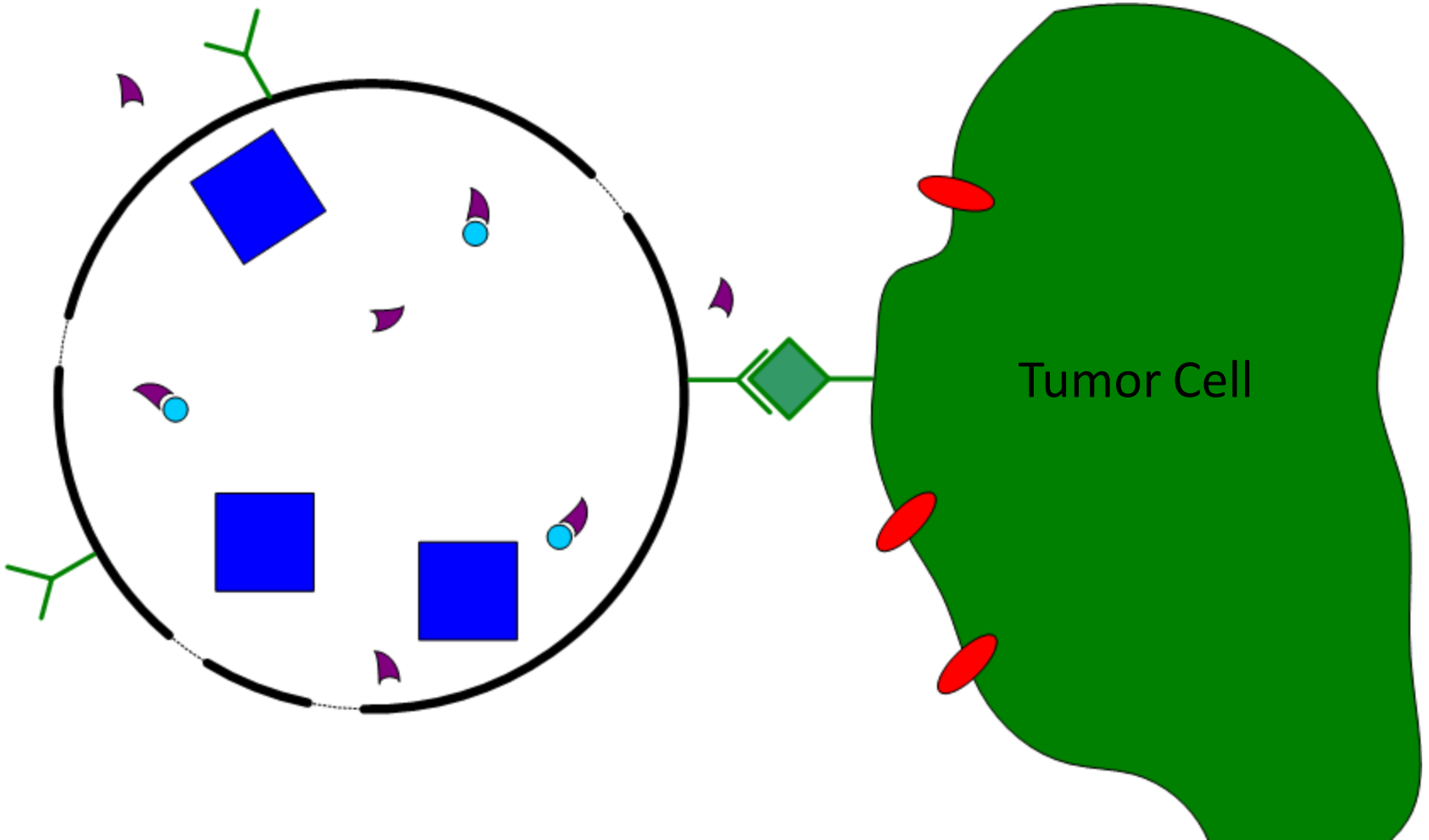


Drug Delivery

- …and attack the target.



Drug Delivery

- Drugs get where they need to be and nowhere else.
  - No spilling or leaking.
- Robust capsule
  - Can take its time to find the target.
- Correct sized capsule
  - Can find its way through tissues like natural liposome.