



Get in My Body

Drug Delivery

Challenge Question



You are a doctor, physician assistant or nurse practitioner. Your patient has a condition that requires her to keep constant levels of a medication in her body. However, she is unable to swallow.

What are some other methods of administering a drug to her?

Remember: She needs to take the drug at least twice a day for the rest of her life and to ensure patient compliance, the drug delivery method must be as simple as possible.



Oral Administration

Taken by mouth through the digestive tract – in liquid or pill form

Advantages:

- Easy, preferred by people
- Slow release of drugs; can extend the duration of action
- Drugs can be protected from harmful digestive tract enzymes and acids



Disadvantages:

- Drugs are absorbed slowly
- Won't work if vomiting profusely
- Unpredictable adsorption due to stomach acid and enzyme degradation

Common usage: aspirin, Advil®, Tylenol®, cough syrup, painkillers, steroids



Injection

By needle into the skin



Three methods:

Intravenous: infusion
directly into the vein

Intramuscular: injection
directly into muscle

Subcutaneous: injection
into the cutis layer of
the skin

Injection: Intravenous

Intravenous (IV): Infusion directly into a vein



Common usage: blood transfusions, saline (for dehydration), painkillers, propofol (sleeping drug), anesthesia

Advantages:

- Dependable and reproducible effects
- Entire administered dose reaches circulatory system *immediately*

Disadvantages:

- Requires a cannula (IV line)
- More labor intensive and costly
- More prone to infections
- Distressing, especially to children

Injection: Intramuscular & Subcutaneous



Intramuscular: injection directly into muscle

Subcutaneous: injection into the cutis skin layer

Advantages:

- Good adsorption, especially for those with poor oral bioavailability
- Rapid effects
- Long duration of activity

Disadvantages:

- Unpredictable adsorption
- Painful with bruising
- Not for needle-phobic people

Common usage: insulin (for diabetes), morphine, vaccines (hepatitis A, rabies, influenza), penicillin, diazepam (Valium)



Topical

Drug delivery directly to the site

Advantages:

- Easy, non-invasive
- High patient satisfaction

Disadvantages:

- Very slow adsorption
- Difficult to control dosage
- Most drugs have a high molecular weight and low lipid solubility, causing them to not be adsorbed via skin or mucous membranes

Common usage: skin ointments and creams (for rashes, poison ivy), eye drops, ear drops (for infections), birth control (patches)



Inhalation

Medications taken into the blood stream via the lungs



Advantages:

- Rapid adsorption due to high surface area
- Fastest way to deliver drug to brain

Disadvantages:

- Requires proper inhaler technique to get correct dosage
- Unpleasant taste; mouth irritation
- Bioavailability of drug depends on its size

Common usage: adrenocorticoid steroids (such as beclomethasone), bronchodilators (such as isoproterenol, metaproterenol, albuterol) and antiallergics (such as cromolyn)

Suppository

Drug delivery via rectum, vagina or urethra

Advantages:

- Good adsorption due to hemorrhoidal vein draining directly to inferior vein cava

Disadvantages:

- Cannot be used after anal or rectal surgery
- Some people dislike and/or find the method uncomfortable

Common usage: laxatives, diclofenac (nonsteroidal anti-inflammatory drug), hemorrhoid medication treatment



Design Considerations

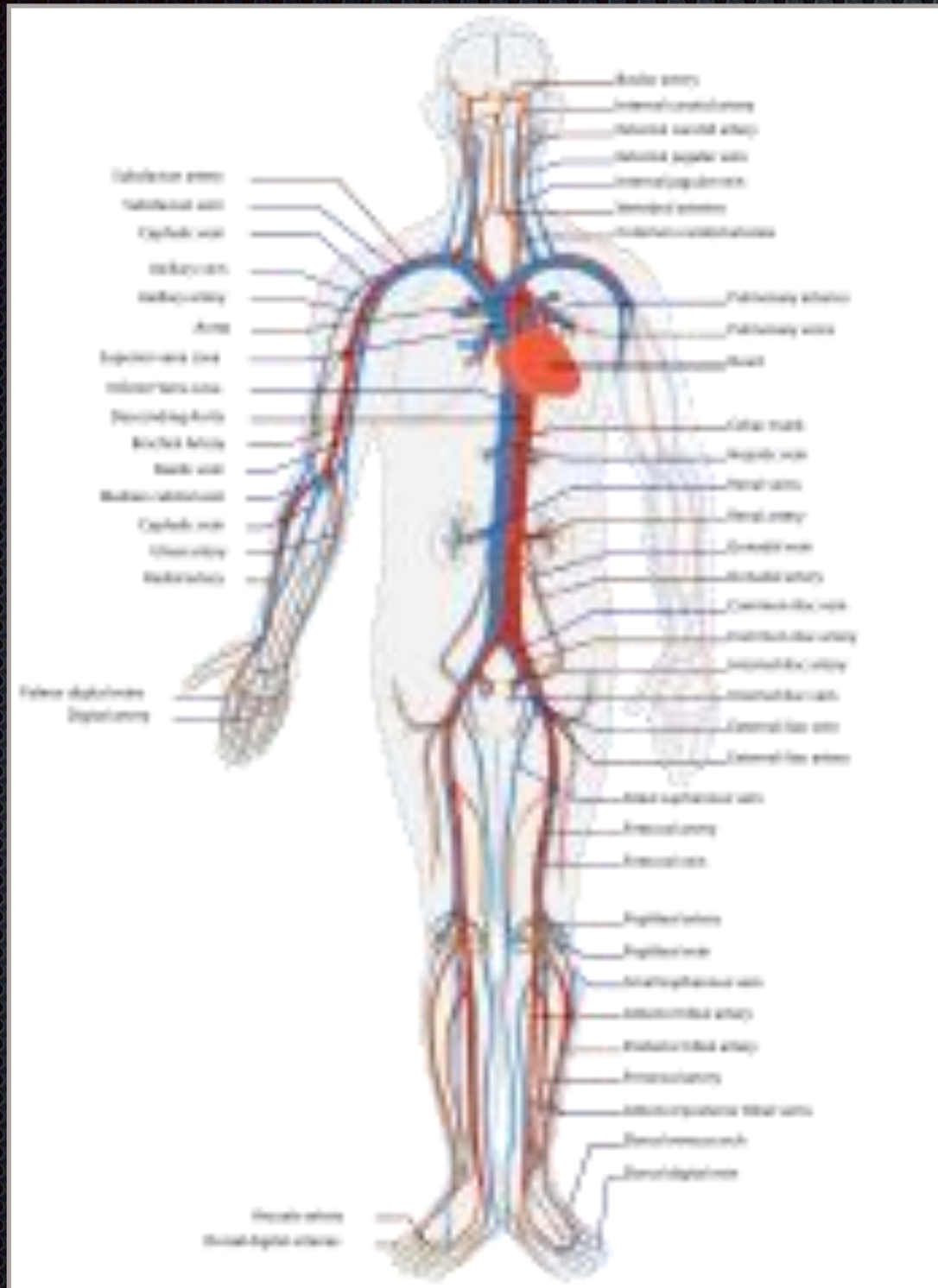


- Toxicity
- Efficacy
- Drug size
- Solubility / bioavailability
- Drug release duration



Circulatory System

Circulatory system transports drugs to the organs of the body

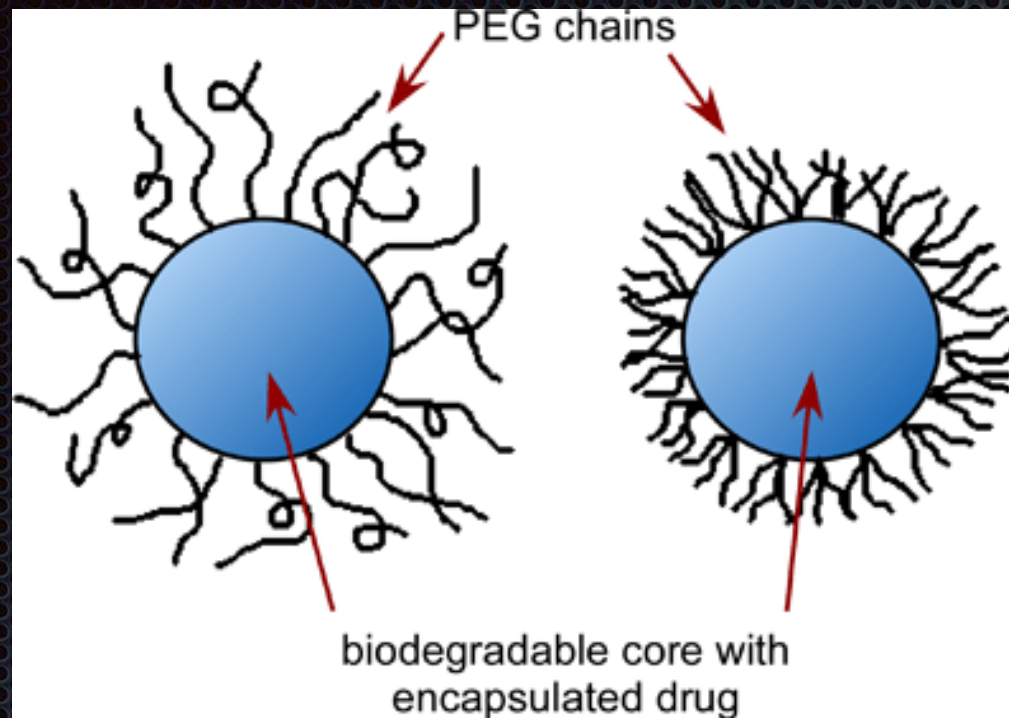


Different areas of the body have different pHs, which affects bioavailability/solubility:

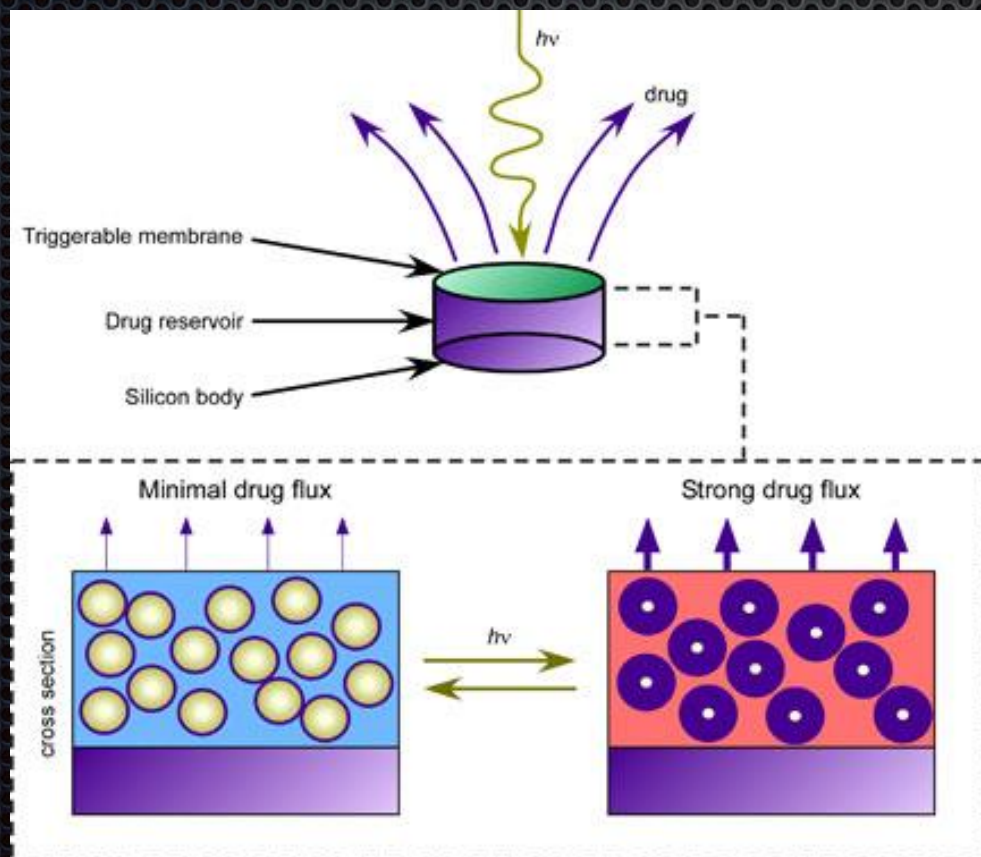
- Stomach = pH 1.5 – 3.5
- Duodenum = pH 6
- Small intestine = pH 6 increasing to 7.4
- Large intestine = pH 5.7
- Rectum = pH 6.7
- Blood = pH 7.35 – 7.45

Polymers

Polymers are useful to encapsulate high molecular-weight drug molecules



- Depending on the polymer, the diffusion rate through the shell can be controlled
- Attached polymer chains can act as specific lock-and-key receptors



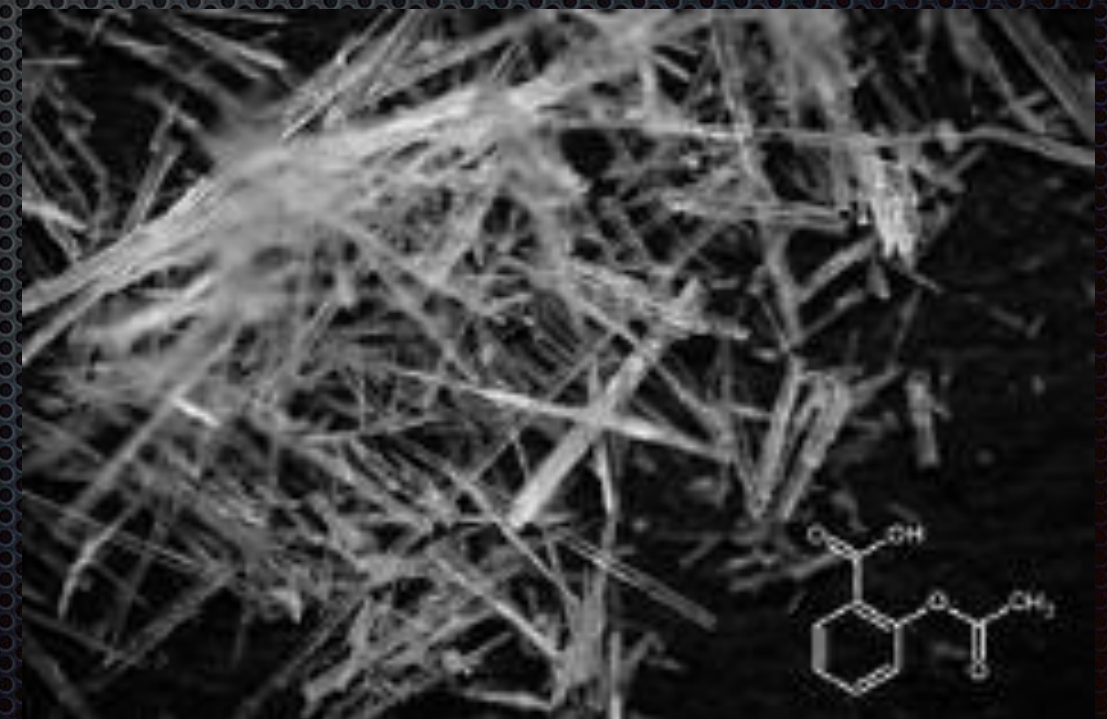
- With a lock-and-key receptor, the drug release location can be controlled
- One problem: The possibility of rapid drug release if certain regions degrade faster than others—causing a toxic pharmaceutical overdose

Cocrystallization

- Most drugs are actually crystals
- However, the properties of certain drugs cause them to not be bioavailable
- To alter drug properties while maintaining efficacy, cocrystals are made

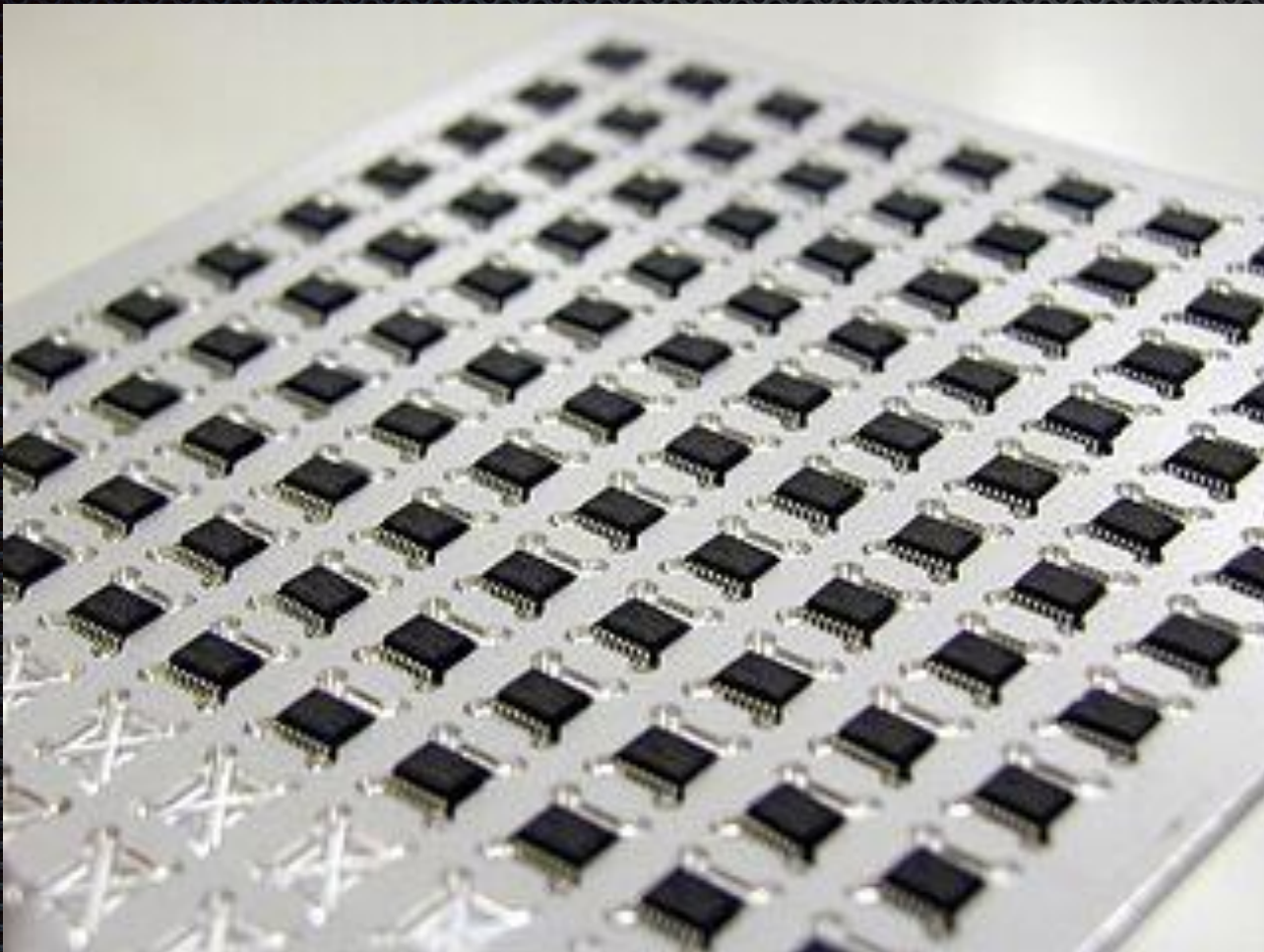


A cocrystal is a crystal composed of two or more components (ions, atoms or molecules) in a specific stoichiometric ratio



New Devices

Computer chips provide inspiration for new pharmaceutical technologies



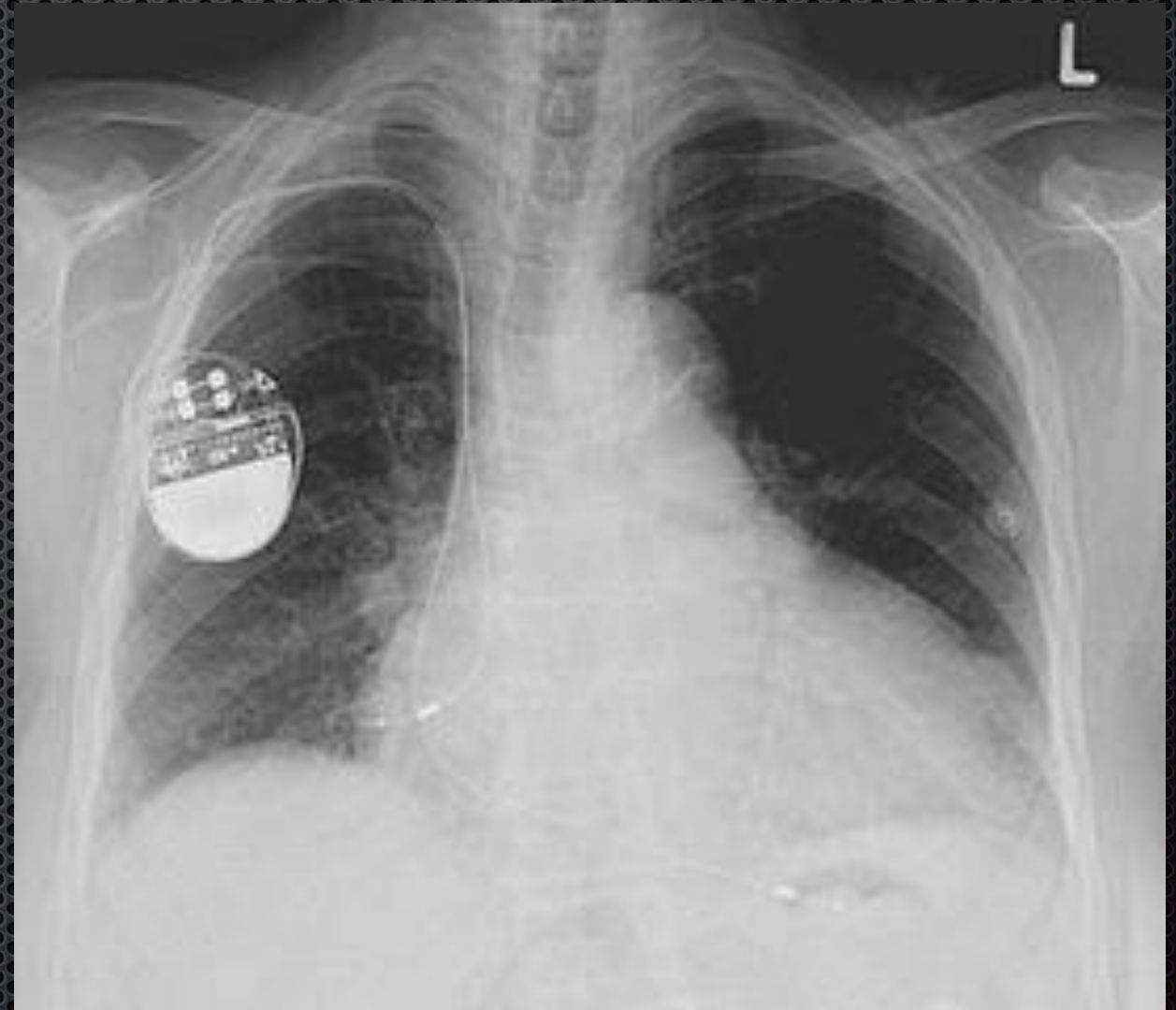
- Biocompatible chip devices are made with wells filled with certain drugs
- The wells are covered with a biodegradable metal covering that is removed when and electrical charge is applied
- Drugs can be released from each well individually at specific, desired times

Example: birth control

Problems with Devices

Body considers devices to be foreign objects

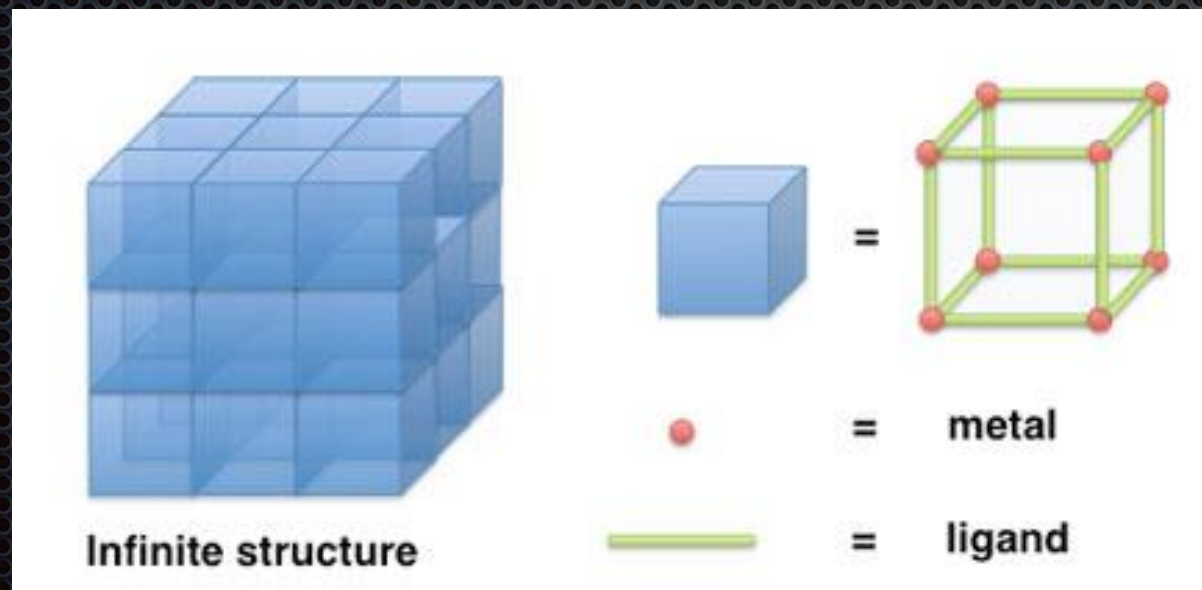
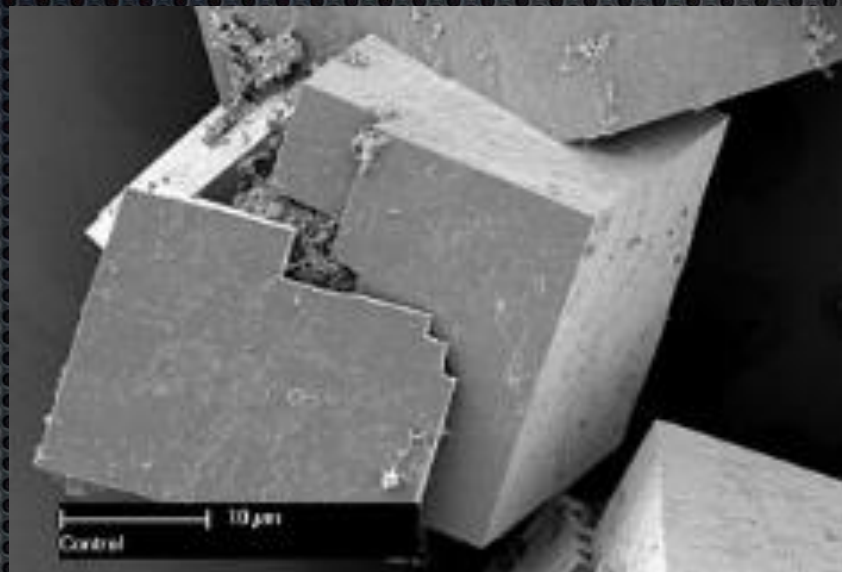
- Medical devices have blood surface interactions, which can cause infections, blood clotting and antibiotic resistance—leading to device failure
- To negate these interactions, artificial surfaces are developed
- One method is a drug eluting surface



Metal Organic Frameworks (MOF)

Drug eluting surface: a drug is released over time by the device surface

Drugs can be made **catalytically** (produce inside the body by chemical reaction) by the device surface



- MOF – compounds consisting of metal ions coordinated to organic molecules creating one-, two- or three-dimensional porous structures
- Nitric oxide – helps neurotransmission for chronic wound treatments
- MOFs can last 2 to 12 weeks to provide sustained nitric oxide release