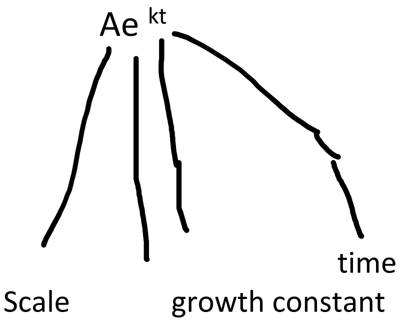
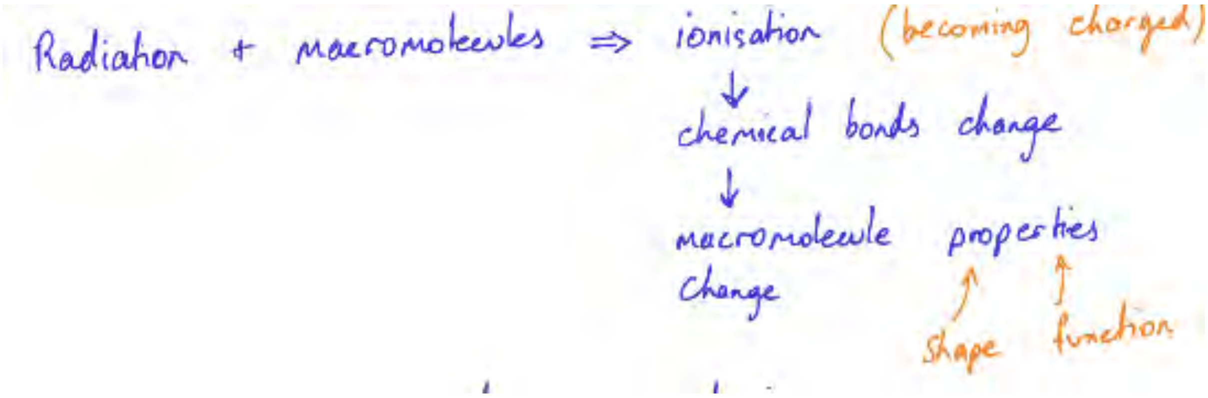
PHYS1250
WEEK 1

$$M = \frac{\text{rise}}{\text{Run}} = \frac{y2-y1}{x2-x1}$$



Discuss the effects of ionising radiation on macromolecules and cells



3 Main damage Mechanisms:

Main chain scission:

- Long chain splits into smaller molecules

Crosslinking:

- New bonding structures attach the macromolecule to other molecules or to another segment of itself

1. Radiation ionises electron in chain
2. Chain has some broken bonds
3. Electron remaining in broken bonds are unhappy
4. They form new bonds to lower their energy

Point lesion:

- Disruption of single chemical bond, cannot be detected analytically, but can modify macromolecule (changes bond but does not break it)

- **PATIENT PROTECTION**

Maximise Benefit > minimise risk

Factors affecting patient dose:

1. Unnecessary exams (DR, NM, RT)
- Do not change patient management (routine chest image for acute coronary syndrome)

2. Repeat exams (DR, NM)
- Should be minimised (4%-15%)
- Reduce by clear communication instructions, and appropriate technique selection

3. Filtration and shielding (DR)
- Expose only useful radiation
- Critical organs may be shielded
- Contact shield (on pt like apron)
- Shadow shield (in beam)

4. Appropriate projection (DR, RT)
- Especially for torso/chest (flip to PA gives lower dose to breast tissue)

MEASURES OF DIAGNOSTIC OUTCOMES

Visual perception

The human visual system -> essential and complex. Can be helped by image processing (machine aid)
Diagnosis by radiologist or NM physician – understanding detection and interpretation of visual data is important for MRS.

Proposed process

1. Look at image and compare with "remembered" images of normal structures
2. Mental image subtraction to focus on differences from normal
3. Close examination, decisions whether normal or unusual

3 sequential processes of visual perception

1. Detection – necessary first step
2. Recognition – clues can be dismissed

In solids, charge is usually carried by electrons
Conductor: mobile electrons available

Semiconductor: electron can move, but require a bit of extra energy

Insulator: no electrons can move easily

Voltage is an energy difference (for a charge) between 2 points

- Measured in volt (V) like "gravity" for charge > acceleration

Current is amount of charge flowing

- Measured in amp (A)

E.g. kids with m & m's in obstacle course

Kids > electrons
M&M's > volts
#kids per time > current

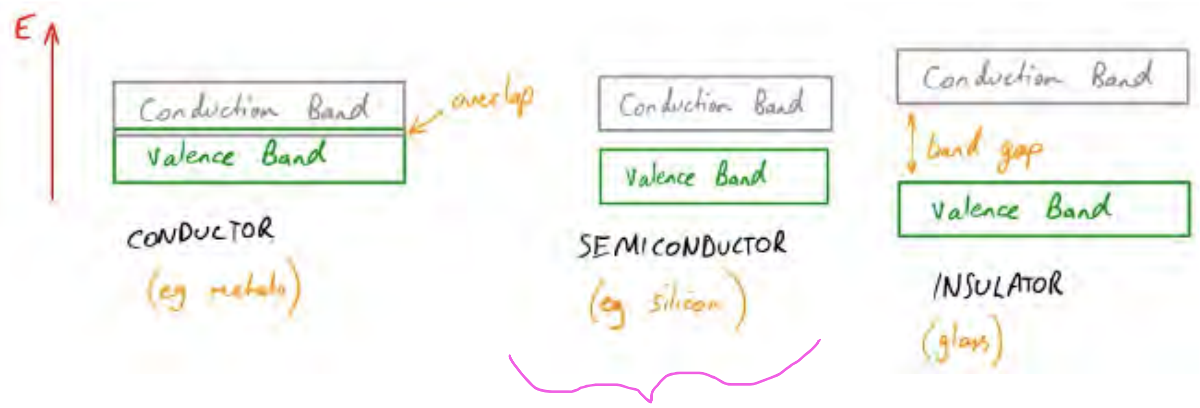
Band theory **REVISE HERE**
Electrons cannot occupy the same state*. In separate atoms it's OK, but chemical bonds mean sharing electrons.

- Means must have states split apart in some way in order for electrons to be different.

*= identical quantities

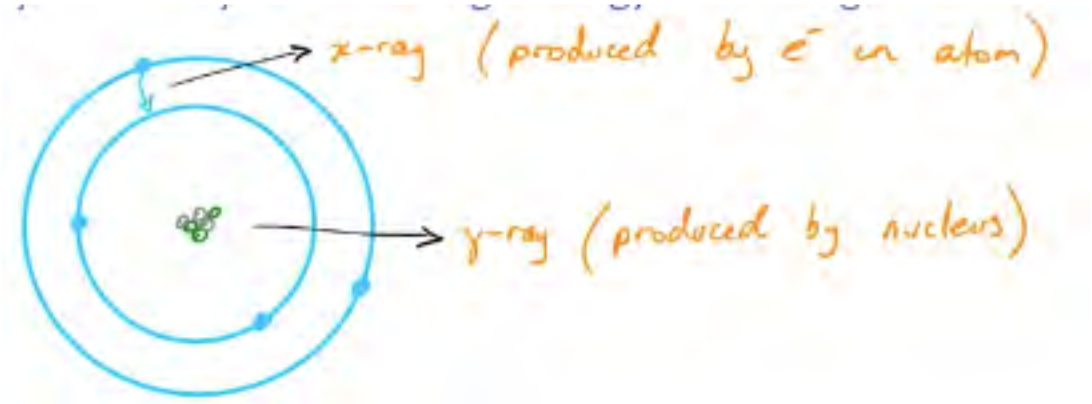
diagram

If electrons can reach conduction band material will have conductivity. We can describe electrical properties from the "band gap".



IMAGING IN NUCLEAR MEDICINE

Uses radioactive substances to diagnose and treat conditions. Radioactive decay produces gamma rays which are detected.



Parallels between DR and NM:
- The patient
- Non-visible ionising radiation
- See internal features of body

How is NM different?
- Position of source (inside patient)
- Source (x-rays vs gamma rays)
- Info desired (function vs anatomy)

Gamma-ray energy is set by isotope (NO kVp adjustment)

Imaging with Gamma Rays

Scintillator (radiation > visible light)
Gamma rays can't be switched off
- ⇨ Lower dose rate
- ⇨ Only few tiny flashes
- ⇨ Need to amplify light to measure it

Photomultiplier Tube (PMT) uses photoelectric effect to turn light into electrical signal.

PHYS1250 COMPRESSED NOTES

Radiation + macromolecules => Ionisation
Chemical bonds change
Macromolecule properties change

3 MAIN DAMAGE MECHANISMS

All 3 can be reversed in healing.

Main chain scission

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Point lesion

Disruption of single chemical bond. Cannot be detected analytically but can modify macromolecule.

Somatic mutations

Occur in single cell of body, cannot be inherited

Genetic/Germline mutations

Occur in gametes – can be passed on to offspring

Direct damage

Radiation itself causes ionisation of molecules (hits DNA)

Indirect damage

Atoms ionised by secondary electron produced by Compton scattering (Bounces off H_2O creating free radicals)
Ionises a molecule that is not crucial for biochemistry, but the reactive chemical by-products do damage to an important biological macromolecule.

Target theory

For a cell to die, target molecule must be hit

Converts light to charge
- Charge is proportional to amount of light
- Array or grid "under" scintillator

Amorphous silicon is photodetector (indirect)
Amorphous selenium is photo conductor (direct)

Capacitor
Purpose is to collect, and store electrical charge produced in the a-Si photodiode array.

Factors affecting DR image quality

Contrast
Differences in shades of grey (brightness), allows anatomical parts to be distinguished.

Dynamic range
- ⇨ Range of signal "brightness" that can give good image
- ⇨ 4 orders of magnitude

Detail
- ⇨ Spatial resolution
- ⇨ Depends on whole imaging instrument

Spatial resolution
Measured in line pairs per mm. (lp/mm)
- ⇨ Better resolution = ^lp/mm

Magnification

Always occurs and radiographers try to minimise its effect
- Object-detector distance needs to be as small as possible
- Sometimes needed to enhance smaller structures

Penumbra
Blurred edge on image or "partial shade".
^ source focal spot = ^ penumbra

^ Focus-Detector Distance (FDD) = ^ resolution
^ FDD = less magnification