Chemistry 224
Environmental Toxicology

Lecture 8

Monitoring the Environment

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Professor Ian Shaw, Pro-Vice-Chancellor
College of Science
email: ian.shaw@canterbury.ac.nz

Why monitor the environment?

- Check pollution levels
- Check pollution effects
- Control pollution
- Check compliance with statutory limits
- Inform legislators/legislation

Monitoring techniques

- Chemical analysis of pollutants
- Monitoring marker species

Monitoring Marker Species

Sensitive to environmental change

- **Algal blooms**
  - e.g. Eutrophication
    Nitrate

- **Lichens**
  - e.g. SO_2 pollution

- **Birds**
  - e.g. Dipper
    Acid rain
    May fly larvae

Marker Species Monitoring Methodology

- Kick sampling
- Terrestrial netting
- Quadrat measurements

Examples of Environmental Impact of Pollution

- **Organochlorine pesticides and bats**
  - e.g. Lindane wood treatment
  - Direct effect on roosting bats in lofts

- **Polychlorinated biphenyls and immunosuppression**
  - e.g. Seals/canine distemper
  - PCB insulator pollution

- **Dieldrin**
  - e.g. Herons

  - 1980's UK – dieldrin in eels
  - Herons eat eels
  - Major UK company prosecuted for dieldrin release

Analytical Methods

Analyte extraction – sample clean-up

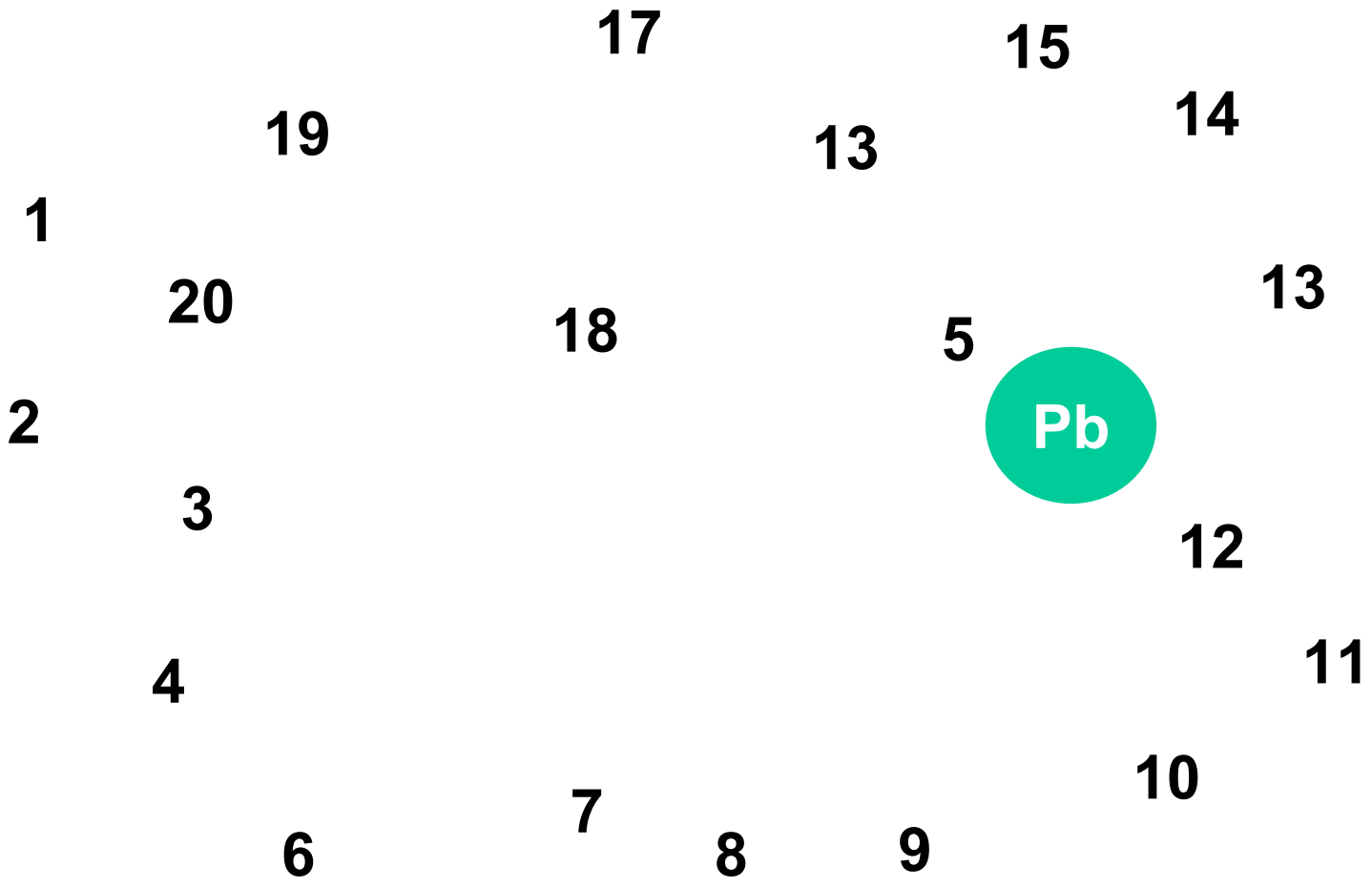
- **Gas liquid chromatography/mass spectrometry**
- **High performance liquid chromatography/mass spectrometry**
- **Atomic absorption spectroscopy**
- **Colorimetry**

Chemical Analysis of Pollutants

Sampling

Table 4.3: Hypothetical analytical results for lead in soil samples, showing variability and mean values

Sample	Lead (μg g^{-1})
1	10
2	10
3	15
4	12
5	**200**
6	10
7	15
8	17
9	10
10	8
11	8
12	**100**
13	10
14	12
15	15
16	13
17	6
18	40
19	13
20	12
Mean $\pm$ SD	26.8 $\pm$ 44.5



Distribution of samples from a point of source of lead pollution

Table 4.2: Examples of samples necessary to assess concentrations (and therefore impact) of lead from car exhaust fumes

Sample	Purpose
Air near to major road	To determine whether lead is present in air near to 'car activity'
Air 500 m from major road	To determine whether lead levels in air travel from source
Soil from roadside	To determine sedimentation of lead from car exhaust
Soil 500 m from roadside	To determine whether sedimentation is related to air concentrations of lead
Vegetation from roadside	(i) To determine vegetation surface concentration of lead (ii) To determine whether lead is absorbed by plants
Water from rivers many kilometres from roadside	Determine 'global' lead contamination of waterways

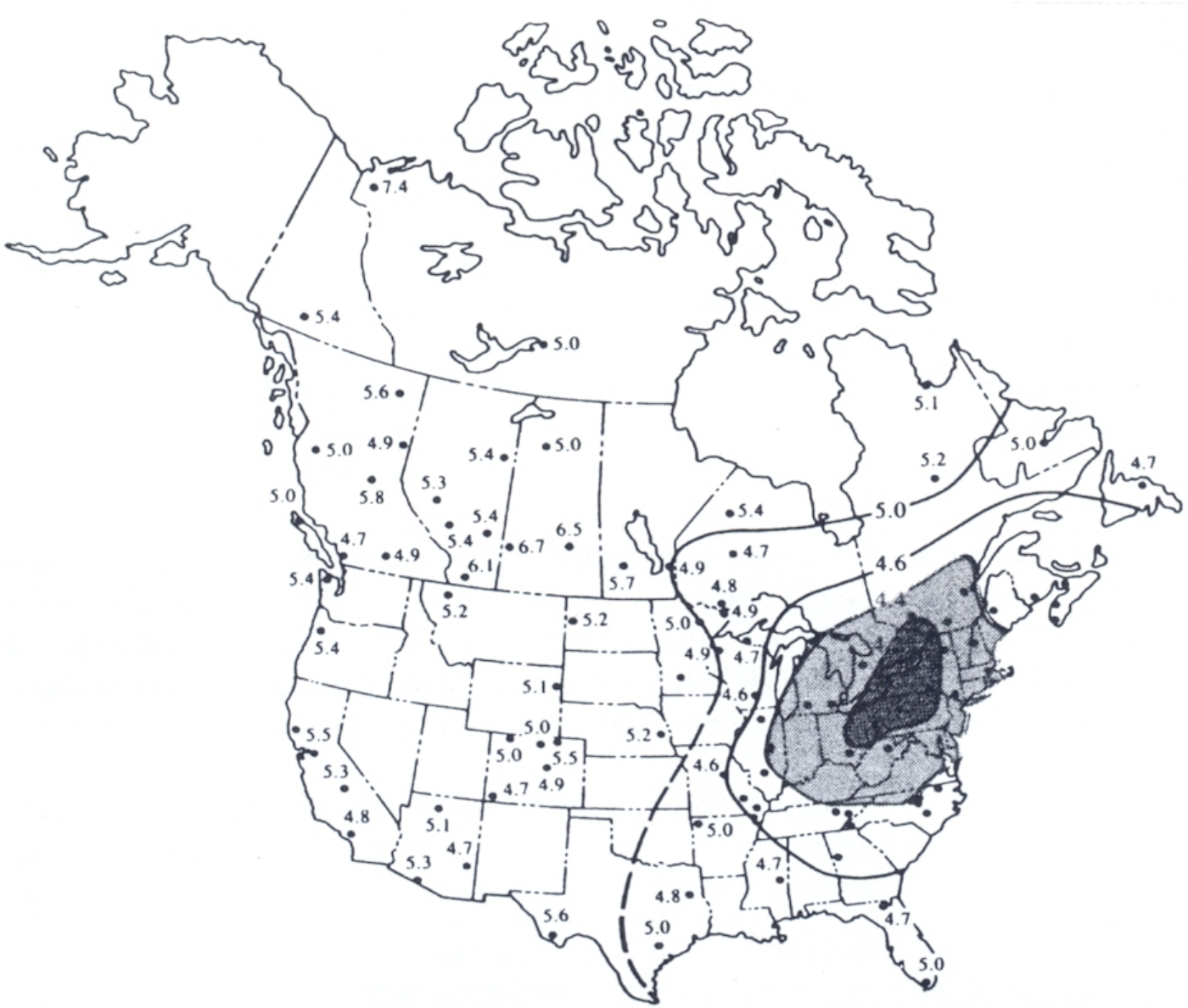
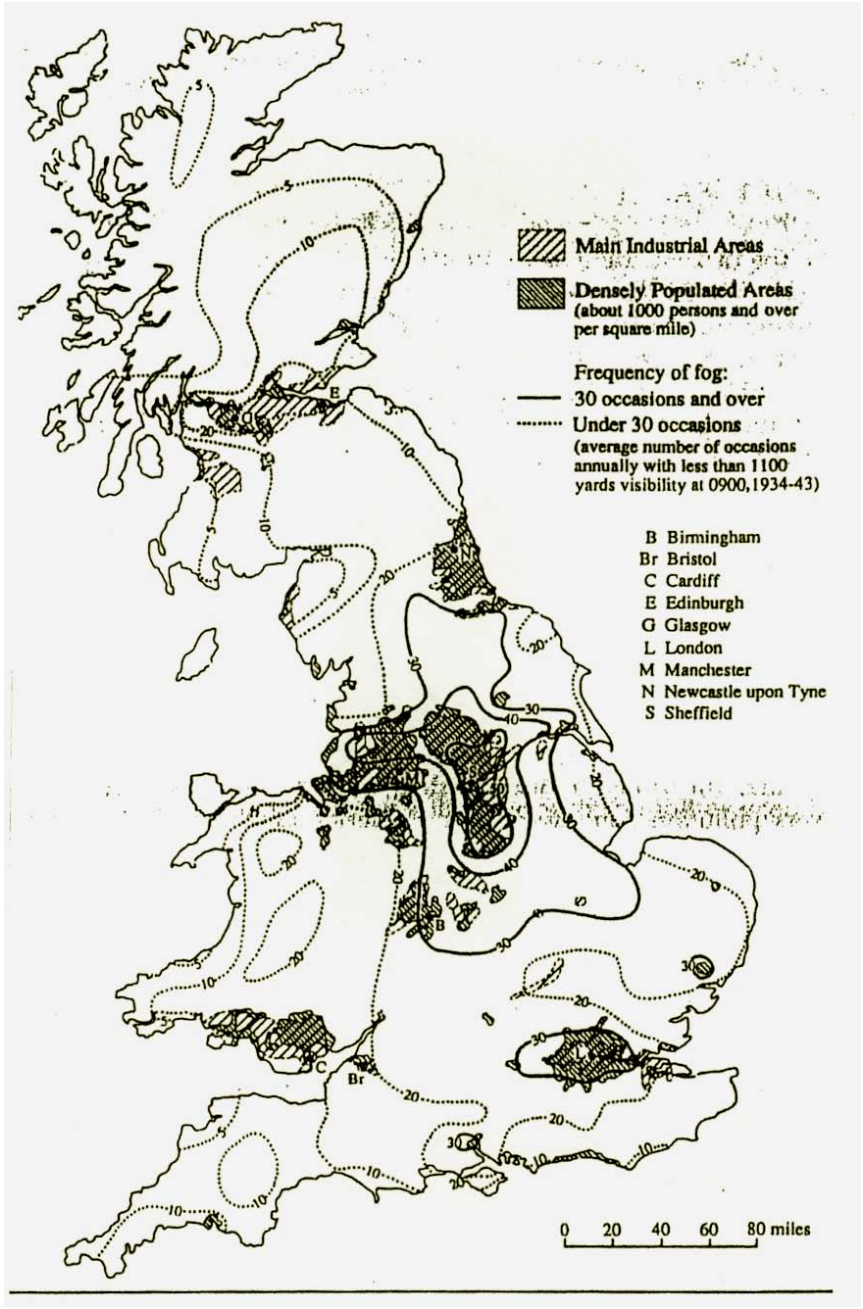


Figure 4.2: Map of the USA showing soil pH decreasing with decreasing distance from an industrial region. This is a good example of a point source of pollution. Reprinted from B. Freedman, 1989, *Environmental Ecology*, Academic Press Ltd, by kind permission of the publishers.



Map 1: Air pollution in Britain at 9am (Source: *The Climatological Atlas of the British Isles*, HMSO, 1952)

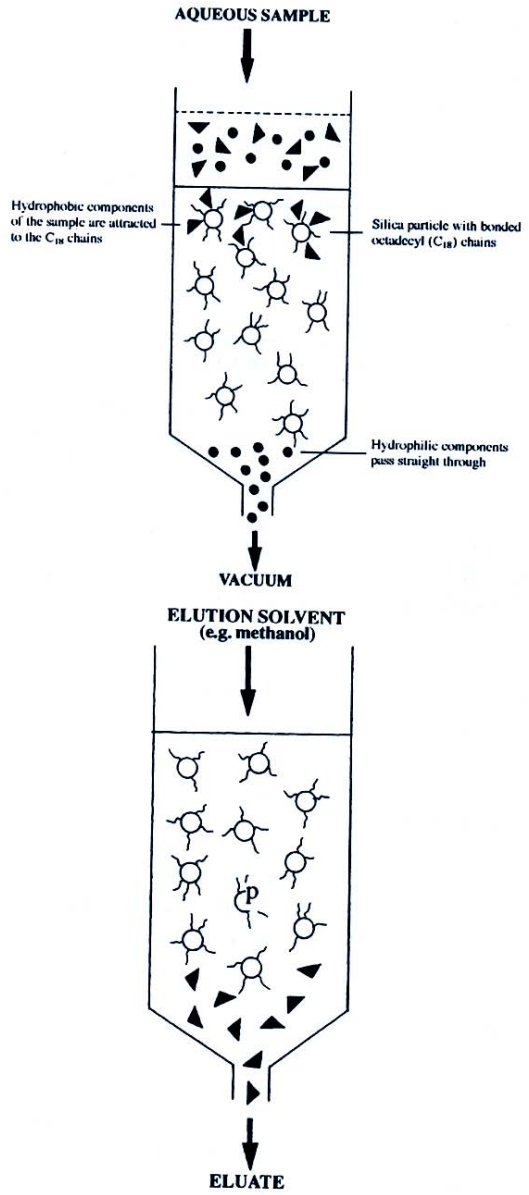


Figure 4.3: Schematic representation of the function of a solid-phase clean-up column. (a) The aqueous sample containing hydrophobic (▲) and hydrophilic (●) components is loaded onto the column and pulled through using a vacuum pump. The hydrophilic molecules pass straight through. The hydrophilic molecules are attracted to the bonded octadecyl chains and are eluted with an appropriate solvent (e.g. methanol). (b) Disposable column showing the small amount of packing material and the relatively large volume to accommodate the sample.

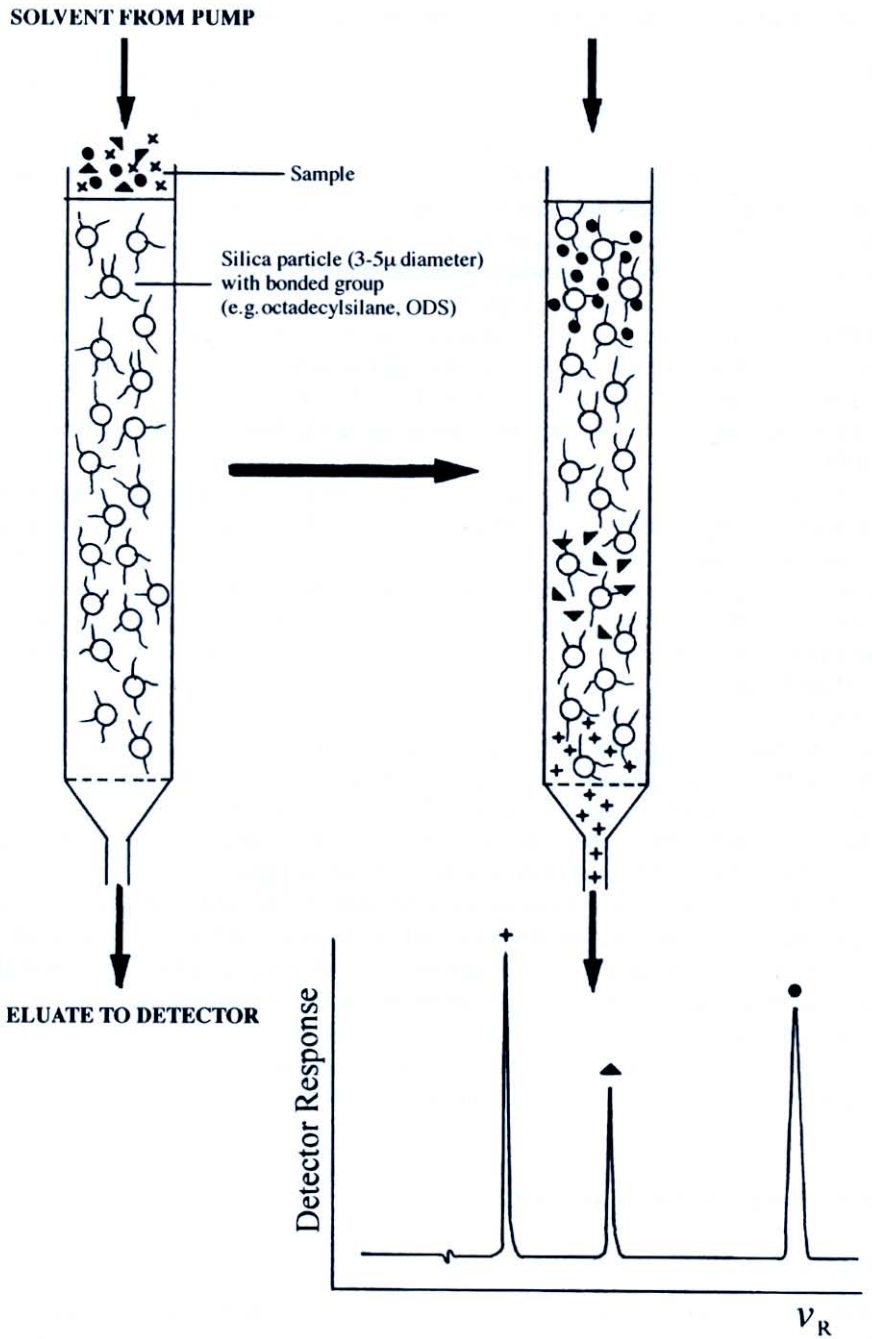


Figure 4.6: Schematic representation of the principles of reverse-phase HPLC. In this example the sample contains three different molecules in the following order of increasing polarity: ● ▲ x

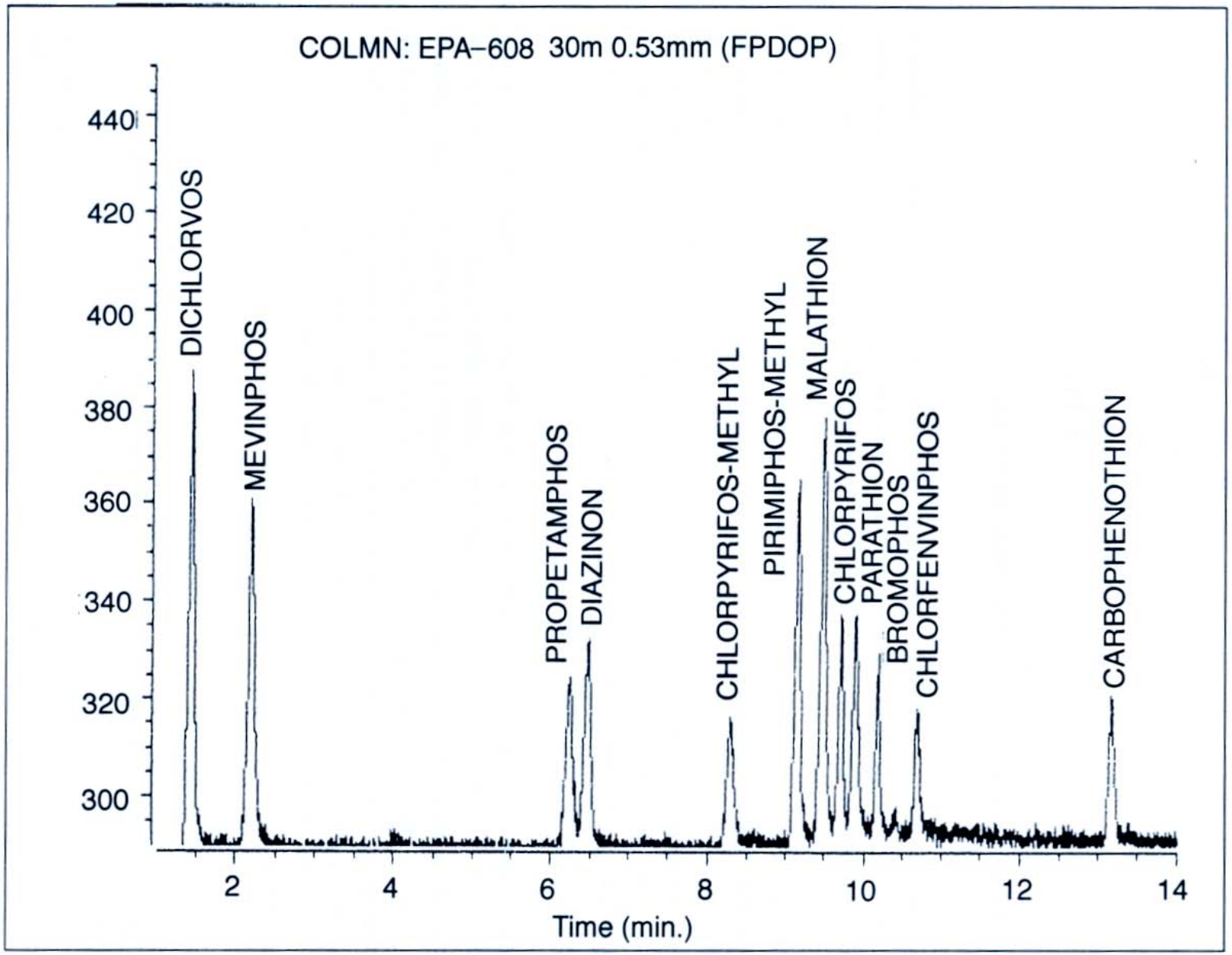


Figure 4.5: GLC trace showing the separation of Diazinon from other OPs. Data kindly provided by Richard Parker, Central Veterinary Laboratory, Weybridge, UK.

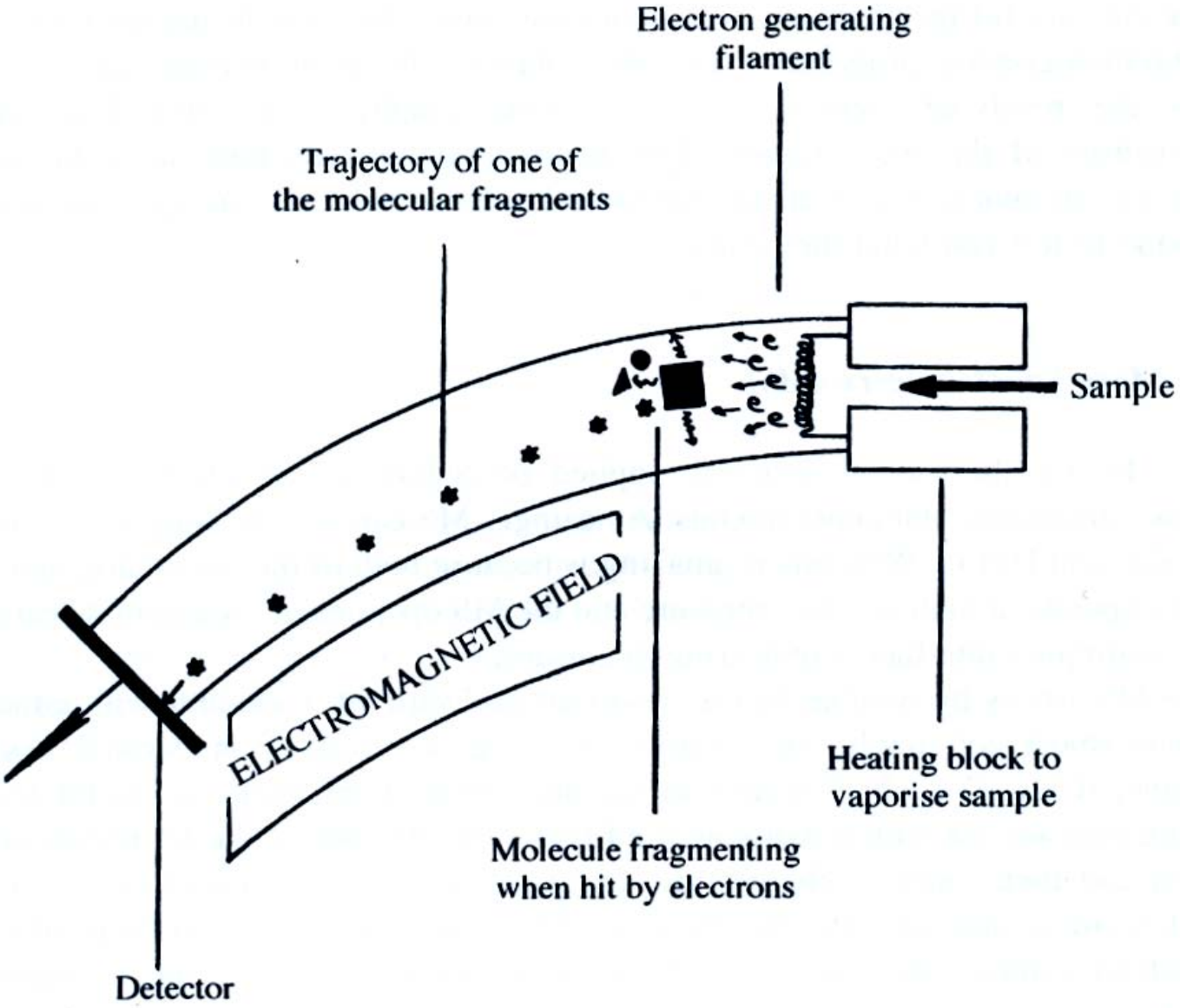


Figure 4.8: Schematic representation of the workings of a mass spectrometer

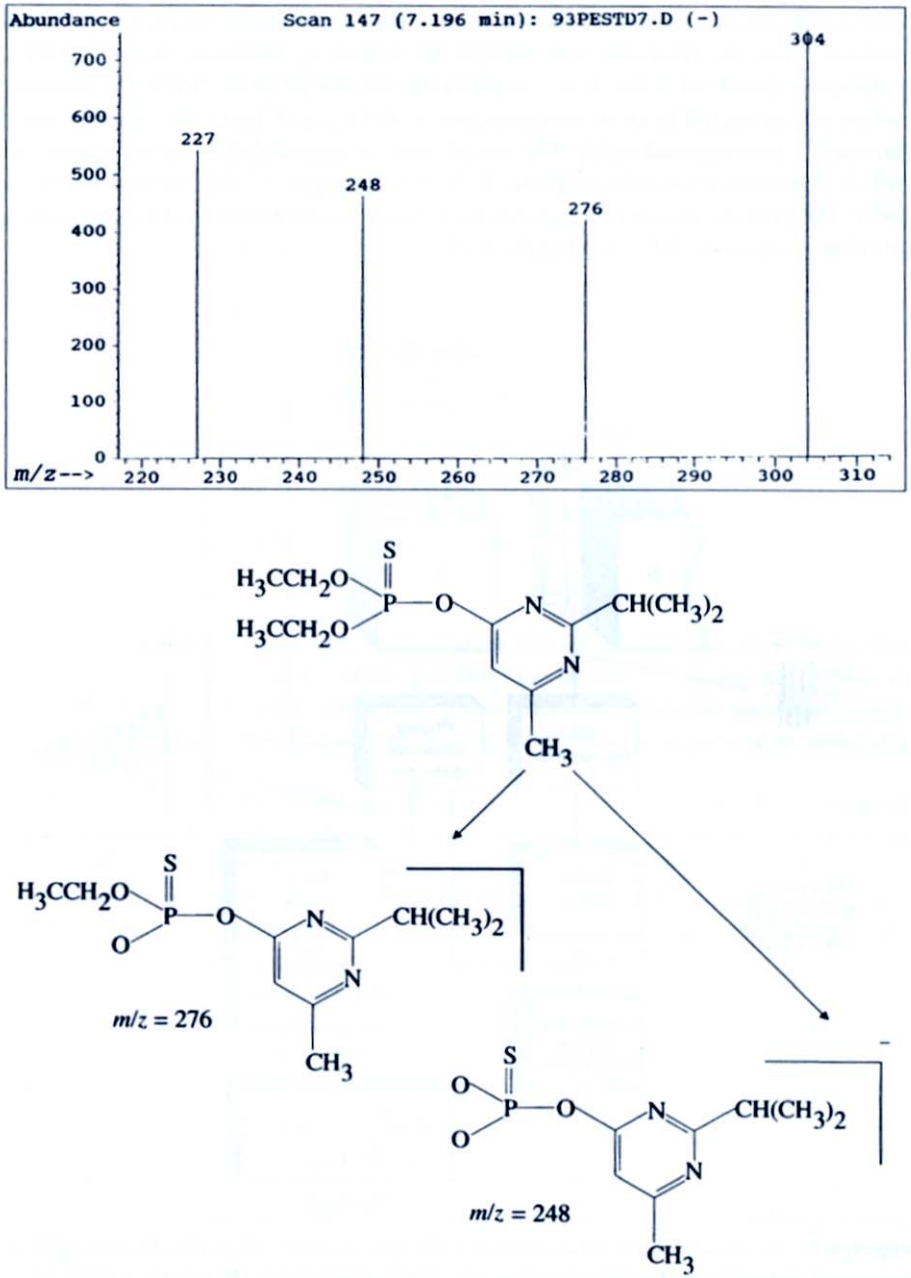


Figure 4.9: Electron impact fragmentation pattern for the organophosphorus pesticide Diazinon clearly shows the molecular ion at *m/z* = 304 which corresponds to the compound's molecular weight. The ions at *m/z* = 276 and 248 represent loss of the ethyl groups. Spectrum kindly provided by Richard Parker of the Central Veterinary Laboratory, Weybridge, UK.

Environmental Exposure to Methyl Bromide in the Workplace

A paper which explains the background…

http://www.nzma.org.nz/journal/118-1208/1273/

Methyl Bromide Uses

Fumigation
Pesticide

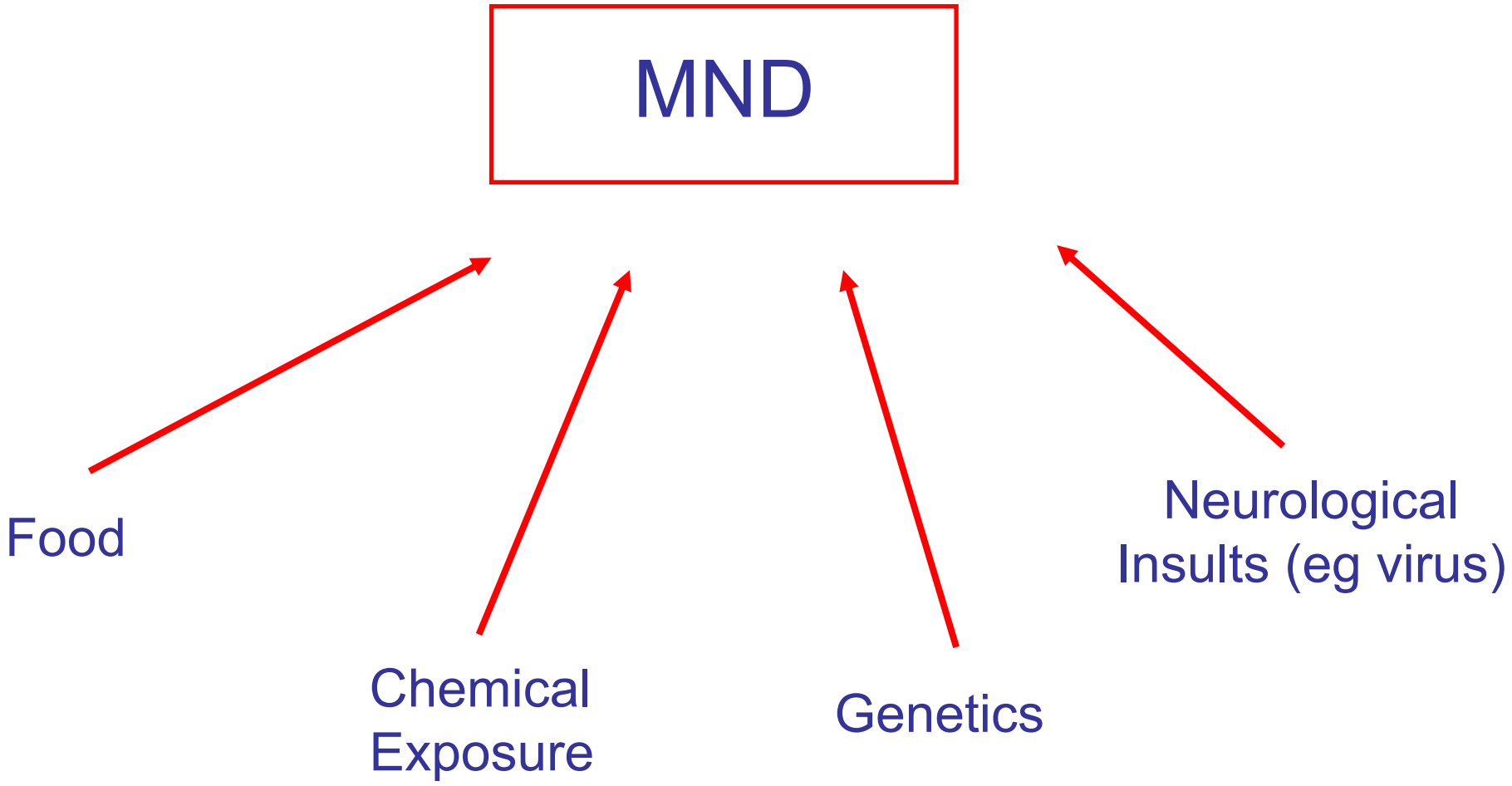
- Grain
- Wood
- Some fruits – eg strawberries

The Problems with Methyl Bromide

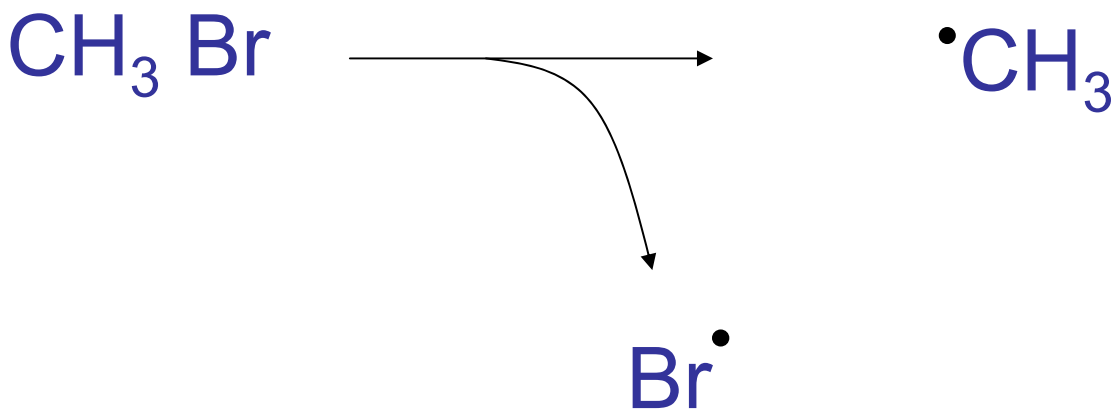
- Toxicity
  - → Acute – Respiratory
  - → Chronic – carcinogenicity
    neurological

- Ozone depletion
  - → Montreal Protocol
    Phase out

What causes MND?



Chemistry of Methyl Bromide



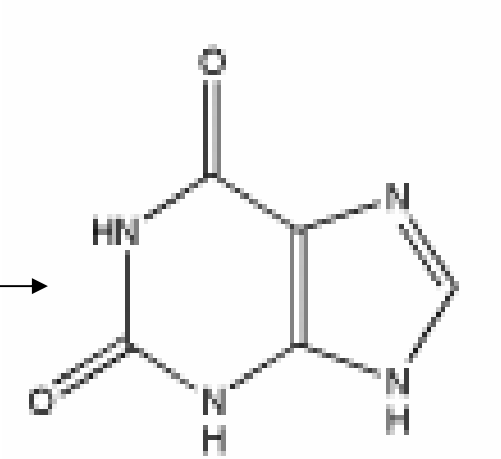
Free radicals in cells

- Interaction with proteins
- Interaction with DNA

What are free radicals?
Where do they come from?

1. ‘Natural’ free radicals

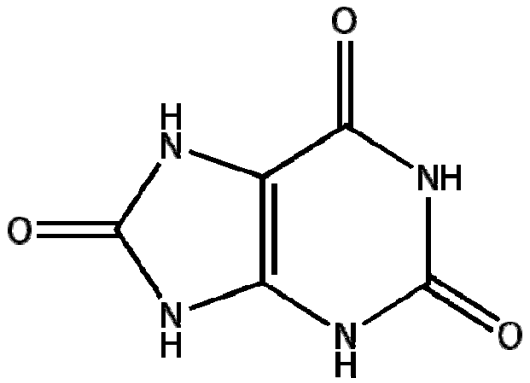
GUANINE →



Xanthine

$O_2^{\bullet -}$

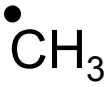
Xanthine Oxidase



Uric Acid

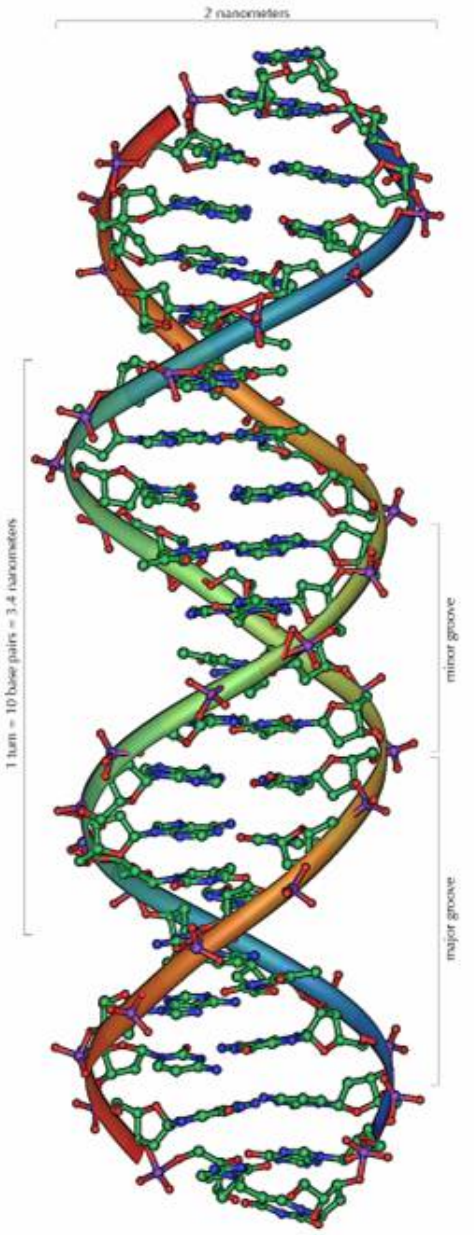
What are free radicals?
Where do they come from?

2. ‘Man Made’ free radicals

eg: Methylbromide - 

Radioactivity - 

Free radical interaction with DNA

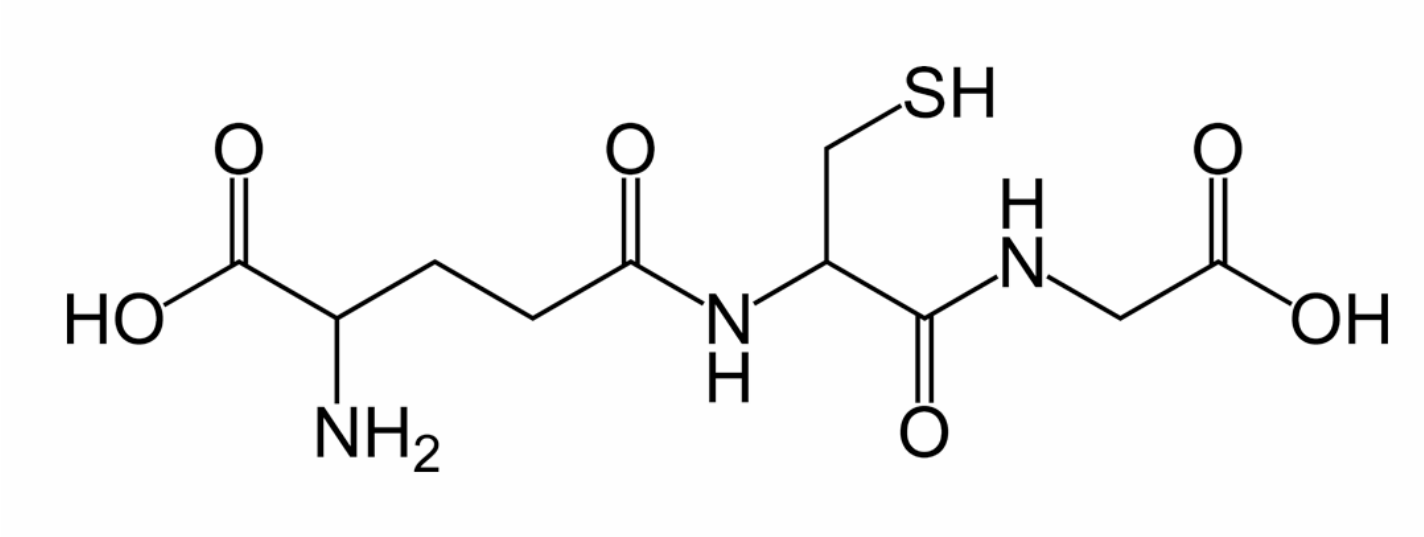


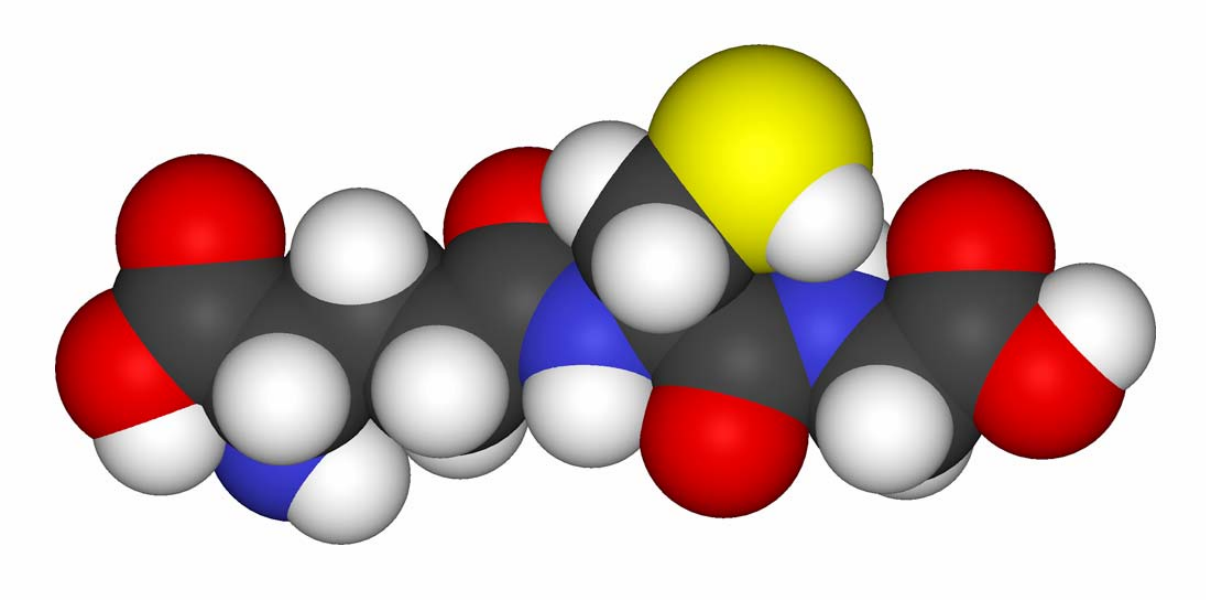
Cellular Protection against free radicals

GLUTATHIONE

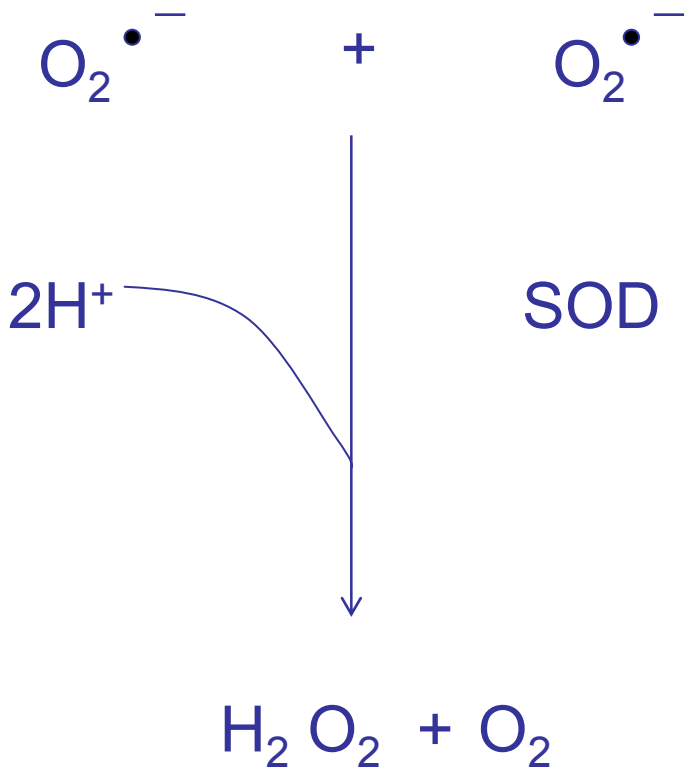
SUPEROXIDE DISMUTASE

Glutathione





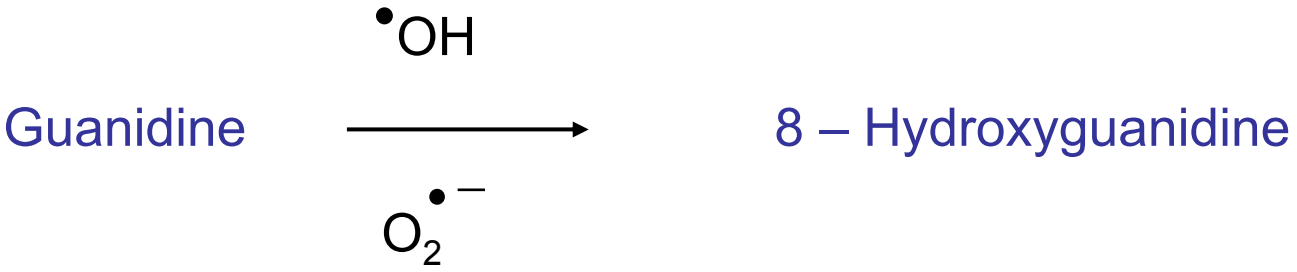
Superoxide Dismutase
SOD



Evidence for free radicals as a cause of MND

SOD Genetics

5-10% of cases



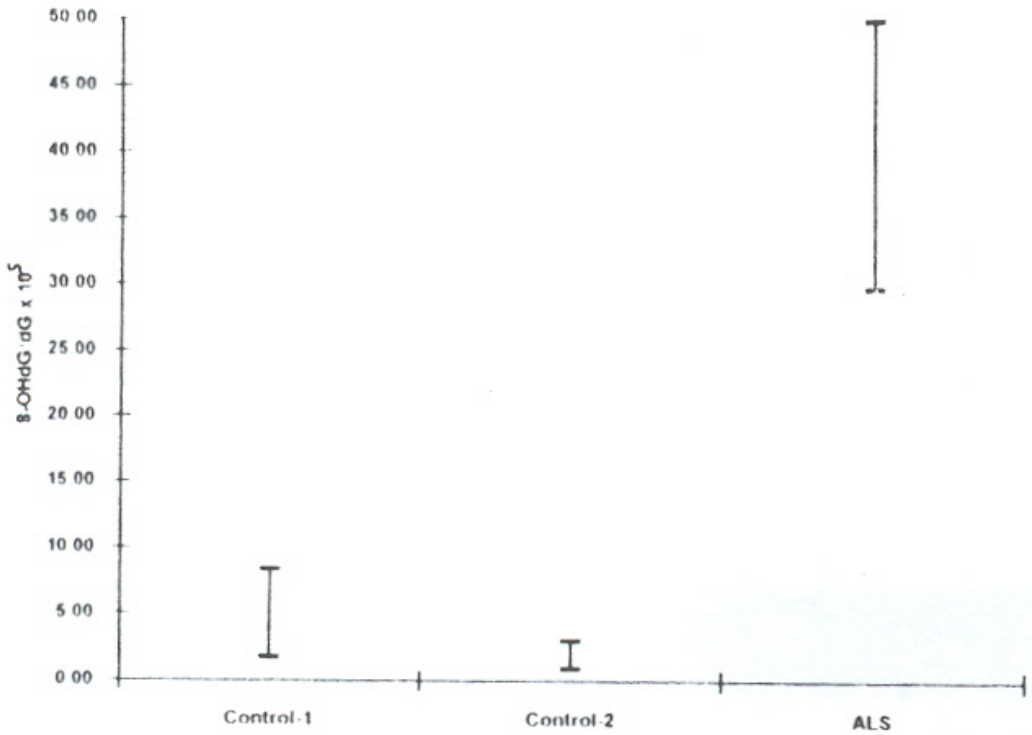


FIGURE 1. Plot showing ranges for 8-OHdG : dG in total neurone DNA from ALS patients (n = 2), controls from the same study (Control – 1; n = 2) and nuclear DNA from controls from published study[3] (Control – 2; n = 8).

From: Fitzmaurice PS, Shaw IC, Kleiner HE, Miller RT, Monks TJ, Lau SS, Mitchell JD, Lynch PG: Evidence for DNA damage in amyotrophic lateral sclerosis. Muscle and Nerve, (1996) 19, 797-798

So what's going on in MND?