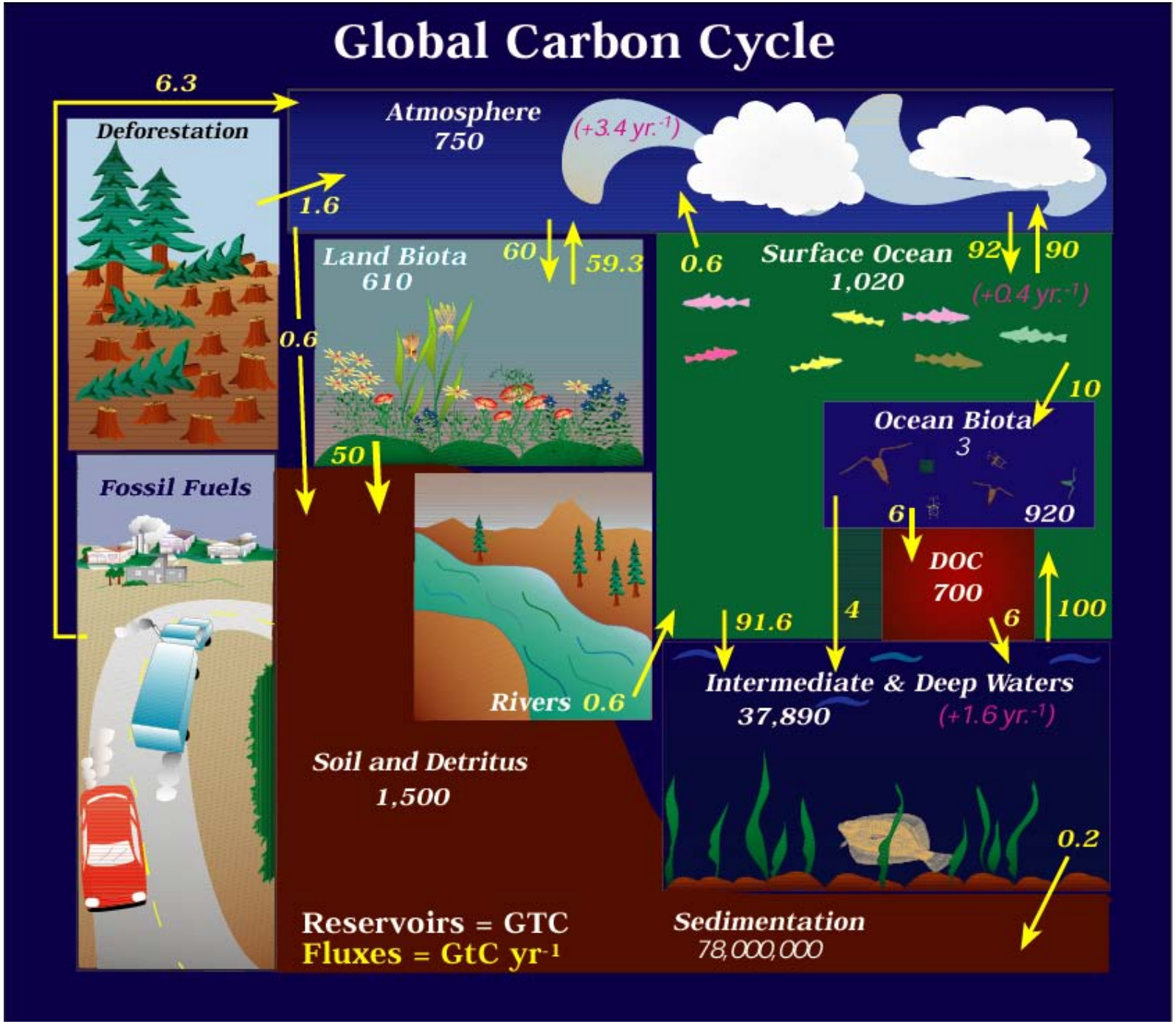
1. Carbon Cycle

2. Analytical techniques in chemical oceanography

12.097 Lecture

January 18, 2006



From www.pmel.noaa.gov/co2/gif/

The Marine C Cycle

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Please see: Valiela, 1994. (See readings.)

DOC distribution

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Please see: Williams 2000. (See readings.)

Summary depth profile of DOC in open ocean, separated into low and high molecular weight components.

Sources of DOC to surface ocean

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Please see: Nagata, 2000. (See readings.)

What is DOC?

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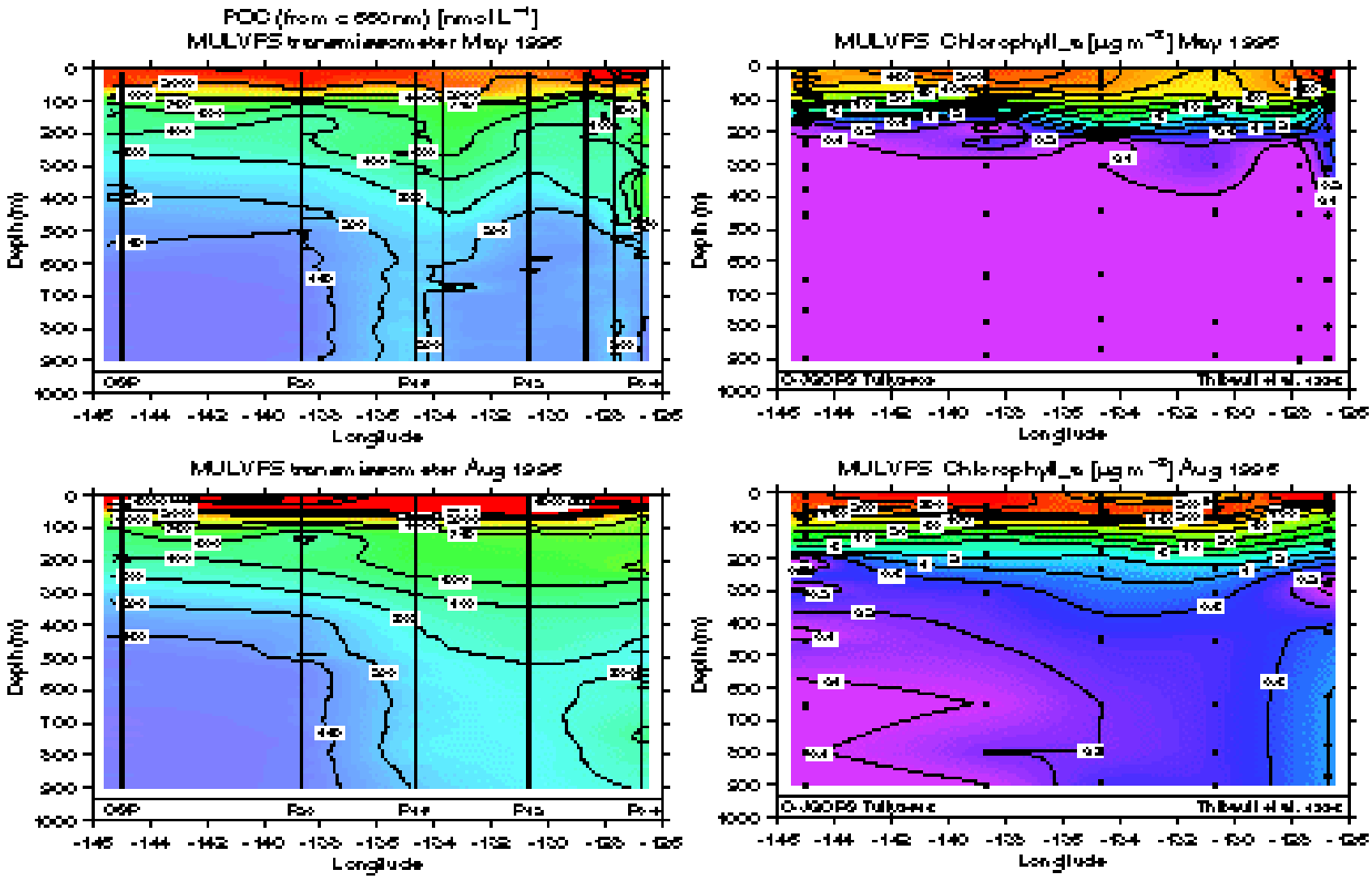
Please see: Williams, 2000. (See readings.)

POC distribution



From: http://esd.lbl.gov/CLIMATE/OCEAN/images/observations.gif

Particulate Organic Carbon (POC)

- POC falls in episodic “clumps”
- Cannot be sampled adequately by Niskin bottles – must use (semi-)permanently moored sediment traps
- Flux: 1-100 mgC / m^2 / d
- Varies seasonally
- Labile organic matter is transported quickly to ocean floor.

Carbon cycle rates

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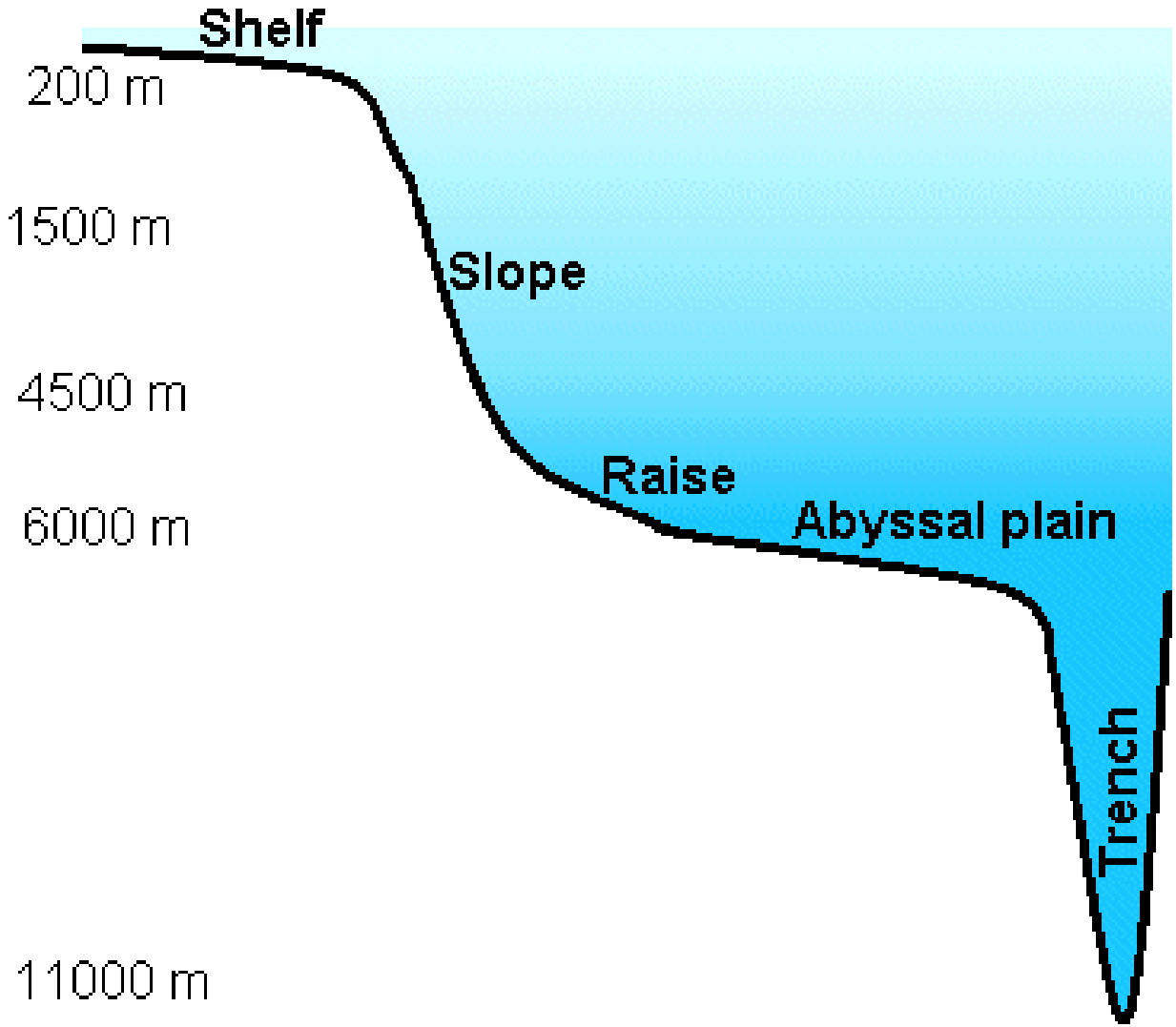
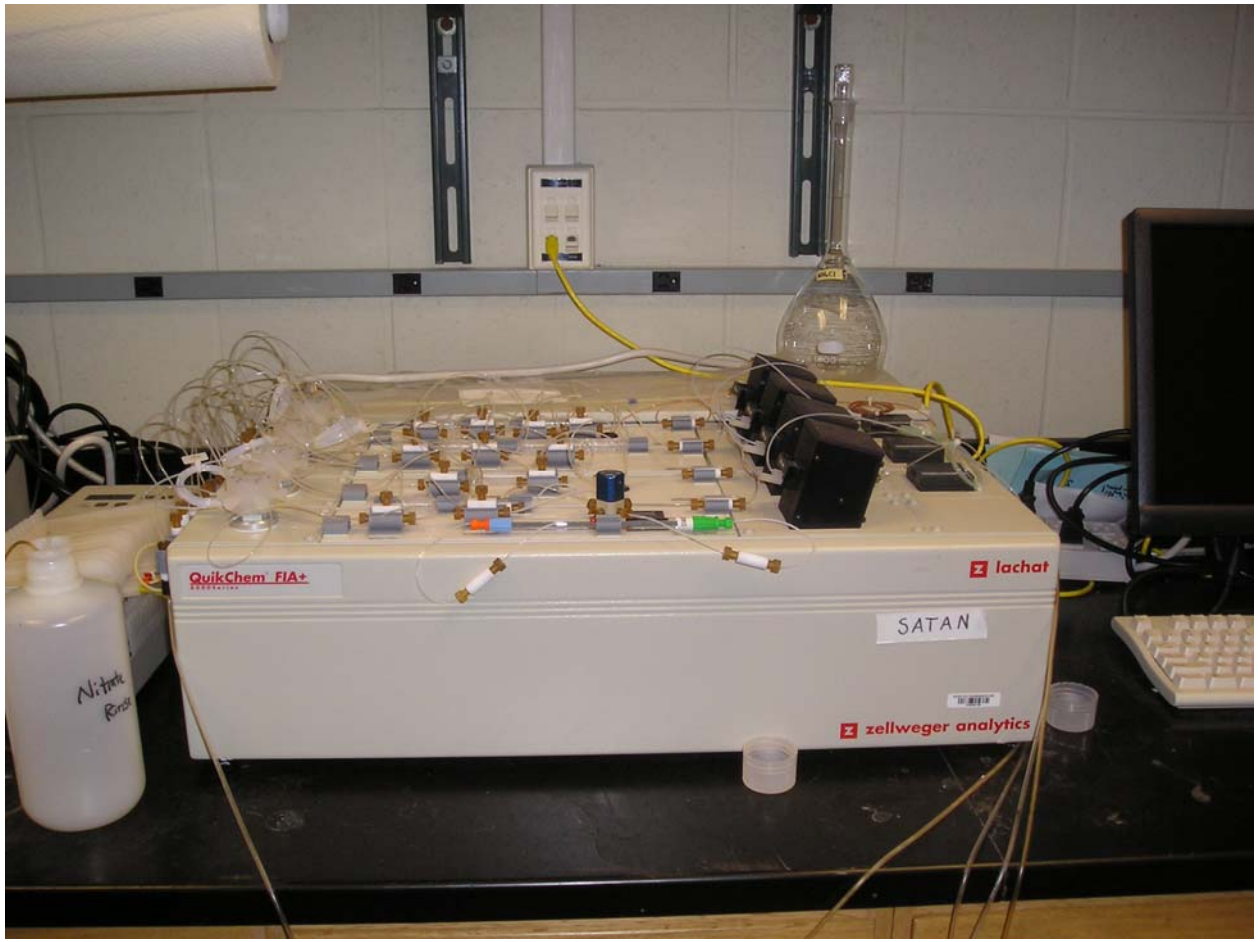
Please see: Williams, 2000. (See readings.)

Analytical techniques in chemical oceanography



Nutrient analyzer

Matt Charette's lab in Marine Chemistry dept at WHOI



- Lachat nutrient auto-analyzer: measures total dissolved nitrogen (TDN), ammonia, nitrate, nitrite, phosphate, silicate
- Based on standard spectrophotmetric techniques

Metals: ICP-MS

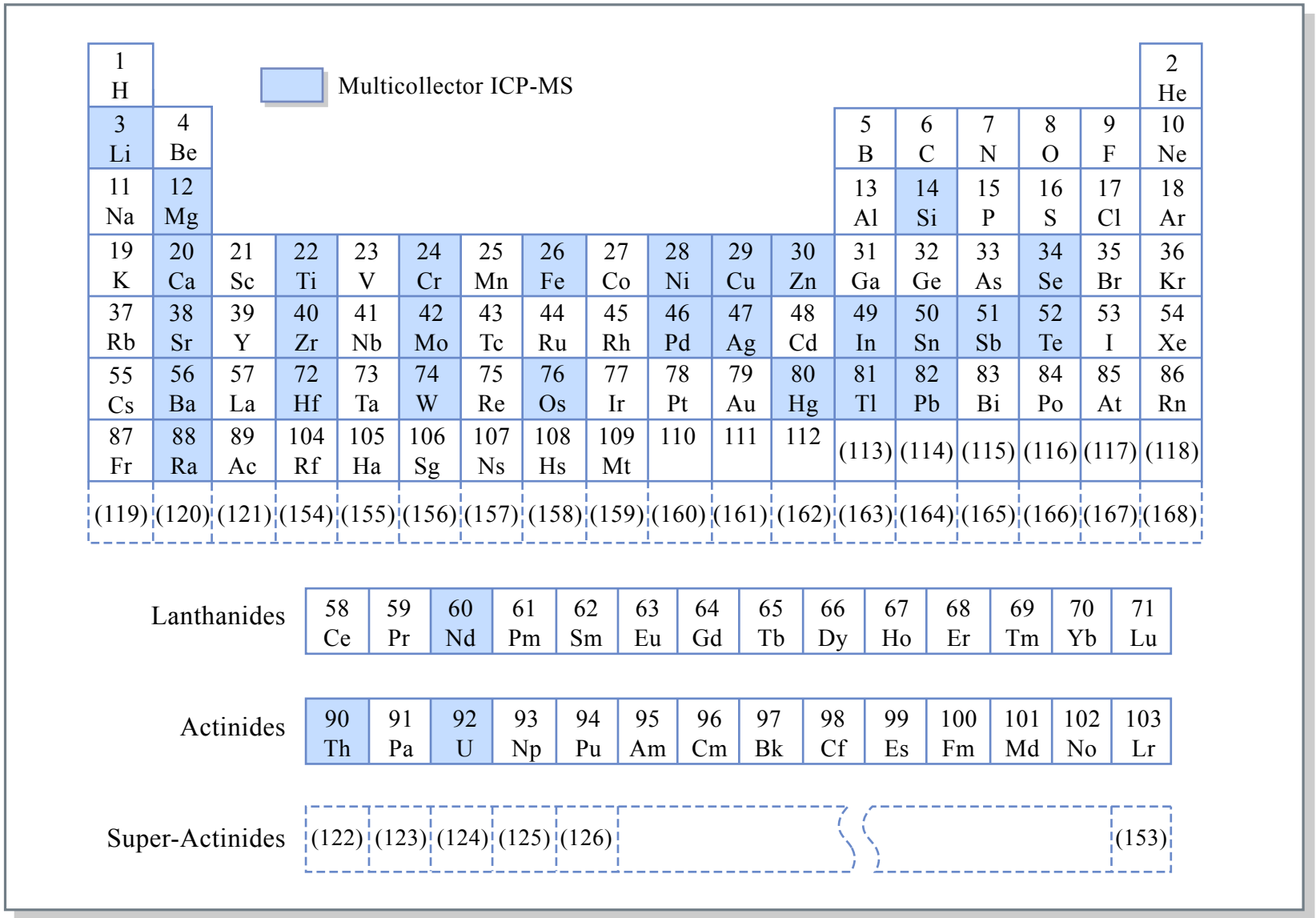


Figure by MIT OCW.

Metals: ICP-MS

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Please see: Thermo-Finnigan NEPTUNE/TRITON brochure

Organic Carbon Analyses 1

- Bulk analyses:
  - Elemental analysis
    - Amt of C, H, or N in solid sample
    - Used on particulate material or freeze-dried "dissolved" material
  - Carbon combustion
    - Amt of C in sample after removal of CO_2
    - High-temperature combustion (>800^{o}C)
    - Used for aqueous samples only.

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Please see: http://www.uark.edu/ua/isotope/about/elemental_analyzer.jpg

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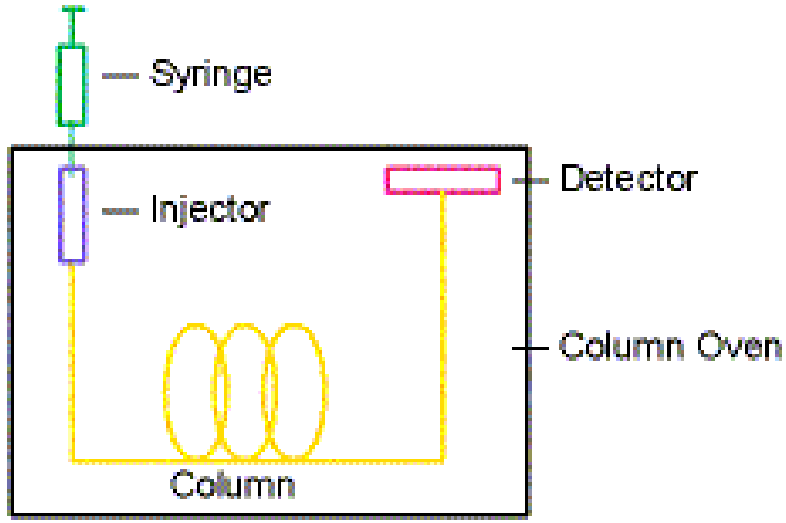
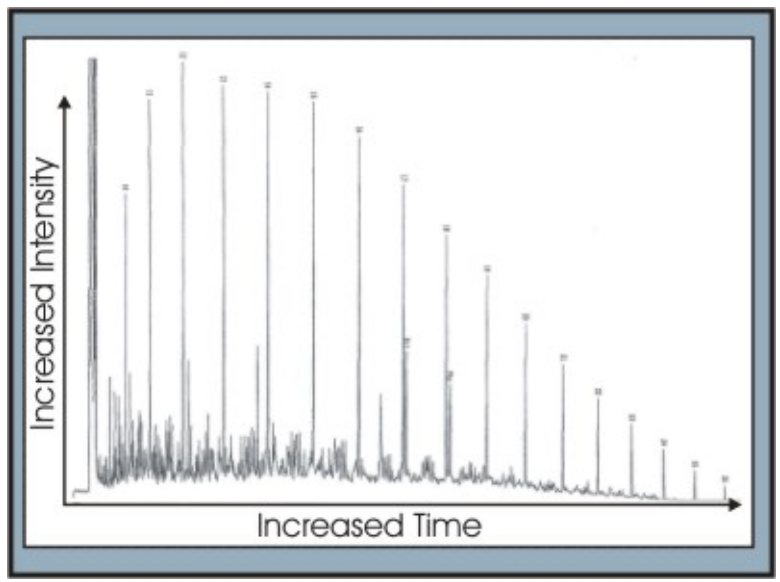
Please see: L. Guo(http://denali.frontier.iarc.uaf.edu/)

Organic Carbon Analyses 2

- Compound-specific analyses require (relatively) large amounts of a single compound: need to concentrate initial sample!
- Polar compounds: remove water
  - Analysis by HPLC
- Nonpolar compounds: extract with organic solvent or solid organic matrix (SPE)
  - Analysis by GC
- Semi-polar compounds
  - Change pH of solution to make compound neutral (non-ionic)
  - Derivatize polar component with non-polar functional group
- Mass spectrometry
  - Used to characterize structure and/or composition of individual molecules



Schematic of a gas chromatagraph



From: www.chemterra.com/imgs/hc-mkwfig10.jpg

Organic Carbon: Isotopes Overview

- There are 3 isotopes of carbon:
  - ^{12}C: 6 neutrons, 6 protons, stable, 98.89% of all carbon
  - ^{13}C: 7 neutrons, 6 protons, stable, 1.11% of all carbon
  - ^{14}C: 8 neutrons, 6 protons, radioactive, 10^{-10}%
- Dominant process for determining $^{13}C/^{12}C$: fractionation
  - The small mass difference (approx 1 Da) creates a small (but significant) in energy requirements for bonds between ^{13}C and the more abundant ^{12}C atoms.
  - Thus, biological systems will preferentially use ^{12}C over ^{13}C, resulting in a decreased $^{13}C/^{12}C$ in biological material and an increased $^{13}C/^{12}C$ in the reservoir.
  - Reported values: $\delta^{13}C$

$$\partial^{13}C = \left[\frac{\left(\frac{^{13}C}{^{12}C}\right)_{sample} - \left(\frac{^{13}C}{^{12}C}\right)_{std}}{\left(\frac{^{13}C}{^{12}C}\right)_{std}} \right] * 1000$$

$\delta^{13}C$ ratios in environment

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Please see: http://basinisotopes.org/basin/tutorial/gifs_2/irms_diagram.html

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Please see: http://www.geosc.psu.edu/~dbice/DaveSTELLA/Carbon/c_isotope_models.htm

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Please see: http://www.eva.mpg.de/evolution/images/isotope.jpg