

ASTR/GEOL-2040: Search for life in the Universe, Lecture 2



Axel Brandenburg

(Office hours: Mondays 2:30 – 3:30 in X590
and Wednesdays 11-12 in D230)

Important dates

- Wednesday, Sep 20 → Q1
- Wednesday, Oct 11 → Fiske
- Friday, Oct 13 → MT
- Monday, Nov 13 → Fiske
- Wednesday, Nov 15 → Q2

Sample HW question

In the reaction $\text{CO}_2 + \text{H}_2\text{O} + \text{energy} \rightarrow \text{CH}_2\text{O} + \text{O}_2$,

the energy comes from: (sunlight/molecules), so the relevant prefix is (photo/chemo)

the electron donor is:, which is (organic/inorganic), so (organo/litho),

and the carbon source is:, which is (organic/inorganic), so (hetero/auto),

and so it is a:troph.

- Also possible in Q, MT, or Final

Sample HW question

In the reaction $\text{CO}_2 + \text{H}_2\text{O} + \text{energy} \rightarrow \text{CH}_2\text{O} + \text{O}_2$,
the energy comes from: **sunlight**, so the relevant prefix is “**photo**”,
the electron donor is: **H₂O**, which is **inorganic**, so “**litho**”,
and the carbon source is: **CO₂**, which is **inorganic**, so “**auto**”,
and so it is a: **photolithoautotroph**.

→ see <https://en.wikipedia.org/wiki/Phototroph> for details.

(Since organoautotrophs are either rare or don't exist, one often just

- Often just → photoautotroph

Sample finals question

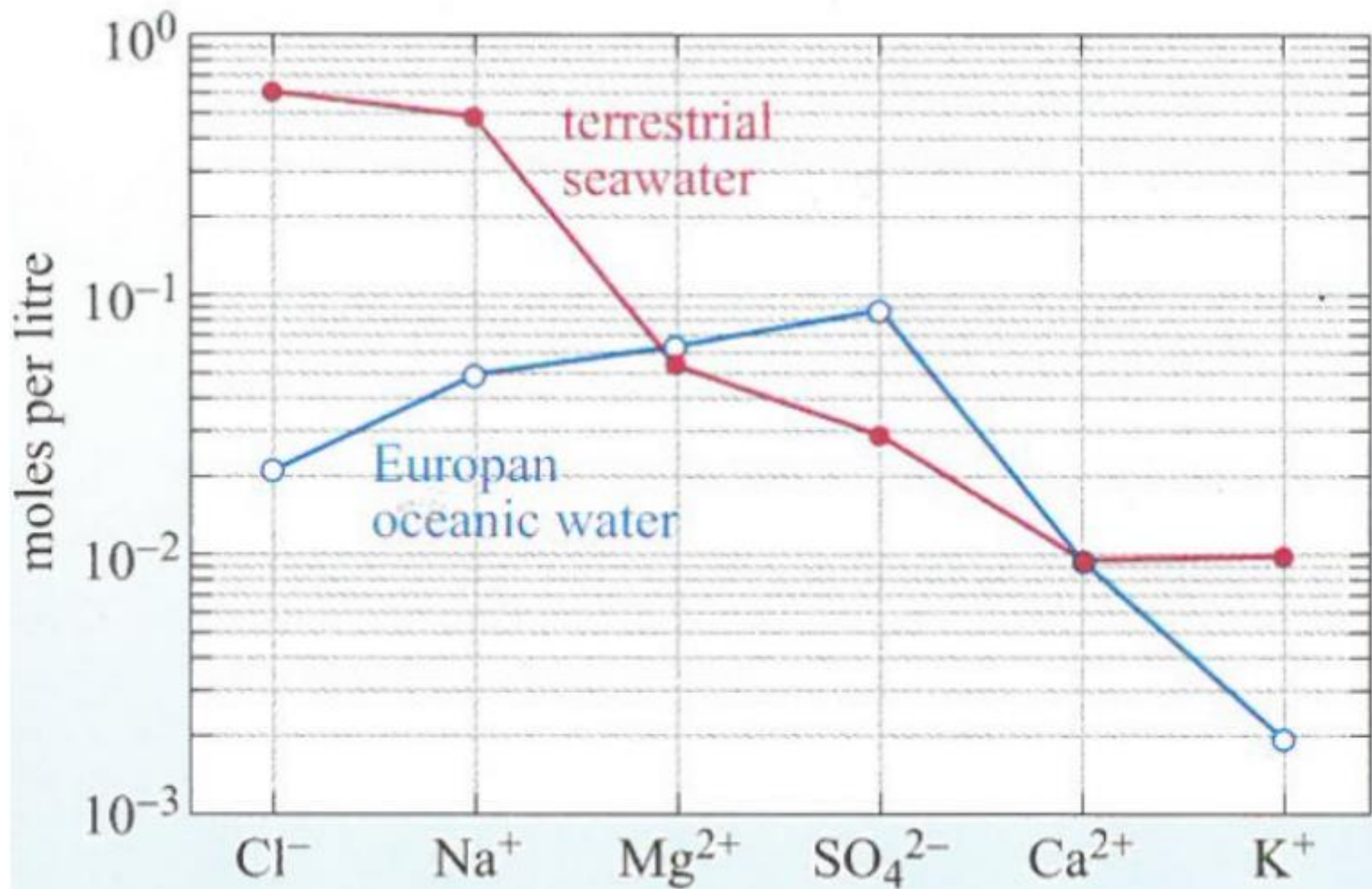
Marble is created when limestone is subducted beneath the surface and repeatedly folded over itself in the hot mantle (without melting). Knowing this, what kind of rock is marble?

- (a) Sedimentary. (b) Metamorphic. (c) Igneous. (d) Marble is none of these types.

Finding exoplanets with the radial velocity (or Doppler) method allows one to obtain

- (a) the radius of the planet
(b) the mass of the planet
(c) a lower limit on the mass of the planet

According to the figure below, how many more times greater is the concentration of chloride (Cl^-) in terrestrial seawater than in Europa's ocean? (Check carefully the numbers on the vertical axis, write down the two concentrations, and then divide.)



A 32 kg block of pure radioactive ^{235}U is left on a shelf...

(a) How many half-lives would I have to wait until only 2 kg of ^{235}U is left?

$$32 \rightarrow 16$$

$$32 \rightarrow 16 \rightarrow 8$$

$$32 \rightarrow 16 \rightarrow 8 \rightarrow 4$$

$$32 \rightarrow 16 \rightarrow 8 \rightarrow 4 \rightarrow 2$$

(b) If the half-life of ^{235}U is 704 million years, how long will I be waiting?

(c) How long is this time compared to the age of the Earth?

A 32 kg block of pure radioactive ^{235}U is left on a shelf...

- (a) How many half-lives would I have to wait until only 2 kg of ^{235}U is left?

$$\frac{2 \text{ kg}}{32 \text{ kg}} = \frac{1}{16} = \frac{1}{2^4},$$

so one has wait 4 half-lives.

- (b) If the half-life of ^{235}U is 704 million years, how long will I be **waiting**?

4 times the half-life, i.e., $4 \times 704 \text{ Myr} = 2816 \text{ Myr} = 2.816 \text{ Gyr}$.

- (c) How long is this time compared to the age of the Earth?

The age of the Earth is about 4.6Gr, so the **waiting** time is a little more than half the age of the Earth (which would be 2.3Gr).

Astrobiology nowadays

- microbial life should exist elsewhere
 - we just have to find examples
 - it could be in unimaginable places
- independent genesis → deeper understanding about ourselves
- exobiology ↔ astrobiology

Transition to life spontaneous?

- Prior to Louis Pasteur (1822-1895)
 - Flies & maggots from rotting meat
 - Lice from sweat
 - Eels & fish from sea mud...
- Disproven by Pasteur
 - All life from existing life
 - First life: from non-living matter?
- Need a strategy

What is life?

Life elsewhere might be different

Need to look for general properties

- Example: cat versus car
 - get energy, can move, produce waste
 - what's different?
- Reproduces itself

Properties of life?

1. ...
2.
3.
4.
5.
6.

Properties of life?

1. Order
2. Reproduction
3. Growth & development
4. Energy utilization
5. Response to environment
6. Evolutionary adaptation

Darwinian evolution

- More individuals produced than survive
- Struggle for existence (limited resources)
- Individuals show variation (often subtle)
- Individuals produce similar offspring

Works also/especially at the molecular level:
RNA can replicate itself → RNA world

Natural selection is

- A. the occasional mutations that occur in DNA;
- B. the mechanism by which advantageous traits are preferentially passed on from parents to offspring;
- C. the idea that organisms can develop new characteristics during their lives and then pass these on to their offspring.

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- B. the mechanism by which advantageous traits are preferentially passed on from parents to offspring;
- C. the idea that organisms can develop new characteristics during their lives and then pass these on to their offspring.

Lamarck is usually remembered for his belief in the **inheritance of acquired characteristics**, and the *use and disuse* model by which organisms developed their characteristics. Lamarck incorporated this belief into his theory of evolution, along with other more common beliefs of the time, such as spontaneous generation. The inheritance of acquired characteristics (also called

What we talked about

- Definition of life
 - Darwinian evolution, natural selection
 - & self-replication
- Next time:
 - Why carbon, & not silicon-based
 - Why water?
 - pp. 3-8, Sects. 1.1 & 1.2