Seawater and its Chemistry

The Water Molecule

- **Elements, Atoms and Molecules:**
  
  An *element* is the simplest form to which matter can be reduced by ordinary chemical means. An *atom* is the smallest component of an element and comprises electrons, protons and neutrons. A *molecule* comprises two or more atoms and is the smallest component of a compound while retaining its chemical characteristics.

- **The water molecule** is made up of one oxygen (O) and two hydrogen (H) atoms. The bonding of these elements is called chemical (or covalent) because electrons in H and O here share the electron orbits. Being an electrically polarized molecule, with H end as +ve and O end as –ve, it attracts the neighboring water molecules. This property is called hydrogen bonding. Because of these, the water molecule
  
  — is light,
  — is stable as liquid over an unusually wide range of temperatures (0°-100°C),
  — freezes over, not under, and
  — is an excellent solvent

  The temperature range over which the H₂O molecule stays liquid is unusually wide for its molecular mass.

- **Salts in seawater:**
  
  - **Law of Constant Proportions:** The percentage of salts dissolved in seawater is constant, no matter the salinity [Salinity (‰) = 1.80655 × Chlorinity (%)].

  - Average seawater, with 35‰ or 3.5% salinity, contains 96.5% H₂O (85.8% O, 10.7% H) and 3.5% dissolved salts (1.9% Cl, 1.1% Na, 0.15% Mg, 0.1% S, 0.04% Ca and 0.04% K).

- Seawater also contains nitrogen, oxygen and carbon dioxide as dissolved gases. Indeed, the atmosphere has lost most of its CO₂ to the oceans via photosynthesis. The depth picture too shows the role of life in modulating the ocean-atmosphere exchange. Note the drop in CO₂ in the near surface waters, coupled with a high O₂ content, reflecting photosynthesis in the Sunlit surface waters by phytoplanktons.

Why is the seawater salty?

- Salt brought from land by streams can explain only ~2% of Cl and ~20% of S in the seawater.

- Hydrothermal activity on the seafloor can provide (a) the sources for seawater’s excess Cl and S, and (b) sinks to balance the continued enrichment in sulfates and Mg by streams.

- Seawater’s composition has remained unchanged over the geologic past. These evidences suggest an internal origin for water on Earth (degassing of ~10% of the mantle could have easily produced the ~360x10⁶ trillion gallons of water on Earth. The abrupt rise in Cl in groundwater immediately before the 1995 Kobe earthquake too supports this.

- Evidences favoring extraterrestrial origin of water too exist. For instance, NASA’s 1996 satellite pictures showed that earth may be continually pelted by snowball-like mini-comets that annually release ~75 billion gallons of water vapor into the atmosphere. Seawater’s deuterium/total hydrogen ratio too matches that in comet Halley’s tail!

- What if water is lost by (a) leakage in the deep-sea trenches? (b) retention in the atmosphere? Of these, perhaps (a) offsets the cometary input while (b) may explain the Devonian aridity at a time that is also known as the “Age of Fish!”