

History of Biological Oceanography

I. Overview: Evolution of Scientific Disciplines

Any scientific discipline can be divided into four periods, or stages:

- 1) Observation
- 2) Hypothesis Testing
- 3) Manipulation
- 4) Control

-Example: In genetics, we can assign Stage 1 (observation) to the recognition that two blonde people will (usually) have blonde children. Stage 2 (Hypotheses) would include Mendelian Genetics, and the discoveries of Watson and Crick (DNA/RNA). Stage 3 (manipulation) could be assigned to Gene Therapy, and Stage 4 (Control) could be assigned to the cloning of animals such as Dolly.

-In Oceanography, we're somewhere between 1 and 2, with some early steps towards 3 (such as the large-scale manipulation of ocean productivity by iron fertilization).

II. Historical Periods of Oceanography:

- A. Prehistoric and Ancient (Greek and Roman) Peoples
- B. Middle Ages, or Discovery and Navigation
- C. Challenger Expedition
- D. Post World War II

A. Prehistoric and Ancient Peoples

- Pacific Islanders probably the first peoples to extensively travel by boat
- Phoenicians explored the Mediterranean, Indian Oceans
- These travels occurred around 2000 BC, without compasses or good maps

Greeks and Romans

- Greeks called the Mediterranean *Thalassa*, and thought it was surrounded by land, and then a big river (oceanus) around that
- 325 BC Pytheas calculated Latitude
- 250 BC Eratosthenes (a librarian from Alexandria, Egypt) calculated the earth's circumference at 40,000 km. The modern estimate is 40,032....very close!
- 150 AD, Ptolemy (Roman) mapped the known world
 - First person to put North at the top, East at the right, and to use a *conic projection*, meaning the earth is a sphere

B. Discovery and Navigation

- By ~250 BC Greeks had reached Great Britain
- Arabs explored much of the Indian Ocean, using the compass (invented in China in the 4th Century) and *monsoon winds* to speed travels
- Vikings colonized Iceland by 900 AD
 - i. Leif Eriksson reached N. America by 995 AD
 - ii. ~1300 AD, the N. Atlantic cooled off, ending the Viking explorations
- In China, from 1405-1433 (Ming Dynasty), explored much of the Indian Ocean and Africa using very modern vessels and navigation
- During this period, Europe lost almost all of its knowledge (the “Dark Ages”)
- Crusades (ca. 1050-1250 AD) allowed Europe to rediscover “lost” knowledge in the Spanish and Arab libraries
- Ptolemy's map was republished in Europe (with the WRONG circumference!)
- Columbus reached the Bahamas in 1492, thought it was Japan
- 1498, Vasco da Gama rounded Cape Horn, Africa
- 1519-1522, Magellan was the first person to circumnavigate the globe (we think)

Navigation

- The biggest problem facing European explorers was the lack of good navigation—no way to determine at sea where they were (Longitude) without an accurate clock
 - i. 1714, Great Britain offered a £20,000 (about \$2 million today) prize for a clock that would work at sea

- ii. 1728, John Harrison, a cabinetmaker, finished his first version
- iii. 1736, first one to be taken to sea
- iv. 1761, H4 was awarded the prize
- 1519-1522 Magellan's expedition circumnavigated the globe for the first time
- 1777, Ben Franklin was the first person to do *retrospective data analysis* (he used data that others collected to prove a hypothesis)—he suggested the Gulf Stream flowed in a clock-wise direction from N. America to England
- 1768-1771 Captain Cook
 - i. First major expedition with a clock (new his latitude and longitude)
 - ii. Avoided scurvy by bringing Sauerkraut (citric acid)
- 1831-1836, HMS Beagle voyage (with Charles Darwin)
 - i. 1859, first publication of "The Origin of Species"
 - ii. Darwin was only a naturalist aboard a mapping cruise—NOT an oceanographic expedition!

C. HMS Challenger Expedition (December 1872-May 1876)

There were several scientific debates raging in the early 1800's....

- In the 1800's, John Ross and James Clark Ross found the same benthic species in Baffin Island, Canada and in the Antarctic—they proposed that there must be a cold-water connection at depth
- Edward Forbes stated that there must not be any life at great depths—no sunlight, cold, and too much pressure. This was called the *azoic hypothesis*
- 1851, first Trans-Atlantic cable laid for the telegraph
- 1857, T.H. Huxley described a "primordial ooze" that was supposed to be the origins of all life, based on sediment samples from a cable dredge (preserved for several years)—he called the organism "*Bathybius*"—this is in direct contradiction of Darwin's hypothesis of evolution
- There was strong debate about whether there were currents at depth, or it was all sluggish water (Physical Oceanography)
- There were also questions about whether salinity changes, and whether the bottom sediments are related to the terrestrial environment (it was thought that the oceans were submerged continents)

The Challenger Expedition was the first truly Oceanographic Expedition and was commissioned by the Royal Society to address these questions:

- Azoic Hypothesis, Bathybius (Biology)

- Carbonate and salinity distributions (Chemistry)
- Ocean currents/temperature (Physical Oceanography)
- Relationship of ocean bottom to continents (Geology)

- 492 soundings, dredgings, trawls and water temperature profiles.
- Described 4717 new species
- Measured the depth of the Mariana Trench-- 8185 m
- first comprehensive survey of ocean salinity
- related the presence of coral reefs to alkalinity
- Disproved the Azoic Hypothesis and the idea of Bathybius
- First comprehensive survey of the bottom geology
- Developed many of the early prototypes for our modern instruments

D. Post World-War to the Present

- Early 1900's, development of Oceanographic Institutions
- Scripps Established in 1907, expanded during WW II
- 1925—the Meteor cruises (Germany) mapped much of the Atlantic using echo sounders, adapted from WWI submarine warfare
- 1968—launch of the Glomar Challenger, the first oceanographic drilling ship—proved the concept of plate tectonics

Development of deep-sea and space sensors

- 1934—William Beebe descended in a bathysphere off Bermuda to 923 m
- 1960—Jacques Piccard developed the Trieste, sold to the Navy
 - i. went to 10,915 m (!) in the Marianas Trench (the Challenger Deep)
 - ii. Modern Deep Submergence Vehicles (DSV):
 1. Alvin (Woods Hole) 4000 m
 2. SeaCliff II, 6,000 m
 3. Shinkei 6500, 6500 m
 -
 4. Tiburon (MBARI Remotely Operated Vehicle), 4,000 m

- Satellites: SeaSat A, the first oceanographic satellite, launched in 1978
- Nimbus 7/Coastal Zone Color Scanner, 1978-1986
- Today, there are many, many different satellites, but not many DSVs...we are moving towards AUVs, or Autonomous Underwater Vehicles

III. History of Photosynthesis

A. Geological

- All oxygen evolved from photosynthetic organisms
- First life, about 4.5 billion years ago, oxygenic photosynthesis ~2.5 billion
- Falkowski transparency

B. Evolutionary

- Lynn Margulis (1974) – endosymbiotic hypothesis
- Chloroplasts came from ancestral cyanobacteria (similar to mitochondria)
- Cyanobacteria got photosynthesis from:
 - PSII Purple Bacteria
 - PSI Green Sulfur bacteria
 - Eukaryotes also got mitochondria from alphaproteobacteria
- Further symbioses:
 - Coral use zooxanthallae
 - Some copepods “harvest” cyanobacteria
 - Some dinoflagellates engulf chloroplasts

C. Scientific History

- 1700s, Joseph Priestly put a candle under a jar, then a mouse, reported that the mouse could “injure” the air
- 1778, Jan Ingenhousz discovered that plants “heal” the air through sun and light
- 1796, Jean Senebier outlined the basic reaction as consumption of CO₂ to produce O₂ by green parts of plants
- 1817, 2 French chemists isolated chlorophyll
- 1845 Mayer, German physician, first to describe the reaction as a chemical transformation of energy (modern definition of photochemistry)
- 1937, Hill isolated chloroplasts, demonstrating that photosynthesis and respiration occur independently...Hill reaction allows one O₂ for every four equivalents of oxidant reduced photochemically (doesn't have to involve CO₂ at all)
- 1942, Calvin-Benson using ¹⁴CO₂, described the Calvin-Benson cycle and won the Nobel prize – byproduct of WWII production of radioactivity
- 1960's – progress in physical chemistry (how the reactions occur)
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1970's – progress in biochemistry (mechanisms)

- 1980's – progress in molecular biology (genes, gene products, etc)
- 1990's – rediscovery of the importance of photosynthesis in the environment