

## Lecture 10-Limiting Factors, and Redfield

### READINGS

- Smith and Smith 28-30; pp.54-56; Ch. 5, esp pp 81-83;
- Redfield, 1934:** "On The Proportions Of Organic Derivations In Sea Water. James Johnstone Memorial Volume, Liverpool University Press, Liverpool. 176-192

**Relevant information also in these articles, which were assigned for Lectures 4 and 5**

- Falkowski: 2002. The Ocean's Invisible Forest. Scientific American August 2002. p.38-45
- Chisholm, 1992 "What Limits Phytoplankton Growth?" Oceanus Magazine. 35:36-46

### Outline:

- I. Limiting factors
  - A. Freshwater
  - B. Oceans
- II. Redfield and the co-evolution of Chemistry and biology in seawater

### Redfield

Alfred Redfield was one of the leading oceanographers of our time, and many of his contributions laid the foundations for modern oceanography. He was a physiologist who viewed the oceans as one would a living organism, with the global ocean circulation being analogous to the human body's circulatory system. (The fact that the composition of blood and seawater is similar in many respects undoubtedly did not escape him). According to Redfield, the close relationship between the relative quantities of essential elements in seawater and living matter **"permits one to approach the biochemical cycle in the sea much the same way as the physiologist examines the metabolism of an individual organism."**

He further wrote, **"It appears that the relative quantities of nitrate and phosphate occurring in the oceans of the world are just those which are required for the composition of the animals and plants which live in the sea. That two compounds of such great importance in the synthesis of living matter are so exactly balanced in the marine environment, is a unique fact, and one which calls for some explanation, if it is not to be regarded as a mere coincidence."**

- (1) Do you think Redfield's image of the sea as having a "physiology" is simply metaphorical? Or do you see direct parallels between the workings of your body and the workings of the sea?
- (2) Redfield hypothesized that "there must be a biochemical circulation which is different from, though dependent upon, the physical circulation of the water." What evidence led to this hypothesis?
- (3) In formulating his hypothesis, Redfield engaged in an "armchair experiment" in which he took a liter of seawater from the deep ocean and returned it to the surface where it could be inoculated with phytoplankton and incubated in sunlight until the nutrients were exhausted, and equilibrate with the atmosphere. He then "returned" this liter of water to the deep ocean where degradative processes could go into operation.  
What questions did he ask of this "experiment", and how did the answers illuminate his theory?

### Limiting Factors

- (1) How would you design an experiment to determine which nutrient is limiting in a particular system?
- (2) What is the compensation depth in aquatic ecosystems? What is it a function of?
- (3) How does the depth of the thermocline affect productivity?

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