

Lesson 4_Dataset 3—Microbial Oceanography: Nutrients and Abundance_Teacher Key

Use nutrient data from the AMT transect and traits of laboratory phytoplankton (Table 2) to estimate the phytoplankton abundances across the AMT transect. You will look at three phytoplankton types: cyanobacterium *Prochlorococcus* (*Pro*), cyanobacterium *Synechococcus* (*Syn*), and the diatom *Thalassiosira* (*Thala*.)

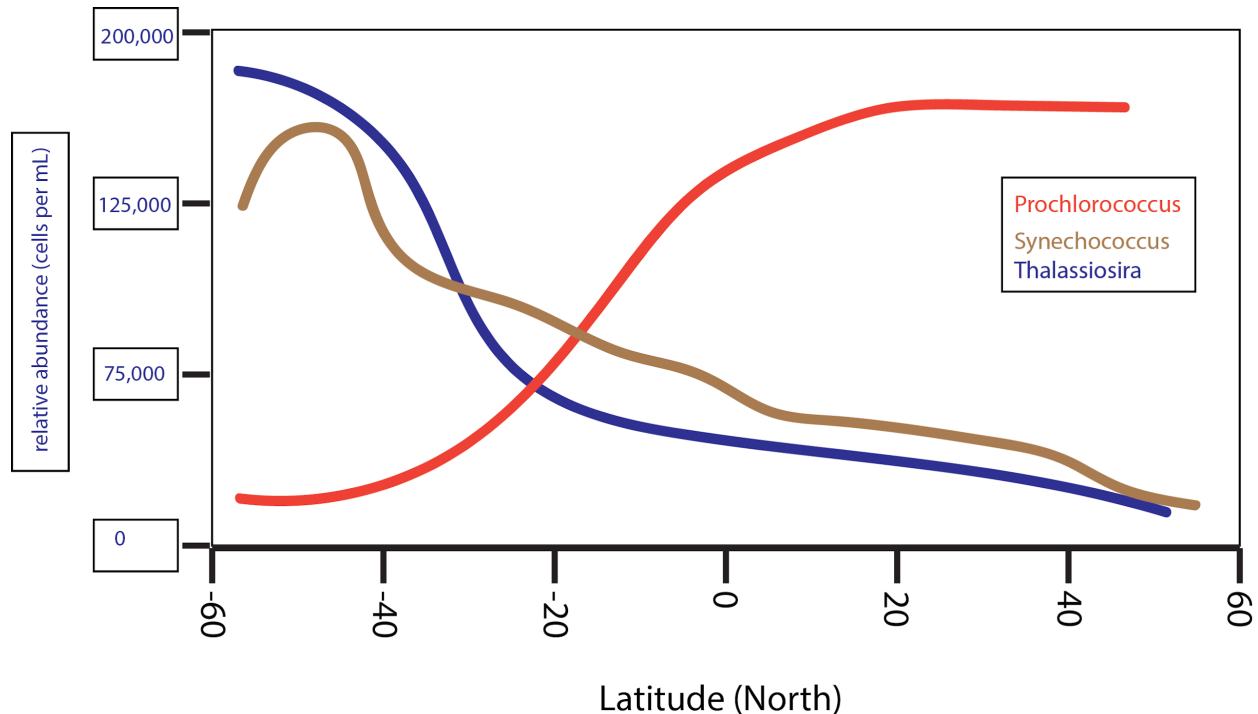
Instructions: Use the empty table to collect nutrient information from 6 points along the transect then plot latitude vs abundance for all three types of phytoplankton. Enter values and labels for y-axis in empty boxes. Hints: Study the table of nutrient requirements (Table 2) and AMT data, to identify the most useful nutrients. Not all will be useful. What does cell size tell you about the amount of nutrients a cell might require?

Table 1.		Nutrient concentrations		Abundance (cells per mL)			
Station #	Latitude	Amm-onium	Silicate_	<i>Syn.</i>	<i>Pro.</i>	<i>Thala.</i>	All
1	45	0.015	0.75	0	200,000	0	200,000
2	30	0.015	1.0	0	200,000	0	200,000
3	10	0.015	0.05	0	200,000	0	200,000
4	-10	0.015	1.25	0	200,000	0	200,000
5	-30	0.05	1.0	120,000	0	80,000	200,000
6	-40	0.075	2.5	100,000	0	100,000	200,000

- There is not a right answer to this table or graph. This can be difficult for students - especially trying to understand what levels of nutrients would correspond to what abundances. This is the same challenge faced by the researchers who made the Darwin model.
- I recommend setting a time-limit on this question - and guiding students to justify their choices rather than dwell on being correct or not. It's an estimate based on a limited dataset.
- One strategy is to start with Ammonium. If there is less than what is required for the organism, then it should get abundance of 0. Green values are filled in based on ammonium data. This should give a fairly full table.
- The next challenge is dealing with the Silicate data. Diatoms require silicate to make their frustules. But silicate doesn't necessarily inhibit the other phytoplankton.
- At Station 6, there is both high silicate and high ammonium. Because the diatoms are larger, they need more nutrients to survive. That nutrient requirement is also reflected in their nutrient concentrations. So Station 6 should have the highest concentrations of diatoms compared to all other stations.

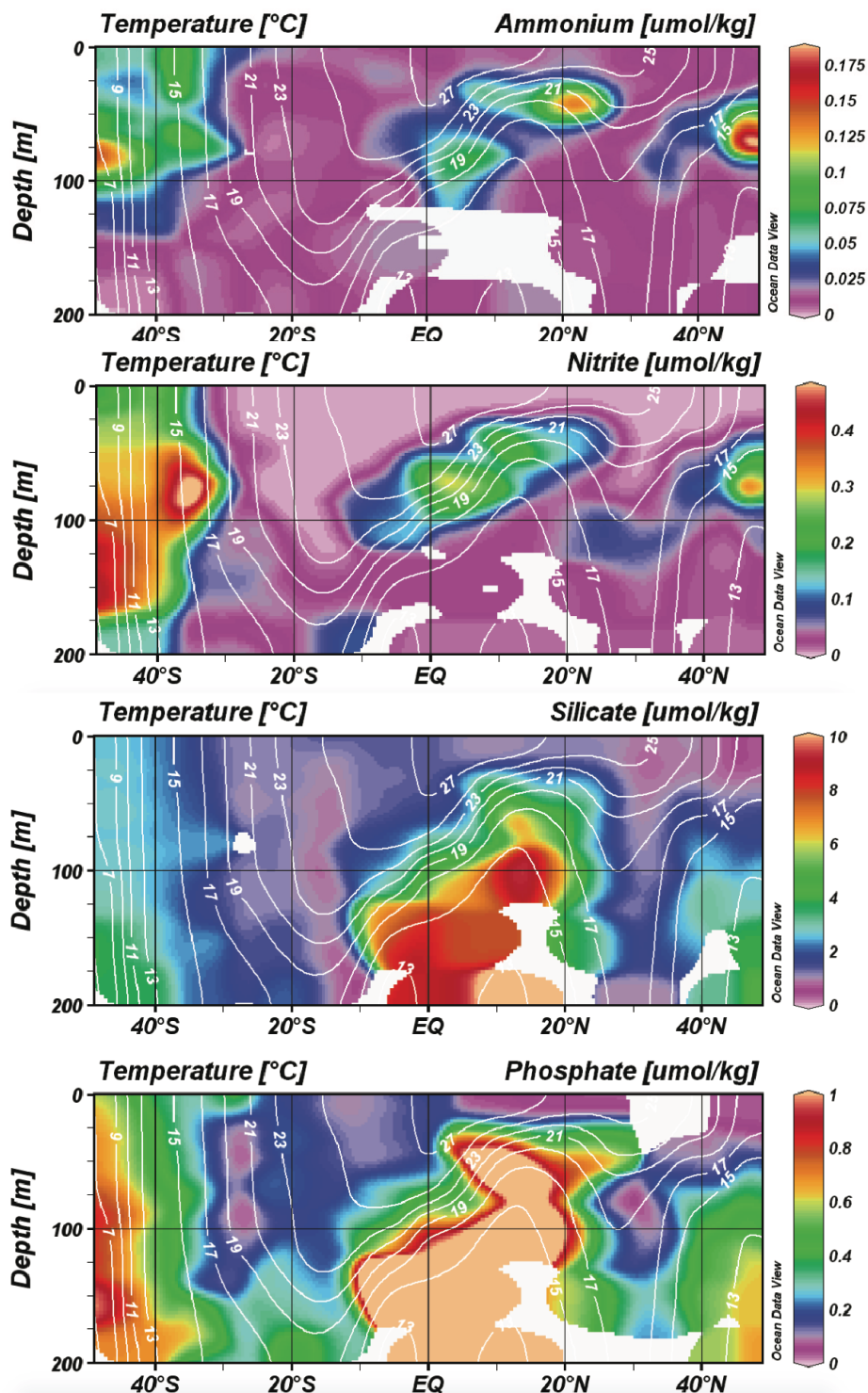
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- Synechococcus is intermediate in terms of nutrient requirements. It is bigger than Pro, so needs more ammonium than Pro, but is smaller than the diatom, and doesn't require silicate, so its highest abundance should be Station 5, which is intermediate in terms of nutrient concentrations.
- The main points:
 - Prochlorococcus dominant in low nutrient open ocean gyres in tropics and subtropics
 - Diatoms and Synechococcus dominant in high nutrient waters.
 - Northern hemisphere and Southern hemisphere are not identical.



AMT nutrient concentrations. Concentrations of several nutrients measured over the AMT transect from surface to deep. Temperature contour lines are shown in white. Use the empty table to select latitudes to determine nutrient concentrations. Hints: Which nutrients are most

useful based on what is known about phytoplankton nutrient requirements? While data from many depths is presented, **just use values from the surface (0 meters) for this exercise.**



Traits of phytoplankton from laboratory experiments. Nutrient requirements of three different types of phytoplankton that were determined in laboratory experiments with cultivated isolates of these organisms. Use this information to estimate what the relative abundances of

these organisms would be along the AMT transect. *Hint: Small cells have higher surface area to volume ratios than large cells. What does this mean for nutrient uptake and nutrient requirements?*

Table 2. Traits of laboratory phytoplankton			
Nutrient requirements	<i>Prochlorococcus</i> Cyanobacterium	<i>Synechococcus</i> Cyanobacterium	<i>Thalassiosira</i> diatom
Ammonium (NH ₄) (μmol/kg)	< 0.025	>0.05	> 0.05
Silicate (μmol/kg)	< 1	< 1	> 2
Cell Size (diameter in μm)	0.5	1	7

Discussion Questions (short answer)

- How did cell size contribute to your answer on the distribution of different phytoplankton types along the transect?
 - Size influences a cell's surface area to volume ratio. So cells with smaller volume and size, have more surface area relative to their nutrient requirements. Therefore, small cells can survive with lower concentrations of nutrients than large cells.
- What other phytoplankton characteristics or ocean characteristics would have been useful to know for this exercise?
 - Temperature preferences
 - Phosphorus requirements, since there was a graph of phosphorus
 - Locations of currents or eddies
 - Light availability
- What are the advantages and disadvantages of estimating global phytoplankton distributions from their nutrient requirements in the lab?
 - Disadvantages: a) Are the laboratory phytoplankton representative of phytoplankton found in the ocean? Could they be like lab rats? b) Using one type of cell from the lab to represent very diverse populations of cells from the wild c) Growth experiments are very simple and controlled, but in the wild there could be complicating factors. For example, could pH or light or temperature change the nitrogen requirements of a cell? d) Lab cultures do not account for interactions with other microorganisms that could change how nutrients are used (competition, cooperation, etc.) e) relies on good measurements of field nutrients in order to predict phytoplankton abundances.
 - Advantages: a) Using models allows high resolution mapping of phytoplankton distributions, b) researchers can test the sensitivity of the system to change. For

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example, test how phytoplankton distributions would change if nutrient concentrations increased or decreased. c) lab work can be less expensive than ship-based work

4. In what ways is your graph the same or different than the graph from dataset #1 and the Darwin Model?
 - There are a lot of cells in “low” latitudes where Dataset 1 shows very low chlorophyll
 - The resolution is lower than the Darwin Model - meaning not as many distinct features were revealed.
 - Similar to the Darwin model in that different types of phytoplankton occupy different regions of the ocean.
 - Both Dataset 1 and Dataset 3 have uncertainty. Phytoplankton abundances are estimates from environmental parameters.