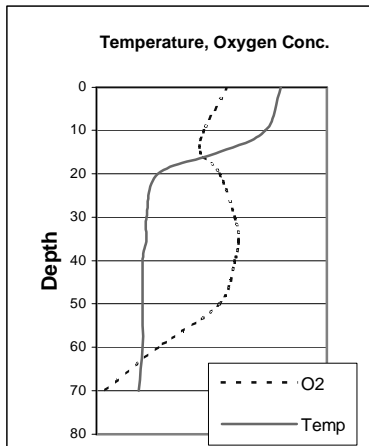


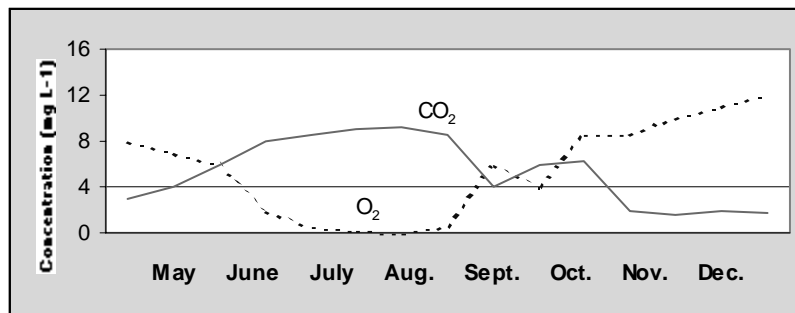
ANSWERS PROVIDED BELOW ARE GUIDELINES ONLY AND WERE PUT TOGETHER AT THE LAST MINUTE AT YOUR REQUEST (by MATT) ...

I (8 points). In a Massachusetts lake, vertical gradients in temperature levels and oxygen concentrations develop during the summer months. Describe the physical, chemical, and biological processes that result in this oxygen profile. In discussing the biological processes, be specific about the types of organisms involved.



- ✓ Temperature trace indicates a stably stratified water column where the surface mixed layer phytoplankton are likely nutrient limited (due to the fact that O₂ is less at surface than ~40m)
- ✓ Surface O₂ is high due to diffusion from atm
- ✓ Subsurface O₂ peaks due to no nutrient limitation of photosynthesis here
- ✓ Drop in O₂ at bottom of lake due to respiration by heterotrophic bacteria and decreasing light available for photosynthesis
- ✓ The dominating phytoplankton are likely to be cyanobacteria due to their higher SA:V ratio allowing them to compete better for the low nutrients available

II. (12 points). The diagram below shows the seasonal variation in oxygen and carbon dioxide in the hypolimnion (the area below the thermocline) of a lake in Massachusetts.



- a) Explain this pattern, discussing the seasonal cycles that occur in temperate lakes and describing the biological, chemical and physical factors that contribute to these cycles.

Imagine that in the surface mixed layer above this hypolimnion region there must be processes going on that influences what we are seeing here in the hypolimnion. I suggest that in May-June the phytoplankton are blooming (stable stratification of warming surface waters allows the mixed layer depth to be shallower than the compensation depth, so light is not limiting now and nutrients are high) and the raining phytoplankton biomass (orgC) into the deeper waters fuels heterotrophic respiration thus CO₂ increases. Then

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nutrients are used up throughout the summer and the bloom slows so CO₂ levels out and then falls off until the fall when the stratification starts to break down causing nutrients to be entrained from deeper waters into the mixed layer ... phytos bloom and rain down causing CO₂ to go up slightly (as in Spring but likely to a lesser degree) ... then bloom becomes light limited as water column breaks down and mixed layer depth becomes >> compensation depth.

- b) In the graph above, sketch how you would expect the concentration of phosphorus to change in the hypolimnion over this cycle.

I think that P in the hypolimnion would increase in the summer due to the raining of phytoplankton (input of C,N,P nutrient fluxes) ... but need to check that one out for certain ...

III. (24 points)

- a) One goal of ecologists is to measure net and gross primary productivity (NPP and GPP) of ecosystems, as well as net community production (NCP). Many techniques have been developed for assessing these values in aquatic and terrestrial ecosystems, each with its own drawbacks and limitations.

Do any of these techniques successfully measure GPP? If so, which ones? If not, why not?

No, ecosystems = heterotrophs and autotrophs, so measuring GPP without R_A or R_H is just not possible without assumptions and drawbacks. More details needed here to describe the plethora ways you could try to measure GPP with all the assumptions and drawbacks ...

- b) To measure productivity in a cornfield, a UROP student cuts, dries and weighs the plants at the end of the harvesting season. Is he or she measuring NPP, GPP, or NCP? Explain your answer.

$$NCP = GPP - R_A - R_H$$

The measurement is the result of productivity in combination with respiration of the autotroph and the heterotrophs in the system.

- c) When you enclose an aquatic ecosystem in a bottle, and measure the change in oxygen concentration in the bottle over 24 hours, are you measuring GPP, NPP, or NCP? Explain your answer.

$$NCP = GPP - R_A - R_H$$

(see above)

- d) A plant is placed in an airtight chamber with a known amount of ¹⁴CO₂. After 30 minutes the plant has assimilated 5 mg of ¹⁴CO₂. If the proportion of ¹⁴CO₂ : ¹²CO₂ in the chamber is 0.05, how much carbon does the plant assimilate in one hour?

¹⁴C:¹²C ratio = 1:20; so, plant assimilates
10mg ¹⁴CO₂/hour x 20¹²C/¹⁴C = **200 mg ¹²CO₂ / hour**

- e) After completing 1.018 and becoming an ecology expert you are asked to advise a commission that is looking into methods of reducing CO₂ in the atmosphere to mitigate global warming. One member of this commission suggests that the tropical rainforests

should be cut and replanted with young trees to increase the rate of carbon uptake in these ecosystems. Will this technique produce the desired result? Why or why not?

No, tropical rainforests are intricately webbed, complicated ecosystems where there is an intense amount of nutrient cycling. With clear-cutting and planting of young trees you would have only a thin layer of topsoil supporting their growth until this intensely recycling ecosystem was re-formed (years? Decades?) so the trees would likely die and nutrients would be lost as run-off / dust.

- f) For the purposes of measuring terrestrial productivity using satellites, ecologists look at the reflectance of the ecosystem in the wave bands between 600 and 700 nm (TM3) and between 800 and 900 nm (TM4). What characteristic of the ecosystem is TM3:TM4 related to and why? How is it related to net primary productivity?

TM = thematic mapper bands of the land-sat satellite (i.e. these wavelengths are meant to correlate to ecosystem function in some way or another)

TM3 = absorption of chlorophyll a

TM4 = emission of excess energy by chlorophyll a ?????

TM3/TM4 shows the red to infrared reflectance and is correlative to the amount of chlorophyll in a given area ... we know that TM4/TM3 is positively correlated to LAI and LAI is positively correlated with NPP, so TM4/TM3 likely correlates to NPP

IV. (12 points).

- a) In the hydrothermal vent ecosystems, what organisms are at the base of the food web? What do they use as their energy, carbon, and electron sources?

SRBs

Methanogenic bacteria

Sulfur oxidizing bacteria

Maybe more???

(see notes from homework for details of their energy, carbon, electron sources)

- b) A microbial mat ecosystem has been described hypersaline ponds in Baja California in which there are no photosynthetic bacteria (purple sulfur bacteria), but there is a layer of a bacterium called *Beggiatoa* in the place where one might expect to find photosynthetic bacteria. Why are photosynthetic bacteria absent? What is the energy and carbon source of *Beggiatoa* in this system?

Don't know that this one was covered in class this year ...

VI. (12 points)

- a) The ratios of C:N and C:P in decomposer microorganisms are shown in the table below, along with the composition of the materials they decompose. Given the same decomposer species and biomass, what do you expect the rates of relative decomposition to be in terrestrial and marine ecosystems. Why?

	C:N	C:P
Decomposers	10:1	100:1
Terrestrial Plant Material	200:1	3000:1
Marine Plankton	7:1	100:1

You are what you eat ... since decomposers look most like marine plankton I suggest that they have been primarily eating marine plankton so the relative decomposition rates should be significantly higher in marine systems

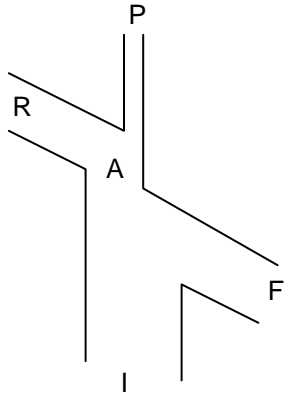
- b) It is the year 2200 and microbial life has been well established on Mars through various geo-engineering feats. There are lakes and oceans, and microbes dominate these ecosystems. Assuming that the evolutionary processes were similar to those when life on Earth evolved, what would you expect the concentrations of N to be in the surface ocean waters given the following:

- The concentration of P in the surface waters is $0.1 \mu\text{g l}^{-1}$
- The concentrations of N and P in the deep ocean waters is $1000 \mu\text{g l}^{-1}$ and $20 \mu\text{g l}^{-1}$ respectively.

Assume a Redfieldian scenario where the ratio of N:P in the deep ocean waters is reflective of what it should be in the surface waters ... then N:P is 50:1 so N in the surface waters should be $5 \mu\text{g l}^{-1}$.

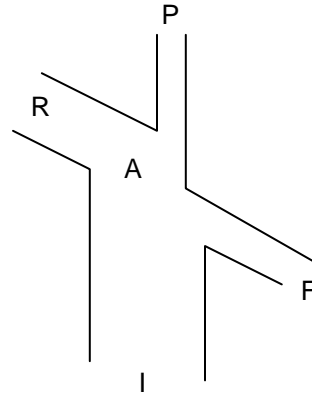
VII. (14 points).

- a) Below are the energy flow diagrams of two different organisms, showing the fraction of the ingested energy that is assimilated, lost as feces and urine, or respired. One is warm-blooded and one is cold blooded, and one is an herbivore and the other is a carnivore. Label which is which.



$A/I = 50\%$, $P/A = 2\%$

Herbivore
Cold blooded



$A/I = 80\%$, $P/A = 10\%$

**carnivore, warm-blooded (higher respiration
required to maintain body temp)**

- b) Assuming that the carnivore eats the herbivore, what is the Ecological Efficiency (Trophic Level Transfer Efficiency) of this simple ecosystem? Assume a consumption efficiency of 100 percent for the ecosystem.

Trophic level #1: Herbivore eats prim. prod. = $0.5 * 0.02 * 1 = 0.01$ ~1% efficiency

Trophic level #2: Carnivore eats herbivore = $0.8 * 0.1 * 1 = 0.08$ ~8% efficiency

Total ecosystem = $0.01 * 0.08 = 0.0008$ ~**0.08% ecological efficiency**

- c) What does the 100% consumption efficiency tell you about this ecosystem?

These organisms feed very efficiently (i.e. don't sloppily eat their food leaving behind lots of chunks and scraps of food) ... not real sure about this answer ...

- d) Sketch a simple energy flow diagram for a detritivore. How does the assimilation efficiency and production efficiency of this organism compare to those of a typical carnivore or herbivore? Explain

You know from your notes that detritivores have greater feces production, lower A/I (~20%) and higher P/A (~36%) ...

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VIII. (8 points). Below is a table of the annual fish catch from an area of the ocean that is fairly self-contained and has yielded this catch for over a decade. The local ecology class has measured the primary productivity of the area and found it to be 2×10^7 t carbon for the entire basin. Do you think their estimate is correct? Why or why not?

Explain your answer in detail.

Fish Species	Trophic Level Occupied	Amount Harvested Annually (tons carbon x 10 ³)
Cod	3	100
Flounder	2	50
Catfish	2	30
Bluefish	4	10

Equation from your notes:

$$PPR = (\text{catch}/9) * 10^{(TL-1)}$$

$$PPR_{\text{cod}} = 100,000/9 * 10^2 = 1.11 * 10^6 \text{ t C}$$

$$PPR_{\text{flounder}} = 5.56 * 10^4$$

$$PPR_{\text{catfish}} = 3.33 * 10^4$$

$$PPR_{\text{bluefish}} = 1.11 * 10^6$$

TOTAL = 2.22 * 10⁶ t C required to support these fisheries ... so their estimate is incorrect

IX (10 points). True or False

F_____ Select types of bacteria can utilize energy from the **reduction** of nitrogen compounds to reduce CO₂ to organic carbon.

T_____ Cyanobacteria use light energy to reduce CO₂ to organic carbon, using H₂O as an electron donor.

T_____ In the process of aerobic respiration O₂ is converted to CO₂. (perhaps this is FALSE though as actually organic C is converted to CO₂, O₂ just acts as a terminal electron receptor)

F_____ Autotrophs require **light** for energy to reduce CO₂ to organic carbon.

T_____ The Calvin-Benson cycle occurs in the metabolic processes of chemosynthetic bacteria.

T_____ Anaerobically respiring bacteria oxidize organic carbon and reduce SO₄, NO₃ etc.