

Science Olympiad Water Quality Exam (CLASS SET) MIT Invitational



Exam by Krish Shah and Katie Wilson

Directions:

- **This test is a class set.** DO NOT write anything in this packet or the image sheet!! Do all writing on the answer sheet or on ungraded scrap paper.
- You will have 50 minutes to complete this exam. Do not open any packet until time begins.
- Feel free to separate this test, the answer sheet, and image packet. At the end of time, I'll give you a few minutes to put everything back together and staple it back together.
- Each multiple choice question has exactly one answer unless stated otherwise.
- This test is long, so you probably won't finish it. It may be beneficial to skip questions you don't know to see as much of the test as possible. Also, partial credit is awarded! If you don't know, you should guess.
- In this test, "type of organism" is used to refer to the group a specimen is in as per the rules (i.e. species, class, phylum, family, etc.). For example, it might be a family (as in mosquitoes), a species (as in zebra mussels), or another group from the rules (as in flatworms).
- For all math questions, please round to **2 decimal places** and **show all work** (lone answers can only receive partial credit).
- Ties will be broken based on scores on the following questions (in this order): 51, 38, 58, 29, 56.

Points by Section:

| Section | Points |
|-------------------------|--------|
| Warm Up! | 30 |
| Graph Theory | 54 |
| Water Doctor | 77 |
| River Walk | 76 |
| Bug Catching | 56 |
| Daily Dips!! | 53 |
| Winooski Watershed Woes | 68 |
| The Salty Dog Rag | 46 |
| Total | 460 |

DO NOT WRITE ON THIS TEST

Section 1: Warm Up!

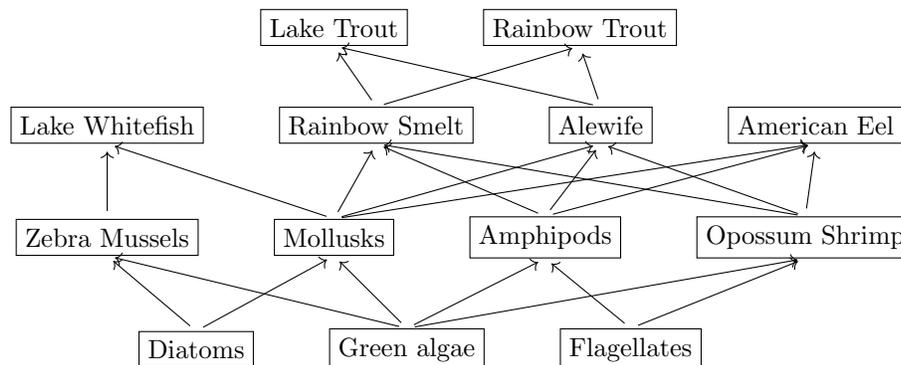
- (2 points) What is the chemical formula for water?
 - P_2O_5
 - CO_2
 - CH_4
 - H_2O
 - PO_4^-
- (2 points) What property of water gives it its high specific heat, high surface tension, and other important properties for life?
 - Hydrogen bonding
 - Ionic bonding
 - Covalent bonding
 - Peptide bonding
 - Van Der Waal's
- (2 points) Nonpolar liquids in a capillary tube form a _____ meniscus and polar liquids like water form a _____ meniscus.
 - Convex, Concave
 - Convex, Convex
 - Concave, Convex
 - Concave, Concave
- (2 points) In the water cycle, when snow/ice turns directly into water vapor, it is called what?
 - Evaporation
 - Condensation
 - Sublimation
 - Precipitation
 - Transpiration
- (2 points) During denitrification in the nitrogen cycle, what conversion occurs?
 - $\text{N}_2 \rightarrow \text{NO}_3^-$
 - $\text{N}_2 \rightarrow \text{NH}_3$
 - $\text{NH}_4^+ \rightarrow \text{NO}_2^-$
 - $\text{R-NH}_2 \rightarrow \text{NH}_3$
 - $\text{NO}_3^- \rightarrow \text{N}_2$
- (2 points) Sediment pollution increases the sediment load of the river, pushing it out of equilibrium and causing all of the following EXCEPT:
 - Shallowing
 - Widening
 - Braiding
 - Increasing sinuosity
 - All of the above could occur

7. (2 points) Which type of functional feeding group could work to counteract the impacts of eutrophication?
- A. Scrapers
 - B. Shredders
 - C. Collectors
 - D. Predators
 - E. Filterers
8. (2 points) In groundwater, where is the water table?
- A. Above the zone of aeration
 - B. In the zone of aeration
 - C. Between the zones of aeration and saturation
 - D. In the zone of saturation
 - E. Below the zone of saturation
9. (2 points) Which of the following concepts in modern biology was created through Traditional Ecological Knowledge (TEK) philosophy?
- A. Biomes
 - B. Symbiotic relationships
 - C. Succession
 - D. Survivorship curves
 - E. Productivity
10. (2 points) A stream runs near a chemical factory, and thus is polluted with PFAS. Which of the following organisms would contain the highest concentrations of PFAS?
- A. Algae
 - B. Zooplankton
 - C. Benthic macroinvertebrates
 - D. Small herbivorous fish
 - E. Large predaceous fish
11. (2 points) Gravimetric analysis can be used to measure which of the following:
- I. Total Solids
 - II. Salinity
 - III. Turbidity
- A. I only
 - B. II only
 - C. I and II only
 - D. I and III only
 - E. I, II, and III

12. (2 points) Which of the following metrics would be most useful for locating groundwater discharge into a stream?
- A. Nitrates
 - B. Temperature
 - C. Turbidity
 - D. Total solids
 - E. Dissolved oxygen
13. (2 points) What do Nephelometric Turbidity Units (NTU) quantify?
- A. Transmittance of a sample
 - B. Light scattered at right angles from the sample
 - C. Secchi depth in a body of water
 - D. Mass of suspended solids
 - E. Ability to read text through the sample
14. (2 points) As salinity increases, dissolved oxygen:
- A. Increases
 - B. Decreases
 - C. No relationship
15. (2 points) Well water throughout New England has a high concentration of which of the following contaminants?
- A. PFAS
 - B. Disinfectant byproducts
 - C. Arsenic
 - D. Nitrate
 - E. Pesticide metabolites

Section 2: Graph Theory

Consider the following simplified (and slightly modified) food web from Lake Ontario (source: NOAA). Yes, zebra mussels are mollusks, but this food web uses mollusks to refer to native species.



16. (a) (1 point) Which of the following are primary producers in this ecosystem? (select all that apply)
 A. Alewife B. Diatoms C. Green algae D. Mollusks E. Lake Trout
- (b) (1 point) Which of the following are primary consumers in this ecosystem? (select all that apply)
 A. Amphipods B. Flagellates C. Rainbow Smelt D. Rainbow Trout E. Zebra mussels
- (c) (1 point) Which of the following are tertiary consumers in this ecosystem? (select all that apply)
 A. American Eel B. Diatoms C. Lake Whitefish D. Mollusks E. Rainbow Trout
17. (a) (1 point) The so-called 10% rule states that only about 10% of energy is transferred between layers in a food web. Given this, draw a pyramid of energy with producers at the bottom and consumers on top.
- (b) (2 points) When, instead of measuring energy, you measure biomass, the shape of the pyramid can become inverted. Sketch the general form of an inverted pyramid, and explain how this is possible given the high loss of energy between each step.
- (c) (1 point) Given that the green algae have about 1000 kJ of energy, about how much energy of this original amount would be lost by the time a Lake Whitefish eats a zebra mussel? Assume the 10% rule holds.
18. Predict the (short term) effects on the population of the rainbow smelt for each of the following ecosystem changes.
- (a) (1 point) An increase in lake trout population.
 A. Decrease B. Increase
- (b) (1 point) An increase in mollusk population.
 A. Decrease B. Increase
- (c) (1 point) An increase in diatom population.
 A. Decrease B. Increase
- (d) (1 point) An increase in phosphates in the water. As a reminder, this is in the short term.
 A. Decrease B. Increase
19. (a) (1 point) What type of competition occurs between zebra mussels and opossum shrimp? (select all that apply)
 A. Apparent B. Exploitative C. Interference D. Interspecific E. Intraspecific
- (b) (1 point) What type of competition occurs between alewife and rainbow smelt? (select all that apply)
 A. Apparent B. Exploitative C. Interference D. Interspecific E. Intraspecific

20. Sea lampreys can also be found in Lake Ontario, and this question deals with their ecology.
- (a) (2 points) Adult lampreys are hematophagous (feeding on blood) and latches onto a variety of native fish, sucking their blood while being attached for a while and then releasing their victim, which usually dies somewhat soon after. What ecological interaction is this most emblematic of, and is this relationship obligate or facultative?
 - (b) (2 points) This species is anadromous. What does this mean?
 - (c) (2 points) How do anadromous species influence nutrient levels in lakes and oceans?
21. Another important part of the ecosystem not included in this simplified food web are so-called blue-green algae.
- (a) (1 point) Blue-green algae are not actually in the same clade as most other algae, and the term is being depreciated because of its misleading nature. What is the more accurate, commonly used modern name for blue-green algae?
 - (b) (2 points) These organisms have a special advantage of using phycobilins in a certain cellular process that confers them a competitive advantage in their ecosystem. What process do phycobilins most directly impact, and how does it give these species an advantage?
22. (3 points) Some species, often types of zooplankton, migrate to the higher layers of water during the night to feed and then migrate back to lower layers of water during the day. What is this called, and how does this relate to the carbon cycle?
23. (a) (1 point) A prevalent idea today is the idea that no two species with overlapping niches can coexist. What law states this?
- (b) (2 points) What is the term for the observation that similar species diverge more in phenotype in areas where they overlap in?
24. (2 points) In one sentence or less, how do ontogenetic niche shifts affect intraspecific competition?
25. Assume that green algae experience ideal, (continuous) unbounded population growth and grow at a rate of 2.3% per year for this question.
- (a) (2 points) After 2 years, with an initial population of $3.13 \cdot 10^{10}$ organisms, what will the population of green algae be?
 - (b) (2 points) How long is the doubling time for this species (to the nearest year)?
 - (c) (3 points) For this part, imagine that this species instead grew discretely each day by 47.5%. Now, what would be the doubling time to the nearest hundredth of a day?
 - (d) (2 points) Given a carrying capacity of 10^{11} individuals, what would the instantaneous growth rate be at the initial condition of $3.13 \cdot 10^{10}$ individuals? Assume that the value of r is still 2.3%.
 - (e) (1 point) At what population is the population growth rate the highest? Answer in terms of n_0 (the initial population), r , K and any other constants you may need.
 - (f) (2 points) At what population is the per capita population growth rate maximized? Again, answer in terms of n_0 (the initial population), r , K and any other constants you may need.
 - (g) (4 points) Sketch a curve representing the idealized growth of the algal population for unbounded continuous growth and continuous growth with a carrying capacity given n_0 .
 - (h) (3 points) Instead of analyzing the green algae, let's imagine that we are instead looking at one of the land plants from the rules. Instead of being eaten fully, the roots persist, so the growth after grazing is faster than normal. Sketch two curves of biomass vs time for this species starting from a low starting biomass m_0 with one starting from seeds and the other starting from roots. Assume seed growth takes 40 months to reach carrying capacity and root regrowth takes 20 months.
 - (i) (5 points) Now, imagine that a novel virus has been introduced which kills all aboveground parts of plants very quickly when the total biomass reaches the maximum capacity. If the time taken to regrow aboveground is 20 months, sketch a curve of the biomass given m_0 and the assumption that the biomass of plants is evenly split between above and belowground at maximum capacity.

Section 3: Water Doctor

On his path to becoming a doctor in philosophy, your friend Yeming accidentally finds himself graduating as a doctor in water! Now, he unexpectedly finds himself with a first patient: the aging water treatment infrastructure of Boston! Help him navigate the complexities of water treatment and learn so that he can diagnose problems troubles with water treatment systems.

26. (a) (1 point) In one sentence or less, explain what the difference between a combined and separate sewer system?
- (b) (1 point) Which of the two methods in part (a) is more common in current US communities?
A. Combined B. Separate
- (c) Yeming lives in Pittsburgh, a famously rainy city.
- i. (1 point) Which of these systems is more likely to struggle under heavy rainfall?
A. Combined B. Separate
- ii. (1 point) What is the term for the issue that arises under heavy rainfall when the capacity of the treatment plant(s) are exceeded in this type of sewer system?
- iii. (1 point) What is one negative effect of the event in ii?
27. Yeming is looking to cut costs by removing steps in water treatment. Help convince him that these steps are important.
- (a) (1 point) In wastewater treatment, what does the acronym FOG stand for?
- (b) (3 points) What structure is used most commonly for flow equalization, and what are two benefits of flow equalization?
- (c) (1 point) What type of sewer system most benefits from flow equalization?
A. Combined B. Separate
- (d) (3 points) When does grit removal occur in sewage treatment, and what are two potential effects of skipping this step in treatment?
- (e) (2 points) In a sentence or less, what property of activated charcoal gives it its pollution reducing properties, and how does this help extract pollutants?
- (f) (1 point) Which of the following steps of sewage treatment requires the most energy?
A. Aeration B. Digestion C. Flow equalization D. Sedimentation
28. Course and fine bubble diffusers are both used to aerate tanks for secondary treatment.
- (a) (2 points) Which one is more efficient, and which one is more commonly used in new developments?
- (b) (2 points) Yeming suggests adding fine bubble diffusers to a new tank, which he proposes adding for the purpose of enhanced biological phosphate removal. Would this be a good idea, and why?
- (c) (2 points) He then suggests adding course bubble diffusers to the tank containing the denitrifying bacteria. Would this be a good idea, and why?
- (d) Now, he wants help designing another tank with bubble diffusers.
- i. (3 points) If he wanted to use bubble diffusers for a grit chamber, which type (if either) should he choose, and why?
- ii. (3 points) Now, Yeming wants to design two tanks – one for an aerobic digestion tank (tank #1) and one for a custom tank that should only be aerated on one half of the water column (the bottom on the diagram) (tank #2). Given four disc type fine bubble diffusers for each tank, mark where the four diffusers should be located on each diagram to maximize aeration.
- iii. (2 points) Without any modification, could the top of tank #2 be used for mesophilic anaerobic digestion? Thermophilic anaerobic digestion? Why?
- iv. (2 points) Yeming wants to use tank #2 as a purely aerobic tank. Without moving the fine bubble diffusers, what is the simplest way for him to do so?

29. Yeming now wants to learn how to disinfect water. (TB #4)
- (a) (1 point) What is the purpose of disinfection in water treatment?
 - (b) (1 point) What water quality measure from the rules best indicates whether disinfection was successful?
 - (c) (1 point) When does disinfection occur in the wastewater treatment process?
A. Start B. After primary treatment C. After secondary treatment D. End
 - (d) (1 point) Which of the following is the most cost-effective method of disinfection?
A. Chlorination B. Iodination C. Ozone D. UV radiation
 - (e) Yeming suggests a few processes for wastewater disinfection for Boston. Assess whether each one would be safe and effective, and if not, explain why.
 - i. (2 points) Chlorination before secondary treatment.
 - ii. (2 points) Chlorination as the last step in treatment.
 - iii. (2 points) Ozone addition as the last step in treatment.
 - iv. (2 points) Ozone addition in a stainless steel tank.
 - v. (2 points) UV radiation treatment on very soft water.
 - vi. (2 points) UV radiation treatment before preliminary treatment.
 - vii. (2 points) Use of a membrane bioreactor before preliminary treatment.
 - viii. (2 points) Treatment of water with phages
30. There are more types of wastewater than just sewage.
- (a) (2 points) What is greywater, and how is it different from black water?
 - (b) (2 points) When would the use of a decentralized wastewater system be desirable? What is one advantage of this type of wastewater system?
31. The jar test is often used to test the effectiveness of coagulants. Help Yeming conduct a jar test and interpret its results.
- (a) (2 points) If Yeming collected his samples by going to the treatment plant and filling a jar from the water near the top of the tank, would the results of the test still be accurate? Why?
 - (b) (2 points) If Yeming used a gang stirrer to mix in coagulants to each sample, would the results of the test still be accurate? Why?
 - (c) (2 points) Reference table 1 for this part. What concentration of coagulant should he use for potable water treatment assuming all samples had the same initial conditions and the jar test was conducted successfully?
 - (d) (1 point) What is the most likely coagulant used in the test?
 - (e) (1 point) What two steps come after coagulation in potable water treatment, in order?
32. (a) (2 points) What is the primary similarity and difference between the anammox process and denitrification?
- (b) (2 points) Both the SHARON and InNitri processes aim to treat water rich in what form of nitrogen?
33. Yeming finds a mass similar to Image 2 in the sewers.
- (a) (1 point) What organism from the rules is in Image 2?
 - (b) (1 point) What type of hermaphrodite is this organism?
 - (c) (2 points) What molecule makes this organism red, and how does this affect the habitats it can inhabit?
 - (d) (2 points) Estimate the water quality index of the water where Yeming found this mass with the assumption that this organism is the only living thing in the water.
 - (e) (3 points) Would this organism survive if the channel the mass was in had significant water flow only once every week? Why?

Section 4: River Walk

Your friend, fellow ecologist Bill, spots a plant on the shore that's about his height with a reddish stem while walking along a river. Excited, he calls you and asks what he just saw. Unfortunately, he's still learning about correct methodology, and you might have to help him fix any issues with his tests.

34. (2 points) Which organism did he most likely see (this is image 3 on the image sheet)?
35. (a) (2 points) Bill claims that this type of organism is an invasive species. Is he correct? In one sentence or less, what are the defining characteristic(s) of an invasive species?
- (b) (2 points) Bill also says that this type of organism is an important indicator species. Is he correct? In one sentence or less, what are the defining characteristic(s) of an indicator species?
- (c) (1 point) What part of the invasion curve would this organism be a part of?
Note: this question refers to the typical invasion curve with 4 steps.
- (d) (2 points) The invasion paradox is the idea that there is conflicting evidence both for invasive species being harmful and helpful. Most people focus on the negative effects of invasive species, but even Wikipedia claims that people are too harsh on some species, so what is one positive environmental effect of this type of organism?
- (e) (2 points) What genus of beetles is most commonly used to control this type of organism?
36. (a) (3 points) Bill suggests using mechanical pest management to limit the spread of this type of organism. What is mechanical pest management, and how effective would it be in controlling the spread of this organism? Why?
- (b) (2 points) Bill suggests using 2,4-Dichlorophenoxyacetic acid (2,4-D) with triclopyr to kill specimens of this type of organism, both of which mimic an important phytohormone. Which phytohormone do they mimic, and would this work in killing individual plant specimens of this organism?
- (c) (4 points) Biological control methods can take many forms, but three common methods are importation, augmentation, and conservation. In one sentence or less per method, what are each of these methods, and which one is currently employed most prominently in the United States to control this type of organism?
37. (3 points) According to Wikipedia, this type of organism can produce a maximum of $2.7 \cdot 10^6$ seeds per year. Assuming that there is an initial population of 1439 individuals, each organism produces 1% of the maximum number of seeds, and 0.7% of seeds germinate, how many individuals will there be after 3 years immediately after reproduction occurs? Assume that all plants that germinate survive, and 15% of plants (including newly germinated seeds) die between breeding cycles. However, since you are measuring right after the reproduction event, this 15% die-off between cycles has not occurred for the third year.
38. **(TB #2)**
- (a) (2 points) Based on the previous question, what type of survivorship curve does this type of organism display, and would it best be classified as r or K-selected?
- Now, Bill wants to create a life table to help him understand more about this organism's life cycle. Assume the x axis of all graphs is long enough that all individuals in a cohort are dead by time t .
- (b) (2 points) On the provided graph, sketch a curve for the percentage of the initial cohort alive at a given age.
- (c) (2 points) Sketch a curve of the age specific risk of death, or the probability of dying at a given age.
- (d) (4 points) Sketch a curve of the life expectancy at each age.
- (e) (2 points) If the death rate for this type of organism was constant, sketch a curve for the percentage of the initial cohort alive at a given age. *Be aware of the axis labels!*
- (f) (1 point) Sketch a curve of the age specific risk of death given a constant death rate.
- (g) (3 points) Sketch a curve for the life expectancy at each age assuming a constant death rate.

39. Bill wants to try measure the total population of this type of organism in this section of the river. Assume all parts are on different parts of the river (i.e. the population sizes in each part need not be close to each other).
- (2 points) Bill walks around and counts every single individual, counting 7543 total. Explain which direction this estimate is likely biased towards (is it an under/overestimate or neither), or describe where Bill's approach failed.
 - (3 points) On the same day as in question 34, he labeled 25 specimens of the same type of organism with a special tag. Then, two weeks later, he comes back to the same area, and only sees 23 tagged individuals. Use the Lincoln–Petersen estimator to estimate the size of this population of the type of organism and justify the use of this method, or explain why this estimator might not work in this case and provide a possible explanation for how the number of marked specimens decreased.
Hint: if you know about mark and recapture, you've probably used the Lincoln–Petersen estimator.
 - (3 points) Bill then tries splitting a rectangle into which the sample region is inscribed into 30 equal sized squares, determining that the number of specimens in one of the squares is 73 by counting each individual. Estimate the total population and justify the use of this method, or explain why this might not work in this case.
40. (a) (2 points) He sends you another image (image 4 on the image sheet) from a nearby lake, and asks you to identify that one too. What organism from the rules is this specimen?
- (1 point) A lake such as this one is best described as which of the following?
A. Lentic B. Lotic
 - (2 points) How does the uncontrolled growth of this type of organism affect atmospheric mixture of oxygen with lake water?
 - (3 points) Which of the following lake regions would this type of organism be expected to be found in? (select all that apply)
A. Benthic B. Limnetic C. Littoral D. Profundal
 - (2 points) When is the pH of lake water highest throughout the day? What nutrient cycle is this daily shift most closely related to?
 - (1 point) Vertically in a lake, where would the pH be expected to be the lowest?
 - (3 points) How does alum addition to lakes affect pH, nitrogen concentration, and phosphorus concentration?
41. (a) (2 points) This type of organism uses vegetative reproduction very frequently. Is this an example of sexual or asexual reproduction, and why is this ecologically important?
- (2 points) Stolons, which this type of organism uses to reproduce, are a modified form of what basic plant structure?
A. Flowers B. Leaves C. Stems D. Roots
 - (2 points) What is phytoextraction, and why is this type of organism a good candidate for it?
42. (a) (3 points) Bill believes that the best way to control the type of organism from image 4 is through chemical control with herbicides like glyphosate. What is one advantage and disadvantage of using chemical herbicides to control this type of organism, and would this be a good idea if there was a large accumulation of this type of organism?
- (2 points) The lake where Bill found these in is covered in this type of organism, so would using mechanical control methods be practical in this situation? Why?
 - (2 points) The government of Queensland recommends that specimens of this type of organism be burnt rather than be left near the river. Why is this the case?
43. (2 points) Bill, in a superhuman feat, manages to manually pull out every single specimen of this type of organism in the lake by himself and burns all of them, declaring that he has saved the lake. What are two reasons that there is still a good chance that this type of organism reappears in this area in the near future?

Section 5: Bug Catching

Carolina, after a long day searching her code for bugs, gives up and goes to search the wilderness for real bugs. She sends you images 5 to 18 from her journey. **Answer with the image number(s) instead of the name of the type of organism unless explicitly stated otherwise.**

44. (a) (1 point) Which of these specimens have no significant freshwater portion in their life cycle?
(b) (1 point) Which of these specimens are not invertebrates?
(c) (2 points) What is the common name of the type of organism shown in Image 6?
(d) (3 points) Which of these specimens are pollution sensitive (class 1)?
(e) (2 points) Which of these images show larval forms?
(f) (4 points) Identify and list all images that depict the same type of organism along with the type of organism in the image. (ex: A, B - fish)
(g) (2 points) What is the common name of the type of organism shown in Image 7?
(h) (3 points) Which of these images show invasive species in North America?
(i) (2 points) Which of these specimens are air breathing?
(j) (1 point) What is the common name of the type of organism shown in Image 14?
(k) (2 points) What is the common name of the type of organism shown in Image 11?
45. The EPT index is used to measure water quality, often calculated as the number of EPT taxa.
(a) (1 point) A high EPT index indicates what about the water quality?
(b) (3 points) Which images show types of organisms that would be included as EPT taxa?
(c) (2 points) Assuming Carolina saw this all on one day at the same place and that every species present at that place is captured in exactly one image, what is the EPT index?
(d) (1 point) What does this say about the water quality of the place where Carolina took the pictures?
46. It's very likely that all of these pictures did not come from only one day or one place.
(a) (2 points) How long do adults of the type of organism in Image 5 live for? How does this affect when the image could have been taken given that this image is of a specific species of this type of organism?
(b) (2 points) What does it mean for a type of organism to be univoltine?
47. (a) (2 points) What is the common name of the type of organism in Image 13?
(b) (1 point) What chemical element does this type of organism need to construct its shells?
(c) (2 points) How does the increasing global carbon dioxide level threaten this type of organism?
(d) (1 point) What are the larvae of this type of organism called?
(e) (2 points) What other specimens also have larvae referred to with the same name?
(f) (1 point) How do large populations of this type of organism affect ecosystem turbidity?
48. (a) (1 point) How are juveniles of the same type of organism as in image 17 different from adults?
(b) (3 points) What is the primary difference between amplexus and broadcast spawning, and which one does the type of organism in image 17 use?
(c) (2 points) In the river continuum concept, what functional group would this type of organism be most commonly classified as?
(d) (3 points) In the river continuum concept, which specimens would be classified as predators?
49. (a) (1 point) Which specimen is known to "jump" out of the water and injure humans?
(b) (2 points) This jumping behavior is unique to the North American population of this type of organism. Assuming this behavior is genetic, what effect is this an example of?
(c) (1 point) What does this type of organism eat?

Section 6: Daily Dips!!

This past summer, I successfully completed a perfect summer of swimming in a natural body of water every day (aka Daily Dipping)!! At the same time, I was taking an environmental chemistry class where my lab project compared the water quality of each of the swimming holes I swam in. Let's dive into some of the data I collected, and determine the health of my favorite places to swim in New Hampshire.

50. Kendal Docks are located just downstream of the Dartmouth Outing Club farm. These docks float on the Connecticut River, a major river in New England. It is the site where the Upper Valley Rowing Club launches their boats, and has a rope swing on the Vermont side!
- (4 points) What type of phosphates would be measurable at Kendal from runoff at the DOC farm? What about from treatments to the boats used by the rowing club? Draw the structure of each type of phosphate you name.
 - (3 points) When you daily dip, you have to swim in the rain some days. On rainy days, I observed that I couldn't see my legs in the water when I sat on the dock. What water quality metric was I observing? Why does this metric change on rainy days?
 - On rainy days, the water temperature was also noticeably colder.
 - (1 point) What is the short term impact of a rainy day on the river's dissolved oxygen?
 - Higher
 - Lower
 - (1 point) On total solids?
 - Higher
 - Lower
 - (1 point) On phosphate concentration?
 - Higher
 - Lower
 - (1 point) What are the long term impacts of prolonged rain on dissolved oxygen levels?
 - Higher
 - Lower
 - (1 point) On biochemical oxygen demand?
 - Higher
 - Lower
 - (3 points) Why does dissolved oxygen have this relationship with temperature?
 - (2 points) On one day that I swam here, I measured the temperature to be 25 degrees and the dissolved oxygen to be 7.3 mg/L. What is the percent saturation? *Note: a saturation monogram is provided on your answer sheet.*
51. Storrs Pond is a family recreation area where summer camps are held, family picnics, etc. It is a relatively small man-made body of water with no affluent or effluent streams. **(TB #1)**
- (4 points) Antimony, ammonium molybdate, and ascorbic acid are the 3 most important reactants in the reaction conducted to photometrically measure phosphate concentration. What is the purpose of each of these reactants?
 - (3 points) After conducting the assay, I measured an absorbance of 0.0324. Using the calibration curve provided on the image sheet (Image 19), find the concentration of orthophosphate in Storrs Pond.
 - (8 points) Along with phosphate concentration, I also conducted turbidity and chlorophyll assays. I measured a Secchi depth of 2 meters, and a chlorophyll concentration of 9.35 $\mu\text{g/L}$. Calculate the Carlson Trophic State Index of Storrs Pond. *Hint: remember to put phosphate concentration into the same units as chlorophyll!*

- (d) (1 point) Based on this TSI, what is the trophic classification of Storrs Pond?
- A. Oligotrophic
 - B. Mesotrophic
 - C. Eutrophic
 - D. Hypertrophic
- (e) (2 points) This was the highest phosphate concentration we measured of any swimming area, even compared to values of the river right along the DOC farm. What about Storrs Pond makes it prone to elevated phosphate concentrations?
- (f) (2 points) Given that this was the highest phosphate concentration I measured in my samples, provide one way my procedure could have been improved.
52. True's Ledges are a series of small waterfalls that are fun to scramble up, and is located in the middle of the New Hampshire Upland forest. The water is Blood's Brook, a tributary of the Connecticut River.
- (a) (2 points) This location had the highest BOD of any location that we measured. What about True's makes it prone to having a high BOD?
- (b) (3 points) You take a sample to find biochemical oxygen demand. On day 1, the DO is 12.3 mg/L. On day 3, it's 10.7 mg/L. Finally, on day 5, it's 5.7 mg/L. What is the biochemical oxygen demand?
- (c) (1 point) What about this location gave it a relatively high dissolved oxygen concentration?
- (d) (1 point) If I were to measure the chemical oxygen demand, would it be higher or lower than your calculated BOD value?
- A. Higher
 - B. Lower
- (e) (5 points) Figure 20 shows all of the tributaries to Blood's Brook. The star marks where True's Ledges are. What is the stream order at True's? (Use Strahler's)
- (f) Where Blood's meets the Connecticut, the Connecticut River has an order of 8.
- i. (1 point) True or false: The order of the Connecticut is the same above and below where Blood's Brook flows in.
 - A. True
 - B. False
 - ii. (1 point) True or false: Blood's Brook would be classified as a headwater stream.
 - A. True
 - B. False
 - iii. (1 point) True or false: The Connecticut River is more "U" shaped than Blood's Brook.
 - A. True
 - B. False
 - iv. (1 point) True or false: The Connecticut likely has a higher discharge than Blood's Brook.
 - A. True
 - B. False

Section 7: Winooski Watershed Woes

Outside of Burlington, Vermont is Oak Tree Blueberry Farm, a pick-it-yourself blueberry farm that lies within the watershed of the Winooski River. Oak Tree uses fertilizers and pesticides, but has an unknown impact on the environment surrounding the Winooski River. The Winooski River drains into Lake Champlain, which provides drinking water for the Burlington area. You are trying to determine Oak Tree's impact on the watershed.

53. Independent testing of their fruit revealed trace amounts of DDT and malathion in their blueberries. These concentrations were at safe levels for fruit consumption, but the amount of runoff impact is unknown.
- (2 points) Under what process is malathion degraded in the environment?
 - (2 points) What about DDT?
- (b) (1 point) Is malathion or DDT longer lasting in the environment?
- Malathion
 - DDT
- (c) (1 point) What is a naturally-occurring alternative pesticide that Oak Tree could utilize instead of these synthetic ones?
54. Oak Tree uses GrowFast's 8-12-32 fertilizer.
- (2 points) Describe the composition of their fertilizer.
 - (2 points) When compared to fertilizers for grass growth, which value will be higher in fertilizers for blueberries? Why?
 - (2 points) When this fertilizer is being made, is there a larger or smaller environmental impact than the synthesis of a 28-0-0 fertilizer. Why?
 - (1 point) Let's say all of the Winooski watershed uses 8-12-32 fertilizer, and another watershed uses 28-0-0 fertilizer. Which region's drinking water poses a higher risk for residents developing blue baby syndrome?
 - Winooski watershed
 - Other watershed
 - (1 point) Oak Tree is not the only farm in the region that uses fertilizers. Fertilizer runoff contributed by these farms is what kind of pollution?
 - Point source
 - Nonpoint source

In order to gain funding for potential watershed remediation, you need to prove Oak Tree and other local farms are having a significant effect on the health of the Winooski and its tributaries. You decide to do this first through biotic metrics of Huntington Stream, a tributary of the Winooski that borders Oak Tree Blueberry farm.

55. For each of the following organisms shown on your image sheet, identify its common name.
- (2 points) Identify the organism in Image 21. 5 individuals found.
 - (1 point) How long does this organism stay in the larval stage?
 - (2 points) If malathion levels were high enough in the river to affect these organisms, through what mechanism in the organism would it kill them?
 - (2 points) Identify the organism in Image 22. 12 individuals found.
 - (1 point) True or false: this family of macroinvertebrates are considered invasive in some countries in the eastern hemisphere.
 - True
 - False

- (c) (2 points) Identify the organism in Image 23. 9 individuals found.
- (1 point) What is a common nickname for this organism?
- (d) (2 points) Identify the organism in Image 24 and give its life stage. 3 individuals found.
- (1 point) Where do these organisms usually lay their eggs?
 - (1 point) What do adults of this species eat?
- (e) (2 points) Identify the organism in Image 25. 6 individuals found.
- (1 point) What functional feeding group does this organism belong to?
 - (1 point) Fill in the blanks: These organisms feed on (dead/live) (coarse/fine) organic particulate matter.
A. dead, coarse B. dead, fine C. live, coarse D. live, fine
 - (2 points) In what section of the river was this organism most likely observed?
A. Lower reach B. Middle reach C. Upper reach
- (f) (2 points) Identify the organism in Image 26. 15 individuals found.
- (1 point) What life stage of this organism would be found in the riparian zone of the stream?
- (g) (2 points) Identify the organism in Image 27. 10 individuals found.
- (1 point) Larvae of this organism often have what kind of symbiotic relationship with mayflies?
A. Mutualism B. Commensalism C. Parasitism D. Competition
 - (1 point) What is a key difference between this organism and another species also in the Water Quality rules that it is often confused with?
56. (5 points) Based upon the species you identified and the number of individuals collected of each species, calculate the Hilsenhoff Biotic Index of Huntington Stream. *Pollution tolerance values are found on the image sheet!* **(TB #5)**
57. (1 point) Using the categories in the same table, what is the water quality of Huntington Stream?
A. Excellent B. Good C. Fair D. Poor
58. (6 points) Calculate the Shannon Equitability Index, E_H , of Huntington Stream. **(TB #3)**
- In addition to biotic metrics, you also choose to move forward with water chemistry metrics near Oak Tree.
59. In the Winooski River, you find an algal bloom downstream of Oak Tree Farm. Do you expect the following metrics to be higher upstream or downstream of the farm?
- (1 point) Nitrates
A. Upstream B. Downstream C. No significant difference
 - (1 point) pH
A. Upstream B. Downstream C. No significant difference
 - (1 point) Temperature
A. Upstream B. Downstream C. No significant difference
 - (1 point) Dissolved oxygen
A. Upstream B. Downstream C. No significant difference
60. Huntington Stream runs along Oak Tree Blueberry Farm, while Thatcher Brook, another Winooski tributary, runs along Ben and Jerry's cattle grazing land. Do you expect the following metrics to be higher in Huntington Stream or Thatcher Brook?
- (1 point) Fecal coliform
A. Huntington B. Thatcher
 - (1 point) Suspended solids
A. Huntington B. Thatcher

- (c) (1 point) Turbidity
A. Huntington B. Thatcher

Finally, as a part of your proposal, you need to suggest possible routes of remediation if it is deemed necessary.

61. (2 points) If you find that remaining DDT in the soil is having significant impact, what is one method that can be used to remove DDT from the soil?
62. (1 point) What is one measure that can be taken to reduce future eutrophication in the watershed?
63. (2 points) The Burlington, VT region is continuing to grow and urbanize. As more infrastructure is built, what are 2 measures that can be taken to minimize impact on the watershed?
- (a) (2 points) If urbanization continues rapidly, which of the following impacts would you NOT expect to see in follow-up testing?
- A. Decreased Shannon's Diversity Index
 - B. Decreased Hilsenhoff Biotic Index
 - C. Increased turbidity
 - D. Decreased bank stability
 - E. Increased salinity

64. (0 points) Last question! Bonus point if you list any water type Pokemon.

Section 8: The Salty Dog Rag

65. (23 points) Event supervisor initials that you have a valid salinometer. Do not write anything on this blank.
66. (23 points) To the nearest tenth, what is the salinity of the provided solution (in % mass/volume)?