MICROSCOPIC HITCHHIKING: TAKING A TRIP WITH MICROBES AND PLANKTON

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Grade Level
Middle School

Subject area
Life Science, Biology, or Environmental Science

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1. Activity Title:

Microscopic hitchhiking: taking a trip with microbes and plankton.

2. Focus:

The main focus of this class is to work concepts on food webs and ecological relationships, giving special attention to microbes and Chesapeake Bay species and dynamics. Lesson plan has one introductory activity and two applied activities, which can be applied separately or alternatively from each other.

3. Grade Levels/ Subject:

7th grade Life Science.

4. VA Science Standard(s) addressed: Use the 2010 editions

LS.8 The student will investigate and understand interactions among populations in a biological community. Key concepts include

a) The relationships among producers, consumers, and decomposers in food webs;

b) The relationship between predators and prey;

c) Competition and cooperation;

d) Symbiotic relationships; and

e) Niches.

LS.10 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic, change over time, and respond to daily, seasonal, and long-term changes in their environment. Key concepts include:

b) Factors that increase or decrease population size; and

c) Eutrophication, climate changes, and catastrophic disturbances.

LS.11 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include:

b) Change in habitat size, quality, or structure;

c) Change in species competition;

d) Population disturbances and factors that threaten or enhance species survival; and

e) Environmental issues.

5. Learning objectives/outcomes:

a. Students will review basic vocabulary about ecological relationships (symbiosis, mutualism, competition, parasitism, commensalism, generalists, and specialists).

b. Students will explore local species and ecosystems, addressing our biodiversity.

c. Students will be able to list and different trophic interactions and give examples of the participating organisms.

d. Based on the activities, students will formulate hypotheses, make predictions and generate data.

e. Students will analyze, manage, and share their own data.

6. Total length of time required for the lesson (approximate):

Between 70 to 90 minutes, depending on which activities will be developed.

7. Key words, vocabulary:

Symbiosis

Mutualism

Competition

Parasitism

Commensalism

Food webs

Environment

Ecosystems

Microbiota - The ecological community of commensal, symbiotic and pathogenic microorganisms that reside in an environmental niche.

Microbial loop - A trophic pathway in the marine microbial food web where dissolved organic carbon is returned to higher trophic levels through incorporation into bacterial biomass, to then become available to the food chain.

Protists – The members of an informal grouping of diverse microscopic eukaryotic organisms that do not form a natural group, or clade, but are often grouped together for convenience.

8. Background information

Ecological relationships are often viewed or taught as stable and unidirectional. This way of thinking severely underestimates diversity and all the adaptions organisms make to respond to ecosystems pressures. Relationships among organisms are more complex and involve multidirectional interactions. In a broad perspective, symbiotic relationships are grouped according to the nature of the interaction between the involved organisms. There are three general types of symbiosis: mutualism, commensalism, and parasitism.

Mutualism is a mutually beneficial relationship to all organisms involved. Each species provides an advantage to the other, enhancing their chances of survival. It is not always easy to analyze the benefit to the individuals in this type of relationship, especially in situations in which organisms receive benefits from a variety of species (as in for plant-pollinator mutualisms). Therefore, mutualism is often categorized mutualisms according to the closeness of the association, as in obligate and facultative mutualism. Obligatory mutualism can refer to mutual dependency (both species cannot live without one another), or to the physical intimacy of the relationship in relation to closeness (as in one species living within the tissues of the other species).

Commensalism can be defined as a symbiotic relationship in which one organism benefits and the other is unaffected/ not harmed. The commensal (the species that benefits from the association) may obtain nutrients, shelter, support, or locomotion from the host species. The host organism is unmodified, whereas the commensal species may show great structural adaptation to its host.

Parasitism is beneficial for one organism and harmful for the other. In general, parasites do not kill their hosts, being usually much smaller and often living in or on their hosts for long periods. Parasites show a high degree of specialization and adaptions to this type of relationship, and reproduce at a faster rate than their hosts.

In the ocean, microbes are an important part of all food webs, interconnecting all types of ecological relationships. Single celled photosynthetic organisms are generally the most important primary producers in the open ocean. Many of these cells are too small to be captured and consumed by planktonic animals, but are consumed by protists, which in turn are preyed upon by larger organisms. These microbial food webs play an essential role in the carbon and nutrient cycles of the marine environment, where dissolved organic carbon is returned to higher trophic levels via its incorporation into bacterial biomass, and then coupled with the classic food chain formed by phytoplankton-zooplankton-nekton, in a pathway called microbial loop (Fenchel, 2008). For more information, please see list of references and the provided Power Point presentation.

9. Student handouts and other materials needed (worksheet, data tables, diagrams, websites, etc.)

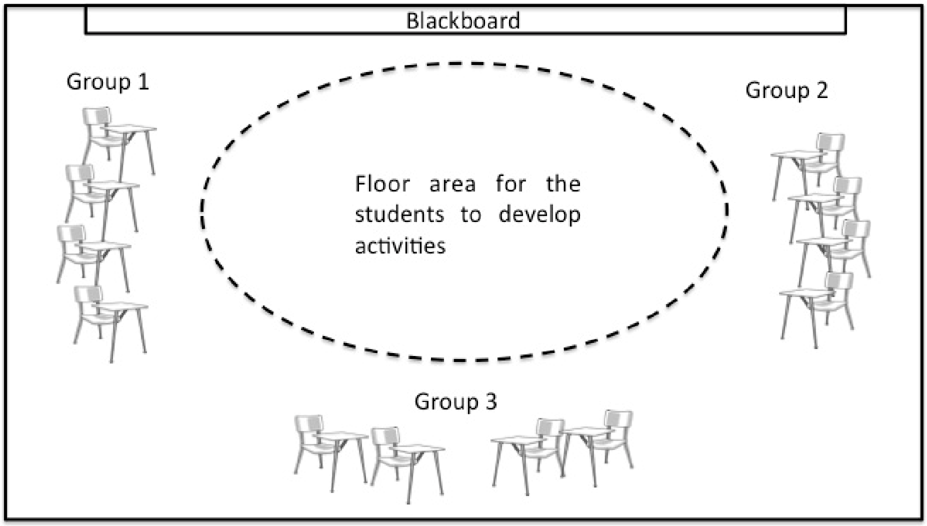
a. Power Point presentation for introduction;
b. Cards of species from Chesapeake Bay;
c. Materials for copepod worksheet (see appendix for activity 2);

10. Materials & Supplies, A/V/Tech Support

a. Computer and projector for Power Point presentation

b. Appendices for activity description and list of materials.

11. Classroom/Lab/Field Study Setup



Ideally, desks and chairs should be arranged so that there is ample space on the floor, preferably near the blackboard. In this space, students will design their "infested and healthy copepods". Therefore, it is important for students to keep the their tables and chairs around if they want to take notes or sit during the discussion of results.

12. Procedure:

a. ENGAGEMENT

-Classroom set -up – 5 minutes

-Accessing prior knowledge – 5 to 10 minutes

-Questions:

- What is the main difference between carnivores and herbivores?
- What is a decomposer? And a consumer?
- What is symbiosis? Can anyone give examples?
- What is predation?
- What is commensalism?
- What is mutualism?
- Are all predators large?
- Are all small organisms bacteria?
- Can bacteria be considered prey?
- In how many ways can an animal relate to other species?

b. EXPLORATION

-Introduction to activity 1 (Chesapeake Bay food webs) – 5 minutes

Students should be organized in teams (small enough they can quickly exchange ideas) and given general rules to play the game.

-Activity 1 (see appendix 1) – 15 to 20 minutes.

-Activity 2 (see appendix 2) – 30 to 40 minutes.

Students should be encouraged to think outside the box and explain answers that are not obviously right or wrong. The idea is to incorporate a broader perspective on food webs and how diverse they can be, at the same time students are presented less "famous" organisms from aquatic environments.

c. EXPLANATION

-Activity discussion - 5 to 10 minutes

Students should discuss why they agree or not with answers from their rival groups. They should try to use the acquired vocabulary. Alternatives to this method of discussion are listed in appendices.

d. ELABORATION

Activities can be performed on a different days, but it is important that students have well-established knowledge on food webs and symbiosis, since it is focused on parasitism and environment. In activity 2, the students will explore the effects of external parasites (peritrich ciliates) on copepods and water quality. They will draw a copepod-model based on data interpretation and prediction. Appendix 2 fully describes the biology and organisms involved in this, and lists more resources.

e. EVALUATION

-Discussion and accessing data - 5 minutes (throughout class)

It is important that the students take notes throughout the activities, since that is what they will use to build their models, plot their graphs and explain if their predictions worked or not. Therefore, students should be encouraged to write down their own questions and predictions.

Questions:

- In which environment the copepod should have more parasites? Why?
- How did the parasite load affect the copepod you built?
  What do you think it would happen in nature?
- Do all copepods made in class look the same?
- How do you think eutrophication (or pollution) will affect copepod population?
- Is having a bigger population always a good thing? Why?

13. Assessment:

One of the primary assessments should be the analysis of data, hypotheses, prediction and graphs. Activities 1 and 2 provide the possibility of different formative assessment analysis. Assessment can be performed through a gallery walk", with students grouped in trios. Questions are presented to student as posters on the walls; student groups have a certain amount of time to take turns answering questions. After all groups answer all questions (or selected questions), teacher summarizes and explains main ideas.

Questions:

- Are all bacteria harmful?
- What is plankton?
- Who are the producers?
- Can you give me examples of planktonic animals?
- Are marine food webs simple or complex?
- Does pollution affect food web interactions?
- Do we see parasites more often in large or small populations?
- Do you think pollution can benefit an animal population?

Another way to assess what was withheld during the activities is in the form of a formal report, as in a group poster session, journal entry, or even as a scientific report, if the student's experience with scientific writing allows it. In these cases, the teacher controls the degree of depth expected, since students will have time and tools to deepen in questions outside the classroom.

Each learning objective can be assessed individually or in different group settings, but whichever way it will be performed, students should be able to answer the questions listed below. Walking galleries can be an interesting sharing tool for groups, as they can draw and compare food webs, or even a vocabulary test. Another form of assessment is to select a learning objective topic per group and have the students organizing a group presentation. Some of the learning objectives cover unexpected ideas on topics discussed routinely outside school, such as parasites, microbes, water ecology, etcetera, and may provide interesting material for discussion and elaboration in group presentations.

a. **Students will explore local biodiversity:** Student groups can draw food webs based on what they learned from Activity 1 and compare the different results from each group. They should be able to answer the following questions: Can you name different organisms from Chesapeake Bay food webs? Would you be able to tell me how they are involved in different types of ecological relationships?
b. **Students will discuss and explain how different organisms participate in ecological relationships and fit into concepts of ecology and food webs:** Can you tell me how these relationships differ from each other? From the host's perspective, what are the consequences? Can the same organism participate in different types of relationship?
c. **Students will be introduced to basic vocabulary about ecological relationships (symbiosis, mutualism, competition, parasitism, commensalism, generalists, and specialists).** Can anyone define symbiosis, mutualism, competition, parasitism, commensalism, generalists, and specialists?
d. **Students will apply their acquired knowledge on a review about microbes and parasites.** What did you learn about parasites? Do you remember who are the ciliates? Are all ciliates

parasites? Are microbes important? Do you think environmental change only impacts large animals?

e. **Based on the activities, students will formulate hypotheses, make predictions and analyze their findings.** What were your initial hypotheses on eutrophication and parasites? What did you think it would happen to the copepod populations? After the activities were over, is there assumption or method you would have changed?

14. References:

Ecological communities (introduces ecological communities and food webs, and talks about keystone species):

▫http://www.globalchange.umich.edu/globalchange1/current/lectures/ecol_com/ecol_com.html

▫National Geographic (discusses ecological relationships with a focus on marine ecosystems):

▫http://education.nationalgeographic.com/activity/ecological-relationships/?ar_a=1

▫Fenchel, T. The microbial loop – 25 years later. Journal of Experimental Marine Biology and Ecology, Volume 366 (1–2): 99–103, 2008.

http://www.sciencedirect.com/science/article/pii/S002209810800333X

Appendices 1 – 3:

Instructions & Support for Activities 1-3

- **Appendix 1: Activity 1 instructions – Chesapeake Bay Food Webs**

- **Appendix 2: Activity 2 instructions – Draw Your Copepod**

  & Student Handout: Microscopic hitchhiking: taking a trip with microbes and plankton

- **Appendix 3: Activity 3 instructions – Hungry Fish**

APPENDIX 1:

Activity 1 – A Closer look at Chesapeake Bay Food Webs

1. Instructions:

This activity requires the students to understand concepts about food webs and producer-consumer interactions. The SOL content (LS.6, LS.7, and LS.8) is more then sufficient to provide the necessary background, but a list of support material can be found below. Before starting the activity, make sure you have the envelopes with all the species cards in it (total number of cards is 17).

Each card contains a picture, and on the back of it you will find its common name. The teacher should draw one card from each envelope, and ask the students to name possible ecological relationships between them. Each group gets one turn to try, but please see list of species to make sure if species present more than one possible relationship). The list of species and relationships below provides an instructor's key.

Encourage the students to explain their answers even if they do not know the proper name for it, so they will not be so focused on right or wrong answers. You can repeat questions used during the knowledge assessment, using the species in the selected cards as the example.

2. Questions:

As with the learning objectives, these questions can be answered individually or in different group settings. Walking galleries, pair or group share, vocabulary tests or even group presentations are encouraged, in order to make the students more familiarized with the terminologies and concepts.

- What is symbiosis? Can anyone give examples?
- What is predation?
- What is commensalism?
- What is mutualism?
- Are all predators large?
- Are all parasites small?
- Are all small organisms bacteria?
- Are plankton species predators or prey?
- Can bacteria be considered prey?
- In how many ways can an animal relate to other species?
- Are symbiotic relationships stable (always the same) in time? Do you think of situations that they may change?

3. Support material:

The content traditionally taught about ecological relationships should be sufficient to carry out this activity. However, if the teacher finds it necessary to provide further background on the subject, these resources contain a good amount of easily understandable information on the topic.

- http://www.mdsg.umd.edu/topics/food-webs/food-web
- http://www.pwrc.usgs.gov/products/factsheets/fact8.pdf
- http://www.chesapeakebay.net/discover/bayecosystem/plankton
- https://www.umes.edu/cms300uploadedFiles/Chesapeake%20Bay%20Organisms%20Food%20Web%20Research.pdf
- http://sciencenetlinks.com/lessons/food-webs-in-the-bay/
- http://www.serc.si.edu/education/k8/estuary/Estuary%20Chesapeake%20Workbook%20april%202012%20single%20pages.pdf

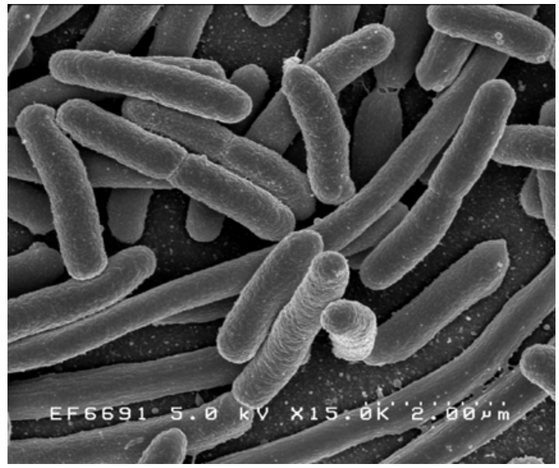
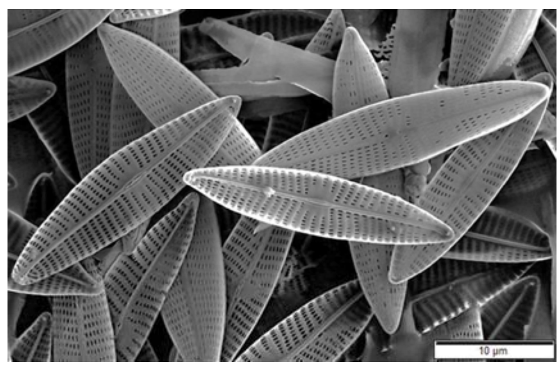
4. List of species and relationships:

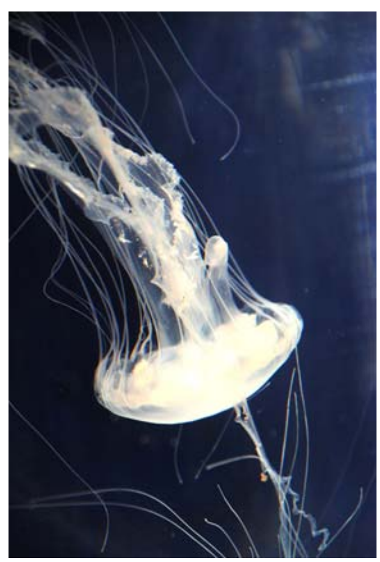
Pictures of the listed organisms can be found on the websites of NOAA and Wikipedia, who provide fair use of images, as well as further information on each species in case the students show curiosity on a particular organism. These images can be printed and used as a matching game of species interactions, by drawing randomly two images of organisms and trying to think of possible ecological relationships. Another possibility is to attach the pictures to the blackboard and have the students drawing connections between the species and explaining possible interactions. A list of examples covering most of the ecological relationships can be found bellow. However, it is not a finite or definitive list, as the students can come up with explanations or different ideas based on their own experiences and concept interpretation.

<table>
<tr><th>Taxon</th><th>Relationship</th><th>Taxon</th><th>Name of Relationship</th></tr>
<tr><td>Bacteria</td><td>Preyed upon by</td><td>Protists</td><td>Predation</td></tr>
<tr><td rowspan="5">Diatoms</td><td rowspan="4">Preyed upon by</td><td>Protists</td><td rowspan="5">Predation</td></tr>
<tr><td>Copepods</td></tr>
<tr><td>Crustacean larvae</td></tr>
<tr><td>Juvenile Shad</td></tr>
<tr><td>Filtered by</td><td>Oyster</td></tr>
<tr><td rowspan="12">Protists</td><td rowspan="2">Preys upon</td><td>Bacteria</td><td rowspan="8">Predation</td></tr>
<tr><td>Diatoms</td></tr>
<tr><td rowspan="5">Preyed upon by</td><td>Crustacean larvae</td></tr>
<tr><td>Copepods</td></tr>
<tr><td>Comb Jelly</td></tr>
<tr><td>Juvenile Shad</td></tr>
<tr><td>Blue Crab</td></tr>
<tr><td>Filtered by</td><td>Oyster</td></tr>
<tr><td rowspan="3">Infects</td><td>Oyster</td><td rowspan="3">Parasitism</td></tr>
<tr><td>Crustacean larvae</td></tr>
<tr><td>Striped Bass</td></tr>
<tr><td>Attach to</td><td>Copepods</td><td>Commensalism and/or Parasitism</td></tr>
</table>

Taxon	Relationship	Taxon	Name of Relationship
Boring sponge	Infects	Oysters	Parasitism
Comb Jelly	Preys upon	Protists	Predation
		Copepods	
		Crustacean larvae	
	Preyed upon by	Sea Nettle	
Sea Nettle	Preys upon	Protists	Predation
		Copepods	
		Crustacean larvae	
		Comb Jelly	
	Preyed upon by	Sea Turtle	
Oyster	Filters	Diatoms	Predation
		Protists	
		Crustacean larvae	
	Infected by	Protists	Parasitism
		Boring sponge	
	Shelters in	Submerged Aquatic Vegetation	Commensalism
Blue Crab	Preys upon	Protists	Predation
		Copepods	
		Crustacean larvae	
		Submerged Aquatic Vegetation	
	Preyed upon by	Striped Bass	
	Infected by	Protists	Parasitism
Juvenile Shad	Preys upon	Diatoms	Predation
		Protists	
		Copepods	
		Crustacean larvae	
	Preyed upon by	Striped Bass	
	Shelters in	Submerged Aquatic Vegetation	Commensalism

Taxon	Relationship	Taxon	Name of Relationship
Striped Bass	Infected by	Protists	Parasitism
	Preys upon	Blue Crab	Predation
		Juvenile Shad	
	Shelters in	Submerged Aquatic Vegetation	Commensalism
Sea Turtle	Preys upon	Comb Jelly	Predation
		Sea Nettle	
		Blue Crab	
		Oyster	
	Cleaned by	Sharksucker	
	Relationship	Taxon	
		Striped Bass	
		Sea Duck	
Submerged Aquatic Vegetation	Shelters	Crustacean larvae	Shelters
		Oyster	
		Juvenile Shad	
	Preyed upon by	Blue Crab	Predation
		Sea Duck	
Crustacean Larvae	Preys upon	Diatoms	Predation
		Protists	
		Copepods	
	Preyed upon by	Comb Jelly	
		Sea Nettle	
		Juvenile Shad	
		Oyster	
	Infected by	Protists	Parasitism
Copepods	Preys upon	Diatoms	Predation
		Protists	
	Preyed upon by	Comb Jelly	
		Sea Nettle	
		Juvenile Shad	
Sharksucker (remora)	Cleans	Sea Turtle	Mutualism

Bacteria	
Diatoms	
Protists	

Boring sponge	
Comb Jelly	
Sea Nettle	

Oyster	
Blue Crab	
Juvenile Shad	

Striped Bass	
Sea Turtle	
Submerged Aquatic Vegetation	

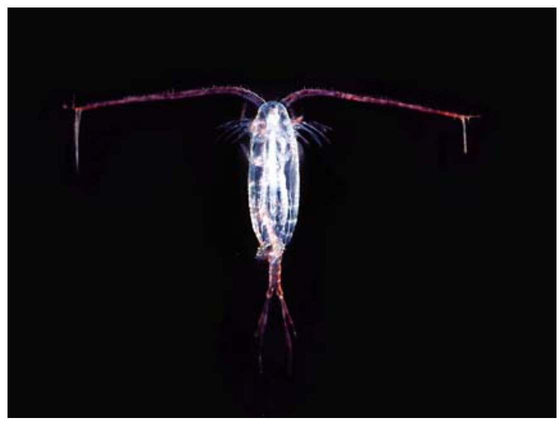
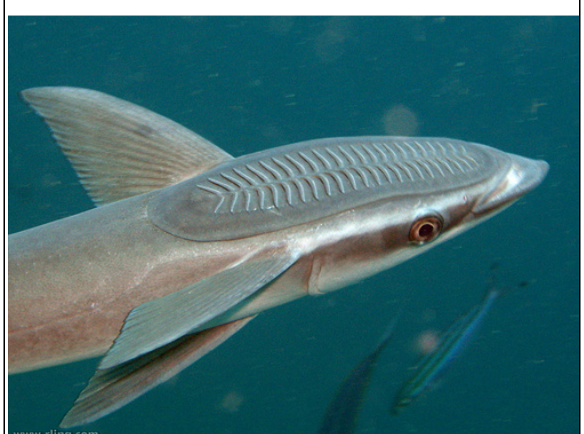
Crustacean Larvae	
Copepods	
Sharksucker (remora)	

Image Sources:

Bacteria – National Institutes of Health, U.S. Department of Health & Human Services, public domain. https://en.wikipedia.org/wiki/Escherichia_coli#/media/File:EscherichiaColi_NIAID.jpg

Diatoms - Mogana Das Murtey and Patchamuthu Ramasamy, Wiki Commons, 2016. https://commons.wikimedia.org/wiki/File:Marine_diatoms_SEM2.jpg

Protists – Proyecto Agua, Creative Commons, 2009. https://www.flickr.com/photos/microagua/3623036432

Boring Sponge – Chris Moody, Creative Commons, 2007. https://www.flickr.com/photos/zpyder/1081124759/

Comb Jelly - Marco Faasse, World Register of Marine Species, Ocean Portal, 2017. http://ocean.si.edu/jellyfish-and-comb-jellies

Sea Nettle - Jarek Tuszyński, Wiki Commons, 2009. https://commons.wikimedia.org/wiki/File:Washington_DC_Zoo_-_Crysaora_quinquecirrha_9.jpg

Oyster – Andrew Canizzaro, Creative Commons, 2015. https://commons.wikimedia.org/wiki/File:Eastern_Oyster_(Crassostrea_virginica)_Top_(16114506758).jpg

Blue Crab – The Children's Museum of Indianapolis, 2011. https://en.wikipedia.org/wiki/Callinectes_sapidus#/media/File:The_Childrens_Museum_of_Indianapolis_-_Atlantic_blue_crab.jpg

Juvenile Shad - Shermon Foote Denton, 1896, Wiki Commons, 2011. https://commons.wikimedia.org/wiki/File:Dentonshad1904.jpg

Striped Bass - D Ross Robertson, Chesapeake Bay Program http://www.chesapeakebay.net/fieldguide/critter/striped_bass

Sea Turtle – Upendra Ukanda, Wiki Commons, 2006.

https://en.wikipedia.org/wiki/Loggerhead_sea_turtle#/media/File:Loggerhead_sea_turtle.jpg

Submerged Aquatic Vegetation – Chesapeake Bay Program, 2008.

https://www.flickr.com/photos/29388462@N06/5052268924/in/photolist-8Gsae1-8GsbeN-8GscwU-9RX2RA-8Gp1x4-8Gsdad-8Gp3Rt-9RX2Xo-8Gp3j6-9RX3Ah-9qX7RS-qsevNC-NRvnL1-wZ5Jse-8GoZcK-8HezRb-AP7XA6-BJebwj-AP7YT6-sFY7sE

Crustacean Larvae – NOAA, 2006.

https://commons.wikimedia.org/wiki/File:Shrimp_nauplius.jpg

Copepods – Uwe Kils, Wiki Commons, 2005.

https://commons.wikimedia.org/wiki/File:Copepodkils.jpg

Sharksucker – Richard Ling, Wiki Commons, 2008

https://en.wikipedia.org/wiki/Live_sharksucker#/media/File:Echeneis_naucrates.jpg

APPENDIX 2:
Activity 2 – Draw Your Copepod

1. Instructions:

This activity requires some preparation time, as it is necessary to time to provide background information, described through a Power Point presentation. This activity describes a real ecological relationship from Chesapeake Bay, and, while students may not use real data, all the major components described for it are real. The informational sheet provides material to be handled to students, and the support material contains enough in-depth information to ensure the teacher is able to answer questions (see Section 3 in this activity and the Student Fact Sheet).

To start the activity, go through the Epibiosis Power Point presentation. You can have this activity as worksheet, listing the questions available below and the three pollution level scenarios, so all groups should have hypotheses for all the scenarios, so, if the teacher decides to have an oral evaluation, all groups will be able to present and discuss their ideas. Following this, you can designate the level of pollution that each group will draw its copepod design. The two simplest levels, POLLUTED versus CLEAN, make models easier to be interpreted. You can also use the level MODERATE to try to promote further discussion about what might happen to the copepod. If there is a need to adapt this activity to larger groups, you can simply repeat the number of groups working with the same level of pollution. Another possibility is to provide the questions and two or three levels of pollution as one set of homework.

2. Questions:

Which environment will have more bacteria in the water?

Do you think copepods may benefit from the increase in bacteria?

Do you think the copepod will be the only one to try to take advantage on this increase in bacteria?

Can the copepod swim well with ciliates living on it?

Do you think the copepod can feed well while hosting epibionts?

In the pristine environment, what do you hypothesize it will happen regarding the ciliate abundance on copepods?

Now, in the moderate and polluted environments, what do you hypothesize it will happen regarding the ciliate abundance on copepods?

Explain how you drew your copepod. How do you think the level of pollution you worked with affected the copepod-ciliate relationship?

Do you think it is possible for the copepod to survive in all levels of pollution? What do you think it would happen if we tested this with an entire population?

Do you think pollution may affect small organisms as much as it affects large organisms?

3. Support material:

▫http://www.int-res.com/articles/meps/58/m058p175.pdf

▫http://www.ncbi.nlm.nih.gov/pubmed/18686057

▫https://oceanrep.geomar.de/23173/1/m058p175.pdf

▫Wahl M, editor. Marine hard bottom communities. Springer; 2009.

Microscopic hitchhiking: taking a trip with microbes and plankton

Microbes? Plankton?

Plankton is a group of organisms that live in the water anc swim against currents. Plankton species form an ecological which includes microbes as **bacteria, microalgae, protist** **animals that can be really small** as copepods (tiny crustacear as big as jellyfish.

Although they are small, plankton organisms provide a source of food to many large organisms, including comme important fish and even whales!

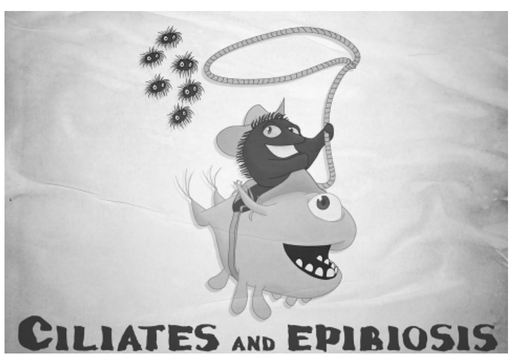
Epibiosis

Epibiosis is what we call when an organism attaches to the exterior of another living being. Epibiotic organisms are traditionally viewed as **commensals**, but one particular species in Chesapeake Bay plankton might change that perspective. *Zoothamnium intermedium* is a **ciliate protist** that lives on copepod hosts. Although it doesn't damage any copepod tissue, these hitchhikers can cause a variety of **detrimental effects** such as interference with feeding, locomotion, reproduction, growth, ability to survive, and even increased sensitivity to contaminants. Wow! This ciliate is not a parasite but it sure behaves like one!

You may be wondering what does this ciliate epibiont eat, since they only "take a ride" on top of the copepod. This ciliate feeds on **bacteria** from the water, and that is what we are going to research today.

Eutrophication

Eutrophication is the water body's response to the addition of artificial or natural **nutrients** to an aquatic system. Untreated sewage, manure, paper pulp, and agricultural run-offs are sources of excess organic matter that may result in eutrophication, a form of water pollution. Unlike on land, where excess nutrients can leave the soil and don't cause too much damage, excess nutrients in bodies of water have nowhere to go and can be disastrous. Eutrophication results in **uncontrolled growth of bacterial populations** because of the nutrient loading, which may end up depleting dissolved oxygen in the water, killing many aquatic animals.



Eutrophication and Diseases

Eutrophication can impact disease and parasite **dynamics**, since it alters species abundances and distribution. It leads to more stress and deaths in host species, making them more susceptible to disease and parasites**, favoring generalist or opportunistic** parasites. Collectively, these pathogens may be particularly dangerous because they can continue to cause mortality even as their hosts decline, potentially leading to sustained disease or extinctions.

Compare this information with what you just read about *Zoothamnium intermedium* and copepods. What do you think this epibiont has in common with parasites? Do you think the epibiont-copepod relationship may be influenced by eutrophication?

APPENDIX 3:
Activity 3 – Hungry Fish

1. Instructions:

This activity requires outside space, since it is an “epibiotic version” of hide-and-seek. This activity describes a real ecological relationship from Chesapeake Bay, and although students will not use data from real research, as they play this game, they will be conducting their own “experiment” and gathering data which they will organize and analyze.

You may use Activity 2 student fact sheet on epibionts as preparation for “Hungry Fish.” It is important that students have first discussed and recorded their hypotheses and ideas before going outside. Before starting the game, advise the students to carry material to write down the data from their “experiment.”

Have the pool noodles pre-arranged so they can be tied to the students’ waists. The pool noodles will be the epibiont loads.

Each ecological scenario should have the same number of predators (seekers), but will vary according to copepods carrying epibiont loads (pool noodles). Start with 2 or 3 seekers and only one of the students carrying epibionts, as in a pristine environment. In successive rounds, increase the number of students with epibiont loads according to the level of eutrophication of the scenario.

Time each round of hiding and seeking according to the number of students, keeping in mind the important issue is to have all rounds with same duration. To include all students, teachers can incorporate the concept of replicates and repeat scenarios. It will have to be clear to students how to handle data from replicate trials. Students in each group can take turns writing the description and data for each round, as in a real lab book. Groups could use that information to write their own scientific journal articles using their hypotheses, experiment and data. Another option is to have student groups discuss expected results before performing the activity and then comparing it with the observed results.

2. Questions:

- In which scenario did copepods experience more predation?
- In which scenario copepods were targeted more easily by the predators?
- Did your results support your hypothesis or prediction?
- Which parts of your assumptions would you have changed?
- How did this experiment change your way of viewing parasites?