

A Study of Learning Gains and Attitudes in Biology Using an
Emerging Disease Model in Teaching Ecology

Susan Chabot
CATALySES, Summer 2017
Science Teacher/Department Chair
Lemon Bay High School
Englewood, Florida
susan.chabot@yourcharlotteschools.net

Abstract

Lemon Bay High School (LBHS) is a mid-sized suburban public high school on the southwest coast of Florida in Charlotte County. Although we have a robust honors and advance placement (AP) science program, the number of general students taking additional science classes is small. We have recognized this trend and account dwindling general science enrollment to the shift in biology instruction that followed the state induction of the biology end-of-course exam (EOC). All students must pass biology and take (not pass) the biology EOC to receive a high school diploma. Instruction in preparation for changing biology standards and focus over the last 15 years has drastically altered the delivery of biology content. Although currently more emphasis is placed on project-based/thematic learning units, teachers of biology have been forced to rely on direct instruction methods in order to complete the necessary material for this state-mandated test. The shift has been away from depth of understanding and scientific thinking skills to quick-coverage of material in the hopes students will recall some vocabulary and concepts during the biology end-of-course exam. With stagnant test scores in general biology classes and waning appreciation for the sciences, the belief is that student attitudes and science content understanding will improve through the integration of thematic, project-based learning units that incorporate emerging pathogens, disease, and biology content standards. The pilot lessons presented in this action proposal associate standards of human biology, aquatic systems, and pathogens in a 6-day unit.

Rationale

Biology education has changed. I have been a Florida public school teacher for the last 14 years having left a career in health care to assume the role of science educator. When I first started teaching and change was implemented in our school, a seasoned educator commented that the “newest change to education” in our district was actually a wave of instructional change from earlier in her career. As a new teacher this did not alter my perception of a “new approach.” To me, all of it was new. Reflecting over my last 14 years of teaching, I have seen new ideas come and go and come back again. The one constant I can reflect on is biology education has changed. I recall fondly the freedom afforded in my first 9 years of biology instruction. Although I am a standards-based teacher - I really had no alternative – I found the level of instructional independence liberating. Becoming an educator through an alternative certification program offered little in the area of teacher practice and classroom management. The majority of our coursework covered educational law, reading strategies, and district policy guidelines. Stepping into my classes on the first day with no prior experience in the classroom was daunting but exciting. Following the Florida Department of Education standards for biology education provided a path of instruction but no vehicle by which to arrive at the end. This allowed me to elaborate on what kids found interesting and assure a basic understanding of those topics that were less-than captivating.

In an attempt to remain compliant in the *No Child Left Behind* (NCLB) legislation of 2001, Florida standards for science instruction have been changed three times in the past ten years. These changes have not come from the teachers but from those outside the classroom, primarily from the state legislature. The NCLB requires state assessment in academic subjects based on specific educational goals along with AYPs (adequate yearly progress). The federal and state government, as a means of forced compliance, can administer penalties and rewards and this has drastically changed the landscape of biology education. (Kaufman & Blewett, 2012). In both the previous SSS (Sunshine State Standards) and NGSSS (Next Generation Sunshine State Standards), the goal was to promote a flexible instructional system and to make suggestions for program planning and evaluation and emphasize what students should know at the appropriate grade level (Filippo & LaHart, 2010). However, the implementation of the Biology End of Course assessment (EOC) has done just the opposite. It is far from a “flexible instructional system.” With little information provided to districts and teachers on the content of the EOC and a massive amount of standards to cover in an already burdened school year with other assessments added seemingly daily, biology instruction has turned from interest-gearred to smash and grab as much as you can before moving onto the next hurdle.

Another initiative introduced in 2009 by the Obama administration is *Race to the Top (RttT)*. Not meant to replace *NCLB*, *Race to the Top* is an initiative that provides a 4.3 billion dollar stimulus for states to 1) reward high performing teachers; 2) reward teachers whose students show the most achievement or highest scores; 3) penalize teachers based on the low achievement and low scores of their students (Ravitch, 2010). *RttT* has forced states/districts to set accountability levels based on EOCs and scores on other state assessments (FSA, PERT). There are many criticisms of *RttT* and one of the most applicable to biology teachers in Florida is that it does not define what constitutes an effective teacher in academic subjects and compares EOC/FSA teachers to teachers whose subjects have no state mandated testing. Now, not only are we forced to administer assessment in biology to meet these federal initiatives, teachers across Florida are competing to achieve evaluation goals based on a faulty evaluation tool. The Florida Biology EOC have driven biology instruction to become a race to cover as many standards as possible with little depth of understanding. The hope is that students will *at minimum* recall hearing the vocabulary, observed a similar diagram, and can comprehend what the questions are asking. The most recent attempt to create national standards for science is the *Next Generation Science Standards (NGSS)*, which were developed through the work of a variety of stakeholders and published in 2013. They have been adopted by some states, but Florida is not currently on that list, so they do not have an impact on the Florida Biology EOCs. They are significant in terms of national conversations about science education reform and may be adopted by Florida in the future, which would impact the content and format of the Biology EOC, and would impact a teacher's educational practice. Another change, though welcome, in biology instruction. NGSS emphasizes the importance of "depth over breadth." This approach entails developing a deeper understanding of a subject instead of speeding through a list of ideas and facts (Pratt, 2013).

Change in pacing and delivery in biology can be difficult for a teacher to foster, especially if their current methods show achievement for students on the Florida Biology EOC. Historically, my students score 10 points above the state average. This year was very successful with an almost 90% "passing score" (3+) for general biology students. This follows a dedication among the biology teachers in my department to a rigorous pacing and assessment guide provided by me; literally a binder of content with a daily pacing guide that led to a school-level improvement of more than a 10% gain in passing scores. However, my time at CATALySES has led me to my current attitude about the Florida Biology EOC – I do not care. I recall my early days of biology instruction and the "wow factor" and words of encouragement that I would regularly hear from my students. Although I know I am influencing their overall opinions of science in a positive manner, I do not believe they are coming away with the same appreciation of biology that students of my past have experienced. One of the ways I feel I can change my students' attitude and perception of biological science is to provide an over-arching thematic presentation of biology in the context of emerging pathogens and disease. I can meet the burden of state standards (NGSSS)

delivery and coverage in the three main reporting categories on the EOC; Molecular and Cellular Biology, Classification, Heredity, and Evolution, and Organisms, Populations, and Ecosystems. By using a combination of both direct and indirect instruction, my goal is two-fold; 1) allow for deeper understanding and greater appreciation of biological science in preparation for future biology coursework and possible careers in the biological sciences and 2) prepare them to show achievement on any standardized assessment they encounter. Historically I have used direct instruction in meeting to goals of instruction for the Biology EOC. Direct instruction has some positive characteristics, mainly that of time management. One of many potential limiting factors of what material a teacher can cover in a class is *time*. In a typical school year, it is estimated that teachers have on average 120 days of instruction in a 180-day school year. For biology, that is 120 days for a 1000+ page textbook and 85 biology standards. 60 days are lost to typical interruptions experienced in a public high school; pep rallies, assemblies, class meetings, field trips, fire drills, state and district assessments to name a few. Due to educational standards, pacing guides, and learning calendars teachers' instructional practices are limited by three distinct criteria: content selection, time allotment, and pedagogical methods of instruction (Keena & Russel III, 2015). According to a study by Huelskamp (2015), due to the limited class time, direct instruction resulted in higher standardized test scores than other types of instructional practices employed by the teachers. Criticisms of direct instruction are many. In one aspect, direct instruction does not allow for active learning. Often students are presented with great amounts of information and are expected to retain that particular knowledge. Another criticism of direct instruction is that students are not actively engaged in the learning process. In order to counter this, a more active learning approach is required and to facilitate this process of active learning, research has proposed a five-step plan in which students are more engaged with the learning process. This thematic approach for a more active learning process includes:

- providing context to the material being taught
- doing fewer and more focused activities or problems
- having the students build a narrative around the problem
- focusing on deep structure of the issue or issues at hand
- having students apply this knowledge in context to the work that they have done (Cook & Klipfel, 2015).

The area of focus for this Action Research Proposal will be the integration of a thematic, project-based learning approach to ecology and ecosystems in biology through an intensive examination of emerging pathogens and disease. (Other members of my cohort group in the Summer 2017 CATALySES program will be re-working/redesigning other reporting categories for the Florida Biology EOC). As a group, we decided our overarching/guiding question is "*Will teaching biology standards through disease modules increase student*

performance on formative assessments as well as increase student engagement/participation and attitudes towards science?" Ecology/ecosystems is a sizeable unit in biology and comprises 4 consecutive chapters in the Florida Biology textbook, 40% of the Florida Biology EOC, and 9 Florida biology standards. My approach will involve chunking of standards to align with the pathogen/disease of focus. This thematic approach may overlap many of the ecology standards with standards in immune function, impact of environmental factors on the individual and public health, identification of major parts of the brain, classification, and evolution. My hope is that providing a foundational understanding of emerging pathogens from the outset, students will have a working understanding of emerging pathogens, infections, and approach to identification as we introduce each new pathogen/disease process and its relationship to the standard being addressed in the lesson or unit. As I examine this approach, it appears evident that the integration of ecology and emerging pathogens could provide a successful avenue for teaching all biology standards, including the more difficult Nature of Science standards, which can be easily integrated throughout the learning units.

Intervention

The intervention used in this action research proposal is a two-fold approach; 1) increased interest and better attitude toward science and learning and 2) stable or improved scores on the Florida biology end-of-course exam. All biology students will take an Interest Inventory and Science Attitude Survey at the start of the 2017-2018 school year. The information provided in this survey will provide a baseline of student affinity toward science and knowledge of basic biological and nature of science standards acquired in middle school science courses. The expectation is that through a thematic, project-based learning approach to biology instruction, students will have high-interest and deeper understanding with better retention of material. The learning units will incorporate the overarching theme of Emerging Pathogens as the "interest hook." This action proposal incorporates 6 biology standards which are typically taught in isolation. By combining these standards into a unified lesson, students will make important connections between the discrete standards and develop a better understanding of the interrelatedness of biological systems.

Data Collection and Analysis

There will be multiple opportunities for Data Collection throughout the incorporation of this action proposal. Although this is a single unit, by working with fellow CATALySES 2017 cohort members, the hope is to integrate Emerging Pathogens as a mechanism to teach each biology standard. Members will collaborate to develop a pre- and post-assessment for the content of each specific action research plan that addresses standards covered on

the biology EOC. In addition, an Interest Inventory and Science Attitude Survey will be given to each student at the beginning of the 2017-2018 school year and again just prior to the state biology testing window. The expectation is that students will not only perform better on the post assessment but have more positive attitude toward science topics and be more likely to enroll in science electives. Scores for the pre- and post-assessment are a quantitative representation of biology content while the Interest Inventory and Science Attitude Survey, in using a Likert Scale, will be a qualitative representation of science interest and attitude.

Connections to CATALySES

- Emerging pathogen content focus
- Giant Microbe Q&A cards
- Microscopy skills
- Ebola-like mapping activity for *Naegleria fowleri*

Budget Request

- Water-borne set of Giant Microbes
 - Ear ache (*Streptococcus pneumonia*)
 - Stomach ache (*Shigella spp.*)
 - Flesh-eating (*Streptococcus pyogenes*)
 - Staph (*Staphylococcus aureas*)
 - Polio (Poliovirus)
 - C. diff (*Clostridium difficile*)
 - Typhoid fever (*Salmonella typhi*)
 - Listeria (*Listeria monocytogenes*)
 - E. coli infection (*Escherichia coli*)
 - Salmonella infection (*Salmonella typhimurium*)
 - Food poisoning (*Bacillus cereus*)
 - Cholera (*Vibrio cholera*)
 - Brain-eating amoeba (*Naegleria fowleri*)
 - Botulism (*Clostridium botulinum*)
 - Giardia (*Giardia lamblia*)
 - Red Tide (*Alexandrium tamarense*)
- Well-slides and Coverslips

Unit Name	Lesson Number/Name	Activity	Standards
Introduction to Emerging Pathogens and Ecology	Lesson 1: What's in the Water	<p>Engagement 8-10 min Bell Ringer Hand out question strips/Post Questions on Board Instruct students to write notes/answer questions during video (3:51 min):</p> <p>Exploration 5 min Class Discussion What is a microorganism? What is a pathogen? 30 How do microorganisms impact human health? How common are water-borne infections?</p> <p>Elaboration 20-25 min Water Microbe Activity Find matching Q&A cards Identify microbe Present highlights Complete Student Worksheet</p> <p>Evaluation 5 min Class Wrap and Homework Direct students to complete Student Worksheet and prepare for quiz.</p> <p>Evaluation 10 min Quiz Provide each partner group from Day 1 assignment with 1 copy of the quiz to complete.</p>	<p>SC.912.N.3.6: Describe the function of models in science and identify the wide range of models used in science.</p> <p>SC.912.L.14.6: Explain the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspectives of both individual and public health.</p> <p>SC.912.L.14.26: Identify the major parts of the brain on diagrams or models.</p>
	Day 2	<p>Engagement 10-15 min Brain Structure Interactive Students complete a brain diagram for major brain regions and functions.</p> <p>Exploration 6 min Class Discussion Why is the brain important? Are some areas of the brain more important than others? What region of the brain is most important? Why? What region of the brain is least important? Why?</p> <p>Elaboration and Evaluation 15 min Clay Brain Modeling Student pairs use 6 different colors of clay – yellow, purple, red, blue, green, orange Student pairs construct a basic model of the 4 main brain regions, making sure to include grooves and ridges to prepare for next day of modeling.</p>	<p>SC.912.L.14.26: Identify the major parts of the brain on diagrams or models.</p> <p>SC.912.L.14.4: Compare and contrast structure and function of various types of microscopes.</p> <p>SC.912.L.14.62: Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics.</p>
	Day 3	<p>Continue with Elaboration and Evaluation 15 min Clay Brain Modeling Student pairs use toothpick flags to identify each of the regions illustrated on the diagram. Turn in model and accompanying diagram/worksheet for formative assessment.</p> <p>Engagement 30 min Article read and highlight NYT Article <i>Scientists scour the globe for a drug to kill deadly brain-eating amoeba</i>. Students read article and highlight answers to questions provided, add additional questions in margins, interpret map provided on question sheet.</p>	<p>SC.912.L.15.4: Describe how and why organisms are hierarchically classified and based on evolutionary relationships.</p> <p>SC.912.L.17.2: Explain the general distribution of life in aquatic ecosystems as a function of chemistry, geography, light, depth, salinity, and temperature.</p>
	Day 4	<p>Exploration 10 min Bell Ringer Class Discussion Use NYT Article as reference for questions about <i>Naegleria fowleri</i> infection and treatment. As students enter class they write additional questions from their article read on Post-its and post on board Teacher uses questions on board to facilitate discussion/clarity questions about <i>N. fowleri</i> infection and the brain. Teacher explains that many questions they may have about <i>N. fowleri</i> infection will be answered during the CDC activity.</p> <p>Elaboration 35 min Part 1 CDC Introduction to Parasites Students read Lesson Guide/Appendix 1A as a class and complete Appendix 2A/Graphic organizer to research <i>N. fowleri</i> infection details. If not finished by end of class, students finish Part 1 for homework.</p>	
	Day 5	<p>Exploration 45 min Part 2 CDC Parasitic Environments Review laboratory procedures and proper microscope use/handling. Demonstrate how to make a wet-mount slide of untreated water sample. Provide time for students to view self-made slides of untreated water samples and compare to online resources or teacher-provided resources for identification.</p>	
	Day 6	<p>Evaluation 10 min Brain-Eating Amoeba Quiz Learning outcome assessed: explain how freshwater organisms are affected by environmental variation Formative assessment – Completion of Scenario Worksheet, Appendix 1A, and Graphic Organizer, 2A Evaluation 30 min – Grouped Public Health Campaign Random grouping (popsicles sticks) for creation of CDC Lesson Guide Public Health Campaign</p>	

References

Bertolotti, J.C. (2013). *Policy implications of select student characteristics and their influence on the Florida biology end-of-course assessment*. (Doctoral dissertation). Retrieved from <http://ufdc.ufl.edu/UFE0046255/00001.pdf>

Centers for Disease Control and Prevention (CDC). Science Ambassador Workshop—Brain-eating Ameba. Atlanta, GA: US Department of Health and Human Services, CDC; 2013. Available at <http://www.cdc.gov/scienceambassador/lesson-plans/index.html>.

Cook, D., & Klipfel, K. (2015). How do our students learn? *Reference & User Services Quarterly*. 55(1), 34-41.

Evans, C., Steadman, S. (2014). Practitioners as decision-makers: what and how they teach. *Journal of Curriculum and Instruction*. 8(2), 1-8.

Filippo, C., & LaHart, D. (2007). Science for all students. Tallahassee, FL: State of Florida, Department of Education.

Huelskamp, D. (2014). Traditional/ block scheduling, gender, and test scores in college biology course. *Learning Assistance Review* 19(1), 45-51.

Kaufman, A., & Blewett, E. (2012). When good enough is no longer good enough: How the high stakes nature of the No Child Left Behind Act supplanted the Rowley definition of a free appropriate public education. *Journal of Law and Education* 41(1), 5-23.

Keller, T.V. (2016). *Selected high school science teachers' perceptions regarding adaptations to their instructional practice due to the implementation of state required end-of-course exams in a midsized Central Florida school district*. (Doctoral dissertation). Retrieved from <http://digitalcommons.unf.edu/etd/639/>.pdf.

Kenna, J., Russell III, W.B. (2015). Secondary social studies teachers' time commitment when addressing the common core state standards. *Journal of Social Studies Education Research*. 6(1), 26-48.

Liedtke, M. (1996). The educational status of the natural science subjects. *European Education* 28, 6-19.

Pratt, H. (2013). Conceptual shifts in the next generation science standards: Opportunities and challenges. *Science Scope*, 37(1), 6-11.

Ravitch, D. (2010). *The death and life of the great American school system: How testing and choices are undermining education*. New York; Basic Books.

Sampson, M. (2003). *Total literacy: reading, writing, and learning*. London; Wadsworth/Thomson Learning. 13:1 – 13:34.

Unit Name	Lesson Number/Name	Activity	Standards	
Introduction to Emerging Pathogens and Ecology	Lesson 1: What's in the Water	Day 1 Engagement/8-10 min Bell Ringer Hand out question strips/Post Questions on Board Instruct students to write notes/answer questions during video (3:51 min).	SC.912.N.3.5: Describe the function of models in science and identify the wide range of models used in science.	
		Exploration/5 min Class Discussion What is a microorganism? What is a pathogen?30 How do microorganisms impact human health? How common are water-borne infections?	SC.912.L.14.6: Explain the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspectives of both individual and public health.	
		Elaboration/20-25 min Water Microbe Activity Find matching Q&A cards Identify microbe Present highlights Complete Student Worksheet	SC.912.L.14.26: Identify the major parts of the brain on diagrams or models.	
		Evaluation/5 min Class Wrap and Homework Direct students to complete Student Worksheet and prepare for quiz.		
	Day 2	Evaluation/10 min Quiz Provide each partner group from Day 1 assignment with 1 copy of the quiz to complete.		
	Lesson 2: CDC Brain-Eating Amoeba	Day 2	Engagement/10-15 min Brain Structure Interactive Students complete a brain diagram for major brain regions and functions.	SC.912.L.14.26: Identify the major parts of the brain on diagrams or models.
		Exploration/5 min Class Discussion Why is the brain important? Are some areas of the brain more important than others? What region of the brain is most important? Why? What region of the brain is least important? Why?	SC.912.L.14.4: Compare and contrast structure and function of various types of microscopes. SC.912.L.14.52: Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics.	
		Elaboration and Evaluation/15 min Clay Brain Modeling Student pairs use 6 different colors of clay – yellow, purple, red, blue, green, orange Student pairs construct a basic model of the 4 main brain regions, making sure to include grooves and ridges to prepare for next day of modeling.	SC.912.L.15.4: Describe how and why organisms are hierarchically classified ad based on evolutionary relationships.	
		Day 3 <i>Continue with Elaboration and Evaluation/15 min Clay Brain Modeling</i> Student pairs use toothpick flags to identify each of the regions illustrated on the diagram. Turn in model and accompanying diagram/worksheet for formative assessment.	SC.912.L.17.2: Explain the general distribution of life in aquatic ecosystems as a function of chemistry, geography, light, depth, salinity, and temperature.	
		Engagement/30 min Article read and highlight NYT Article <i>Scientists scour the globe for a drug to kill deadly brain-eating amoeba.</i> Students read article and highlight answers to questions provided, add additional questions in margins, interpret map provided on question sheet.		
		Day 4 Exploration/10 min Bell Ringer Class Discussion Use NYT Article as reference for questions about <i>Naegleria fowleri</i> infection and treatment. As students enter class they write additional questions from their article read on Post-Its and post on board Teacher uses questions on board to facilitate discussion/clarify questions about <i>N. fowleri</i> infection and the brain. Teacher explains that many questions they may have about <i>N. fowleri</i> infection will be answered during the CDC activity.		
		Elaboration/35 min Part 1 CDC Introduction to Parasites Students read Lesson Guide/Appendix 1A as a class and complete Appendix 2A/Graphic organizer to research <i>N. fowleri</i> infection details. If not finished by end of class, students finish Part 1 for homework.		
		Day 5 Exploration/45 min Part 2 CDC Parasitic Environments Review laboratory procedures and proper microscope use/handling. Demonstrate how to make a wet-mount slide of untreated water sample. Provide time for students to view self-made slides of untreated water samples and compare to online resources or teacher-provided resources for identification.		
		Day 6 Evaluation/10 min Brain-Eating Amoeba Quiz Learning outcome assessed: explain how freshwater organisms are affected by environmental variation Formative assessment – Completion of Scenario Worksheet, Appendix 1A, and Graphic Organizer, 2A Evaluation/30 min – Grouped Public Health Campaign Random grouping (popsicles sticks) for creation of CDC Lesson Guide Public Health Campaign		

CDC Science Ambassador Workshop

2013 Lesson Plan

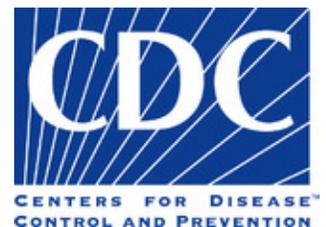
Brain-Eating Ameba

Developed by

Jewel B. Moses, PhD
Southeast Middle School
Hopkins, South Carolina

Arcot M. Saibaba, PhD
Newton High School
Covington, Georgia

This lesson plan was developed by teachers attending the Science Ambassador Workshop. The Science Ambassador Workshop is a career workforce training for math and science teachers. The workshop is a Career Paths to Public Health activity in the Division of Scientific Education and Professional Development, Center for Surveillance, Epidemiology, and Laboratory Services, Office of Public Health Scientific Services, Centers for Disease Control and Prevention.



Acknowledgements

This lesson plan was developed in consultation with subject matter experts from the Division of Foodborne, Waterborne, and Environmental Diseases, National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention.

Jennifer Cope, MD, MPH
Medical Epidemiologist

Jonathan Yoder, MSW, MPH
Epidemiologist

Scientific and editorial review was provided by Ralph Cordell, PhD and Kelly Cordeira, MPH from Career Paths to Public Health, Division of Scientific Education and Professional Development, Center for Surveillance, Epidemiology, and Laboratory Services, Office of Public Health Scientific Services, Centers for Disease Control and Prevention.

Suggested citation

Centers for Disease Control and Prevention (CDC). Science Ambassador Workshop—Brain-eating Ameba. Atlanta, GA: US Department of Health and Human Services, CDC; 2013. Available at <http://www.cdc.gov/scienceambassador/lesson-plans/index.html>.

Contact Information

Please send questions and comments to scienceambassador@cdc.gov.

Disclaimers

This lesson plan is in the public domain and may be used without restriction.
Citation as to source, however, is appreciated.

Links to nonfederal organizations are provided solely as a service to our users. These links do not constitute an endorsement of these organizations nor their programs by the Centers for Disease Control and Prevention (CDC) or the federal government, and none should be inferred. CDC is not responsible for the content contained at these sites. URL addresses listed were current as of the date of publication.

Use of trade names and commercial sources is for identification only and does not imply endorsement by the Division of Scientific Education and Professional Development, Center for Surveillance, Epidemiology, and Laboratory Services, CDC, the Public Health Service, or the U.S. Department of Health and Human Services.

The findings and conclusions in this Science Ambassador Workshop lesson plan are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC).

Contents

Summary	1
Learning Outcomes	2
Duration	2
Procedures	3
Day 1: Introduction to Parasites, 45 minutes	3
Preparation	3
Materials	3
Online Resources	3
Activity	4
Day 2: Parasitic Environments, 45 minutes	5
Preparation	5
Materials	5
Online Resources	5
Activity	6
Conclusion	7
Assessments	7
Educational Standards	8
List of Appendices	10
Appendix 1A: Waterborne Disease Case Study, Scenario Worksheet.....	11
Appendix 1B: Waterborne Disease Case Study, Scenario Worksheet Answer Key	12
Appendix 2A: Waterborne Disease Case Study, Graphic Organizer	13
Appendix 2B: Waterborne Disease Case Study, Graphic Organizer Answer Key	16
Appendix 3A: Waterborne Disease Case Study, Laboratory Exploration	19
Appendix 3B: Waterborne Disease Case Study, Laboratory Exploration Answer Key	22
Appendix 4: Waterborne Disease Case Study, Public Awareness Campaign.....	26
Appendix 5A: Brain-Eating Ameba Quiz	27
Appendix 5A: Brain-Eating Ameba Quiz, Answer Key	28

Brain-Eating Ameba

Summary

Swimming is a fun summer activity, but it can increase your risk for contracting certain waterborne diseases. *Naegleria fowleri* (*N. fowleri*) is among many organisms that live in recreational waters, such as ponds and lakes, and is commonly referred to as the *brain-eating ameba*. It is a single-celled, bacteria-eating organism that can be found in warm fresh water around the world. It is a free-living ameba that lives in the environment and does not need a human host to complete its life cycle. Fortunately, infections caused by *N. fowleri* are rare and the risk for diseases is very low. During the summer of 2013, only four cases were reported in the United States and during the 10 years from 2005 to 2014, a total of 35 cases were reported, despite millions of recreational water exposures each year. By comparison, during the 10 years from 2001 to 2010, >34,000 drowning deaths occurred in the United States. *N. fowleri* usually infects people when contaminated water enters the body through the nose. You **cannot** become infected from **swallowing** water contaminated with *N. fowleri*.

This lesson plan demonstrates how microorganisms normally found in environments, such as the bottom of warm freshwater ponds and lakes can cause illness when they enter the human body. Students engaged in this lesson plan will learn about *N. fowleri* (the scientific name of the brain-eating ameba), where it lives, how it can cause infection, and how persons can protect themselves from this infection. Students will also have the opportunity to identify other organisms living in local freshwater reservoirs, such as ponds and lakes. At the end of the lesson, students should have an enhanced understanding of the environment's role in disease transmission and ways to reduce the risk for contracting waterborne infections.

This material is suitable for use in high school biology or environmental science classes and can be included as part of lessons on aquatic ecosystems. Before studying this lesson, students should have a basic understanding of the following six kingdom classifications: Archaeobacteria, Eubacteria, Protista, Fungi, Plantae, and Animalia. Student prior knowledge of anatomy of the human nose and brain would also be helpful.

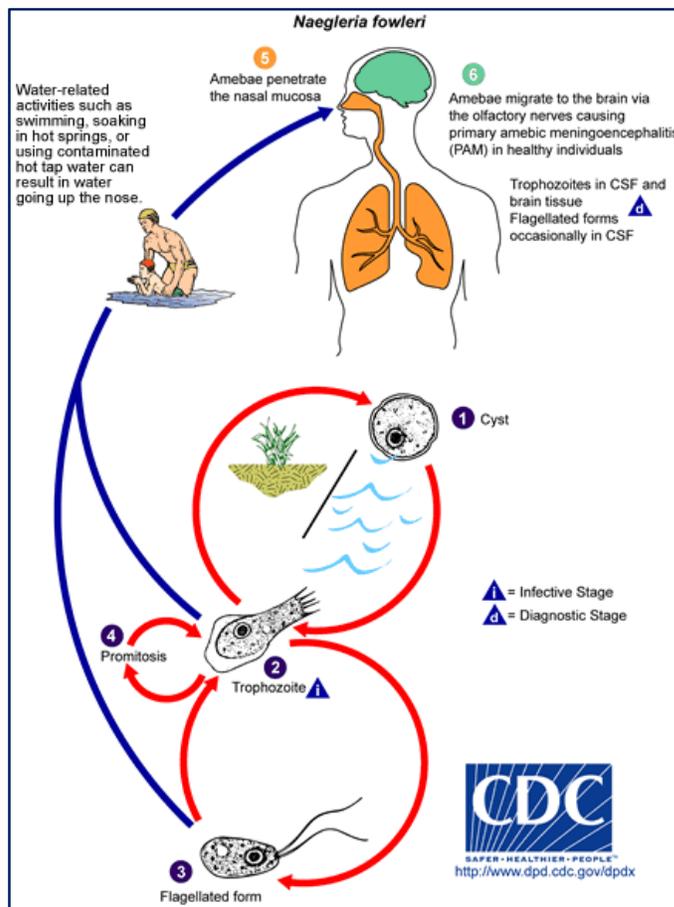


Figure 1. *Naegleria fowleri* has 3 stages in its life cycle: **1** cysts, **2** ameboid trophozoites, and **3** flagellates. The only infective stage of the ameba is the ameboid trophozoite. Trophozoites are 10–35 μm long with a granular appearance and a single nucleus. The trophozoites replicate by binary division during which the nuclear membrane remains intact (a process called promitosis) **4** Trophozoites infect humans or animals by penetrating the nasal tissue **5** and migrating to the brain **6** via the olfactory nerves causing primary amebic meningoencephalitis (PAM).

Source:
<http://www.cdc.gov/parasites/naegleria/pathogen.html>

Learning Outcomes

After completing this lesson, students should be able to

- explain how freshwater organisms, such as the brain-eating amoeba (*N. fowleri*), are affected by environmental variations (e.g., temperature, nutrient availability, geography, and life-cycle stages);
- describe limitations of epidemiologic and laboratory evidence; and
- use critical thinking to construct an evidence-based explanation as to why an *N. fowleri* infection might occur.

Duration

This lesson can be conducted as one 90-minute lesson or divided into two 45-minute lessons.

Procedures

Day 1: Introduction to Parasites, 45 minutes

Preparation

Before Day 1,

- Review the Centers for Disease Control and Prevention (CDC) Internet site regarding *N. fowleri*. See the Online Resources section that follows.
- Schedule computer laboratory or library time or reserve student laptop cart.
- For the Waterborne Disease Case Study, make one copy per student of Appendix 1A, Scenario Worksheet; and Appendix 2A, Graphic Organizer.
- Collect water samples from a local untreated water source (preferably a lake or a pond) or prepared slides of organisms that would be in lake or pond water, including protista (flagellates, amebae, heliozoans, and ciliates), bacteria, algae, rotifers, hydra, worms, and arthropods. Students will use these water samples on Day 2 to prepare wet mounts or use prepared slides for microscopic analysis. **Note:** Surface water often has a relatively low concentration of organisms; because you likely will require a higher concentration to be able to see much with a light microscope, try to collect the sample from a greater depth, preferably near the bottom. Alternatively, collect prepared slides of organisms that would be in lake or pond water, including protista (flagellates, amebae, heliozoans, and ciliates), bacteria, algae, rotifers, hydra, worms, and arthropods.

Materials

- Appendix 1A, Scenario Worksheet
Description: This case study engages student curiosity as they investigate the cause of infection in a male aged 14 years.
- Appendix 2A, Graphic Organizer
Description: Students use this worksheet to organize their notes.
- Computers with Internet access.

Online Resources

- CDC Internet site <http://www.cdc.gov>
Description: To determine the correct pathogen responsible for the victim's death in the case study, students research the three ameba options (*Dientamoeba fragilis*, *Acanthamoeba*, and *N. fowleri*) by entering the terms into CDC's search function.
- CDC Internet site on *N. fowleri*: <http://www.cdc.gov/parasites/naegleria/index.html>
Description: Students will use this website to complete their graphic organizer.
- Matthews S, Ginzl D, Walsh D, et al. Primary amebic meningoencephalitis—Arizona, Florida, and Texas, 2007. *MMWR Morbidity and Mortality Weekly Report* 2008;57:573–7.
URL: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5721a1.htm?s_cid=mm5721a1_eURL.
Description: The original case study of an Arizona male aged 14 years infected with *N. fowleri*.

Activity

1. Read the Appendix 1A scenario aloud. Challenge students to determine the ameba (*Dientamoeba fragilis*, *Acanthamoeba*, or *N. fowleri*) responsible for the infection described in the case study by using <http://www.cdc.gov> and other search functions. After students discover that *N. fowleri* is responsible for the infection, pose the question, “What are some dangers of swimming in untreated water?” Talking points for this discussion can include
 - a. *N. fowleri* infections can be serious, but they are rare; although there is no need to be scared of swimming in local lakes and ponds to avoid *N. fowleri*, it is best to practice simple prevention measures, such as keeping head above water or using nose clips.
 - b. More common dangers related to swimming in fresh water include
 - infections, such as leptospirosis, swimmer’s itch (cercarial dermatitis), giardiasis, cryptosporidiosis, cholera, shigellosis, and norovirus and infections of *Escherichia coli*, including *E. coli* O157:H7;
 - wound infections;
 - diving hazards and other water-related injuries; and
 - drowning.
 - c. The majority of infections and dangers related to swimming in fresh water can be prevented.
2. Assign Appendix 2A, Graphic Organizer. Direct students to research *N. fowleri* environment, nutrients, portal of entry into the human host, and patient symptoms using the CDC Internet site on *N. fowleri* at <http://www.cdc.gov/parasites/naegleria/index.html>.

Day 2: Parasitic Environments, 45 minutes

Preparation

Before Day 2,

- Review Internet resources and microscope procedures and safety.
- Make copies of Appendix 3A, Laboratory Exploration; Appendix 4, Public Awareness Campaign; and Appendix 5A, Brain-Eating Ameba Quiz.
- Schedule computer laboratory or library time or reserve student laptop cart.
- Retrieve water samples collected on Day 1 and prepare microscopes for the laboratory.

Materials

- Appendix 5A, Brain-Eating Ameba Quiz
Description: This test gauges student knowledge of the brain-eating ameba.
- Water samples from a local untreated water source (preferably a lake or a pond) or prepared slides of organisms that would be in lake or pond water, including protista (flagellates, amebae, heliozoans, and ciliates), bacteria, algae, rotifers, hydra, worms, and arthropods
Description: Students use these water samples to prepare wet mounts or will use prepared slides for microscopic analysis.
- Compound microscopes
- Laboratory gloves
- Computers with Internet access
- Appendix 3A, Laboratory Exploration
Description: This worksheet is used for the laboratory activity.
- Appendix 4, Public Awareness Campaign
Description: This worksheet is used for the laboratory activity.

Online Resources

- Pond Life Identification Kit
URLs:
<http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/pond/index.html>
and
<http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/pond/protozoa.html>.
Description: These Internet sites provide images and descriptions of key features of certain common freshwater organisms, including protista.
- Recreational Water Illnesses and Prevention Tips
URL: <http://www.cdc.gov/healthywater/swimming/rwi/illnesses/index.html>.
Description: This Internet site contains information regarding recreational water illnesses and how to avoid them.

Activity

1. Assign students Appendix 5A, Brain-Eating Ameba Quiz. Students should complete the short quiz on their own and then review the answers as a class.
2. Review laboratory and microscope procedures, including microscope parts, magnification, and focusing techniques; safe handling of the water samples; and wet-mount preparation.
3. Divide the class into pairs or groups of 3 for the microscope activity. Have each group analyze the water sample assigned to them and identify organisms living in the sample. Have students draw each organism on Appendix 3C, Laboratory Exploration. Using the Pond Life Identification Kit, have students determine the scientific name of each organism.
4. Ask students to state the most common organism group found in their sample and to estimate the number of amoebae found in their sample. As a class, discuss potential reasons why the number of amoebae differs from group to group. Use this example to discuss why no method exists that accurately and reproducibly measures the number of amoebae in the water.
5. Prompt students to answer questions 3–5 in their group. Discuss the answers.
6. For homework, instruct students to design a public health awareness campaign using a most-wanted-type poster or a brochure that illustrates how to reduce the risk for acquiring their assigned waterborne disease. See Appendix 4.

Conclusion

Students use a public health scenario to learn about limnology, microbiology, and public health. By examining the life cycle of *N. fowleri*, students examine how environmental variation in the lake, such as temperature, nutrient availability, and geography, can affect the life cycle of an organism. Then, students learn how life-cycle changes can increase the risk for human infection leading to the disease called primary amebic meningoencephalitis. However, since no data exist to accurately estimate the true risk, students use critical thinking to formulate hypotheses that account for limitations in epidemiology and the laboratory.

Assessments

- Appendix 1A, Scenario Worksheet

Learning Outcomes Assessed:

- Explain how freshwater organisms, such as the brain-eating amoeba (*N. fowleri*), are affected by environmental variations (e.g., temperature, nutrient availability, geography, life-cycle stages).
- Describe limitations of epidemiological and laboratory evidence.
- Use critical thinking to construct an evidence-based explanation as to why a case of brain-eating infection may occur.

Description: This case study engages student curiosity as they investigate the cause of infection in a male aged 14 years.

- Appendix 5, Brain-Eating Amoeba Quiz

Learning Outcome Assessed:

- Explain how freshwater organisms, such as the brain-eating amoeba (*N. fowleri*), are affected by environmental variations (e.g., temperature, nutrient availability, geography, and life-cycle stages).

Description: This quiz of five multiple-choice questions gauges student knowledge of the brain-eating amoeba and should take approximately 10 minutes to complete.

Educational Standards

In this lesson, the following CDC Epidemiology and Public Health Science (EPHS) Core Competencies for High School Students¹, Next Generation Science Standards* (NGSS) Science & Engineering Practices², and NGSS Cross-cutting Concepts³ are addressed:

HS-EPHS1-2. Discuss how epidemiologic thinking and a public health approach is used to transform a narrative into an evidence-based explanation.

NGSS Key Science & Engineering Practice²

Obtaining, Evaluating and Communicating Information

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

NGSS Key Crosscutting Concept³

Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HS-EPHS2-4. Use patterns in empirical evidence to formulate hypotheses.

NGSS Key Science & Engineering Practice²

Asking Questions & Defining Problems

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information, that arise from examining models or a theory, to clarify and/or seek additional information and relationships, to determine relationships, including quantitative relationships, between independent and dependent variables, and to clarify and refine a model, an explanation, or an engineering problem.

NGSS Key Crosscutting Concept³

Patterns

Empirical evidence is needed to identify patterns.

HS-EPHS3-5. Make a claim about causality with consideration of a mathematical analysis of empirical data and Bradford Hill's Criteria for Causality.

NGSS Key Science & Engineering Practice²

Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

NGSS Key Crosscutting Concept³

Systems and System Models

Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

- ¹ Centers for Disease Control and Prevention (CDC). Science Ambassador Workshop—Epidemiology and Public Health Science: Core Competencies for high school students. Atlanta, GA: US Department of Health and Human Services, CDC; 2015. Not currently available for public use.
- ² NGSS Lead States. Next Generation Science Standards: For States, By States (Appendix F—Science and Engineering Practices). Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS. 2013. Available at: <http://www.nextgenscience.org/sites/ngss/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf>
- ³ NGSS Lead States. Next Generation Science Standards: For States, By States (Appendix G—Crosscutting Concepts). Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS. 2013. Available at: <http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf>.

Appendices: Supplementary Documents

Appendix 1B

Waterborne Disease Case Study Scenario Worksheet Answer Key

Name: _____ Date: _____

Directions: Read the following case study on a waterborne disease. Next, use the CDC Internet site (<http://www.cdc.gov>) to determine if the ameba responsible for the victim's death might have been *Dientamoeba fragilis*, *Acanthamoeba*, or *Naegleria fowleri*.

In Arizona, an adolescent male aged 14 years was enjoying the last of his summer days swimming in a northeastern Arizona lake. He was observed diving and splashing in shallow water. The water temperature on that day, September 8, was 86.3°F (30.2°C), and the air temperature was 108.0°F (42.2°C). Approximately 1 week later, on September 14, he experienced a severe headache, stiff neck, and fever. On September 16, he was hospitalized with possible meningitis (inflammation of the meninges of the brain). From a spinal tap, doctors observed an ameba in his cerebrospinal fluid by using a microscope. **Note:** The meninges are three layers of tissue that surround the brain and spinal cord to protect the central nervous system.

1. What is the name of the ameba responsible for the victim's death?

Answer: *Naegleria fowleri*. **Note:** Students should be able to deduce which ameba was responsible by the characteristics given in the scenario and the information provided on the CDC Internet site: <http://www.cdc.gov/>. For more details, see question 3.

2. How might have infection occurred?

Answer: Infection might have occurred as a result of swimming in the northeastern Arizona lake. Students can also consider some of the other possible sources before coming to this conclusion, including bodies of warm freshwater, such as lakes and rivers; geothermal (naturally hot) water, such as hot springs; warm water discharge from industrial plants; geothermal (naturally hot) drinking water sources; swimming pools that are poorly maintained, minimally chlorinated or unchlorinated; water heaters; and soil.

3. List at least three factors that led you to your answer in Question 1.

Answer: Explanations might include the following: infection might have occurred as a result of swimming in a lake in a U.S. state with a high number of case reports (5–9 cases); the optimal water temperature range for the growth of the brain-eating ameba is 45°C–55°C; average time of symptom onset is typically 5 days (range, 1–7 days); average time from symptom onset to death is 5.3 days (range, 1–12 days); early signs and symptoms include fever and headache; later signs and symptoms include neck stiffness and seizures; amebae in the trophozoite morphology were observed in the spinal fluid.

Appendix 2A

Waterborne Disease Case Study Graphic Organizer

Name: _____ Date: _____

Directions: Complete the case study graphic organizer.

After *Naegleria fowleri* (*N. fowleri*) was found in trophozoite form in the spinal fluid, the boy was diagnosed with primary amebic meningoencephalitis. To become more familiar with this waterborne disease, use this worksheet to organize your notes into five sections: (1) scientific name and life-cycle overview, (2) the cause-and-effect association between the environment and parasites, (3) diagnostics and treatment strategies, (4) surveillance and epidemiology, and (5) risk communication challenges. Use *N. fowleri* as an example in each section. Use the CDC Internet site on *N. fowleri* at <http://www.cdc.gov/parasites/naegleria/index.html> to find information; take notes with a partner.

Scientific name and life-cycle overview
<p>What is the common name for <i>N. fowleri</i>?</p> <p>Describe or illustrate the life cycle of the brain-eating ameba.</p>

Cause-and-effect association between the environment and parasites

How can the environment affect a parasite's life cycle?

State examples of environmental factors that can affect a parasite's life cycle:

What is the optimal temperature for growth of the brain-eating ameba?

How does the brain-eating ameba cause disease?

What is primary amebic meningoencephalitis (PAM)?

Diagnostics and treatment strategies

What are some diagnostic strategies for brain-eating amebic infection and PAM?

What are the treatment options for brain-eating ameba infection/PAM?

Surveillance and epidemiology

How many cases of PAM were reported during 1962–2014?

Who is most likely to be infected with this brain-eating ameba?

When is the most common time of the year to become infected with this brain-eating ameba?

Where is exposure to the brain-eating ameba most likely to occur?

Environmental prevention challenges

What are certain environmental concerns regarding *N. fowleri* infection?

Appendix 2B

Waterborne Disease Case Study Graphic Organizer Answer Key

Name: _____ Date: _____

Directions: Complete the case study graphic organizer.

After *Naegleria fowleri* (*N. fowleri*) was found in trophozoite form in the spinal fluid, the boy was diagnosed with primary amebic meningoencephalitis. To become more familiar with this waterborne disease, use this worksheet to organize your notes into five sections: (1) scientific name and life-cycle overview, (2) the cause-and-effect association between the environment and parasites, (3) diagnostics and treatment strategies, (4) surveillance and epidemiology, and (5) risk communication challenges. Use *N. fowleri* as an example in each section. Use the CDC Internet site on *N. fowleri* at <http://www.cdc.gov/parasites/naegleria/index.html> to find information; take notes with a partner.

Scientific name and life-cycle overview

What is the common name for *N. fowleri*?

Answer: Brain-eating ameba

Describe or illustrate the life cycle of the brain-eating ameba.

Answer: *N. fowleri* has three stages in its life cycle: ameboid trophozoites, flagellates, and cysts. The only infective stage of the ameba is the ameboid trophozoite. Trophozoites are 10–35 μm long, with a granular appearance and a single nucleus. The trophozoites replicate by binary division during which the nuclear membrane remains intact (a process called promitosis). Trophozoites infect humans or animals by penetrating the nasal tissue and migrating to the brain through the olfactory nerves, causing primary amebic meningoencephalitis (PAM).

Source: <http://www.cdc.gov/parasites/naegleria/pathogen.html>

Cause-and-effect association between the environment and parasites

How can the environment affect a parasite's life cycle?

Answer: Trophozoites can turn into a temporary, nonfeeding, flagellated stage (10–16 μm long) when stimulated by adverse environmental changes, such as a reduced food source. If the environment is not conducive to continued feeding and growth (e.g., cold temperatures and scarce food), the amoeba or flagellate forms a cyst. The cyst form is spherical and 7–15 μm in diameter. It has a smooth, single-layered wall with a single nucleus. Cysts remain resistant to environmental stresses to increase their chance of survival until better conditions occur.

Source: <http://www.cdc.gov/parasites/naegleria/pathogen.html>

State examples of environmental factors that can affect a parasite's life cycle:

Answer: Examples include cold temperatures or food scarcity.

What is the optimal temperature for growth of the brain-eating amoeba?

Answer: *N. fowleri* grows best at higher temperatures up to 115°F (46°C). Although the amoeba might not be able to grow well, *N. fowleri* can still survive at even higher temperatures for limited periods. The trophozoites and cysts can survive from minutes to hours at 122°F–149°F (50°C–65°C), with the cysts being more resistant to these higher temperatures. Although trophozoites are killed rapidly by refrigeration, cysts can survive for weeks to months at cold temperatures, but they appear to be sensitive to freezing temperatures. Consequently, colder temperatures are likely to cause *N. fowleri* to encyst in lake and river sediment, which offers more protection from cold and freezing water temperatures.

Source: <http://www.cdc.gov/parasites/naegleria/pathogen.html>

How does the brain-eating amoeba cause disease?

Answer: The amoeba infects humans when contaminated water enters the body through the nose. It then travels up the olfactory nerve to the brain, where it causes PAM. Contaminated water can come from different types of untreated water sources.

What is primary amoebic meningoencephalitis (PAM)?

Answer: Answers will vary. PAM is an acute disease that rapidly leads to death in approximately all cases. Only 3 of 133 U.S. patients have survived the infection. On average, humans die <10 days after exposure to the amoeba. The disease presents much like bacterial meningitis, which can lead to delayed diagnosis and treatment. In approximately 25% of cases, the trophozoites were observed in the cerebrospinal fluid while the patient was still alive, but more often, the diagnosis is not made until after the patient dies and an autopsy is performed. In those cases, the amoeba is usually observable in tissue sections of the brain.

Diagnostics and treatment strategies

What are some diagnostic strategies for brain-eating amebic infection and PAM?

Answer: Answers will vary. Diagnostic strategies include (1) direct visualization (motile trophozoites observed in the cerebrospinal fluid), (2) immunohistochemistry (antibody staining of the amebae in tissue), (3) polymerase chain reaction testing (detecting ameba DNA), and (4) culture (amebae grown by using bacteria as a food source and incubating at high temperature).

What are the treatment options for brain-eating ameba infection/PAM?

Answer: Treatment includes a combination of antibiotics and an investigational drug (miltefosine). The documented survival rate when using the combination or cocktail of antibiotics is 2% (3 of 133 cases). Miltefosine has been used in other ameba infections and appears to improve survival rates.

Surveillance and epidemiology

How many cases of PAM were reported during 1962–2014?

Answer: The number of cases of PAM reported during 1962–2014 was 133, with a range of 0–8 infections/year.

Who is most likely to be infected with this brain-eating ameba?

Answer: Male children. The median age of patients reported is 11 years, and 77% were male.

When is the most common time of the year to become infected with this brain-eating ameba?

Answer: The most common months of illness onset are July and August, with a range of April–November.

Where is exposure to the brain-eating ameba most likely to occur?

Answer: The most probable water exposure sources are lakes, ponds, and reservoirs (untreated fresh water). Texas and Florida have the highest number of reported cases in the United States.

Environmental prevention challenges

What are certain environmental concerns regarding *N. fowleri* infection?

Answer: A major concern is that as water temperatures increase worldwide, the geographic range of brain-eating ameba is anticipated to shift northward. Another concern is moderate chlorine resistance, which affects water treatment as a prevention measure.

Appendix 3A

Waterborne Disease Case Study Laboratory Exploration

Name: _____ Date: _____

Directions: In groups of 3–4, complete the case study laboratory exploration.

Assume that the samples provided are from the northeastern Arizona lake where the boy with brain-eating ameba was swimming. Pretend you are a team of microbiologists. Each team will receive a sample to observe. With your team, create wet-mount slides of your water sample. Use the microscopes to explore organisms in your sample. In the spaces below, draw the organisms you see. Be sure to include the magnification level. Next, to identify the scientific name of the organism, use the Pond Life Identification Kit at <http://www.microscopy-uk.org.uk/index.html>?<http://www.microscopy-uk.org.uk/pond/index.html> and <http://www.microscopy-uk.org.uk/index.html>?<http://www.microscopy-uk.org.uk/pond/protozoa.html>.

Table 1: Organisms in your sample

Picture: Organism Group: _____ Magnification: _____	Picture: Organism Group: _____ Magnification: _____
Picture: Organism Group: _____ Magnification: _____	Picture: Organism Group: _____ Magnification: _____

<p>Picture:</p> <p>Organism: _____</p> <p>Magnification: _____</p>	<p>Picture:</p> <p>Organism: _____</p> <p>Magnification: _____</p>
<p>Picture:</p> <p>Organism Group: _____</p> <p>Magnification: _____</p>	<p>Picture:</p> <p>Organism Group: _____</p> <p>Magnification: _____</p>
<p>Picture:</p> <p>Organism Group: _____</p> <p>Magnification: _____</p>	<p>Picture:</p> <p>Organism Group: _____</p> <p>Magnification: _____</p>

Appendix 3B

Waterborne Disease Case Study Laboratory Exploration Answer Key

Name: _____ Date: _____

Directions: In groups of 3–4, complete the case study laboratory exploration.

Assume that the samples provided are from the northeastern Arizona lake where the boy with brain-eating ameba was swimming. Pretend you are a team of microbiologists. Each team will receive a sample to observe. With your team, create wet-mount slides of your water sample. Use the microscopes to explore organisms in your sample. In the spaces below, draw the organisms you see. Be sure to include the magnification level. Next, to identify the scientific name of the organism, use the Pond Life Identification Kit at <http://www.microscopy-uk.org.uk/index.html>?<http://www.microscopy-uk.org.uk/pond/index.html> and <http://www.microscopy-uk.org.uk/index.html>?<http://www.microscopy-uk.org.uk/pond/protozoa.html>.

Table 1: Organisms in your sample

Picture: Organism Group: _____ Magnification: _____	Picture: Organism Group: _____ Magnification: _____
Picture: Organism Group: _____ Magnification: _____	Picture: Organism Group: _____ Magnification: _____

<p>Picture:</p> <p>Organism: _____</p> <p>Magnification: _____</p>	<p>Picture:</p> <p>Organism: _____</p> <p>Magnification: _____</p>
<p>Picture:</p> <p>Organism Group: _____</p> <p>Magnification: _____</p>	<p>Picture:</p> <p>Organism Group: _____</p> <p>Magnification: _____</p>
<p>Picture:</p> <p>Organism Group: _____</p> <p>Magnification: _____</p>	<p>Picture:</p> <p>Organism Group: _____</p> <p>Magnification: _____</p>

Questions

1. What was the most common organism found?

Answer: Answers will vary.

2. Approximately, how many amoebae were in your sample?

Answer: Answers will vary.

3. If *N. fowleri* was not found in the lake samples in the case of the Arizona male, it might still have been possible for infection to be caused by *N. fowleri*.

- a. Explain why the male was diagnosed with primary amoebic meningoencephalitis likely caused by *N. fowleri*.

Answer: The laboratory test results from the spinal fluid confirmed that the male was infected with *N. fowleri*. He presented with early symptoms of primary amoebic meningoencephalitis, such as fever and headache, within the average time of symptom onset. He later presented with neck stiffness.

- b. Why was swimming in the lake the likely cause of *N. fowleri* infection?

Answer: Answers can include: Swimming in warm freshwater lakes is the most common type of exposure that leads to the brain-eating amoeba infection. However, the water temperature on that day, September 8, 2007, was 86.3°F (30.2°C), which was not within the optimal water temperature range for the growth of *N. fowleri* (45°C–55°C).

Note: Consider discussing what epidemiologists might do at this stage. For example, epidemiologists would systematically identify other cases in the area and look at the distribution (e.g., person, place, and time) and possible determinants of infection (i.e., other sources of infection, including bodies of warm freshwater, such as lakes and rivers; geothermal water, including hot springs; warm water discharge from industrial plants; geothermal drinking water sources; swimming pools that are poorly maintained, minimally chlorinated or unchlorinated; water heaters; and soil) across cases.

4. If *N. fowleri* were present in the lake samples in the case of the Arizona boy, explain why more people were not infected. Hint: consider the organism's life cycle and influencing environmental factors (e.g., climate, water pH, nutrient availability, and spatiality).

Answer: Multiple factors are needed that must come together at the same time to result in infection. *N. fowleri* infects person when water containing the amoeba enters the body through the nose, and *N. fowleri* must be in an infective life-cycle stage. Life-cycle stages are influenced by environmental factors that affect an organism's ability to feed, grow, and survive. Humans will not be infected if the water ingested does not contain the amoeba, if life cycle conditions are not ideal for infection, or if the water is ingested other than through the nose.

5. Explain why CDC does not recommend testing rivers and lakes for *N. fowleri*.

Answer: The amoeba is naturally occurring and no established relationship between detection or concentration of *N. fowleri* and risk for infection is known.

6. *N. fowleri* infections are rare. During 2005–2014, a total of 35 infections were reported in the United States. Of those cases, 31 persons were infected by contaminated recreational water. What are some more likely dangers related to swimming in recreational water, such as a lake?

Answer: Drowning; infection (e.g., leptospirosis, swimmers itch [cercarial dermatitis], giardiasis, cryptosporidiosis, cholera, shigellosis, norovirus, and *Escherichia coli* infections, including *E. coli* O157:H7 infections); wound infections (e.g., the flesh-eating bacteria *Aeromonas*); diving hazards and other water-related injuries. (Answers will vary.)

Appendix 4

Waterborne Disease Case Study Public Awareness Campaign

Name: _____ Date: _____

Directions: Create a public awareness campaign through a most-wanted-type poster or a brochure that illustrates how to reduce the risk for acquiring a particular waterborne disease.

1. Choose and circle a recreational water illness from the following
 - “Crypto” (*Cryptosporidium*)
 - *Giardia*
 - Hot tub rash
 - *Legionella*
 - Swimmer's ear (otitis externa)
 - Head lice
 - Methicillin-resistant *Staphylococcus aureus*
 - Pinworm
2. Complete the graphic organizer below by using the CDC Internet site concerning Recreational Water Illnesses and Prevention Tips: <http://www.cdc.gov/healthywater/swimming/rwi/illnesses/index.html>.

What is it?	
Why should you be concerned about it?	
How is it spread in aquatic facilities?	
How do you protect yourself and your family?	

3. Use your graphic organizer to create a public awareness campaign through a most-wanted-type poster or a brochure that illustrates how to reduce the risk for acquiring a particular waterborne disease.

Appendix 5A

Brain-Eating Ameba Quiz

Name: _____ Date: _____

Directions: Circle the best answer for each question.

1. The scientific name of the brain-eating ameba is . . .
 - a. *Haemophilus influenzae*.
 - b. *Escherichia coli*.
 - c. *Naegleria fowleri*.
 - d. *Salmonella typhi*.
2. From the case study, *this pathogen is detected in* . . .
 - a. skin.
 - b. hair.
 - c. bones.
 - d. cerebrospinal fluid.
3. Which of the following is NOT a morphologic stage of *this pathogen's* life cycle?
 - a. Cyst
 - b. Polyp (Answer)
 - c. Trophozoite
 - d. Flagellate
4. The optimal temperature range for the growth of this pathogen is . . .
 - a. 45°C –55°C.
 - b. 10°C –20°C.
 - c. 25°C –45°C.
 - d. 75°C –90°C.
5. Which of the following can reduce your risk for becoming infected with PAM?
 - a. Avoid swimming in lakes and ponds during periods of high water temperature.
 - b. Hold your nose shut, use nose clips, or keep your head above water when taking part in water-related activities in bodies of warm fresh water.
 - c. Avoid disrupting the sediment (digging or stirring) while taking part in water-related activities in shallow, warm freshwater areas.
 - d. All of the above.

Appendix 5B

Brain-Eating Ameba Quiz Answer Key

Name: _____ Date: _____

Directions: Circle the best answer for each question.

1. The scientific name of the brain-eating ameba is . . .
 - e. *Haemophilus influenzae*.
 - f. *Escherichia coli*.
 - g. *Naegleria fowleri*. (Answer)
 - h. *Salmonella typhi*.
2. From the case study, *this pathogen is detected* in . . .
 - e. skin.
 - f. hair.
 - g. bones.
 - h. cerebrospinal fluid. (Answer)
3. Which of the following is NOT a morphologic stage of *this pathogen's* life cycle?
 - e. Cyst
 - f. Polyp (Answer)
 - g. Trophozoite
 - h. Flagellate
4. The optimal temperature range for the growth of this pathogen is . . .
 - e. 45°C –55°C. (Answer)
 - f. 10°C –20°C.
 - g. 25°C –45°C.
 - h. 75°C –90°C.
5. Which of the following can reduce your risk for becoming infected with PAM?
 - e. Avoid swimming in lakes and ponds during periods of high water temperature.
 - f. Hold your nose shut, use nose clips, or keep your head above water when taking part in water-related activities in bodies of warm fresh water.
 - g. Avoid disrupting the sediment (digging or stirring) while taking part in water-related activities in shallow, warm freshwater areas.
 - h. All of the above. (Answer)

Introduction to Emerging Pathogens: Lesson 1 - What's in the Water?

Teacher: Susan Chabot

Date: June 2017

Subject/Grade level: Biology 9-12; Environmental Science 9-12; Anatomy & Physiology 10-12 general/honors

Materials:

Load YouTube Video Clip (3:51) Monsters Inside Me – Outbreak of Cryptosporidium

Discussion questions on board/overhead/printed for students during video

Microbe Question and Answer Cards (1 card per student, part of kit from UF CPET)

Giant Microbe Set (15 microbes/1 per student pair) – water-borne infections

Ear ache (*Streptococcus pneumonia*)

Stomach ache (*Shigella spp.*)

Flesh-eating (*Streptococcus pyogenes*)

Staph (*Staphylococcus aureus*)

Polio (Poliovirus)

C. diff (*Clostridium difficile*)

Typhoid fever (*Salmonella typhi*)

Listeria (*Listeria monocytogenes*)

E. coli infection (*Escherichia coli*)

Salmonella infection (*Salmonella typhimurium*)

Food poisoning (*Bacillus cereus*)

Cholera (*Vibrio cholera*)

Brain-eating amoeba (*Naegleria fowleri*)

Botulism (*Clostridium botulinum*)

Giardia (*Giardia lamblia*)

What's in the Water? Student Worksheet – Appendix A

What's in the Water? Microbe Matches – Appendix B

Florida NGSSS

- SC.912.N.3.5: Describe the function of models in science and identify the wide range of models used in science.
- SC.912.L.14.6: Explain the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspectives of both individual and public health.
- HE.912.C.1.8: Analyze strategies for prevention, detection, and treatment of communicable and chronic diseases.

Lesson objective(s):

- Define a pathogen.
- Explain how microorganisms impact human health.
- Describe the different water-borne pathogens that impact human health.

ENGAGEMENT

8-10 mins for video and discussion

- Introductory Video (Time: 3:31) to emerging infection from water-borne pathogen, Cryptosporidium
<https://www.youtube.com/watch?v=ebjG6N7JlQs>
- Follow-up questions for discussion.
 1. How many people were infected with the parasite?
 2. Where did this outbreak occur?

Introduction to Emerging Pathogens: Lesson 1 - *What's in the Water?*

3. What is the name of the pathogen?
4. What was considered the source? Be specific.
5. What does Dr. Fayer believe caused the outbreak?
6. What samples did they use to test Dr. Fayer's hypothesis?
7. What were the results? What was the source?
8. Were cows responsible for this outbreak?
9. How is water treated in Milwaukee now?

EXPLANATION

Tell the students they are going to participate in an activity to learn more about pathogenic microbes and how they impact human health. By the end of the lesson, students should be able to answer the following questions:

- What is a microorganism? What is a pathogen? How are they related?
- Why is it important for scientists to learn about infections?
- Why is it important for scientists to learn specifically about water-borne infections?

EXPLORATION

5 minutes for specific questions on microorganisms

- Big Idea Questions
1. What is a microorganism?
 2. What is a pathogen?
 3. How do microorganisms impact human health?
 4. How common are water-borne infections?

ELABORATION

20-25 minutes for instructions, student match-up, and Part A of Student Worksheet/Appendix A

- What's in the Water Microbe Activity
Organisms available through CPET University of Florida (hand-select pack)
- During this activity, students then read their card and ask fellow classmates questions to match the appropriate question and answer cards.
- After matched, partners seek to identify the correct Giant Microbe for their disease/pathogen combination.
- Partners prepare a 2-minute presentation to provide fellow classmates with highlights of their pathogen/disease.
- Students complete Part B of Student Worksheet/Appendix A and may need to finish for homework.

EVALUATION

- Students will complete the discussion questions following the intro video clip.
- Students will successfully find their Q&A match and complete Part A of the Student Worksheet.
- Following student presentations, students will complete Part B of the Student Worksheet.
- Students will demonstrate at minimum a 75% proficiency on Lesson 1 Summative Assessment/Quiz on pathogens, microorganisms, and water-borne infections.

Introduction to Emerging Pathogens: Lesson 1 - *What's in the Water?*

PRODUCT NAME	UNIT PRICE	QTY	SUBTOTAL
 Ear Ache (<i>Streptococcus pneumoniae</i>)	\$7.95	<input type="text" value="1"/>	\$7.95 <input type="button" value="x"/>
 Stomach Ache (<i>Shigella</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Flesh Eating (<i>Streptococcus pyogenes</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Staph (<i>Staphylococcus aureus</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Polio (<i>Poliovirus</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Typhoid Fever (<i>Salmonella typhi</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Listeria (<i>Listeria monocytogenes</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 E. coli (<i>Escherichia coli</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Salmonella (<i>Salmonella typhimurium</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Food Poisoning (<i>Bacillus cereus</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Cholera (<i>Vibrio cholerae</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Brain-Eating Amoeba (<i>Naegleria fowleri</i>) Petri Dish	\$19.95	<input type="text" value="1"/>	\$19.95 <input type="button" value="x"/>
 Botox / Botulism (<i>Clostridium botulinum</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Giardia (<i>Giardia lamblia</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Red Tide (<i>Alexandrium tamarense</i>)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Superbug & Friends	\$19.95	<input type="text" value="1"/>	\$19.95 <input type="button" value="x"/>

[SHOP ALL](#)

[UPDATE QUANTITIES](#)

Subtotal 16 Item(s):

\$177.20

Introduction to Emerging Pathogens: Lesson 1 - *What's in the Water?*

Video Questions - Monsters Inside Me – Outbreak of Cryptosporidium

1. How many people were infected with the parasite?
2. Where did this outbreak occur?
3. What is the name of the pathogen?
4. What was considered the source? Be specific.
5. What does Dr. Fayer believe caused the outbreak?
6. What samples did they use to test Dr. Fayer's hypothesis?
7. What were the results? What was the source?
8. Were cows responsible for this outbreak?
9. How is water treated in Milwaukee now?

Video Questions - Monsters Inside Me – Outbreak of Cryptosporidium

1. How many people were infected with the parasite?
2. Where did this outbreak occur?
3. What is the name of the pathogen?
4. What was considered the source? Be specific.
5. What does Dr. Fayer believe caused the outbreak?
6. What samples did they use to test Dr. Fayer's hypothesis?
7. What were the results? What was the source?
8. Were cows responsible for this outbreak?
9. How is water treated in Milwaukee now?

Introduction to Emerging Pathogens: Lesson 1 - *What's in the Water?*

Video Questions KEY- Monsters Inside Me – Outbreak of Cryptosporidium

1. How many people were infected with the parasite?
400,000
2. Where did this outbreak occur?
Milwaukee
3. What is the name of the pathogen?
Cryptosporidium
4. What was considered the source? Be specific.
Local cattle, runoff from a local farm. Melting snow allowed for infection cattle feces to flow into the water and then infect people.
5. What does Dr. Fayer believe caused the outbreak?
Human infection
6. What samples did they use to test Dr. Fayer's hypothesis?
Stool samples from 1993 outbreak from infected people.
7. What were the results? What was the source?
Found that DNA fingerprint matched a species carried by people. Isolated sewage leak allowed infected human species to enter local water supplies and drinking supplies.
8. Were cows responsible for this outbreak?
NO. Cattle are not involved in cycle. Carried from human to people
9. How is water treated in Milwaukee now?
Ozone treatment – Milwaukee now has the cleanest water in the country

Introduction to Emerging Pathogens: Lesson 1 - *What's in the Water?*

Water-borne Microbe Questions and Answers Game

1. Ear ache (*Streptococcus pneumoniae*)

1. Q: This bacterium causes acute otitis media. Symptoms include ear pain, redness, and fever. This bacterium is responsible for causing the most common health ailment in young children. Nearly every child gets this health ailment at least once and most get it several times. This health ailment is the number one cause of emergency room admission each year and is also responsible for more antibiotic prescriptions than any other condition. What is this bacterium and what is the common name for this illness?

A: *Streptococcus pneumoniae* causes ear aches (otitis media). Ear aches are more commonly found in children because of their high susceptibility to upper-respiratory infections. Also, children's ear tubes are shorter and straighter than adult ear tubes, which provides bacteria with easier access. Although there is an antibiotic for ear aches, *S. pneumoniae* is beginning to adapt.

2. Stomach ache (*Shigella*)

2. Q: This microbe causes an intestinal tract infection that produces abdominal cramps, fever, and diarrhea. It is extremely contagious. In fact, it is so contagious that if even 10 individual bacteria get into your system, you can become infected! What is the name of this bacterium and what does it cause?

A: *Shigella* is an extremely contagious microbe that causes stomach aches. Over 140 million people are infected by *Shigella* every year. It is responsible for 10 to 20% of the cases of diarrhea worldwide. If you are infected, it is important to stay hydrated. Currently, there is no vaccine available to prevent shigellosis. The best way to prevent being infected is to wash your hands frequently.

3. E. Coli (*Escherichia coli*)

3. Q: Multiple strains of this bacterium exist. Most are harmless and are present in large numbers in the human and animal gut; however, some can make you sick. This bacterium can twirl its flagella around, propelling it forward at the bacterial-equivalent speed of a torpedo. Under ideal conditions, these bacteria can divide every 20 minutes; a single cell can become over a billion in less than 10 hours! What is the name of this bacterium?

A: Most strains of *E. coli* (*Escherichia coli*) are harmless. However, certain strains of this fast moving bacterium can cause food poisoning. Contamination typically occurs at the slaughterhouse, when cattle's internal bacteria are inadvertently brought into contact with the beef's surface. Because *E. coli* contamination requires very few bacteria, contaminated meat looks and smells normal.

Introduction to Emerging Pathogens: Lesson 1 - *What's in the Water?*

4. Flesh Eating (*Streptococcus pyogenes*)

4. Q: This bacterium causes one of the fastest-spreading infections known. It is very rare, and because its initial symptoms are similar to the flu, more often than not its diagnosis is tragically delayed. This bacterium is passed from person to person through physical contact. If a person has a skin injury- as small as a pinprick or scratch- this bacteria can enter. The infection can destroy skin, fat, and the tissue covering the muscles. Without immediate medical care, toxic shock sets in. What is the name of this bacterium?

A: *Streptococcus pyogenes*, commonly known as “flesh eating disease,” refers to a rare infection that leads to the destruction of the “fibrous tissues.” Typically, originating from a skin injury, the bacterium causes great pain and discomfort within 24 hours of infection. Approximately 50% of the people who contract this disease are in good health prior to infection; nonetheless, about 1 in 4 people die from it.

5. Staph (*Staphylococcus aureus*)

5. Q: This bacterium can often be found living harmlessly on human skin. If it gets into your bloodstream, however, it can cause a variety of infections that range from a simple boil to flesh-eating infections. The difference in the severity of infection is dependent on how deep it goes, how fast it spreads, and how resistant it is to antibiotic treatment. Patients undergoing surgery are at significantly increased risk for infection, because their skin-barrier is compromised and their immune systems are typically suppressed. What is the name of this bacterium?

A: Staph bacterium, *Staphylococcus aureus*, causes a slew of common infections that are commonly acquired by patients undergoing surgery. Antibiotics are used to treat staph infections. But there has been a gradual change in how well these antibiotics work. While most staph infections used to be treatable with penicillin, that changed in the 1980s and stronger antibiotics are now used. In about 50% of cases, however, resistance is seen to even these stronger antibiotics. These cases are not just happening in hospitals -- as once was true -- but now are occurring in the general community.

6. Polio (*Poliovirus*)

6. Q: Up to 95% of persons infected with this virus will have no symptoms. About four to eight percent of infected persons have minor symptoms such as fever, fatigue, nausea, headache, flu-like symptoms, stiffness in the neck and back, and pain in the limbs which often resolves completely. Less than one percent of these cases result in permanent paralysis of the limbs (usually the legs). Of those paralyzed, 5-10% die when the paralysis strikes the respiratory muscles. What is the name of this viral disease?

A: Poliomyelitis (polio) is a highly infectious disease caused by a virus that invades the nervous system. Only 5% of those that are infected display symptoms. Poliovirus is transmitted through contact with an infected person. There are two types of vaccine that can prevent polio: inactivated polio vaccine (IPV) and oral polio vaccine (OPV). IPV has been used in the United States since 2000; however OPV is still used throughout much of the world.

Introduction to Emerging Pathogens: Lesson 1 - *What's in the Water?*

7. Listeria, *Listeria monocytogenes*

7. Q: This serious infection has recently been recognized as an important public health problem in the United States. The infection can be caused by eating fresh meats and vegetables that have been exposed to a certain bacterium. Elderly people, pregnant women, newborns, and adults with weakened immune systems are most susceptible to contamination. Symptoms of infection include fever, muscle aches, nausea, or diarrhea. If infection continues to spread headache, stiff neck, confusion, loss of balance, or convulsions may occur. What is this infection and what bacterium causes it?

A: Listeriosis is caused by the bacterium *Listeria* (*Listeria monocytogenes*). This bacterium is commonly found on vegetables grown in soil that has been fertilized with manure. Animals can also carry *Listeria monocytogenes* without appearing ill and can contaminate foods of animal origin such as meats and dairy products. To reduce risk of infection, thoroughly cook raw food from animal sources, such as beef, pork, or poultry; wash raw vegetables thoroughly before eating; avoid unpasteurized (raw) milk or foods made from unpasteurized milk; and wash hands, knives, and cutting boards after handling uncooked foods. In the United States, an estimated 2,500 persons become seriously ill with listeriosis each year. Of these, 500 die.

8. C. Diff (*Clostridium difficile*)

8. Q: This bacterium causes diarrhea and serious intestinal conditions such as colitis. The elderly and individuals with preexisting health conditions that require the prolonged use of antibiotics are at a greater risk of acquiring this disease. These bacteria are commonly found in the feces and spread through the contact of infected surfaces. Healthcare workers can spread these bacteria to other patients or contaminate surfaces through hand contact. What is the name of this bacterium?

A: *Clostridium difficile* is a bacterium that can cause colitis, more serious intestinal conditions, sepsis, and rarely death. The infection is most common in people who are taking antibiotics while in the hospital. The large intestine normally contains many good bacteria that keep it healthy and do not cause disease. Antibiotics taken to kill bacteria that do cause disease also kill the good bacteria. This may allow *C. difficile* bacteria to grow in the large intestine and release harmful substances called toxins. Hand-washing and hygienic restrooms help prevent infection and spread of this bacterium

9. Giardia (*Giardia lamblia*)

9. Q: This illness is an infection of the intestines caused by a parasite and is most often a problem in undeveloped countries where tap water is not safe. After a person is exposed to the parasite, it usually takes 7 to 10 days for the infection to develop. This parasite can be passed to others during the entire period of infection. Symptoms include bloating, nausea, vomiting, and fatigue. You may be infected for months, even if you don't have symptoms. What is the name of this parasitic disease?

A: *Giardia* is caused by the parasite, *Giardia lamblia*. You may become infected with giardia if you eat food or drink water that is tainted with human or animal waste. This infection is most common in developing nations; however, in the United States you can get giardia by drinking untreated water from wells, streams, rivers, and lakes. This is true even in mountain lakes and streams where the water may seem very pure.

**Introduction to Emerging Pathogens:
Lesson 1 - What's in the Water?**

10. Typhoid Fever (*Salmonella typhi*)

10. Q: Persons with this illness carry the bacteria in their bloodstream and intestinal tract. In addition, a small number of people, called carriers, recover from the illness but continue to carry the bacteria. Both ill persons and carriers shed bacteria in their feces. Once these bacteria are consumed, they multiply and spread into the bloodstream. Symptoms associated with this infection include fever, diarrhea, weight loss, sore throat, rash, exhaustion, and a distended abdomen. What is the name of this bacterial illness?

A: Typhoid fever is a life-threatening illness caused by the bacterium *Salmonella typhi*. You can get typhoid fever if you eat food or drink beverages that have been handled by a person who is shedding the bacterium or if sewage contaminated with *S. typhi* bacteria gets into the water you use for drinking or washing food. Therefore, typhoid fever is more common in areas of the world where hand-washing is less frequent and water is likely to be contaminated with sewage.

11. Salmonella (*Salmonella typhimurium*)

11. Q: These bacteria are among the leading causes of food poisoning in the world. It is very common and can be found in many foods. The most popular habitats include poultry and eggs. The infections typically occur after an incubation period of 6 to 48 hours, lasts less than a week and requires no medical treatment, unless in severe cases with victims who are young, old, or have an impaired immune system. What is this bacteria?

A: *Salmonella typhimurium* causes gastroenteritis in humans and other mammals. When the bacterial cells enter epithelial cells lining the intestine they cause host cell ruffling which temporarily damages the microvilli on the surface of the cell. This causes a rush of white blood cells into the mucosa, which throws off the ratios between absorption and secretion, and leads to diarrhea.

12. Food poisoning (*Bacillus cereus*)

12. Q: This bacteria produces toxins which can cause two types of illnesses: diarrheal and emetic. Diarrheal is least common and characterized by diarrhea and abdominal cramps. This is typically from eating infected milk, meat and fish. Emetic is characterized by nausea and vomiting, most typically found in rice and other starchy products. What is this bacteria?

A: *Bacillus cereus* (food poisoning) is the general description, although two recognized types of illness are caused by two distinct metabolites. The diarrheal type of illness is caused by a large molecular weight protein, while the vomiting (emetic) type of illness is believed to be caused by a low molecular weight, heat-stable peptide. In food animals such as chickens and pigs, harmless strains of *B. cereus* are used as a probiotic feed additive to reduce *Salmonella* in the intestines and cecum. This improves the animals' growth as well as food safety for humans who eat their meat.

**Introduction to Emerging Pathogens:
Lesson 1 - What's in the Water?**

13. Cholera (*Vibrio cholerae*)

13. Q: Although this illness is not nearly as prevalent as it was many years ago, it is most common in undeveloped regions of the world. The bacteria that cause this disease acts by releasing a toxin that stimulates the expulsion of water and electrolytes from the cells in the lining of the small intestine. Symptoms of this disease include watery diarrhea which can result in severe dehydration and dangerously low blood pressure. Hydration and replenishing of electrolytes are crucial to treating this illness. What is the name of this bacterial illness?

A: Cholera is a bacterial disease caused by *Vibrio cholera*. You can contract cholera through various sources of infection such as drinking water contaminated with the bacteria, contact with infected fecal matter, or consumption of seafood contaminated with *Vibrio cholera*. Cholera is a more common occurrence in underdeveloped regions where poor sanitation and limited access to clean water is a significant problem.

14. Brain-Eating Amoeba (*Naegleria fowleri*)

14. Q: These microbes are found in warm bodies of water across the globe. Though very deadly, infections are rare, approximately 300 cases have been reported, though only seven of those individuals have survived. Those who fall victim to this infection usually have a life expectancy of less than two weeks. The microbe swills red and white blood cells as they feast on critical body tissue. What is this?

A: Though called Brain-Eating Ameoba, *Naegleria fowleri* is not technically an amoeba, but can morph into three different body shapes. If pH levels or ionic concentrations change it can transform into a flagellate, growing little tails to propel to new environments. If there is a drop in food supply or temperature, it can transform into a cyst. Otherwise, it stays as an amoeboid trophozoite to stalk bacterial prey.

15. Giardia (*Giardia lamblia*)

15. Q: This illness is an infection of the intestines caused by a parasite and is most often a problem in undeveloped countries where tap water is not safe. After a person is exposed to the parasite, it usually takes 7 to 10 days for the infection to develop. This parasite can be passed to others during the entire period of infection. Symptoms include bloating, nausea, vomiting, and fatigue. You may be infected for months, even if you don't have symptoms. What is the name of this parasitic disease?

A: Giardia is caused by the parasite, *Giardia lamblia*. You may become infected with giardia if you eat food or drink water that is tainted with human or animal waste. This infection is most common in developing nations; however, in the United States you can get giardia by drinking untreated water from wells, streams, rivers, and lakes. This is true even in mountain lakes and streams where the water may seem very pure.

Introduction to Emerging Pathogens: Lesson 1 - What's in the Water?

Name _____

Date _____

Introduction to Emerging Pathogens Lesson 1 - What's in the Water

Part A: Partner Work

Directions: Answer the following questions with your partner once you have found your microbe.

1. What is a microorganism? _____

2. What is a pathogen? _____

3. What pathogen do you have? _____
4. Is your pathogen a bacteria? A virus? A protozoan? A algae? _____
5. Describe the symptoms and details of your pathogen. This information will come from both Question and Answer cards.

6. Sketch your microbe in the box.



Introduction to Emerging Pathogens: Lesson 1 - What's in the Water?

Name _____

Date _____

Introduction to Emerging Pathogens Lesson 1 - What's in the Water

Part B: Independent Work

Directions: Answer questions below as your classmates present their pathogen/disease.

Select 1 bacteria, virus, parasite to describe in the table below.

Identification	Why did you select this example?	How does this microbe effect humans?
Bacterium:		
Virus:		
Parasite:		

7. Are all microorganisms pathogens? Provide 2 examples of microorganisms that are helpful or useful to humans.

Introduction to Emerging Pathogens: Lesson 1 - What's in the Water?

Name _____ KEY _____

Date _____

Introduction to Emerging Pathogens Lesson 1 - What's in the Water

Part A: Partner Work

Directions: Answer the following questions with your partner once you have found your microbe.

1. What is a microorganism? Microscopic organisms that are invisible to the naked eye; include bacteria, protozoans, viruses, some algae and some fungi.
2. What is a pathogen? Disease-causing microorganism
3. What pathogen do you have? Answers will vary
4. Is your pathogen a bacteria? A virus? A protozoan? A algae? Answers will vary
5. Describe the symptoms and details of your pathogen. This information will come from both Question and Answer cards.

Answers will vary

6. Sketch your microbe in the box.



**Introduction to Emerging Pathogens:
Lesson 1 - What's in the Water?**

KEY Continued

Part B: Independent Work

Directions: Answer questions below as your classmates present their pathogen/disease.

Select 1 bacteria, virus, parasite to describe in the table below.

Identification	Why did you select this example?	How does this microbe effect humans?
Bacterium:		
Virus:		
Parasite:		

1. Are all microorganisms pathogens? Provide 2 examples of microorganisms that are helpful or useful to humans.

Answers will vary. Ex: probiotics in yogurt and supplements that help us digest our food; yeast and bacteria normally found on our skin and mucus membraned for protection; antibiotics provided from naturally occurring sources in the soil.

Introduction to Emerging Pathogens: Lesson 2 – ID of the Brain-Eating Amoeba

Teacher: Susan Chabot

Date: June 2017

Subject/Grade level: Biology 9-12; Environmental Science 9-12; Anatomy & Physiology 10-12 general/honors

Materials:

- Computers with Internet access
<https://www.koshland-science-museum.org/explore-the-science/interactives/brain-anatomy>
- Modeling clay for Brain Region Modeling
6 colors – yellow, purple, blue, red, green, orange
- Toothpicks for ID flags
- CDC Lesson Guide for Brain-Eating Amoeba
<https://www.cdc.gov/careerpaths/scienceambassador/documents/hs-brain-eating-ameba-2013.pdf>
This lesson is offered in 2 parts and accompanying worksheets are included in the Lesson Guide.
GREAT teacher summary for more information on *N. fowleri* infection.
Lesson Guide also includes advance preparation notes and talking points for activity discussion.
- Water samples from local untreated water sources (lakes, ponds, ditches) or prepared slides of appropriate organisms
- Compound microscopes
- PPE – gloves and goggles
- Well slides and coverslips
- Dichotomous key for lake/pond organism identification
<http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/pond/index.html>
<http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/pond/protozoa.html>
- Banner paper or Large Post-It notes for public Health Campaign
- Markers

Florida NGSSS

- SC.912.L.14.26: Identify the major parts of the brain on diagrams or models.
- SC.912.L.14.4: Compare and contrast structure and function of various types of microscopes.
- SC.912.L.14.52: Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics.
- SC.912.L.15.4: Describe how and why organisms are hierarchically classified and based on evolutionary relationships.
- SC.912.L.15.6: Discuss distinguishing characteristics of the domains and kingdoms of living organisms.
- SC.912.L.17.2: Explain the general distribution of life in aquatic ecosystems as a function of chemistry, geography, light, depth, salinity, and temperature.

Lesson objective(s):

- Describe how *Naegleria fowleri* impacts human health.
- Explain the necessary aquatic environment for *N. fowleri* to thrive.
- Identify the parts of the brain impacted by *N. fowleri* infection.
- Successfully use a microscope to isolate and identify various aquatic microorganisms.

Introduction to Emerging Pathogens: Lesson 2 – ID of the *Brain-Eating Amoeba*

ENGAGEMENT

Day 2 – 15-20 min Brain Structure/Function Interactive

- Students complete a brain diagram for major brain regions and functions.
- Class Discussion
Why is the brain important?
Are some areas of the brain more important than others?
What region of the brain is most important? Why?
What region of the brain is least important? Why?

Day 2 – 15 min Clay Brain Modeling

- Student pairs see 6 different colors of clay – yellow, purple, red, blue, green, orange
- Student pairs construct a basic model of the 4 main brain regions (cerebrum, cerebellum, brainstem, and spinal cord), making sure to include grooves and ridges to prepare for Day 3.

Day 3 - 15 min Complete Clay Brain Modeling

- Student pairs use toothpick flags to identify each region of the cerebrum illustrated in the diagram completed during the web interactive.
- Students turn in model and accompanying diagram/worksheet for formative assessment

Day 3 - 30 min (end of class) Article read, highlight, and vocabulary identification

- Provide each student with 1 copy of NYT article *Scientists scour the globe for a drug to kill deadly brain-eating amoeba* (pdf) and Student question sheet (Appendix E).
- Instruct students to highlight important information to answer questions provided, write additional questions in the margins of the article, and underline unfamiliar vocabulary.
Complete reading assignment for homework.

EXPLANATION

Day 4 - 10 min Bell Ringer/Class Discussion

- Students write additional questions on Post-Its and place on board/at central location.
- Teacher uses questions on board to facilitate discussion/clarify questions about *N. fowleri* infection.
- Teacher explains that many questions they may have about *N. fowleri* infection will be answered during the CDC activity.

ELABORATION

Day 4 – 35 min Part 1 - CDC Introduction to Parasites

- Students read Lesson Guide/Appendix 1A as a class
- Students complete Appendix 2A/Graphic organizer as they research *N. fowleri* infection details.
links provided on Appendix 2A.

Day 5 – 45 min Part 2 - CDC Parasitic Environments

- Teacher reviews laboratory procedures and proper microscope use/handling.
- Teacher demonstration – how to make a wet-mount slide of untreated water sample.
- Provide time and instruction for students to view self-made slides of untreated water samples and compare to online or teacher-provided resources for identification.

EXPLORATION

Day 5 – 45 min Part 2 - CDC Parasitic Environments

- Teacher reviews laboratory procedures and proper microscope use/handling.
- Teacher demonstration – how to make a wet-mount slide of untreated water sample.

Provide time and instruction for students to view self-made slides of untreated water samples and compare to online or teacher-provided resources for identification.

**Introduction to Emerging Pathogens:
Lesson 2 – ID of the *Brain-Eating Amoeba***

EVALUATION

Day 6 – 10 min Brain-Eating Amoeba Quiz

- Provided as part of CDC Lesson Guide
- Learning outcome assessed - explain how freshwater organisms are affected by environmental variation.

Day 6 – 35 min Grouped Public Health Campaign

- Random group assignment (popsicle sticks)
- CDC Lesson Guide Public Health Campaign

PRODUCT NAME	UNIT PRICE	QTY	SUBTOTAL
 Ear Ache (Streptococcus pneumoniae)	\$7.95	<input type="text" value="1"/>	\$7.95 <input type="button" value="x"/>
 Stomach Ache (Shigella)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Flesh Eating (Streptococcus pyogenes)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Staph (Staphylococcus aureus)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Polio (Poliovirus)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Typhoid Fever (Salmonella typhi)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Listeria (Listeria monocytogenes)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 E. coli (Escherichia coli)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Salmonella (Salmonella typhimurium)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Food Poisoning (Bacillus cereus)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Cholera (Vibrio cholerae)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Brain-Eating Amoeba (Naegleria fowleri) Petri Dish	\$19.95	<input type="text" value="1"/>	\$19.95 <input type="button" value="x"/>
 Botox / Botulism (Clostridium botulinum)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Giardia (Giardia lamblia)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Red Tide (Alexandrium tamarense)	\$9.95	<input type="text" value="1"/>	\$9.95 <input type="button" value="x"/>
 Superbug & Friends	\$19.95	<input type="text" value="1"/>	\$19.95 <input type="button" value="x"/>

[SHOP ALL](#)

[UPDATE QUANTITIES](#)

Subtotal 16 Item(s):

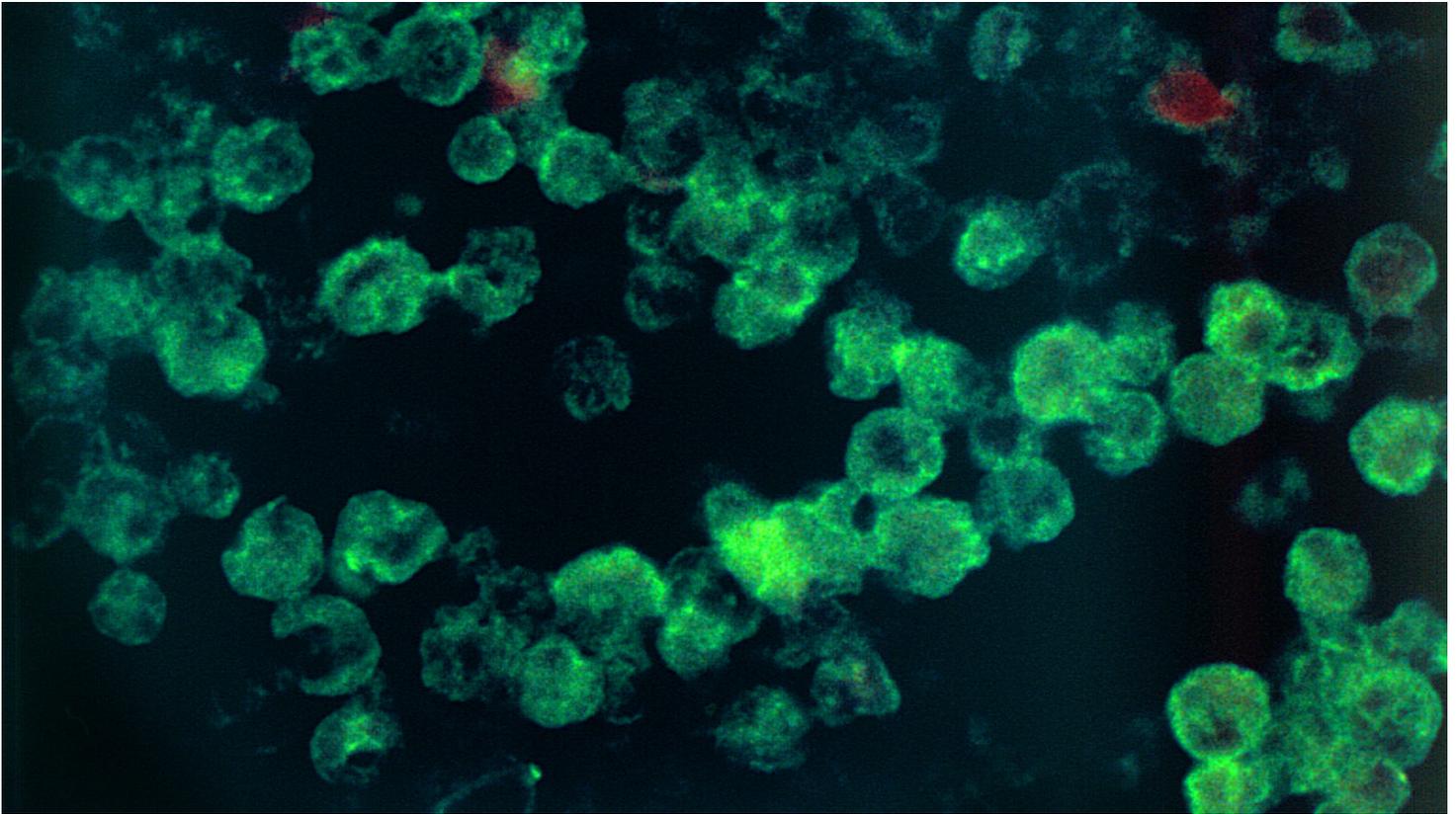
\$177.20

STAT

Scientists scour the globe for a drug to kill deadly brain-eating amoeba

By Lindzi Wessel

July 22, 2016



The *Naegleria fowleri* amoeba seen under the microscope. Dr. Visvesvara/CDC

The deaths hit the headlines every summer, sometimes five or six of them across the country. They're newsworthy for their rarity and for how innocuous the events leading up to them are — it's usually a young person who was swimming in a lake, got some water up their nose, and within days, was dead.

The cause is an amoeba called *Naegleria fowleri*, which when it infects the brain, causes massive swelling that is almost always fatal. Over the past half-century, [135 people in the US](#)¹ have died of the infection.

That rarity means that hardly any research money exists to find treatments. The best line of attack at present is a combination of drugs designed for other conditions.

“Even with the best drug combinations, the fatality rate is over 98 percent,” said Dennis Kyle, an infectious disease researcher at the University of South Florida. “People are dying from this disease all the time, and we really have nothing to treat it effectively.”

But Kyle and his team are working to change that reality. Borrowing from techniques used to develop drugs for diseases like [malaria](#)², they have created the first high-volume screening setup to hunt for

compounds that kill *N. fowleri*. With the help of collaborators, Kyle has amassed a collection of over 30,000 natural compounds gathered from far-flung corners of the globe, including microbes fished out of mangrove swamps, salty Antarctic oceans, and off sea sponges in the Gulf of Mexico.

Adding this supply to their arsenal of synthetic compounds and already-approved FDA drugs, the team is optimistic that they will eventually find something that can enter the human brain and take the amoeba out.

Chemical warfare

The amoebas, which are thought to thrive in the soil and scum layers of warm waters, enter the brain when water is forced up the nose. Once there, they feed on brain matter, leading to rapid inflammation. Of all US victims, only three have survived. The antimicrobial drug miltefosine is the most promising existing treatment, and is credited with helping save two children in 2013. But it's considered an investigational treatment, and others treated with the drug have not survived.

Kyle and his group hope that a systematic survey of natural compounds will turn up a better drug.

"We think that microorganisms use chemical warfare — if you like — to kill other things that might be fighting for the same resources," said Cedric Pearce, one of Kyle's collaborators and founder of Mycosynthetix, a small company which boasts a library of 55,000 fungal strains from all over the world.

Kyle's lab can screen about 7,500 compounds in 72 hours, an improvement over other methods that took scientists about a week to evaluate a handful of candidate molecules. The speed not only allows his team to examine more compounds, it also means they are screening for fast-acting compounds — an important consideration for an infection that can kill within days of initial symptoms. In test-tube studies, some of these fast-acting compounds are 20 times more potent than miltefosine. Pearce said the team has already identified hundreds of compounds that kill amoeba in the lab.

A different tack to finding a treatment for *N. fowleri* infection is being pursued by a research group in Seattle. Rather than broadly screening a bunch of compounds in a bottom-up fashion, the Seattle Structural Genomics Center for Infectious Disease aims to design a drug from the top down. They are using X-rays to understand the structure of proteins that keep *N. fowleri* alive, and then using computer modeling to develop compounds to target them.

Working alongside Kyle, the Seattle group is in the early stages of investigating 157 different *N. fowleri* proteins. The researchers hope their different approaches will meet in the middle, said Robin Stacy, senior project manager for the center, using computer modeling to tweak Kyle's most promising compounds.



3

Cedric Pearce stands in his culture room surrounded by a quarter of a million test tubes filled with fungi. *David Wilson, Chris English/UNC Greenboro*

Last year Kyle's group [reported](#)⁴ their first drug candidates, after screening about 150 synthetic antimicrobial chemicals. The team is now testing eight of those compounds in mice, hoping to identify versions that can cross the blood-brain barrier. At the same time, they continue to search for even more potent compounds from nature.

Their work “looks quite promising,” said Elizabeth Winzeler, a developmental biologist who studies malaria at the University of California, San Diego, and who is not involved in the research. “We and others in the field have used the same kind of approach and it’s worked quite well” to develop treatments against malaria. She cautioned, though, that the steps in drug development are numerous and complex and that it’s not unusual for a decade to pass between the discovery of molecular candidates and when drugs make it to the shelf.

A moving target

Finding a treatment may be more important than ever as unusual cases have startled US health officials in the last five years. Infections contracted in Minnesota lakes — 600 miles farther north than ever before — and the first deaths from treated tap water have led some experts to hypothesize that a changing climate is expanding the range and transmission routes of these amoebas.

“It’s not hypothetical. It’s occurring,” said Michael Beach, associate director of the healthy water division of the CDC’s National Center for Emerging, Zoonotic, and Infectious Diseases. “We’ve seen first cases in Kansas, first cases in Indiana, first cases in Minnesota, and the first case since 1969 in Virginia.”

Beach urges awareness but not fear. To reduce the already-tiny risk of infection, the CDC recommends people use distilled and sterile water for nasal rinses, not submerge their heads in warm and brackish water, and consider wearing nose clips during water sports.

Funding for research, meanwhile, has been rising but is still sparse. The National Institutes of Health awarded less than \$800,000 in grants to scientists studying *N. fowleri* for 2016 — and about two-thirds of that went to Kyle and Pearce’s group.

One reason for the low dollar amount is the rarity of the disease relative to others, says Lee Hall, chief of the Parasitology and International Programs Branch of the NIH’s National Institute of Allergy and Infectious Diseases. Another is that few researchers have applied for grants to study this disease.

Kyle and Pearce are planning to apply for a new grant in September, and this time they will be asking for “a lot more money,” said Pearce.

“There’s a significant need for more research,” said Kyle. “Better awareness of this in the research community is as important as it is in the general community.”

*This article has been updated to correct the number of US deaths from *N. fowleri*.*

Tags

Links

1. <http://www.cdc.gov/parasites/naegleria/infection-sources.html>
2. <https://www.statnews.com/2016/06/29/malaria-vaccine-delays-infection/>
3. https://www.statnews.com/wp-content/uploads/2016/07/PIC13174_2_Nick_Oberlies_060-compressed.jpg
4. <http://aac.asm.org/content/59/4/2037.full>
5. <https://www.statnews.com/tag/amoeba/>
6. <https://www.statnews.com/tag/brain/>

© 2017 STAT

Video Questions - Monsters Inside Me – Outbreak of Cryptosporidium

1. How many people were infected with the parasite?
2. Where did this outbreak occur?
3. What is the name of the pathogen?
4. What was considered the source? Be specific.
5. What does Dr. Fayer believe caused the outbreak?
6. What samples did they use to test Dr. Fayer's hypothesis?
7. What were the results? What was the source?
8. Were cows responsible for this outbreak?
9. How is water treated in Milwaukee now?

Video Questions - Monsters Inside Me – Outbreak of Cryptosporidium

1. How many people were infected with the parasite?
2. Where did this outbreak occur?
3. What is the name of the pathogen?
4. What was considered the source? Be specific.
5. What does Dr. Fayer believe caused the outbreak?
6. What samples did they use to test Dr. Fayer's hypothesis?
7. What were the results? What was the source?
8. Were cows responsible for this outbreak?
9. How is water treated in Milwaukee now?

Video Questions - Monsters Inside Me – Outbreak of Cryptosporidium

1. How many people were infected with the parasite?
2. Where did this outbreak occur?
3. What is the name of the pathogen?
4. What was considered the source? Be specific.
5. What does Dr. Fayer believe caused the outbreak?
6. What samples did they use to test Dr. Fayer's hypothesis?
7. What were the results? What was the source?
8. Were cows responsible for this outbreak?
9. How is water treated in Milwaukee now?

Video Questions - Monsters Inside Me – Outbreak of Cryptosporidium

1. How many people were infected with the parasite?
2. Where did this outbreak occur?
3. What is the name of the pathogen?
4. What was considered the source? Be specific.
5. What does Dr. Fayer believe caused the outbreak?
6. What samples did they use to test Dr. Fayer's hypothesis?
7. What were the results? What was the source?
8. Were cows responsible for this outbreak?
9. How is water treated in Milwaukee now?

Introduction to Emerging Pathogens

Lesson 1 - What's in the Water

Part A: Partner Work

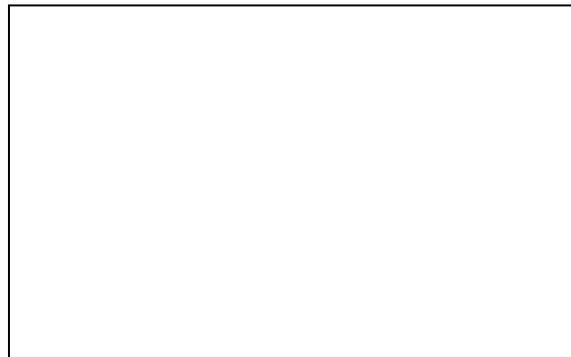
Directions: Answer the following questions with your partner once you have found your microbe.

1. What is a microorganism? _____

2. What is a pathogen? _____

3. What pathogen do you have? _____
4. Is your pathogen a bacteria? A virus? A protozoan? A algae? _____
5. Describe the symptoms and details of your pathogen. This information will come from both Question and Answer cards.

6. Sketch your microbe in the box.



Introduction to Emerging Pathogens

Lesson 1 - What's in the Water

Part B: Independent Work

Directions: Answer questions below as your classmates present their pathogen/disease.

Select 1 bacteria, virus, parasite to describe in the table below.

Identification	Why did you select this example?	How does this microbe effect humans?
Bacterium:		
Virus:		
Parasite:		

7. Are all microorganisms pathogens? Provide 2 examples of microorganisms that are helpful or useful to humans.

Introduction to Emerging Pathogens

Lesson 1 - What's in the Water

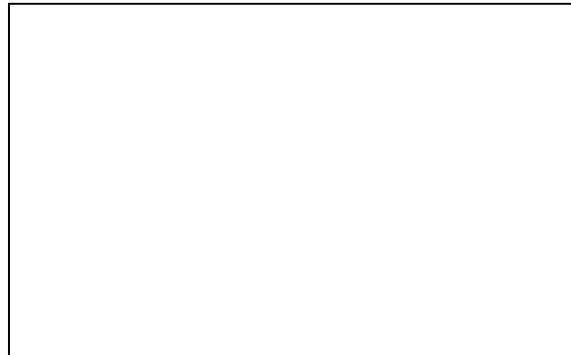
Part A: Partner Work

Directions: Answer the following questions with your partner once you have found your microbe.

1. What is a microorganism? Microscopic organisms that are invisible to the naked eye; include bacteria, protozoans, viruses, some algae and some fungi.
2. What is a pathogen? Disease-causing microorganism
3. What pathogen do you have? *Answers will vary*
4. Is your pathogen a bacteria? A virus? A protozoan? A algae? *Answers will vary*
5. Describe the symptoms and details of your pathogen. This information will come from both Question and Answer cards.

Answers will vary

6. Sketch your microbe in the box.



Introduction to Emerging Pathogens

Lesson 1 - What's in the Water

Part B: Independent Work

Directions: Answer questions below as your classmates present their pathogen/disease.

Select 1 bacteria, virus, parasite to describe in the table below.

Identification	Why did you select this example?	How does this microbe effect humans?
Bacterium:		
Virus:		
Parasite:		

7. Are all microorganisms pathogens? Provide 2 examples of microorganisms that are helpful or useful to humans.

Answers will vary. Ex: probiotics in yogurt and supplements that help us digest our food; yeast and bacteria normally found on our skin and mucus membraned for protection; antibiotics provided from naturally occurring sources in the soil.

Water-borne Microbe Questions and Answers Game

1. Ear ache (*Streptococcus pneumoniae*)

1. Q: This bacterium causes acute otitis media. Symptoms include ear pain, redness, and fever. This bacterium is responsible for causing the most common health ailment in young children. Nearly every child gets this health ailment at least once and most get it several times. This health ailment is the number one cause of emergency room admission each year and is also responsible for more antibiotic prescriptions than any other condition. What is this bacterium and what is the common name for this illness?

A: *Streptococcus pneumoniae* causes ear aches (otitis media). Ear aches are more commonly found in children because of their high susceptibility to upper-respiratory infections. Also, children's ear tubes are shorter and straighter than adult ear tubes, which provides bacteria with easier access. Although there is an antibiotic for ear aches, *S. pneumoniae* is beginning to adapt.

2. Stomach ache (*Shigella*)

2. Q: This microbe causes an intestinal tract infection that produces abdominal cramps, fever, and diarrhea. It is extremely contagious. In fact, it is so contagious that if even 10 individual bacteria get into your system, you can become infected! What is the name of this bacterium and what does it cause?

A: *Shigella* is an extremely contagious microbe that causes stomach aches. Over 140 million people are infected by *Shigella* every year. It is responsible for 10 to 20% of the cases of diarrhea worldwide. If you are infected, it is important to stay hydrated. Currently, there is no vaccine available to prevent shigellosis. The best way to prevent being infected is to wash your hands frequently.

3. *E. Coli* (*Escherichia coli*)

3. Q: Multiple strains of this bacterium exist. Most are harmless and are present in large numbers in the human and animal gut; however, some can make you sick. This bacterium can twirl its flagella around, propelling it forward at the bacterial-equivalent speed of a torpedo. Under ideal conditions, these bacteria can divide every 20 minutes; a single cell can become over a billion in less than 10 hours! What is the name of this bacterium?

A: Most strains of *E. coli* (*Escherichia coli*) are harmless. However, certain strains of this fast moving bacterium can cause food poisoning. Contamination typically occurs at the slaughterhouse, when cattle's internal bacteria are inadvertently brought into contact with the beef's surface. Because *E. coli* contamination requires very few bacteria, contaminated meat looks and smells normal.

4. Flesh Eating (*Streptococcus pyogenes*)

4. Q: This bacterium causes one of the fastest-spreading infections known. It is very rare, and because its initial symptoms are similar to the flu, more often than not its diagnosis is tragically delayed. This bacterium is passed from person to person through physical contact. If a person has a skin injury- as small as a pinprick or scratch- this bacteria can enter. The infection can destroy skin, fat, and the tissue covering the muscles. Without immediate medical care, toxic shock sets in. What is the name of this bacterium?

A: *Streptococcus pyogenes*, commonly known as “flesh eating disease,” refers to a rare infection that leads to the destruction of the “fibrous tissues.” Typically, originating from a skin injury, the bacterium causes great pain and discomfort within 24 hours of infection. Approximately 50% of the people who contract this disease are in good health prior to infection; nonetheless, about 1 in 4 people die from it.

5. Staph (*Staphylococcus aureas*)

5. Q: This bacterium can often be found living harmlessly on human skin. If it gets into your bloodstream, however, it can cause a variety of infections that range from a simple boil to flesh-eating infections. The difference in the severity of infection is dependent on how deep it goes, how fast it spreads, and how resistant it is antibiotic treatment. Patients undergoing surgery are at significantly increased risk for infection, because their skin-barrier is compromised and their immune systems are typically suppressed. What is the name of this bacterium?

A: Staph bacterium, *Staphylococcus aureas*, causes a slew of common infections that are commonly acquired by patients undergoing surgery. Antibiotics are used to treat staph infections. But there has been a gradual change in how well these antibiotics work. While most staph infections used to be treatable with penicillin, that changed in the 1980s and stronger antibiotics are now used. In about 50% of cases, however, resistance is seen to even these stronger antibiotics. These cases are not just happening in hospitals -- as once was true -- but now are occurring in the general community.

6. Polio (Poliovirus)

6. Q: Up to 95% of persons infected with this virus will have no symptoms. About four to eight percent of infected persons have minor symptoms such as fever, fatigue, nausea, headache, flu-like symptoms, stiffness in the neck and back, and pain in the limbs which often resolves completely. Less than one percent of these cases result in permanent paralysis of the limbs (usually the legs). Of those paralyzed, 5-10% die when the paralysis strikes the respiratory muscles. What is the name of this viral disease?

A: Poliomyelitis (polio) is a highly infectious disease caused by a virus that invades the nervous system. Only 5% of those that are infected display symptoms. Poliovirus is transmitted through contact with an infected person. There are two types of vaccine that can prevent polio: inactivated polio vaccine (IPV) and oral polio vaccine (OPV). IPV has been used in the United States since 2000; however OPV is still used throughout much of the world.

7. Listeria, *Listeria monocytogenes*

7. Q: This serious infection has recently been recognized as an important public health problem in the United States. The infection can be caused by eating fresh meats and vegetables that have been exposed to a certain bacterium. Elderly people, pregnant women, newborns, and adults with weakened immune systems are most susceptible to contamination. Symptoms of infection include fever, muscle aches, nausea, or diarrhea. If infection continues to spread headache, stiff neck, confusion, loss of balance, or convulsions may occur. What is this infection and what bacterium causes it?

A: Listeriosis is caused by the bacterium *Listeria (Listeria monocytogenes)*. This bacterium is commonly found on vegetables grown in soil that has been fertilized with manure. Animals can also carry *Listeria monocytogenes* without appearing ill and can contaminate foods of animal origin such as meats and dairy products. To reduce risk of infection, thoroughly cook raw food from animal sources, such as beef, pork, or poultry; wash raw vegetables thoroughly before eating; avoid unpasteurized (raw) milk or foods made from unpasteurized milk; and wash hands, knives, and cutting boards after handling uncooked foods. In the United States, an estimated 2,500 persons become seriously ill with listeriosis each year. Of these, 500 die.

8. C. Diff (*Clostridium difficile*)

8. Q: This bacterium causes diarrhea and serious intestinal conditions such as colitis. The elderly and individuals with preexisting health conditions that require the prolonged use of antibiotics are at a greater risk of acquiring this disease. These bacteria are commonly found in the feces and spread through the contact of infected surfaces. Healthcare workers can spread these bacteria to other patients or contaminate surfaces through hand contact. What is the name of this bacterium?

A: *Clostridium difficile* is a bacterium that can cause colitis, more serious intestinal conditions, sepsis, and rarely death. The infection is most common in people who are taking antibiotics while in the hospital. The large intestine normally contains many good bacteria that keep it healthy and do not cause disease. Antibiotics taken to kill bacteria that do cause disease also kill the good bacteria. This may allow *C. difficile* bacteria to grow in the large intestine and release harmful substances called toxins. Hand-washing and hygienic restrooms help prevent infection and spread of this bacterium

9. Giardia (*Giardia lamblia*)

9. Q: This illness is an infection of the intestines caused by a parasite and is most often a problem in undeveloped countries where tap water is not safe. After a person is exposed to the parasite, it usually takes 7 to 10 days for the infection to develop. This parasite can be passed to others during the entire period of infection. Symptoms include bloating, nausea, vomiting, and fatigue. You may be infected for months, even if you don't have symptoms. What is the name of this parasitic disease?

A: Giardia is caused by the parasite, *Giardia lamblia*. You may become infected with giardia if you eat food or drink water that is tainted with human or animal waste. This infection is most common in developing nations; however, in the United States you can get giardia by drinking untreated water from wells, streams, rivers, and lakes. This is true even in mountain lakes and streams where the water may seem very pure.

10. Typhoid Fever (*Salmonella typhi*)

10. Q: Persons with this illness carry the bacteria in their bloodstream and intestinal tract. In addition, a small number of people, called carriers, recover from the illness but continue to carry the bacteria. Both ill persons and carriers shed bacteria in their feces. Once these bacteria are consumed, they multiply and spread into the bloodstream. Symptoms associated with this infection include fever, diarrhea, weight loss, sore throat, rash, exhaustion, and a distended abdomen. What is the name of this bacterial illness?

A: Typhoid fever is a life-threatening illness caused by the bacterium *Salmonella typhi*. You can get typhoid fever if you eat food or drink beverages that have been handled by a person who is shedding the bacterium or if sewage contaminated with *S. typhi* bacteria gets into the water you use for drinking or washing food. Therefore, typhoid fever is more common in areas of the world where hand-washing is less frequent and water is likely to be contaminated with sewage.

11. Salmonella (*Salmonella typhimurium*)

11. Q: These bacteria are among the leading causes of food poisoning in the world. It is very common and can be found in many foods. The most popular habitats include poultry and eggs. The infections typically occur after an incubation period of 6 to 48 hours, lasts less than a week and requires no medical treatment, unless in severe cases with victims who are young, old, or have an impaired immune system. What is this bacteria?

A: *Salmonella typhimurium* causes gastroenteritis in humans and other mammals. When the bacterial cells enter epithelial cells lining the intestine they cause host cell ruffling which temporarily damages the microvilli on the surface of the cell. This causes a rush of white blood cells into the mucosa, which throws off the ratios between absorption and secretion, and leads to diarrhea.

12. Food poisoning (*Bacillus cereus*)

12. Q: This bacteria produces toxins which can cause two types of illnesses: diarrheal and emetic. Diarrheal is least common and characterized by diarrhea and abdominal cramps. This is typically from eating infected milk, meat and fish. Emetic is characterized by nausea and vomiting, most typically found in rice and other starchy products. What is this bacteria?

A: *Bacillus cereus* (food poisoning) is the general description, although two recognized types of illness are caused by two distinct metabolites. The diarrheal type of illness is caused by a large molecular weight protein, while the vomiting (emetic) type of illness is believed to be caused by a low molecular weight, heat-stable peptide. In food animals such as chickens and pigs, harmless strains of *B. cereus* are used as a probiotic feed additive to reduce *Salmonella* in the intestines and cecum. This improves the animals' growth as well as food safety for humans who eat their meat.

13. Cholera (*Vibrio cholerae*)

13. Q: Although this illness is not nearly as prevalent as it was many years ago, it is most common in undeveloped regions of the world. The bacteria that cause this disease acts by releasing a toxin that stimulates the expulsion of water and electrolytes from the cells in the lining of the small intestine. Symptoms of this disease include watery diarrhea which can result in severe dehydration and dangerously low blood pressure. Hydration and replenishing of electrolytes are crucial to treating this illness. What is the name of this bacterial illness?

A: Cholera is a bacterial disease caused by *Vibrio cholera*. You can contract cholera through various sources of infection such as drinking water contaminated with the bacteria, contact with infected fecal matter, or consumption of seafood contaminated with *Vibrio cholera*. Cholera is a more common occurrence in underdeveloped regions where poor sanitation and limited access to clean water is a significant problem.

14. Brain-Eating Amoeba (*Naegleria fowleri*)

14. Q: These microbes are found in warm bodies of water across the globe. Though very deadly, infections are rare, approximately 300 cases have been reported, though only seven of those individuals have survived. Those who fall victim to this infection usually have a life expectancy of less than two weeks. The microbe swills red and white blood cells as they feast on critical body tissue. What is this?

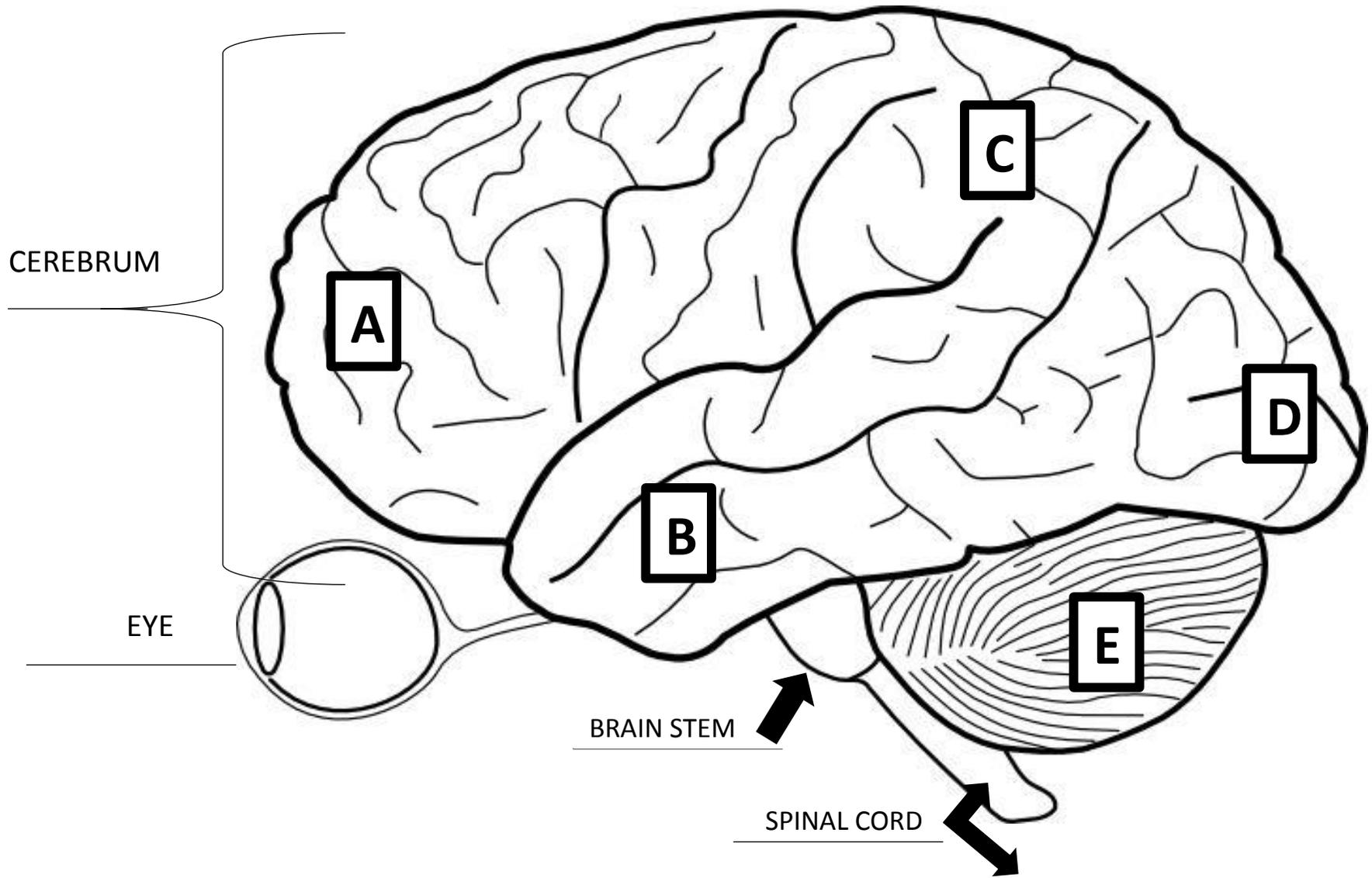
A: Though called Brain-Eating Ameoba, *Naegleria fowleri* is not technically an amoeba, but can morph into three different body shapes. If pH levels or ionic concentrations change it can transform into a flagellate, growing little tails to propel to new environments. If there is a drop in food supply or temperature, it can transform into a cyst. Otherwise, it stays as an amoeboid trophozoite to stalk bacterial prey.

15. Giardia (*Giardia lamblia*)

15. Q: This illness is an infection of the intestines caused by a parasite and is most often a problem in undeveloped countries where tap water is not safe. After a person is exposed to the parasite, it usually takes 7 to 10 days for the infection to develop. This parasite can be passed to others during the entire period of infection. Symptoms include bloating, nausea, vomiting, and fatigue. You may be infected for months, even if you don't have symptoms. What is the name of this parasitic disease?

A: Giardia is caused by the parasite, *Giardia lamblia*. You may become infected with giardia if you eat food or drink water that is tainted with human or animal waste. This infection is most common in developing nations; however, in the United States you can get giardia by drinking untreated water from wells, streams, rivers, and lakes. This is true even in mountain lakes and streams where the water may seem very pure.

Name _____



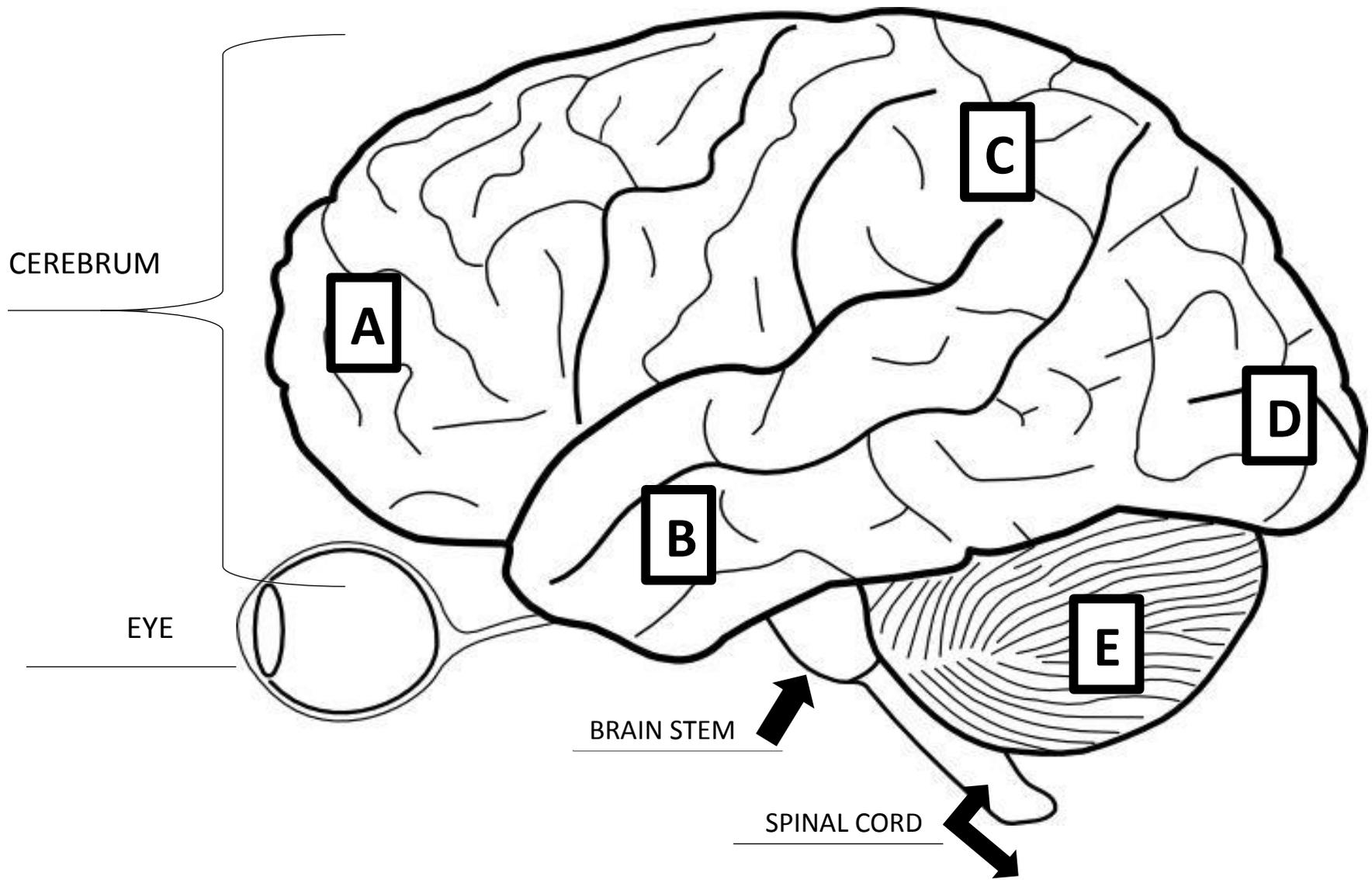
Name _____

1. Navigate to the following website: <https://www.koshland-science-museum.org/explore-the-science/interactives/brain-anatomy>
2. Use the interactive to identify/name the labeled regions on the diagram.
Click on the color-coded regions to the right to highlight specific regions. You can use the slide button below the brain to change the orientation of the diagram for easy comparison.

Main Area	Region Name	Functions
Cerebrum	A	
	B	
	C	
	D	
E		
Brain Stem		Control automatic body processes like breathing, heartrate, digestion, maintenance of body temperature.
Spinal Cord		Transmit impulses from brain to muscles. Transmit impulses from the body to the brain for processing.

3. Read each description and list 2 important functions for each region identified.
4. Color-code each of the regions to correspond to the color on the interactive.

Name KEY



Name KEY

1. Navigate to the following website: <https://www.koshland-science-museum.org/explore-the-science/interactives/brain-anatomy>
2. Use the interactive to identify/name the labeled regions on the diagram.
Click on the color-coded regions to the right to highlight specific regions. You can use the slide button below the brain to change the orientation of the diagram for easy comparison.

Main Area	Region Name	Functions
Cerebrum High-order thinking/processing integration of senses, muscles, and glands	A Frontal Lobe	Answers will vary Ex: store memories, planning, social and emotional processing, attention
	B Temporal Lobe	Process sound, interpret and understand language, visual memory/recognition
	C Parietal Lobe	Sensing touch, language, and memory
	D Occipital Lobe	Visual perception and visual memory
E Cerebellum		Ability to learn and perform a skill, coordinate muscle movement, and memory storage for movement.
Brain Stem		Control automatic body processes like breathing, heartrate, digestion, maintenance of body temperature.
Spinal Cord		Transmit impulses from brain to muscles. Transmit impulses from the body to the brain for processing.

3. Read each description and list 2 important functions for each region identified.
4. Color-code each of the regions to correspond to the color on the interactive.

Name _____

New York Times/IN THE LAB

<https://www.statnews.com/2016/07/22/brain-eating-amoeba/>

Scientists scour the globe for a drug to kill deadly brain-eating amoeba.

PART 1

Instructions: Read the accompanying article and highlight the answers to the following questions.

Underline unfamiliar words.

Add additional questions that you still have about infection with *Naegleria fowleri* in the margins.

1. How many people have died from this amoebic infection in the last 50 years?
2. What is the fatality rate?
3. Why is it important for scientists to research this infection?
4. Where are scientists looking for new medicine?
5. What is significant about the infections in Minnesota? Explain.
6. What precautions does the CDC (Centers for Disease Control and Prevention) recommend to prevent *Naegleria* infection?
7. How much money did the NIH (National Institutes of Health) award to research of this disease in 2016? Is this enough money? Explain.

Name _____

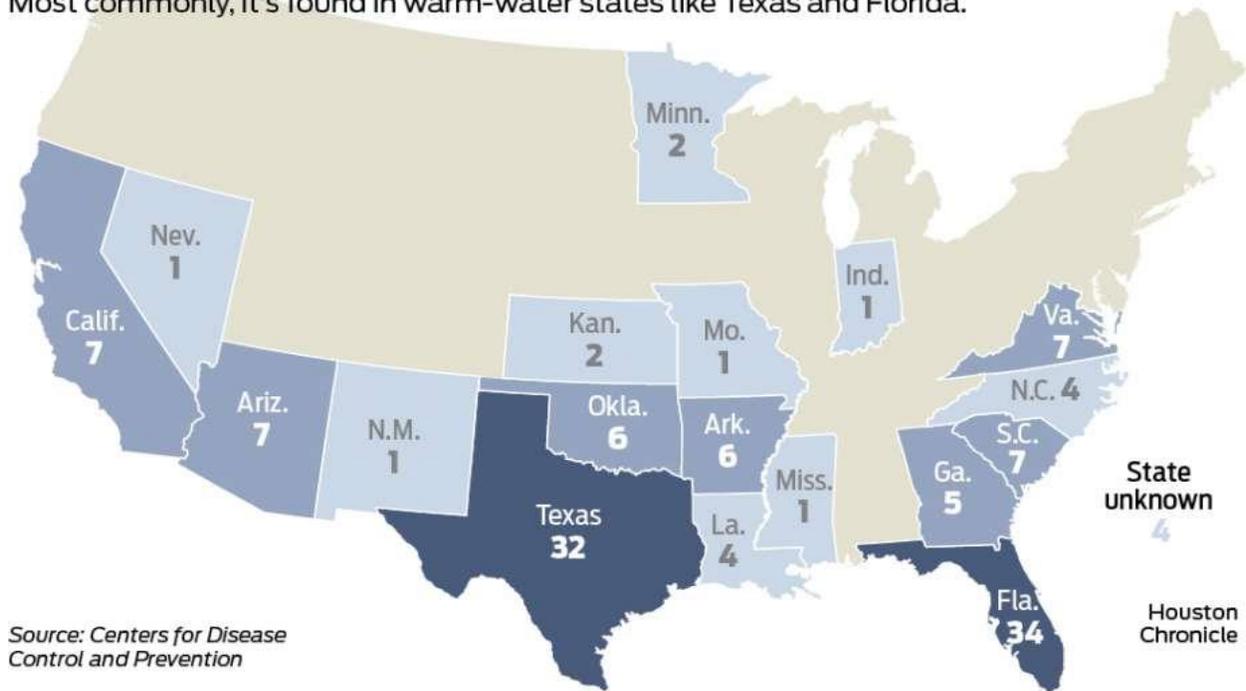
Instructions: Refer to the map for the following questions.

PART 2

8. What region of the United States has the highest rates of Primary Amoebic Meningoencephalitis?
9. What do these states have in common?
10. What is significant about the infections in Minnesota, Indiana, Kansas, and Missouri?

Primary Amoebic Meningoencephalitis

This rare disease is caused by a brain-eating amoeba. There have been only 132 cases identified by the CDC in the United States since 1962. Most commonly, it's found in warm-water states like Texas and Florida.



Name KEY

New York Times/IN THE LAB

<https://www.statnews.com/2016/07/22/brain-eating-amoeba/>

Scientists scour the globe for a drug to kill deadly brain-eating amoeba.

PART 1

Instructions: Read the accompanying article and highlight the answers to the following questions.

Underline unfamiliar words.

Add additional questions that you still have about infection with *Naegleria fowleri* in the margins.

1. How many people have died from this amoebic infection in the last 50 years?
135
2. What is the fatality rate?
98%
3. Why is it important for scientists to research this infection?
Ex: Not many medicines are effective even with the best combination of drugs that treat diseases like malaria.
4. Where are scientists looking for new medicine?
Studying over 30,000 natural compounds collected from all over the globe. Warm water sources, cold water sources, fresh water, and salt water.
5. What is significant about the infections in Minnesota? Explain.
Historically, Minnesota has not had the warm water environment necessary for the amoeba organism to thrive and infect a host.
6. What precautions does the CDC (Centers for Disease Control and Prevention) recommend to prevent *Naegleria* infection?
The CDC recommends to use distilled or sterile water for nasal rinses, do not submerge heads in warm or brackish water, and wear nose clips when your head may go underwater.
7. How much money did the NIH (National Institutes of Health) award to research this disease in 2016? Is this enough money? Explain.
\$800,000 in grants in 2016 to scientists that study *N. fowleri*. Compared to other diseases, this is a low amount because amoebic infection is rare compared to other infections.

Name KEY

Instructions: Refer to the map for the following questions.

PART 2

8. What region of the United States has the highest rates of Primary Amoebic Meningoencephalitis?
Southeast USA
9. What do these states have in common?
All are warm environments with fewer winter/freezing months
10. What is significant about the infections in Minnesota, Indiana, Kansas, and Missouri?
These states are typically too cold for the amoeba to survive. Could global warming be making the water in these states favorable for this organism?

Primary Amoebic Meningoencephalitis

This rare disease is caused by a brain-eating amoeba. There have been only 132 cases identified by the CDC in the United States since 1962. Most commonly, it's found in warm-water states like Texas and Florida.

