

# BIOFILMS ARE EVERYWHERE

GRADES 9-12

JODALE ALES

**TIME ALLOTMENT:**

Approximately four 50-minute classes.

**OVERVIEW:**

Students will work in groups to produce an informational brochure about biofilms for the general public. They will creatively integrate conceptual understanding, communication skills, computer technology skills, and science processing skills. The finished product must meet well-defined criteria.

**SUBJECT MATTER:**

Integrated or General Science, Life Science, Biology, Health and Physical Education, Environmental Science

**LEARNING OBJECTIVES:**

Students will be able to:

- Research Internet resources and gather data and other information.
- Credit sources of information.
- Design and publish an informational brochure using computer software.
- Effectively communicate through images and writing.
- Describe biofilms.
- Classify biofilms as helpful or harmful.

**STANDARDS:**

**National Science Education Standards**

<http://bob.nap.edu/html/nses/>

*Unifying Concepts and Processes*

- Systems, order, and organization
- Evidence, model, and explanation
- Form and function

*Science as Inquiry*

- Abilities necessary to do scientific inquiry



*Life Science*

- (5-8) Structure and function in living systems
- (5-8) Populations and ecosystems
- (5-8) Diversity and adaptations of organisms
- (9-12) Interdependence of organisms
- (9-12) Matter, energy, and organization in living systems

*Science in Personal and Social Perspectives*

- (5-8) Personal health
- (5-8) Natural hazards
- (5-8) Risks and benefits
- (5-8) Science and technology in society
- (9-12) Personal and community health
- (9-12) Natural and human-induced hazards
- (9-12) Science and technology in local, national, and global challenges

**Excellence in Environmental Education Guidelines**

[http://www.naaee.org/npeee/learner\\_guidelines.php](http://www.naaee.org/npeee/learner_guidelines.php)

Strand 1: Questioning and Analysis Skills

- Guidelines:
- A) Questioning
  - C) Collecting information
  - D) Evaluating accuracy and reliability
  - E) Organizing information
  - G) Developing explanations

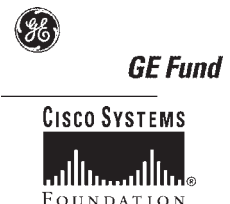
Strand 2: Knowledge of Environmental Processes and Systems

2.2: The Living Environment

- Guideline:
- A) Organisms, populations, and communities
  - C) Systems and connections
  - D) Flow of matter and energy

2.4: Environment and Society

- Guideline:
- A) Human/environment interactions
  - D) Technology



**Louisiana Science Frameworks:**

State Standards for Curriculum Development

<http://www.doe.state.la.us/doe/assessment/standards/SCIENCE.pdf>

**SI-M-A7:** Communicating scientific procedures, information, and explanations

**SI-M-B1:** Recognizing that different kinds of questions guide different kinds of scientific investigations

**SI-M-B4:** Using data and logical arguments to propose, modify, or elaborate on principles and models

**SI-M-B6:** Communicating that scientific investigations can result in new ideas, new methods or procedures, and new technologies

**LS-M-C4:** Explaining the interaction and interdependence of nonliving and living components within ecosystems

**SE-M-A1:** Demonstrating knowledge that an ecosystem includes living and nonliving factors and that humans are in integral part of ecosystems

**SE-M-A8:** Investigating and analyzing how technology affects the physical, chemical, and biological factors in an ecosystem

**SI-H-A1:** Identifying questions and concepts that guide scientific investigations

**SI-H-B4:** Analyzing a proposed explanation of scientific evidence according to the following criteria: following a logical structure, following rules of evidence, allowing for questions and modifications, and basing it on historical and current scientific knowledge

**SI-H-B5:** Communicating that the results of scientific inquiry, new knowledge, and methods emerge from different types of investigations and public communication among scientists

**LS-H-D4:** Investigating population dynamics

**LS-H-G2:** Contrasting how organisms cause disease

**LS-H-G5:** Researching technology used in prevention, diagnosis, and treatment of diseases/disorders

**SE-H-A4:** Understanding that change is a fundamental characteristic of every ecosystem and that ecosystems have varying capacities for change and recovery

**MEDIA COMPONENT:****Video:**

**Enviro-Tacklebox™, *A Biofilm's Bio*** (20 minutes)

Louisiana Public Broadcasting, **Enviro-Tacklebox™** program, Louisiana Education Television Authority. 2000.

**Web site:**

**Human Intervention on Our Coast?** <http://www.cofc.edu/CGOInquiry/human.htm> This Web site focuses on jetties, groins,

**Enviro-Tacklebox™** resource materials for ***A Biofilm's Bio*** can be found at <http://www.envirotacklebox.org/> This excellent site provides a teacher guide, streaming video, student guide, and other resources for ***A Biofilm's Bio, Module 1*** of the **Enviro-Tacklebox™** program. RealOne Player is used to view the video and can be downloaded from the Web site. Shockwave Player is needed to play the game on the Web site and can also be downloaded.

**The American Society of Microbiology** has a variety of images of biofilms and information that can be found at <http://asmusa.org/edusrc/biofilms/>.

**Biofilms Online**, <http://www.biofilmsonline.com/> is also an excellent source of information.

**Microbeworld** at <http://www.microbeworld.org> is geared towards student audiences.

Information about marine biofilms if available at the **Maryland Sea Grant Education** site at <http://mdsg.umd.edu/MDSG/Education/biofilm/resource.htm>.

**Cornell University** has set up an excellent biofilm tutorial with animations at <http://instruct1.cit.cornell.edu/Courses/biomi290/Horror/Biof.tutorial.HTML>.

**Multimedia Tools:**

**Microsoft® Publisher®**, or another software publisher, is needed to create the brochure.

**MATERIALS:**

*Per Student:*

- **Research Worksheet**
- ***A Biofilm's Bio Student Viewing Guide***
- **Biofilms Brochure Criteria**

*Per Teacher:*

- **A Biofilm's Bio Student Viewing Guide Answers.**

**PREP FOR TEACHERS:**

1. Prior to teaching the unit, bookmark the Web sites students will use as references and if possible put links to them from your school Web site or provide links on your course management site (for example Blackboard) if you have access to one.
2. Download the RealOne Player and Shockwave Player needed for viewing the video online and playing the biofilm game from the **Enviro-Tacklebox™** Web site.
3. Review the **Module 1 Enviro-Tacklebox™** Web resources and the video related to ***A Biofilm's Bio***.
4. Review how to use **Microsoft® Publisher®** to publish a brochure.
5. Make a large collage of biofilm images to post in the classroom. Cut out familiar objects where biofilms grow (***contact lenses, toothbrushes, space shuttle, vase of flowers, teeth, ship hulls and others***) from magazines or use clip art, or actual biofilm images from the web sites.

**INTRODUCTORY ACTIVITY:**

1. A couple of days before the learning activities draw the students' attention to the collage and tell them that these are objects and places related to biofilms.
2. Next ask students to write responses in their journals to the following questions. What is a biofilm? Where are biofilms found? Would you like to have a biofilm? Ask them to explain their answers. Lead a discussion to go over their responses now and again after the learning activities. Anonymously post the different student responses to the questions, "What is a biofilm?" This should start them wondering about biofilms.

**LEARNING ACTIVITIES:**

1. Video Viewing
  - A. Hand out ***A Biofilm's Bio Student Viewing Guide***.
  - B. **PLAY** the **Enviro-Tacklebox™** video, ***A Biofilm's Bio***. During each clip students will record their responses to questions on the **video viewing guide**. Lead a class discussion after each clip.

**Video Clip 1** – The video begins with Greg in the bait shop looking for something to eat. When he opens the refrigerator a horrendous odor is emitted. Upon close inspection Greg finds a container of old cottage cheese that is the culprit. Greg takes the container to the Center for Biofilm Engineering at Montana State University to have its contents analyzed. There he meets scientist Dr. Wendy who identifies the foul smelling substance as a biofilm. Biofilms are defined as a group of bacteria living communally and meeting three criteria. As the teacher you will need to define the term community for the students as all of the organisms living and interacting in a certain area. The concept ecosystem also needs to be explained. An ecosystem would include the community (living) plus the nonliving factors in an area. Dr. Wendy and Greg describe many of the places where biofilms can be found, including dirty gym socks and a dog's water dish. During the discussion following the clip you can point out items in the collage you made. Biofilms are both helpful and harmful in our bodies. Biofilms help break down undigested foods into solid waste. Some biofilms cause infections. Stop the clip after the section about how some biofilms can hurt us because they are protected from white blood cells by their slime.

**Video Clip 2** – Next we learn about research with biofilms. Engineers, microbiologists, and mathematicians conduct studies about how bacteria interact to form biofilms. Technologies such as laser and electron microscopy and genetic engineering are used to study biofilms. Biofilms are everywhere and Dr. Dave tells us that we are finding helpful uses for biofilms as technology (biotechnology) including water and waste treatment and mining. Understanding biofilms could improve our health. End the clip after biotechnology is discussed. During the discussion you will need to elaborate on the term “biotechnology.” Biotechnology is the use of living things (biofilms digesting oil in an oil spill) and/or their parts (DNA) to improve the quality of life.

**Video Clip 3** – Greg and the scientists take a trip to Yellowstone National Park to examine biofilms in the boiling hot geysers. These bacteria live in extreme environments of high temperatures and high acidity. It is pointed out that the organisms in the biofilms have adapted to live at different temperatures and use different nutrients. The different communities produce different colors. Bioprospecting, or the harvesting of biofilms to be used for economic gain, cannot be done without approval of the park system. This clip ends with a Holy Mackerel fact.

**Video Clip 4** – This clip begins with a Cool Demo where students demonstrate how to easily grow soil biofilms. Next one student takes a trip to the dentist where she learns that plaque is a biofilm. The importance of brushing your teeth is emphasized because it helps break up the plaque that causes tooth decay. Greg begins to summarize the importance of biofilms to our personal environments; both inside and out and ways to help control biofilms. This clip ends after Greg talks about air and water filter systems on the Space Shuttle. Your discussion may lead to other ways that medical biofilms affect our health.

**Video Clip 5** – Louisiana State University researcher Dr. Ralph Portier explains how microbes (bacteria) are used to help clean up oil spills. LSU used these biofilms during the Exxon Valdez oil spill in Prince William Sound, Alaska. This use of biofilms in biotechnology has been shown to be effective in water, soil, and waste water clean up.

The end of the video is a good time to summarize how biofilms can be both helpful and harmful.

### CULMINATING ACTIVITIES:

1. After the class discussion of the video and the viewing guide the students should have reached a better understanding of biofilms. Go over the pretest with the students and ask them to compare their initial responses to what they know now.
2. Explain to the students that most people do not know anything about biofilms. In fact when you ask someone what a biofilm is the most common response is “a movie about biology.” Ask the students why the general public needs to know what a biofilm is and what types there are.
3. Assign students to groups each of which represents an individual advertising firm. The Center for Biofilm Engineering has selected several firms to compete for the job of creating and publishing a brochure that will be distributed to the public. The purpose of the brochure is to educate people about biofilms and their benefits and drawbacks. Each firm is asked to design a brochure and present it to a committee of employees of the Center for Biofilm Engineering who will make a recommendation to the president of the company.
4. Hand out the criteria for the brochure.
5. Groups (companies) research the Web sites for information and images of biofilms.
6. Each company compiles its information and creates its brochure.
7. Representatives of the advertising firm make a presentation to the committee and the committee selects the best brochure.

**CROSS-CURRICULAR EXTENSIONS:****FINE ARTS / ENGLISH:**

- Students create “Wanted Dead or Alive” posters for the biofilm that is most interesting to them. If the biofilm is helpful, it is wanted “alive.” Harmful biofilms are wanted “dead.”

**SCIENCE / ENGLISH:**

- Construct a concept map that connects the concepts related to biofilms. Seed concepts can include harmful, helpful, slime, nutrients, water, surface.

**COMMUNITY CONNECTIONS:**

- Take a virtual tour of your local water plant or sewage treatment plant by visiting its Web site. E-mail the company and ask if and how biofilms are used in removing pollutants from the water or the sewage.
- Investigate the economics of biofilms by researching the annual expense of treating dental plaque and tooth decay. Include factors such as the cost of toothbrushes, mouthwash, visits to the dentist, toothpaste, and dental floss. The National Dental Association (<http://www.nda.com/>) has available information.

**STUDENT MATERIALS:**

- **Research Worksheet**
- ***A Biofilm’s Bio Student Viewing Guide***
- **Biofilms Brochure Criteria**

NAME \_\_\_\_\_ CLASS \_\_\_\_\_ DATE \_\_\_\_\_

**A BIOFILM'S BIO  
STUDENT VIEWING GUIDE**

1. Compare and contrast the terms community and ecosystem.

\_\_\_\_\_

2. Describe the three criteria needed for biofilms to grow.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

3. A) How is a biofilm a community? B) How is a biofilm an ecosystem?

A) \_\_\_\_\_

B) \_\_\_\_\_

4. Name at least 5 places where biofilms can be found if the criteria for biofilms are met.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

5. How can biofilms be both helpful and harmful inside our bodies?

\_\_\_\_\_

6. What are some technologies that are used to study biofilms?

\_\_\_\_\_

7. How are biofilms used as technology (biotechnology)?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

8. Yellowstone National Park is a location where a large diversity of biofilms can be found in the natural environment. What causes the different colors in the geysers and boiling hot pools of Yellowstone?

\_\_\_\_\_

9. A) What is dental plaque? B) Why is brushing your teeth important? C) Why should you change your toothbrush regularly?

A) \_\_\_\_\_

B) \_\_\_\_\_

C) \_\_\_\_\_

10. What are some other ways we use technology to prevent medical biofilms from growing and becoming hazards to our health?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

11. Bacteria are decomposers. Explain what this means.

\_\_\_\_\_

12. What are some ways that biofilms are being used in biotechnology to clean up pollution in the environment?

\_\_\_\_\_

13. Summarize. List ways biofilms are used in biotechnology and ways technology is used to destroy biofilms

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

14. Complete the following table by listing ways biofilms can be helpful or harmful.

Helpful Biofilms	Harmful Biofilms

**A BIOFILM'S BIO**

## STUDENT VIEWING GUIDE ANSWER KEY

1. community = all of the different populations in an area; all of the different species of living things in an area  
ecosystem = all of the living and nonliving things in an area
2. surface to attach to (boat hulls, inside your intestine...)  
nutrients and water  
sometimes oxygen
3. A) A biofilm is a community because it is made up of different species of bacteria and often contains other organisms such as algae and small invertebrates.  
B) A biofilm is an ecosystem because it also consists of nonliving factors such as the sticky slime it makes, water, and air.
4. dirty gym socks, intestine, catheters, dog's water bowl, geysers of Yellowstone, refrigerator, shower stall, and others
5. Biofilms of *E. coli* are helpful in our intestines because they help break down undigested food to form solid waste. Biofilms on contact lenses can cause eye infections.
6. Laser and electron microscopy, the tools of genetic engineering
7. Biofilms are used to digest harmful chemicals (pollutants) in the environment such as oil. They are used in mining to purify precious metals such as gold and copper. They are used in water treatment and sewage treatment. They can also be used to remove pollutants from the soil.
8. The colors are caused by different species of bacteria that live at different temperatures and use different compounds for energy. Those that use iron oxides produce a reddish brown color. Algae that are photosynthetic produce a green color.
9. A) Dental plaque is a biofilm of food particles and bacteria.  
B) Brushing your teeth helps remove nutrients (food particles) that biofilms need and also disrupts the biofilm somewhat.  
C) You should change your toothbrush every few months because a biofilm can grow on it.
10. Abrasive cleaners are used to clean toilets and other areas of the bathroom. Often chlorine is a component of these cleaners. Toothpaste contains abrasive substances from sea algae that helps too. Air conditioning and water filters also help remove biofilms.
11. Decomposers break down organic molecules from living things in the process of decay. They can also break down other molecules such as oil and kerosene that pollute the environment.
12. Examples are the Exxon Valdez oil spill and water and waste treatment plants.
13. and 14. summarize information previously presented.



**RESEARCH WORKSHEET**

**Information Source:**

1. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

2. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

3. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

4. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

What is a biofilm? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



*In the space below draw and label a biofilm.*

**Describe the factors that a biofilm needs in order to survive.**

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**Name several places where biofilms can be found.**

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**Give examples of helpful and harmful biofilms and describe them.**

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**BIOFILM BROCHURE CRITERIA**

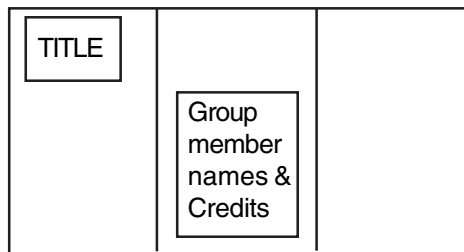
Your brochure should include the following:

- Clear, descriptive title
- Photographs, diagrams, or other images of biofilms and where they can be found
- Accurate description of biofilms
- Examples of helpful and harmful biofilms and their impact on humans and the environment.
- Examples of where biofilms can be found
- Credits of sources of information (minimum of three sources)
- Name of group members
- One color copy for teacher; 8 ½" X 11" paper, b/w copies for peers

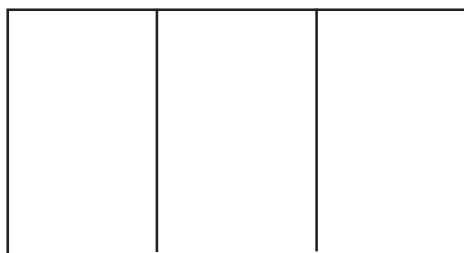
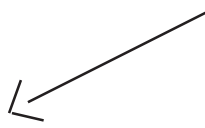
Your brochure and your group will be assessed on the following factors:

- Creativity
- Design (includes layout and flow of information)
- Use of images to enhance understanding
- Ability to follow directions
- Punctuality
- Accuracy of content
- Ability to enhance reader’s understanding of biofilms
- Ease of reading (font size, font style, shading & color)
- Grammar
- Ability to capture reader’s interest
- Group effort and ability to collaborate
- Ability to cite sources

General Layout:



**BACK**– Right panel folds inside with left panel folding on top of it



**INSIDE**

