Teachers' Guide: Does Sunscreen Protect my DNA?

Activity Overview

Abstract:
All information needed for this activity is contained within this handout. In this laboratory experiment students explore how effectively different sunscreens protect yeast cells from damage caused by exposure to ultraviolet (UV) radiation.

Key Concepts:
DNA; Ultraviolet (UV) radiation; Sun Protection Factor (SPF)

Prior Knowledge Needed:
DNA contains the instructions for proper cell function; changes to DNA can cause cancer; skin cancer can be caused by exposure to UV radiation, which comes from the sun; and the meaning of SPF ratings on sunscreens.

Materials (see detailed list below):
Yeast-Extract Dextrose media plates; UV-sensitive yeast strain; source of UV radiation; different sun protection items

Appropriate For:
Ages: 10-20+
USA grades: 5-16

Prep Time:
1-2 hours

Class Time:
Two 45-minute class periods

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Pedagogy

Learning Objectives

In this laboratory experiment students explore how effectively different sunscreens protect yeast cells from damage caused by exposure to ultraviolet (UV) radiation. Students may compare differing SPFs of the same brand of sunscreen or different brands with the same SPF. The experiment utilizes a strain of yeast that lacks several DNA repair mechanisms; UV-induced mutations lead to cell death. The experiment provides data for students to make relative comparisons between sunscreens.

Background Information

Before carrying out this experiment, students minimally need to understand that DNA contains the instructions for proper cell function; DNA can be changed so that cells no longer function normally, such as in cancer, which is uncontrolled cell growth; skin cancer and other adverse health effects can be caused by exposure to ultraviolet (UV) radiation, which comes from the sun; and the meaning of sun protection factor (SPF) ratings on sunscreens.

Teaching Strategies

Timeline:

Preparation time — One hour to order materials, streak yeast plate, and set up student materials; an additional hour if pouring your own plates of media.

Classroom time — One 45-minute class period for students to set up their experiments and expose the plates to UV radiation; 30 minutes several days later for students to collect, analyze and report on their data. Depending on students' existing knowledge, more time may be needed before carrying out the experiment to present or have students learn background information.

Four or more weeks before the activity —

- Order UV-sensitive yeast strain.

- Order YED Media Plates or YED Medium and Petri Dishes.

A week or more before the activity —

- Prepare YED media plates if you are pouring them yourself.
- After the media has solidified, turn the plates upside down and allow them to dry for 3-5 days before storing them in sealed plastic bags. For this activity, it is important that the media be a bit dry so that it will absorb the water with the yeast solution.

Two-four days before the activity — Prepare a fresh culture of UV-sensitive yeast.

- Use the rounded end of a sterile toothpick to collect a very small amount of yeast from the culture you ordered.
- Gently streak the yeast in several lines across the surface of a YED media plate. Yeast cells will be spread on the media even if you cannot see them.
- Turn the plate upside down and wrap it in aluminum foil to protect the yeast from UV radiation damage.
- Incubate the upside down plate at $30^{o}C$ (1-2 days) or room temperature (several days) until the yeast has grown.
- Store the plate upside down in a sealed plastic bag in a refrigerator.

One day or more before the activity —

- Engage in learning experiences with students to prepare them to carry out the experiment (see Topics to Explore, below).
- Have students plan their experiments.
- Ask students to bring sunscreen samples or other sun protection items for their experiment to class if you would like them to do so.
- If students will be going outdoors to expose their plates to UV radiation, request that they bring their own sun protection items to wear, such as a hat, sunscreen, and sunglasses.

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Immediately before the activity —

- Prepare a visibly turbid suspension of UV-sensitive yeast cells in sterile water.
    - Use the rounded end of a sterile toothpick to collect a small amount of yeast from the YED plate.
    - Place the yeast on the side of a sterile container and add sterile water; you will need 1 ml of water for each student or pair.
    - Replace the lid on the container and swirl it to mix the yeast and water. Add more yeast cells if necessary to make a visibly cloudy suspension of cells.
- You may choose to aliquot 1 ml of yeast solution for each student or pair into sterile, capped test tubes or dispense the yeast yourself.
- Yeast cells do not survive long in water; it is best to prepare a fresh yeast suspension immediately before each class.

During the activity — Students set up their experiments and expose the plates to UV radiation.

One to four days after setting up the experiments — Incubate the yeast plates at 30oC for 1-2 days or at room temperature for several days until a lawn of white yeast has grown on the plates.

- The plates should be incubated upside down and kept in the dark (incubator, in a drawer or closet, or covered with aluminum foil).
- If students are unable to look at the plates after the lawn of yeast is visible, the plates can be stored upside down in sealed plastic bags in a refrigerator.

Two to four days after setting up the experiments —

- After a lawn of yeast has formed on the plates, students collect and analyze their data, draw conclusions and report their results.

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- Photographs of sample results are available at http://www.phys.ksu.edu/gene/photos/solaruv.html

Classroom Implementation Strategies: Use the background information on student pages S1-2 to prepare students for the sunscreen experiment. The step-by-step experiment procedure is found on student pages S3-4. The following tips on the procedure are keyed to the steps numbered 1-8 on those student pages.

1. Cleaning with alcohol provides some sterilization and removes possible sources of contamination from dust, molds, etc.
2. Remind students to write in small letters around the bottom edge of the Petri dish so that they can later see the results of their experiments. Depending on the products available, students may choose to compare different SPFs of the same sunscreen, different sunscreens of the same SPF, or other differences among products. They may also use other sun protection items such as lip gloss, fabric, or sunglass lenses (an optician may be willing to provide you with "blanks", which are lenses that have not been shaped to fit particular frames, or lenses from old glasses).
3. Swirl the container of UV-sensitive yeast to re-suspend the cells before removing each sample. Lift the lid of the Petri dish only enough to add the yeast suspension near the center of the agar. Keep the dishes closed as much as possible to reduce contamination.
4. Place the media plates in a dark location such as a cupboard, drawer or brown paper bag. If you plan to expose the plates to UV radiation by holding them perpendicular to the sun, it is particularly important that all of the water from the yeast suspension be absorbed by the media before continuing with the next step of the experiment. If the water is not absorbed, the yeast cells will migrate across the surface of the plate when it is tilted, obscuring differences between treatments. If the plates will remain horizontal while being exposed to lights, it is not as crucial that all of the water be absorbed, although it is preferable.
5. Transparent tape absorbs UV radiation so it should not extend onto the top of the Petri dish. Taping the two halves of the dish

together keeps them from accidentally coming apart and allowing contamination to enter, and preserves the labeling for each treatment.

6. Try to use equal amounts of sunscreen for each treatment; for more precise comparisons, use a balance to weigh each sunscreen amount. SPF testing is conducted using 2 mg per square centimeter of skin.
7. Hold the dishes so the surface of the agar is perpendicular to the sun's rays. Placing a paper or card under the dish to show a shadow may be helpful; when the dish is perpendicular to the sun, the shadow will be smallest. You could also use a quartz halogen light, or a germicidal lamp as a UV source. (See Sources of Ultraviolet Radiation for exposure times.)
8. If you place the dishes in a dark location, such as a cupboard or drawer, you will not need to cover them with aluminum foil. Placing the dishes upside down prevents moisture from collecting on the yeast.

Extensions/Adaptations: Listed below are suggestions for topics you may choose to present to prepare students for this activity or have students investigate in connection with this activity.

1. UV radiation
   - The three types of UV radiation and the extent to which each penetrates the earth's atmosphere
   - Seasonal and latitudinal variations in the amount of UV radiation reaching the earth's surface
   - The UV Index and the information it provides
   - Factors affecting ozone depletion and how these can be addressed
   - Effects of ozone layer depletion on other organisms
2. DNA
   - DNA structure
   - Types of DNA mutations caused by UV radiation
   - DNA repair mechanisms
   - How DNA mutations may affect protein products

3. Health effects of exposure to UV radiation
   - Skin anatomy
   - How UV radiation damages each layer of skin
   - Types of skin cancers and their prognosis and treatment
   - Risk factors for skin cancer and skin cancer incidence
   - Premature skin aging
   - Cataracts
   - Immune system suppression
4. Sunscreens
   - How sunscreens work
   - How SPF ratings are determined
   - The chemicals used in sunscreens and their effectiveness for UVA and UVB protection
   - Proper sunscreen application

Assessment Suggestions: Have students create a media piece related to what they have learned. This might be a brochure, a poster, a press release or a public service announcement (PSA) for TV, radio or print media. You may choose to offer students all of these options or only 1-2. The media piece needs to have a clearly-defined message, target a specific audience, and be creative.

Before beginning this assignment, it is helpful to review several media pieces with students. Focus the discussion on what factors make each piece effective (or not) and what audience is being targeted. The Campaign Materials section of the Center for Disease Control and Prevention website, Choose Your Cover, contains examples of each media type, including Quick Time movies of PSAs for TV; http://www.cdc.gov/chooseyourcover/index.htm.

Additional Resources

Detailed Materials List

1. UV-sensitive yeast strain
2. YED (Yeast-Extract Dextrose) media plates - 1 to grow yeast, and 1/student or student pair [NOTE: If you are not purchas-

ing pre-poured media plates, more equipment and materials are listed in the section below for preparing YED media plates.]

3. Sterile container with lid
4. Sterile pipet to measure 1 ml
5. Pipet bulb or pipet pump to use with the pipet, if needed
6. Sterile test tubes with caps (optional)
7. Sterile distilled water
8. 70% or 95% ethyl or isopropyl ("rubbing") alcohol
9. Waterproof marking pens with fine tips - 1/student pair
10. Sterile, flat toothpicks
11. Aluminum foil
12. Paper towels
13. Self-sealing ("Zip-lock") plastic bag
14. Transparent ("Scotch") tape
15. Small brown paper bags (optional)
16. Sunscreens of different SPFs and/or different brands
17. Other sun protection items such as lip gloss, lenses from sun glasses and fabric
18. 2-inch squares of dark paper such as construction paper
19. Source of UV radiation – sun, quartz halogen or fluorescent light
20. Sun protection - UV-protective glasses, hats, sunscreen, etc. (needed if using the sun as your UV radiation source)
21. Place to incubate the yeast (30 degrees C incubator or room temperature)

Material sources

- Carolina Math and Science, 1-800-334-5551, http://www.carolina.com
- Fisher Science Education, 1-800-955-1177, http://fisheredu.com
- Fisher Scientific, 1-800-766-7000, http://fishersci.com

Note: Catalog numbers and prices are from 2002-2003 catalogs

* The polystyrene in some brands of Petri dishes filters out UV radiation, making them unsuitable for this experiment. If using Petri dishes

from other sources, you will need to run a sample experiment with the yeast to make sure they do not filter out UV radiation.

Item	Company	Catalog #	Quantity	Price
UV-sensitive yeast	Carolina	WW-17-3634	Each	$8.90
YED media plates	Carolina	WW-17-3690	Sleeve of 10	$20.00
YED medium (dry)	Carolina	WW-17-3650 WW-17-3651	For 500 ml For 2 liters	$3.40 $12.00
Yeast extract	Fisher Education	S71605	100 g	$41.75
Dextrose, anhydrous (glucose)	Fisher Education, or any	S73415 S73418	100 g 500 g	$3.50 $5.95
Powdered agar	Fisher Education Carolina	S70210 S70213 WW-84-2131 WW-84-2133	100 g 500 g 120 g 500 g	$17.75 $63.00 $24.95 $59.95
Agar agar	Health food or Oriental market		1 g or more	$0.05 - $0.40/g
Sterile, polystyrene Petri dishes*, 100 x 15 mm	Carolina Fisher Education Fisher Scientific	WW-74-1250 S33580 08-757-12	Sleeve of 20 Sleeve of 20 Case of 500	$4.90 $4.25 $110.01
Sterile containers	Fisher Scientific	02-540-10	Case of 100	$132.23
Sterile, graduated, plastic pipets	Fisher Scientific	13-711-20	500, indiv. wrapped	$53.01
Sterile water	Carolina	WW-19-8697	1 liter bottle	$12.00

Materials Preparation Guide

Sterile technique: Dust is the most common carrier of contamination (bacteria and molds) to yeast cultures and media. It can come from people, from the air or from the bench or table top. To minimize contamination, do the following:

- When you are streaking or pouring plates choose a time (usually after classes end for the day) and place where you will not be interrupted by students, colleagues or janitors. Lock the door to your work area.
- If possible, choose a work area that is far from plants, animals, *Drosophila* (fruit fly) cultures, and other biological materials that are sources of mold.
- Choose a work area with the least amount of air turbulence possible. Do not talk, sing, whistle, cough or sneeze in the di-

rection of sterile items or your work area.

- Before beginning to work, clean your work area with soap and water. Then wipe it down with 70% or 95% ethyl or isopropyl (rubbing) alcohol (70% is actually more effective). Wash your hands with soap and water and then wipe them with alcohol.
- Keep sterile media, plates, toothpicks, etc. covered as much as possible.
- Only touch the yeast and sterile things with other sterile things or surfaces.

YED (Yeast-Extract Dextrose) media plates: For convenience you can use pre-poured media plates or save some money by pouring your own. Pre-poured plates can be ordered from Carolina Math and Science – see Material Sources.

Instructions for pouring plates yourself are listed below. You will need approximately 25 ml of liquid media for each 100 x 15 ml Petri dish. Resource on preparing yeast media plates: Yeast Experiments Video 3: Methods and Materials - "Taking the Magic out of Making Media" demonstrates the complete media preparation and plate pouring process. Available from Carolina Math and Science, catalog # WW-17-3682, $25.75.

Equipment and materials for YED media plates

1. Dry YED media
   - Packets of pre-measured dry media (for 500 ml or 2 liters) can be ordered from Carolina Math and Science – see Material Sources.
   - Or these are the materials for making your own dry media for 500 ml: 5 grams Yeast Extract, 10 grams Dextrose, anhydrous (glucose), and 10 grams Agar or Agar-agar
2. Sterile, polystyrene Petri dishes – 100 x 15 ml size (1 per student or team)
3. Glass flasks with a capacity of about twice the amount of liquid media you will place in them.
4. Deionized or distilled water (500 ml or 2 liters depending on dry media amount)

5. Aluminum foil (autoclave or pressure cooker) or plastic wrap (microvave)
6. Autoclave, canning pressure cooker or microwave
7. Heat-resistant gloves or potholders (for handling hot flasks)
8. Sterile facial tissues (from a freshly-opened box, or several tissues down in an opened box)
9. 70% or 95% ethyl or isopropyl (rubbing) alcohol
10. Graduated cylinder
11. Balance, weighing paper, and scoopulas (if not using pre-weighed media)

Autoclave or pressure cooker preparation of media

1. Use a flask with a capacity of about twice the amount of liquid media you plan to place in it; flasks larger than 2 liters are difficult to handle.
2. Pour the dry media into the flask, weighing chemicals if needed.
3. Add the appropriate amount of deionized or distilled water to the dry media.
   - Pour about one-fourth of the water into the flask.
   - Swirl the flask until most of the lumps are dissolved and the media is thoroughly wet.
   - Use the rest of the water to wash any dry media on the sides of the flask down into the solution; avoid further mixing.
4. Cover the flask with aluminum foil.
5. Sterilize the media in an autoclave or canning pressure cooker for 15 minutes at 15 pounds per square inch of pressure. Allow the pressure to return to zero.
6. Swirl the hot flask vigorously after sterilization; this eliminates layering of the ingredients and ensures a uniform distribution of nutrients.
7. Cool the media to 55^{o}C – the flask will be warm, but not too hot to touch comfortably (do not place a thermometer in the sterile media). It will take about 30 minutes at room temperature for the media to cool. If you prepare several flasks at the same time, you may place them in a 55^{o}C water bath to keep them at pouring temperature. If you allow the media to become too cool, it will

begin to "gel" in the bottom of the flask. Cooling the media to 55°C before pouring prevents excess condensation from forming on the Petri dish lids.

8. While the media cools, prepare to pour the plates.
   - Wash your hands with soap and water.
   - Wipe down your work space and hands with alcohol to remove possible contaminants.
   - Remove the Petri dishes from their plastic bags.
   - Arrange the Petri dishes along the edge of your working surface so they will not need to be moved after you pour in the liquid media. You may lay them out singly or in stacks of 3-5.
9. Remove the aluminum foil from the neck of the flask. Wrap several layers of sterile facial tissues around the neck of the flask to protect your hand while pouring (the media is still hot).
10. Pour liquid media into the Petri dishes:
    - Lift the lid of each Petri dish only enough to pour in the media; this helps prevent contamination of the media by mold spores, etc. Replace the lid as soon as you finish pouring.
    - If you have arranged the Petri dishes in stacks, first lift the lid of the bottom dish, balancing the other dishes on top of it; continue upward through the stack, pouring each dish in sequence.
    - Fill each Petri dish about one-half full. This can be estimated by pouring the media on one side of the dish and stopping when the flow of media reaches the other side.
    - Once you begin pouring, keep the flask in pouring position until it is empty; this keeps contaminants from falling into the media. Since most contamination is airborne, do not talk, sing or whistle while pouring plates.
11. When the flask is empty, immediately rinse it with very hot tap water to remove any remaining media.
12. When the media in the Petri dishes has cooled and solidified, invert them so that condensation does not drip onto the media surface.
13. It is very important that the media be a bit dry for this experiment so that it will quickly absorb the water in the yeast solution. Let the plates sit in an undisturbed place for 4-5 days (or longer if you

have high humidity) before using or storing them.

14. To store the plates, return them to the bags they came in (keep them inverted) and tightly seal the bag tops with rubber bands or tape. The plates can be stored for several months at room temperature, or in the refrigerator, which inhibits the grown of contaminants.

Microwave preparation of media: Media prepared in a microwave will not be as sterile as media that is autoclaved. However, microwave preparation is a viable alternative if you do not have an autoclave or canning pressure cooker. It is also useful for preparing small amounts of media for emergency use. Because media prepared in this way is not as sterile, plates usually can not be stored for long periods of time without growing molds or other contaminants. This method does not work with agar agar products purchased at a health food or Oriental market; these agars seem to contain contaminants that are not killed by microwaving. To prepare media in the microwave, use the procedure below:

Follow Steps 1-3 in the autoclave procedure above.

4. Cover the flask with a piece of plastic wrap. Punch a hole in the plastic wrap to allow steam to escape.
5. Dissolve the media in the microwave.
   - Microwave the flask on HIGH for several minutes. Watch the media carefully through the window in the door.
   - When the media boils, stop the microwave and swirl the media; use a folded paper towel or hot pad to protect your hand. Continue to do this until the media dissolves.

Continue with Steps 6-14 in the autoclave procedure.

Removing water condensation on the lids of media plates: Before turning media plates right side up to use them, look to see if there are droplets of water on the inside of the lid. If there are, do the following:

- Hold the plate in the upside down position.
- Grasp the bottom (which is facing up) with one hand.

- Remove the lid with the other hand, turn it over, and briskly flick it to remove the water droplets.
- Replace the lid on the plate and turn it over.

If there is moisture condensation in the lid that cannot be removed by flicking, pull a sterile facial tissue out of the box and use a part of it that you have not touched to wipe the condensation from the lid.

UV-sensitive yeast strain: This strain of yeast has mutations in an excision repair gene (rad1), an error prone repair gene (rad18) and a photoreactivation repair gene (phr1).

For explanations and diagrams of each type of DNA repair see "Part F.6. A Closer Look at… Repair of DNA" in A Classroom Guide to Yeast Experiments, available at http://www.phys.ksu.edu/gene/chapters.html

Sterile container with lid: Use a beaker covered with aluminum foil, a baby food jar, or any other container that you can sterilize and cover. If you can get a donation from a doctor's office, clinic or hospital, a sterile, plastic specimen container with a lid is easy to use. The container needs to hold at least twice the volume of the yeast solution you will need (1 ml/student or student pair). To reduce contamination, use a different container for each class.

To sterilize a container, place the cover or aluminum foil loosely over the mouth and use one of the following sterilization methods:

autoclave or pressure cook for 15 minutes at 15 pounds of pressure or

bake at 320^{o}F for 2 hours.

Sterile pipet: If you do not purchase sterile, graduated, plastic pipets, glass pipets can be sterilized using the same methods as those for sterilizing a container (see above).

Sterile distilled water: Sterile distilled water can be purchased or you can prepare it with either of the following ways:

- Autoclave or pressure cook a loosely covered bottle of water

for 15 minutes at 15 pounds of pressure

- Place a loosely covered bottle of water in a pan of boiling water for 15 minutes. After the water and container cool, tighten the lid.

Sterile, flat toothpicks: Toothpicks in unopened boxes are sterile and can be used directly from the box. Use scissors to cut a small hole (about 1/4 inch across) in one corner of the box to serve as a dispenser. The toothpicks in the box are pointing in both directions; use only the ones you grasp by the pointed end (leaving the rounded end sterile, for use).

Yeast incubation temperature and growth rates: The optimum growth temperature for yeast is 30°C, but it will grow satisfactorily at room temperature; the cooler the room, the slower it will grow.

Incubate yeast in the dark as much as possible.

For optimal growth, the plates must be aerobic. Do not tightly seal them in plastic bags while they are incubating. You may find it helpful to incubate them in open food-storage bags, which keep them from drying out too quickly and protects them from contamination.

If the yeast has grown enough to show differences among the treatments and students are not able to immediately observe the plates, place the plates upside down in the refrigerator in a sealed plastic bag. This will stop the yeast from growing. If the yeast grows too much it may obscure differences among the treatment areas on the dish.

Yeast strains can be stored on media plates in the refrigerator for up to six months or a year.

Sources of UV radiation:

Sunlight — For maximun exposure and effectiveness, hold plates of yeast so that the surface of the agar is perpendicular to the sun's rays. Placing a piece of paper or 3x5" card behind the Petri dish to show a shadow may be helpful; when the dish is perpendicular to the sun, the shadow will be smallest. Use the following table to deter-

mine the number of minutes to expose the plates:

	Number of minutes to expose plates		
Season	**Mid-morning**	**Noon**	**Mid-afternoon**
Summer	3-4	2-3	3-4
Spring & Fall	5-6	3-4	4-5
Winter	40-50	15-20	20-30

Table from "A Classroom Guide to Yeast Experiments"
http://www.phys.ksu.edu/gene/chapters.html

Quartz-halogen bulbs — Quartz-halogen bulbs emit UV radiation which is very similar to that reaching the earth's surface from the sun. These bulbs are used in some decorative lamps and work lights. Lights with these bulbs have a piece of glass over the bulb to absorb the UV radiation. If you remove the glass, these bulbs can be used as a source of artificial sunlight.

Set the light up in a way that minimizes UV exposure. This includes placing the light below students' eye level and directing the light downward onto the surface where you place the yeast plates. Because quartz-halogen bulbs put out considerable heat, place the plates of yeast at least 20 cm (8 inches) from the bulb so as not to kill the yeast, warp the plastic Petri dishes, or melt the agar. Instructions for building a stand to hold a quartz-halogen work light are available at http://gslc.genetics.utah.edu/disorders/units/environment/light.html.

There is considerable variation among bulbs in the amount of UV radiation and heat they produce. Before using this light source with students, test your bulb to determine the length of exposure time needed to kill most of the yeast. In our tests, exposure times have ranged from three to six minutes with 300W and 500W bulbs.

Fluorescent lights — Fluorescent light tubes are filled with a mercury vapor that emits UV-C radiation when electric current passes

through it. Most fluorescent tubes are coated on the inside with a fluorescent material that absorbs this UV radiation. However, other types of fluorescent coatings can cause these tubes to emit each of the three types of UV radiation. UVA tubes are used as "black lights". UVB tubes are used to fluoresce the ethidium bromide dye used to stain DNA fragments in DNA electrophoresis. UVC tubes have no fluorescent coating and are often called germicidal lamps.

Instructions for constructing a UV radiation chamber that utilizes fluorescent lights are available at http://www.phys.ksu.edu/gene/RAD.html.

Sources of 15 Watt UV fluorescent tubes to use with this chamber are listed below:

Company*	UV Type	Wavelength (nm)	Item Number	Price
Cole-Palmer	UVA	365	EW-09815-55	$12.25
	UVB	312	EW-09815-63	$37.00
	UVC	254	EW-09815-59	$17.35
Carolina	UVC	(not in catalog)	WW-70-3462	$41.10

*Cole-Parmer Instrument Co., 1-800-323-4340
http://www.coleparmer.com
Carolina Math and Science, 1-800-334-5551
http://www.carolina.com

The wavelengths of light emitted by the fluorescent tubes is strongly temperature dependent; allow the lights to warm up for 30 minutes before use. Before using each type of bulb with students, test it to determine the length of exposure time needed to kill most of the yeast; 15-20 seconds is usually adequate for UVC.

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Standards

U.S. National Science Education Standards

Grades 5-8:

- Content Standard A: Science as Inquiry – designing and conducting an experiment analyzing and interpreting data; communicating the results.
- Content Standard B: Physical Science, Transfer of Energy – ways in which light interacts with matter; wavelengths of the sun's energy.
- Content Standard C: Life Science, Structure and Function in Living Systems – cellular composition of organisms; cell function; tissues.
- Content Standard D: Earth and Space Science, Structure of the Earth System – atmospheric properties at different elevations. Earth in the Solar System – tilt of the earth's rotation on its axis affects the amount of solar radiation hitting the earth's surface.
- Content Standard F: Science in Personal and Social Perspectives, Personal Health – natural environments may contain substances that are harmful to humans. Risks and Benefits – risks associated with environmental hazards; risk analysis; critical thinking about risks and benefits; personal decisions.
- Content Standard G: History and Nature of Science, Nature of Science – use of model systems for conducting experiments; the process of scientific inquiry.

Grades 9-12:

- Content Standard A: Science as Inquiry - formulating and testing hypotheses; designing and conducting scientific investigations communicating and defending a scientific argument.
- Content Standard B: Physical Science, Chemical Reactions – light can initiate chemical reactions that break and/or form chemical bonds; Interactions of Energy and Matter – electromagnetic waves and their effects.
- Content Standard C: Life Science, The Cell – storage of information in DNA and its direction of protein synthesis; regulation of cell function. The Molecular Basis of Heredity – structure of DNA; DNA mutations; how mutations can affect cells.
- Content Standard D: Earth and Space Science, Energy in the Earth

System – global climate.

- Content Standard F: Science in Personal and Social Perspectives, Personal and Community Heath – environmental hazards and ways to reduce or modify them; cancer prevention; personal health choices. Environmental Quality – how the quality of the atmosphere effects humans and how we are affecting that quality. Natural and Human-Induced Hazards – effect of slow and progressive environmental changes on humans; risk assessment; weighing costs and benefits to society. Science and Technology in Local, National, and Global Challenges – humans must decide how to use science and technology; how human effects on the environment (atmosphere) affect other species.
- Content Standard G: History and Nature of Science, Nature of Scientific Knowledge – the nature of scientific explanations.