



Teacher's Guide for YSI Online

Grades 6-12



The Dr. Samuel D. Harris

**NATIONAL
MUSEUM of
DENTISTRY**

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Jeremy Haack
Resource Teacher, K-12
Office of Science, PreK-12
Baltimore County Public School System
Middle River, Maryland

Mary Monte
Forensic Science Teacher
Eastern Technical High School
Essex, Maryland



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Exhibit and Museum Overview

Your Spitting Image Exhibit

From CSI to the real world, unlock the mysteries of the body with hands-on investigations that reveal what your mouth says about you. Find out how forensic scientists use DNA analysis, dental records, and saliva to solve real cases – and discover how your mouth is a window to health for your body.

Your Spitting Image Exhibition Highlights:

Forensics: Solving Mysteries

- Learn how forensic dentists help law enforcement identify missing persons.
- Compare dental radiographs to identify a crime victim.
- See how DNA samples from a toothbrush are used to make identifications.
- Use replica skulls to determine gender and ethnicity.
- Learn how to chart the dental characteristics of an unknown victim.

Saliva: A Remarkable Fluid

- See how much saliva we produce in a day
- Open wide and look in the mirror to see where saliva comes from.
- Look under a magnifying glass to identify the molecules in saliva and find out what they do.
- Find out how saliva is being used as a diagnostic tool.
- Dare to sniff bad breath and good breath – then learn the right way to brush, floss, and rinse for a healthy mouth.

Bioengineering: Making a New You

- Discover how bioengineering is changing how we take care of our teeth.
- Trace the evolution of tooth replacement from 2,500 B.C. to the near future.
- Learn how stem cells begin the process of growing replacement teeth in the laboratory.
- Find the key to how salivary glands may be used to cure diseases.

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National Museum of Dentistry

The **National Museum of Dentistry**, an Affiliate of the Smithsonian Institution, offers a series of engaging traveling exhibitions that travel to children's and science museums across the country, raising awareness of the importance of good oral health to healthy life.

How to Use This Guide

This guide was created to assist teachers in using some of the exhibit's interactives within a classroom setting. Each of these lessons can be used as a stand-alone lesson about oral health or may be grouped together to form a unit.

- Each lesson is divided into a teacher brief and a lesson page.
- The teacher brief includes the purpose of the lesson, online activity links, and background information about the topic of the lesson.
- The lesson page contains a key point, materials, procedure, and questions to aid in discussion.
- The activities were designed to meet the National Science Education Standards developed by the National Committee on Science Education Standards and Assessment and the National Research Council.
- After completing these lessons, consider inviting an odontologist, geneticist, or bioengineer to speak to your class about their profession.

Links to National Science Education Standards

Grades 6-8

Content Standard	Student Understanding
<p>Content Standard A Abilities Necessary to Do Scientific Inquiry</p>	<ul style="list-style-type: none"> • Identify questions that can be answered through scientific investigations. • Think critically and logically to make the relationships between evidence and explanations.
<p>Content Standard A Understandings About Scientific Inquiry</p>	<ul style="list-style-type: none"> • Current scientific knowledge and understanding guide scientific investigations. • Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data.
<p>Content Standard C Reproduction and Heredity</p>	<ul style="list-style-type: none"> • Every organism requires a set of instructions for specifying its traits. • Hereditary information is contained in genes, located in the chromosomes of each cell.
<p>Content Standard C Structure and Function in Living Systems</p>	<ul style="list-style-type: none"> • All organisms are composed of cells—the fundamental unit of life. • Specialized cells perform specialized functions in multicellular organisms.
<p>Content Standard E Understandings About Science and Technology</p>	<ul style="list-style-type: none"> • Many different people in different cultures have made and continue to make contributions to science and technology.
<p>Content Standard G Science as a Human Endeavor</p>	<ul style="list-style-type: none"> • Women and men of various social and ethnic backgrounds—and with diverse interests, talents, qualities, and motivations—engage in the activities of science, engineering, and related fields such as the health professions.

Links to National Science Education Standards

Grades 9-12

Content Standard	Student Understanding
Content Standard A Abilities Necessary to Do Scientific Inquiry	<ul style="list-style-type: none">• Identify questions and concepts that guide scientific investigations.• Design and conduct investigations.
Content Standard A Understandings About Scientific Inquiry	<ul style="list-style-type: none">• Scientists conduct investigations for a wide variety of reasons.• Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists.
Content Standard C The Cell	<ul style="list-style-type: none">• Cells store and use information to guide their functions.
Content Standard C The Molecular Basis of Heredity	<ul style="list-style-type: none">• In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T).• Changes in DNA (mutations) occur spontaneously at low rates.
Content Standard E Understandings About Science and Technology	<ul style="list-style-type: none">• Science often advances with the introduction of new technologies.
Content Standard G Science as a Human Endeavor	<ul style="list-style-type: none">• Individuals and teams have contributed to the scientific enterprise.

Purpose

In this lesson, students will learn about DNA extraction and why it is important to the advancement of oral health.

Online Activities Link

DNA Extraction Module

Exhibit Link

Saliva: A Remarkable Fluid, Bioengineering: Making a New You, Forensics: Solving Mysteries
Each of these sections of the exhibit show how DNA extraction is important to different types of studies. Research in stem cells, gene therapy, and forensic DNA analysis all require the use of extracted DNA.

Background

DNA (deoxyribonucleic acid) is found inside the nucleus of a cell in tight bundles called chromosomes and contains all of our genetic information. Every cell in the human body, except red blood cells, has DNA. Unless you are an identical twin, no one else in the world has the same genetic information as you.

The structure of DNA is a double helix with alternating sugar and phosphate along the sides. DNA is made up of four building blocks or nucleotides (adenine, thymine, cytosine, and guanine) which are arranged in pairs along very long strands. The human genome (complete set of DNA) has about 3 billion nucleotides. The order of the nucleotides in a DNA strand is a sequence.

Each person in the world has a unique sequence. We are all 99.9% the same; but our uniqueness is found in 0.1% of our DNA sequence. This uniqueness in our DNA sequence is what sets us apart from each other. Our DNA can be broken down into smaller parts called genes that are the hereditary units passed from parent to child.

In order to study DNA, researchers must collect samples from people. One of the best DNA samples is saliva because it contains mouth and cheek cells. There are many different ways to get saliva for DNA testing. Saliva can be found on a phone after a conversation, on licked envelopes, toothbrushes, and anything else that may come in daily contact with your saliva and/or mouth.

There are many reasons why scientists use DNA to conduct research. It allows them to locate specific genes that cause diseases and learn how our body works and functions based on our genetic makeup. Gene therapy is a new technique used to replace “bad” genes with “good” genes to find cures for inherited diseases. Additionally, DNA research is looking for ways to improve our oral and overall health.

In this experiment, students will extract DNA from their saliva. Students need to swish with salt water as it helps to separate their DNA from RNA in cells. Dish soap is combined with the saliva water to remove the cell membranes so the DNA can be exposed. Alcohol is used in the last step to remove DNA from the soap-saliva liquid since DNA does not dissolve in alcohol. Scientists use DNA extraction not only for oral health research but to identify people as well..

Note

If your school district does not allow bodily substances to be used, juice from fruits such as kiwis and strawberries, can be used in place of the saliva in this experiment. It will be necessary to add a pinch of meat tenderizer (enzyme) to the saliva cup before adding the alcohol.

Key Point

DNA is found in most of our cells and can be extracted for scientific study and identification.

Materials

DNA Extraction Module	Rubbing alcohol	Graduated
Small, clear drinking cups	Water	cylinder/measuring cup
Table salt	Measuring spoons	Tape
Dish soap		

Procedure*

PREP - Place a container of rubbing alcohol in the freezer at least one hour prior to the start of the experiment. Keep the alcohol cold during the experiment or the experiment will not work.

1. Discuss with students where they can get DNA from their body. As a class, try to identify good sources of DNA that are easily obtainable. Explain that saliva is an excellent source of DNA as it contains mouth and cheek cells. Ask students if they have any ideas about how you can extract DNA from a cell.
2. Show students the online DNA Extraction Module, found on the YSI website (**INSERT LINK**). Discuss each step of the process.
3. Explain to the class that they will be extracting their own DNA from saliva today. Have students work in pairs to complete the experiment. Do each step as a whole class so everyone spends the same amount of time swishing and waiting.
4. Have students work in groups to make a salt water mixture and soap solution. Each group should collect two cups, salt, and soap. A cup for each group member is also needed.
5. Using tape, label the first cup "salt-water mixture." Measure $\frac{1}{2}$ cup of water (100mL) and put in the cup. Add one tablespoon of salt to the water. Stir until the salt has dissolved into the water.
6. Label the second cup "soap solution." Measure three tablespoons (45 mL) of water and pour into the cup. Add 1 tablespoon (15 mL) of liquid dish soap (a colored one will work best) to the water. Stir to mix.
7. Measure one teaspoon (5mL) of the salt-water mixture from the first cup. Place the mixture into a cup that is labeled with the student's name. Swish the salt-water mixture in your mouth for one minute. When the time is up, spit the salt water back into your labeled cup.
8. Measure 1 teaspoon (5 mL) of the soap solution and add to the student labeled cup that has the salt-water mixture and saliva. Swirl the cup for one minute to gently mix.
9. Measure three tablespoons of rubbing alcohol and carefully add it to the student labeled cup. The experiment will work the best if the alcohol is carefully poured down the side of the cup so it does not mix with the soap.
10. Wait one – two minutes. Bubbles and small white strings will begin to appear. This is the extracted DNA.
11. Have partners discuss why DNA extraction would be important to dentistry and oral health. Let each group write their ideas and report their ideas in a whole-group discussion. Make sure to discuss gene therapy, bioengineering, and forensics.

Questions

1. How can we get DNA from our bodies? What are good sources of DNA?
2. Why is saliva a good source of DNA?
3. How is DNA extraction important to dentistry and oral health?

*Adapted from The Museum of Science and Industry, Chicago

Purpose

In this lesson, students will learn how saliva can be a mirror to your health. Students will learn about saliva and how it is used in different types of health testing to understand the overall health of a person.

Online Activities Link

Saliva Tests

Exhibit Link

Saliva: A Remarkable Fluid

The Saliva exhibit investigates how saliva is used in various health tests. Since it is more patient/health professional friendly than traditional blood testing, researchers are looking into how saliva can be used in more health tests in the future. The current saliva tests help indicate clues about a person's oral and overall health.

Background

Our saliva is a good source of DNA because it contains many mouth and cheek cells. There are many different ways to get saliva for DNA testing. Saliva can be found on a phone after a conversation, on licked envelopes, toothbrushes, and anything else that may come in daily contact with your saliva and/or mouth.

There are many reasons why scientists use DNA to conduct research. It allows them to locate specific genes that cause diseases and learn how our body works and functions based on our genetic makeup. Gene therapy is a new technique used to replace "bad" genes with "good" genes to find cures for inherited diseases. Additionally, DNA research is looking for ways to improve our oral and overall health.

In addition to DNA testing, saliva can be used for various health tests as well. Saliva tests can tell if a person has HIV, has used illegal drugs, is prone to cavities, and many other clues into a person's overall health.

Changes in your saliva can help indicate temporary illnesses or more serious conditions. Soon health care professionals will be able to tell as much about your health from saliva as they can from blood. Saliva testing is less painful and more patient/health professional friendly than traditional blood testing.

Key Point

Saliva is a mirror to your health and can be tested to find clues to a person's overall health.

Materials

Saliva Test Module

Saliva and Your Health Worksheet

Saliva Testing Worksheet

Exhibit Text Sheet

Procedure

1. Discuss with students what they know about saliva (what it is made of, what it is used for, how much you produce, etc.).
2. Have students work in small groups to look up information about saliva using the Saliva Exhibit Text Sheet. Allow them to collect information on the Saliva and Your Health Worksheet.
3. Once they have finished researching about saliva, ask them how saliva would be beneficial to health testing (easier to get a sample, less messy than blood, less painful, etc.)
4. As a class, complete the Saliva Test Module found on the YSI website (**INSERT LINK**). As the class goes through the tests, talk about the benefits of health testing and how saliva plays an important role in these tests.
5. Have students work in their small groups to complete the Saliva and Your Health Worksheet by looking at the Saliva Exhibit Text Sheet to see how many tests can be performed with saliva.
6. Gather the class back together to talk about their findings. List the various tests that can be performed using saliva.
7. Have students think about health testing and come up with ways that saliva could be beneficial for future types of testing. Have each group brainstorm their ideas and then write a proposal for a new type of testing using saliva. Have them complete the Saliva Testing Worksheet to write their proposal.
8. Allow students time to research their ideas and then report back to the class.

Questions

1. What is your saliva made of?
2. What is saliva used for?
3. How much saliva do you produce?
4. How can saliva help in health testing?
5. What other illnesses could saliva help detect?

Name _____ Date _____

Saliva and Your Health

Directions: Using the text from the Saliva section of the Your Spitting Image Exhibit, answer the questions below.

1. How much saliva do you produce every day? _____
2. What makes up saliva? _____
3. What is your saliva used for? _____

Write three facts about saliva:

1. _____
2. _____
3. _____

What health tests can be performed using saliva?

How is saliva beneficial to health testing? Why might it be a better choice than blood?

How is your saliva a mirror to your health?

Name _____ Date _____

Saliva Testing

Directions: As a group, develop a new way saliva can be used to test for an illness. Research how testing for the illness is currently conducted and what the benefits of using saliva might be.

Illness: _____

How is this illness tested for currently?

How may saliva be beneficial in testing for this illness?

Are there any negatives in using saliva to test for this illness?

How do you think using saliva would change how health testing is performed around the world?

Saliva: A Remarkable Fluid

Take an interactive odyssey through your mouth to discover that oft-ignored, but oh-so-essential liquid that protects your teeth, aids in digestion and improves your sense of taste.

- Saliva is made in your mouth 24 hours a day, every day.
- Saliva is produced by a series of major and minor glands located throughout your mouth.
- The average person creates approximately 600mL of saliva daily, enough to fill a vending machine soft-drink bottle (20oz.).
- Teeth would decay much more quickly without the remarkable 1% of saliva that contains enzymes and proteins.
- Tasting sweet, salty, bitter and sour foods would be much more difficult without saliva.
- The mere mention of food is enough to increase the flow of saliva.
- Children produce almost as much saliva as adults.
- The pH of saliva is between 6.0 and 7.0, making it slightly acidic.

Saliva: A Mouthwatering Recipe for Health

Like the individual elements in your favorite recipe, your saliva contains essential ingredients for your health and wellness. From a sprinkle of proteins that protect your immunity, to a dash of buffers that restore the pH balance on your teeth, every ingredient is crucial. Just add water (99 parts) and bake at 98.6 degrees, 24 hours a day, and you'll always be ready with your own recipe for health.

Supporting Immunity

- **Proteins**
 - **Antibodies** – Immunoglobulin proteins responsible for the body's immunity. Saliva contains secretory Immunoglobulin A (IgA).
 - **Enzymes** - Reusable proteins that speed up or slow down chemical reactions/
 - **Lysozyme** – An enzyme found in saliva, sweat and tears that destroys the cell walls of certain bacteria.
 - **Cytokines** – Any group of immunoregulatory proteins that are secreted by cells of the immune system that help regulate immune response.
 - **“Slippy”** – SLPI, secretory leukocyte protease inhibitor – prevents HIV from binding to cells and helps heal wounds.
 - **Lactoferrin** – A minor protein that has anti-viral, anti-bacterial, anti-cancer and other immune enhance effects.
 - **Histatin** – A protein that has anti-bacterial properties.
 - Others neutralize viruses.

Protecting Teeth

- **Buffers** – Substances that counter the addition of acid or base to a solution in order to maintain a neutral pH.
- **Proteins**

- **Mucins (glycoproteins)** – Long sticky proteins covered in carbohydrates that give saliva its stinginess allowing it to coat the teeth and gums. They also stick to the bacteria that cause cavities and gum disease, hindering their ability to clump together, helping our immune system to attack them.
- Others enable saliva to be super saturated with calcium and phosphorous ions.
- **Minerals** – Naturally occurring inorganic substances.

Supporting Overall Health

- **Electrolytes** – Salts of acids and bases whose ions are capable of conducting an electric current in solution.
- **Enzyme Inhibitors** – Prevent enzymes from affecting chemical reactions.
- **Proteins**
 - **Enzymes** – Reusable proteins that speed up or slow down chemical reactions.
 - **Peroxidase** – A group of enzymes that remove hydrogen peroxide from the cell by turning it into water.
 - **Growth Factors** – Proteins that stimulate cell differentiation, division and growth.

Saliva: Mirror to Your Health

As a mirror reveals your unique traits, your saliva mirrors your health. Changes in your saliva can help indicate temporary illnesses or more serious conditions. Soon health care professionals will be able to tell as much about your health from saliva as they can from blood. This less painful, more patient and health professional friendly testing option is within spitting distance!

What can saliva be used for?

- Fertility testing
- Nutritional deficiencies in the elderly
- Monitoring prescribed drug use for treatment compliance
- Detecting illegal drug use
- Monitoring alcohol intoxication levels
- Identifying local and systemic diseases such as Alzheimer's and Sjögren's syndrome
- Monitoring chronic diseases
- Diagnosing infections – influenza, measles, mumps, rubella, herpes, hepatitis A, B, and C, HIV, and others
- Testing a person's susceptibility to getting cavities
- Assessing contamination from lead and other poisons
- Determining the genetic make-up of an individual (genotyping)
- Other genetic tests including forensic testing
- Testing for an increased concentration of the protein that could indicate breast cancer

How Dry is Dry?

- Your whole mouth feels like it is sticking together as you stand before a crowd, preparing to give a speech.
- Your lips get chapped and your tongue gets inflamed as your body adjusts to a new medication.
- You spend every day sipping water, sucking sugar-free lozenges, chewing sugar-free gum and waiting for a cure that has yet to be discovered.

In every case, you have a form of dry mouth.

Major Causes of Chronic Dry Mouth

- Medications – especially anti-depressants and diuretic blood pressure medications
- Systemic diseases – especially Sjögren’s syndrome
- Radiation therapy (X-rays) to treat mouth, neck and head cancers

Problems Resulting from Dry Mouth

- Increased number of cavities
- Inflamed tongue
- Fissured tongue
- Oral yeast infections
- Difficulty speaking
- Difficulty eating
- Difficulty swallowing

Treatments

- Over-the-Counter
 - Artificial salivas
 - Mouth sprays
 - Mouth washes
 - Moisturizing gels
 - Swabs
 - Sugar-free lozenges
 - Sugar-free chewing gums
- Prescription
 - Pilocarpine hydrochloride
 - Cevimeline

Sjögren’s Syndrome

Sjögren’s syndrome is, one of the most prevalent autoimmune disorders, in which the body’s immune system mistakenly attacks its own moisture-producing glands. One condition of the syndrome is chronic dry mouth.

- Symptoms vary widely from mild inconveniences to debilitating conditions affecting quality of life
- Strikes approximately 4 million Americans
- 9 of 10 are women
- Average age of onset: late 40s but can occur at any age

Purpose

This lesson investigates how to take care of your teeth and the importance of your oral health to your overall health.

Online Activities Link

Brush, Floss, Rinse

Exhibit Link

Saliva: A Remarkable Fluid

The Saliva exhibit investigates the mouth-body connection to health. Keeping your mouth healthy is important to your overall health. Scientists are investigating possible links between periodontitis and some systemic conditions, including heart disease, diabetes, and stroke.

Background

Taking care of your teeth is important to maintain overall health. Emerging scientific research suggests a link between periodontitis, advanced gum disease, and some health problems. Bacteria that causes periodontitis can enter the bloodstream and have an affect on other systemic conditions, such as heart disease, diabetes, and stroke. Oral bacteria entering the bloodstream due to advanced gum disease may attach to fatty plaques in the arteries surrounding the heart helping to form clots and could lead to a heart attack. The link between advanced periodontal disease and diabetes may be a two-way street. Diabetics develop gum disease more easily because diabetes slows the body's natural healing process and blood-sugar levels may be adversely affected by advanced gum disease. Oral bacteria entering the bloodstream due to advanced gum disease may attach to fatty plaques in the arteries of the brain helping to form clots, which can block blood flow and lead to a stroke.

In addition to a mouth-body connection, researchers are trying to find ways to improve oral health for the future. These studies include gene therapy and bioengineering. To end oral diseases, such as Sjögren's Syndrome, scientists are looking into gene therapy techniques to correct misspellings in DNA. Through bioengineering, researchers are using stem cells from wisdom teeth and recently extracted baby teeth to find ways to grow new teeth to replace lost permanent teeth.

Key Point

It is important to take proper care of your teeth in order to have a healthy mouth and body.

Materials

Brush, Floss, Rinse Online Module
Exhibit Text Sheet

Procedure

1. Ask students what they do to take care of their teeth. Ask them why they need to take care of them.
2. View the Brush, Floss, Rinse Module found on the YSI website (**INSERT LINK**). Ask students to tell you something they learned from the video.
3. Talk to students about the importance of oral health to their overall health.
4. Explain to the class that there may be a connection between heart attack, stroke, diabetes, and oral health. Tell the class that they will be divided into three groups to research a way that oral health is connected to another disease. Assign students to each of the following groups: heart attack, stroke, and diabetes.
5. Each group is responsible for researching their disease and how it may be linked to oral health. Each group will present their findings to the class. They may present in a powerpoint, play, demonstration, etc. Hand out an Exhibit Text Sheet to each group for reference. If students want to learn more about their topic, they may use the Internet as an additional reference.
6. Give students class time to research and prepare their presentations. Have students present to the class.
7. As a class, discuss the importance of oral health to your overall health.
8. If extra time permits, you may consider setting up a school health fair to give students the opportunity to educate peers and staff about the importance of oral health.

Questions

1. How do you take care of your teeth?
2. Why is oral health important?
3. How does oral health affect your overall health?

Brush, Floss Rinse

- You can help saliva protect your teeth, mouth and body by removing plaque.
 - Plaque is a white film of bacteria (biofilm) and food debris that covers your entire mouth.
- Plaque left on teeth can lead to:
 - **Gingivitis** – is a mild periodontal disease, which affects only the gums, causing bleeding and is the first step to periodontitis
 - **Periodontitis** - is a serious gum infection affecting the structures supporting the teeth and results in bone loss around the teeth

Steps to a Healthy Mouth

- Brushing
 - Brush Twice each day with fluoride toothpaste.
 - Use a soft bristle brush.
 - Brush your tongue.
- Flossing
 - Floss once a day to effectively remove plaque from the surfaces of teeth which touch.
 - Hold the floss in a “C” shape against the side of the tooth.
 - Move the floss up and down to remove plaque.
 - Never use a “back-and-forth” motion.
- Antimicrobial mouthrinse
 - Why use it? – Because the bacteria in plaque causes gingivitis and periodontitis
 - Brushing and flossing only removes plaque from your teeth.
 - Antimicrobial mouthrinse can reduce bacterial activity in your whole mouth. Even in places where a brush and floss can't reach.
 - How to use it – Rinse for 30 seconds morning and night.
- Eat a balanced diet and limit between-meal snacks.
- Visit a dentist regularly.

The Mouth-Body Connection

Is there a link between periodontitis (advanced gum disease) and some health problems?

Emerging scientific research suggests that bacteria causing periodontitis can enter the blood stream and have an affect on other systemic conditions.

- **Heart Disease** – Oral bacteria entering the bloodstream due to advanced gum disease may attach to fatty plaques in the arteries surrounding the heart helping to form clots and could lead to a heart attack.
- **Diabetes** – The link between advanced periodontal disease and diabetes may be a two-way street. Diabetics develop gum disease more easily because diabetes slows the body's natural healing process and blood-sugar levels may be adversely affected by advanced gum disease.
- **Stroke** – Oral bacteria entering the bloodstream due to advanced gum disease may attach to fatty plaques in the arteries of the brain helping to form clots, which can block blood flow.

Purpose

This lesson will explore the future of oral health and a visit to the dentist.

Online Activities Link

Tooth Timeline

Exhibit Link

Saliva: A Remarkable Fluid, Bioengineering: Making a New You

The Saliva exhibit investigates the mouth-body connection of health. Both of these sections of the exhibit show advances in oral healthcare as a result of gene therapy and bioengineering research completed by various professionals with different kinds of backgrounds.

Background

Through emerging scientific research, a visit to the dentist will be different in the future. Current steps are underway to learn about a connection between oral health and a person's overall health. Once this can be determined, dentistry will not only pertain to teeth but taking care of your whole body as well. With this new mouth-body connection, scientists are conducting research to find ways for people to have healthy smiles that will last a lifetime.

Currently, dentures and implants are used to help a person maintain a healthy smile if he loses his teeth. Scientists are discovering ways to grow teeth in the future by using stem cells from baby and wisdom teeth. With these breakthroughs, people will have more options when deciding how to maintain their smiles.

The Future of Oral Health

Lesson Plan

Key Point

Researchers are studying ways to grow teeth in the future and use gene therapeutics to improve a person's oral and overall health.

Materials

Tooth Timeline Module
Exhibit Text Worksheet

Procedure

1. Ask students what happens if they don't take good care of their teeth. Have them talk about what happens if you are missing teeth. Explain that currently implants and dentures are the only ways to replace lost teeth.
2. Ask students if they know of any research about growing teeth.
3. As a class, watch the Tooth Timeline Module found on the YSI website (**INSERT LINK**) to see advances in oral care.
4. Explain that soon, we may be able to grow new teeth if we need a replacement.
5. As a class, discuss these advances in oral health and how they might change dentistry and the dental office.
6. Have each student explore the future of dentistry and oral health by reading the Exhibit Text Worksheet. If time permits, students may research the internet or read journal articles to find more information.
7. Once they have gathered some information, have each student write a creative writing piece about the future of dentistry and/or a dental visit in the future. They may write a poem, short story, essay, or any other style of their choosing.
8. If needed, allow students time to brainstorm in small groups.
9. Let each student share their writing piece with the class.

Questions

1. What is the future of dentistry and oral health?
2. What might a visit to the dentist look like in the future?
3. How are scientists growing teeth to replace missing teeth?
4. What do you think scientists could study in the future to improve our oral health?

I've Lost a Tooth: Now What?

The earliest form of bioengineering began with the use of biomaterials – any substance other than foods or drugs used for patient treatment. Those uses have evolved from holding teeth in place with gold wires and bands to filling holes in teeth with gold, platinum, tin and silver amalgam to using metallic implants as replacements for lost teeth. Imagine a time when you will be able to replace a diseased or missing tooth with a new one grown from your own stem cells.

The next step in the evolution of bioengineering is the advancement of tissue engineering and gene therapy. Tissue engineering researchers are developing ways to design and fabricate new tissues and organs while other bioengineering researchers are studying ways to treat oral and systemic diseases using genes.

Growing Teeth: Is That Possible?

Researchers are working on ways to grow teeth right now – and they are using adult stem cells found in and around teeth to do it.

What is the ideal replacement for a lost tooth?

A natural tooth formed from adult dental stem cells obtained from the patient's own teeth would make the best replacement for a lost tooth. Why?

- Natural teeth are held in place by fibers that allow it to move
 - An artificial implant is embedded in bone and cannot move.
- The fibers holding a tooth in place (periodontal ligament) cushion biting forces, which maintains the surrounding bone.
 - Artificial implants do not have periodontal ligaments to cushion forces, which can lead to bone resorption and ultimately implant failure.
- Natural teeth can tell your body when something is wrong with it; an implant cannot.
- Gum tissue will attach to a natural tooth. Gum tissue does not attach to an implant.

Where are stem cells that form dental tissue found?

- On the inside wall (dentin) next to the nerve and blood vessels (pulp) and in the pulp itself of baby teeth that have fallen out
- In the nerve and blood vessels (pulp) from extracted adult teeth
- At the developing tip of the tooth root
- In the fibers that hold the teeth into their sockets (periodontal ligament)

How are researchers using them?

Researchers have used stem cells obtained from pig teeth and the baby teeth from rats to successfully grow structures resembling perfectly formed small tooth crowns.

- The cells are placed into/onto biodegradable scaffolds. After 12-30 weeks tiny crown-like structures were observed.
- These structures were made up of all of the various cells that make up a naturally formed tooth crown and were shaped much like normal tooth crowns.

Researchers have also used stem cells harvested from the tips of tooth roots and the fibers that hold the teeth into their sockets (periodontal ligament) of adult wisdom teeth to grow tooth roots.

- The stem cells were placed into/onto a root-shaped biomaterial scaffold.
- This structure was then inserted as a replacement for a tooth extracted from a pig.
- After three months, the new bio-root was uncovered and an artificial porcelain crown was attached to the new root structure. The bio-root/artificial crown unit functioned during a four-week observational period.

Finding a Cure: Are Genes the Key?

The completing of the Human Genome Project has advanced our understanding of human genes and their function. Today, research is exploring ways to use genes as diagnostic tools and for treatments and cures for systemic disorders such as diabetes.

Gene Therapeutics

Gene therapeutics is a promising approach for the treatment of some systemic disorders like diabetes. Scientists are even beginning to learn how to customize or individualize drug therapy (often termed pharmacogenomics). Gene therapeutics involves placing the gene of the missing protein into cells that normally do not make protein. Those cells then begin to make that protein.

- Getting the gene into target cells is called gene transfer and involves using an inactive virus (viral vector) to carry the gene.
- Millions of viral vectors carrying the gene are injected or infused into the desired site.
- The viruses infect the target cells inserting the genes into the cells.
- Once inside the cell, the gene causes the cell to make the desired protein.

Why salivary glands make great protein factories.

- They are covered with connective tissue (encapsulated), limiting the spread of the viral vector carriers and gene.
- Getting to them is relatively easy.
- They make large amounts of protein that either goes into saliva or the blood stream.
- A single salivary gland is not critical for life and can be removed if there is a problem.

How does it work?

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Gene therapeutics is just one of the many advances made possible by the Human Genome Project that will affect the oral and systemic health of future generations.

Gene Transfer: Restoring Saliva, Restoring Hope

The debilitating condition of dry mouth may soon be cured by transferring the gene coding for the Aquaporin-1 protein into the duct cells of non-functioning salivary glands. The Aquaporin-1 protein opens microscopic holes in cell walls allowing water to pass through them. This allows salivary gland duct cells to produce saliva.

Steps to Restore Salivary Gland Function

- Identify the gene that codes for the Aquaporin-1 protein
- Choose an appropriate vector (usually an inactive virus)
- Multiply the gene and vector
- Place one copy of the gene into one vector
- Infuse the vectors into the salivary gland
- Test the results
 - Possible Outcomes
 - Correction (cure) of the disease or condition
 - No change in the disease or condition
 - Side effects – immune response to the vector or diffusion of the vector outside the target organ

The Future

- There is currently no cure for permanent salivary gland damage; therefore, altering salivary gland function through gene therapy has become one of dentistry's chief concerns. The promise of current gene transfer research may soon result in the day when people with chronic dry mouth celebrate a cure by recycling their plastic sip-cups and enjoying a life without the constant worry of moistening their mouths.

Glossary

Bioengineering	Use of engineering to solve problems in medicine and biology
Cell	Basic unit of any living organism
Chromosome	Long strand of DNA that is bundled in the nucleus of a cell
DNA	Also known as deoxyribonucleic acid, it is found inside the nucleus of a cell and contains all genetic information
Enzyme	A protein that encourages a biochemical reaction, usually speeding it up
Forensic science	Use of science to answer questions for the legal system
Gene	Unit of heredity from DNA passed from parent to child
Gene therapy	A technique used to treat inherited disease
Genetics	Study of inheritance patterns of specific traits
Genome	Complete set of genes
Genomics	Study of genes and their function
Human Genome Project	International research project to map each human gene and to completely sequence human DNA
Nucleus	Central cell structure that contains chromosomes
Odontology	The scientific study of teeth. In forensics, it is often used to identify a victim by his/her teeth or a suspect by his/her bitemark
Protein	A large complex molecule made up of amino acids that performs a variety of activities in the cell
Stem cell	Unspecialized cell that has the ability to renew itself for a long period of time and is able to turn into a specialized cell when given the appropriate signal