Chemistry of the Human Body

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James Martin Middle School

This curriculum unit is recommended for:
Science/Grade Seven

Keywords: Cells, Digestive System, Urinary System, Circulatory System, Respiratory System

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: The concepts found in chemistry overlap into every type of science there is. Within our human body chemistry dictates how we breathe, how our body filters waste, how we digest food, and how every other reaction takes place. As students are learning about these topics within the human body they often do not fully understand what is happening within our body systems. They memorize facts that the teacher presents instead of understanding why something reacts as it does. Within this unit students will be introduced to the basic atoms and molecules found in our body. From there, they will learn how molecules are broken down, transported, and excreted from our body. Students will learn these through inquiry based lessons which each consist of a teacher demonstration to promote student engagement and a student laboratory component. Student journaling is also used as a way for students to evaluate their data and observations from each demonstration and lab. This unit was designed for teachers who want to incorporate engaging and inquiry based activities into their science class.

I plan to teach this unit during the coming year in to 100 students in grade seven science.

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Jennifer Thompson

Introduction

Chemistry concepts can be very intimidating to the middle school student. Students often experience minimal science exposure in elementary school. In seventh grade we cover the topics of weather, atmosphere, human body, cells, genetics, and physics. These concepts can be better understood if a student has a working knowledge of chemistry. I find myself saying "nitrogen molecules" or "chemical digestion" and my kids do not understand what those terms really mean. Students received instruction in sixth grade on the parts of an atom and simple characteristics of the Periodic Table and in eighth grade they would have seen the basics of bonding and reactions. When studying this chemistry in sixth and eighth grade, often the chemistry is taught as stand-alone concepts without a unifying narrative. I want my students to understand that chemistry connects to other types of sciences and unifies many concepts. In this unit, students will be shown how chemistry connects the different processes in our human body. They will understand that digestion, or breathing, or blood and oxygen circulation is due to the chemistry of our body.

The purpose of this unit is to expose the students to the basics of atoms, molecules, and reactions in the cells and human body. My standards will still be fully addressed, but we will simply go deeper into the topics to learn the "why" behind those concepts. The topics being focused on in this unit are the structure and function of cells, the circulatory and respiratory system, the digestive system, and the urinary system. Upon completion of this unit my students will hold a deeper understanding of cells and human body. They will also be more prepared for the genetics unit to follow, as well as have a solid foundation for chemistry taught in 8th grade.

This unit is designed for the 7th grade students of James Martin Middle School. James Martin is a Title 1 middle school of about 1400 students in Charlotte, NC. It is a very diverse school with its study body consisting of 69% African American students, 19% Hispanic, 5% Asian, 4% Caucasian, and 3% other. I currently teach 105 of these 7th grade students. This year about 85% of my students read below grade level. Within my students I have several students labeled as ELL coming from such places as Mexico, Saudi Arabia, and China. The unit is designed to be taught in 70 minute classes which held every day, not on an A-day B-day schedule. The activities can be easily adapted for any ability level (EC through honors) because of their hands on and highly visual nature. One of the goals of this unit, which you will see from the activities which follow, is to be very visual and hands-on while reaching every type of student in the classroom.

This unit is taught according to North Carolina Essential Standards for Middle School. Our cells and human body unit is taught during the second quarter of the year, beginning with cells and moving into topics involving the human body. There are two seventh grade standards being addressed in this unit. The first standard requires that students understand the structure and functions of the parts of the cell. The second standard requires students to understand the functions of the major systems of the human body and how these systems work together to help us survive. One activity focuses on the molecules found in the cell and their contribution to the daily functions of our cells followed by three activities in the unit focusing on the chemistry of the circulatory/respiratory system, digestive system, and urinary system.

Background

Chemistry of Cells

Even they seem small in size, cells are made up of millions of small molecules. All of these molecules help the cell to complete its specific jobs. The bulk of living things are composed of the elements carbon hydrogen, nitrogen, oxygen, and phosphorous. The multiple ways in which these elements combine result in a wide variety of molecules which help our body complete its daily functions. Most molecules in the cell can be divided into one of four macromolecules: carbohydrates, lipids, proteins, and nucleic acids.

Carbohydrates serve as a means of short term energy storage in our body. Carbohydrates are molecules which contain carbon, hydrogen, and oxygen and have the general formula $[CH_2O]_n$ where *n* is a positive integer Carbohydrates are made of one or more monomers or repeating units. A Carbohydrate with one monomer is called a monosaccharide. Carbohydrates with two monomers are called disaccharides and carbohydrates with multiple monomers are called polysaccharides. Monosaccharides, also called simple sugars, which include the sugars glucose, galactose, and fructose. All three of these simple sugars have the chemical formula $C_6H_{12}O_6$ but the way in which the atoms are arranged varies in each of the three different molecules. This molecular arrangement can be found in figure one below. In your body, glucose, fructose and galactose are all absorbed into the bloodstream during digestion. After absorption these sugars are broken down further in combustion-like processes to provide our body energy.[i] Disaccharides are formed when monosaccharides join together. Common disaccharides in our body include sucrose, maltose and lactose. Figure two shows these three disaccharides and show the specific monosaccharides that bond together to form them. The chemical formula for all of these disaccharides is $C_{12}H_{22}O_{11}$. Polysaccharides form when multiple monosaccharides join together. Starch, for example, is made up of a chain of 200 glucose monomers.[ii]

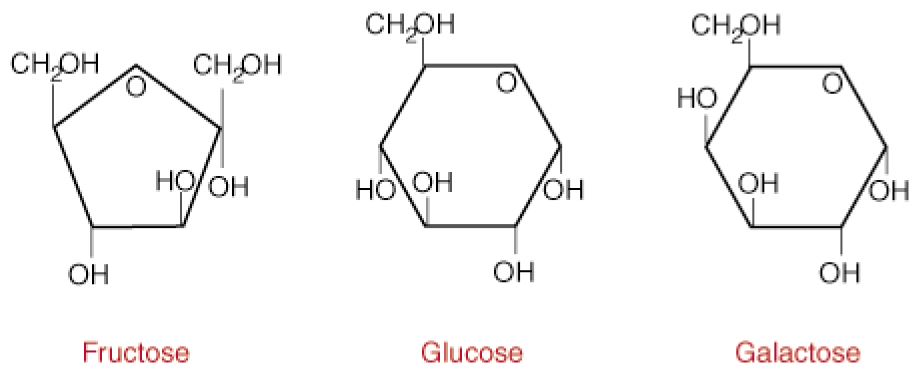


Figure 1: Common Monosaccharides[iii]

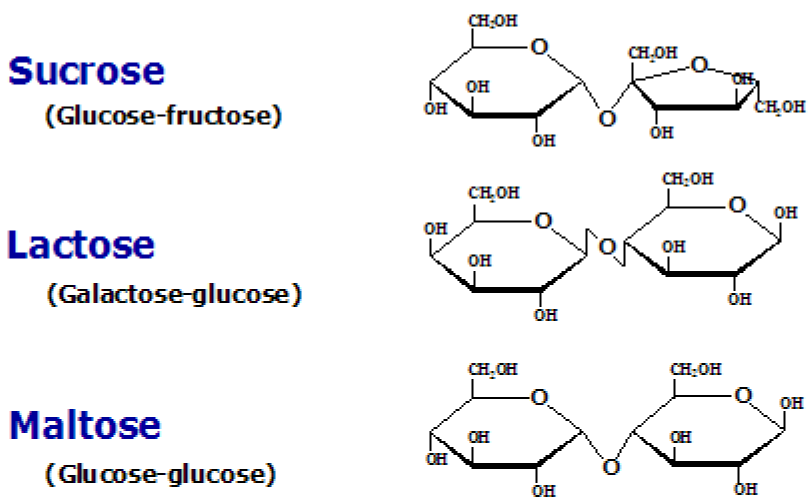


Figure 2[iv]

Similar to the carbohydrates, lipids are made up of the elements carbon, hydrogen, and oxygen, but lipids are more complex than carbohydrates as they are not made up of repeating units. The main purpose of lipids in the body is for long term energy storage. They are also used as structural components in the cell membranes and as messengers. Fats, oils, steroids, some vitamins, and sex hormones are all types of lipids. Lipids are characterized by their insolubility in water. Vitamin A, D, E and K are all lipids. Lipids can also be found in the cell membrane. Cholesterol, the most common steroid in animals, is a lipid as well.[v]

Proteins are made up of repeating units of amino acids. Amino acids are made up of carbon, hydrogen, oxygen, and nitrogen. Figure 3 shows that every amino acid has a central carbon which bonds with an NH_2, amino group, and a COOH, carboxyl group. The “R” is the part which varies with each amino acid; deferring R-groups result in different amino acids. There are twenty different R groups, making twenty different amino acids. The order that these twenty different amino acids combine gives us the variety of proteins which we have in our bodies. When these amino acids want to bind together, they simply drop a hydrogen from the amino group and an OH from the carboxyl group making one water molecule and a new bond called a peptide bond, and the chain of amino acids are called polypeptides. Once there are more than 50 amino acids in the polypeptide chain it is considered a protein. One example of an important protein found in the human body is insulin. Insulin is produced and released by the pancreas and regulates carbohydrate and fat metabolism in the body. Chymotrypsin also aids in digestion and helps to digest proteins. Hemoglobin binds to oxygen in the blood and helps your bloodstream deliver this oxygen to different organs in the body.[vi]

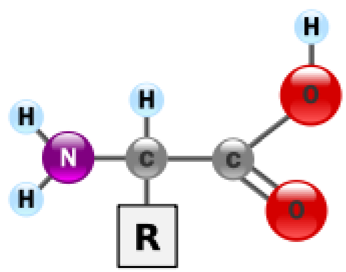


Figure 3: Amino Acid[vii]

Nucleic acids store genetic information within our cells and are found, for the most part, within the nucleus. Nucleic acids are made up of carbon, oxygen, hydrogen, nitrogen and phosphorous. Similar to carbohydrates and proteins, nucleic acids are also made up of monomers called nucleotides. Chemically, nucleotides are made up of a carbon ring, a phosphate group, and a nucleic acid base. The carbon ring and phosphate group are always the same and repeating, but the nucleic acid base can be one of five possible molecular arrangements. How these nucleotides arrange themselves is what gives us our unique genetic code.

Chemistry of the Circulatory and Respiratory System

The circulatory and respiratory systems work together to exchange and transport gases within the body. The purpose of your respiratory system is to bring fresh oxygen into the body and to expel carbon dioxide waste from the body. To take in this oxygen your diaphragm contracts and pulls in air from outside the body. This air travels down the trachea, into the lungs, and into smaller and smaller tubes within the lungs. The alveoli are found at the very end of the tiniest tubes within the lungs. This is where the oxygen in the air passes through the very thin membrane of the alveoli into the bloodstream. There is no chemical reaction during breathing. The oxygen passes through the walls of the alveoli into the bloodstream through diffusion.[viii]

The purpose of the circulatory system is to transport nutrients, water, and gases to different organs in the body. As your blood enters the right side of the heart it is pumped to the lungs and gas exchange takes place as described above. Your blood is then passed from the lungs to the left side of your heart and pumped throughout the body. While breathing is a physical change, the transport of oxygen around the body involves a chemical change. Hemoglobin, discussed briefly within the "chemistry of cells" section, binds oxygen in the blood stream. As the hemoglobin binds to the oxygen, it changes its shape and its electronic orbital structure which in turn causes a change in color to a bright red.[ix] Once the oxygen is dropped off at its destination the hemoglobin changes shape again and the blood turns a darker shade of red. A common misconception is that deoxygenated blood is blue because of how it appears through the skin, but actually it is just a darker shade of red.

Chemistry of the Digestive System

The purpose of digestion is to create energy. Upon eating breakfast, lunch, dinner, and any snacks in between, your body is taking in a wide range of molecules. As these bonds are broken and reformed energy is released. Your body relies on two types of digestion to break down your food into manageable parts: physical digestion and chemical digestion. Without both of these types of digestion, your body could not break down your food into small enough pieces that your system could turn into energy. Digestion starts in the mouth with the physical chomping of food with your teeth. Chemical digestion also occurs in the mouth through the release of salivary amalyse, or saliva. Saliva breaks down the carbohydrates into simple sugars.[x]

Chemical and physical digestion continues in the stomach. The smooth muscle walls of the stomach are always moving to mix the food and acidic mixture in the stomach. Acids in the stomach include hydrochloric acid and the enzyme pepsin. These two chemicals help to break down proteins. This mixture of food, acids, and enzymes is called chime. After 1-2 hours, the chime is passed from the stomach and into the small intestine. Chemical digestion continues at the beginning of the small intestine where digestive chemicals from the pancreas, such as insulin, are released and further digest and regulate carbohydrates and sugars. By the middle of the small intestine, these food particles are small enough to pass into the blood where the body can transport them into the cells that need them. A mass of waste, water and some nutrients are finally passed into the large intestine. Within the large intestine, water is reabsorbed into the blood stream as well as some vitamins.[xi]

Chemistry of the Urinary System

The urinary system acts as a giant strainer for our blood. It removes molecules and particles not needed in our blood and helps to keep our body in balance. The urinary system interacts with the circulatory system when blood enters the kidneys by way of the renal artery. Blood passes into smaller vessels which weave through the kidneys. Approximately 125 mL of blood pass through the kidneys every minute which is 180 liters every day. The blood is filtered based on pressure, meaning no chemical reactions take place during the filtration of blood.

A variety of molecules can be found inside of our urine. Urine is composed mostly of water, but sodium, potassium, and chloride ions are also found in urine. Doctors can take urine samples and determine a great deal about a person's health by what they are excreting from their body. There can be color changes or odor changes depending on the molecules present. For example, a light orange color can indicate vitamin B. Most people are aware of the pungent odor urine can get after eating asparagus, or even that urine can turn pink if you eat too many beats. Sugar in the urine can indicate diabetes or other blood sugar instabilities. No red blood is filtered out of the vessels during filtration, so signs of blood in urine can indicate an infection or other medical issue.[xii]

Strategies

Four distinct activities make up this unit. All activities, except for the one on the digestive system, will take one 70-minute class, while the digestive system activity will take two. Each activity addresses one of the following topics: cell parts, circulatory system, digestive system and urinary system. The cell parts, skeletal system, and circulatory system activities will help teach the chemical concepts of atoms, molecules, and the Periodic Table. The digestive system activity will help teach the concept of chemical and physical changes. Within each activity there will be a teacher demonstration to start the activity which will lead into a student laboratory component. The student laboratory components are all inquiry based. Students will record observations and be assessed on their success of each activity with a journaling exercise. These five days would not be consecutive, but rather spaced over the weeks that we spend on cells and the human body. To have the most impact and inquiry within each activity, activity will be completed at the beginning of each topic as an introduction to that particular body system.

Inquiry

It is common knowledge among teachers that middle school students learn better by doing an activity rather than just being lectured at. The best science lessons have a piece of inquiry in them, even if it is small. Scientific inquiry can be defined as, "a multifaceted activity that involves making observations, posing questions, examining sources of information, planning investigations, reviewing others' data, using tools to gather and analyze data, proposing explanations and predictions, and communicating the results of investigations". Inquiry can be implemented into lessons simply by prompting students to ask their own questions. More complex ways of using inquiry in lessons includes students collecting their own data and using that data to come to their own conclusions. The important tactic is for the experiments to be as student led as they can be, while the teacher takes more of a backseat role.

Students benefit from inquiry based lessons in many different ways. The asking of questions and discovering of new answers allows students to build their new knowledge based on the prior knowledge they already have. It allows students to understand that scientific questions can be complex and that there is often more than one right answer, or multiple steps to finding those answers. One of the most important parts of inquiry lessons is that students are involved in discussions with their peers about the conclusions they are making. [xiii] Inquiry is so important in the science classroom because it teaches students to collaborate and problem solve just as real scientists do.

Each activity in this lesson is rooted in inquiry. Each activity begins with a teacher demonstration. The demonstration will be introduced simply as something "cool" to show the kids that relates to the body system we are studying that week. Minimal background knowledge about that body system will be given to the students. This will begin the activity with questions in their mind. Many of these questions may be answered during their student laboratory component. Students will record these questions and observations within their journals to use throughout the activity. Inquiry within the activities continues into the student lab component, where they will collect data, make comparisons, and communicate the results of their lab to myself and their peers.

Demonstrations

Engaging students could possibly be one of the most important parts of any lesson. If a student is not interested in the topic, it is very difficult to get them motivated enough to learn, understand, and remember the content. Engagement can be thought of as something that builds on itself. Once students are engaged, they are more willing to complete the activities and assignments that follow. One simple way to engage students is through carefully selected teacher demonstrations. There are pros and cons to demonstrations. A poorly displayed demonstration simply demonstrates a teacher's power over their class while showing them there is some science that is not accessible to the students. A well-executed teacher demonstration can do the opposite. It can share a new world of science with students and get them excited about the content and assignments to come. Effective science demonstrations lead to student-student interaction and student-teacher interactions. [xiv] Demonstrations that lead to such interactions help to promote inquiry as well.

Each activity within this unit will begin with a teacher demonstration. These demonstrations were chosen for many reasons: the first being the enhancement of student engagement and the second reason is that they necessarily will need to be conducted by the teacher simply because some of these materials are either unsafe for students to handle or simply too expensive to provide to an entire class. To avoid the demonstration being un-motivating to students, each demo will be energetically proposed to students as the "coolest thing they will ever see"!

Science Journaling

Journals are used in many different subjects for many different reasons. Journals can be used as a way for students to organize their observations and their thoughts. It gives students a way to share their findings with an audience. Entries in journals are not limited to writing, but can include charts, stories, observations, drawings, graphic organizers, diagrams, and many other examples. The benefits to using journals appropriately are endless.

> "By using the journals, students are provided with the opportunity to model the data collection forms that scientists use. Another reason for keeping the interactive journals it to provide a means of reference and resource for the student throughout the year. The journals are also a great communication tool between the teacher and the parent/guardian. The last compelling reason to use interactive journals in the science classroom is to give the teacher another tool to make the student more successful." [xv]

The best journals use a variety of formats to enhance the journaling experience. For one lab you may want students to complete a full laboratory write up. For another activity you may want to focus on diagrams with labels and captions. Journals also allow for student-to-teacher communication. Students can write questions in the journals for teachers to respond to. Teachers can leave questions at the end of labs for students to further answer, or leave feedback that allows for student growth and improvement. Communication does not have to be between teacher and student, but can be between students as well. Allowing students to read, comment, and reflect on each other's work enhances learning, and teaches collaboration skills that they will need to be ready for college and their future careers.

Journals will be utilized during each of the four activities during this unit. Each journal entry will be set up in a similar way. The journal entry will begin with a question that students should be able to answer by the end of the activity. Next, students will write down their observations and questions based on the teacher demonstration. Students will finish up their journal entry with a short chart or diagram that details the chemistry they learned. More details about the journal entries can be found within the activity details below. The journal entries within this activity are designed to help students with recording their data and communicating their results to an audience.

Activities

Each activity within the unit will consist of a teacher demonstration piece and a student laboratory component. Every activity will only take one 70-minute class period except for the digestion activity. The digestion activity requires an overnight wait period.

Activity #1: Carbohydrates, Lipids, Proteins and Nucleic Acids...Oh My!

Purpose

This activity will show students that carbohydrates, lipids, and proteins are found in many of our food sources. As we ingest these food sources, these macromolecules enter our body and our body uses them as it needs.

Materials needed for teacher demonstration

Three glass petri dishes
Alcohol
Lighter
$LiNO_3$
$CuSO_4$
NaCl

Materials needed for student laboratory component

(Materials listed are per group)
24 test tubes
5mL starch solution
Benedict's reagent
40 drops vegetable oil
20 mL ethanol
20 mL water
5mL chicken broth
Biuret reagent
15 mL beef broth
15 mL potato juice
15 mL almond extract

Hazards/Safety

All salts can be disposed of in the trash from the teacher demonstration. The teacher and students should have safety goggles on during the demonstration. The lighting of salts should be performed at a safe distance from the students over a fire safe desk or lab table. The carbohydrate, lipid, and protein solutions in this lab pose no hazards or safety concerns and can be washed down the sink. This is the same with the ethanol and water.

A copy of the MSDS for Benedict's reagent can be found at http://www.sciencelab.com/msds.php?msdsId=9925648. A copy of the MSDS for Biuret reagent can be found at http://www.sciencelab.com/msds.php?msdsId=9925659.

Teacher demonstration

This demonstration shows students that you can sometimes identify different compounds by the color in which it burns. Place a pinch of $LiNO_3$, $CuSO_4$, and NaCl each into their own glass peitri dish. Pour enough alcohol over the salts to wet them. Light each of the mixtures in the dishes. Each salt will burn a different color. Lithium burns red, sodium burns orange, and copper burns green. Talk with students about how we can identify what is in each of these salts with how the color burns. At the end of the student laboratory component, revisit the ideas in the demonstration and discuss how the indicators used by the students were similar and different from the fire "indicator" shown in the demonstration.

Student laboratory component[xvi]

This student lab component is divided into two parts. Part one and two are summarized below. See appendix 2 for a student lab sheet with a detailed procedure, charts, and directions for what students will write in their journals. Since this unit was designed for middle school, teacher preparation directions include premeasuring these materials. A high school class may be able to help with the set up depending on the scientific level and background of the students.

At each lab station set up 24 test tubes. Label them: starch, vegetable oil (prepare two), chicken broth, unknown A carb test, unknown A lipid test (prepare two), unknown A protein test, unknown B carb test, unknown B lipid test (prepare two), unknown B protein test, unknown C carb test, unknown C lipid test (prepare two), unknown C protein test, ethanol (prepare four), and water (prepare four). The chart below details what needs to go into each tube for part one. For part two, add 5mL beef broth to each "unknown A" tube. Add 5 mL potato juice to each "unknown B" tube. Add 5mL of almond extract to each "unknown C" tube. Into each "ethanol" tube add 5mL of ethanol. Into each "water" tube add 5mL water.

Tube	Starch	Vegetable oil	Vegetable oil	Chicken broth
Add	15 mL starch solution	20 drops vegetable oil	20 drops vegetable oil	15 mL chicken broth

Part One: Students will add indicators to known solutions to show which contains carbohydrates, lipids, and proteins. Students will add Benedict's reagent to a starch solution and watch a color change to purple or black. Students will then add vegetable oil to ethanol and then to water and see that the lipid dissolves in ethanol but not in water. Lastly, students will add Biuret reagent to chicken broth and see a violet color if proteins are present. Before moving onto part two, be sure to stop the class and discuss what the students observed. A quick check of their data charts will ensure that they have the proper answers to help them be successful in part two.

Part Two: Once students have identified the color changes and solubility that they are expecting with each macromolecule, they will be given three unknowns. These unknowns are almond extract, beef broth, and potato juice. The carbohydrates are found in potato juice, the proteins in beef broth, and the lipids in almond extract. They will have three samples of each unknown and test each unknown with Benedict's reagent, water/ethanol, and Biuret reagent. Students will complete a data chart to track their observations and identify which unknown is the carbohydrate, which is the lipid and which is the protein. Students should identify that unknown A is the protein (beef broth), unknown B is the carbohydrate (potato juice), and unknown C is the lipid (almond extract).

Activity #2: Round and Round We Go – Your Circulatory System and Respiratory System

Purpose

This activity will help students physically interact with each other as the respiratory and circulatory systems.

Materials needed for teacher demonstration
Empty soda can
Hot plate
Ice water bath
Small amount of water
Tongs

Materials needed for student demonstration

"Outside air" label
"Alveoli" label
"Capillaries" label
"Muscles and organs" label
"Blood" label – enough for half of your class
"Lungs" label – enough for half of your class
30 large blue circles
30 large red circles

Masking tape

Hazards/Safety

There are no chemical hazards present in this activity. Be sure to move furniture, bags, coats, or any other items that students can trip on out of the way during the activity.

Teacher demonstration

For this demonstration the teacher will crush a can using a simple application of heat to turn water into steam. The steam displaces the air in the can. We then quickly condense the steam back into water using a water bath, which also is used to cover the mouth of the can so no steam escapes. Once the steam condenses, there is now very little, if any air in the can. The difference in pressure between the air inside the can and the air outside the can causes the can to collapse. Once the demonstration is completed discuss with students how this might be similar to how your body takes in oxygen. Our diaphragm quickly expands the lungs which lowers the pressure in our lungs. The pressure outside is greater than inside the lungs, so air quickly rushes into our lungs. To expel the air, our diaphragm then shrinks the lungs, upping the pressure in our lungs above that in the atmosphere, and the air then quickly escapes our body to the atmosphere because of this pressure difference.

Place a few drops of water inside the can and place on a hot plate. Heat until steam is escaping from the can. Using a pair of tongs, take the can and quickly invert it into the ice water bath.[xvii] The can will crush in on itself once in the ice water.

Student laboratory component

See appendix 3 for a diagram on how to set up your room with the labels. Divide your students into two groups, and give each student in one group the "lung" labels and each student in the other group the "blood" labels. Direct the lung students to the "outside air" side of the room. Direct the blood students to the "muscles and organs" side of the room. Tell students it is very important that no one should cross the line down the middle of the room. Discuss with them why they should not cross this line. Sample answers could include "blood should not be traveling into the lungs". The students who are the lungs are going to take the red circles, run them to the students who are acting as the blood. The blood students will take the oxygen label and deposit them over to the "muscle and organs". Once there, the blood students will take the carbon dioxide labels and run them back to the lung students. The lung students will then place the carbon dioxide labels at the "outside air" area.

Discuss with students how they were acting similar to the circulatory system and respiratory system. Discuss with students what would happen if one of the students did not do their job or if something was wrong with the process. These are questions which can be answered in the students' journals. Have the students draw the layout of the room in their journals and trace the route that they took. Students can then label what took place at each step of the activity in their journal. Examples of labels could be: oxygen exchange, carbon dioxide exchange, and waste from muscles/organs.

Activity #3: Chemical and Physical Changes in the Digestive System

Purpose

Students will understand the difference between physical and chemical changes. This knowledge will help them make conclusions about physical and chemical digestion in the mouth and stomach.

Materials needed for teacher demonstration include

Flash paper
Lighter
Safety goggles
16 oz empty soda bottle
½ cup of 6% hydrogen peroxide
Dawn dish detergent
Food coloring
1 tsp yeast dissolved in water
Funnel
Disposable cake pan
Hand boiler
Marshmallow
Large plastic syringe

Materials needed for student laboratory component include

Cooked egg white pieces
Muriatic acid (found at hardware store, mix one part acid to 60 parts water)
One small glass beaker per group
One small cup of water per group
Three test tubes per student group
Test tube racks
Glass stir rod
One jar of sweet potato baby food
Safety goggles
Lab aprons
Gloves

Hazards/Safety

Make it clear to students that these activities should not be tried at home unless otherwise stated, and that none should ever be done without supervision. Students and teachers need to be wearing safety goggles and lab coast/aprons at all times. The fire component of the teacher demonstration must be completed outside. When mixing the acid solution, always add acid to water and never water to acid. Have baking soda nearby to neutralize spilled acid.

Teacher demonstration

The teacher will complete four demonstrations. These first two demonstrations are physical changes. For the first demonstration show students a hand boiler. The colored liquid appears to move with magic as the temperature of your hand causes the liquid to move up and down in the boiler. For the second demonstration place a marshmallow in a large plastic syringe. With the cap on the syringe, push the plunger in and out. The marshmallow will expand and contract with the difference in air pressure. Try different size or colored marshmallows for added effect.[xviii] Discuss with students how these two demonstrations are similar. A chart can be found in appendix 4 to record their observations.

These next two demonstrations are chemical changes. Flash paper is a highly engaging demonstration for students. Holding a piece of flash paper with a long pair of tongs, light the corner of the paper on fire with a long handled lighter. This should be completed outside or in a room that is well ventilated. Flash paper can be made if you have the supplies [xix], or purchased at magic shops or through amazon.com. The second chemical change demonstration is to prepare elephant toothpaste [xx]. This is another demonstration that is highly engaging to the kids. Stand the empty soda bottle in the disposable cake pan. To the empty soda bottle add food coloring, peroxide, a squirt of Dawn dish detergent, and the yeast/water mixture. The mixture will quickly shoot out of the bottle and overflow into the pan. Discuss with students how these two demonstrations are similar. A chart can be found in appendix 4 to record their observations.

When finished with all four demonstrations ask the students to make a chart in their journals. An example chart is shown in appendix 4. Lead the class in a discussion about what was different between the demonstrations and what was similar between the demonstrations. Questions to ask could include: Can you change any of these back into what we started with? Have you seen anything similar to these demonstrations outside of school? Which type of change do you think would break down your food faster? How does this relate to the digestive system?

Student laboratory component

This activity has two parts for the students to complete. Part one will be completed as a class. Part two will be completed by the students in groups at their lab stations. See appendix 4 for the procedure and charts for students. For part one a student will donate a very large spit wad to a jar of freshly opened sweet potato baby food. Seal up the jar and place it in an undisturbed area of the classroom. Check back daily to see how the salivary amylase breaks down the starch in the sweet potato food.

Part two involves comparing the effectiveness of chemical and physical digestion within the stomach. Basic supplies should be set up for students prior to starting the lab. Label one test tube “churning”, one test tube “stomach acid”, and one test tube “churning and stomach acid”. Set the three test tubes in the test tube rack and place a small piece of cooked egg white in each. Set up one small glass beaker of acid, one small cup of water, and one stir rod. Distribute enough safety goggles for one per student. See appendix C for the student laboratory sheet which includes their procedure, chart, and what students will include in their journal. Discuss the lab as a class when completed. Ask students what would happen to your body if certain parts of this digestion, either the chemical or physical, failed to occur.

Activity #4: Filtering Your Way through the Urinary System

Purpose

Students will learn that filtering in the kidneys take place through a physical change. Students will set up a filtering system to represent the kidney which filters water based on pressure.

Materials needed for teacher demonstration

Coffee filter
Ruler
At least 3 small beakers
Water
Assorted washable markers (Black is a cool color to try for this)
Scissors

Materials needed for student laboratory component

Top half of three 2-liter soda bottles
One large beaker or cup
Rocks
Sand
Paper towel
Dirty water mixture in a large beaker or cup
Masking tape

Hazards/Safety

There are no hazard/safety concerns in this teacher demonstration or lab.

Teacher demonstration

The teacher will perform a filtering demonstration by separating the colors in pens. Cut several pieces of coffee filters into strips of approximately one inch by six inches. One half inch up from the bottom of the paper place an ink dot about one quarter inch in diameter. The teacher can do this with as many slips of filter with as many colors as he or she decides to do. Fill the bottom of a beaker with about one quarter inch of water. The teacher will be placing the slip of paper in the beaker dot side down. When placing into other beaker be sure that the dot does not become submerged into the water. There will need to be one beaker per slip of paper. Over time, the water will travel up the filter taking certain colors with it. Some colors will stay where the original dot was while some colors will travel further. Discuss with students that this separation of colors has to do with solubility – a characteristic of the ink in the pens. Talk to them about how this may be similar or different to how our kidneys filter our blood.

Student laboratory component

The students will be putting together a filter which represents the kidney. Minimal teacher preparation is needed for this lab. Distribute lab supplies at each station. Students can put together the parts of the filter themselves. See appendix 5 for the student laboratory sheet which includes the procedure, questions, and what to include in the students' journals. Upon completion students should be able to explain that as the dirty water traveled through the different parts of the filter the water turned out clean on the other side. Discuss with the students what the water represented and what each part of the filter represented. Discuss with the students what would happen if one part of the filter did not function properly and how that would affect our body.

Conclusion

The purpose of this unit was to seamlessly integrate chemistry concepts into a unit on the human body. It begins with the basics of the molecules found in the human body and gradually moves through each of the human body systems. By the end of the unit, students should know the molecules present in the human body and how physical and chemical changes affect many of our body systems. They should be able to then take the chemistry basics learned during this unit and apply them during their eighth grade chemistry unit.

Appendix 1

Implementing District Standards

My unit will be integrating the North Carolina Essential Standards for grade seven science. It addresses the standard which expects students to understand how the systems of the human body work and how these systems work together to keep humans alive. Within this standard students need to know the main structures and functions of the digestive, respiratory, reproductive, circulatory and excretory systems. They also must know how these systems maintain homeostasis. This unit focuses on the function of the excretory (digestive and urinary), respiratory and circulatory systems.

7.L.1.4 Summarize the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, and excretion) and ways that these systems interact with each other to sustain life.

Appendix 2

Carbohydrates, Lipids and Proteins…Oh my!

Objective

Today you will complete an investigation on three of the four macromolecules: carbohydrates, lipids and proteins.

Carbohydrates, lipids and proteins are found everywhere! We need them in our body to complete our daily functions. In order to get these into our body we ingest them in many of the common foods that we eat. Today you will identify some food products which have these macromolecules present.

Procedure:

Part One: Identify the color change

1. Locate your tube labeled “starch” and add 5 drops of Benedict’s reagent. Record the color change in your chart.
2. Locate your tubes labeled vegetable oil. Into one “vegetable oil” tube add one tube of water. Into the other “vegetable oil” tube add one tube of ethanol. Record your observations in your chart.
3. Locate your tube labeled “chicken broth”. Add 5 drops of Biuret reagent. Record the color change in your chart.

Part Two: Identify the unknown

1. Locate your tubes which have “carb test” as part of their label. Into EACH of these tubes add 5 drops of Benedict’s reagent. Record the color change in your chart. Be careful to write the observation for the proper tube on the proper line of your chart.
2. Locate your tubes which have the “lipid test” as part of their label. You should have two “A”, two “B”, and two “C” tubes.
3. Into ONE A tube, ONE B tube, and ONE C tube add one tube of “water”.
4. Into ONE A tube, ONE B tube, and ONE C tube add one tube of “ethanol”.
5. Record the results of steps 3 and 4 into your chart. Be careful to write the observation for the proper tube in the proper line of your chart.
6. Locate your tubes which have the “protein test” as part of their label. Into EACH of these tubes add 5 drops of Biuret reagent. Record the color change in your chart. Be careful to write the observation for the proper tube on the proper line of your chart.

Part One Data Chart:

	Carb Test	Lipid Test		Protein Test
		Water	Oil	
Starch (Carbohydrate)				
Vegetable Oil (Lipid)				
Chicken Broth (Protein				

Part Two Data Chart:

	Carb Test	Lipid Test		Protein Test
		Water	Oil	
Unknown A				
Unknown B				
Unknown C				

Post Lab Questions:

Cut and paste the above two charts into your journal. Answer the following questions in your journal as well. Refer to our previous class discussions as well as the findings of this lab to answer the questions below.

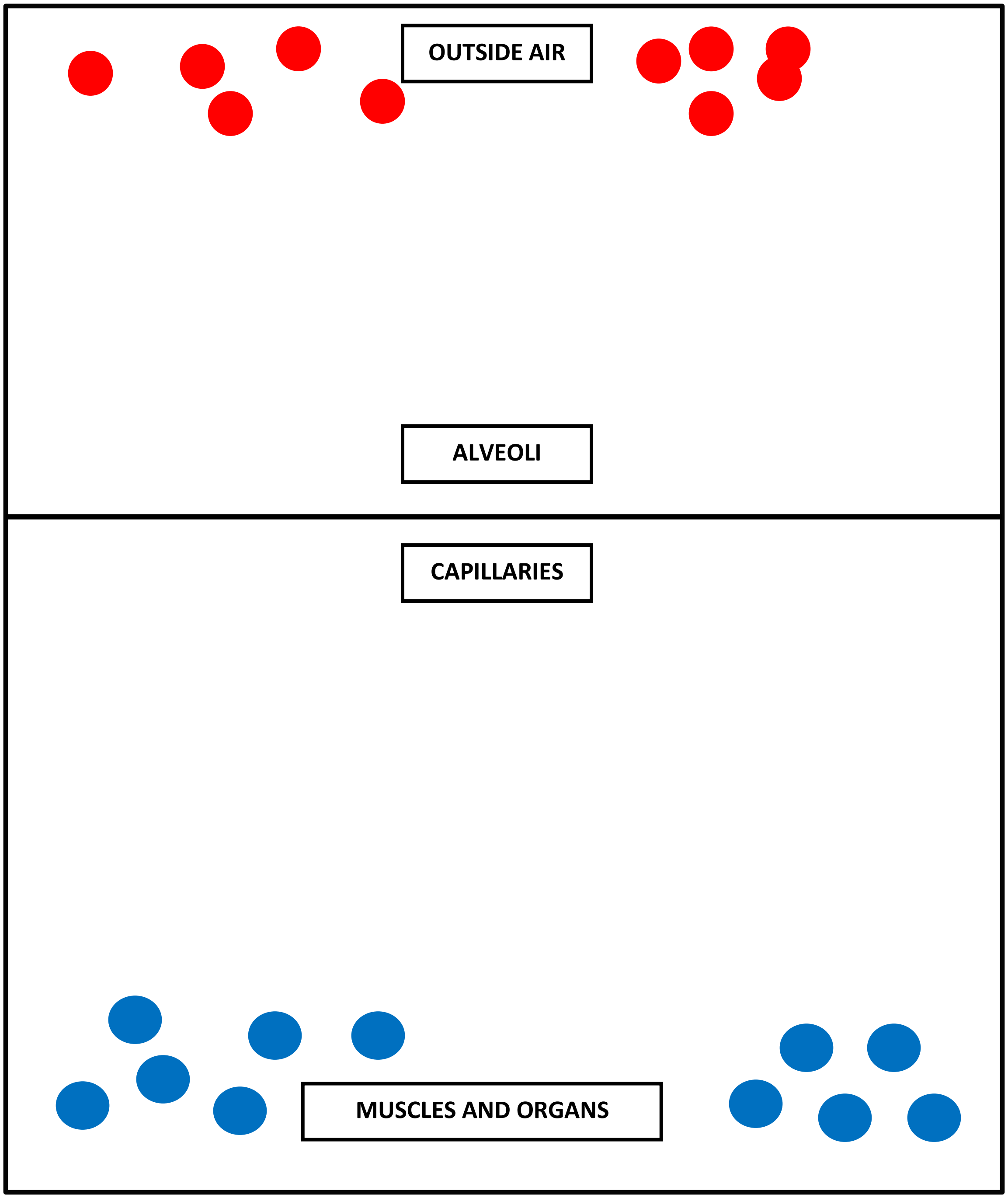
1. If you were looking for a short term energy increase, which of the unknown's would you consume?

2. If you were looking for a food that would give you long term energy, which of the unknown's would you consume?

3. What dangers would it pose to your body if any of these macromolecules were in short supply?

Appendix 3

Layout of room for “Round and Round We Go – Your Circulatory System and Respiratory System”



Appendix 4

Chemical and Physical Changes in Your Digestive System

Objective:
Today you will view demonstrations to determine the difference between a physical and a chemical change. You will also perform two lab exercises to show how chemical and physical digestion help digest our food at different points in the digestive system

Part One:
Copy the following chart into your journals and fill in while your teacher completes the below demonstrations.

	What happened?	Can it be reversed?	Physical or chemical?
Hand boiler			
Marshmallow Magic			
Flash paper			
Elephant Toothpaste			

Part Two:
Digestion in the Mouth:
To observe the chemical digestion which occurs in the mouth we need a brave volunteer! Please donate a large wad of spit to this jar of sweet potato baby food. We will set up the food and check back on it for the next few days. Fill in the following chart each day.

	Observations
Day 1	
Day 2	
Day 3	

Digestion in the Stomach:
1. Add 80 drops of water into the tube labeled "churning".
2. Add 80 drops of acid to the tube labeled "stomach acid".
3. Add 80 drops of acid to the tube labeled "stomach acid and churning".
4. Take your stir rod and mix and mash up the egg piece in the "churning" tube. Mash and mix for 30 seconds then put the test tube down.

5. Take your stir rod and mix and mash up the egg piece in the "stomach and churning" tube. Mash and mix for 30 seconds then put the test tube down.
6. Do not mix the "stomach acid" tube.
7. Place your test tube rack in an undisturbed location and wait until tomorrow to observe.

	Observations	Physical or Chemical Digestion?
Churning		
Stomach Acid		
Churning and Stomach Acid		

<u>Post Lab Questions:</u>

1. What type of macromolecule is present in the sweet potatoes?

2. What type of macromolecule must saliva (salivary amylase) break down?

3. What type of macromolecule is present in the egg white?

4. What type of macromolecule must the stomach acid break down?

5. Is one type of digestion better than the other in the stomach when comparing the physical and chemical digestion taking place?

6. Do you think physical or chemical digestion would work without the other?

7. What do you believe happens next in the digestive process?

8. In your journal, sketch the part of the digestive system from the mouth to the stomach. Label the parts. Label what type of digestion occurs where. Label which macromolecules are digested where.

Appendix 5

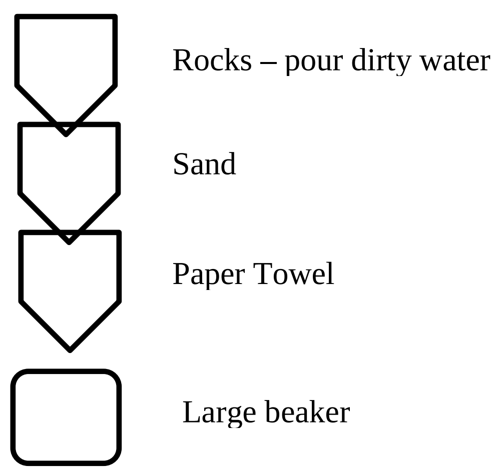
Filtering Your Way through the Urinary System

Objective:

Today you will construct a filter to filter a mixture of dirty water. You will learn through the lab and discussions with your classmates how this filter is similar to and different from the kidneys in your body.

Procedure:

1. Turn the bottles upside down and place a piece of masking tape in the opening.
2. Punch holes in the masking tape with your pencil.
3. Fill the first bottle with pebbles.
4. Fill the second bottle with sand.
5. Fill the third bottle with crumpled up paper towels.
6. Stack the bottles like the figure below. The paper towel bottle should be at the bottom, the sand bottle in the middle, and the rocks bottle at the top.
7. Have one student hold the three bottles above the large empty beaker.
8. Have the second student pour the beaker of dirty water into the top of the rocks bottle and watch it filter through all three stages.



Post Lab Questions:

Complete the following questions in your journal.

1. Draw your lab set up of filters and water. Label all parts of this set up.

2. What part of your body do the filters represent?

3. What part of your body does the water represent?

4. When these filter clean the water, is there a chemical or a physical change occurring? Explain your answer.

5. What would happen if any one of the filters were missing?

6. What would happen in your body of a part of your kidney did not function properly? Think about the consequences it might have for your health.

Bibliography for Teachers

“Amino Acid.” November 13, 2013, http://en.wikipedia.org/wiki/Amino_acid.

This is an easily understood article which gives details as to what an amino acid is. There were quality diagrams and pictures within the article.

“Carbohydrates.” http://www.sparknotes.com/health/carbohydrates/section1.html.

The *Carbohydrates* article was used for its diagrams and simple explanations as to what a carbohydrate is, what it is made of, and how our body uses them.

“Circulatory System.” November 18, 2013, http://en.wikipedia.org/wiki/Circulatory_system.

This is an easily understood article which gives details as to what the purpose of the circulatory system is. There were quality diagrams and pictures within the article. The resource was used for a good explanation of the steps that the circulatory system goes through within our body.

“Digestive System.” November 18, 2013, http://en.wikipedia.org/wiki/Digestive_system

This is an easily understood article which gives details as to what the purpose of the digestive system is. There were quality diagrams and pictures within the article. The resource was used for a good explanation of how the digestive system breaks down molecules and gives our body energy.

“Glucose.” November 16, 2013, http://en.wikipedia.org/wiki/Glucose.

This article was valued for its diagrams and sketches of the molecule glucose. The explanations supported those diagrams and is a good reference for gaining background knowledge.

Joesten, M., Hogg, J. “CHEM In Your World,” (2011): 329 – 331.

The *CHEM In Your World* book was a great resource for the molecules found within the body. It goes into great detail about the main groups of molecules, how they assemble, break apart, give use energy, and other facts. There are pictures and captions which support the content as well.

Milne, C., Otieno, T. “Understanding Engagement: Science Demonstrations and Emotional Energy. Science Education. 10 January 2007.

Understanding Engagement is an article which discusses why science demonstrations are vital to the science classroom. It mentions how these demonstrations engage students and get them hooked on the lesson. It shares evidence as to how demonstrations not only increase engagement, but also increase achievement in the classroom as well.

Ohio Department of Education. "The Evidence Base for Science: Scientific Inquiry" http://ims.ode.state.oh.us/ode/ims/rrt/research/Content/Scientific_Inquiry_What_We_.Know.asp.

The Evidence Base for Science gives descriptions of what inquiry is and what it looks like in the classroom. It continues on to describe several of the ways in which inquiry benefits students when it is properly integrated into lessons.

"Respiratory System." November 20, 2013, http://en.wikipedia.org/wiki/Respiratory_system.

The *Respiratory System* website gives simple explanations of what the respiratory system is, what it does for our body, and how it works with other body systems. It includes good diagrams as well.

Rossi, Dara. "Using Elementary Interactive Science Journals to Encourage Reflection, Learning and Positive Attitudes toward Science," (2004): 1-14.

Rossi's *Using Elementary Interactive Science Journals* has a multitude of examples of how to use journals in the science classroom. She includes examples through pictures and descriptions of the many ways which journals can be simply or complexly integrated into the science classroom.

"The Chemistry of Carbohydrates Found in Food." http://www.medbio.info/horn/time%201-2/carbchem1.htm.

The Chemistry of Carbohydrates Found in Food links topics from the molecules in the human body to our digestive system. It is a good explanation of what carbohydrates are found in our food, and how and where they are broken down in our body.

"Urinary System." November 18, 2013, http://en.wikipedia.org/wiki/Urinary_system.

This article on the urinary system gives diagrams and explanations of how the urinary system filters molecules from our blood. It goes into more detail than what a student would need to know for this unit, but it gives teachers a good background into the basic filtering that a kidney does.

Reading List for Students

Skipor, Andrew. “What Makes Blood Red?” June 2012, http://www.newton.dep.anl.gov/askasci/bio99/bio99423.htm.

What Makes Blood Red gives a simple and easy to understand the color changes in blood. It replaces many student misconceptions about the color of blood with good fact.

List of Materials for Classroom Use

Rogers, Casey, “Marshmallow Magic,” July 12, 2012, http://sites.jmu.edu/chemdemo/2011/09/09/marshmallow-magic/.

Dr. Rogers “Marshmallow Magic” website gives teachers step by step instructions on how to complete the marshmallow demonstration from the unit plan. It mentions the topics addressed by the activity, materials, and the procedure

Shakhashiri, Bassam Z. Chemical demonstrations: a handbook for teachers of chemistry Volume 1. Madison, Wis.: University of Wisconsin Press, 19832011.

Chemical Demonstrations has a wide range of demonstrations to enhance chemistry in any level classroom. This particular volume has demonstrations for thermochemistry, chemiluminescence and polymers. For this unit plan, it is used for the flashpaper procedure.

Shakhashiri, Bassam Z. Chemical demonstrations: a handbook for teachers of chemistry Volume 2. Madison, Wis.: University of Wisconsin Press, 0299101304.

Chemical Demonstrations has a wide range of demonstrations to enhance chemistry in any level classroom. This particular volume has demonstrations for physical behaviors of gases, chemical behavior of gases, and oscillating chemical reactions. For this unit plan, it is used for the crushing a can demonstration.

Steve Spangler Science. “Elephant Toothpaste: Kid Version.” http://www.stevespanglerscience.com/lab/experiments/elephants-toothpaste.

The *Steve Spangler Science* website includes directions, materials, and pictures on how to make elephant toothpaste. It is simple and quick for a teacher to follow.

Endnotes

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[xiii] Ohio Department of Education. "The Evidence Base for Science: Scientific Inquiry" http://ims.ode.state.oh.us/ode/ims/rrt/research/Content/Scientific_Inquiry_What_We_.Know.asp.
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