Biochemistry

Fourth Grade

Unit Rationale: In this curriculum, the girls will learn about the basic chemical processes that occur within living organisms. They will come to understand how the major biological macromolecules give rise to the processes carried out by cells and organisms, and demonstrate these principles through interactive demonstrations and experiments.

Session One

Focus on: Introduction: Atoms and Molecules

Get to know one another and establish a baseline of biochemical knowledge. Learn about atoms and molecules. Use gumdrops and toothpicks to make models of important biological molecules.

Session Two

Focus on: The Cell

Learn about the parts of animal and plant cells. Examine onion and cheek cells under a microscope, and make your own cell models.

Session Three

Focus on: Lipids and Membranes

Learn about lipids and the role that they play in cell membranes. Examine the principles of solution density and diffusion through a membrane demonstration.

Session Four

Focus on: Proteins and enzymes

Learn about that the different roles that proteins can play within a cell, specifically the role of enzymes. Learn about how factors like pH interact with proteins through a demonstration with egg proteins.

Session Five

Focus on: Carbohydrates : Building them Up (Part 1)

Learn about the structure of carbohydrates and their functions within cells. Explore principles of chemical reactions through a baking soda and vinegar demonstration. Investigate the process of photosynthesis through an experiment using spinach leaves.

Session Six

Science Club for Girls

Focus on: Carbohydrates: Breaking them Down (Part 2)

Learn more about carbohydrates and the way that they can provide energy for cells. Perform an experiment to test for levels of starch in different substances. Explore the process of cellular respiration through a demonstration with yeast.

Session Seven

Focus on: Nucleic Acids

Learn about nucleic acids and the important role that they play in directing the activities of cells. Build a model of a DNA molecule out of candy. Isolate and observe DNA from a strawberry.

Science Club for Girls

Session One
Focus on: Introduction: Atoms and Molecules

Itinerary:

- Question of the Day
- Setting the Tone
  - Pledge
  - Rules and Expectations
  - Goals
- Review of Atoms and Molecules
- Activity One: Modeling an Atom
- Activity Two: Modeling Molecules
- Science Notebooks

Session Objectives:

At the end of this session, the girls will:

1. Agree to the rules and expectations of the club
2. Know the science topic they will be exploring during the semester
3. Gain a basic fundamental understanding of atoms and molecules
4. Create their own models of biologically important atoms and molecules

About This Session

In this first session, you will set the tone for the entire program, providing the girls with a sense of physical and intellectual security, and with a sense that this will be a friendly, fun experience for them. Please note that this session will be a bit more close-ended and directed than the future science club sessions. Those that follow will have a much more engaging and rewarding experience as a Mentor Scientist with your young scientists!

You'll need to introduce the Science Club for Girls Code of Conduct, our guidelines based on safety, respect and teamwork. With the girls you'll create more specific expectations that the girls will agree to follow and you agree to uphold. This will give you something to lean on if the girls become a little over-zealous later on in the program.

You will also present an overview of this season's sessions. The Biochemistry sessions are tied together by the theme of exploring various biologically important macromolecules and processes. The girls will learn how elements come together to create the molecules that are the building blocks of all life, including carbohydrates, lipids, proteins, and nucleic acids They will make three-dimensional models, perform experiments, and investigate these molecules through hands-on demonstrations. In this first session, you will introduce the basis of the curriculum- atoms and molecules, and help them to model biologically important molecules of their choice.

Before Clubs Begin

- Find out from your Site Coordinator what additional first-day activities will be occurring at your site. (All-club assembly? Name game? Etc.) This will vary from site to site.
- Discuss with your mentoring team who will be responsible for what portions of the session and prepare in advance of clubs.
- Create nametags for yourself and the girls.
- Discuss the reflection tool that will be used at the end of the session

Question of the Day

The Question of the Day is a great way to introduce the activity of the day and get the girls centered. It should be a regular starting routine of your club. The Question of the Day will usually be a question that kids and adults think about in everyday life or a question that can lead to answering a common question. Use it to get the girls talking but also focused.

Question: What are the building blocks that make up our world?

Assessment Questions

Assessment questions are an opportunity to test the girls' comprehension of the material presented and track progress throughout the sessions. At the start of each session, the mentors should ask the girls a series of three questions related to the material to be covered that day. Each girl will be given three Popsicle sticks, labeled A, B, and C. Each assessment question will be a multiple choice question with three possible responses. The mentor should read the question and all of the choices first. Then tell the girls that they should pick the one answer which they think is correct. Ask the girls to raise the popsicle stick with the letter option they believe is correct. Encourage the girls to think about the answer independently, without consulting with other members of the group, or looking to see how others have answered. Let the girls know that it is completely alright if they don't know the correct answer. After all, it deals with material that they haven't learned yet, but which will be covered in the session. After recording all answers, proceed with the session. Don't reveal the answers. Finally, at the end of the session (perhaps while the girls are writing in their journals), pass out the popsicle sticks again. Re-ask the same assessment questions and have the girls answer as before using their popsicle sticks. Record the responses, and finally reveal the answer.

Assessment Questions for Session #1:

1) What is the smallest unit of an element called? (A: a)
    a. An atom
    b. A molecule
    c. A particle
2) What is a proton? (A:c)
    a. a negatively charged particle inside an atom
    b. a particle of light
    c. a positively charged particle inside an atom

3) What is one thing that makes an atom of gold different from an atom of oxygen? (A:b)
   a. Gold atoms are shinier
   b. They contain different numbers of protons
   c. There is no difference. They are the same

Materials for This Session

Activity One: Introduction		
Per Club	**Per Group**	**Per Girl**
Club Expectation Poster	Markers	Nametag
Whiteboard Markers	Pencils	Journal
Activity Two: Modeling Atoms and Molecules		
Per Club	**Per Group**	**Per Girl**
	Toothpicks	Sheet of construction paper
	Gumdrops	
	Plastic Beads(3 different colors)	
	Clear tape	

The building blocks of our world: Definitions

- Monomers= the "building blocks," or essential units which can be bonded together to form a polymer
- Polymer= a long molecule consisting of many similar or identical building blocks called monomers linked by bonds
- Atom= the basic unit of matter; the "smallest" unit of an element
- Molecule=group of atoms bonded together; smallest fundamental unit of a chemical that can take part in a chemical reaction

Activity One: Introduction Set the tone and create rules together that all the girls agree to follow.

- 1) Get the girls' attention and make sure they are clearly focusing on you. Explain to them that before they can do any science experiments, they must all agree to follow the three rules of Science Club. Introduce the Code of Conduct. These are the 3 expectations that Science Club for Girls expects all participants to follow. Guide the girls to create more specific rules and write these under each code of conduct. Ask the girls probing questions like, —Why do you think this is a rule we've made? Or —What do we mean when we say to be safe in Science Club for Girls? The girls will offer very directive and obedient rules like, —No touching dangerous materials. Or —Don't talk when the teacher is talking. Think of ways to consolidate these so that you don't end up with a long list of —do's and don'ts. Add these to the Code of Conduct so that the girls have a voice in the rules as well.

- Be sure the girls are calmly sitting in a circle or at desks. Ask the Junior Mentors to sit with the girls as well. They may have a tendency to sit separate from the girls and sit with each other, but get them mixed in right away.

- 2) Once done, ask the girls to put their —thumbs up to signify that they agree to follow the rules. You can also have all the girls sign the rules sheet. Whatever you do, be sure that you have all the girls physically show that they can agree to follow the rules. You'll need this as back up as the sessions go on!
- 3) At this point, explain to the girls the consequence of not following a rule. KNOW THE SCFG DISCIPLINE POLICY. Make sure they know that not following rules can result in a call home, being taken out of Science Club and that it also makes the club less fun because they might not be able to do all of the fun projects if people were to act up. This is not used to scare the girls, but rather, a strict (and strictly enforced) discipline policy is a regular part of an afterschool program due to the nature of kids' energy after 7 hours of school. It's like showing them the boundaries of a box. Free to roam anywhere within the box, but always knowing where the boundaries are set.
- 4) Now, explain to the girls the benefit of following the rules. (Best to have a reward policy already decided among co-Mentors.)
  - A great way to continue to involve the girls is to ask them, —What happens when rules aren't followed? What happens when the rules are followed? —Do groups have more or less fun when rules are followed?
- 5) Now, clearly go over the basic routine of the club. This involves: Where they meet each day there is SCFG. What they are to do when entering the classroom (Sit on the rug? at a table? sit in a circle? some tables off limits? Get their journals from the bin?) How you will show that you are ready to begin. (Hands-up? Peace signs in the air? Clapping rhythm?)
  - Review how the club will end each session for reflection time (return to sitting on rug, back to tables? All areas cleaned up?)
  - Your Pledge can be found on the back of the Code of Conduct or in the Volunteer Handbook.
  - Make sure the girls hear the routine that you and your co-Mentor have agreed upon so they can begin to follow it.
- 6) Before moving on, spend a few minutes introducing your Junior Mentors to the girls as well. Be sure the girls know:
  - The Junior Mentors' names
  - The Junior Mentors will be helping everyone in the club
  - If the JMs ask the girls to do something, the girls should listen and do it
  - That the JMs are a part of the club too!
  - You may want to play a quick round of the "name game" to help everyone get to know each other
- 7) Lastly, before moving to the next activity, make sure the girls understand a few things that are important to know over the course of the semester:
  - Their science/topic for the semester that all projects will relate to.

- The type of scientist they are (Physicists, Biologists, Chemists, Engineers, etc.)
- At the end of the semester, the entire site will have a Science Fest and each club will teach others about what they learned.

Activity Two: Modeling Atoms and Molecules

- Ask the girls if they remember from the beginning of clubs what an atom is? A molecule?
- Ask the girls to name some elements that they know and in what context
  - Some common ones include: Helium, Oxygen, Neon, Sodium, Aluminum, Chlorine, Potassium, Calcium, Iron, Copper, Silver, Tin, Gold, Mercury
  - Have the girls describe the properties of some of the elements that they know? How is helium different than gold, for example, just in terms of physically observable properties?
  - Ask the girls why they think different elements have different properties
  - Have the girls guess how many elements there are (A: almost 120 known elements; and new ones are still being made!)
- Explain to the girls that one reason for the properties of different elements is the different numbers and arrangements of subatomic particles
  - Do any of the girls know the names of subatomic particles?
  - Here we will be focusing on protons, neutrons, and electrons
- Protons= positively charged particles; in the nucleus of the atom. The number of protons in an atom determines what kind of atom it is. For example, hydrogen has one proton, carbon has 6, and oxygen has 8
  - Neutrons= particles with a neutral charge; in the nucleus of the atom; can be the same or different as the number of protons
    - For simplicity's sake, the models built today will contain equal numbers of protons and neutrons
  - Electrons= negatively charged particles; outside of the nucleus of the atom; can be the same or different as the number of protons
    - When the number of protons equals the number of electrons, the atom has a charge of 0. Ask the girls why they think this is? (A: they can think of the positively charged protons and negatively charged electrons as "canceling out" the charge of the other)
    - When the number of protons doesn't equal the number of electrons, the atom has either a positive or negative charge. There is no longer a "balance" of positively charged protons and negatively charged electrons. The resulting atom is called an ion. Ask the girls how they think ions form? What would make a positively charged atom? What would make a negatively charged atom (A: protons can't be lost without changing the identity of the atom. Instead, if electrons are gained, the ion has a negative charge (more negative than positive charge). If electrons are lost, the ion has a positive charge (more positive than negative charge).
- As the girls where they have seen positive and negative charges before? Possibly in the context of magnets or batteries?

Modeling Atoms

- Give each girl a piece of construction paper, and set out plastic beads and clear tape at each table
- Explain to the girls that the beads will represent subatomic particles

- Assign each subatomic particle a specific bead color(Ex. Red=protons, blue=neutrons, green=electrons)
- Ask the girls if they remember where each color bead should go(i.e. protons and neutrons in the center of the atom; electrons outside the center)

❖ Let each girl pick the type of atom that she will create
- For reference:
  1 proton- Hydrogen
  2 protons- Helium
  3 protons- Lithium
  4 protons-Beryllium
  5 protons- Boron
  6 protons-Carbon
  7 protons- Nitrogen
  8 protons- Oxygen
  9 protons- Fluorine
  10 protons-Neon
- Try to limit the girls to atoms with 10 or fewer protons to conserve supplies

❖ Have the girls count out the number of protons(beads) for their atom and tape them in the center("nucleus") of their construction paper
- Have the girls count out an equal number of neutron beads and tape these in the center as well
- For simplicity's sake, the girls will make uncharged atoms with equal numbers of protons and electrons. Have the girls count out an equal number of electron beads and tape them around the edges of their construction paper. Don't worry about the particular arrangement of the atoms. Just make sure the girls understand that the electrons are in orbitals or "clouds" outside of the nucleus

❖ Have the girls write the name of their element on the construction paper

Molecules

❖ Explain to the girls that different physical properties are also due to different combinations and arrangements of different atoms. When atoms combine, they form a molecule.
- Ask the girls what kind of matter they think results from densely packed atoms? (A: solid) from very loosely packed atoms(A: gas)

❖ Ask the girls to think of some molecules that they know.
- Water? Do they know which elements combine to form water? (A: hydrogen and oxygen)
  - Ask the girls to describe the properties of water
- Carbon dioxide? Do they know which elements combine to form carbon dioxide? (A: carbon and oxygen)

❖ Have the girls take the atoms that they made in the previous activity and put them together to form molecules. Below are some common molecules which can be formed from the elements listed above:
- Water: H_2O: 2 hydrogen atoms, one oxygen atom
- Carbon dioxide: CO_2: one carbon atom, two oxygen atoms
- Carbon monoxide; CO: one carbon atom, one oxygen atom
- Methane: CH_4 : one carbon atom, four hydrogen atoms
- Ammonia: NH_3: one nitrogen atom, three hydrogen atoms

- Don't worry about the specific arrangements of the atoms within the molecule. The objective of this activity is to help the girls to picture how atoms come together in different combination and proportions to form molecules. However, you could mention to the girls that the specific arrangement of the atoms within a molecule can also affect its properties.

After the girls have finished playing with their atom and molecule models, hand out journals. Ask each girl to fill out the front of her journal, and write something inside about today's session. The girls can use their journal to describe what we learned, discuss activities or experiments, ask questions, draw pictures, or anything else related to the topic being covered. Encourage the girls to use their journals to reflect on what they learned.

Session Two
Focus On: The Cell

Itinerary:

- Question of the Day
- Activity 1: Viewing Cells under the Microscope
- Activity 2: The Human Cell
- Activity 3: Modeling the Cell(Time Permitting)
- Science Notebooks

Session Objectives:

By the end of this session, the girls will have:

1. Observed some key differences between plant and animal cells
2. Gained a basic understanding of the structure and function of the human cell
3. Identified the roles of various organelles in carrying out a cellular process

Question of the Day:

What are the building blocks of living things and how do they help us function?

Assessment Questions:

1) What is one way in which plant cells and animal cells differ? (A:b)
    a. Animal cells have organelles, but plant cells don't
    b. Plant cells have chloroplasts for making food from light, but animal cells don't
    c. Plant cells are always larger than animal cells
2) What is one function of a ribosome? (A: a)
    a. Manufacture protein
    b. Break down food to release energy
    c. Prevent certain materials from entering the cell

3) What is one function of vesicles? (A:b)
   a. Encode the instructions for the manufacture of protein
   b. Transport and deliver materials to different parts of the cell
   c. Capture light

Materials for this Session:

Activity One: Cell Observation		
Per Club	**Per Group**	**Per Girl**
Onion	Light microscope(or per club)	Toothpick
Bottle of iodine	Slide	Journal
	Cover slip	
Activity Two: The Human Cell		
Per Club	**Per Group**	**Per Girl**
Pens		
Colored construction paper		
White paper		
Pipe cleaner		
Beads		
Pliers		
Plastic bags(2)		
Stickers		
Battery		
White poster board w/ whole cut out		
Scissors		
Plastic container		
Activity Three: Modeling Cells		
Per Club	**Per Group**	**Per Girl**
Whiteboard Marker	Markers	Pen/Pencils
	Construction Paper	Cell Worksheet
	Play Dough	Piece of Cardboard
	Pipe Cleaners	
	Stickers	
	Beads	
	Glue	
	Tape	

The Cell

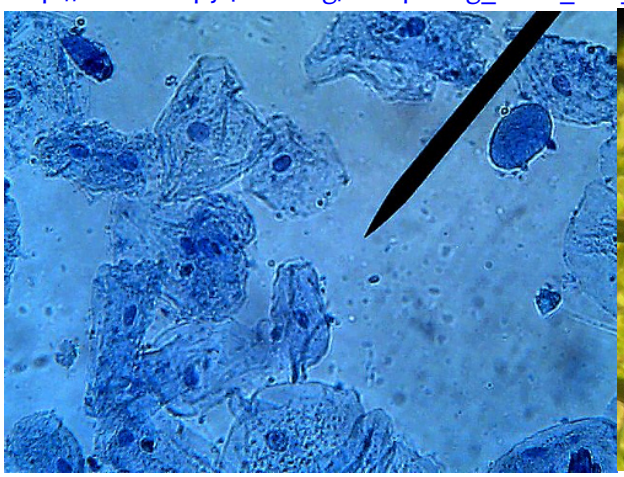
First, we will go through the function of the major organelles as a class. Then, we will engage in an activity in which each person can investigate the role of each organelle more closely.

What is a Cell?

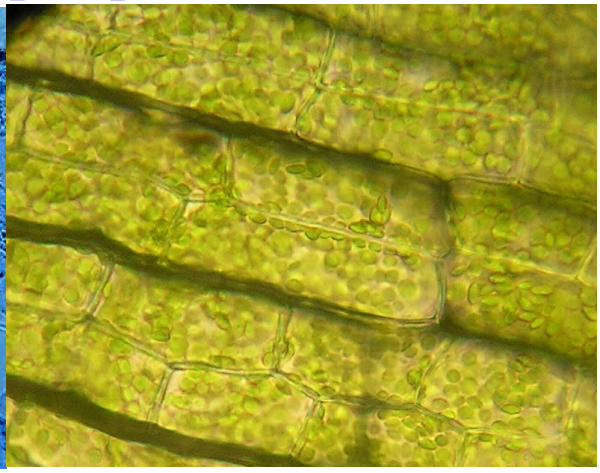
- We learned that atoms are the building blocks of molecules which make up everything you experience around you. In living organisms, these molecules are arranged in units called cells, the fundamental unit of life. A cell is the simplest collection of matter that can live.
    - Q: Can you think of any single-celled organisms? (A: many bacteria, fungi, algae, amoebas)
- Cells are bigger than atoms and molecules but still very tiny! For example, look at a piece of your hair. The Cells that make up your hair are about 1/10 the diameter of a single piece of hair. Other cells are hundreds of times smaller.
    - If you have access to a computer, you can show the girls this animation to appreciate the size of a cell:
    - http://learn.genetics.utah.edu/content/cells/scale/
- Because cells are so tiny, scientists use microscopes to view cells. We will be using a light microscope, an instrument which can magnify an image, to view cells.

Activity One: Viewing Cells under a Microscope

Note: If you do not have access to a microscope, skip to the next activity. If you have access to a computer, you can show the girls images of a cheek cell and a leaf cell under a microscope at http://microscopy4kids.org/Comparing_Plant_and_Animal_Cells



Human Cheek Cells 400X



Elodea Plant Cells 400X

- Prepare the slides and set them up under the microscopes before the girls arrive.
    - Check cells can be obtained by scraping the inside of a mentor's check with a toothpick. Place a small drop of water on the slide, and roll the toothpick in the water until the check cells are deposited on the slide. Add a cover slip. If methylene blue stain is available, this can be added to the slide to make the check cells more visible under the microscope
      Note: if time permits, the girls may wish to make slides using their own check cells.
    - Prepare the plant cell slide by peeling off the thin translucent film that covers each layer of the inside of an onion. Mount the film on the slide with a drop of water and add a coverslip.
- Ask the girls to record their observations of the plant and human check cells in their journals with pictures or diagrams.
    - Ask the girls what differences they observe between the two cell types?
    - Ask the girls to describe the cells? What is their general shape? Color? Texture? Structure?

- Why do the girls think the plants and animal cells look different? How are their functions different? Could their structure be related to their function?

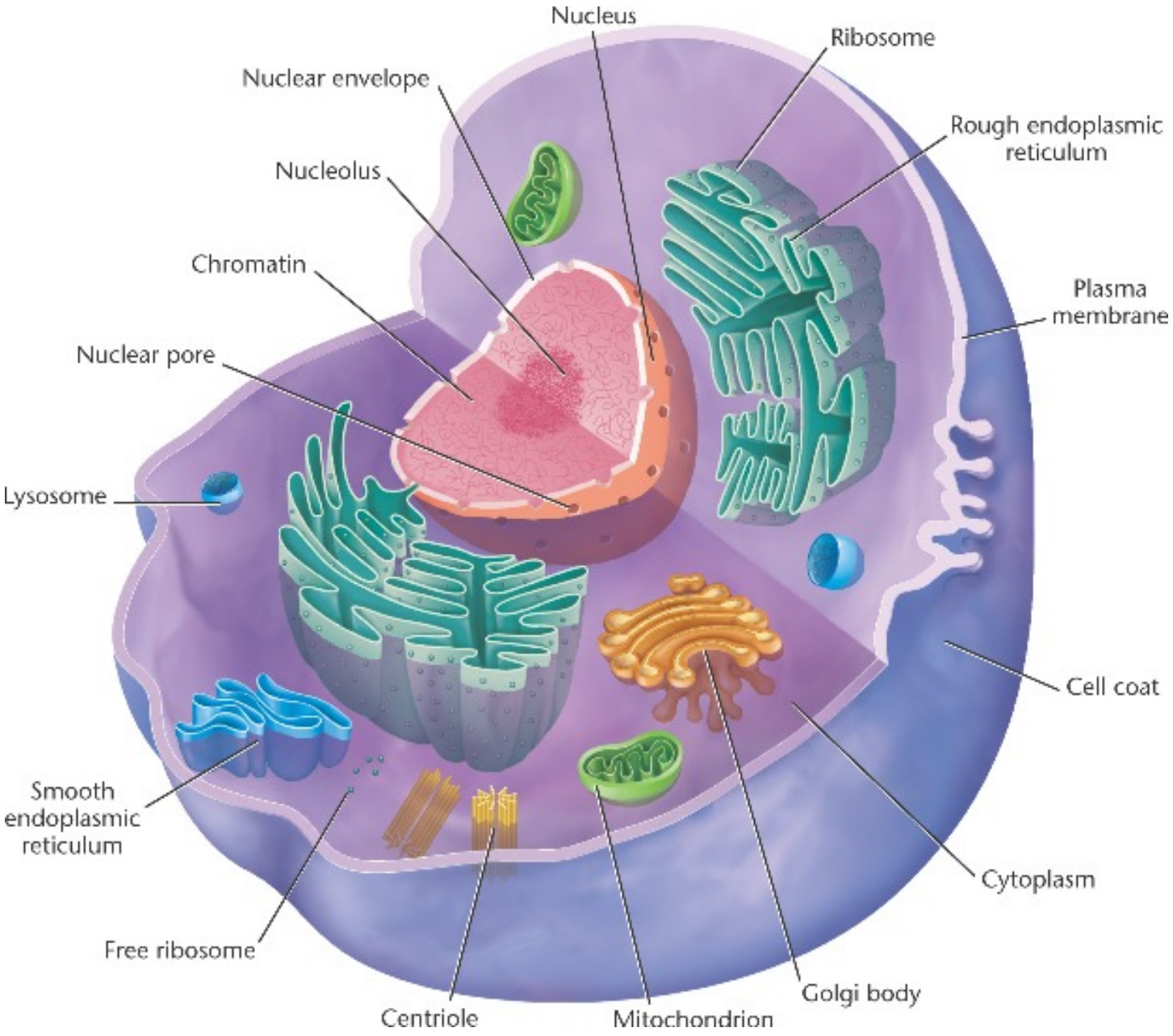
Activity Two: The Human Cell

Parts of the Cell:

Pass out diagrams of an animal cell so the girls can follow along as you explain the major parts of the cell.

- You can think of a cell as a city, where each structure represents a job or facility necessary for maintaining the city. All of the structures work together to carry out a function.
- Nucleus: City Hall
  - The nucleus is the place where the plans are made for the construction and operation of the cell. It stores all of the genetic information necessary to carry out the synthesis of proteins in the form of DNA which allows a cell to perform its functions.
- RNA: Mayor
  - RNA interprets the instructions of the DNA and transcribes it into instructions about how to construct proteins that ribosomes can understand.
- Ribosome: Construction Workers
  - Ribosomes are the protein factories of the cell
- Endoplasmic Reticulum: Road System
  - The Endoplasmic reticulum allows molecules to move throughout the cell. It also synthesizes things, including lipids and proteins along the way.
- The Golgi Apparatus: Mail Center
  - The Golgi apparatus manufactures molecules, stores them, stores then and ships them off to other locations in the cell. Molecules can be modified by removal of some elements or the addition of new elements, such as sugars.
- Vesicles: Delivery Trucks
  - Vesicles deliver products made in the endoplasmic reticulum or Golgi to other locations in the cell. They can also transport materials in and out of the cell (across city lines).
- Lysosomes: Recycling Plant
  - Lysosomes contain enzymes that cells use to digest and break down macromolecules into smaller molecules that can be reused within the cell
- Vacuoles: The Warehouse
  - Vacuoles store material needed by the cell
- Mitochondria: Power Plant
  - Mitochondria convert food into energy that the cell can use for work
  - Note: plant cells contain another structure called chloroplasts which convert light energy from the sun into energy that the cell can use for work
- Cell Membrane: the city wall
  - The cell membrane controls what substances enter and exit the cell
- Cytoplasm: Lawns
  - The cytoplasm is the thick liquid solution that fills each cell. It contains mainly water, salts, and proteins.

Science Club for Girls



- We will now be using all of the cell structures that we learned about to perform a basic function of the cell: manufacturing a protein to be released out of the cell
- Cut out the cards with the various roles and give one to each girl. If there are more students than cards, students may share one card. If there are more cards than students, encourage mentors and junior mentors to participate as well!
- Ask the girl to read the cell structure that she has been assigned on her card and retrieve her "materials"
- The numbers on the cards indicate the order in which each girl will perform her "function" in the cell. For example, the activity starts with food molecules being brought into the cell membrane. Have the girls pay attention to their number, and jump in when their structure is needed.

- When it is each girls turn to perform her structure's function, have her read out the name and function of the structure listed on her card to the whole class.
    - Note: some structures (such as the vesicle), are needed more than once. If there are fewer than 14 girls, have one girl (possibly a junior mentor) serve as the vesicle for all of its roles.
- For clarity, here is the order in which the structures will perform their tasks
    1) Cell Membrane
    2) Vesicle
    3) Vacuole
    4) Lysosome
    5) Vesicle
    6) Mitochondria
    7) Nucleus
    8) RNA
    9) Ribosome
    10) Endoplasmic Reticulum
    11) Vesicle
    12) Golgi Apparatus
    13) Vesicle
    14) Cell Membrane

#7. Nucleus: City Hall	#8. RNA: The Mayor
The nucleus is the place where the plans are made for the construction and operation of the cell. It stores all of the genetic information necessary to carry out the synthesis of proteins in the form of DNA which allows a cell to perform its functions. **Your Materials:** Pen and colored paper **Your Job:** Write a series of instructions (DNA sequence), explaining that you want to build a new protein for the city.	RNA interprets the instructions of the DNA and transcribes it into instructions about how to construct proteins that ribosomes can understand. **Your Materials**: pen and white paper **Your Job:** Read the instructions written by the DNA in the nucleus and write them in a different way that the ribosomes will be able to understand.
#9. Ribosome: Construction Worker	**#10. Endoplasmic Reticulum: Road System**
Ribosomes are the protein factories of the cell **Your Materials:** pipe cleaner, beads	The Endoplasmic reticulum allows molecules to move throughout the cell. It gets things where they need to go in the way they need to get there. It also modifies

Your Job: Then, read the instructions delivered to you by the RNA. Follow the instructions and use the ATP from the mitochondria to build a polypeptide, stringing different beads onto the pipe cleaner (amino acids making up a protein)	proteins and synthesizes things, including lipids and proteins along the way. **Your Materials**: pliers **Your Job:** Take the polypeptide chain (pipe cleaner) made by the ribosome and fold it into its proper shape using the pliers
#11. Vesicle : Delivery Truck Vesicles deliver products made in the endoplasmic reticulum or Golgi to other locations in the cell. They can also transport materials in and out of the cell (across city lines). **Your Materials:** plastic bag, your feet **Your Job**: Take the protein from the endoplasmic reticulum and package it in a membrane (plastic bag). Deliver the protein to the Golgi Apparatus	#12. Golgi Apparatus: Mail Center The Golgi apparatus manufactures molecules, stores them, stores then and ships them off to other locations in the cell. Molecules can be modified by removal of some elements or the addition of new elements, such as sugars. Your Materials: stickers, your hands Your Job: Modify the protein delivered to you by the vesicle. Add stickers (sugars, small proteins) to the protein. Change its shape.
#13. Vesicle : Delivery Truck Vesicles deliver products made in the endoplasmic reticulum or Golgi to other locations in the cell. They can also transport materials in and out of the cell (across city lines). **Your Materials:** plastic bag, your feet **Your Job**: Take the protein from the Golgi and package it in a membrane (plastic bag). Deliver the protein to the cell membrane.	#6. Mitochondria: Power Plant Mitochondria food into energy that the cell can use for work **Your Materials**: battery **Your job**: take in the glucose from the vesicle and use it to make ATP, energy that can be used by the cell. Give some of this energy to the ribosome.
#1:Cell Membrane: the city wall The cell membrane controls what substances enter and exit the cell **Your Materials:** White poster board with hole in it(membrane), plastic bag(vesicle), construction paper(food)	#2: Vesicle: Delivery Truck Vesicles deliver products made in the endoplasmic reticulum or Golgi to other locations in the cell. They can also transport materials in and out of the cell (across city lines). **Your Materials:** your feet

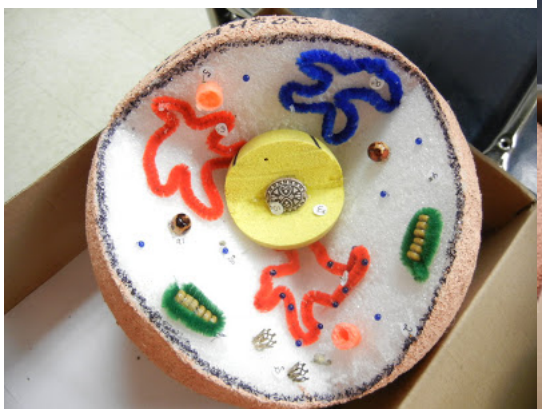
Your Job: Take in the food molecules from outside of the cell and package it in a vesicle	**Your Job:** Take food molecules and bring them to a vacuole
#4: Lysosome: Recycling Plant Lysosomes contain enzymes that cells use to digest and break down macromolecules into smaller molecules that can be reused within the cell **Your Materials:** scissors **Your Job:** Fuse with the vacuole, take the food molecules and break them down into smaller molecules, including glucose	#3: Vacuole: The Warehouse Vacuoles store material needed by the cell **Your Materials:** plastic container, construction paper(food) **Your Job**: Store the food molecules until they are needed
#5: Vesicle: The Delivery Truck Vesicles deliver products made in the endoplasmic reticulum or Golgi to other locations in the cell. They can also transport materials in and out of the cell (across city lines). **Your Materials:** plastic bag, your feet **Your Job:** Take the glucose from the lysosome and deliver it to the mitochondria	#14:Cell Membrane: The City Wall The cell membrane controls what substances enter and exit the cell **Your Materials:** White poster board with hole in it, plastic bag, protein molecule **Your Job:** Take the newly made protein molecule from the vesicle and transport it out of the cell

Activity Three: Modeling the Cell

- If time permits, allow each girl to construct a model of the cell using the materials available from the previous activity.
- Each girl should be given a sheet of construction paper (or cardboard), which will be their cell. Allow the girls to decide which materials to use to represent each organelle in their cell. Use glue or tape to attach the organelles to the cell.
    - Encourage the girls to label the organelles

Science Club for Girls

- Below are some examples of possible uses of common materials to create cell models:



Session Three
Focus on: Lipids and Membranes

Itinerary

- Question of the Day

- Activity One: Dissolving Substances in Water: Solubility
- Activity Two: Membrane Transport
- Activity Three: Interacting with Everyday Lipids
- Journals

Session Objectives

By the end of this session, girls will have:

- Learned about general principles of solubility
- Identified key properties of lipids
- Explored the ways in which cell membranes regulate transportation of materials

Question of the Day

- How do cells regulate what materials enter and leave?

Assessment Questions

1) If a molecule is "hydrophobic", describe its behavior in water(A: a)
    a. It will be repelled by the water
    b. It will be attracted to the water
    c. It splits when placed in water
2) At room temperature, unsaturated fats are usually(A:b)
    a. solids
    b. liquids
    c. gasses
3) Which is NOT a common function of lipids?
    a. Energy storage
    b. Insulation
    c. Protein production

Activity One: Dissolving Substances in Water: Solubility		
Per Club	**Per Group**	**Per Girl**
Vegetable Oil	Three Plastic Cups	Journal
Salt	Popsicle Sticks or Plastic Spoons	Pen/Pencil
Sugar		
Water		
Activity Two: Membrane Transport		
Per Club	**Per Group**	**Per Girl**
Water	12 cm dialysis tubing	Journal
Cornstarch	Plastic container(Tupperware)	Pencil/Pen
Iodine	Small paper/plastic cups	

Newspaper(for tables)	Measuring spoons	
Activity Three: Interacting with Everyday Lipids		
Per Club	**Per Group**	**Per Girl**
Dish Soap	Paper Plate	Plastic Straw
Vegetable Oil	Plastic Bowl	Toothpick
Gallon of Whole Milk	Food Coloring	

Lipids

- Lipids mix poorly with water, if at all, so their behavior is called hydrophobic("water fearing")
  - Water is a polar molecule, meaning that it will bond to other charged molecules. However, lipids are generally nonpolar (uncharged), and avoid bonding to water. Instead, water bonds to itself and the lipid molecules are kept separate.
  - The water fearing characteristics of lipids come mainly from their long hydrocarbon chains(C—H bonds), which are nonpolar

Monomers and Polymers

- Macromolecule/Polymer: fat
  - Monomer: fatty acid

Fats

- One type of lipid is called a fat
  - What are some common fats that you know of?
  - Saturated fat= fat with no double bonds; hydrogen atoms bond and stabilize the structure. The fat molecules can pack together tightly, the reason that saturated fats are usually solid at room temperature.
    - Q: What are some examples of saturated fats? (A: animal fats, butter, lard)
  - Unsaturated fat= fat with double bonds; kinks form in its hydrocarbon chain. The kinks in the molecule prevent the molecules from packing closely together, and as a result, unsaturated fats are usually liquid at room temperature.
    - Q: What are some examples of unsaturated fats? (A: fish oil, plant oils like olive oil, sesame oil, palm oil, peanut oil)

What Purpose Do Fats Serve?

- The major function of fats is energy storage. Fat can store more than twice as much energy as a gram of sugar.
- Fat tissue also cushions vital organs like the kidneys and insulates the body.
  - Q: Marine mammals such as whales and seals have especially thick layers of fat beneath their skin. Why do you think this is? (A: to insulate and protect them from the cold ocean water)

Lipids Make Up Cell Membranes

- Cell membranes are made up of a special type of lipid called phospholipids

- Phospholipids are special because they have hydrophilic heads ("water loving") but hydrophobic ("water fearing) tails. This means that when they line up in two layers, the heads can face towards the lipid (inside or outside of the cell) while the tails can face each other, away from the water.

Activity One: Dissolving Substances in Water: Solubility

- Each group of girls should be given three plastic cups filled with distilled water
- Ask the girls to label these cups with a permanent maker based on what they will put inside(sugar, salt, or vegetable oil)
- First, have the girls predict what will happen when each substance is added to the water? Do they think the salt and sugar will dissolve? How about the vegetable oil? As if any of the girls have had experience dissolving substances in water, possibly in the kitchen
  - Have them record their predictions in their journals
- Add one tablespoon of salt to the cup labeled salt, one tablespoon of sugar to the cup labeled sugar, and one tablespoon of vegetable oil to the cup labeled oil
- Using a spoon or popsicle stick, stir the solution in each of the cups for about 30 seconds
- Have the girls observed what happened to the substances in each of the cups?
  - Did the salt dissolve? The sugar? How do you know?
  - What happened to the vegetable oil? Have the girls describe where they see the vegetable oil in the cup of water. Based on what they learned about lipids, as them to guess why this might be.
- We learned that lipids don't easily dissolve in water because they are hydrophobic ("water fearing"). However, the salt and sugar crystals should dissolve at least somewhat in the water. As the girls what they think this means about sugar and salt. Are they hydrophobic?
  - Explain to the girls that salt and sugar are not hydrophobic, but instead bond to the water. Both salt and sugar crystals have charged regions. When placed in water, these charged regions form bonds with water, which also carries slight positive and negative charges in different areas of the molecule. Therefore, water gets between the salt and sugar crystals to dissolve them.

Activity Two: Membrane Transport

- Remind the girls that cell membranes are made up of lipids, which separate the inside of the cell from the outside of the cell. This membrane is also important for regulating the transport of materials in and out of the cell (remember cell city!). It lets some substances move in and out, but not other substances. In this activity, we will demonstrate how membranes regulate the movement of particles.
- Give each group a 12cm piece of dialysis tubing, a beaker of water, a small cup of corn starch, and a small cup of iodine
  - Explain to the girls that in this experiment, the dialysis bag will serve as the selectively permeable membrane and the iodine and the corn starch will be the substances trying to pass through the membrane
- Make the dialysis tubing pliable by wetting it with water
  - Tie one end of the tubing into a knot
  - In a cup, mix one teaspoon of corn starch with 9 teaspoons of water
  - Pour the corn starch/water solution into the dialysis bag

- After filing the bag, tie the other end of the dialysis tubing into a knot
- Wipe any liquid off of the outside of the tubing
- Fill the plastic container with water
- Add two tablespoons of iodine to the water in the plastic container
- Place the dialysis bag inside of the plastic container so that it is covered with the water/iodine solution
- Wait 20-30 min, sending one girl over every five minutes to check on the experiment and make observations, which she can share with the class.

❖ Tell the girls that the iodine and starch undergo a special reaction, such that when the iodine comes into contact with the starch, it will turn the starch a blue/black color. By looking at the color of the solution on the inside and outside of the membrane, we can see if the starch or iodine has moved.
- To make sure the girls understand how we will be measuring the movement of materials, ask them what they would expect to see if:
  - the iodine could move across the membrane, but the corn starch could not(A: blue/black color inside of the bag only)
  - the corn starch could move across the membrane, but the iodine could not(A: blue/black color outside of the bag only)
  - the iodine and the corn starch could both move across the membrane(A: blue/black color both inside and outside of the bag)
  - neither the iodine nor the corn starch could move across the membrane(A: no blue/black color)

Activity Three: Interacting with Everyday Lipids

❖ While we are waiting for the results of our membrane transport experiment, we will play around with lipids that are common in everyday life
❖ Give each girl a plastic straw and each group a paper plate covered in dish soap.
❖ Let the girls take turns making bubbles by placing one end of the straw in the dish and blowing into the other end
- Ask the girls to discuss what they see with their groups. How big are the bubbles? How can you change the size of the bubbles? Have the girls make predictions about why bubbles form
- explain to the girls that soap contains lipids, which stick together to form spheres, or bubbles

❖ While one group is doing the bubble blowing activity, give another group a cup of vegetable oil and have each girl put a few drops of the oil on their hands and rub them together
- Have the girls try to wash the oil off of their hands using only water. What happens? Do their hands still feel greasy? Ask the girls to discuss why they think this is based on their knowledge of lipids.
- Now have the girls try to wash the oil off of their hands using dish soap and water. What happens now? Do their hands still feel greasy? Which was more effective: the water, or the soap? Ask the girls to discuss why this is.
- Explain to the girls that soap is made up of lipid molecules with a "water-loving end" (hydrophilic) and a "water-fearing end" (hydrophobic). The hydrophobic end sticks to the oil on your hands, and the hydrophilic end sticks to the water, so the oil is pulled off of your hands by the soap.

❖ We will now experiment with soap, and another type of everyday lipid, the fat molecules in milk.
❖ Have each group pour about a cup of milk into a plastic bowl.

- Let each group add whatever colors of food coloring they would like. Add no more than five drops to the bowl.

- Explain to the girls that we will be introducing dish soap into the milk. Have them predict what they think will happen.
  - Ask the girls what they know about dish soap. Remember, molecules of soap have one hydrophobic end and one hydrophilic end.
  - Ask the girls what they think the hydrophobic ends of the soap molecules will do. How about the hydrophilic ends? Remember, the fat molecules in milk are also a type of lipids. Do you think the fat molecules will attract the hydrophobic ends of the soap molecules? Will the soap molecules move? Where will they move?
- Have the girls dip one end of a toothpick into the dish soap. Touch it to the center of the bowl of milk and watch what happens!
  - Ask the girls to discuss with their groups what they saw.
  - The food coloring was a way to visualize what happens when the dish soap and milk are combined. What happened to the food coloring? What does this suggest is happening between the dish soap and milk?
  - At the grocery store, you can buy milk with different fat contents (skim, 1%, 2% whole milk). In this experiment, we are using whole milk. Ask the girls why they think this is? Ask them to predict how the experiment might be different if we used skim milk (milk with little or no fat).
- Explain to the girls that when the drop of dish soap comes in contact with the milk, the hydrophobic ends of the soap molecules bind together with the hydrophobic fat molecules in the milk. Since the fat molecules are distributed throughout the bowl, the dish soap will spread over the surface of the bowl. This movement also drags the food coloring with it, resulting in the cool pattern that the girls observed.

- Check to see if there is any change in the dialysis bag experiment. Did the solution inside the bag change color? The solution outside the bag?
- Based on these results, ask the girls to figure out what substances the membrane lets through. Can the corn starch move through the membrane? The iodine? How do you know?

Session Four
Focus on: Proteins and Enzymes

Itinerary

- Question of the Day
- Discussion/Explanation of Protein structure and function
- Activity One: pH Testing
- Activity Two: Everyday Enzymes
- Journals

Session Objectives

Science Club for Girls

By the end of this session, the girls will have:

- Learned about the principle of pH and experimented with it using common substances
- Understood some of the key structural elements and functions of proteins
- Experimented with the idea of enzyme denaturation

Question of the Day:

- What is a protein?

Assessment Questions

1) What are proteins made up of? (A:c)
    a. Nucleotides
    b. Sugars
    c. Amino acids
2) Which is not a common function of proteins? (A:b)
    a. Speed up chemical reactions
    b. Becoming lipids
    c. Cellular communication
3) The scale to measure how acidic or basic something is called the: (A:a)
    a. pH scale
    b. acid test
    c. Scoville scale

Materials for this Session

Activity One: pH Testing		
Per Club	**Per Group**	**Per Girl**
Plastic Cups	Toothpicks or Plastic Spoons	Journal
Distilled Water		Pen/Pencil
Dish Detergent		
Lemon Juice		
Tomato Juice		
Baking Soda		
Container of pH Strips		
Activity Two: Everyday Enzymes		
Per Club	**Per Group**	**Per Girl**
Baking Soda	Plastic Cups	Saltine Cracker
Lemon Juice	Glass Beaker(w/lid)	Plastic Gloves
Isopropyl Alcohol		Journal
Portable Electric Stove		Pen/Pencil
Metal Pot		
Carton of Egg Whites		

Distilled Water		
Salt		

Introduction

- Ask the girls where they have heard the term "protein" before? Maybe in the context of nutrition? Do the girls know what foods are high in protein? Why is protein important?
- Explain that proteins are important building blocks for many structures within organisms. For example, our muscles need lots of proteins to function. Even our hair is made of protein. The girls probably know that animal products (like meat, milk, eggs) generally contain more protein than plant products (think fruits and vegetables). Ask the girls to predict why they think this is. What is different about plants and animals and the things that they do? (A: animals generally need more protein to support their large, complex structures, and the wide range of functions they carry out)

Functions of Proteins

- Speed up chemical reactions(enzymes)
- Play a role in structural support
- Storage
- Cellular communication
- Movement
- Defense against foreign substances

Monomers and Polymers

- Proteins are a special type of molecule made up of monomers called amino acids
- Monomer: amino acids
  - There are 20 different amino acids which are assembled into chains to form polypeptides
- Polymer: polypeptides
- A protein may be one or many polypeptides, folded in specific ways

Building a Protein

- The specific function of the protein is determined by the sequence of amino acids, the way that the protein is folded, and the different polypeptides that make up the protein
- Proteins can be globular(roughly spherical), fibrous(like long fibers), or countless other shapes
- Ask the girls to think back to the second week of club, in which we explored the functions of the cell, and their role in producing a protein? What do they remember about how proteins are made?

For the Curious Scientist

- Amino acids are made up of an amino group(H-N-H) and a carboxyl group(O=C-OH), a hydrogen atom and an "R group" all bonded to a central carbon atom
- The different properties of amino acids, including their polarity, is largely determined by this variable R group side chain
  - These R groups also help to control that the polypeptide chain folds to give a protein its shape and structure
- Amino acids are linked through covalent bonds through peptide bonds to form a polypeptide

Science Club for Girls

Enzymes

- Enzymes= a type of protein that regulate biochemical reactions by acting as catalysts, chemical agents that speed up chemical reactions
    - Q: One function of enzymes is to speed up reactions which break down molecules. Why then, do you think there are many enzymes in parts of the digestive system, including the saliva and stomach? (A: breaking down food molecules)

The Environment Can Influence Protein Structure

- Protein structure also depends on the physical and chemical conditions of the protein's environment. If different aspects of its environment are altered, such as pH, salt concentration, temperature, the protein may unravel and loose its shape
- pH= a scale to measure how acidic or basic a substance is
- For the curious young scientist:
    - When molecules are put in water, they can break down and release ions. If a molecule releases many hydrogen ions (H+), the solution becomes acidic. If a molecule releases many hydroxide ions (OH-), the solution becomes basic.
- Q: What common substances do you know of that are acidic? Basic?

Activity One: pH Testing

- Set up 5 stations around the room, each with a cup filled with a particular substance. Label the cup with the substance inside. The cups should be filled with:
    - Water
    - Dish Detergent
    - Lemon Juice
    - Tomato Juice
    - Baking Soda and Water
- Give each group five pH strips and ask them to go around and at each station, dip one pH strip into the cup, and look for a change of color. Have them compare the color on the strip to the chart provided with the pH strips, assigning each substance a pH. Have the girls record these measurements in their journals.
    - After all groups have gotten a chance to sample all of the substances, have them share their results and put the substances tested on the pH scale, from most basic to most acidic. Have them draw out this scale on the board.
- Based on their measurements, have the girls guess which substances release the most hydrogen ions and which substances release the most hydroxide ions

Activity Two: Everyday Enzymes

- Ask the girls to recall the function of enzymes, to catalyze, or speed up chemical reactions
    - Enzymes are proteins, and as with other proteins, they require a specific environment to work optimally, including a particular pH, salt concentration, and temperature
    - If the physical and chemical conditions are wrong for a specific protein, it may not function properly, or may even become misshapen, a process called denaturation

- For this experiment, we will be using the protein contained in egg whites and will test how different conditions affect the structure of the protein
- Have the class split up into five groups. Each group will be responsible for testing the effects of one condition on the egg white. Each group should begin by pouring egg whites into their test tube, until it is about half filled. Then, each group should add/apply their experimental variable. Have each group label the test tube with their variable (Ex. Heat, acid, etc.). Each group should make predictions about what will happen to the egg whites in their tube, and record their observations as they carry out the experiment.
    - Condition#1: Heat
        - Fill a pot with water and place it over the electric stove until the water boils.
        - Have a mentor drop the tube with the egg whites into the boiling water until the contents of the tube change from clear to white. Have the girls watch as this process happens and make observations.
    - Condition #2: Basic Solution
        - Add one teaspoon of baking soda and one teaspoon of water to the test tube.
    - Condition #3: Acidic Solution
        - Add two teaspoons of lemon juice to the test tube.
    - Condition #4: Alcohol
        - Add two teaspoons of Isopropyl Alcohol (rubbing alcohol) to the test tube.
    - Condition #5: Salt
        - Add one teaspoon of table salt and one teaspoon of water to the test tube.
- After each group has finished their experiment, have them present their findings to the class. What physical changes did the girls observe in the egg whites? What conditions had the largest effect? Why do you think this is? Based on the results, ask the girls to predict which condition is closest to the "optimal" condition for the egg white protein.

- In the human body, many different environments are maintained, in order to ensure that proteins function optimally. For example, the enzymes in your mouth that break down food work best at a certain pH. Test the pH of saliva using the pH strips.
- Now let's see those enzymes in action! Have the girls each (unless in the case of allergies), place a saltine cracker in their mouth. Ask the girls not to chew the cracker, but rather, allow the enzymes in their saliva to break the cracker down.
    - Other body regions, including the stomach, are even more acidic, which is required for the breakdown of larger molecules for digestion.

Session Five
Focus on: Carbohydrates: Building them Up

Itinerary

- Question of the Day
- Discussion/ Explanation of Chemical Reactions and Carbohydrates
- Activity One: Reactions

- Discussion/Explanation of Photosynthesis
- Activity Two: Photosynthesis
- Activity Three: Photosynthetic Pigments
- Journals

Session Objectives

By the end of this session, girls will have:

- Understood the basic principles of what occurs in a chemical reaction
- Identified changes that can come about as a result of chemical reactions
- Explored the role of photosynthesis in fueling life
- Experimented with photosynthesis in plant leaves

Question of the Day

- How do plants make food?

Assessment Questions

1) If a plant is red, that means it best absorbs: (A:c)
   a. red light
   b. orange light
   c. green light
2) What do plants release into the air?(A:b)
   a. Carbon dioxide
   b. Oxygen
   c. Nitrogen
3) The energy that plants use to power photosynthesis comes from: (A:c)
   a. Carbon dioxide
   b. The soil
   c. The sun

Materials for this Session

Activity One: Reactions		
Per Club	**Per Group**	**Per Girl**
Baking Soda	Plastic Cup	
Vinegar		
Whiteboard Marker		
Activity Two: Photosynthesis		
Per Club	**Per Group**	**Per Girl**
Baking Soda	Needle-less plastic syringe	Journal
Dish Soap	Plastic Straw	Pen/Pencil
Bag of Spinach	2 Plastic Cups	

Aluminum Foil	Flashlight	
Activity Three: Photosynthetic Pigments		
Per Club	**Per Group**	**Per Girl**
Yellow bell pepper	White printer paper	
Carrot	Plastic butter knives	
Head of Lettuce		
Tomato		

Carbohydrates

- **Carbohydrates**= sugars and polymers of sugar; most are made up of carbon(C), Hydrogen(H) and Oxygen(O) in a 1:2:1: ratio
    - They often have long carbon chain bonded to hydroxide(OH-, which contains oxygen and hydrogen atoms), which is why there are called carbo-hydrates

Where do these Carbohydrates come from?

- As the girls if they know how carbohydrates are made. Ask them to think about what kinds of foods are high in sugar (plants), and ask them how these plants grow and make this food?
- Explain to the girls that plants synthesize sugars, particularly glucose, from materials in the environment. They convert water and carbon dioxide into glucose and oxygen. This process is called photosynthesis. Write this equation on the board (in words).
    - Photosynthesis is a chemical reaction which requires energy. Where does this energy come from? (A: the sun)
    - Photosynthesis takes place in the chloroplasts, special organelles in plants which capture light energy and convert it to glucose. These chloroplasts contain a green pigment called chlorophyll, which gives many plants their green color.
- After plants make these sugars, they are stored in a variety of forms in the plant tissue, where they are then eaten by other organisms (like us).
- In addition to providing energy, carbohydrates also serve as structural support for the plant and serve as raw material for the creation of other molecules(sometimes other sugars)

Activity One: Reactions

- The process of photosynthesis is a chemical reaction. Ask the girls if they know what a chemical reaction is. What happens when different substances chemically react? Is something new produced?
- Have the girls think of other examples of chemical reactions. One good example is the reaction between baking soda and vinegar. This is a common reaction, something the girls have likely already seen, but serves as a good demonstration of two substances, baking soda (a basic solid), and vinegar (an acidic liquid) combining to form something new (a gas), easily visualized as the bubbling foam produced.
    - If the girls would like to see this experiment, you can briefly demonstrate it for them.

Activity Two: Photosynthesis

- In this activity, we will model the process of photosynthesis using spinach leaves.

- BEFORE CLASS: mentors should cut out small circles from spinach leaves, using a hole punch or plastic straw. Prepare enough so that each group of girls has about 10 leaf disks.
    - Stir a tablespoon of baking soda into a cup of water until dissolved. Add about 2 drops of dish detergent.
    - Place the leaf disks inside of a needle-less plastic syringe
    - Draw up the baking soda solution into the syringe until it is about half full and the leaf disks are suspended
    - Hold the syringe upward and expel any excess air by pushing the plunger. Don't let any of the solution escape
    - Put one finger over the tip of the syringe while pulling back on the plunger to create a partial vacuum. Hold this position for about 10 seconds, and then release the plunger and finger at the same time. Continue until the leaf disks float to the bottom of the syringe. This step is meant to remove the air from the spinach leaves and fill this space with the baking soda solution.
    - Place the leaves in a cup with the baking soda solution and store it in complete darkness until the start of the activity
- Before starting the experiment, ask the girls what plants require for photosynthesis. Explain to them that in this experiment, the baking soda will be used instead of pure CO_2 since it releases CO_2 when combined with water. What else is required? Water? Light?
- Have each group take two plastic cups, labeling one "light" and one "dark"
- Fill each cup about ¾ with water, and add a tablespoon of baking soda to each. Stir until dissolved
    - Explain to the girls
- Have the girls place 10 leaf disks in each cup. Immediately cover the cup labeled "dark" in aluminum foil and place it in a dark place. Have the girls predict what will happen to the leaf disks in each case. Think about what the products of photosynthesis are (oxygen, glucose). What happens when oxygen is produced?(Hint: it is a gas)
- Have the girls shine a flashlight on the cup labeled "light" and observe what happens. The leaf disks should begin to float as the leaves photosynthesize and release oxygen. After observing what happens to the leaves under the light, have the girls uncover their "dark" cup. Most of the leaf disks should still remain at the bottom of the cup. Ask the girls why this is. (A: without light, the leaves couldn't photosynthesize)
- If time allows, ask the girls why we needed to do the "dark" experiment, even though nothing happened. Explain to them that this condition serves as a "control." Since the purpose of the experiment was to see what the effect of the light was, it is important to have another experiment with all of the same conditions except for the light (the condition we were testing), to make sure that it was really the light, and not something else, which affected the experiment to produce the results that we saw.

Activity Three: Photosynthetic Pigments

- Earlier, we discussed that the process of photosynthesis takes place in chloroplasts, special structures in plant cells which contain special pigments
    - These pigments capture the light from the sun that is needed to drive photosynthesis
    - In many plants, the primary pigment is a substance called chlorophyll, which gives plants their green color.
- Ask the girls what other plant colors they have observed? What do they think gives plants these colors?

- Explain that the types of pigments vary between different types of plants. These pigments are different because they can capture different "colors" of light. The light that is not absorbed is reflected. For example, spinach leaves absorb primarily blue and red light. They don't "like" green light, so they reflect it, causing the leaves to appear green.
- Based on this information, let the girls explore other vegetables (carrots, tomatoes, lettuce, yellow peppers) that contain different pigments. Cut up the vegetables and distribute one piece of each vegetable to each group. They can cut them and use white paper to investigate their colors. Have them predict what colors of light each vegetable absorbs most for use in photosynthesis. Remember, the light that is not absorbed is reflected. The color of the vegetable appears to have this reflected color. Pulling up an image of a color wheel might help.

- Answers:
  - Yellow peppers- Lutein ; absorbs mainly blue light
  - Tomatoes- lycopene ; absorbs indigo, blue, green, yellow light
  - Lettuce- lactucaxanthin ; absorbs blue and red light
  - Carrots- alpha carotene ; absorbs blue and purple light
- Girls can use the pigments to "paint" on white paper if time allows.

Session Six

Focus on: Carbohydrates: Breaking them Down

Itinerary

- Question of the Day
- Discussion/Explanation of Sugars
- Activity One: Starch Test
- Activity Two: Yeast and Balloon Experiment
- Journals

Session Objectives

By the end of this session, girls will have:

- Gained a basic understanding of the structure and function of carbohydrates

- Identified common sugars and starches and their properties
- Experimented with starch levels in common foods
- Learned about the process of cellular respiration
- Observed a reaction indicative of general principles of cellular respiration

Question of the Day

- How do we get energy from our food?

Assessment Questions

1) What is not required for cellular respiration? (A:a)
    a. Water
    b. Carbohydrates
    c. Oxygen
2) Cellular respiration produces energy in the form of: (A:c)
    a. Sunlight
    b. Carbohydrates
    c. ATP
3) Starch is: (A: b)
    a. The same as lactose
    b. A type of carbohydrate
    c. An enzyme

Materials for this Session

Activity One: Starch Test		
Per Club	**Per Group**	**Per Girl**
Loaf of Bread	Potato	Saltine Cracker
Plastic Butter Knife	Plastic Cups (7)	Journal
Sugar		Pen/Pencil
Corn Starch		
Iodine		
Activity Two: Yeast and Balloon Experiment		
Per Club	**Per Group**	**Per Girl**
Dry Yeast	Plastic Soda Bottle	Journal
Warm Water	Balloon	Pen/Pencil
Sugar	Measuring spoons	
Masking Tape		

Carbohydrates

- **Carbohydrates**= sugars and polymers of sugar; most are made up of carbon(C), Hydrogen(H) and Oxygen(O) in a 1:2:1: ratio
    - They often have long carbon chain bonded to hydroxide(OH-, which contains oxygen and hydrogen atoms), which is why there are called carbo-hydrates
- Sugar molecules are broken down by chemical reactions within the cell which release energy to power cellular work.
- The carbon components of carbohydrate also serve as a material for the creation of other small molecules within the cell
- The monomers of carbohydrates are called **monosaccharides** or simple sugars. They combine with thousands of other monosaccharides to form macromolecules called **polysaccharides.**
- Ask the girls what carbohydrates they know of? (Hint: plants use carbon dioxide and water to produce ___ and oxygen).
    - Common carbohydrates include glucose, maltose(high levels in things like sweet potatoes), fructose(high in fruits), and sucrose(table sugar, sugar cane), lactose(milk sugar)

Activity One: Starch Test

- Carbohydrates can exist in many different forms. Often times, reactions take place within an organism to convert one type of carbohydrate to another type. Let's see this process in action
- Have each girl take a saltine cracker (check for allergies first), and place it in her mouth. Ask the girls to make note of how the cracker tastes when the initially put it in their mouth. Have the girls hold the cracker in their mouth for about a minute without chewing. Then ask them to make another note about how the cracker tastes after it had been in their mouth for a minute.
    - Did the taste change? How so? Why do you think this is?
    - Explain to the girls that a chemical reaction occurs in their mouth, whereby the bland starch in the cracker is converted into sweet sugar. This reaction is catalyzed by the enzymes contained in your saliva. (Think back to last session when we did the same demonstration and learned about enzymes).
- Different types of food have different types of sugar. They also have different amounts. In this next activity, we will test the levels of starch(one type of carbohydrate) in different types of food
- Split the club up into four groups. Each group will be responsible for testing the starch level in one common food item. First, introduce the foods that we will be testing (bread, sugar, corn starch, potato), and have the girls predict which food item contains the most starch.
- Have each group place their food item in a small plastic up and add three drops of iodine. Wait a few minutes and observe what happens. If they want, girls can also try adding saliva to their food. Remember, the enzymes in saliva should convert some of the starch into sugar.
    - Explain to the girls that we are using iodine to test how much starch each item contains. Iodine and starch undergo a chemical reaction, which will produce a blue/black product (think back to the experiment with the dialysis tubing). Therefore, the more blue/black the sample turns, the more starch it contains.
- After everyone has had the chance to test their food product, bring all the samples together and have the girls order the products based on the amount of starch. Record observations in journals.

Carbohydrates as Energy

- Where does the energy that we use to power all of our bodily functions come from?
- Carbohydrates are stored in plants and used to provide structural support. Perhaps more importantly, however, they are used by the plant (and by organisms which eat them) to provide energy.
- The process by which carbohydrates(which are made by and stored in plants) are broken down by an organism to provide energy is called cellular respiration
    - As the girls if they remember which organelle is primarily responsible for providing energy for the cell. (A: mitochondria). Mitochondria are the site of several important steps of cellular respiration.
- Cellular respiration can be thought of as the "opposite" of photosynthesis
    - Ask the girls if anyone remembers the equation for photosynthesis (A: water +carbon dioxide (+ energy)= glucose + oxygen)
    - If cellular respiration is this reaction "backwards", ask the girls to predict its equation (A: glucose+ oxygen= water+ carbon dioxide (+energy)).
    - Note that in photosynthesis, something was being assembled, a process which required the input of energy (from the sun). However, in cellular respiration, something is being broken down, which releases energy. This is the energy that we use to power many of the processes that allow us to function. It is called ATP.
- As animals, we don't photosynthesize. However, we do perform cellular respiration. Ask the girls to think about how this reaction takes place in our bodies, paying particular attention to the equation.
    - What do we need for cellular respiration? (A: oxygen and carbohydrates(glucose))
    - Where do we get these materials? (A: we breathe in oxygen from the air and obtain carbohydrates from our food)
    - What we get out of cellular respiration? (A: carbon dioxide, water, and energy)
    - Where do these materials go? (A: we release carbon dioxide when we breathe out; we use the water in our bodies, and release it as urine when we have too much; we use energy to power everything we do!)

Activity Two: Yeast and Balloon Experiment

- In this next experiment, we will see respiration in action. For this experiment, we are using yeast, an organism who breaks down carbohydrates to obtain energy, but does so in a slightly different way from the way that we animals do. This process does not require lots of oxygen, for example. However, it will still demonstrate the basic principles involved in cellular respiration
- Split the club up into two groups. Each group will perform their own reaction.
- Before starting the reaction, have the girls list out what is required for this experiment(A: carbohydrates, and for us, oxygen)
    - In this experiment, the carbohydrate we will be using is sucrose(table sugar)
- To the plastic soda bottle, add one tablespoon of yeast and one tablespoon of sugar
- Fill the bottle ¾ full of warm water. This will help to "activate" the yeast
- Quickly stretch the balloon over the opening of the bottle and secure it in place with masking tape. Once it is secure, shake the bottle a bit to mix everything together.
- Have the girls observe what happens and talk with their groups about why they think this is happening.
    - What is happening to the balloon? What is it being filled with? (A: carbon dioxide gas)
    - Where is this gas coming from? (A: it is produced as a product of the respiration reaction)

Session Seven
Focus on: Nucleic Acids

Itinerary

- Question of the Day
- Discussion/ Explanation of Nucleic Acids and Basic Genetics
- Activity One: Isolating Fruit DNA
- Discussion/ Explanation of DNA structure and function
- Activity Two: Isolating Fruit DNA
- Journals

Session Objectives

By the end of this session, girls will have:

- Learned about the way in which DNA encodes genetic information
- Experimented with isolating DNA from common fruits
- Use the process of DNA extraction to make connections with topics introduce in previous sessions
- Gained an understanding of the basic structure and function of DNA
- Constructed models of a DNA molecule

Question of the Day

- How do our cells know what to do?

Assessment Questions

1) Which of the following is a direct function of DNA? (A:a)
    a. Encodes genetic information
    b. Creates energy for the cell
    c. Controls the passage of materials into and out of the cell
2) Where is DNA located in the cell?
3)
4) Which describes the structure of DNA?
    a. A ring
    b. A checkerboard
    c. A double helix

Materials for this Session

Activity One: Isolating Fruit DNA		
Per Club	**Per Group**	**Per Girl**
Container of Strawberries	Plastic Zipper-Lock Bags	Journal

Distilled Water	2 clear beakers or plastic cups	Pencil/Pen
Isopropyl Alcohol		Small, sealable plastic test tubes
Tight Mesh Strainer		
Tweezers		
Dish Detergent		
Salt		

Activity Two: Candy DNA Model		
Per Club	**Per Group**	**Per Girl**
	Black and Red Licorice with Hollow Centers	
Bag of Colored Mini Marshmallows		About 10-15 toothpicks
Paper Plates or Cups		1ft piece of string

Monomers and Polymers

- Monomer: nucleic acid bases
- Polymer: DNA or RNA

For the Curious Young Scientist:

- DNA and RNA differ in the sugar which is used in their nucleic acid molecules
  - DNA's full name is deoxyribonucleic acid, because it contains the sugar deoxyribose
  - RNA's full name is ribonucleic acid, because it contains the sugar ribose
- DNA directs the synthesis of RNA and RNA controls protein synthesis
- Nucleic acids are made up of a nitrogenous base (contains the element nitrogen), a sugar (deoxyribose or ribose), and a phosphate group (remember these from the lipids session?)

What is the Function of Nucleic Acids?

- There are two types of nucleic acids, DNA and RNA. We will focus mainly on DNA
- Q: Do you remember from the second week of clubs what the function of DNA is? Do you remember where it is found? (A: encodes genetic information, located in the nucleus)
- DNA is the genetic material that organisms inherit from their parents in the form of chromosomes, which contain DNA molecules
  - Encoded in the structure of DNA is the information that programs the activities of the cell- it provides instructions on which proteins to assemble in order to carry out all of the cell's functions
  - Q: What traits do humans inherit from their parents through DNA? Do you resemble your family or other family members?

How Does DNA Encode Information?

- There are four main types of nucleic acid bases: cytosine(C), thymine(T), adenine(A), and guanine(G)
- A DNA molecule is made up of sequences of As, Cs, Ts, and Gs arranged in specific patterns which can be interpreted by machinery within the cell and translated into proteins

DNA Structure

- DNA molecules form a spiral shape called a double helix, a structure which looks kind of like a twisted ladder. The steps of the latter are made up of the nucleotide bases(A, C, T, G) which connect together in specific ways
    - This allows the bases to pair with each other:
    - A pairs with T
    - C pairs with G
- The "sides" of the ladder are made up of sugars and phosphates
- This structure makes it easy for DNA to replicate. It unzips its double helix and the nucleic acids separate. They then connect with new matching nucleic acids to form complete double helices again.

Activity One: Isolating Fruit DNA

- DNA is in the cells of almost every organism. However, it is ordinarily difficult to see. In this activity, we will use a variety of materials to extract DNA from common strawberries
- Place the bottle of isopropyl alcohol in a refrigerator or freezer if available
- Have each group pour 1/3 cup of water into one of the clear beakers
    - Add 2 teaspoons of dish soap to the beaker and mix in with the water
    - Ask the girls why they think we might be using the dish soap. Remember, the DNA is contained inside the nucleus of the cell, so to get to the DNA, we need to break apart other parts of the cell. (A: the soap will break apart the cell membrane. The hydrophobic ends of the soap molecules bind to the lipid membrane and the hydrophilic ends bind to the water, ripping apart the membrane)
    - Add ¼ teaspoon of salt to the mixture. Ask the girls why we might be using the salt. Think back to our session on proteins and think about the way that adding salt affected the egg white protein. (A: the salt will help to break apart the protein chains in the strawberry cells, allowing us to better access its DNA)
- Place one strawberry in a small plastic zipper-lock bag
- Pour the soap and water solution into the bag with the strawberry
- Seal the bag and use your hands to mash the strawberry until there are no large pieces left.
- Pour the mixture from the bag through a fine mesh strainer and into the other clear beaker
- Add one teaspoon of alcohol to the beaker. Hold the mixture at eye level. You should see DNA rising from the strawberry mixture. It will appear white, clumpy, and stringy.
    - The alcohol helps to separate the DNA from the solution because DNA is not soluble in alcohol. Have the girls think back to our lesson on solubility. Some substances dissolved in certain solutions, and others separated. Oil separated from water, and in this case, DNA separates from alcohol.
    - If you cannot observe DNA rising from the mixture, you may need to add more alcohol, or try stirring the mixture gently.
- Use tweezers to lift the DNA out of the beaker.
    - Each girl can place some of the DNA in their small sealable plastic test tubes, to take home.
- Have the girls record their observations in their journals

Activity Two: Candy DNA Model

- In this activity, we will become more familiar with the structure of DNA by building models out of candy
- Depending on resource availability, each girl may make her own candy DNA molecule or each group can work on one cooperatively
- Give each girl(or each group) two strings, each about 1ft long, and about 12 toothpicks
- Cut the red and black licorice into one inch pieces. Red licorice will represent sugar molecules and black licorice will represent phosphates in this activity.
- Assign each nucleotide base (adenine, guanine, cytosine, thymine) a specific color of mini marshmallow. Write these color assignments on the board. They will be used by the whole class. It could also be helpful to write the base-pairs on the board. (adenine pairs with thymine, cytosine pairs with guanine).
    - Pair the mini marshmallows with their appropriate pair, poking the toothpick through both marshmallows. Push them towards the center of the toothpick so that there is still space at both ends of the toothpick.
- Tie a knot at the end of each string. Thread the licorice pieces on to the string, alternating red (sugar) and black (phosphate) pieces. Make sure to start with the same color on each string. When you get to the top of each string, tie another knot.
- Attach the nucleotide bases to the sugar-phosphate backbone by poking the ends of the toothpicks into the sugars (red licorice pieces) of both strings, creating a latter-like pattern. Add these base-pairs in any order you want. In real DNA, the number of each nucleotide base and the order in which they appear determines differences in the genes they form. This is how genetic information is encoded in DNA.
- Finally, twist the strings in a counter-clockwise direction to create a double helix
- Feel free to eat your finished DNA double helix (or share if you worked as a group)!