Prior to the lesson, the students will be given a 15-item Pre-test. (See Attachment 1: Pre-Post Test). The Pre-test will identify the prior knowledge of students about MITOSIS & MEIOSIS and whatever misconceptions they have about the lesson.

**MOTIVATION:**
To refresh students with mitosis and its stages, they will watch a short video clip titled, STAGES OF MITOSIS by HYBRID MEDICAL. This is critical so students will be able to compare meiosis to mitosis.

The following are links to the video:

http://www.youtube.com/watch?v=VGV3fv-uZYI or


As they watch the video clip, the students will answer the following questions:

1. What are the stages of mitosis shown in the video? *Interphase (G1, S, G2)*, *mitotic phase (prophase, prometaphase, metaphase, anaphase, telophase)*
2. Why do you think it is advantageous for cells to go through the different events of the cell cycle (such as copying their genes or building the materials needed for division) in an ordered way? What might happen if a cell underwent all of these activities at once? *Accept any reasonable answer. Students may write that going through the various events one at a time allows a cell to devote more energy to each task, or that if too many events occur at once, the environment inside the cell may become disrupted.*

**NEEDED MATERIALS & SET-UP:**
For a class of 20 - 24 students, divide the class into six groups, each with 3 - 4 members. In pairing up/grouping students for the activity, group/sit beginning and
intermediate speakers with advanced and advanced high speakers. This will help
struggling students to follow instruction and quickly ask clarifications and help from
group mates. Table set-up can vary as long as each member in each group will have
access to the materials.

Although it is recommended to have less than 5 students in each group, teachers can
modify the number of students per group depending on the availability of materials,
space, and time.

Below is a suggested classroom set-up for the labs. This will allow for a quick
transitioning from a whole class lecture/providing instructions to a small group lab
work.

**Materials/Instructional Aids for Bell Ringer/Motivation: (for a class of 25
students)**

- 25 copies of Attachment 1: Pre-Post Test (modified into Pre-Test)
- 1 computer
- internet access
- LCD projector
- Speaker
- Individual student notebook (require students to write and answer the Bell
  Ringer/Motivation questions in their composition notebook)

**Materials/Instructional Aids for Learning Activity: Mitosis & Meiosis on the
Table (for a class of 25 students)**

- 6 sets of:
  - 5 single pieces, blue pipe cleaners
  - 5 single pieces, red pipe cleaners
  - 3 double pieces, blue pipe cleaners
  - 3 double pieces, red pipe cleaners
  - 1 mitosis sheet (See Attachment 2)
  - 2 meiosis sheets (See Attachment 3)
  - 6 individual summary sheets (See Attachment 4)

**Materials for Post-Testing (for a class of 25 students)**
- 25 copies of Attachment 1: Pre-Post Test (modified into Post Test)
  Suggestion: If the teacher has a set of Response Clickers, Part A: Multiple-Choice of
  the Post-Test can be programmed in it so the teacher can quickly make an item
  analysis and immediate feedback can be given.

**COMMUNITY RESOURCE:**
An ideal community resource speaker for this lesson is a scientist or university
professor who is expert in the field of Cell Biology or Genetics. If possible, set-up a
live conference with the scientist or professor during the execution of the lesson so
students can ask their questions directly to the resource person.

**OUTCOMES:**
*Dimensions of K-12 Science Education Standards*

**Scientific & Engineering Practices**
- Asking questions and defining problems
- Developing and using models
- Analyzing and interpreting data
- Constructing explanations and designing solutions
- Obtaining, evaluating and communicating information

**Crosscutting Concepts**
- Patterns
- Cause & effect: Mechanism and explanation
- Scale, proportion, and quantity
- System and system models
- Structure & Function
- Stability and change

**Disciplinary Core Ideas**
LS3: Heredity: Inheritance and Variation of Traits across generations, focuses on the
flow of genetic information between generations. This idea explains the mechanisms of
genetic inheritance and describes the environmental and genetic causes of gene
mutation and the alteration of gene expression.

*Next Generation Sunshine State Standards*

**Standard 16: Heredity & Reproduction**

**SC.912.L.16.17** Compare and contrast mitosis and meiosis and relate to the processes
of sexual and asexual reproduction and their consequences for genetic variation. (Also
assesses SC.912.L.16.8)

**SC.912.L.16.14** Describe the cell cycle, including the process of mitosis. Explain the
role of mitosis in the formation of new cells and its importance in maintaining
chromosome number during asexual reproduction.

SC.912.L.16.16 Describe the process of meiosis, including independent assortment and crossing over. Explain how reduction division results in the formation of haploid gametes or spores.

**Common Core Literacy Standards**

Reading Standards: Science & Technical Subjects - Integration of Knowledge & Ideas

Speaking & Listening Standards: Comprehension & Collaboration

**Key Ideas and Details**

CCSS.ELA-Literacy.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

**Craft and Structure**

CCSS.ELA-Literacy.RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.

**Integration of Knowledge and Ideas**

CCSS.ELA-Literacy.RST.9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

**Learning Outcomes**

Students will...
- differentiate the processes of mitosis and meiosis;
- **demonstrate & show the different stages of mitosis & meiosis**;
- illustrate the stages of mitosis & meiosis;
- describe the role of mitosis in asexual reproduction, and/or the role of meiosis in sexual reproduction, including how these processes may contribute to or limit genetic variation;
- describe specific events occurring in each of the stages of the cell cycle and/or phases of mitosis;
- explain how mitosis forms new cells and its role in maintaining chromosome number during asexual reproduction;
- describe the process of meiosis, including independent assortment and crossing over;
- explain how meiosis results in the formation of haploid gametes or spores, and;
- explain the similarities and differences between mitosis and meiosis, including their significance by...
  - watching a short video clip on mitosis, and conducting a simulation lab comparing mitosis and meiosis...
  - within 30 – 45 minutes and with 100% accuracy.
These learning outcomes will be shared to the students at the beginning of the lesson and these will be present on the board configuration. In the course of the activity, the teacher together with the students will check if the learning outcomes/goals are being met.

LEGEND: BLACK – PERFORMANCE; RED – CONDITION; BLUE - CRITERION

PRESENTATION & PARTICIPATION:

Instructional Strategies:

Behavior - Demonstrations, Discussion, Cooperative learning

Cognitive - Brainstorming, Simulations, Kagan Strategies, Conversations, Using Analogies

Application/Process - Inquiry-based, Projects, Problem-Solving

Other - Homework, Providing feedback, Questioning, Cooperative Learning, Self-Assessment

Summary:
In this lesson, the students will be doing a simulation activity/lab to examine the processes of mitosis and meiosis and their similarities and differences. Students manipulate pipe-cleaner chromosomes on a template showing stages of mitosis with one pair of chromosomes until approved by the teacher. Then they repeat the exercise for meiosis until approved. It is important that the teacher emphasize and that the students understand that both of these processes are important in maintaining chromosome number, genetic variation as well as human reproduction.

ACTIVITY: MITOSIS & MEIOSIS ON THE TABLE
ADAPTED FROM: http://www.indiana.edu/~ensiweb/lessons/gen.mm.html

In this lab activity the students will discover the critical differences between mitosis and meiosis, and possible misunderstanding about the two processes by showing key “movie frames” of the key stages in each process on their table. Students will work in small group (3-4 students per group) in doing this lab.

PROCEDURE:

1. The students, with the guide of the teacher, will identify the materials needed for the lab activity. Tell the students that:
   - Each single fuzzy piece (pipe cleaner) equals one chromosome (a red piece equals one chromosome inherited from the mother; a blue piece equals one chromosome inherited from the father)
   - Two fuzzy pieces, held together by a bead—the centromere—equals one chromosome duplicated into two new strands (chromatids), each of which
becomes a duplicate chromosome when the centromere splits at the beginning of anaphase.

2. Make an inventory of the materials before doing the lab activity. A complete set will have:
   - 5 single pieces, blue
   - 5 single pieces, red
   - 3 double pieces, blue
   - 3 double pieces, red
   - 1 mitosis sheet (See Attachment 2)
   - 2 meiosis sheets (See Attachment 3)
   - 1 summary sheet (See Attachment 4)

3. For purpose of this lab activity, tell the students of the following assumptions:
   - The diploid number (2N) of this organism is “2” or 1 pair
   - Chromosomes are NOT visibly divided into chromatids (think “chromosomes kids”) until metaphase
   - Twisting and crossing over are NOT to be shown here

4. Give students/groups ample time to read the procedure (about 5 minutes). Ask them for questions/clarifications after reading the procedure. Remind the students to visualize the procedure from memory and understanding so far and think of each stage as a frame in a movie film of the process.

Lab Procedure:
1) Arrange the pieces on the MITOSIS sheet, showing the essential chromosome arrangements during mitosis. You will not need all the pieces for this part. When done, raise your hand to be checked. Your teacher will provide you with index cards for labeling. Write on the index card your class period, group number and the stage of mitosis shown. The teacher will take a picture of your mitosis stage frame/diagram.

2) When your group MITOSIS layout is approved, copy those arrangements onto your MITOSIS-MEIOSIS SUMMARY SHEET using red and blue pencils (or using clear and shaded shapes).

3) Remove all pieces and proceed to arrange them on the two MEIOSIS sheets, with MEIOSIS I sheet placed above the MEIOSIS II sheet so the arrows flow from sheet to sheet. Remember to show the essential differences between mitosis and meiosis. Be sure to end up with sperm if you are a boy, or an egg with polar bodies if you are a girl. **The teacher may identify whose groups will be girls and whose groups will be boys.** Your group should use ALL of the pieces for meiosis. When finished, raise your hand to be checked by your teacher.

4) When your meiosis layout is approved, copy the arrangements onto your MITOSIS-MEIOSIS SUMMARY SHEET using red and blue pencils (or using clear and shaded shapes).

5) Count all pieces back into their container/bag and return the container and
“layout” sheets to the tray.

6) You may help other/group by giving clues but remember not to show the correct arrangements. Let other discover this as you did. When others get it right, praise and tell them, “YOU GOT IT!” and have them show arrangement on the summary sheet.

7) Complete your worksheet by identifying the distinguishing features of MITOSIS and MEIOSIS and answer the POST-LAB questions.

5. Gather students to talk about the distinguishing features of MITOSIS and MEIOSIS that they have written on their summary sheet. Emphasize the three main differences. Challenge students to think of a TOPIC for each comparison.

<table>
<thead>
<tr>
<th>MITOSIS</th>
<th>MEIOSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO synapsis (pairing of matching homologous chromosomes)</td>
<td>Homologous chromosomes pair off (synapsis)</td>
</tr>
<tr>
<td>Centromere splits; 2 chromatids become 2 chromosomes</td>
<td>Homologous pairs separate (in first division or meiosis I)</td>
</tr>
<tr>
<td>1 division (2 cells: 2n→2n, n→n)</td>
<td>2 divisions (4 cells: 2n→n)</td>
</tr>
</tbody>
</table>

6. Ask the students the POST-LAB questions.

- **What are the two main functions of meiosis?** POSSIBLE ANSWER: 1) Keeps chromosome number from doubling and redoubling; 2) increases variation by random assortment and crossing over.
- **How does meiosis lead to genetic variability (3 ways)?** And why is genetic variability a good thing?
- **Are mitosis and meiosis similar?** Are they different? Explain.

Suggestions:
- Prepare all materials in separate bags in such a way that each container/bag contains all the materials that each group will use for the activity.
- Do an inventory of the materials before and after doing the lab. Check the number of chromosomes (pipe cleaner), count all pieces in the container/bag. Tell them to notify the teacher if there are any extras or shortages. Also, inform the students not to remove beads from double fuzzy pieces.
- Assign task for each student in a group (recorder/illustrator, frame director, supply manager/collaborator)

QUESTIONS:
1. Do cells need to divide? Explain and justify your answer. (**Moderate Complexity**)
2. What are the main events of the cell cycle? What happens in each stage? (**Moderate Complexity**)
3. Does each cell increases in size? Why did you say so? (**High Complexity**)
4. Do daughter cells split apart after mitosis? Why? (**Moderate Complexity**)
5. Is growth related to cell division? Explain and justify your answer. (High Complexity - Analysis)


7. Are mitosis and meiosis similar? Are they different? Explain and justify your answer. (Moderate Complexity)


9. Is mitosis related to asexual reproduction? Explain. (High Complexity - Analysis)

10. Why is meiosis a significant process in terms of: the passing on of information to new generations? Variation of traits among siblings? (High Complexity - Analysis)

11. Think of an analogy that can explain the at least two differences and/or similarities between mitosis and meiosis. How does your analogy explain the comparison between mitosis and meiosis? Justify your answer. (High Complexity - Synthesis)

12. The karyotype of one species of primate has 48 chromosomes. In a particular female, cell division goes awry and she produces one of her eggs with an extra chromosome (25). In which stage/s could be the most probable source of this error? Justify your answer. (High Complexity - Application)

**REFLECTION:**
Students’ output for mitosis and meiosis on the simulation lab will be used as part of formative assessment tool. This includes drawing on their summary sheets and answers to post-lab questions. This will be explained to the students before they begin the lab activity. The students’ mitosis/meiosis stage frame/diagram will be checked right after they finished constructing or framing each stage. Feedback will be provided as they finished and before they draw each stage in their MITOSIS/MEIOSIS Summary sheets. In the process, students who think they understand the critical distinctions and essential functions of the two processes going in, usually discover that it is not quite what they thought, and come out of this with a sharper understanding. This is significant part of the Formative Assessment tool.

After the lesson, the teacher will give the post-test to the students. The post-test is the same questions as the 15-item multiple-choice pre-test. The results will be recorded and the paper will be given back to the students during the next meeting. (See Attachment 1: Pre-Post Test)

**SAFETY:**
Before the whole class activities begin, reiterate to the students the importance of observing the “Laboratory Safety Rules”. Remind the students of the general safety rules and procedure that were discussed at the beginning of the school year and during the execution of previous labs. Specifically, remind the students of the following:
• Never eat, drink, or smoke while working in the laboratory.
• Read and follow the procedures carefully.
• Do not use any equipment/supplies/materials without any instruction given by the teacher or approved by the teacher.
• Do not play with the pipe cleaner or point them to your classmates. Be extra careful not to prick or poke yourself or your classmates.
• Keep the work area clear of all materials except those needed for your work.
• Be responsible for the proper disposal of used material if any in appropriate containers.
• Clean up your work area before leaving.

As much as possible, demonstrate proper handling of supplies.

TRANSFORMATIVE:

• **For Less Proficient Readers & English Language Learners**
  In pairing up/grouping students for the activity, group/sit beginning and intermediate speakers with advanced and advanced high speakers. Ask each pair/group to collaborate in understanding and rephrasing the instructions for the activity. Students can read instructions individually and work with their partner/group mates to clarify confusions. ESOL students will be provided the worksheet in digital form to translate to their native language.

• **Use Visuals/Demonstrations for ELL/ESOL/Visual Learner/Students**
  Use the computers to provide visuals, animations and videos to visual learners. Demonstrate and provide examples on how to manipulate objects.

• **Special Needs**
  Help students model the steps in meiosis using pipe cleaners of the same color to represent chromosome pairs, with different pairs having different colors. Monitor students to make sure they double each chromosome before meiosis begins by adding another pipe cleaner of the same color. They can use beads to hold chromatids together or twist the pipe cleaners together in the middle. Make sure they separate the chromosome pairs during meiosis I, and the chromatids during meiosis II.

• **Advanced Students**
  Provide various art materials for advanced students, and challenge them to illustrate what might happen if sex cells, or gametes, did not have half the number of chromosomes as body cells. Have them present their models to the class and explain why sex cells must have the number of the chromosomes as body cells.

• **ESE Students**
  For ESE students, provide a longer time to complete assignments and give more explicit/simplified instructions. Have them also read aloud the description/procedure for the lab activity, for each stage of mitosis and meiosis and for the post-lab questions and answers.

UTILIZE:

Challenges
Challenge 1: Prior to this lesson, the students must have prior knowledge of the steps of mitosis and meiosis. However, a number of students may not have enough background knowledge about mitosis and meiosis or may have misconceptions of the process.

Challenge 2: The teacher or the student may not have enough supplies of varying color of pencils for students to draw the chromosomes.

Challenge 3: The teacher may not have enough supplies of pipe cleaners and beads for all classes (multiple classes) or supplies used during the previous class would have missing pieces and misplaced pieces.

Challenge 4: The majority of students will not fully understand mitosis/meiosis after reading the text, listening to lecture, and looking at static models or pictures.

Addressing the Challenges

Challenge 1: Identify students' misconceptions by looking at pre-test scores and answers and identify concepts that should be reinforced or misconceptions that must be addressed. Address these misconceptions during the course of the activity. Closely monitor students during the simulation labs and as they answer post-lab questions. A short video clip on mitosis/meiosis will help students recall previous lessons.

Challenge 2: If supplies would be a problem, students can draw red ones solid, and blue ones open (not shaded).

Challenge 3: Have students take inventory of materials at beginning and end. Require students to pay particular attention to the Identification info, the Assumptions and the Procedure steps.

Challenge 4: Active learning techniques are crucial with this topic. To diagnose and correct sources of student confusion, it is essential to have students draw the stages of meiosis as they perform the simulation lab and members of the group alternate in modeling the process with pipe cleaners.

Strengths

- The hands-on activity (lab) used in the lesson is designed to help students to learn the critical distinctions between what happens to chromosomes during mitosis vs. meiosis, which is the main goal of the lesson.
- The lesson uses materials that are easy to find and produce and can be replaced easily by other materials like yarn or construction paper.
- The lesson allows students to use and enhance different learning styles: Auditory/visual, kinesthetic (through manipulatives), physical, logical and social learning.
**Weaknesses:**

- The hands-on activity in this lesson uses pipe cleaners that might have sharp wires. On the other hand, reminding students of this safety issue, to wear gloves while handling the wires, will avoid injuries. The teacher must keep an eye on the students who have tendencies to become playful.
- Crossing over cannot be shown clearly using the pipe cleaners. This is an important aspect of meiosis that the students must visualize and understand.