Making Cells and Seeing Organelles: A Visual and Tactile Exploration of Cellular Structure

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This curriculum unit is recommended for:
7th-8th Grade Integrated Science

Keywords: cells, organelles, hierarchical organization, tissue, plant cell, animal cell, cell membrane, nucleus, ribosome, specialized cell, cytoplasm, cell wall, microscope, living, scientific representation, unit of life, cell art, cellular structure, biology, STEAM, imaging, primer diagrams, ambitious science teaching, culturally relevant science

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

Synopsis: In this four-week unit students will apply their knowledge of cellular structure and functions to create various iterations of cell diagrams. Students will engage in several attempts at creating and revising cellular models in a manner that requires explanations and evidence-based arguments through experience. Images of cells vary due to the different imaging methods of microscopes. Students' visual experience of cells changes and the continuity of the organelles becomes distorted by the biological magnifying microscope, the electron imaging of cells, and the 3D renderings under optical microscopes. And too often textbooks provide oversimplified diagrams in varying iterations. Student participation in multiple creative iterations and depictions of cellular structure allows them to focus on the pieces of the whole and to compare and contrast organelles across images and diagrams. By manipulating the pieces of a cell structure, they formulate connections and obtain a greater understanding of cellular structure, while reconciling the inconsistencies in images of cells. Students will be able to visually identify and communicate scientific knowledge of cellular forms in a multitude of ways while engaging in a culturally relevant and community practice that activates resources in nontraditional ways.

I plan to teach this unit during the coming spring to 180 seventh grade integrated science students.

Introduction

What is the common thread that binds us all together? All to often the answer is something along the lines of "because we are all human," "we are part of the human family" or as my students in my first year teaching told me "because we all alive." This all too simple question made me question how was I practicing science in the classroom to engage my class in symbolic ways. We are all human because we are all alive is not what could be inferred or seen in the textbook. Cells are not threaded together but isolated in generalized diagrams with the token phrase, "cells are the building blocks of life." To make science apparent the goal and anchor of this project is cell quilt that links these pieces, creates a living product. Improving visual literacy of science diagrams and illustrations by participating in the conversation. My unit and especially quilting requires students to engage in a series of performance tasks to learn scientific communication and answer the aforementioned question in a method that is public, markedly different and literal because cells are the fabric of life.

Rationale

When I went to school I studied social science although I always kept a place in my heart for natural science. When I graduated from college I applied for Teach for America with the intention of paying it forward. Teach for America has a unique model in which they believe that the high achievement of its selected participants means they can teach anything. That is not to say they do not look at areas of expertise, but need in schools does not always match the wants of its corps members. I fully expected to teach social studies when I was recruited and preferred social studies. When I received my assignment, I was given my first-choice region but also science, which was not even on my preference form. But I powered ahead and studied for my praxis, and in the following summer while in Atlanta for the TFA Summer Institute threw myself into the world of science education. The most important thing to me while entering the corps was that Teach for America taught the populations that I identified as low income, racial minorities and disenfranchised.

My own story and connection with these students have a lot of relevance in how I choose to teach academic content and cultivate my students academically, personally, and in relation to access and social-political consciousness. There are two things that I notice teaching in my community that operate as a barrier to education, relevance, and literacy. Science has long been victim to the mindset that it doesn't matter, because "who needs to know about the water cycle," "who cares about cells," and "it doesn't matter if these kids are trying to survive." Being someone who "survived" low income, family dysfunction etc., it perturbs me to hear that it doesn't matter. In a knowledge-based economy production has evolved so that you don't need to know math but rather algorithms, code, sequences, and basic stats. We are done with the period of only manufacturers and laymen; if you look at the occupational outlook handbook, the most job growth is occurring in STEM field. College and career readiness goals should orient around the sciences.

My own recollection as a student in science or in education in general was always more clear as it related to puzzling phenomenon anchored in culturally relevant practice that activated my knowledge in untraditional ways. The units that I still remember in detail are events such as the egg drop, bridge-building from popsicle sticks, and edible assignments. These units also shared another common thread: community and collaboration. As I work with this population that is not at grade level, struggles with literacy and independent assignments, it is important to me to implement strategies that interest my students and make science relevant to them now because it will be relevant later. In this case they will make a quilt which in many communities, specially within the demographic I teach, is representative of community, family and a shared history of struggle and strength.

School/Student Demographics

Cochrane Collegiate Academy was founded in 1963 and has long identified as a neighborhood school. This historical and demographic composition of the school contributes heavily to the pedagogy used in the curriculum unit. Most of the students walk to school, their siblings attend the school and in many cases, the parents attended the school. Despite such a long history and legacy of Cochrane Colts, a rift exists between school pride and neighborhood pride. Many students and parents often say they wish the school were shut down.

The school has shifted and gone through several iterations since its establishment. Once a junior high, traditional school, full magnet school, it now houses a magnet high school program for 9-12 known as IMeck, as well as Cochrane Middle School, a 6-8 middle school program, which together comprise Cochrane Collegiate Academy. Data at the school is also a point of contention. The NC School Report Cards show a long and tenuous journey for Cochrane's status.[1] As far back as the 2001-02 school year, schools have been categorized by six distinctions: honor school of excellence, school of excellence, school of distinction, school of progress, no recognition, priority school, and low-performing. In 2001-02 Cochrane was ranked as a priority school that did not achieve growth. In 2007-08 the school was downgraded to the lowest status of low-performing, but in 2009-10 it revived as a school of progress and high growth. In the NC School Report Card one can also observe a high turnover of principals, so perhaps it could be attributed to leadership or just a community revival. Recently the six levels of distinctions have changed to A-F, and Cochrane has received a D. The teacher makeup according to the past year's NC School Report Card is 60% beginning teachers, meaning teachers are in the first 3 years of their practice. Turnover rate among teachers is also higher than the district average at 24% in comparison to the district's 18%. Several teachers and staff attended Cochrane at one point but the majority of the 58 teachers this 2017-18 school year are new to the school.

In addition to school history and past data, the economic and racial demographics are also important in setting the stage for the pedagogical reasoning behind this CU. Cochrane in 2006-07 received Title I status. Title I status is a federal designation by the government that provides financial assistance to state educational agencies, local educational agencies, and public schools with high numbers or percentages of children suffering from poverty. Financial funding is to help ensure that all children meet challenging state academic content and student academic achievement standards. Examples include free lunch regardless of income, positive behavior intervention support, community engagement initiatives, and strengthening the curriculum. Although Cochrane is constantly evolving at the administrative, staff, and teacher level, the students remain the neighborhood kids whose families have never left. But of course, Charlotte is a transient city, and immigration has affected the demographics as well. The demographics of Cochrane have altered racially in the past decade. It was once a predominately African American school with the highest recorded percentage at 98.6% black. Currently, the racial demographics have shifted to approximately 51% African American, 48% Hispanics, and 1% other.

Of the 200 students that I teach, 17 are on an Individualized Education Plan (IEP), and 5 are on Section 504. Despite this significantly small number of IEPs and 504s, it does not negate the data that puts the majority of students not on grade level. Reading EOG proficiency places students at a 35%, Math EOG proficiency at 23%, and Science EOG proficiency at 49%. Data for the current Science 7 class is unavailable because students in Science 6 were not required to take the NC Science Final Exam by virtue of participating in a hybrid science/social studies program.

Unit Goals

- Facilitate learning and activate knowledge utilizing nontraditional resources
- Implement a culturally relevant and community-driven science project
- Develop an interdisciplinary science and art curriculum unit
- Engage students in multiple rounds of creating and revising scientific models
- Student-driven sense-making through the design of original science visualizations

Objectives

During this unit students will be able to:

- Evaluate scientific images and identify forms of various objects
- Design scientific images and diagrams to communicate scientific knowledge
- Use visual thinking to dissect scientific images and diagrams and interpret visual data
- Draw conclusions based on the data and communicate them within the science classroom

Students will be introduced to the form and function of calls through diagrams, readings, vocabulary, model making, and hands-on exercises that will allow them to engage with the cell in a multitude of ways. Students will learn to identify and then create models of the cell organelles. Models will be created with a multitude of purposes, including but not limited to: basic form, exact replication and scale, and modeling significance or function through form and creative science communication.

Content

North Carolina Essential Science Standards

The following North Carolina Essential Science Standards will be addressed in the unit:

- Understand the processes, structures and functions of living organisms that enable them to survive, reproduce, and carry out the basic functions of life.
- Compare the structures and functions of plant and animal cells, including major organelles

The ultimate goal of this unit is to aid in the production of associative experiences in the science classroom to allow students to pass this standard on the North Carolina Final Exam. The cells questions on the seventh grade NCFE are typically visual. This means that students will need to understand the function of cell organelles and their overall importance to life as well as be visually literate and able to identify organelles. Students will understand that cells are the building blocks of living organisms by creating multiple iterations of a cell, culminating in a form, quilting, that ultimately determines if they have mastered the subject matter by requiring students to manipulate the individual parts of the cell. Cells contain organelles that each serve a function and differ in form. Students will understand that the organelles working together is important to the overall functioning of the cell and that cells working together are essential to the overall form and function of the organism. Students must understand that any defect or absence will result in damage or abnormalities in the cells because they are interdependent (See Appendix 1).

Although the cells have a number of parts, the North Carolina Essential Science Standards only requires students to focus on the following organelles

- cell membrane
- cell wall
- chloroplast
- cytoplasm
- mitochondria
- vacuole
- ribosome

For the purposes of this curriculum unit the following organelles will be the primary focus in the learning process and for the final product, the quilt (See Appendix 1).

General Teaching Strategies

Ambitious Science Teaching is a fourfold process that aims to encourages students of various backgrounds and levels to be intellectually engaged while maintaining an attention to equity. The first step in the planning process, which grounds content in the interesting and puzzling phenomenon, is to set the framework for teaching. The phenomenon that this curriculum unit is engaged in is that cells are not only the building blocks of life but organelles and cells are pieces in the fabric of life. The second step is to elicit student ideas. Quilt making allows the process of learning the functions and associated organelles in a tactile manner. The product allows students to reproduce their learning in a model with a clearly defined purpose and to model the interaction of cells to create a “living thing.” It is closely related to the “how”: “How would cells change if you removed this piece,” “How does this organelle function,” and “How are cells important to the overall composition of the body.” The third step is supporting ongoing changes in thinking and the fourth step is pressing for evidenced-based explanations. These two steps are closely related. Because if you provide the proper experiences and priming models or probes, student thinking will change and shift so that they can substantiate their explanations with those experiences. Ambitious science teaching, in addition to its commitment to some certain processes to facilitate learning, uses essential strategies:

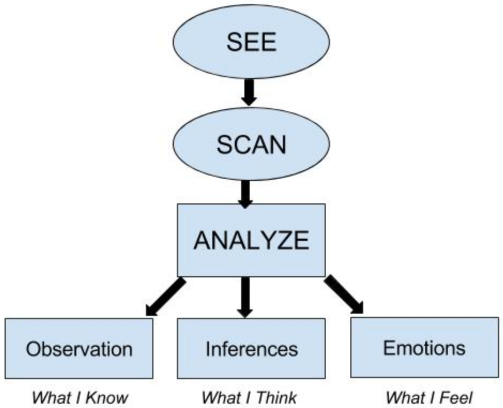
- Teachers anchoring their instruction in complex and puzzling natural events
- Students engaging in multiple rounds of creating and revising scientific models, explanations, and evidence-based arguments
- Students prompting each other to engage in sense-making talk during investigations and other activities
- Students’ ideas being represented publicly and worked on by the class
- Students speaking up about what information or experiences they need to move their thinking forward [2]

Multiple rounds and ideas being represented publicly are the two most valuable strategies in my unit. Although the project is typical in the use of normative practices of model making such as clay cell models and plate cell models, ambitious cell teaching is using the quilt as a nontraditional and yet culturally relevant way of anchoring their learning.

Another framework for this unit comes from “Teaching as Science for Social Justice” by Angela Calabrese Barton. She positions science as a responsive subject, meaning adaptable and accommodating of the student experience, especially for students in urban poverty because "everyone is always doing science". Thus, as science educators we must rethink what we define as scientific and consider what our students see as scientific. Cultivating “scientific thought” can be just as important as teaching “science.”[3] Her book recounts tales and experiences as she teaches science in after-school programs and in the classroom. It is from her that I derive the strategy “activating science knowledge using nontraditional resources.”[4]

In Developing Visual Literacy in Science K-8, “good observers of visual images follow the same steps as fluent readers do,” those steps being the see-scan-analyze thinking process.[5] When reading images, the brain almost without effort records the information, and then analyzes it, sorting it into one or more of the three categories: I know, I think, or I feel. The teacher’s task is having students slow down and process the content. When the common misconception is that students are just seeing, teachers must enhance their metacognition and overall ability to communicate and think critically about the content.

Fig 1.



The Problem with Teaching Visual Literacy in Middle School Science

In "Visual Literacy in Biology: A Comparison of Visual Representations in Textbooks and Journal Articles," Brian Rybarczyk observes: "Scientists use scientific visualization as a conduit to communicate knowledge and discovery generated from experimental research, exposing what is unseen in the natural world via external representation."[6] So much of the connections we make are based on sight and other sensory inputs but much of science is unseen. This leads to the question: how do teachers teach a visual language with a limited sensory background to make a connection with the unseen?

Science also posits seeing the discipline as an evident and objective process by which empirical knowledge derives, although seeing as a process is anything but neutral and a highly subjective experience. In James Elkin's "The Object Stares Back," he observes "we imagine that seeing is entirely objective" and that what we see is "soaked with our unspoken and unthought desires."[7] What we see is entirely dependent on the relationship we have with the world and what we have seen and defines what we fill in as we see and what we do not see. The problem notion is that in science the creation of many diagrams often alludes to the presupposed knowledge. The creator assumes the reader has knowledge bases it can derive and fill in. Arthur Miller in "Insights of Genius: Imagery and Creativity in Science and Art" asserts from early times scientists like Galileo and Aristotle communicated through visuals via a process of intuition and common sense and that in anchoring their theories in the senses "visual imagery abstracted from the world of sense perception."[8] According to Miller, intuition is the central issue in science visualizations.

Intuition looks different for different people: "students come to science class with this repertoire of multiple normative and non- normative ideas that have emerged from their experiences" and it is the teacher's job to help them use evidence-based approaches to refine their experiences.[9] Kali and Linn in "Designing Effective Visualizations for Elementary School Science" conclude: "To help students integrate their repertoire of ideas, successful science instruction should (a) add powerful, durable, and generative examples to their repertoire of ideas, and (b) enable students to grapple with their full repertoire of ideas to form a more coherent perspective on the scientific domain."[10] This occurs by making thinking visible, which happens by making students a part of the design process and decision-making in the visualization of science.[11] The shift needs to happen from making students consumers of diagrams to designers of them. If students participate, they cultivate and inform what they see.

Sandy Wiedmeyer describes her process of activating student knowledge about cells as follows:

> I always begin my instruction of cells by having students examine the various parts of each cell and their functions. There are many new terms and unfamiliar words to explain when introducing organelles to students. I encourage students to use word associations, or mnemonic devices when trying to remember and understand new terms. One effective strategy is the creation of an association chart.[12]

The life sciences typically begin the conversation about cells just as she describes, instructing students about cell organelles and functions using mnemonic devices and flash cards, then ultimately with a model based on a diagram of the cell. Finally, students are asked to point out the differences between an animal and plant cell. Too often textbooks provide oversimplified diagrams in varying iterations. The imagery of cells occurs in several iterations. There are inconsistencies in diagrams and organelles do not always look the same because the organelles may vary in size and the color is not always the same. Making a model based on a diagram doesn't necessarily make students aware of the design process so much as reproduce it. True design requires decision-making.

Lesson Plans

Day 1-3 Primers and Performance Task

Day	Activity	Materials	Comments
Day 1	Day 1 cells primer response journal to introduce students to familiar images and prime them for probing Keely Life Science Probe: Atoms and cells. Students categorize objects by statements about atoms and cells to deepen their understanding that living things cells are the basic function of life. Cell snapshot worksheet (See Appendix 3) Facilitate a PowerPoint on the introduction to cells Display a picture of a plant cell and/or animal cell and ask students to make a cell. Use modeling clay or plasticine so you don't have to store it to not dry out.	Day 1 Cells Primer Keely- Life Science Probes Vol 1. Pg. 40-43 Cell Snap shot worksheet Create a basic Intro to cells PPT Modeling Clay	This first day is all about teaching students to see, scan, and analyze. The focus should not be on specific function but rather basic function and form. Cells are the building blocks of living things. Essential Questions include: How do non-living and living things differ? And what are cells? Cell snapshot worksheet: Students will view a cell with no prior teaching to activate and discern prior knowledge and what students think they know. Also access comfortability with diagrams.
Day 2	Hook: Cells Cells Rap- https://youtu.be/-zafJKbMPA8 Developing Visual Literacy in Science K-8 pg. 9 Activity Plant and Animal Cells Vocabulary using Quizlet and graphic organizer (see Appendix 2).	Projector and audio hookup Developing Visual Literacy in Science K-8 One-to one classroom.	Introduces and cultivates students. (Can incentivize participation for non-interested class) For the Developing Visual Literacy Activity per the lesson advice give the following instructions: Read the information in Figure 1.3. As you are reading, you should be thinking about how you are taking in the information, mentally organizing it, and making meaning from it. Then

			answer the questions at the end of the figure." (Vasquez, Comer and Troutman 2010: 4). The purpose is to get students thinking about how they are taking in the visual information. This is a "you do activity:" students should have the opportunity to simply write and reproduce at this point.
Day 3	What's going on in this image activity? Cells flipbook	A picture of Faith Ringold's Tar Beach Part 1 with guided questions (See Appendix 3) Plant and Animal Cells Vocabulary using Quizlet and graphic organizer (see Appendix 2).	A spin on the *NY Times* activity that introduces and walks students through the See-scan-analyze process. Priming students to see Students will use their definition sheet from the day prior to create a flipbook as a reference tool. It is important to create a separate more interactive tool to reinforce the content.

Day 4-6 Reading and Modeling

Day	Activity	Materials	Comments
Day 4	Hook: What's going on in this image? Storytime: Tar Beach What is an adaptation? Open discussion My family is like a Cell	A picture of Faith Ringgold's *Tar Beach* Part 1 with guided questions (See Appendix 3) Ringgold, Faith. 2009. *Tar Beach*. Paw Prints. Document Camera Paper	Show students the image again and ask them to describe what is going on in the image. Move to SCAN portion of see-scan-analyze (See Appendix 3) Read the adaptation of Faith Ringgold's *Tar Beach* and pause at images. How teachers facilitate this discussion is dependent on the class but the overall purpose is to come to the conclusion that adaptation is a related communication on a specific subject. Explain to students in the book Ms. Ringgold's family all serve a function. Relate your own family to specific functions of a cell and explain why. For example, My mother is like the nucleus because she is the brain and controls my family. Or my little brother is like the mitochondria because he creates a lot of energy.
Day 5	Film screening "The Quiltmakers of Gee's Bend"	DVD of *The Quiltmakers of Gee's Bend*	Teacher will show the film to communicate the importance of quilt making and its legacy, as well as introduce students to elements of design
Day 6	Stitching tutorial	Fabric Squares Needles Fabric Shears Recording of teacher doing a basic running stitch	Afterwards students will complete a basic tutorial on the running stitch and back stitch. Although small groups would work well, a recording scaffolds learning for struggling students.

Day 7-10

Students will be released to adapt their models of the cell into a square. They will not be given many instructions other than to recreate a model of the animal cell and include the essential parts in your flipbook. Consider things like scale, color, and contrast to make your cell pop. If students need assistance with sewing, follow along with the video or ask the teacher for assistance.

Post lesson

Teacher will sew together the cells using a sewing machine and present the final product to students. Students will utilize their own product to analyze how well they communicated scientific knowledge. First take them through a similar see and scan process like students underwent when examining the *Tar Beach* (See Appendix 3)

Resources

1. List of Materials Needed

    Construction Paper
    Modeling Clay
    Needle and thread
    Donated Clothing Items
    Fabric Shears
    Scissors
    Sewing machine

2. Resources for Students
    a. Running Stitch, https://youtu.be/W4nhj8kMpAI, is an easy to follow tutorial on the basic running stitch that students can follow as they begin to stitch their cell squares.
    b. Back stitch, https://youtu.be/rZ_wVC84UmM is for more advanced students once they have mastered the running stitch.
    c. Quizlet Plant and Animal Cell Vocabulary, https://quizlet.com/160701979/flashcards. This website allows students to complete the 7.L.1.2 Plant and Animal Cells Vocabulary Handout. It also serves as an online mastery tool when students utilize the various gaming features.

3. Resources for Teachers
    a. Keely- Life Science Probes Vol 1. Pg. 40-43, is a traditional way of probing students and accessing prior knowledge and misconceptions about living and non living things. It requires students to explain their reasoning and think about why they come to their conclusions.
    b. Developing Visual Literacy in Science K-8 is an all around good resource for understanding visual literacy in science and how it can be cultivated in students. It also provides activities relevant to this unit.
    c. Cells Cells Rap, https://youtu.be/-zafJKbMPA8. This resource aids teachers in hooking the students on cells, but provides a lot of rich information on the individual organelles. Students should be encouraged to sing the song with the video.
    d. Ringgold, Faith. 2009. *Tar Beach*. Paw Prints. It is a relatable work that the students can see themselves, but that also gets them thinking about the process of quilting. It can be used to spark conversations, but more importantly as an adaptation of an original work it is an example of modifying images to communicate more effectively and creatively.

Appendix 1

NC Essential Standard: Plant and Animal Cells

- 7.L.1 Understand the processes, structures and functions of living organisms that enable them to survive, reproduce, and carry out the basic functions of life.

Clarifying Objectives:

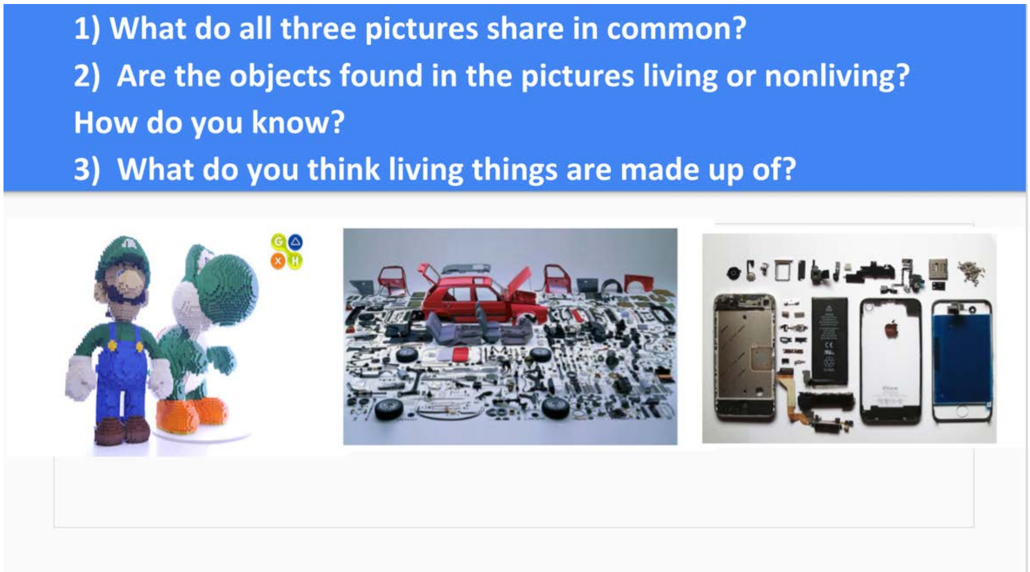
- 7.L.1.2 Compare the structures and functions of plant and animal cells, including major organelles (cell membrane, cell wall, nucleus, chloroplasts, mitochondria, and vacuoles).

Unpacking: What does this standard mean a student will know and be able to do?

- Students will be able to identify organelles and describe their functions
- Students will be able to understand and explain why cells are the building blocks of life
- Students will be able to recreate cell diagrams[13]

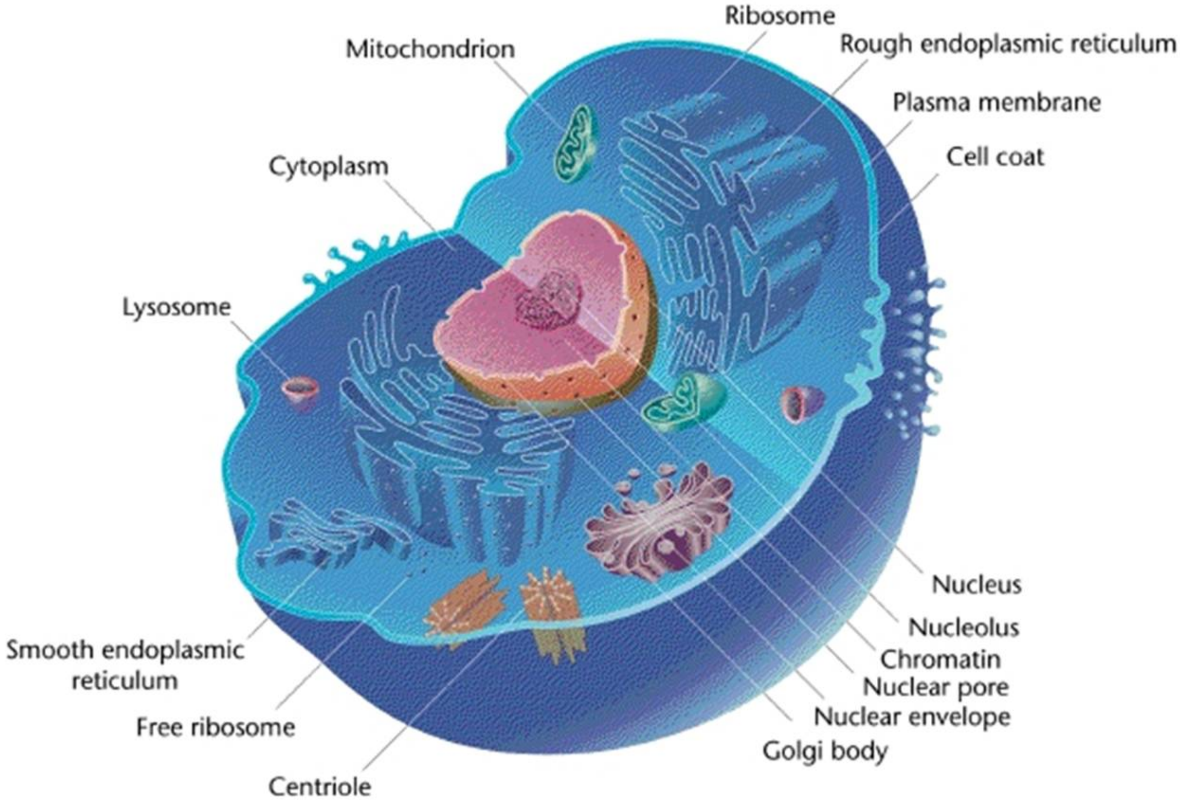
Appendix 2. Class Handouts

Day 1 Cells Primer



Name:___________________________________ Date:__________Block:________

Cell SnapShot



What do you see in this image?

What do you think is going on in this image?

Describe what this image without using any of the labels.

How is the cell constructed?

Can you draw any conclusions about the cell? Explain why or why not.

Name:__________________________________ Date:__________Block:________

7.L.1.2 Plant and Animal Cells Vocabulary

Go to https://quizlet.com/160701979/flashcards and look for "Plant and Animal Cell Quizlet" and click the link and then complete this chart using the quizlet set!

Vocabulary Word	Definition	Picture

Appendix 3. See Scan Analyze Image

Ask students the following guided questions for the images:

Figure 1. Faith Ringold. Tar Beach (Part I from the Woman on a Bridge series), 1988.

SEE

1. What do you observe?
2. What can you infer?
3. How does this image make you feel?
4. How can you relate this image to your own experience? Use anecdotal evidence.

Allow students to relate silently to these images and record their responses on paper before they share. Make sure that students understand the difference between an observation and an inference. Prior to releasing students to read the image the teacher should go over the questions. Introductory questions could be, “Today we are going to learn how to read images. We are going to ask ourselves four questions. Firstly ‘what can I observe’ and secondly ‘what can I infer.’ Can someone tell me the difference between an observation and an inference?” Possible student answers include silence or “something that you know,” which the teacher would dispel by asking students’ how they know. The important part is that an observation is what you see and an inference is an educated guess based on what you see your observation.

SCAN

Ask students what is going on in the image and how they know. Together create a list of things that are going on. Ask students the following questions after creating the list: Where are your eyes drawn? What is the purpose of this quilt? What is the artist trying to tell us? How does the artist create interest?

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Notes

[1] http://www.ncreportcards.org/src/main.jsp

[2] https://ambitiousscienceteaching.org/eliciting-students-ideas-2/

[3] Calabrese Barton, Angela. 2003. Teaching Science for Social Justice. The Teaching for Social Justice Series. New York: Teachers College Press, 12.

[4] Calabrese Barton, 2003. 9.

[5] Vasquez, Jo Anne, Michael W Comer, Frankie Troutman, and National Science Teachers Association. 2010. *Developing Visual Literacy in Science, K-8*. Arlington, VA: NSTA Press, National Science Teachers Association, 4.

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[9] Kali, Yael, and Marcia C Linn. 2008. "Designing Effective Visualizations for Elementary School Science." Elementary School Journal 109 (2): 183.

[10] Kali and Linn, 2008. 183.

[11] Kali and Linn, 2008. 185.

[12] Wiedmeyer, Sandy. 2003. "Simply Cells." Science Scope 26 (7): 44.

[13] http://www.dpi.state.nc.us/docs/curriculum/science/scos/support-tools/unpacking/science/7.pdf