ORGANELLE EXTRAVAGANZA: A PORTABLE SCIENCE SUITCASE FOR

HIGH SCHOOL BIOLOGY STUDENTS

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DEDICATION

I would like to thank the members of my Graduate Committee: Lewis Calver, Kim Krumwiede, and Joel Goodman for all of their help and guidance. Amy Rommel, thank you so much for your help and expertise in designing the laboratory experiments. Thank you to the Howard Hughes Medical Institute for funding this project. I would also like to thank Paul Vinson and Jorge Escobar at the Museum of Nature and Science for your help printing and fabricating the game components. Thank you to Laurie Mueller for all of your help gathering electron micrographs for the animation. I would also like to thank Rene McCormick and Steve Hinkley for their help and expertise in designing age appropriate materials. Thank you to Kristie Conner, Jeannie Song, and the STARS program for all of your help. Thank you to Bruce DuBose for recording the narration for the animation.

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ORGANELLE EXTRAVAGANZA: A PORTABLE SCIENCE SUITCASE FOR HIGH SCHOOL BIOLOGY STUDENTS

by

JENNIFER LEIGH HULSEY

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ORGANELLE EXTRAVAGANZA: A PORTABLE SCIENCE SUITCASE FOR HIGH SCHOOL BIOLOGY STUDENTS

JENNIFER LEIGH HULSEY, M.A.

The University of Texas Southwestern Medical Center at Dallas, 2008

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The goal of this thesis project was to create a portable Science Suitcase on organelles designed to supplement the current high school biology curriculum in the Dallas Independent School District. The Science Suitcase includes a narrated animation, three laboratory experiments, and an interactive game that can be borrowed by teachers and brought into their classrooms. The Science Suitcase will help enhance students' interest in science, bridge the gap between ninth grade biology and Advanced Placement biology, and help students meet the state of Texas science education requirements based on the National Science Education Standards.

TABLE OF CONTENTS

ABSTRACT v

LIST OF FIGURES x

LIST OF APPENDICES xiii

LIST OF DEFINITIONS xiv

CHAPTER 1- INTRODUCTION 1

GOALS AND OBJECTIVES 1

BACKGROUND INFORMATION 2

SIGNIFICANCE 3

LIMITATIONS 5

CHAPTER 2- REVIEW OF THE LITERATURE 6

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS (TEKS) 6

CURRENT TEACHING METHODS AND MATERIALS 8

TEXTBOOKS 8

PRELIMINARY SURVEY 10

LEARNING STYLES 11

ANIMATION 13

PROTEIN PRODUCTION GAME 18

LABORATORY EXPERIMENTS 20

REVIEW OF AVAILABLE RESOURCES 22

ANIMATION 22

PROTEIN PRODUCTION GAME 22

LABORATORY EXPERIMENTS 23

CONCLUSION 24
CHAPTER 3- METHODOLOGY 25
CONCEPT DEVELOPMENT 25
TARGET AUDIENCE 26
PRE-PROJECT PLANNING 26
MEETINGS 26
PRELIMINARY SURVEY 29
CHOOSING ELEMENTS TO INCLUDE IN THE SCIENCE SUITCASE 32
ANIMATION 32
SCRIPT 33
STORYBOARD 34
RECORDING THE SCRIPT 35
DESIGNING THE CARTOON CHARACTERS 36
BUILDING THE 3D MODELS 42
FINDING THE ELECTRON MICROGRAPHS (EMS) 45
ANIMATING THE CARTOON 47
ANIMATING THE 3D MODELS 49
QUESTIONS 50
COMPOSITING THE ANIMATION 51
PROTEIN PRODUCTION GAME 57
TESTING THE GAME 58
CHANGES MADE TO THE GAME 59
GAME MATERIALS 60

NAME TAGS 65
LABORATORY EXPERIMENTS 68
TESTING THE LABORATORY EXPERIMENTS 69
FEEDING PARAMECIA LABORATORY 69
ANIMAL AND PLANT CELL LABORATORY 72
PAPER CHORMATOGRAPHY LABORATORY 75
ORDERING SUPPLIES 76
TEACHER'S MANUAL AND STUDENT HANDOUTS BOOKLET 77
PRE-TEST AND POST-TEST 80
THE SUITCASES AND CONTAINERS 81
CHOOSING THE SUITCASE 81
CHOOSING THE CONTAINERS 82
LABELING THE CONTAINERS 82
PHOTOGRAPHING THE CONTAINERS 83
FITTING THE CONTAINERS INSIDE THE SUITCASES 85
PHOTOGRAPHING THE SUITCASES 88
SUITCASE LABELS 89
CONCLUSION 90
CHAPTER 4- RESULTS 91
SURVEY DEVELOPEMENT 91
SURVEY DISTRIBUTION 92
SURVEY RESULTS 92
LIST OF STATEMENTS 94

EVALUATION OF RESPONSES 96
ADDITIONAL QUESTIONS 104
CONCLUSION 107
CHAPTER 5- CONCLUSIONS AND RECOMMENDATIONS 109
PROJECT SUMMARY 109
DISCUSSION 110
SUGGESTIONS FOR FURTHER RESEARCH 111
BIBLIOGRAPHY 539

LIST OF FIGURES

FIGURE 3-1. STORYBOARDS 34

FIGURE 3-2. STORYBOARD 35

FIGURE 3-3. MICROSOFT® EXCEL SPREADSHEET: CARTOON CHARACTERS 37

FIGURE 3-4. CARTOON LAYERS IN ADOBE® ILLUSTRATOR 39

FIGURE 3-5. CARTOONS AND BACKGROUNDS IN ADOBE® ILLUSTRATOR . 40

FIGURE 3-6. CARTOONS AND BACKGROUNDS IN ADOBE® ILLUSTRATOR . 41

FIGURE 3-7. CARTOON LAYERS PREPARED TO ANIMATE..... 42

FIGURE 3-8. MICROSOFT® EXCEL SPREADSHEET: 3D MODELS 43

FIGURE 3-9. NUCLEUS MODEL SCREENSHOT IN 3D STUDIO MAX®..... 44

FIGURE 3-10. 3D MODELS OF AN ANIMAL CELL AND A PLANT CELL 44

FIGURE 3-11. MICROSOFT ® EXCEL SPREADSHEET: ELECTRON MICROGRAPHS 45

FIGURE 3-12. ELECTRON MICROGRAPH..... 46

FIGURE 3-13. ELECTRON MICROGRAPH WITH LAYER MASK..... 46

FIGURE 3-14. ELECTRON MICROGRAPH WITH SOLID COLOR FILL (LEFT) AND WITH THE BLENDING MODE SET TO MULTIPY (RIGHT) 47

FIGURE 3-15. NEW COMPOSITION SETTINGS IN ADOBE® AFTER EFFECTS.. 47

FIGURE 3-16. IMPORT FOOTAGE SETTINGS IN ADOBE® AFTER EFFECTS..... 48

FIGURE 3-17. COMPOSITION IN ADOBE® AFTER EFFECTS 48

FIGURE 3-18. ANIMATION BACKGROUNDS 49

FIGURE 3-19. 3D STUDIO MAX® EXPORT SETTINGS 50
FIGURE 3-20. COORDINATED VISUALS FOR INDIVIDUAL ORGANELLES 52
FIGURE 3-21. COORDINATED VISUALS FOR INDIVIDUAL ORGANELLES 53
FIGURE 3-22. COORDINATED VISUALS FOR INDIVIDUAL ORGANELLES 54
FIGURE 3-23. COORDINATED VISUALS FOR INDIVIDUAL ORGANELLES 55
FIGURE 3-24. NUCLEUS COMPOSITION IN ADOBE® AFTER EFFECTS 56
FIGURE 3-25. FULL ANIMATION COMPOSITION IN ADOBE® AFTER EFFECTS 56
FIGURE 3-26. QUICKTIME EXPORT SETTINGS IN ADOBE® AFTER EFFECTS 57
FIGURE 3-27. PROTEIN PRODUCTION GAME SUPPLIES PRACTICE ROUND... 61
FIGURE 3-28. MRNA INSTRUCTIONS 62
FIGURE 3-29. LABELED ORIGAMI SHEET 63
FIGURE 3-30. ENDOPLASMIC RETICULUM CHECK SHEET 64
FIGURE 3-31. CELL PLACEMENT CHART 65
FIGURE 3-32. NAME TAG FILE 66
FIGURE 3-33. PIZZA FILES 66
FIGURE 3-34. FINISHED PIZZA SLICES 67
FIGURE 3-35. FINISHED NAME TAGS 68
FIGURE 3-36. PARAMECIA CAUDATUM LIVE CULTURE 69
FIGURE 3-37. PARAMECIA CAUDATUM 70
FIGURE 3-38. PARAMECIA CAUDATUM FEEDING ON YEAST STAINED WITH CONGO RED INDICATOR 71
FIGURE 3-39. ONIONS, SCORING, AND PEELING MEMBRANE 72

FIGURE 3-40. ONION SKIN SLIDES 73
FIGURE 3-41. ONION SKIN STAINED WITH IODINE 73
FIGURE 3-42. CHEEK CELL SLIDES 74
FIGURE 3-43. CHEEK CELLS STAINED WITH METHYLENE BLUE 74
FIGURE 3-44. CHROMATOGRAM 75
FIGURE 3-45. CHROMATOGRAPHY TUBES 77
FIGURE 3-46. LAYOUT TEMPLATE 78
FIGURE 3-47. TEACHER'S MANUAL AND STUDENT HANDOUTS BOOKLET . 80
FIGURE 3-48. PRE-TEST AND POST-TEST TEACHER'S MANUAL AND STUDENT HANDOUTS 81
FIGURE 3-49. LABELS 83
FIGURE 3-50. SUPPLIES PAGE 84
FIGURE 3-51. CLEAN UP 85
FIGURE 3-52. PLACEMENT TRIAL OF LABORTORY CONTAINERS 86
FIGURE 3-53. SUITCASE WITH LABORATORY SUPPLIES 87
FIGURE 3-54. SUITCASE WITH GAME MATERIALS, TEACHER'S MANUAL, STUDENT HANDOUTS BOOKLET, AND DVD 88
FIGURE 3-55. HOW TO: ACCESS HANDLE, LOAD THE SUITCASE, AND TRANSPORT THE SUITCASE 89
FIGURE 3-56. SUITCASE LABELS 90
FIGURE 4-1. SUMMARY OF SURVEY RESULTS 94

LIST OF APPENDICES

APPENDIX A: PRELIMINARY SURVEYS 112

APPENDIX B: PRELIMINARY SURVEY RESPONSES 114

APPENDIX C: ANIMATION SCRIPT 125

APPENDIX D: STORYBOARDS 132

APPENDIX E: PERMISSION TO USE ELECTRON MICROGRAPHS 213

APPENDIX F: VARIOUS LABORATORY PROTOCOLS 230

APPENDIX G: TEACHER'S MANUAL 237

APPENDIX H: STUDENT HANDOUTS BOOKLET 364

APPENDIX I: EVALUATION SURVEY 425

1APPENDIX J: EVALUATION SURVEY RESPONSES 431

LIST OF DEFINITIONS

3D Studio Max- a modeling, animation and rendering package developed by Autodesk Media and Entertainment

Adobe® After Effects- a digital motion graphics and compositing software published by Adobe Systems. Its main purpose is for film and video post-production.

Adobe® Encore- a DVD authoring software tool produced by Adobe Systems.

Adobe® Illustrator- a vector-based drawing program developed and marketed by Adobe Systems.

Adobe® Photoshop- is a graphics editing program developed and published by Adobe Systems.

Adobe® Premiere- a real-time, timeline based video editing software application published by Adobe Systems.

Microsoft® Excel- a proprietary spreadsheet-application written and distributed by Microsoft.

Microsoft® Powerpoint- a presentation program developed by Microsoft.

Portable Document Format (PDF)- a file format created by Adobe Systems for document exchange.

Quicktime- a multimedia framework developed by Apple Inc. capable of handling various formats of digital video, media clips, sound, text, animation, music, and interactive panoramic images.

CHAPTER ONE
Introduction

Goals and Objectives

The goal of this thesis project was to create a portable Science Suitcase on organelles designed to supplement the current high school biology curriculum in the Dallas Independent School District. The Science Suitcase includes a narrated animation, three laboratory experiments, and an interactive game that can be borrowed by teachers and brought into their classrooms. The Science Suitcase will help enhance students' interest in science, bridge the gap between ninth grade biology and Advanced Placement biology, and help students meet the state of Texas science education requirements based on the National Science Education Standards.

To achieve this goal, several objectives had to be met. The first objective was to develop a survey to discover how teachers in the Dallas Independent School District (DISD) are currently teaching the topic of organelles, the problems their students are having with this topic, and what resources they have available to them. The next objective was to research the most effective methods of teaching science to high school students and examine the requirements of the Texas Essential Knowledge and Skills (TEKS) for the topic. The information gathered from the surveys and research was then used to develop an effective program that covered several different learning styles and many of the objectives set out by the TEKS. Once the components for the program were decided, the

next objective was to create each of the individual components which included a narrated animation covering the structure and function of organelles found in both plant and animal cells; three laboratory experiments exploring specific organelles; an interactive game in which the students perform the tasks of specific organelles in order to produce a protein; a pre-test and post-test; teacher's manual; and student handout booklet. The final objective was to incorporate all of these components into a portable Science Suitcase that was presented to DISD teachers and evaluated through a secondary survey. The results of this survey would determine whether the final product met the goals and objectives set forth for this project.

Background Information

The Howard Hughes Medical Institute has awarded a grant to the University of Texas Southwestern Medical Center, administered by the Science Teacher Access to Resources at Southwestern (STARS) office, in collaboration with the Museum of Nature and Science, the Dallas Independent School District, Advanced Placement Strategies, the UTSW Graduate Program in Biomedical Communications, and National Instruments to create a "STARS Science Triathlon." This program has been established in Dallas to provide training for biology teachers, enhance secondary school students' interest in science, and boost enthusiasm for science in the community. One of the main goals of this project is to encourage more ninth grade students to take AP biology in high school. Thirteen high schools in the DISD were targeted for this program, because they did not have effective AP biology courses. These schools also performed poorly on the Texas

Assessment of Knowledge and Skills exams. "Only 29.5% and 56.0% of students from these schools 'met standards' on the 10th and 11th grade Science exams respectfully, in 2006 and only 1% were scored 'commendable' on these exams."[1]

The Triathlon consists of three events spread out over a fifteen month period. These events include a twelve day summer workshop, a series of symposia throughout the year, and an eight week summer research program the following summer. Along with these events, Science Suitcases (portable laboratories with exhibits) and Virtual Instruments will be developed to enrich the teachers' resources. The Science Suitcases will be designed to supplement seven topics in the current high school biology curriculum on which students have continually scored poorly on the Texas Assessment of Knowledge and Skills Test. These topics include: Introduction to Chemistry, Biochemistry, Enzymes, Membranes, Organelles, Cell Respiration, and Photosynthesis.[2]

Significance

According to the results of a preliminary survey sent to High School Biology teachers in the DISD, their students have been found to have particular difficulty understanding the topic of organelles, specifically how an organelle's structure relates to its function. Currently there is no set curriculum for teaching this topic. Most teaching methods used

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[1] Goodman, Joel. 2007 Initiative for Biomedical Research Institutions. University of Texas Southwestern Medical Center at Dallas. 2007.
[2] Goodman, Joel. 2007 Initiative for Biomedical Research Institutions. University of Texas Southwestern Medical Center at Dallas. 2007.

to teach organelles included the use of static images in materials such as worksheets and Powerpoint® Presentations. These pose a problem for this particular topic because organelles are dynamic structures with specific functions, and these qualities are difficult to convey through static two-dimensional images. In the preliminary survey, one teacher stated that she had her honors biology students use analogies in which they compare a cell to a familiar structure such as a school or a factory. She found that this was an effective approach to teaching organelles, but could possibly be enhanced by presenting the analogy along with an animation with models of the organelles. In the survey responses, no teachers mentioned laboratory experiments for organelles, and there were very few experiments for organelles found in the textbooks used by the DISD. This is an area that needs to be improved upon since laboratory experiments provide a unique experience through direct interaction and active learning.

This Science Suitcase on organelles includes multiple approaches and activites. It includes an animation that demonstrates the dynamic structures of the organelles in a plant and animal cell as well as their individual functions and also uses an analogy in which a cell is compared to a factory. This analogy continues throughout the animation as each individual organelle is introduced to further the comparison. The animation also includes electron micrographs of each of the organelles. When students are presented with a 3-dimensional model of a cell, an analogy comparing a cell to something familiar like a factory, and actual organelle images integrated into an animation, they can get a better understanding of the organelles and how they work together. The suitcase also provides a game, which allows students to interact with each other and work together as

groups to act out the roles of each of the organelles and further emphasizes their functions. Finally, the materials and directions for laboratory experiments are provided in the suitcase to allow students to explore several organelles a little deeper. By having opportunities to directly interact with cells, such as their own cheek cells, students can see organelles at work in the world around them.

Limitations

This thesis project is limited to high school level information regarding organelles in plant and animal cells. This information is geared towards the current Texas Essential Knowledge and Skills and what teachers are currently teaching. Therefore, the information may become outdated and may not represent the most current information available on the topic. Another limitation was that only an informal formative evaluation could be conducted to see what teachers thought of the Science Suitcase due to the time constraints of a master's thesis project. A more formal evaluation will be performed after the Science Suitcase has been in circulation for several years.

CHAPTER TWO
Review of the Literature

The purpose of the literature review was to determine the requirements set forth by the Texas Essential Knowledge and Skills (TEKS) regarding organelles, to investigate current teaching methods and materials, and to research learning styles in order to develop an effective educational program.

Texas Essential Knowledge and Skills (TEKS)

The first step was to determine what high school biology students are required to know about organelles, as stated in The Texas Essential Knowledge and Skills (TEKS), a set of learning objectives mandated by the State Board of Education for students in the Texas public school system. "The Texas Essential Knowledge and Skills identify what Texas students should know and be able to do at every grade level and in every course in the required curriculum."[3] They also contain the knowledge and skills required for success on the Texas Assessment of Knowledge and Skills (TAKS) test.

The TEKS are divided into four categories including English language arts and reading, Mathematics, Science, and Social Studies. They can be found under Title 19, Part II of the Texas Administrative Code (TAC). Chapter 112 covers the Texas Essential

[3] "Texas Essential Knowledge and Skills (TEKS) Learning Standards for Texas Children: A Summary For Parents." Texas Education Agency. 26 Sept. 2008 <http://http://www.tea.state.tx.us/curriculum/learningstandards.pdf>.

Knowledge and Skills for Science. The TEKS for High School Biology can be found within subchapter C under 112.43.Biology. The TEKS that contain information applying to the topic of organelles states;

> (4) Scientific Concepts: The student knows that cells are the basic structures of all living things and have specialized cell parts that perform specific functions, and that viruses are different from cells and have different properties and functions. The student is expected to: (A) identify the parts of prokaryotic and eukaryotic cells; (B) investigate and identify cellular processes including homeostasis, permeability, energy production, transportation of molecules, disposal of wastes, function of cellular parts and synthesis of new molecules; (C) compare the structures of viruses to cells and describe the role of viruses in causing diseases and conditions such as acquired immune deficiency syndrome, common colds, smallpox, influenza, and wart; and (D) identify and describe the role of bacteria in maintaining health such as in digestion and in causing diseases such as in streptococcus infections and diphtheria.[4]

From these requirements, the science suitcase would concentrate on the parts and functions of eukaryotic cells including both plant and animal cells. Through the investigation of the organelles and cell parts of eukaryotic cells, the cellular processes of permeability, energy production, transportation of molecules, disposal of wastes, and synthesis of new molecules were also introduced.

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[4] "Chapter 112. Texas Essential Knowledge and Skills for Science Subchapter C. High School." Texas Education Agency. 4 Sept. 2008. 25 Sept. 2008 <http://www.tea.state.tx.us/rules/tac/chapter112/ch112c.html#112.43>.

The Texas Essential Knowledge and Skills also requires that "at least 40% of instructional time" is spent conducting "field and laboratory investigations."[5] To fill this requirement, three laboratory experiments were included, each of which further investigates organelles previously covered. Laboratory experience is extremely important at the high school level and hands on experiences help assure that students retain the critical knowledge and skills presented to them.[6]

Current Teaching Methods and Materials

After researching the information the Texas Essential Knowledge and Skills requires high school biology students to know on the topic of organelles, I needed to determine if there was a program similar to the science suitcase in existence. After a thorough literature review I determined that a program that combines multiple activities to aid in teaching the topic of organelles that are contained in a portable suitcase for use by high school biology students does not exist.

Textbooks

I then researched how organelles are being taught. I started by looking at common textbooks used by high schools in the Dallas Independent School District and across the

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[5] "Chapter 112. Texas Essential Knowledge and Skills for Science Subchapter C. High School." Texas Education Agency. 4 Sept. 2008. 25 Sept. 2008 <http://www.tea.state.tx.us/rules/tac/chapter112/ch112c.html#112.43>.

[6] "Laboratory and Field Experiences in Texas Schools." Aug. 2004. Oct. 2008 <http://www.tea.state.tx.us/curriculum/science/laboratory_experiences.pdf>.

country. Several textbooks were identified including Holt Biology[7], Prentice Hall Biology[8], and Glencoe Science Biology[9].

In the teacher's edition of Holt Biology, it suggested that students develop a chart listing the different organelles in a cell. The students should include the names and functions of each organelle and three structures that can be found in plant cells that are not in animal cells. It also suggests having each student choose one cell part or organelle and write a "what am I?" essay in which the student pretends to be the structure. And designing a poster about an organelle. Another activity included in Holt Biology involved having students identify and color organelles on electron micrographs of cells. Then asking students to name 3 organelles and to describe the job of those organelles within the cell. It also suggests having students make a model of a eukaryotic cell out of gelatin and other food products. A cheek cell and onion cell lab were included in this book as well.

The teacher's edition of Prentice Hall Biology suggests displaying a three-dimensional model of a cell and challenging students to name any structures they think they recognize in the cell. This activity encourages debate between the students. This book also suggests dividing the class into groups at the beginning of the organelles section and

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[7] Johnson, George B., and Peter H. Raven. Biology: Teacher Edition. Austin, Texas: Holt, Rinehart and Winston, 2004.

[8] Miller, Kenneth R., and Joseph Levine. Prentice Hall Biology: Teacher's Edition for Texas. Upper Saddle River, New Jersey: Pearson Prentice Hall, 2004.

[9] Biggs, Alton, Whitney C. Hagins, Chris Kapicka, Linda Lundgren, Peter Rillero, Kathleen G. Tallman, and Dinah Zike. Glencoe Science Biology: The Dynamics of Life Texas Teacher Wraparound Edition. New York, New York: The McGraw-Hill Companies Inc, 2004.

having them create a two-dimensional drawing of a cell before having read the chapter so they can discuss what the cell might contain. Then having them meet again after reading the chapter to create a second labeled drawing. Another activity encourages students to make copies of labeled illustrations from their textbook. And making a large class model of a cell.

Glencoe Biology suggests having the advanced students write a play about the process of creating a protein including the functions of each organelle in the process. It also includes a lab for studying plant and animal cells using frog skin, elodea, and bacteria. This book included a suggestion for using electron micrographs to study organelles as well, and suggested turning the classroom into a giant animal cell and having the students construct giant organelles.

Most of the activities mentioned in the textbooks involved two dimensional media such as charts and worksheets. Two of the books suggested creating a large cell in the classroom, but neither of them focused on the functions of the organelles. All of the labs provided for studying organelles involved studying plant and animal cells, and were very basic with very little detail. All of the activities suggested were available to the teachers, and I wanted to provide activities that they were not already using in their classrooms.

Preliminary Survey

From the preliminary survey distributed to approximately one hundred teachers in the DISD, I accessed the methods that the teachers were addressing the topic of organelles.

Several of the teachers mentioned using Powerpoint® presentations, videos, and worksheets where students could color and label organelles and write in their functions. Another teacher used "foldables" where students created booklets of paper of different lengths. One teacher had their students create 3-dimensional cell models using household items. And a second teacher had their students "sell a cell organelle" to their class. All of these activities were very similar to the activities listed in the textbooks. Most of these activities also involved two dimensional images of the organelles and required very little student interactivity.

Learning Styles

After determining that there are currently no other projects similar to this in existence, I researched learning styles to get a better idea of what types of activities to include in the science suitcase. Students learn in a variety of ways, and to accommodate these differences several different activities covering a wide range of learning styles must be implemented to reach the maximum number of students. Repetition of the information in different ways is also important to reinforce the key concepts. According to an article in the Center for Implementing Technology in Education, "learners are better able to grasp new pieces of information and discern patterns when they are presented with numerous effective examples."[10] By incorporating several different learning styles, all of the

[10] "Using Multimedia Tools to Help Students Learn Science." Center For Implementing Technology in Education. 26 Sept. 2007 <http://www.cited.org/index.aspx?page_id=148>.

students are comfortable some of the time, while being stretched to develop new learning abilities at other times.

There are many different learning styles including visual learning, auditory learning, tactile learning, and kinesthetic learning. In addition to these differences in learning styles, "left brain" dominance and "right brain" dominance can also play a role in student learning. Brain research has shown that "the two halves of the brain, right and left hemispheres process information differently."[11] In contrast, students with a dominant left hemisphere tend to learn better from verbal stimuli, structure, sequence, and analysis. They prefer to study the details and to work alone. While students with a dominant right hemisphere learn better visually with the use of manipulatives, and hands on activities. They prefer to study the whole picture and work in groups. Cooperation and competition can also be used to aid in student learning. "Many students also learn better when engaged in multisensory learning activities, e.g. combining tactile and kinesthetic, or visual and auditory."[12]

After the initial research into learning styles, I decided to include a narrated animation for the visual and auditory learners, as well as an interactive game and lab experiments for the kinesthetic and tactile learners. The animation also accommodates the differences in "right brain" and "left brain" learners by allowing them to watch the whole video or

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[11] Hassard, Jack, comp. Minds on Science Online. Georgia State University. 26 Sept. 2007 <http://scied.gsu.edu/hassard/mos/mos.html>.
[12] Hassard, Jack, comp. Minds on Science Online. Georgia State University. 26 Sept. 2007 <http://scied.gsu.edu/hassard/mos/mos.html>.

select the individual parts. Once the components of the suitcase were decided, I researched each of the components further to determine the best way to implement each of them.

Animation

It is important to engage the students and get them excited about the topic at hand. "A visual input such as an animation is a major factor in drawing attention to a topic, which in turn acts as a stimulus to transfer the content into working memory."[13] "We are currently teaching an electronic generation of students, individuals whose everyday life is primarily based on auditory and visual learning."[14] As a result students tend to prefer animations over reading from a textbook.

"Cell biology involves many dynamic processes that lend themselves to animation, and there is accumulating evidence that animations are more effective than static sequential images in the learning process."[15] Motion distinguishes animations from static images and captures the critical steps in biological processes. Two-dimensional animations however are not ideal for illustrating such dynamic structures and processes. "Because

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[13] McClean, Phillip, Christina Johnson, Roxanne Rogers, John Reber, Brian Slator, Jeff Terpstra, and Alan White. "Molecular and Cellular Biology Animations: Development and Impact on Student Learning." Cell Biology Education 4 (2005): 169-79.
[14] O'Day, Danton H. "The Value of Animations in Biology Teaching: A Study of Long-Term Memory Retention." Life Science Education 6 (2007): 217-23. CBE. 4 Oct. 2007.
[15] O'Day, Danton H. "Animated Cell Biology: A Quick and Easy Method for Making Effective, High-Quality Teaching Animations." CBE- Life Sciences Education 5 (2006): 255-63.

they are flat, important spatial relationships of the process are not captured."[16] I therefore decided that the animation needed to be three-dimensional and dynamic.

"It is well documented that narrated animations are more effective than those that lack narration. Furthermore, animations with concurrent verbal narration are more beneficial to the learner than visual narration"[17] In multimedia learning it is beneficial when the student receives information as words either spoken or printed text, and through pictures either in an animation or illustrations. "The promise of multimedia learning is that teachers can tap the power of visual and verbal forms of expression in the service of promoting student learning."[18] According to Paivio's dual channel assumption, humans possess separate information processing systems for verbal and visual information. In this model, animations are processed in the visual channel and the spoken word or narration is processed in the verbal channel.

> The active learning assumption is that meaningful learning occurs when learners engage in active cognitive processing include paying attention to relevant incoming words and pictures, mentally organizing them into coherent verbal and

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[16] McClean, Phillip, Christina Johnson, Roxanne Rogers, John Reber, Brian Slator, Jeff Terpstra, and Alan White. "Molecular and Cellular Biology Animations: Development and Impact on Student Learning." Cell Biology Education 4 (2005): 169-79.
[17] O'Day, Danton H. "Animated Cell Biology: A Quick and Easy Method for Making Effective, High-Quality Teaching Animations." CBE- Life Sciences Education 5 (2006): 255-63.
[18] Mayer, Richard E. "The Promise of Multimedia Learning: Using the Same Instructional Design Methods Across Different Media." Learning and Instruction 13 (2003): 125-39.

> pictorial representations, and mentally integrating verbal and pictorial representations with each other and with prior knowledge.[19]

I decided to incorporate this research into my animation by including verbal narration explaining the events throughout the animation.

The spatial contiguity effect states that "students learn more deeply from multimedia explanations when corresponding words and pictures are presented near to rather than far away from each other on the page or screen."[20] When the written words are presented near the corresponding pictures, the student is more likely to hold the information in their working memory at the same time. "This situation enables the process of integrating visual and verbal models, a key step in active learning."[21] Research has also found that the important terms within the animation should be included as "written text or labels adjacent to the event or structure under consideration, and include narration of the labels as they appear (to reinforce learning and how words/terms are said)."[22] It is helpful when "corresponding visual and auditory material are synchronized so learners do not have to recall the information presented in one form as information is presented in the second

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[19] Mayer, Richard E. "The Promise of Multimedia Learning: Using the Same Instructional Design Methods Across Different Media." Learning and Instruction 13 (2003): 125-39.
[20] Mayer, Richard E. "The Promise of Multimedia Learning: Using the Same Instructional Design Methods Across Different Media." Learning and Instruction 13 (2003): 125-39.
[21] Mayer, Richard E. "The Promise of Multimedia Learning: Using the Same Instructional Design Methods Across Different Media." Learning and Instruction 13 (2003): 125-39.
[22] O'Day, Danton H. "Animated Cell Biology: A Quick and Easy Method for Making Effective, High-Quality Teaching Animations." CBE- Life Sciences Education 5 (2006): 255-63.

form."[23] I therefore decided to have labels and text of important terms appear as they are mentioned in the narration.

It is imperative that the animation is age appropriate and is produced in the appropriate level of detail. Too little detail can be detrimental. Oversimplifying a concept or skipping too many steps in a process can be misleading. "Even if an animation is accurate, overly simple animations may not improve on a static illustration."[24] It is also important that the animation not be overly complicated with extraneous information or interesting but irrelevant material. "The coherence effect refers to the findings that students learn more deeply from a multimedia explanation when extraneous material is excluded rather than included."[25] Research shows that "students do not perform better with animations when the animations contain more information than is appropriate."[26] I therefore tried to find an appropriate level of difficulty in the animation that was not too detailed but was not oversimplified either. I decided to present them with the information they were required to know while including some additional details that were not necessary for comprehension but allowed for further investigation if the teacher decided to do so. The teachers can then have the option of showing the process and teaching the

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[23] Cradler, John, Molly Freeman, and Ruthmary Cradler. Research Basis for the Schlessinger Media Programs Grades K-12. Library video. 1-10. 22 Oct. 2007 <http://www.libraryvideo.com/articles/article25.asp>.

[24] Stith, Bradley J. "Use of Animation in Teaching Cell Biology." Cell Biology Education 3 (2004): 181-88.

[25] Mayer, Richard E. "The Promise of Multimedia Learning: Using the Same Instructional Design Methods Across Different Media." Learning and Instruction 13 (2003): 125-39

[26] O'Day, Danton H. "Animated Cell Biology: A Quick and Easy Method for Making Effective, High-Quality Teaching Animations." CBE- Life Sciences Education 5 (2006): 255-63.

major events or go into more depth in a particular area. “Although the students will be asked to focus only on these events, the complexity is still in their visual field. This strategy allows students to realize that more is going on than they are being asked to learn.”[27]

The running time for the animation is approximately 23 minutes and will fit well into the current curriculum. I decided to separate it into small sections of animations followed by questions. According to an interview with René McCormick, director of standards and quality for the National Math and Science Initiative, it is important to keep the animation sections short, no more than 10 to 20 seconds, and interrupt them with questions to keep the students engaged.[28] Dividing the animation into smaller sections also allows the teacher to play the animation in its entirety or play shorter sections as necessary. Research has also shown that including opportunities for built in assessment and feedback increases students’ acquisition of knowledge and skills.[29] Having questions embedded in the animation also provides the opportunity for class discussion. Class discussions provide the opportunity “for developing a language for talking about scientific ideas, for making students’ thinking explicit to the teacher and to the rest of the

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[27] McClean, Phillip, Christina Johnson, Roxanne Rogers, John Reber, Brian Slator, Jeff Terpstra, and Alan White. "Molecular and Cellular Biology Animations: Development and Impact on Student Learning." Cell Biology Education 4 (2005): 169-79.
[28] McCormick, Rene. 26 Sept. 2007.
[29] Cradler, John, Molly Freeman, and Ruthmary Cradler. Research Basis for the Schlessinger Media Programs Grades K-12. Library video. 1-10. 22 Oct. 2007 <http://www.libraryvideo.com/articles/article25.asp>.

class, and for learning to develop a line of argumentation that uses what one has learned to solve problems and explain phenomena and observations."[30]

It was also important to have an element that would connect the animation to other parts of the suitcase. "Animations best support learning when they are contextualized by a complete educational experience."[31] I decided to have an analogy comparing a cell to a factory that would appear throughout the animation and the game for consistency and to create a degree of familiarity. "Science classes are full of abstract or challenging concepts that are easier to understand if they are related to something from our everyday experience."[32] An effective analogy can motivate students and help them overcome misconceptions. "According to constructivist learning theory, knowledge is constructed as students integrate new information with their pre-existing knowledge base."[33] Analogies can make it easier for students to understand new concepts.

Protein Production Game

Research shows that cooperative learning groups increase students' motivation to attain desired goals. Students must work together within the group to accomplish a task. The

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[30] Bransford, John D., Ann L. Brown, and Rodney R. Cocking, eds. "Effective Teaching: Examples in History, Mathematics, and Science." How People Learn (1999): 143-77. 5 Oct. 2007.
[31] McClean, Phillip, Christina Johnson, Roxanne Rogers, John Reber, Brian Slator, Jeff Terpstra, and Alan White. "Molecular and Cellular Biology Animations: Development and Impact on Student Learning." Cell Biology Education 4 (2005): 169-79.
[32] Orgill, MaryKay, and Megan Thomas. "Analogies and the 5E Model." The Science Teacher 74 (2007): 40-45.
[33] Orgill, MaryKay, and Megan Thomas. "Analogies and the 5E Model." The Science Teacher 74 (2007): 40-45.

groups compete against students in the other groups increasing their motivation to succeed. When competing in groups, "students are placed in a situation where their success is dependent on the behavior and performance of other students in their group."[34] It is important that the tasks required of these groups require multiple skills and ability levels so that the work is not dominated by the high-ability students. As a result of this research, the game would consist of three groups that would each form a cell and complete the task of protein synthesis while competing against the other groups in a relay race.

In high school the greatest emphasis is given to auditory and visual learning. However teachers who have used "manipulatives have reported increased achievement and interest for the tactile students."[35] Teachers who used kinesthetic activities in their classrooms such as dramatization and role-playing reported an increase in interest and achievement among students. Laurence Nemerow found that "students are more highly motivated and their self-esteem increases when concept learning and review games are used in the classroom."[36] As a result of this research, the game includes manipulatives as well kinesthetic activities.

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[34] Hassard, Jack, comp. Minds on Science Online. Georgia State University. 26 Sept. 2007 <http://scied.gsu.edu/hassard/mos/mos.html>.
[35] Hassard, Jack, comp. Minds on Science Online. Georgia State University. 26 Sept. 2007 <http://scied.gsu.edu/hassard/mos/mos.html>.

[36] Nemerow, Laurence G. "Do classroom games Improve Motivation and Learning?" Teaching and Change 3 (1996): 356-66.

High school students rarely have the opportunity to play games in the classroom. "When games are used well in the classroom, they show a positive influence on the student's attitude toward school personnel, motivation to learn, self-esteem, and behavior."[37] When students play games they "feel directly involved in the process and can relate to it in a personal, social way. All the student are involved and must keep alert and know what is going on."[38] In his studies, Nemerow found that "even students who couldn't be motivated by anything else enjoyed being in the room and watching or participating in role-playing simulations and competitive games."[39] He also found that learning was more effective when participation was high and that students tend to remember events that affect them emotionally.

Laboratory Experiments

It is widely known that students learn best by doing especially when it applies to learning scientific concepts. "When students are engaged in actively constructing knowledge from a combination of experiences, interpretation, and structured interactions with peers and teachers, they are more likely to gain an expert understanding of science concepts."[40]

> Advocates for hands-on science argue that it promotes learning because it is consistent with the concrete-to-abstract nature of cognitive development, because

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[37] Nemerow, Laurence G. "Do classroom games Improve Motivation and Learning?" Teaching and Change 3 (1996): 356-66.
[38] Stencel, John, and Allen Barkoff. "Protein Synthesis: Role Playing in the Classroom." The American Biology Teacher 55 (1993): 102-03.
[39] Nemerow, Laurence G. "Do classroom games Improve Motivation and Learning?" Teaching and Change 3 (1996): 356-66.
[40] "Using Multimedia Tools to Help Students Learn Science." Center For Implementing Technology in Education. 26 Sept. 2007 <http://www.cited.org/index.aspx?page_id=148>.

> it provides additional sources of brain activation via kinesthetic involvement, and because its intrinsic interest increases motivation and engagement.[41]

Research shows that "students learn science best when they are actively engaged in doing science or in performing activities that allow them to think like scientists."[42]

It is also important to divide students into lab groups because collaboration allows students to learn from each other's point of view. "Decades of research into peer and collaborative work demonstrate measurable learning benefits for all students, regardless of academic level."[43] Collaboration also allows students who are struggling to learn from their peers. "Peers may be more effective explainers than adults because peers share a similar language, and they can translate difficult vocabulary into a language that fellow students understand."[44] Working together allows students to learn from each other and presents the opportunity for them to be able to understand more difficult concepts than they would be able to understand on their own.

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[41] Klahr, David, Lara M. Triona, and Cameron Williams. "Hands on What? Relative Effectiveness of Physical Versus Virtual Materials in an Engineering Design Project by Middle School Children." Journal of Research in Science Teaching 44 (2006): 183-203. ERIC. EBSCO. UT Southwestern, Dallas. 5 Oct. 2007.

[42] Orgill, MaryKay, and Megan Thomas. "Analogies and the 5E Model." The Science Teacher 74 (2007): 40-45.

[43] "Using Multimedia Tools to Help Students Learn Science." Center For Implementing Technology in Education. 26 Sept. 2007 <http://www.cited.org/index.aspx?page_id=148>.

[44] "Using Multimedia Tools to Help Students Learn Science." Center For Implementing Technology in Education. 26 Sept. 2007 <http://www.cited.org/index.aspx?page_id=148>.

Review of Available Resources

After researching learning styles I decided to do a thorough evaluation of the resources available to teachers in animations, games, and laboratory experiments. I reviewed the activities provided in Biology textbooks, current DISD teachers' resources, the UTSW Medical Center library, and the Internet.

Animation

One teacher mentioned that she showed her class a video called "The Incredible Cell." This video involved students entering into a cell and talking to each organelle. The organelles were two dimensional drawings with animated video of human lips superimposed over the drawings. This video was informative, but very outdated and included two dimensional drawings that did not provide an accurate depiction of the organelles' structure. It also did not provide insight into how the organelles work together. I also did a search on the Internet to see what animations on organelles were available. There were several animations on individual organelles and different cell processes available online, but I was unable to find one that addressed each organelle's structure and function while introducing cellular respiration, protein synthesis and secretion. I also was unable to find an animation comparing plant and animal cell organelles. Many of the animations were low quality and most of them were two dimensional.

Protein Production Game

In the review of games involving organelle function, I found an example of a role-playing protein production game.[45] This game was very complicated and included much more information than necessary for a high school Biology class. Another article I found included a protein production role playing activity.[46] This activity was also more complex than needed for the target audience. One of the textbooks also suggested that the students write a play chronicling the creation and process of a protein in a cell with each organelle playing its part. The protein could begin with planning in the nucleus, continue with transport through the cells organelles, and end with destruction within a lysosome. This seemed like a good suggestion, but after a discussion with Steve Hinkley it was evident that a play would be too slow of a pace to keep high school students engaged.

Laboratory Experiments

I started the search for laboratory experiments during a meeting with Amy Rommel, a graduate student at UTSW Medical Center. She provided me with several protocols for various laboratory experiments involving organelles. I also researched several laboratory experiments on the Internet. The textbooks each had a plant and animal cell laboratory, but they were all involved very little detail and did not provide information for teacher setup and clean up or provide any photographs. I found several other experiments similar to the experiments Amy and I had chosen online, but Amy and I worked together to write our own protocols as we tested them.

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[45] Tester, Steve. "Protein Synthesis Role Play." Protein Synthesis Role Play. 2005. Feb. 2008 <http://sciencespot.net/media/protsynoutline.pdf>.

[46] Stencel, John, and Allen Barkoff. "Protein Synthesis: Role Playing in the Classroom." The American Biology Teacher 55 (1993): 102-03.

Conclusion

Based on my literature review there is nothing currently available similar to my project and many of the resources that the teachers have available to them are two dimensional, and do not cover both the structure and function of organelles. It is important to have a program available for students that addresses a wide variety of learning styles so that all of the students will be reached by at least one of the elements in the suitcase.

CHAPTER THREE
Methodology

Concept Development

The goal of this thesis project was to create a portable Science Suitcase on organelles designed to supplement the current high school biology curriculum in the Dallas Independent School District (DISD). The Science Suitcase was designed to be borrowed by teachers and brought into their classrooms to help enhance students' interest in science, help bridge the gap between ninth grade biology and Advanced Placement biology, and help students meet the State of Texas science education requirements based on the National Science Education Standards. This goal was achieved by meeting several specific objectives. These objectives were used to determine the process of completing the Science Suitcase.

After determining what the teachers currently had available to them in terms of technology and lab equipment through a pre-project survey, the individual components that would be included in the suitcase were determined. The components included a narrated 3d animation, three laboratory experiments, and an interactive game as well as a teacher's manual and student handouts booklet. After the components were decided, a script and storyboards were created for the animation. Next models for the animation were built and a cartoon analogy of a factory was created that would run throughout the animation and the game to tie them together. The animation was then produced and burned onto a DVD. The game was then designed to reinforce the organelles' functions

in the process of protein synthesis and secretion from the animation. The necessary elements were then created, and they were then produced by the Museum of Nature and Science. The final element was the laboratory experiments. Three laboratory experiments were chosen that focused on specific organelles previously studied in the animation. These laboratory experiments were designed and tested several times, and the necessary lab materials were ordered. A teacher's manual and student handouts booklet were then produced. All of the elements were organized into their own containers and the containers were organized into two portable Pelican™ suitcases. Finally the animation, labs, protein production game, teacher's manual, and student handouts booklet were presented to a group of teachers for evaluation.

Target Audience

The target audience for this project was high school biology students studying the topic of organelles. All of the elements in the Science Suitcase were designed with this audience in mind.

Pre-Project Planning

Meetings

An initial meeting was held to discuss the 2007 Howard Hughes Pre-college Program "STARS Science Triathlon." Representatives from the Howard Hughes Medical Institute, the STARS program, the O'Donnell Foundation, the Museum of Nature and Science, the

Biomedical Communication Program at UTSW Medical Center, as well as the Assistant Dean of the Graduate School at UTSW, and the writer of the grant proposal, Dr. Joel Goodman, were in attendance at this meeting. During the course of this meeting, we were presented with an overview of the project, which consisted of three events spread out over a fifteen-month period. These events included a twelve-day summer workshop, a series of symposia throughout the year, and an eight-week summer research program the following summer. The Science Suitcases and Virtual Instruments will also be included to enrich the teachers' resources. The concept behind the Science Suitcases was also discussed. We were told that the suitcases would each be based on one topic that would also be covered in the twelve-day summer workshop. The suitcases could include wet labs, manipulatives, and multimedia components. We were also told that we would be matched up with a graduate student who was currently working on our topic, and who would help us by serving as a content expert. The Museum of Nature and Science would help us with the physical labor in their workshop. The Virtual Instruments were introduced in the meeting as well. A team at Texas A&M would be working on an optical microscope, a spectrophotometer, a gel electrophoresis chamber, and a polymerase chain reaction thermocycler that would be part of the triathlon.

After the initial meeting, I attended a meeting with Lewis Calver, M.S., Stuart Ravnik, Ph.D, Joel Goodman, Ph.D., and Brenda McArthur, Biomedical Communications student, to discuss the suitcase topics. The topics included chemistry, biochemistry, enzymes, membranes, organelles, cell respiration, and photosynthesis. Each suitcase would cover only one of the listed topics, but the suitcases should have interconnections

between the topics as well. The suitcases would be expressions of creativity that would give a better understanding of the topics and would include one or more exercises. Because the UTSW Medical Center's name would be attached to the suitcases, they should be consistent. I chose to create a suitcase on organelles.

Once we had chosen our topics, we discussed the next steps in the process. First we would need to discover how our topics were currently being taught in the Dallas Independent School District, and find the problems, if any, in the current system. If there were deficits we could find ways to address them. To do so we would need to get input from the teachers currently teaching biology. We would also need to meet with René McCormick to see if there was a particular way that they were covering these topics. We would need to consult the Texas Essential Knowledge and Skills to see what the state of Texas required for students to learn. The current textbooks would also need to be reviewed and general research would need to be done on each topic. We also needed to decide on the details of the suitcase. What would they see when they opened the box? What would they need to do? What was necessary to make the project successful?

Next Brenda and I had a meeting with Paul Vinson, the Director of Exhibits at the Museum of Nature and Science. We were told that each suitcase had a budget of $3500 with $1000 to support the suitcase each year. The budget would include the price of the suitcase or suitcases and all of the materials and labor needed to complete the project. We were also told that we should not rely on the schools having any resources. Also in order to make the suitcases accessible to the greatest number of teachers we should make

them low tech and include a high tech element. The suitcases would also need to include a lesson plan and a photo book or CD that would instruct them how to use the suitcase components. We were then given a tour of the museum's resources. The museum had a metal studio, a wood shop, a paint room, a large plotter, a laminator, and many other supplies that we would be able to access. We were also shown the museum's Discovery Boxes, which were similar to the Science Suitcases, but designed for elementary aged students.

In a meeting with René McCormick we discussed the ways biology teachers were currently teaching the topics of organelles and enzymes. She instructed us to find the textbooks that the Dallas Independent School District was using to see how the students were accustomed to seeing organelles and enzymes. She also told us find out how our topics were taught in honors or AP courses and standard high school biology classes, and to find a happy medium between the two. She suggested that we only present short segments of animation, no more than 10-20 seconds, at a time, and that we interrupt them with questions so the students have an opportunity to reflect on what they have just seen. She also suggested that we use the proper terminology and not oversimplify the processes, because both can lead to confusion in future biology courses.

Preliminary Survey

A survey was sent by e-mail to approximately one hundred teachers in the Dallas Independent School District. The surveys evaluated what resources the teachers had available to them, how they currently taught the topics of organelles and enzymes, what

problems the students were currently having with the topics, and what suggestions they had for improving students' understanding of these topics (see Appendix A). The surveys were sent out to approximately one hundred teachers, and of this group only four responded (see Appendix B). Steve Hinkley, the Educational Director at the Museum of Nature and Science and a former Biology teacher, also filled out the survey and provided his input (see Appendix B).

Of those that responded, all five teachers were either currently teaching the topics of organelles and enzymes or had taught them in the past. One of the teachers had limited access to computers for each student, while another did not have access at all. As a result, we decided not to include interactive computer programs since the student would not have access to individual computers to run them. All of the teachers did have at least limited access to computers with an overhead projector and would therefore be able to play an animation in their classroom. They also all had access to lab desks with sinks, which would allow for laboratory experiments to be included in the suitcase.

When asked how they currently taught the topic of organelles there was a wide range of responses, indicating that there was not a set curriculum for this topic. Several of the teachers mentioned using Powerpoint® presentations, videos, and worksheets where students could color and label organelles and write in their functions. Another teacher used "foldables" where students created booklets of paper of different lengths. Each layer was shorter than the layer below it. The student would write the name of the organelle on the top sheet and then write the function on the sheet below it. One teacher

had their students create 3-dimensional cell models using household items. And a second teacher had their students "sell a cell organelle." In this activity, each group of three or four students made up a magazine add or commercial and tried to sell their organelle to the class. Another teacher mentioned that she had her honors class compare a cell to a different system such as a city or a factory and make comparisons with ten organelles. She said that this activity really cemented the organelles' functions with the students. She also suggested using a wide variety of different activities for teaching the topic of organelles. Of the activities mentioned by the teachers, only a few of them involved interaction with manipulatives and none of them mentioned laboratory experiments. Most of the activities also only involved 2-dimensional representations of the cell, which make it difficult for students to understand the dynamic nature of cell organelles and their functions.

One problem that the teachers found their students having was identifying the structure and functions of organelles. The students were able to identify the nucleus and name its function, but had trouble with other organelles. Students were also found to have trouble with the names of organelles since many of them look and sound the same. The dynamic nature of the cell was also difficult for students to grasp. One teacher also mentioned that the students often had difficulty relating colored models with the actual cells themselves. He suggested teaching what the actual cells look like in conjunction with a model. All of these problem areas were taken into consideration when producing the final product.

When asked if they had any suggestions for improving instruction in these areas, the teachers all agreed that interactive games would be helpful. It was mentioned that ninth graders like to build things, an element that could be added into the game. One teacher mentioned that it would be helpful to have more lab ideas, and another suggested incorporating data collection and analysis into the labs. It was also suggested that time was allowed for reflection after the activities or experiments so that the concepts could soak in. I kept all of these suggestions in mind when creating the elements of the suitcase.

Choosing Elements to Include in the Science Suitcase

After reviewing the results of the preliminary survey and researching other common teaching methods for organelles, I had several meetings with my committee members to decide which elements I would include in the Science Suitcase. From my previous research, I knew that I would need to include several different types of activities to reach the different learning styles of the students. Each of the activities preferably needed to fit into one class period. They needed to play off of each other. All of the materials necessary for each of the elements also needed to fit nicely into one or two portable suitcases. Taking all of these things into consideration, I decided to include an 3d animation that would cover the structure and function of organelles in both plant and animal cells, an interactive game in which students perform the functions of organelles, and three laboratory experiments addressing several organelles in both plant and animal cells.

Animation

Script

The first step in creating the animation was to do some basic research on the topic of organelles in several textbooks used by the DISD. This was important because it allowed me to see the level of complexity the students were accustomed to viewing. I used this information to write a script that explained each of the organelle's structure and function, and addressed the processes of protein synthesis, cellular respiration, and photosynthesis (see Appendix C). It was important to show how the organelles worked together in the cell. I addressed the organelles in both plant and animal cells, and made sure to emphasize which organelles were only found in plant cells.

I also decided that it was important to include an analogy of a cell to a factory in the animation. The analogy would be presented as a 2-dimensional cartoon that would be presented at the beginning of the animation. As Steve Hinkley mentioned in his preliminary survey, it was also important to explain to students that actual cells did not look like the 3-dimensional model used in the animation. In order to explain this, I chose to show what a cell looked like through a compound light microscope, an electron microscope, and as a 3D model. With all of this information presented to them, it was important that the students relate the 3D model with the factory analogy and images of actual cells. After several different attempts, I chose to address this issue by introducing each organelle by showing the corresponding character in the cartoon factory, the organelle in the 3D model, and an electron micrograph of the organelle. The script went through many versions, and was reviewed for accuracy many times by my content expert, Joel Goodman. The final script included only the most essential information.

Storyboard

The script was then used to produce a storyboard for the animation (see Appendix C). At this time, I decided to use an analogy comparing a cell to a factory. I also decided that each organelle would be introduced by the corresponding cartoon character, the cell model, and the electron micrograph. The introduction was followed by a 3D animation addressing the function of the organelle and finally a multiple choice question was inserted after each organelle had been presented.

The storyboard was viewed several times by the committee and small changes were made including the way each of the organelles was introduced and the order the plant organelles were presented, and several frames were removed (**Figure 3-1**).

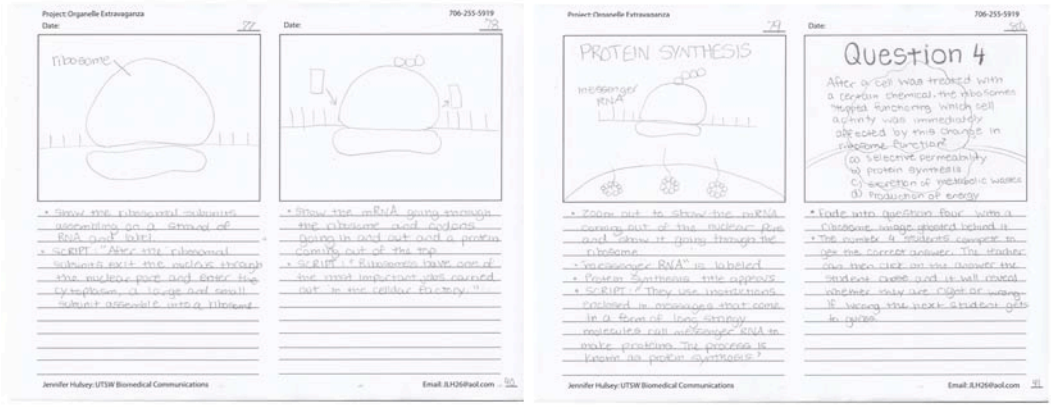


Figure 3-1. Storyboards

In the final storyboard meeting, the storyboard was pinned to the wall (**Figure 3-2**) and reviewed as the script was read aloud. Several small changes were made to the script and

several confusing terms were excluded. Once the storyboard and script were approved by all three of my committee members, I could have the narration recorded, begin designing the cartoon characters, build the 3D models, and gather the appropriate electron micrographs.

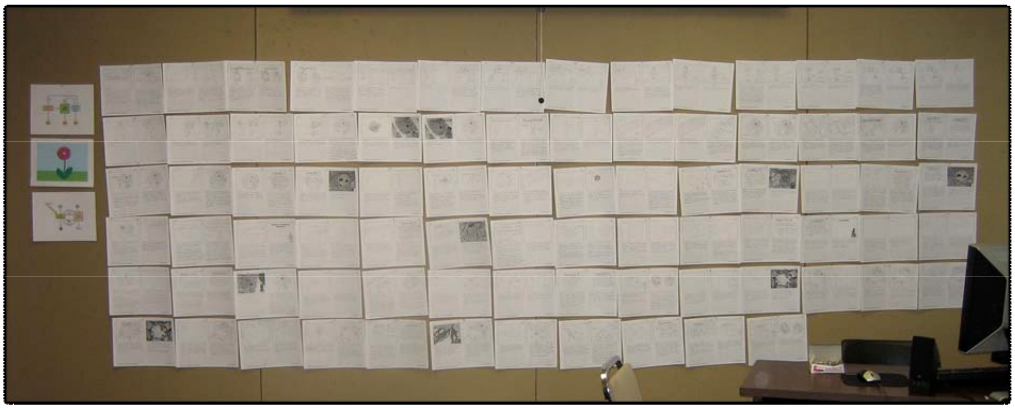


Figure 3-2. Storyboard

Recording the Script

Once the final script and storyboards were approved, I contacted The Mary Collins Agency in Dallas, Texas and booked professional voice talent, Bruce DuBose, to record the audio for the script. I also booked one hour of studio time at The Medical Television Center at UTSW Medical Center. It was very important to have the script narrated, because many studies have proven that animations with narration are more effective than animations that use text alone. Once the script was recorded, I edited out the mistakes and added pauses where they were needed using Adobe® Premiere. I also divided the narration into several segments so that they could be brought into the individual compositions in Adobe® After Effects. Music was also selected from www.flashkit.com

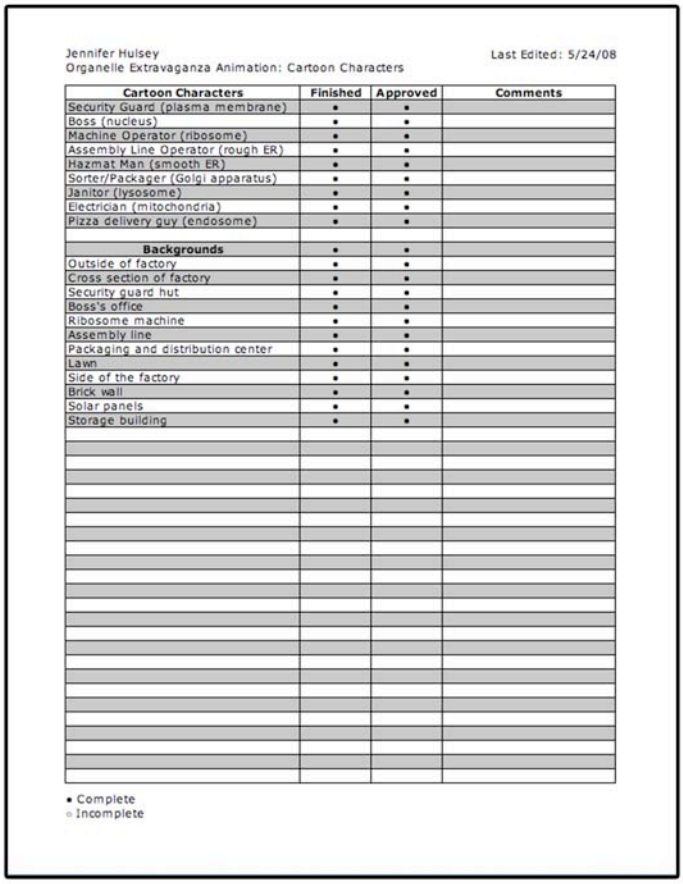
to be used in the introduction sequences as well as at the beginning and end of the animation.

Designing the Cartoon Characters

Designing the cartoon characters was one of the most difficult aspects of the project for me. I did not have much experience with cartooning before this project, and I knew that I should probably start working on the characters first. The cartoon analogy was very important, because it provided a connection between the animation and the game. I started by researching cartooning and learning how to make each of the cartoon characters unique while also making them look like they belonged together.

I also had to decide which characters would represent each organelle. I chose a security guard for the plasma membrane since it is responsible for controlling what gets into and out of the cell. The nucleus is the control center of the cell so I decided to represent it as the boss of the factory. The ribosomes are similar to the machines working inside the factory and the rough endoplasmic reticulum is similar to the assembly line. The smooth endoplasmic reticulum is the poison control center for the cell. The lysosomes clean up all of the trash in the factory and I chose to make it a maintenance man. The mitochondria is the powerhouse of the cell so I chose to have its character provide power to the factory. The cell wall is similar to a brick wall surrounding the fence around the factory. I chose to represent the chloroplasts as solar panels on the roof of the factory since they harvest the light to produce energy for the factory. And finally the central vacuole functions in storing extra materials for a plant cell and is similar to a storage

building. Each of the characters needed to be analogous to the organelle's function. I also created a Microsoft® Excel® spreadsheet listing all of the characters and scenes that needed to be created (**Figure 3-3**).



Jennifer Hulsey
Organelle Extravaganza Animation: Cartoon Characters
Last Edited: 5/24/08

Cartoon Characters	Finished	Approved	Comments
Security Guard (plasma membrane)	•	•	
Boss (nucleus)	•	•	
Machine Operator (ribosome)	•	•	
Assembly Line Operator (rough ER)	•	•	
Hazmat Man (smooth ER)	•	•	
Sorter/Packager (Golgi apparatus)	•	•	
Janitor (lysosome)	•	•	
Electrician (mitochondria)	•	•	
Pizza delivery guy (endosome)	•	•	
Backgrounds	•	•	
Outside of factory	•	•	
Cross section of factory	•	•	
Security guard hut	•	•	
Boss's office	•	•	
Ribosome machine	•	•	
Assembly line	•	•	
Packaging and distribution center	•	•	
Lawn	•	•	
Side of the factory	•	•	
Brick wall	•	•	
Solar panels	•	•	
Storage building	•	•	

• Complete
◦ Incomplete

Figure 3-3. Microsoft® Excel Spreadsheet: Cartoon Characters

The characters started as rough sketches that were presented to the committee several times and changes were made accordingly. The finished pencil sketches were then scanned into Adobe® Photoshop. I then opened a new document in Adobe® Illustrator

and placed the Adobe® Photoshop file of the sketch into the document. The sketch layer was then locked and named "template" (**Figure 3-4**). This layer would serve as a template for outlining the character. A new layer was then created above the sketch layer and was named "outline" (**Figure 3-4**). The character was outlined using the pen tool on this layer. I chose to have a thicker outline around the outside of the entire character with a thinner line used for the inside details. The thicker outline was created on a separate layer named "thick outline" and placed above the "outline" layer (**Figure 3-4**). Color was then added in a fourth layer that was named "color" and was placed under the "outline" layer (**Figure 3-4**). I added color to the outlines by making shapes using the outlines already established and adding a solid color fill to them with the paint bucket tool. A color was chosen for each organelle that would apply to the cartoon character, the 3D model, and the highlight on the electron micrograph to further relate them in the eyes of the students. The plasma membrane would be blue, the nucleus would be purple, the ribosome would be green, the endoplasmic reticulum would be yellow, the Golgi apparatus would be orange, the lysosome would be red, the mitochondria would be pink, the cell wall would be green, the chloroplast would be yellow-green, and the central vacuole would be blue-green.

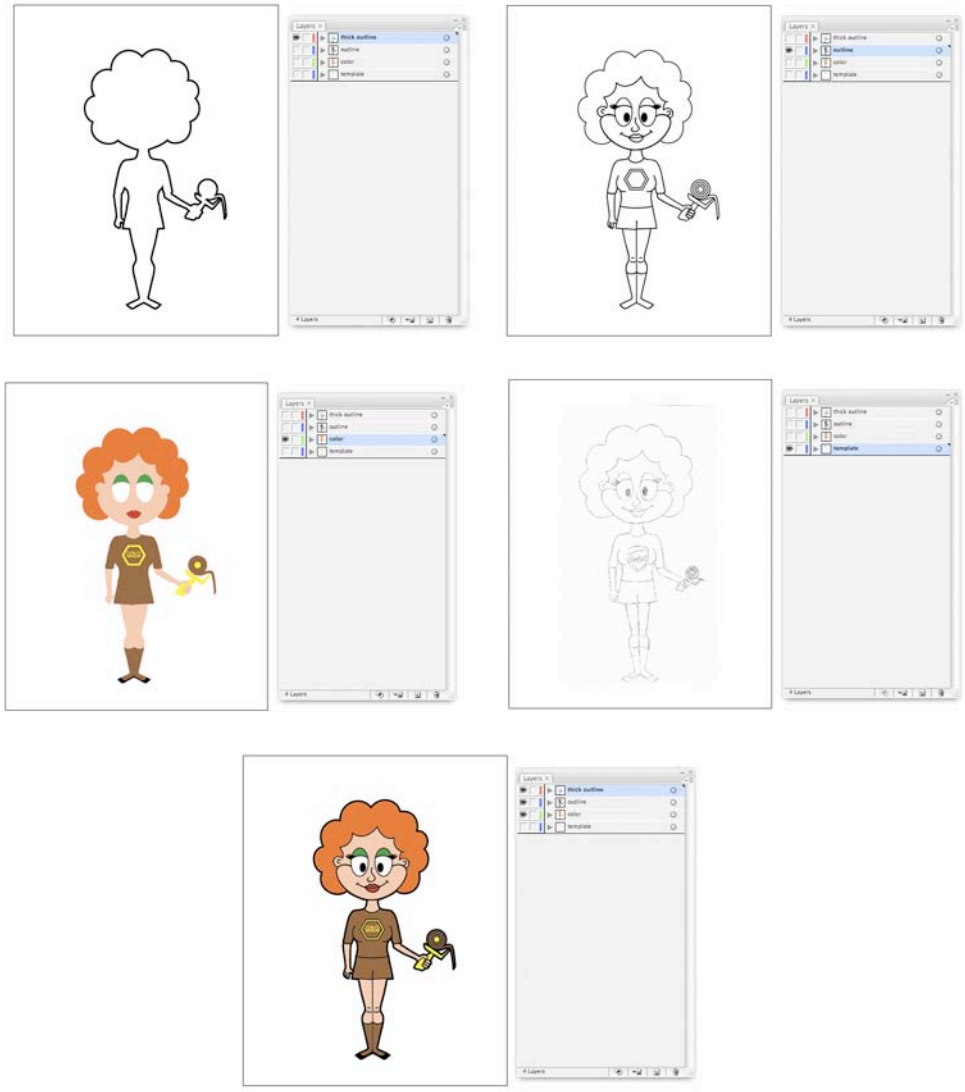


Figure 3-4. Cartoon Layers in Adobe® Illustrator

The cartoon characters each needed to be able to fit onto a name tag for their use in the game and they also needed to be incorporated into scenes for the animation. I designed the outside of the factory as well as a cross-sectional view of the inside of the factory and

the individual scenes for each character. Each of these scenes was produced in an Adobe® Illustrator document that was 640 pixels wide by 480 pixels tall (**Figure 3-5** and **Figure 3-6**) so that it could be imported into the animation format in Adobe® After Effects. A few of the characters had to be altered to fit into the scenes.

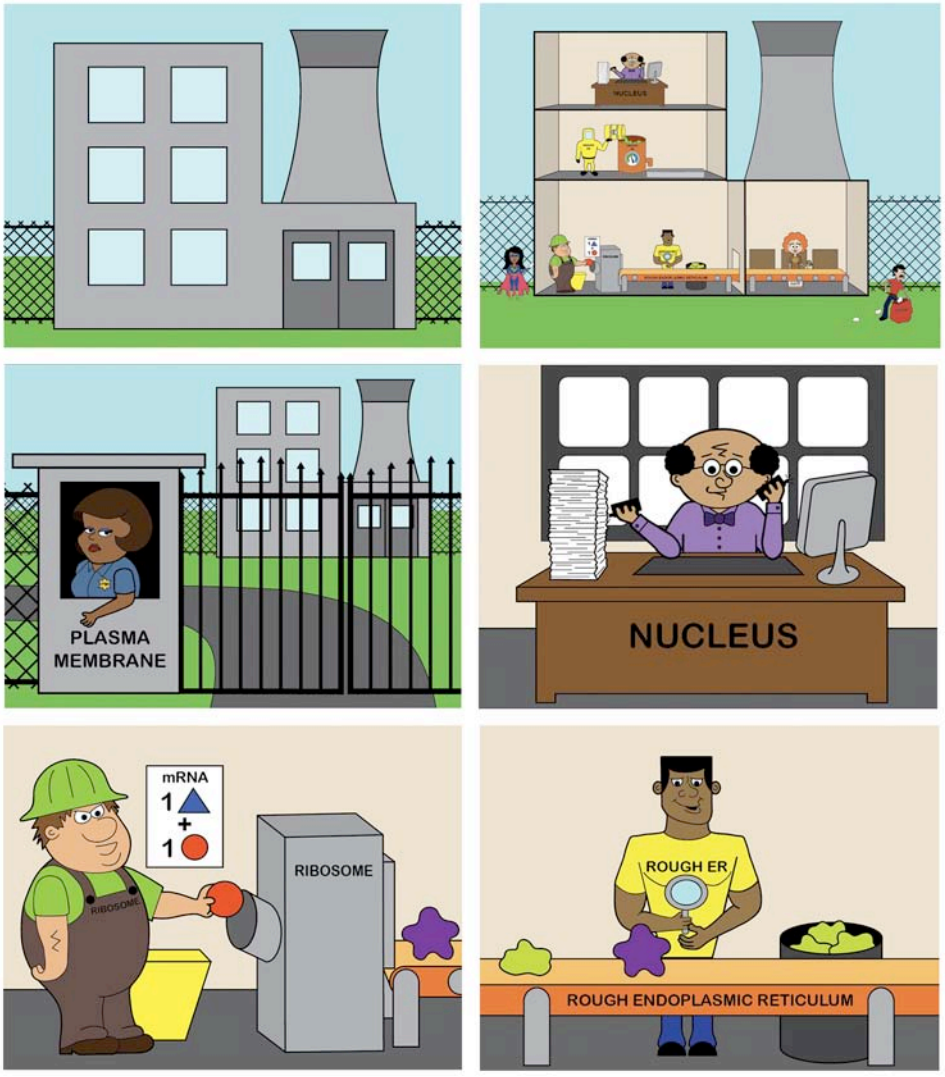


Figure 3-5. Cartoons and Backgrounds in Adobe® Illustrator

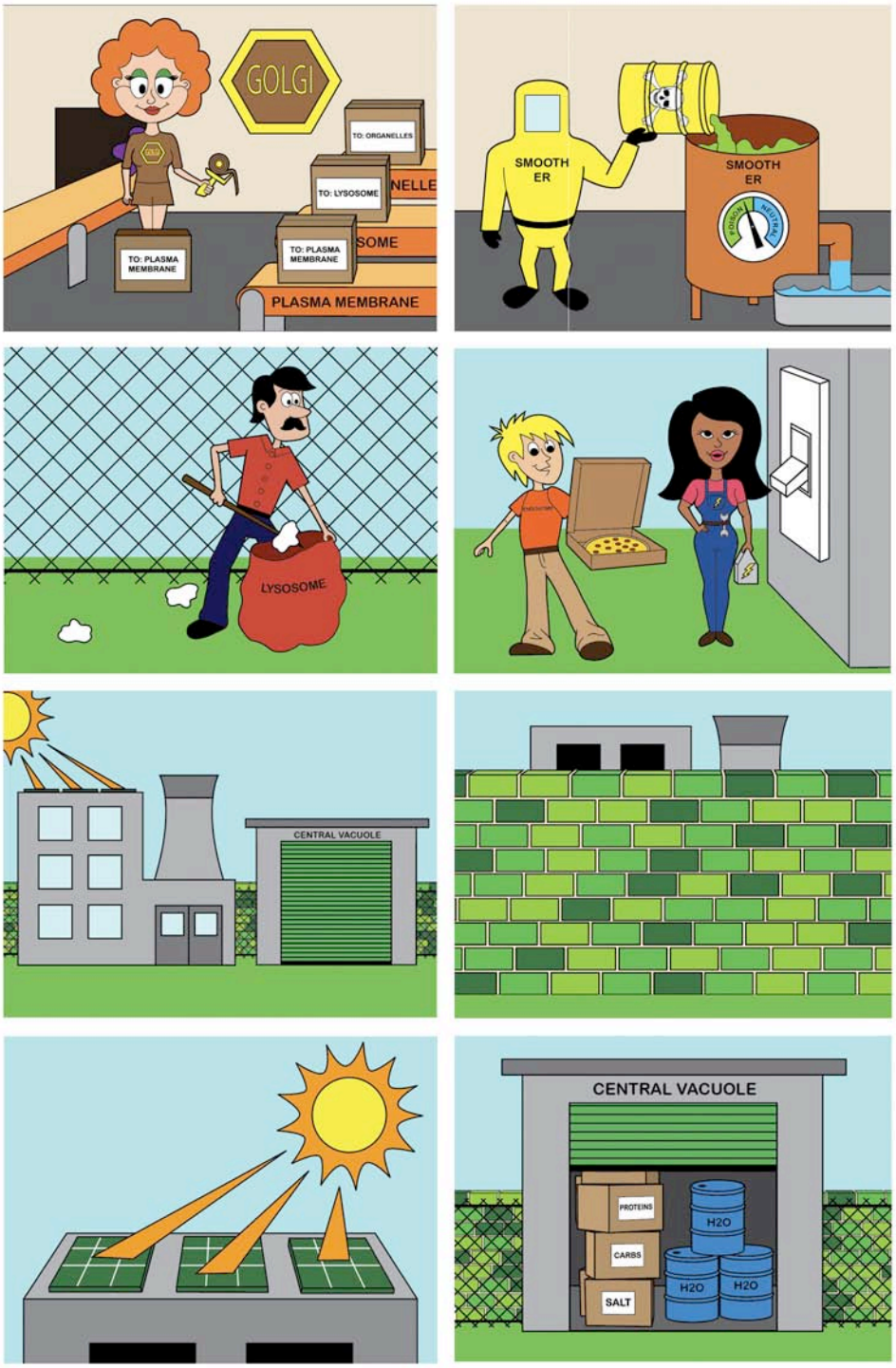


Figure 3-6. Cartoons and Backgrounds in Adobe® Illustrator

The next step was to create separate layers for the elements that would move. Many of the characters had arms that needed to move. To accomplish this, I divided the arm into two pieces, one for the forearm and one for the arm, and placed them on separate layers so that they could move independently (**Figure 3-7**). I did this for all of the characters and elements that need to move.

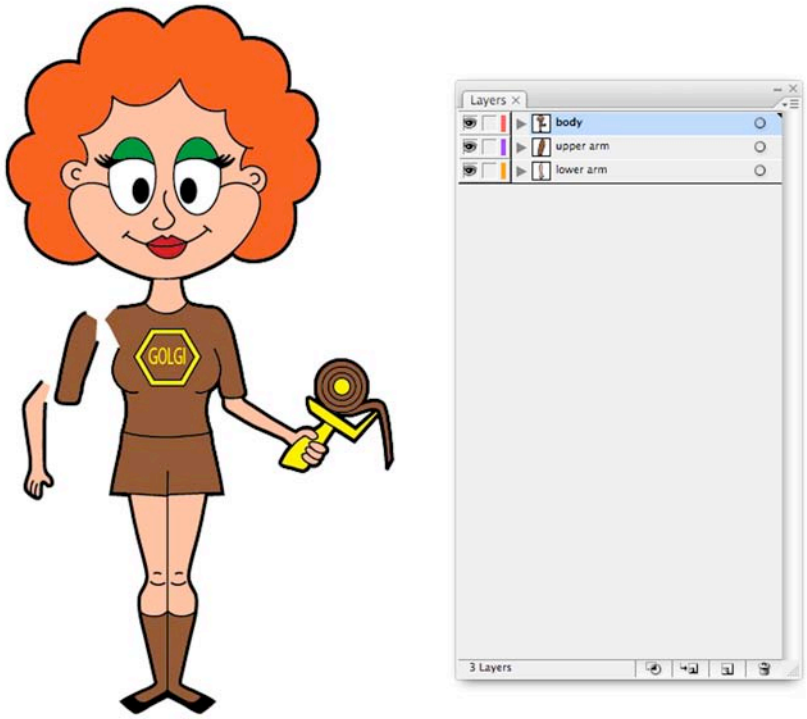


Figure 3-7. Cartoon Layers Prepared to Animate

Building the 3D Models

After the storyboard was approved, I could begin building the 3D models that would be needed for the animation in 3d Studio Max®. I needed to build a large number of

models, so I started by making a Microsoft® Excel® spreadsheet of the models to stay organized (**Figure 3-8**).

Jennifer Hulsey
Organelle Extravaganza Animation: 3d Models
Last Edited: 5/24/08

Models	Finished	Approved	Comments
Animal Cell	•	•	
Plasma Membrane	•	•	
Phospholipid	•	•	
Membrane Protein	•	•	
Water molecule	•	•	
Lipid Bilayer one layer	•	•	
Lipid Bilayer (receding in space)	•	•	
Lipid Bilayer with Proteins	•	•	
Cholesterol	•	•	
Carbon Dioxide	•	•	
Oxygen	•	•	
Glucose	•	•	
Nucleus whole	•	•	
Nucleus Cut	•	•	
DNA	•	•	
Protein	•	•	
Chromatin	•	•	
Chromosome	•	•	
Nuclear Envelope	•	•	
Nuclear Pore	•	•	
Nucleolus	•	•	
rRNA	•	•	
Ribosomal Small Subunit	•	•	
Ribosomal Large Subunit	•	•	
mRNA	•	•	
tRNA	•	•	
Amino Acid	•	•	
Rough Er	•	•	
Rough ER Up close	•	•	
Transport vesicle	•	•	
Damaged protein	•	•	
Smooth Er	•	•	
Smooth ER membrane	•	•	
Enzyme on Smooth ER membrane	•	•	
Lipid	•	•	
Hormone	•	•	
Poison	•	•	
Neutralized Poison	•	•	
Golgi Apparatus	•	•	
Enzymes	•	•	
Lysosome	•	•	
Lipid in Vesicle	•	•	
Lipid Broken down	•	•	
Protein in Vesicle	•	•	
Protein Broken Down	•	•	
Mitochondria in Vesicle	•	•	
Mitochondria Broken Down	•	•	
Food Particle	•	•	

• Complete
◦ Incomplete

Jennifer Hulsey
Organelle Extravaganza Animation: 3d Models
Last Edited: 5/24/08

Models	Finished	Approved	Comments	Models	Finished
Food Particle	•	•		Food Particle	•
Mitochondria	•	•		Mitochondria	•
Mitochondria	•	•		Mitochondria	•
ATP	•	•		ATP	•
Circular DNA	•	•		Circular DNA	•
Plant Cell	•	•		Plant Cell	•
Cell wall	•	•		Cell wall	•
Cell wall com	•	•		Cell wall com	•
Chloroplast	•	•		Chloroplast	•
Chloroplast C	•	•		Chloroplast C	•
Central Vacu	•	•		Central Vacu	•
Salt	•	•		Salt	•

• Complete
◦ Incomplete

Figure 3-8. Microsoft® Excel Spreadsheet: 3D Models

I used the images of organelles in the textbooks used by DISD as well as electron micrographs as references when building the models. The same colors were assigned to the organelle models as their corresponding cartoon characters for consistency. Once the individual organelle models were created, I sent screenshots of them at different angles for my committee to review and make corrections (**Figure 3-9**).

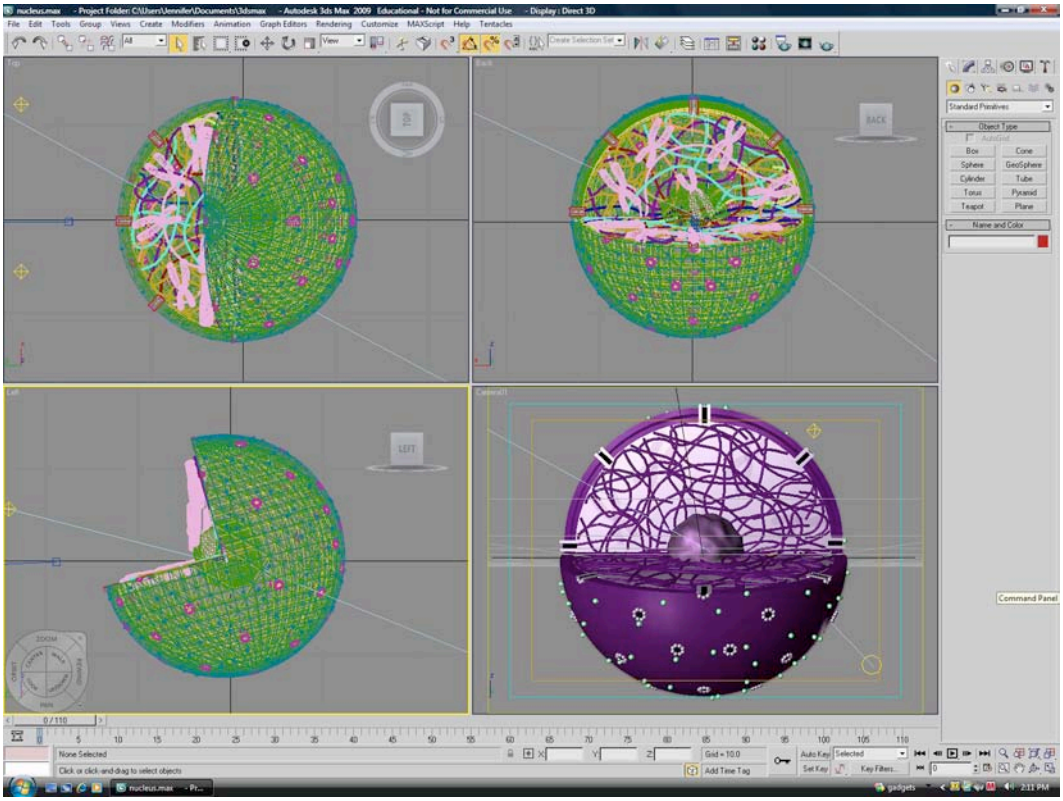


Figure 3-9. Nucleus Model Screenshot in 3D Studio Max®

Once the models were approved by my committee members, a complete animal cell and a complete plant cell were assembled using the organelle models (**Figure 3-10**).

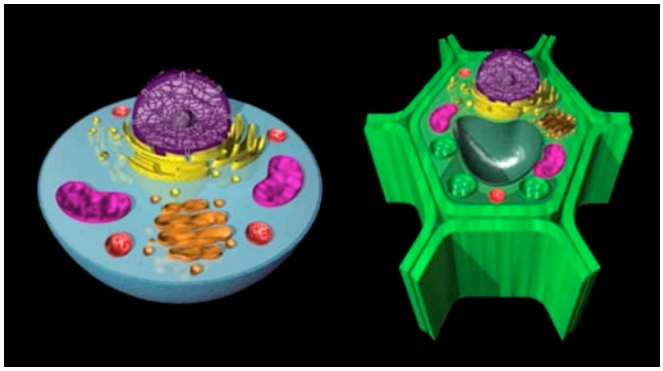
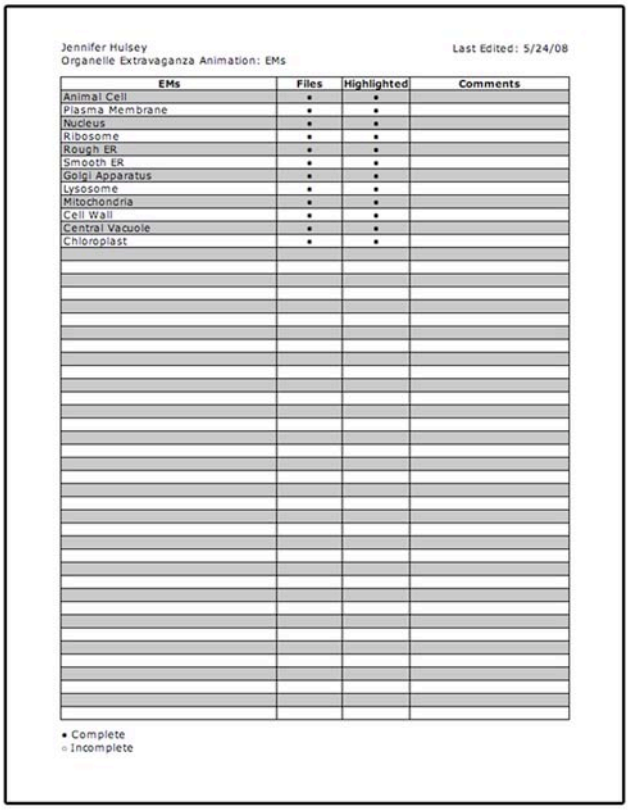


Figure 3-10. 3D Models of an Animal Cell and a Plant Cell

Finding the Electron Micrographs (EMs)

The next step was to find electron micrographs of each of the organelles to be included in the animation. I began by creating another Microsoft® Excel® spreadsheet of the EMs that would be needed in the animation (**Figure 3-11**).



Jennifer Hulsey
Organelle Extravaganza Animation: EMs

Last Edited: 5/24/08

EMs	Files	Highlighted	Comments
Animal Cell	•	•	
Plasma Membrane	•	•	
Nucleus	•	•	
Ribosome	•	•	
Rough ER	•	•	
Smooth ER	•	•	
Golgi Apparatus	•	•	
Lysosome	•	•	
Mitochondria	•	•	
Cell Wall	•	•	
Central Vacuole	•	•	
Chloroplast	•	•	

• Complete
◦ Incomplete

Figure 3-11. Microsoft® Excel Spreadsheet: Electron Micrographs

I contacted Dr. Christopher Gilpin, the director of the Molecular and Cellular Imaging Facility (MCIF) at UTSW Medical Center and scheduled a meeting. In the meeting we discussed why I needed the electron micrographs and which images I would need. I was then directed to work with Ms. Laurie Mueller in the MCIF for the remainder of the

project. Ms. Mueller contacted many researchers and received permission to use their images in the Science Suitcase (See Appendix E). After receiving these images, I brought them into Adobe® Photoshop and resized them to 640 pixels by 480 pixels to fit the animation format (**Figure 3-12**).

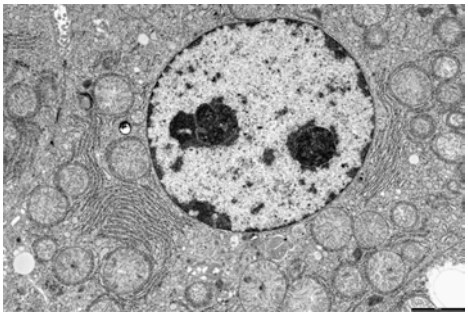


Figure 3-12. Electron Micrograph

I then created a second layer and created a layer mask, excluding everything in the image except for the organelle in question (**Figure 3-13**).

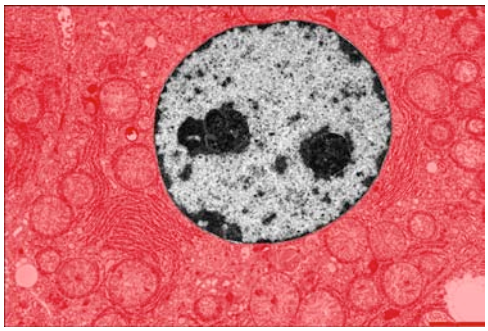


Figure 3-13. Electron Micrograph with Layer Mask

I then saved the mask as a selection, and with the selection active I applied a solid color to the area using the paint bucket tool. I then set the blending mode to multiply, so that

the electron micrograph image underneath was visible (**Figure 3-14**). I followed this method with each of the EMs, and used the colors previously selected for each of the organelles.

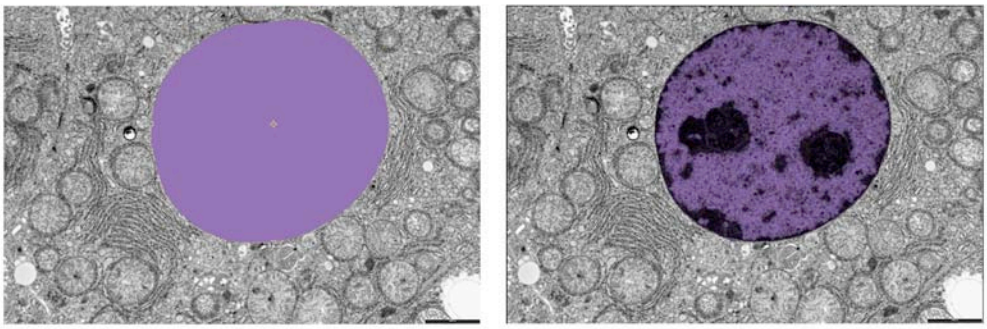


Figure 3-14. Electron Micrograph with a Solid Color Fill (left) and with the Blending Mode Set to Multiply (right)

Animating the Cartoon

Once the cartoon elements were approved, they could be brought into Adobe® After Effects to be animated. I created a separate composition for each organelle, the animal factory, the plant factory, and the cross section of the factory. I started each animation by creating a new composition that was 640x480 pixels (**Figure 3-15**).

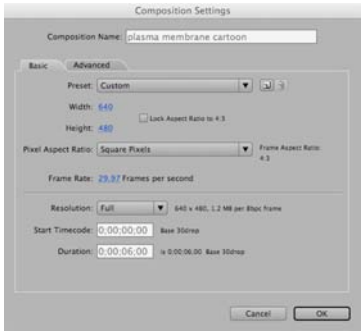


Figure 3-15. New Composition Settings in Adobe® After Effects

I then imported the individual layers of the corresponding Adobe® Illustrator file as footage (**Figure 3-16**).

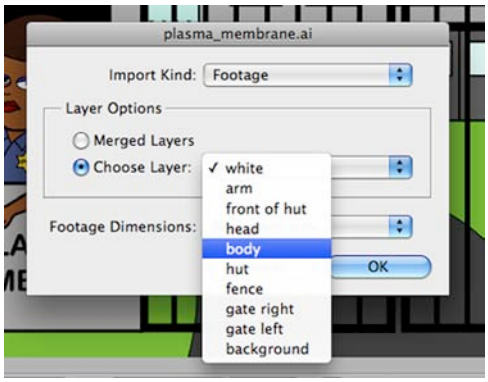


Figure 3-16. Import Footage Settings in Adobe® Aftereffects

The footage could then be placed into the composition in the same order as the layers of the Adobe® Illustrator file (**Figure 3-17**). Each layer could then be manipulated accordingly to create the motion decided in the storyboard.

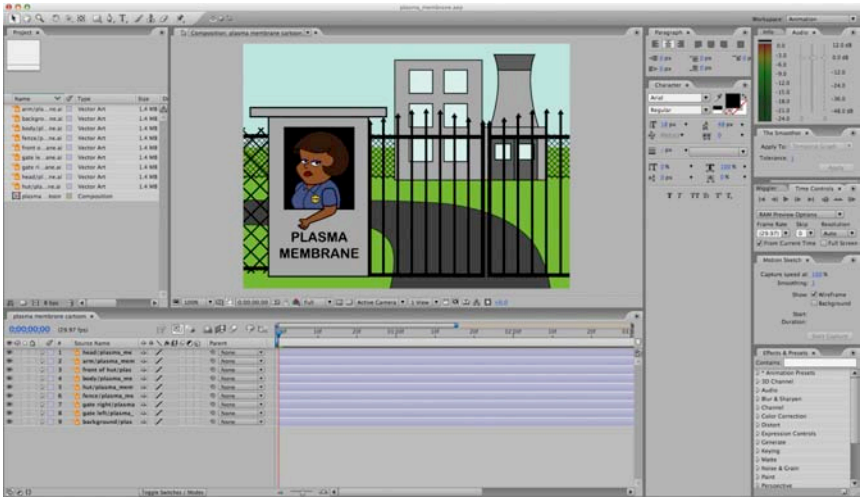


Figure 3-17. Composition in Adobe® After Effects

Animating the 3D Models

Once the appropriate lighting was established, several backgrounds were created for the animation (**Figure 3-18**). A background was created using the texture of the plasma membrane for the animal cell organelles and a second background was created using the texture of the cell wall for the plant cell organelles. Several backgrounds were also created for the inside of the nucleolus and the Golgi apparatus.

Figure 3-18. Animation Backgrounds (Animal Cell, Plant Cell, Nucleolus, and Golgi Apparatus from upper left clockwise)

The 3d models were then animated using 3D Studio Max®. I divided the animation into several short sections for each organelle. This allowed me to control the timing and

allowed for shorter rendering times. Each animation segment was exported as a targa file at 640x480 pixels (**Figure 3-19**).

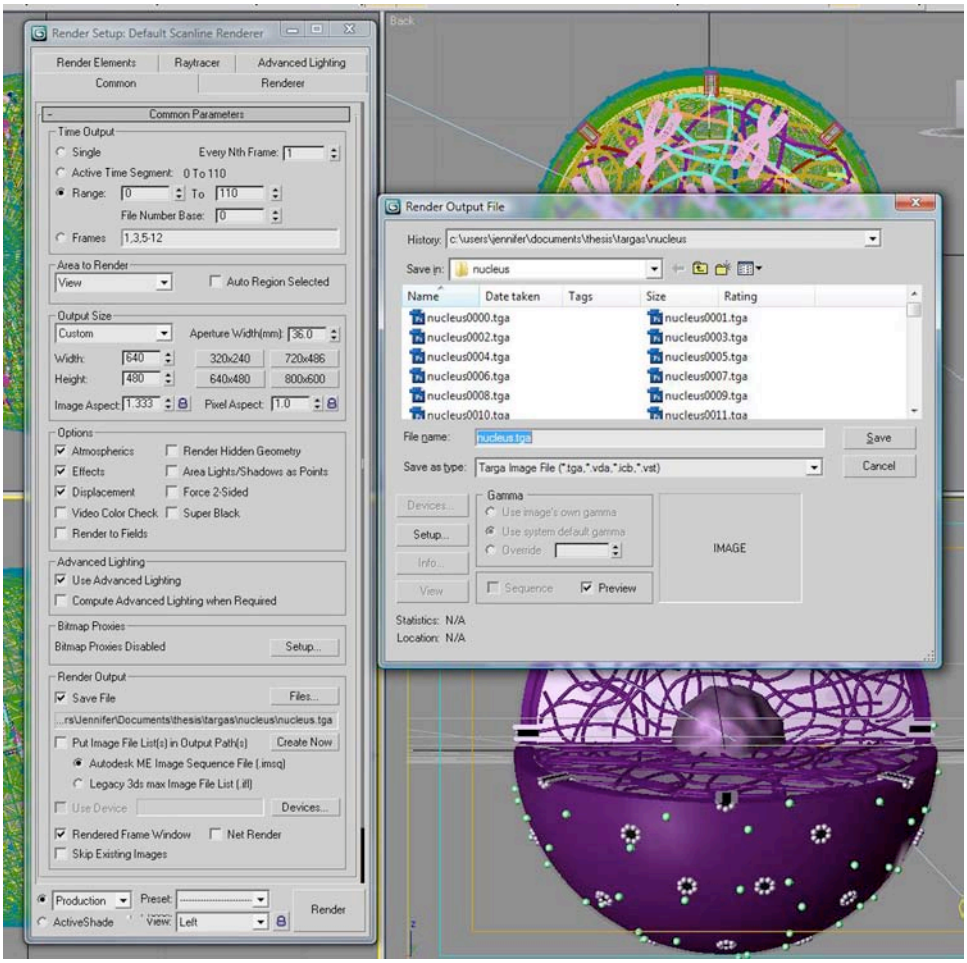


Figure 3-19. 3D Studio Max® Export Settings

Questions

Multiple choice questions were written for each organelle based on the information presented in the animation. After each organelle was presented in the animation the question was read aloud in the narration and the text appeared on the screen. "Pause

Now" then appeared on the screen after each question to instruct the teacher when to pause the animation. This allowed time for the teachers to hold a class discussion. Each question was created in its own composition in Adobe® After Effects.

Compositing the Animation

I decided to create individual compositions in Adobe® After Effects for each of the organelles, the plant and animal factories, and several compositions for the beginning and end of the animation to keep the number of layers low and to make the files less confusing. Each organelle has an introduction sequence including the cartoon character, the cell model, and an electron micrograph image (**Figure 3-20 - 3-23**).

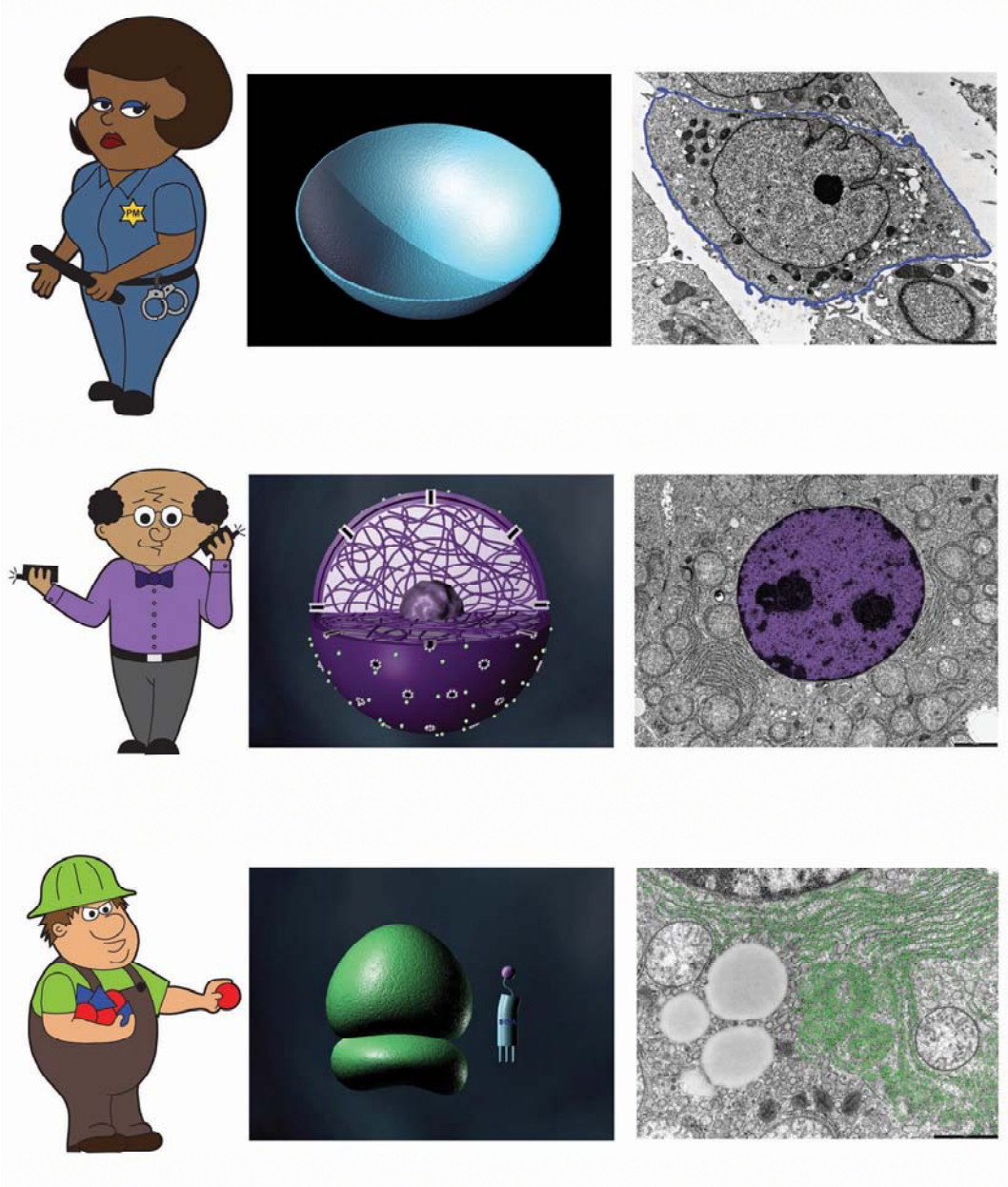


Figure 3-20. Coordinated Visuals for Individual Organelles

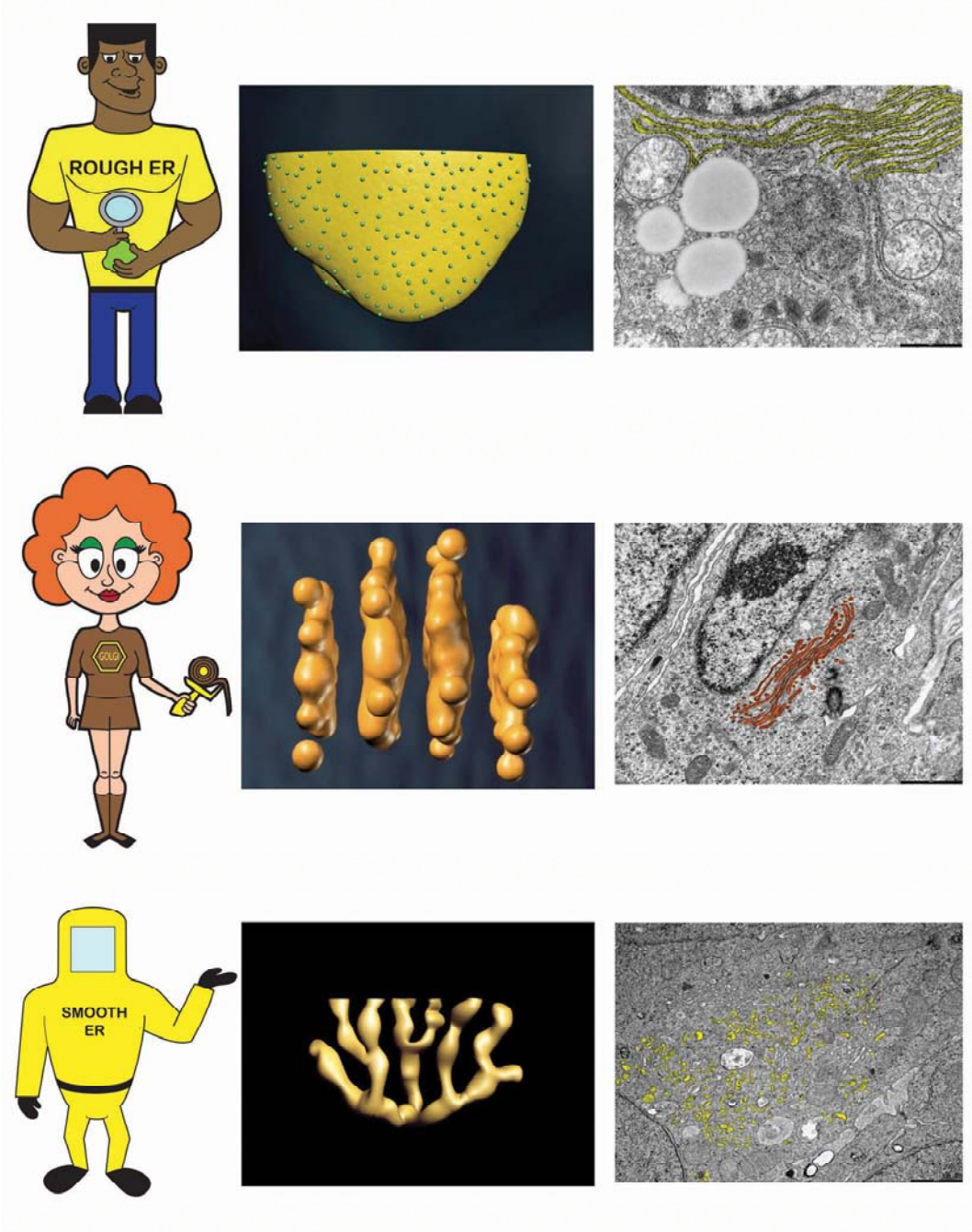


Figure 3-21. Coordinated Visuals for Individual Organelles

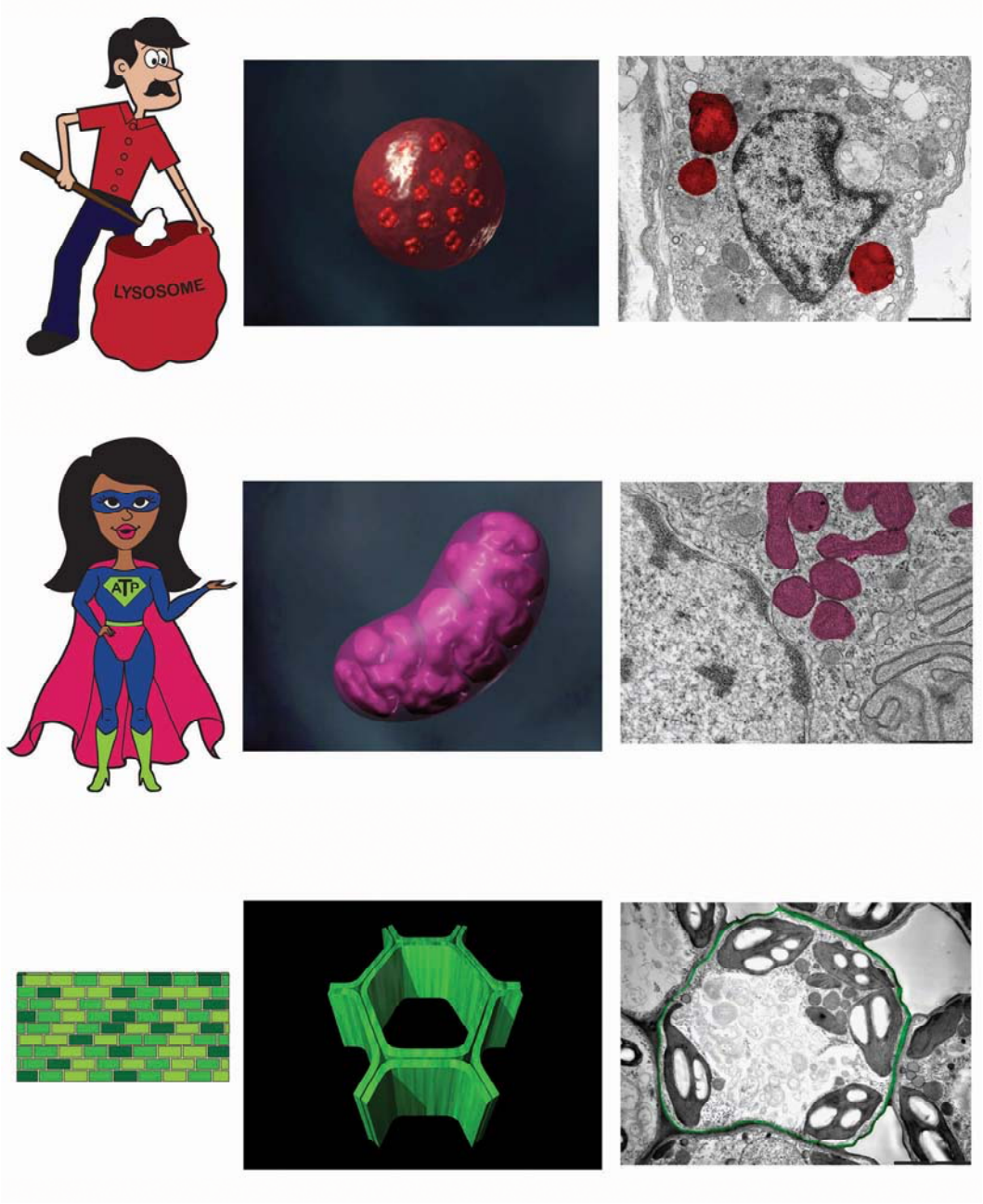


Figure 3-22. Coordinated Visuals for Individual Organelles

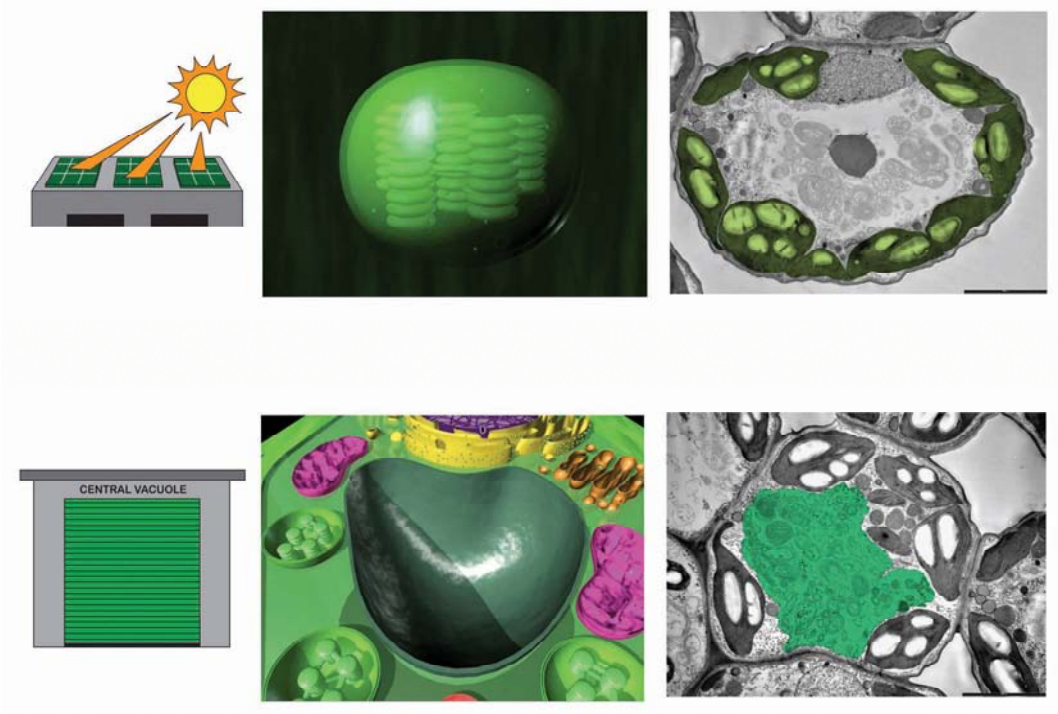


Figure 3-23. Coordinated Visuals for Individual Organelles

The introduction sequence is followed by the body of the animation, and the corresponding question. The introduction composition, targa files, and the question composition for each organelle was imported into a new composition and the narration segment was copied from Adobe® Premiere and pasted into the composition (**Figure 3-24**). The labels and leader lines were then added in Adobe® After Effects and the transitions between animation segments were created. The compositions were then imported into a final composition and transitions were added (**Figure 3-25**).

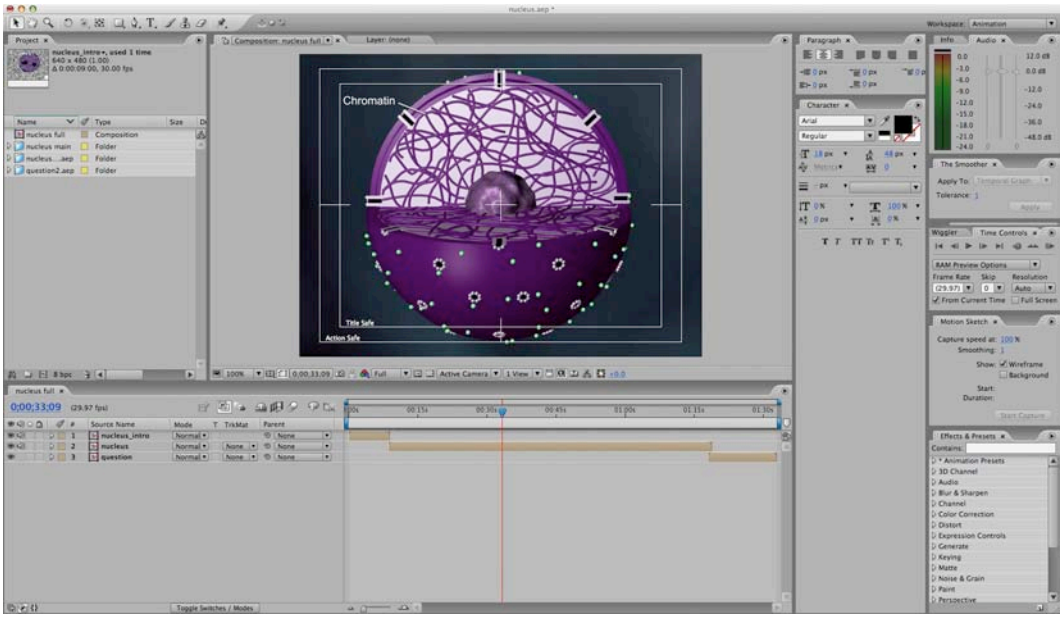


Figure 3-24. Nucleus Composition in Adobe® After Effects

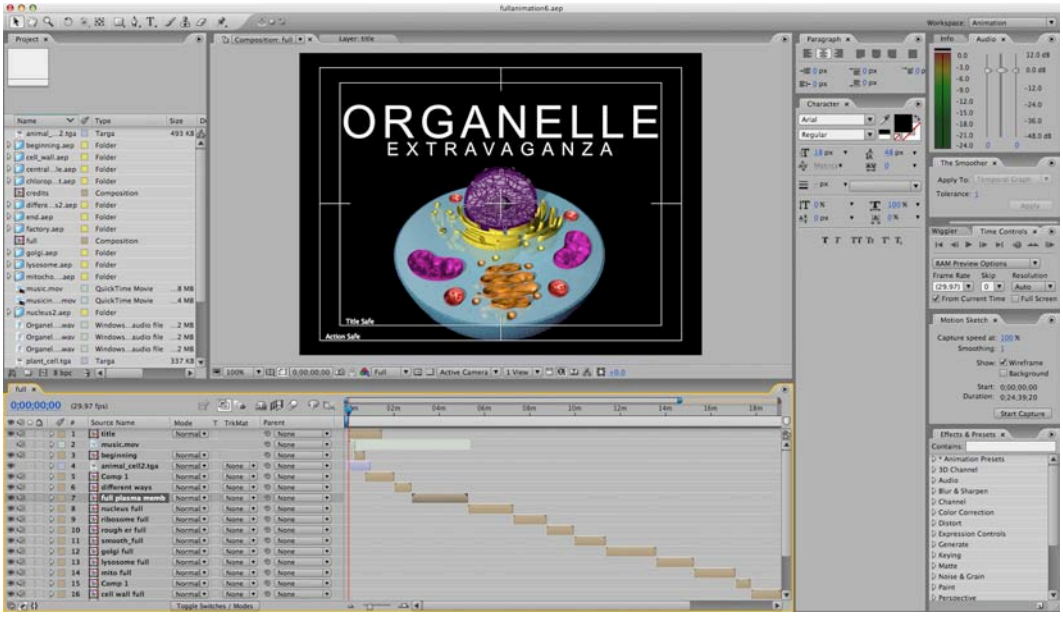


Figure 3-25. Full Animation Composition in Adobe® After Effects

The entire animation was exported as a compressed Quicktime .MOV file with the H.264 compression (**Figure 3-26**). The .MOV file was then imported into Adobe® Encore and chapters were added at the beginning of each organelle. The Adobe® Encore file was then burned to a DVD.

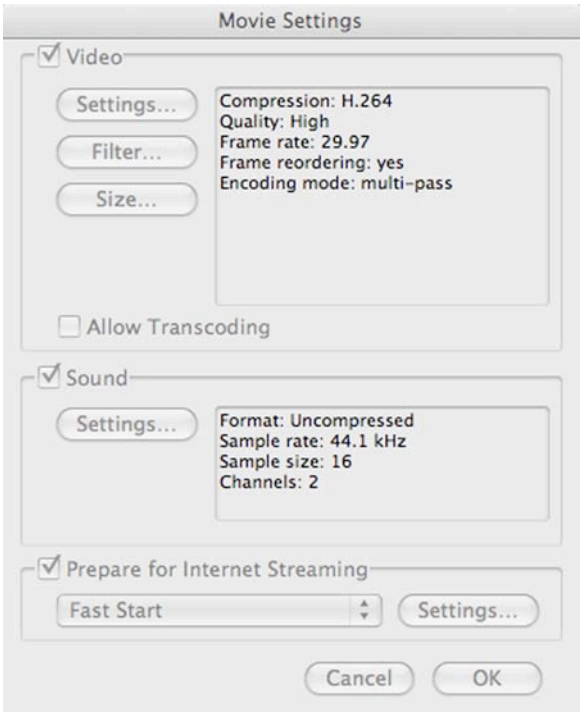


Figure 3-26. Quicktime Export Settings in Adobe® After Effects

Protein Production Game

The second element of the Science Suitcase was the interactive Protein Production Game. The original concept for the game began as a play performed by the students with groups of students performing the functions of the different organelles in the processes of cellular respiration and protein synthesis and secretion. It was decided that the format of

a play would be too slow, and that students would lose interest when not actively engaged. Several alternatives were discussed with the committee, and it was decided that it would be better to divide the class into several groups, and to make it into a competition. By creating competition between the groups, each student would need to be involved in the process and paying attention in order for their team to succeed. The game was altered accordingly.

Testing the Game

The first draft was then tested on the first and second year Biomedical Communication students. In the original prototype that was tested, each group would have ten members, each acting as a different organelle. They would be organized into a circle. The game would start with an endosome grabbing an envelope of food particles, or pizza pieces, from outside of the cell. Each envelope would have a different number of food particles inside. The endosome would then hand the envelope of food particles to the lysosome. The lysosome would take the pizza slices out of the envelope and give them to the mitochondrion. The endosome would then grab another envelope from outside of the cell and repeat the process until all the pizza slices were given to the mitochondrion. The mitochondrion would then arrange the pizza slices to form an entire pizza. Once the pizza was formed the mitochondrion could then signal to the nucleus to open the DNA box and take out the mRNA instructions for folding (making) a protein. The nucleus would then read the mRNA instructions aloud to the ribosome, who had a pre-labeled sheet of origami paper. The ribosome would then fold the origami protein. The ribosome would give the folded protein to the endoplasmic reticulum. The endoplasmic reticulum would

check to make sure the protein was folded correctly according to the endoplasmic reticulum check sheet and draw the face onto the protein. The endoplasmic reticulum would then hand the protein to the Golgi apparatus. The Golgi apparatus would place the protein into an envelope and label it "to: the outside of the cell" and hand it to the transport vesicle. The transport vesicle would go to the plasma membrane and ask permission to leave. The plasma membrane would let the transport vesicle out of the cell and the transport vesicle would take the envelope to the teacher.

Changes Made to the Game

The game was successful, but several suggestions were made to improve the prototype. One student suggested that the food particles be attached to each other so that the lysosome had to break them apart into smaller pieces. This was a great suggestion and made for a more accurate depiction of the lysosome's function. Another student suggested that a pizza pan be included for the mitochondrion to arrange the pizza slices inside. A committee member also suggested having the pizza slices spell out ATP with the toppings to reinforce the idea of the mitochondria actually producing ATP from the food particles. It was also suggested that only one envelope of food particles be used to be more accurate and not cause confusion with students thinking a cell cannot produce energy until it has a certain amount of food. During the original test, we tested the game with the nucleus giving the mRNA instructions to the ribosome and also with the nucleus reading the mRNA instructions aloud to the ribosome. It was much more effective when the nucleus read the instructions aloud. This also reinforced the idea that the nucleus was the control center of the cell. I also decided to have a DNA folder instead of a DNA box

to save space in the suitcase. All of these suggestions were taken into consideration and implemented into the final version of the game.

I decided that there would be one practice round, where the teacher could explain the concept and run through the process with the students for the first time. Then the relay race would start, and the students would have to run through three rounds and produce three proteins correctly in order to finish the game.

Game Materials

Each of the four rounds needed to be distinguished from one another, so I established a color-coding system. The elements of the practice round would be red (**Figure 3-27**), round one would be green, round two would be purple, and round three would be blue. It was important that the materials also be durable, since they would be used by many students. I bought red, green, purple, and blue plastic envelopes to hold the food particles. I also bought matching plastic folders that would serve as the DNA folders and hold the mRNA instructions. Labels were made for the envelopes and folders to establish which round they were to be used in. I also ordered eight-inch aluminum pizza pans for the mitochondrion to arrange the pizzas in.

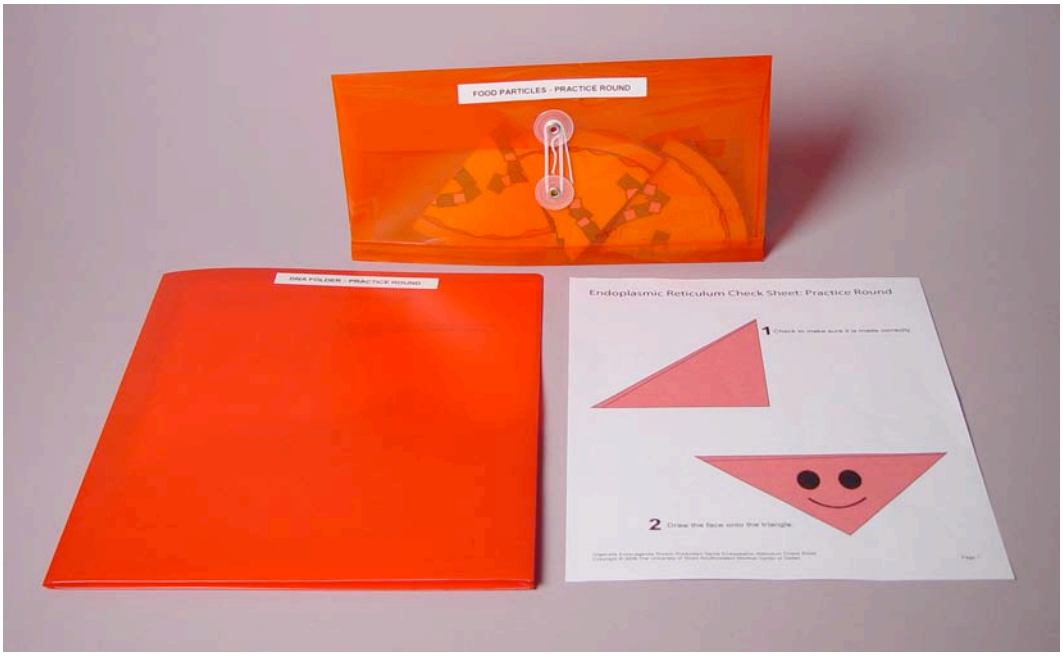


Figure 3-27. Protein Production Game Supplies Practice Round

Each group represented a hypothetical cell that produced animal shaped proteins. Since proteins are folded inside a cell, I decided that it would be fitting for the ribosome to fold an origami animal to represent the protein. I began by searching traditional origami instructions and chose several different examples. The practice round would be the easiest, and they would get harder in subsequent rounds. I designed the "mRNA Instructions" for each round in Adobe® Illustrator and wrote clear instructions for the nucleus to read aloud to the ribosome (**Figure 3-28**). I also assigned letters and numbers to the corners and folds of the origami paper to make the instructions easier to understand and follow. The same colors established for the rounds were used in the images on the mRNA instructions.

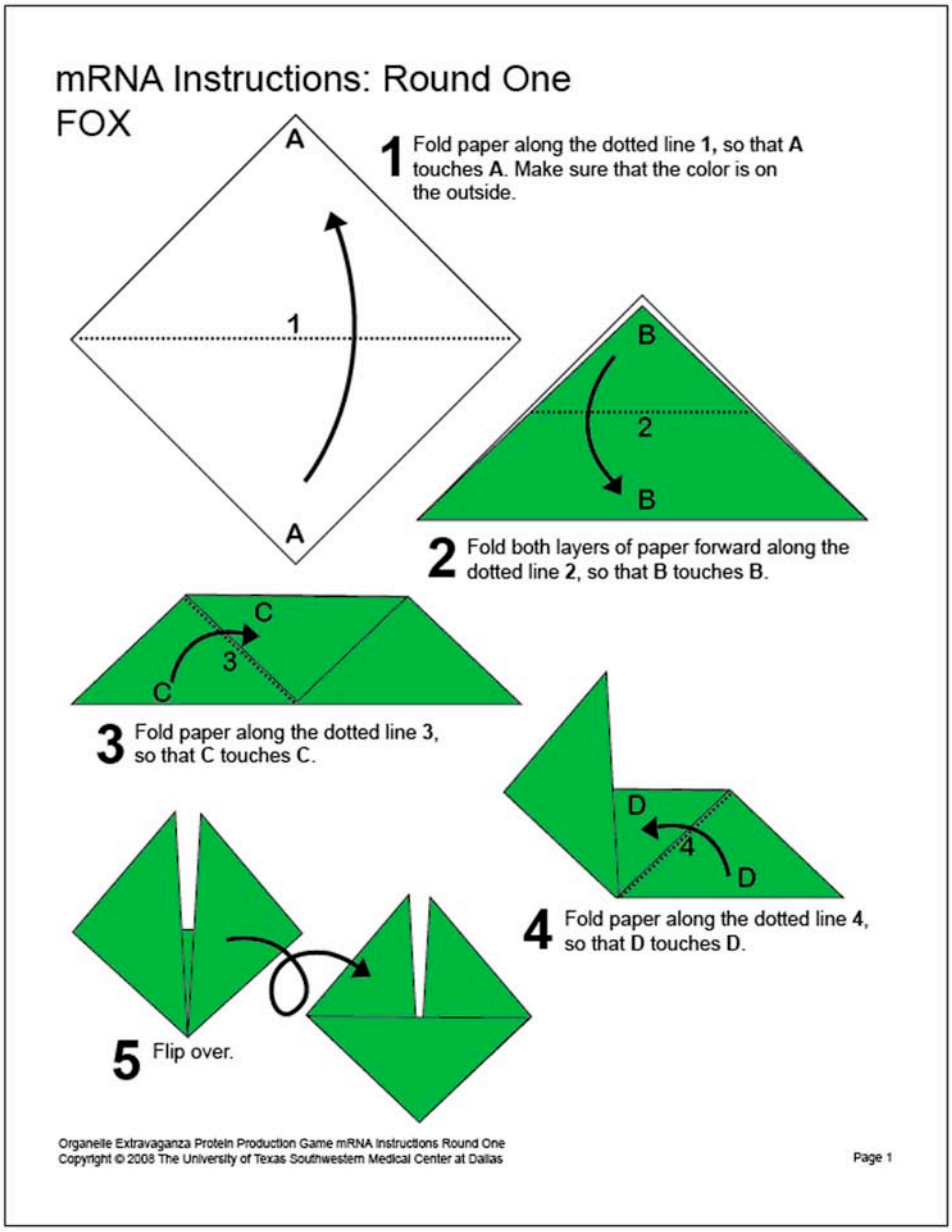


Figure 3-28. mRNA Instructions

After the mRNA instructions were created, I could use them to create the labeled "Origami Sheet" templates that the ribosome would use (**Figure 3-29**). The origami

paper had to be small enough to fit into a standard sized envelope when folded. They also needed to be able to be reproduced easily with a copy machine. I created a two-sided file that could be used to create a double-sided copy on a standard copy machine, and then the paper could be cut to the correct size along the dashed lines labeled "cut here."

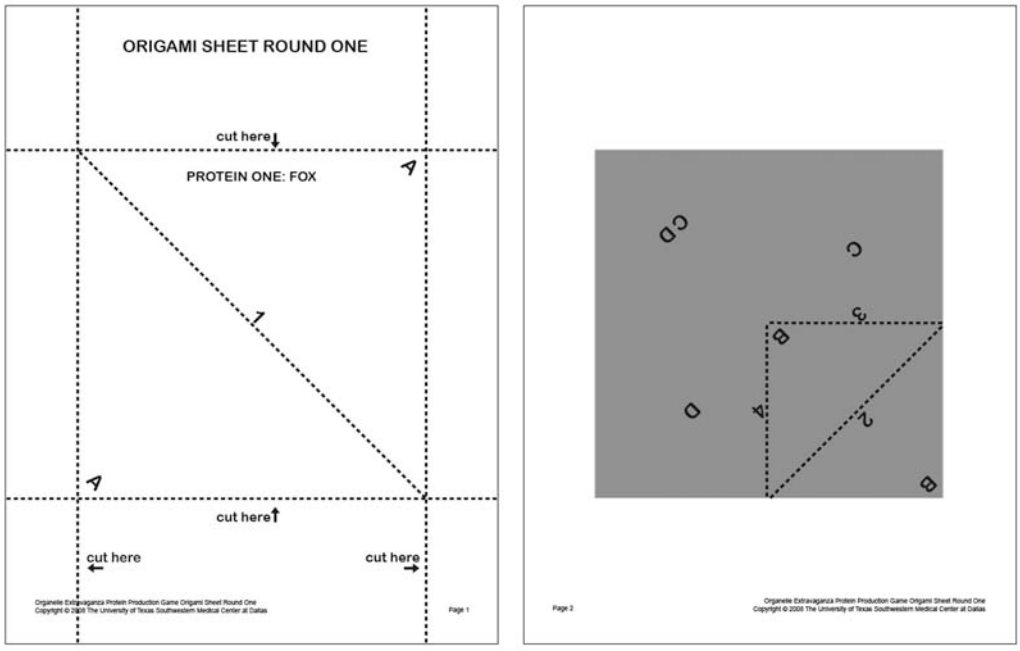


Figure 3-29. Labeled Origami Sheet

"Endoplasmic Reticulum Check Sheets" were also created (**Figure 3-30**). These sheets showed how the correctly folded proteins were supposed to look, and how the faces were supposed to be drawn.

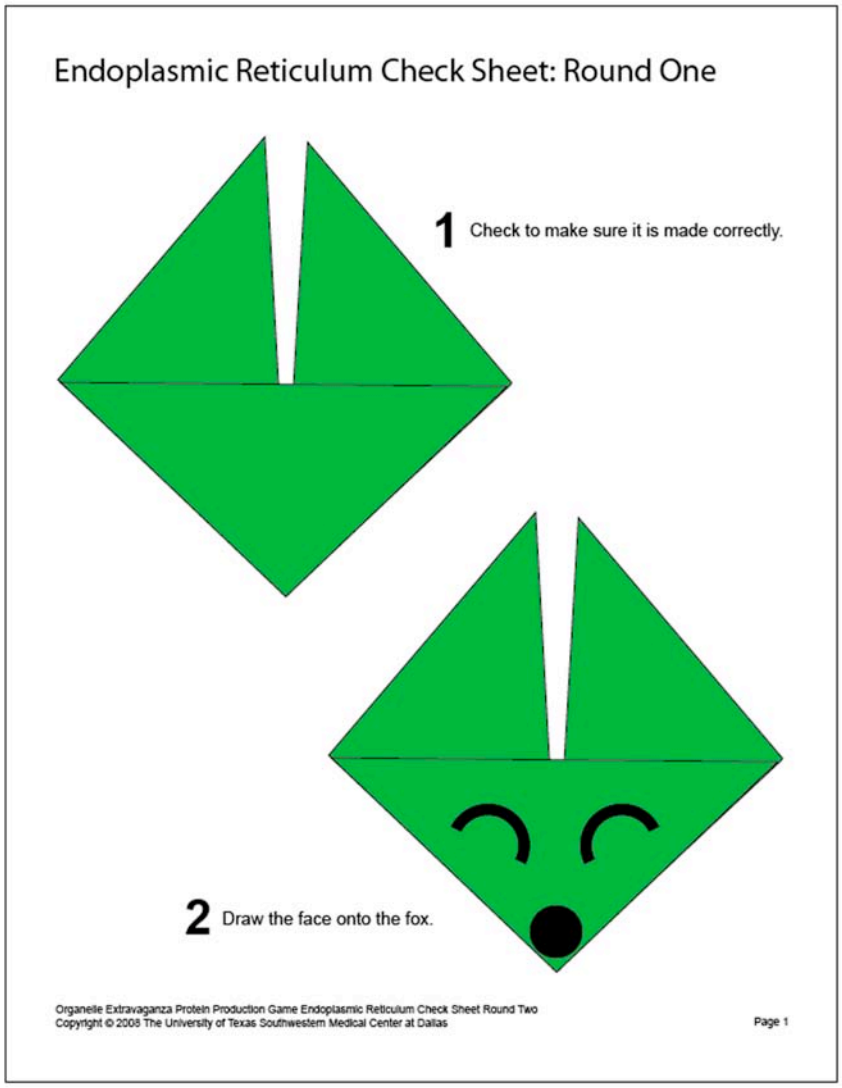


Figure 3-30. Endoplasmic Reticulum Check Sheet

I also created a "Cell Placement Chart" so that the students would know where they needed to be at the beginning the game (**Figure 3-31**). I used the colors from the nametags for the circles on the cell placement chart for consistency. The mRNA

instructions, endoplasmic reticulum check sheets, cell placement charts, and origami files were all printed and laminated so that they would be durable.

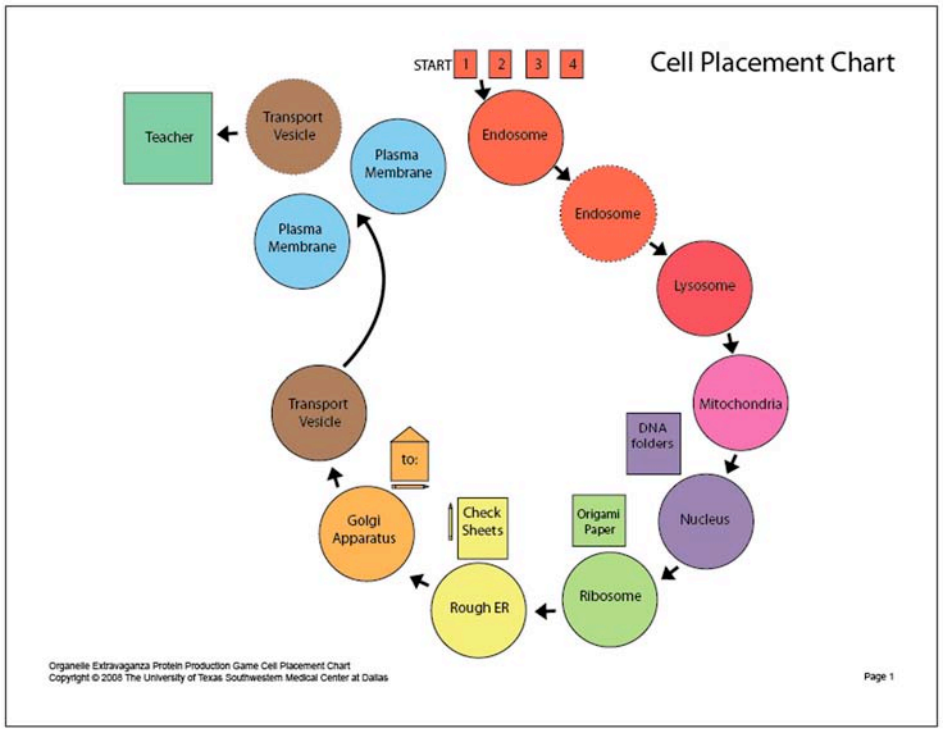


Figure 3-31. Cell Placement Chart

Name Tags

It was also very important for the game to be tied to the animation to reinforce the concepts addressed by the animation. In order to do this, I created name tags using the same cartoon characters used for the organelles in the animation with the name of the organelle next to each of the characters. The name tags were created in Adobe® Illustrator and were 12.5 inches long by 4 inches high (**Figure 3-32**).

Figure 3-32. Name Tag File

The pizzas were also created in Adobe® Illustrator and were 8 inches in diameter so that they would fit into the pizza pans. The base of all the pizzas remained the same, but there were four different toppings that spelled out ATP including pepperoni, sausage, vegetables, and mushroom (**Figure 3-33**).

Figure 3-33. Pizza Files

The pizza files and name tags were then saved as .PDF files and sent to the Museum of Nature and Science to be printed. Once printed the pizza files were attached to a piece of colored cintra (a light plastic) and laminated. Each different type of pizza was attached to a different color that corresponded to the plastic envelopes and was then cut into six slices. I then attached squares of Velcro to the back of the pizza slices so that they could be attached together and placed them into the color-coordinated envelopes (**Figure 3-34**).

Figure 3-34. Finished Pizza Slices

Each name tag was also attached to a colored piece of cintra, and each set had a different colored back so that they could be divided properly. The name tags were also laminated. Lanyards were then ordered by the Museum of Nature and Science. Then holes were drilled into the center of each name tag for the lanyards to be attached (**Figure 3-35**).

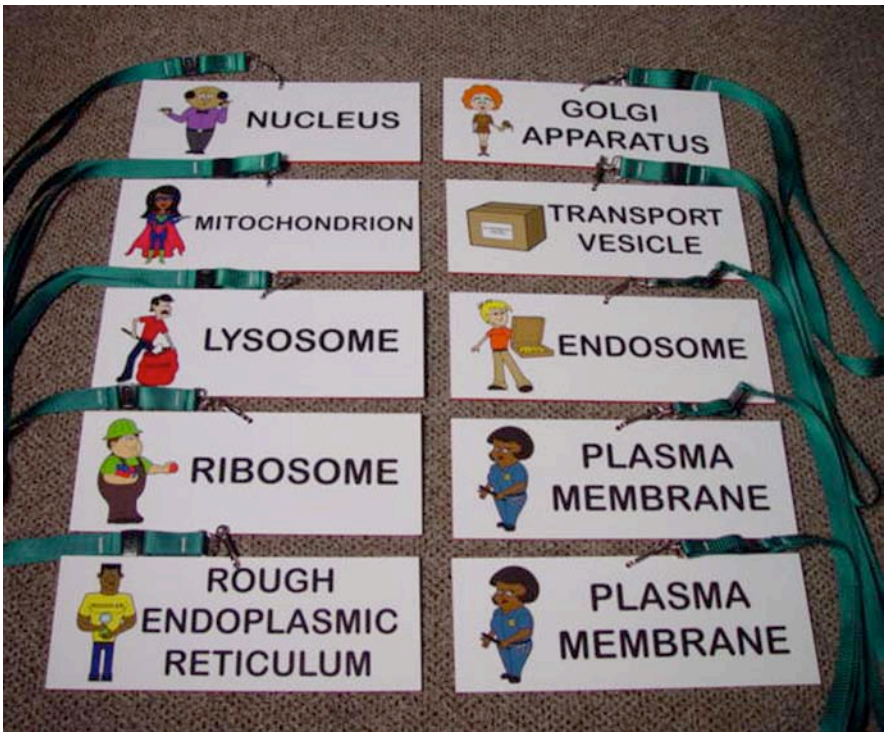


Figure 3-35. Finished Name Tags

Laboratory Experiments

A meeting was held with Amy Rommel at the beginning of the project. She suggested several different laboratory experiments for organelles and sent me the protocols (See Appendix F). From the experiments she sent, I chose to use the onion skin and cheek cell lab and the paper chromatography lab. I also liked the DNA extraction lab, but I was informed that the exact same experiment was used in the summer workshop. I also decided to include a feeding paramecia lab. I researched each of these labs on the Internet and found several different protocols. From what I learned, I created my own protocol for each of the labs with Amy's help.

Testing the Laboratory Experiments

The next step was testing the experiments. I met with Amy several different times to test each of the experiments, and had a high school student that was interning in Amy's lab run the experiments two of the times.

Feeding Paramecia Laboratory

For the first trial I ordered a live *Paramecia caudatum* culture from www.wardsci.com (**Figure 3-36**). I ordered the culture on a Tuesday and it arrived on Friday morning. We decided that I should suggest that the culture be ordered on a Monday for a Friday lab. We tried making a ring on a blank microscope slide with PEG and another ring on a second microscope slide with glycerol to contain the paramecia culture fluid. Neither one was very effective, so we decided that it would be best to buy slides with depressed wells.

Figure 3-36. *Paramecia caudatum* Live Culture

The paramecia were easily viewed and very large even under low magnification (**Figure 3-37**). They were moving fairly quickly, so we briefly placed the slide in the freezer to slow them down. This method was very effective.

Figure 3-37. *Paramecia caudatum*

For the feeding section of the lab we used a 1mL overnight culture of yeast from Amy's lab and added a pinch of Congo red indicator and diluted it with 50mL of distilled water. This mixture seemed to be very effective, and we could see the paramecia take the yeast in through their oral groove and observe the food vacuole as it passed through the body, fused with the lysosomes, and changed color (**Figure 3-38**). We decided however that it would be best to try the experiment again using dry yeast from the grocery store, because it would be easier to include in the suitcase.

Figure 3-38. *Paramecia caudatum* Feeding on Yeast Stained with Congo Red Indicator

The next two times we tested the experiment, a high school student ran them and gave some input. Amy gathered a water sample from the Trinity River to see if we could include another option for teachers. We found some paramecia, but they were very small and you could not observe the structures clearly. We decided that this was an unreliable source. The high school student suggested that I include a better explanation of lysosomes in the introduction and explain how the paramecia move. We tried two different types of dry yeast from the grocery store, Feischman's Dry Active Yeast and Feischman's Rapid Rise Yeast. We soaked a small amount of each of the yeast types in 10mL of water. The Rapid Rise Yeast was unsuccessful and caused the paramecia to either regurgitate the yeast or explode. The Dry Active Yeast, however, was very successful and we decided to include it in the suitcase. We also tried a different method for slowing the paramecia down in this trial. We added a small amount of glycerol to the

culture in the well, and it caused the paramecia to explode and shrivel up. As a result we decided that cooling them would be the best solution, and I included several ice packs for the teachers to use. We also thought it would be a good idea to have slides with two well depressions so that they could have one with yeast added and one without. The high school student was able to successfully run the lab and answer all of the questions. Changes were made, and the final protocol was tested again and approved.

Animal and Plant Cell Laboratory

We began by testing the onion skin section of the lab. I bought a red, white, and yellow onion to see if they would have different results. We began by cutting the onion and separating the layers. It worked best when we scored the underside of the onion sections and created small squares, and then used curved forceps to pull the thin membrane starting at a corner (**Figure 3-39**).

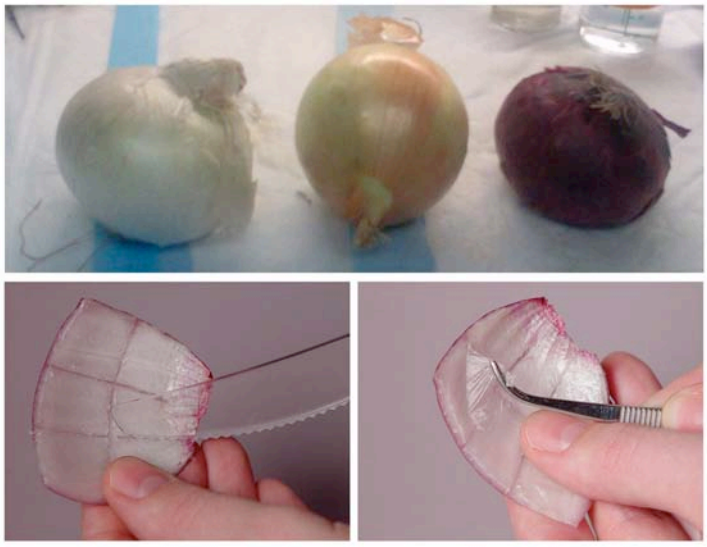


Figure 3-39. Onions, Scoring, and Peeling Membrane

In the first trial we tested several different stains to see which one worked the best. These stains included Congo red indicator, methylene blue, bromophenol blue, Coomassie brilliant blue, Ponceau S, and iodine (**Figure 3-40**).

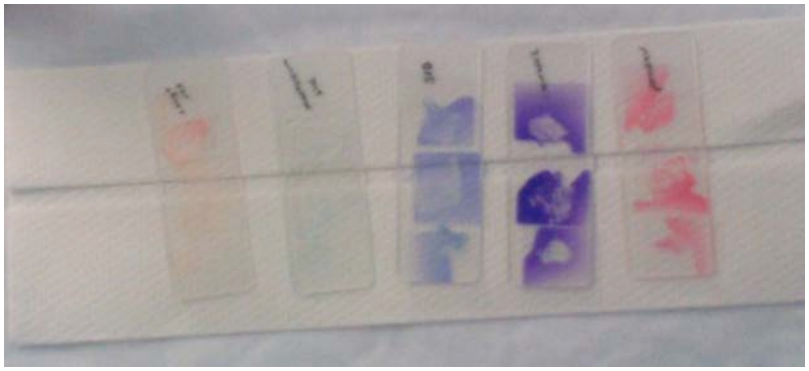


Figure 3-40. Onion Skin Slides

The methylene blue and iodine worked best, but we decided to include only one stain for each cell type and chose iodine for the onion skin since it showed the nucleus, cell wall, and starch very well (**Figure 3-41**). We also thought it would be nice to have the students view an untreated slide so that they could compare the two.

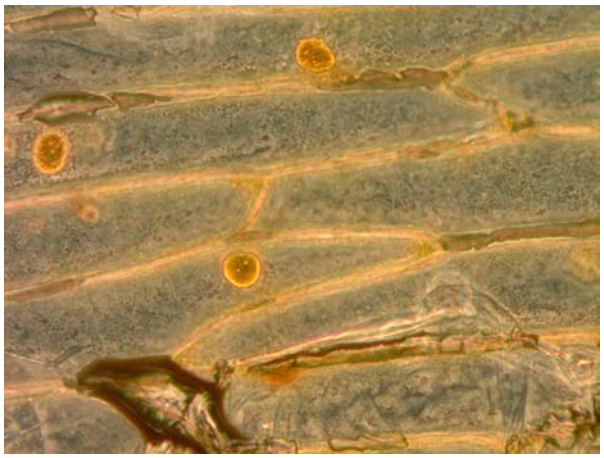


Figure 3-41. Onion Skin Stained with Iodine

With the cheek cell lab we also tried several stains including Congo red indicator, methylene blue, bromophenol blue, coomassie, ponceau S, and iodine (**Figure 3-42**).

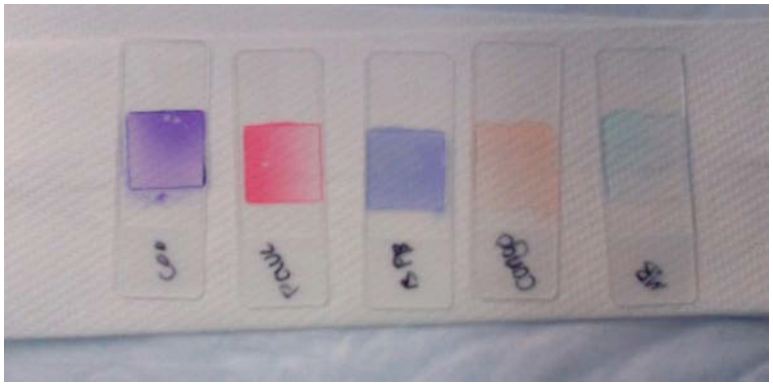


Figure 3-42. Cheek Cell Slides

The methylene blue stain worked best for the cheek cells and we decided to include it as well (**Figure 3-43**). The high school student was able to perform the final lab and answer the questions correctly.

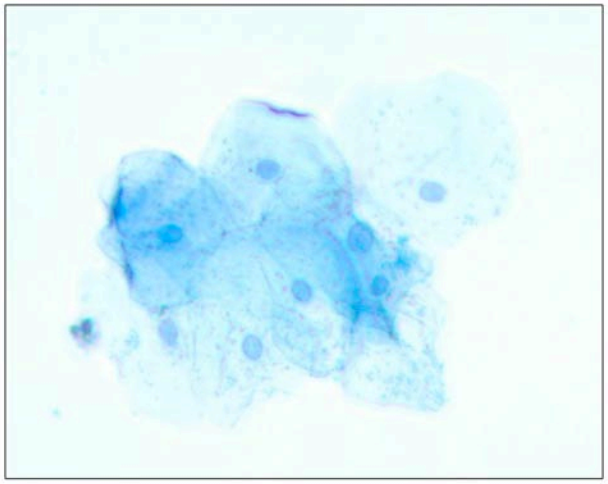


Figure 3-43. Cheek Cells Stained with Methylene Blue

Paper Chromatography Laboratory

For the paper chromatography experiment, we tested many different solvents over a series of trials. The solvent that worked the best was a 9 to 1 solution of petroleum ether and acetone. The pigment separated into very distinct color bands (**Figure 3-44**). We could not include petroleum ether and acetone in the suitcase however because they are highly flammable and would not be safe to transport. So we tried to find a better solution using something less flammable such as vinegar or Lysol. No other solvent that we tried had such clear and effective results, so we decided that we would write the protocol for the petroleum ether and acetone solvent, and the teachers could either get the solvent from their chemistry department or order the solvent.

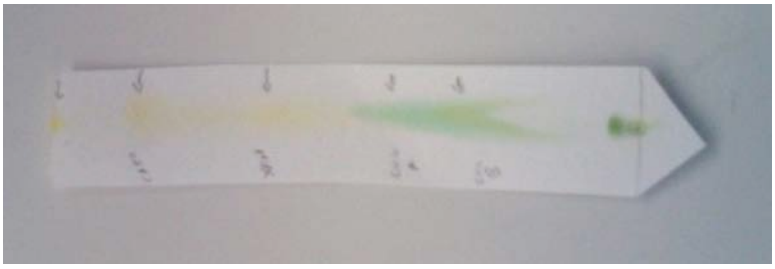


Figure 3-44. Chromatogram

When we ran the lab with the high school student, it became clear that we needed to add several notes in the protocol. I explained how a capillary tube works a little better and made a note that they needed to only get the fluid from the pigment solution and not actually pick up pieces of spinach. I also made a note for the students not to use too much isopropyl alcohol when making the pigment solution and not to poke a hole in the filter paper with the capillary tube when applying the pigment. It was also very important

that the pigment spot be dark and concentrated. These additions were made, and the final protocol was tested on the high school student. She was able to perform the experiment correctly and answer all of the questions.

Ordering the Supplies

After all of the laboratory experiment protocols were tested and approved, I could begin ordering the supplies that I would include in the suitcase. It was important not to assume that the high schools in the DISD had any supplies. I could not include the live paramecia culture in the suitcase, but I provided the link and catalogue numbers for ordering. I also could not include the onion for the onion skin lab or the spinach for the paper chromatography lab, but these items could be easily found at a local grocery store. The petroleum ether, acetone, and isopropyl alcohol could also not be included because they were flammable. I chose not to include a hot plate for the feeding paramecia lab because it was not absolutely necessary and it would take up a lot of room in the suitcase. I also chose not to include graduated cylinders or beakers since they are common laboratory supplies. I ordered the remaining supplies through Ward's Science and Fisher Scientific.

The chromatography tubes required some assembly, since I could not find any that were ready-made (**Figure 3-45**). To create them, I bought large test tubes and the corresponding solid rubber stoppers. Then I had to find something for the paper to hang from inside the tube. In one of the protocols I found online, it suggested using a paper clip that was pushed through the rubber stopper, but I wanted to make something more

substantial. I then made a trip to the hardware store and found brass hooks with screws at the end. I then screwed the hooks into the center of the rubber stopper.

Figure 3-45. Chromatography Tubes

Teacher's Manual and Student Handouts Booklet

Two very important aspects of the Science Suitcase were the Teacher's Manual (See Appendix G) and the Student Handouts Booklet (See Appendix H). The suitcase needed to be very user friendly, and the Teacher's Manual and Student Handouts Booklet would be instrumental in accomplishing this. The first step of creating the Teacher's Manual was designing a template. I created a first draft of the layout for the laboratory experiments and then worked with Susan Douglass, an adjunct professor for the Biomedical Communication Program at UTSW Medical Center, to make the graphic

design elements more modern. The steps needed to be easily discernable, so I chose to make the numbers very large and separated by dashed lines (**Figure 3-46**).

ORGANELLE
EXTRAVAGANZA

LAB 2: Separation and Identification of Chloroplast Pigments Through Paper Chromatography Teacher's Manual

Time Required: One Class Period

Organelles to Study: Chloroplast

OBJECTIVES

1) Identify the pigments found in chloroplasts.
2) Provide an introduction to Paper Chromatography.

INTRODUCTION

Plants use **chloroplasts** found inside their leaves to capture light that is used in **photosynthesis** to produce energy. Light is composed of different **wavelengths**. The efficiency of plants at capturing light is increased by the variety of light absorbing **pigments** found inside the chloroplasts. By having several different pigments the plant can absorb a wider range of wavelengths of light.

There are several different groups of pigments. **Chlorophylls** are green pigments that are most effective in driving photosynthesis. There are two types of chlorophyll pigments. **Chlorophyll B** is yellow-green, while **chlorophyll A** is blue-green. **Carotenoids** are **accessory pigments** that can drive photosynthesis but some carotenoids also function as **photoprotectors** by absorbing and scattering excessive light energy that would otherwise damage chlorophyll. Of the carotenoids, **xanthophylls** are yellow and **carotenes** are orange-yellow. Chlorophyll typically hides these other pigments until the fall, when the chlorophyll breaks down revealing xanthophyll and carotene.

The different pigments present in a leaf can be separated into bands of color using a technique known as **paper chromatography**. In paper chromatography the individual components of a mixture are separated based on their **solubility**. The pigments in plants have different solubilities and will separate depending on their attraction for a **stationary phase** (the filter paper) or a **mobile phase** (the solvent). The pigments will separate as the **solvent** moves up the filter paper and will show up as colored streaks. Pigments with a stronger attraction to the filter paper than to the solvent will move more slowly than the pigments with a strong attraction to the solvent and will separate first.

Organelle Extravaganza Lab 2: Paper Chromatography Teacher's Manual
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MATERIALS

Need to be bought ahead of time:
- Fresh spinach leaves

Not Provided:
- Safety goggles
- Lab aprons
- Chromatography Solvent
  - Acetone 10
  - Petroleum Ether 90
- Isopropyl Alcohol (rubbing alcohol found at drug stores)
- Graduated Cylinders (2)
- Beaker

Provided in the science suitcase:
- Disposable pipettes (2 for the teacher setup)
- Test tubes (36- one per student)
- Rubber stoppers with hooks for hanging (36- one per student)
- Test tube racks that hold six (6- one per lab group)
- Test tube brush (6- one per group)
- Mortar and pestle (6-one per lab group)
- Filter paper cut into 1 cm x 15 cm strips
- Glass dropper bottles for isopropyl alcohol (6- one per lab group)
- Capillary tubes (15- one for every two students)
- Colored tape (6- one roll per lab group)
- Markers (6- one per lab group)
- Colored pencils (6- one box per lab group)
- Scissors (6- one per lab group)
- Rulers (12- two per lab group)

PRE-LAB PREPARATION

- Buy fresh spinach leaves at the grocery store.
- Order or pick up acetone (you can use nail polis remover), petroleum ether, and isopropyl alcohol (rubbing alcohol) if you do not have available at your school.

Page 2 Organelle Extravaganza Lab 2: Paper Chromatography Teacher's Manual
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TEACHER SETUP

1 Prepare chromatography solvent using graduated cylinders and a beaker (make enough solvent for each student to have 5 mL. (200 mL for 40 students):
- 1 part acetone (20 mL for 200 mL of solvent)
- 9 parts petroleum ether (180 mL for 200 mL of solvent)

Note: Chromatography solvents are flammable and toxic. Have no open flames; maintain good ventilation; avoid inhaling fumes. Keep stored in a closed container. Preparing the solvent under a fume hood is recommended.

2 Using a disposable pipette, transfer approximately 5 mL of chromatography solvent into enough test tubes for each student to have one and insert a rubber stopper to seal. Place six test tubes into each test tube rack.

3 Using a different disposable pipette, transfer a small amount of isopropyl alcohol into enough glass dropper bottles labeled "Isopropyl Alcohol" for each lab group to have one.

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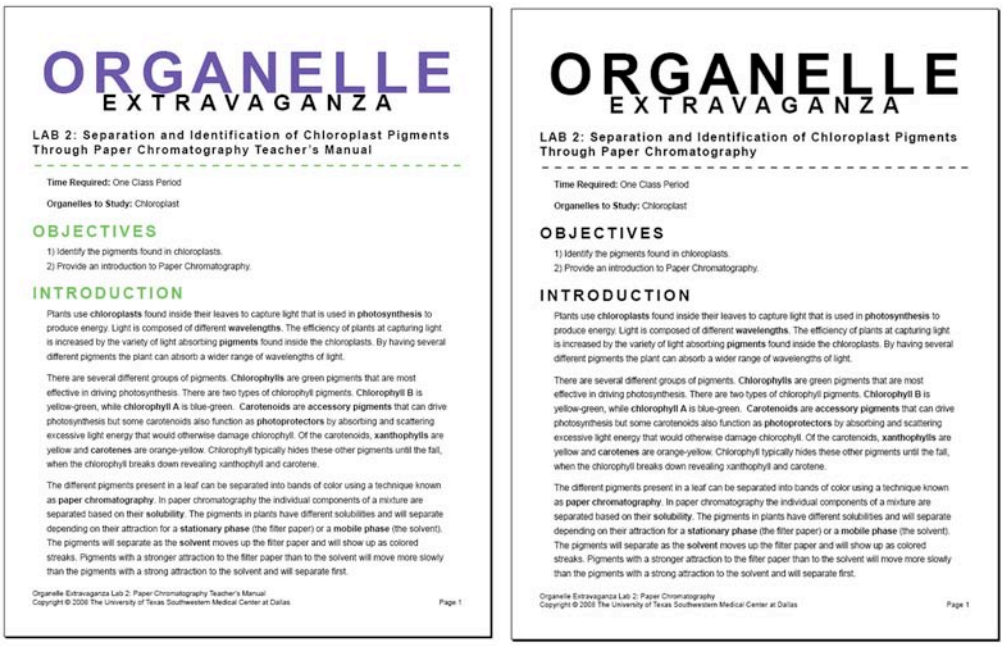
Figure 3-46. Layout Template

I also chose to include photographs to make the manual easier to follow. To take the photographs I set up a photography light and a digital camera on a tripod. I tried several different backgrounds when taking the photographs. Originally I used a black box made from foam board. The foam board was too reflective and the box created a horizon line which was distracting. The next background I tried was a black sheet pinned to the wall and draped over a table. This eliminated the horizon line, but every wrinkle was visible. After viewing the photographs with my committee, we decided that a black background was not the best choice for all of the elements, and that it was important for the photographs to be consistent. We decided that a gray background would probably be best. We found several large mat boards in varying degrees of gray. I set up the mat board by taping it to the wall and also to a table that was pushed up against the wall. This eliminated the horizon line and was much less distracting. I then took several test photographs on each of the four gray mat boards and sent them to my committee. A mid-tone gray was chosen for the background and the remaining photographs were taken with this background. The photographs were then implemented into the layouts.

I chose to make the teacher's manual in color and the student handouts booklet in black and white so that it would be easier to photocopy (**Figure 3-47**). Both the teacher's manual and student handouts booklet were printed and laminated to make them more durable. They were also spiral bound so that they could be photocopied easily and would also lay flat on a table. Tabs were also added for clarity and to provide easy access to the individual components.



ORGANELLE
EXTRAVAGANZA

LAB 2: Separation and Identification of Chloroplast Pigments Through Paper Chromatography Teacher's Manual

Time Required: One Class Period

Organelles to Study: Chloroplast

OBJECTIVES

1) Identify the pigments found in chloroplasts.
2) Provide an introduction to Paper Chromatography.

INTRODUCTION

Plants use **chloroplasts** found inside their leaves to capture light that is used in **photosynthesis** to produce energy. Light is composed of different **wavelengths**. The efficiency of plants at capturing light is increased by the variety of light absorbing **pigments** found inside the chloroplasts. By having several different pigments the plant can absorb a wider range of wavelengths of light.

There are several different groups of pigments. **Chlorophylls** are green pigments that are most effective in driving photosynthesis. There are two types of chlorophyll pigments. **Chlorophyll B** is yellow-green, while **chlorophyll A** is blue-green. **Carotenoids** are **accessory pigments** that can drive photosynthesis but some carotenoids also function as **photoprotectors** by absorbing and scattering excessive light energy that would otherwise damage chlorophyll. Of the carotenoids, **xanthophylls** are yellow and **carotenes** are orange-yellow. Chlorophyll typically hides these other pigments until the fall, when the chlorophyll breaks down revealing xanthophyll and carotene.

The different pigments present in a leaf can be separated into bands of color using a technique known as **paper chromatography**. In paper chromatography the individual components of a mixture are separated based on their **solubility**. The pigments in plants have different solubilities and will separate depending on their attraction for a **stationary phase** (the filter paper) or a **mobile phase** (the solvent). The pigments will separate as the **solvent** moves up the filter paper and will show up as colored streaks. Pigments with a stronger attraction to the filter paper than to the solvent will move more slowly than the pigments with a strong attraction to the solvent and will separate first.

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ORGANELLE
EXTRAVAGANZA

LAB 2: Separation and Identification of Chloroplast Pigments Through Paper Chromatography

Time Required: One Class Period

Organelles to Study: Chloroplast

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Figure 3-47. Teacher's Manual and Student Handouts Booklet

Pre-Test and Post-Test

Something needed to be developed to determine if the suitcase helped students understand the topic of organelles. I developed a test that consisted of five questions to be given to the students before they used the components of the Science Suitcase and after they used it (**Figure 3-48**). The questions were based on information presented in the animation, protein production game, and laboratory experiments. I used a multiple choice format similar to that found in the textbooks used by the DISD and in the TAKS test.

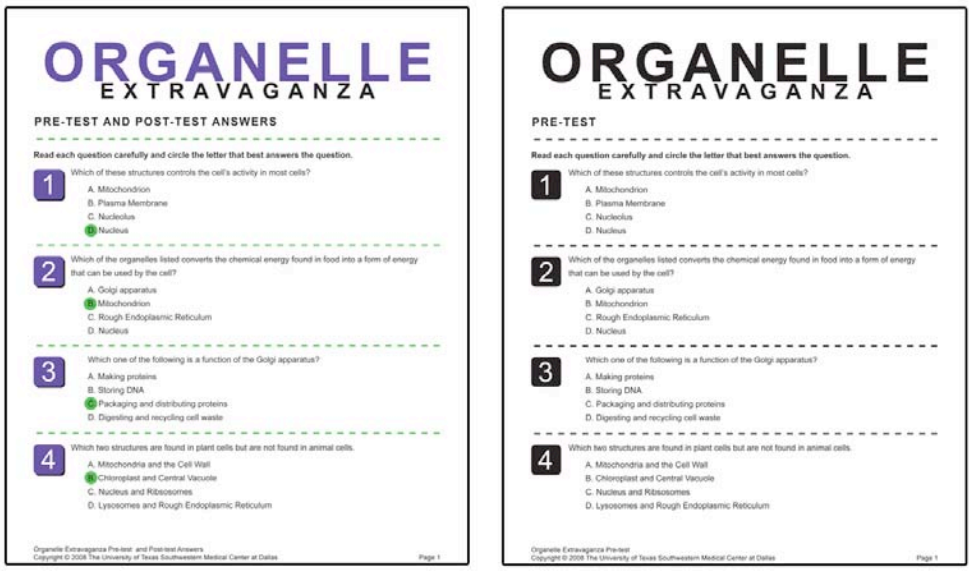


Figure 3-48. Pre-Test and Post-Test Teacher's Manual and Student Handout

The Suitcases and Containers

Choosing the Suitcase

One of the final steps was to order the physical suitcases themselves. We chose to use Pelican™ Cases for this project because they were watertight, crush proof, and dust proof. The cases also had retractable handles and wheels for easy transport and had a place for a padlock to protect the contents from theft. They also included Pick 'N' Pluck™ foam that was precut into ½ inch squares for easy removal. This foam allowed me to create specialized holes inside the foam for each of the suitcase elements. Because of feedback that the previous Science Suitcase was too large and difficult to transport, I selected to use two smaller Pelican™ Cases and ordered two of the 1620 Case. The interior dimensions of this case were 21.37" X 16.31" X 12.56" and the exterior dimensions were 24.81" x 19.37" x 13.87."

Choosing the Containers

Before I could order the Pelican™ Cases however, I needed to find containers for all of the lab supplies, game materials, the teacher's manual and student handouts booklet, and the DVD, and make sure that they would all fit in the cases I had selected. I began with the lab materials. I gathered them all together and brought them to the Container Store. I spent the day looking for containers that would fit the interior dimensions of the case. I ended up having several containers for each lab, and all but one of them would fit into one of the suitcases.

Finding the containers for the game materials was a little more difficult. I wanted to have one container for all of the supplies but when the nametags had the lanyards attached to them they took up much more space than I had anticipated. After several different trials, I ended up finding two containers at Office Max that worked perfectly. One large plastic container would hold the nametags, and a second plastic container, which was divided into two smaller containers that were connected to each other, would hold the remaining supplies. Both containers had handles, which made them easier to transport. I also found a plastic container to hold the teacher's manual, student handouts booklet, and DVD.

Labeling the Containers

After I was confident that all of the materials would fit into two 1620 Pelican™ Cases, I had the Museum of Nature and Science order them for me. The next step was to label all of the individual containers so that the teachers would know which containers belonged

to each activity. I used a Dymo LetraTag to create labels on plastic label paper so that they would be durable. For example, the labels for the three Animal and Plant Cell Lab boxes read "Lab 1: Animal and Plant Cell 1," "Lab 1: Animal and Plant Cell 2," and "Lab 1: Animal and Plant Cell 3" (**Figure 3-49**). I made labels for all of the containers.

Figure 3-49. Labels

Photographing the Containers

After the labels were made, I took photographs of each of the containers with their components to include in the teacher's manual. I took one photograph of the container with its materials laid out in from of it to include in a "Supplies" page that would be at the beginning of each activity and would list the materials included in each container (**Figure 3-50**).

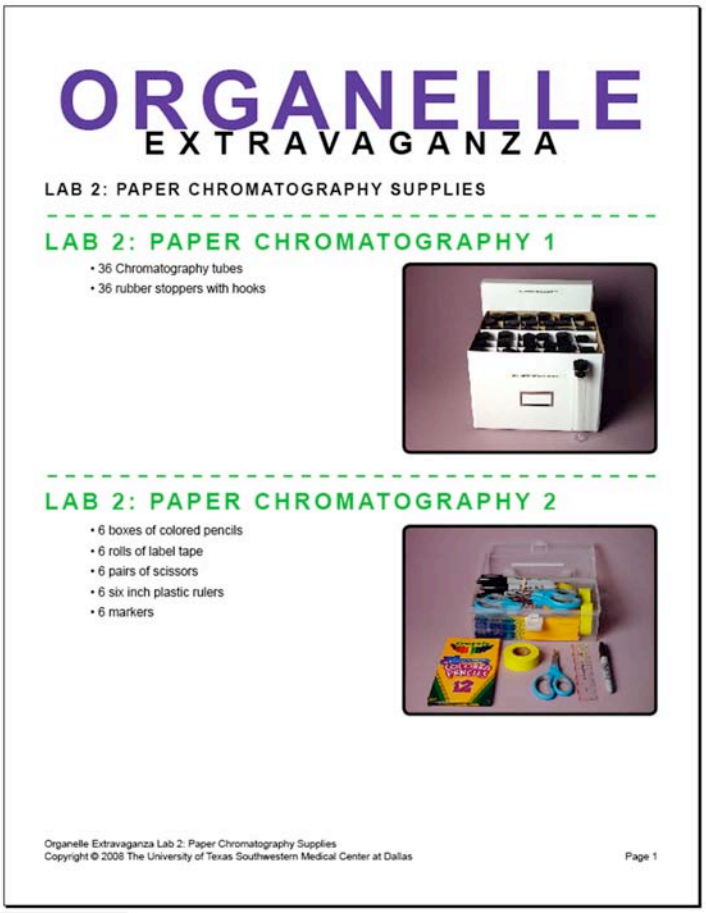


Figure 3-50. Supplies Page

I also took a photograph of each container with the materials packed inside to include in the "Clean Up" section so that the teachers would know how to store the materials (**Figure 3-51**).

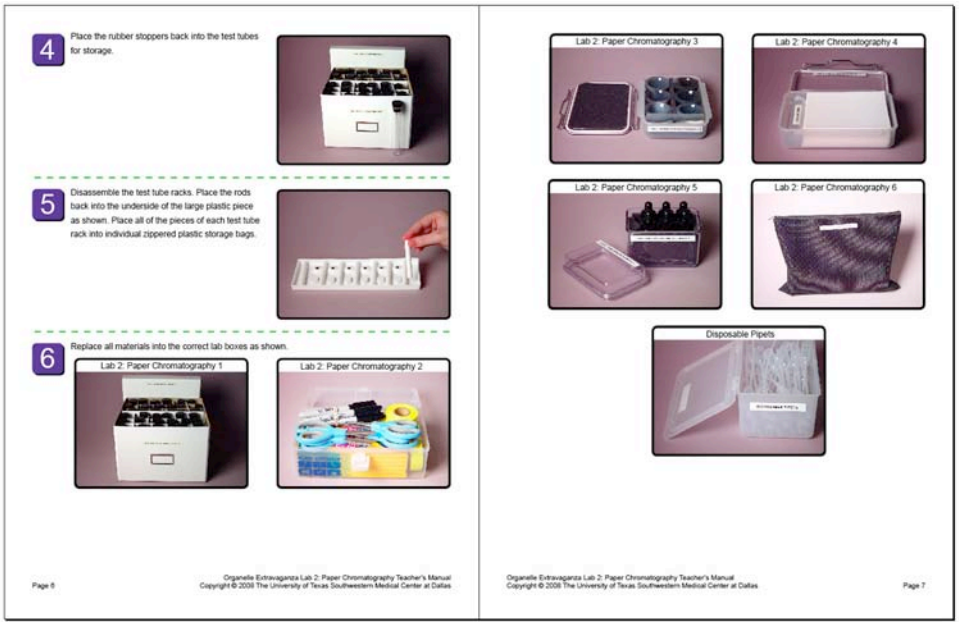


Figure 3-51. Clean Up

Fitting the Containers Inside the Suitcases

Once the suitcases arrived, the next step was to find the most efficient way to store the containers inside the suitcases. I decided that I wanted the majority of the lab materials in one suitcase and the game materials, teacher's manual, student handouts booklet, and DVD in the other suitcase. I began with the lab containers suitcase. I measured each of the containers and made paper cutouts the same size as each of them so I could figure out the best placement inside the suitcase (**Figure 3-52**).

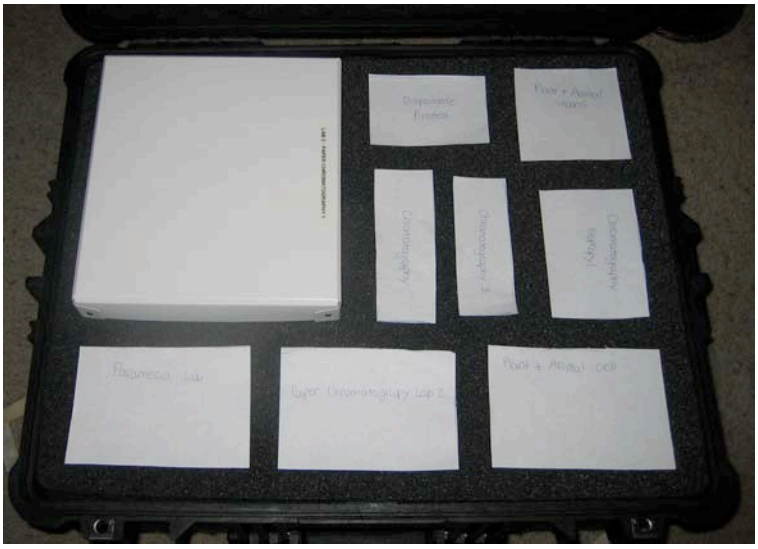


Figure 3-52. Placement Trial of Laboratory Containers

It was important that one inch of foam was in between all of the elements for support purposes. I then began trying different ways of arranging the containers and found that only one arrangement would work. I then marked the edges of the containers with toothpicks so that the removal process would be easier. I could then begin removing the foam in blocks one layer at a time until the correct depth was reached (**Figure 3-53**). Once all of the foam was removed, I glued the three layers of foam together to make them more secure.

Figure 3-53. Suitcase with Laboratory Supplies

The second suitcase was not as difficult. Since the game materials were in large containers and the supplies were not fragile, I decided to have foam around the outside and not in between them. The two game materials boxes fit snuggly together inside the suitcase, and allowed enough space for the container holding the teacher's manual, student handouts booklet, and DVD, and a bag holding the last of the lab supplies to lie on top of them (**Figure 3-54**). The foam inside this suitcase was glued together as well.

Figure 3-54. Suitcase with Game Materials, Teacher's Manual, Student Handouts Booklet, and DVD

Photographing the Suitcases

Once the suitcases were packed, I took photographs of each of them to include in the teacher's manual. These photographs would be used to show the suitcase contents. They would also be used on the "Supplies" page at the beginning of each section to show the teachers which containers would be needed for that activity, and also be used in the "Clean Up" section of each of the activities so that the teacher would know how to store the containers. I also took photographs showing how to access the handle, how to transport the suitcases and how to load them inside of a car (**Figure 3-55**). These photographs would be used on the label attached to the outside of each of the suitcases.

Figure 3-55. How to: Access the Handle, Load the Suitcase, and Transport the Suitcase

Suitcase Labels

After I had photographs of the suitcases I was able to incorporate them into the labels for the outside of the suitcases (**Figure 3-56**). The labels identified that the suitcase contained the Organelle Extravaganza components and also indicated whether it was suitcase number one or suitcase number two. The label also included photographs of how to access the handle, how to transport the suitcase, and how to load the suitcase in the trunk of a car. The labels were printed and laminated at the Museum of Nature and Science and then attached to the top of the suitcase.

Figure 3-56. Suitcase Labels

Conclusion

In order to create an effective portable Science Suitcase on organelles designed to supplement the current high school biology curriculum in the Dallas Independent School District, several objectives were met. I designed a 3d animation, an interactive game, three laboratory experiments, a teacher's manual, and a student handouts booklet and incorporated them all into two portable Pelican™ suitcases. The Science Suitcase was then presented to a group of teachers for evaluation.

CHAPTER FOUR
Results

Survey Development

The Science Suitcase was presented to approximately 45 teachers at a STARS symposium on October 11, 2008. Approximately 45 minutes were allocated for the presentation and review. I prepared a Powerpoint® presentation to show the teachers the protocols for the laboratory experiments. In the Powerpoint® presentation I also showed examples of the layouts for the Teacher's Manual and Student Handouts Booklet, and I passed around the physical manuals during the presentation. I also showed the teachers the beginning of the animation and explained that the remaining animation covered the other organelles in an animal and a plant cell. Finally I ran the Protein Production Game with two groups of volunteers.

A survey was developed and distributed to the teachers for them to fill out after the presentation. The survey consisted of 20 statements about the contents of the Science Suitcase. These statements employed a 5-point Likert scale ranging from Strongly Disagree (SD) to Strongly Agree (SA). The teachers were asked to circle the sentiment that most closely corresponded to their attitude toward the statement. Space was provided below each statement for additional comments. The survey also included four questions used to determine the demographic of the respondents and the resources they had available to them at their schools. At the end of the survey, I provided a space for the teachers to choose which components of the Science Suitcase they would use in their

classroom, which component they felt was most effective, and which component they felt was least effective. The final survey was produced in Adobe® InDesign and printed for use by the teachers (see Appendix I).

Survey Distribution

The survey was given to approximately 45 teachers at the STARS symposium. They were asked to view the presentation, fill out the survey, and return it to me. Thirty-two of the teachers filled out the survey.

Survey Results

The surveys were collected and evaluated. Four questions were asked at the beginning of the survey to get an idea of the demographic of those surveyed and to see what resources they have available to them at their schools.

Question 1: Are you a: Teacher Administrator Other:_____

31 were teachers and 1 was other.

This question allowed me to see who was responding to the survey.

Question 2: Do you currently teach Biology? Yes No If yes what grade?

23 answered yes and 9 answered no.

This question was also used to see who was responding to the survey. Biology teachers are more familiar with the target audience and therefore their responses are more helpful than the other respondents. Of those that taught Biology, most of them taught high school which ranged from grade 9-12. Two teachers taught in college and one taught AP Biology. One teacher also taught Biology in 8th grade and another in 5th grade. And one teacher that responded yes was a substitute teacher.

Question 3: Do you have access to a DVD player or a projector to play a DVD in your classroom? Yes No

31 responded Yes.

This question was intended to determine the type of technology the teachers had in their classrooms. This information will help the students creating future Science Suitcases.

Question 4: Do you have access to light microscopes for student use? Yes No If yes how many?

31 responded yes and 1 responded no.

This question was intended to determine if teachers had access to light microscopes. I had contemplated including a microscope in the suitcase in case teachers didn't have access to them, but the overwhelming positive response to this question proved that I did not need to include one. This information was also important for the future Science Suitcases.

Eighteen of the twenty-three teachers who taught Biology, taught at the high school level. I chose to evaluate only these responses, because these teachers were more familiar with the target audience and would provide the most accurate feedback (See appendix J). A graph was created using the data collected from the survey (**Figure 4-1**).

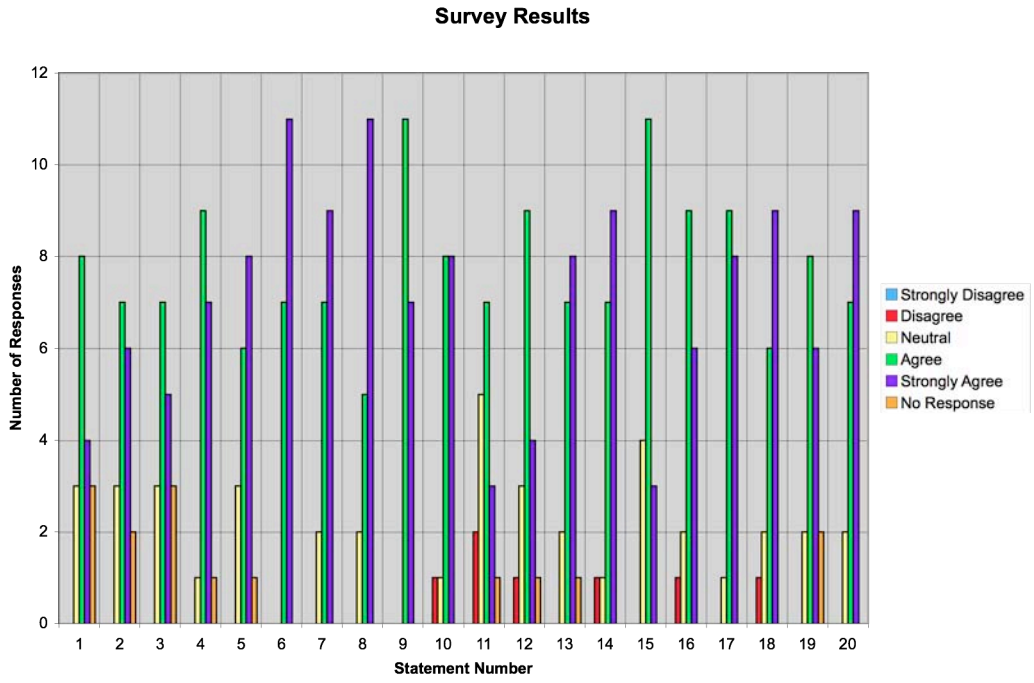


Figure 4-1. Summary of Survey Results

List of Statements

1. *The Teacher's Manual is clear and easy to follow.*
2. *The Student Handouts are clear and easy to follow.*
3. *The instructions for the labs are clear, concise, and easy to follow.*
4. *The photographs are beneficial to the lab instructions.*
5. *The lab experiments are beneficial in teaching students about organelles.*

6. *The animation clearly explains organelle structure and function.*
7. *The use of the factory analogy is effective.*
8. *The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.*
9. *The questions throughout the video are helpful in keeping the students engaged.*
10. *The animation appeals to students.*
11. *The game instructions are clear and easy to follow.*
12. *The game is effective in teaching the functions of the different organelles in the production of a protein.*
13. *The use of teamwork and competition will keep students involved and interested in the game.*
14. *The factory analogy is effective in tying the animation and game together.*
15. *The suitcases are easy to transport.*
16. *The components of the suitcase are appropriate for the target audience (high school Biology students).*
17. *The components of the suitcase will fit into my current curriculum.*
18. *The components of the suitcase will enhance my current curriculum for teaching organelles.*
19. *The components of the science suitcase will help students with the TEKS and TAKS.*
20. *I would recommend this Science Suitcase to other teachers.*

Evaluation of Responses

Statement 1: The Teacher's Manual is clear and easy to follow.

3 Neutral, 8 Agreed, 4 Strongly Agreed, 3 Did Not Respond.

The overall positive response to this statement indicates that the teachers found the Teacher's Manual clear and easy to follow. Several teachers who responded with Neutral indicated that they had not had the chance to view the Teacher's Manual.

Comments:

"It looks easy to follow."

"On powerpoint."

"Didn't get to see."

Statement 2: The Student Handouts are clear and easy to follow.

3 Neutral, 7 Agreed, 6 Strongly Agreed, 2 Did Not Respond.

As in the statement above, the overall positive response to the statement indicates that they found the Student Handouts clear and easy to follow as well. One teacher mentioned that she liked the picture of the onion skin retrieval technique.

Comments:

"On Powerpoint."

"Seem to be."

"Good pic of onion skin retrieval techique."

Statement 3: The instructions for the labs are clear, concise, and easy to follow.

3 Neutral, 7 Agreed, 5 Strongly Agreed, 3 Did Not Respond.

It can be concluded by the overall positive response to this statement that the teachers found the lab instructions clear and easy to follow. Several teachers responded that they did not get to see them, and they did not respond to the statement.

Comments:

"Didn't get to see."

"What I observed in game."

Statement 4: The photographs are beneficial to the lab instructions.

1 Neutral, 9 Agreed, 7 Strongly Agreed, 1 Did Not Respond.

The strong positive response to this statement indicates that the teachers felt that photographs were beneficial to the lab instructions.

Statement 5: The lab experiments are beneficial in teaching students about organelles.

3 Neutral, 6 Agreed, 8 Strongly Agreed, 1 Did Not Respond.

This statement received a positive response. It can be concluded that the laboratory experiments were good additions to the Science Suitcase. One teacher mentioned that the experiments chosen were the same experiments that were generally done for organelles. Although the Animal and Plant Cell Laboratory and Paper Chromatography Laboratory are commonly used when teaching organelles, the Feeding Paramecia Laboratory is not. The Science Suitcase also includes the laboratory supplies necessary to run the

experiments and provides the opportunity for schools without adequate lab supplies to perform them.

Comments:

"Same kinds of experiments as generally done for organelles."

Statement 6: The animation clearly explains organelle structure and function.

7 Agreed, 11 Strongly Agreed.

All of the teachers agreed that the animation clearly explained organelle structure and function. This supports the decision to include a 3d animation in the Science Suitcase. There were many positive comments about the animation.

Comments:

"Cute, especially the components picture."

"Well explained."

"Very good."

"Loved this."

Statement 7: The use of the factory analogy is effective.

2 Neutral, 7 Agreed, 9 Strongly Agreed.

The response to this statement was very positive, indicating that the teachers believed the factory analogy was effective. One teacher mentioned that it was the same analogy that she used. The teachers also found the cartoon analogy humorous.

Comments:

"This is the analogy I use in class (last year a city analogy was included for a different approach for students)."

"Good analogies and good use of humor."

"Well done with LM (light microscope) and EM (electron microscope)."

"Very good!"

Statement 8: The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

2 Neutral, 5 Agreed, 11 Strongly Agreed.

It can be concluded by the strong positive response that the integration of a cellular model, electron micrographs, and the factory cartoon clearly explains the organelles. This statement was intended to evaluate the introduction segment for each of the organelles within the animation. The positive response indicates that it was effective. There were no additional comments for this statement.

Statement 9: The questions throughout the video are helpful in keeping the students engaged.

11 Agreed, 13 Strongly Agreed.

This statement received an extremely positive response, and validated the use of questions throughout the animation to keep the students engaged.

Comments:

"It's tough but can be done."

Statement 10: The animation appeals to students.

1 Disagreed, 1 Neutral, 8 Agreed, 8 Strongly Agreed.

The majority of the responses for the statement were positive. It can be concluded that the animation appeals to students. The respondent that chose neutral commented that the animation was a little boring, but she chose the animation as the most effective in one of the final questions. The respondent that disagreed made no additional comments. One teacher also mentioned that some students would appreciate it more than others. This statement corresponds with the information I found when researching student learning styles and is the reason I included several different types of activities in the Science Suitcase.

Comments:

"Excellent!"

"A little boring."

"Some will appreciate more than others."

Statement 11: The game instructions are clear and easy to follow.

2 Disagreed, 5 Neutral, 7 Agreed, 3 Strongly Agreed, 1 Did Not Respond.

The response for this statements was varied, however the majority of respondents agreed with the statement. The game was presented at the end of the presentation and was rushed. I believe that the negative responses were a result of the time constraints.

Statement 12: The game is effective in teaching the functions of the different organelles in the production of a protein.

1 Disagreed, 3 Neutral, 9 Agreed, 4 Strongly Agreed, 1 Did Not Respond.

The responses for this statement were also varied, but the large majority of respondents agreed that the game was effective in teaching the functions of organelles in the process of protein synthesis. It can be concluded that the game was successful.

Comments:

"Especially the envelope taking it outside the cell."

Statement 13: The use of teamwork and competition will keep students involved and interested in the game.

2 Neutral, 7 Agreed, 8 Strongly Agreed, 1 Did Not Respond.

It can be concluded from the overall positive response to this statement that the use of teamwork and competition will keep students interested in the game.

Comments:

"Usually."

Statement 14: The factory analogy is effective in tying the animation and game together.

1 Disagreed, 1 Neutral, 7 Agreed, 9 Strongly Agreed.

The responses to this statement were varied however the majority of responses were positive. It can be concluded that the factory analogy was effective in tying the

animation and game together. The teacher that Disagreed did not leave any additional comments.

Comments:

"Any analogy is effective."

"Better than asking students to make analogy to organelles and city that they may not be familiar with."

Statement 15: The suitcases are easy to transport.

4 Neutral, 11 Agreed, 3 Strongly Agreed.

The strong positive response to this statement confirmed that the suitcases were easy to transport.

Comments:

"Seemed to be."

Statement 16: The components of the suitcase are appropriate for the target audience (high school Biology students).

1 Disagreed, 2 Neutral, 9 Agreed, 6 Strongly Agreed.

Most of the respondents agreed with this statement, confirming that the components of the suitcase are appropriate for the high school Biology students. There were no additional comments for this statement.

Statement 17: The components of the suitcase will fit into my current curriculum.

1 Neutral, 9 Agreed, 8 Strongly Agreed.

Based on the responses, it can be concluded that the components of the suitcase would fit into the current curriculum of most teachers.

Statement 18: The components of the suitcase will enhance my current curriculum for teaching organelles.

1 Disagreed, 2 Neutral, 6 Agreed, 9 Strongly Agreed.

This statement received a positive response overall, and it can be concluded that the components of the suitcase will enhance the curriculum of most teachers. This statement was important, because it indicated whether teachers would use the Science Suitcase in their classrooms.

Statement 19: The components of the suitcase will help students with the TEKS and TAKS.

2 Neutral, 8 Agreed, 6 Strongly Agreed, 2 Did Not Respond.

The positive response to this statement indicated that the suitcase was successful in providing the student with information to help with the TEKS and TAKS. Another teacher mentioned that TAKS is very interested in students understanding the functions of organelles. This area was addressed in both the animation and the game.

Comments:

"Not applicable to our school."

"The envelope idea drives home."

"Visual and kinesthetic and of course verbalizing the story (auditory). Good ideas Jennifer."

"TAKS is all over the comprehension of these organelle functions."

Statement 20: I would recommend this Science Suitcase to other teachers.

2 Neutral, 7 Agreed, 9 Strongly Agreed.

Due to the overwhelming positive response to this statement, it can be concluded that the teachers would recommend the Science Suitcase to colleagues and most likely use it themselves.

Comments:

"We talked it up last year. Organelles is a great idea."

Additional Questions

At the end of the survey I asked three questions to determine which components the teachers would use in their classroom, which component they felt was least effective, and which component they felt was most effective. The teachers were instructed to mark all that applied.

Question 1: Which component(s) would you most likely use in your classroom?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

17 for the Animation, 11 for the Protein Production Game, 8 for the Animal and Plant Cell lab, 7 for the Paper Chromatography Lab, and 12 for the Feeding Paramecia Lab.

There was a pretty even distribution of selections among the suitcase components. And a large number of teachers said that they would use all of the components. This was encouraging and validated the inclusion of all of the components. One teacher mentioned that they would use the paper chromatography lab for photosynthesis. I included this lab to connect it to the photosynthesis suitcase. Most of the other comments had been mentioned before and addressed.

Comments:

"Great ideas.

Protein Production Game:

"The game seems a little confusing."

Animal and Plant Cell Lab:

"Already do this."

Paper Chromatography Lab:

"For photosynthesis."

Feeding Paramecia Lab:

"Super visual."

Question 2: Which component is most effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

10 for the Animation, 13 for the Protein Production Game, 4 for the Animal and Plant Cell Lab, 3 for the Paper Chromatography Lab, and 5 for the Feeding Paramecia Lab.

This was more for my personal knowledge than anything else. The most popular component was the protein production game, followed by the animation, the feeding paramecia lab, the animal and plant cell lab, and finally the paper chromatography lab. Several teachers mentioned using all of the components together.

Comments:

"All these I think need to be given applause."

"Labs look standard. I have done all but last."

Question 3: Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

1 for the Animation, 3 for the Protein Production Game, 2 for the Animal and Plant Cell Lab, 6 for the Paper Chromatography Lab, and 2 for the Feeding Paramecia Lab.

This question was more for my own information as well. According to the responses, the least effective component was paper chromatography lab, followed by the protein

production game, the feeding paramecia lab and the animal and plant cell lab, and finally the animation. One teacher mentioned that the real test would be with the students. The Science Suitcase will be reviewed by STARS once it is in circulation.

Comments:

"It depends on the profile of the class."

"The real test is always with students. What seems great to teachers doesn't always work as well with students. It looks very promising and deserves to be tested."

"Don't know. I need to use first."

"Not sure yet."

Animation:

"Possibly the animation would be the least as compared to doing for high school kids. However visual is still necessary and valuable components to tie in all labs, animation, and game."

Protein Production Game:

"The game requires students to follow verbal instructions, work with a group and manipulatives. I think this is too much for students to coordinate. Also protein production is taught in more depth, and I don't feel captures the true concepts and details that a high school class addresses."

Feeding Paramecia Lab:

"You have to order paramecia for lab which is time consuming."

Conclusion

Overall the feedback for the Science Suitcase was very positive and can be considered successful. When asked which components of the suitcase they would use in their classroom, most of the teachers said that they would use all of the components. When asked which component was most effective the responses varied but each component was at least chosen once. This reinforced the decision to include several different components. Further testing will be performed once the suitcase has been used in classrooms for several years and will provide more information about its effectiveness.

CHAPTER FIVE
Conclusions and Recommendations

Project Summary

The thesis question that this project attempted to answer was whether a portable Science Suitcase including a 3D animation, an interactive lab, and laboratory experiments could be developed that would aid in teaching high school Biology students about organelles? The goal of this thesis project was to create a portable Science Suitcase on organelles designed to supplement the current high school biology curriculum in the Dallas Independent School District. The Science Suitcase includes a narrated 3D animation, three laboratory experiments, and an interactive game. The suitcase can be borrowed by teachers and brought into their classrooms to help enhance students' interest in science, help bridge the gap between ninth grade biology and Advanced Placement biology, and help students meet the state of Texas science education requirements based on the National Science Education Standards.

In order to meet this goal, several objectives were met. I developed a survey to discover how teachers in the Dallas Independent School District (DISD) were currently teaching the topic of organelles, the problems their students were having with this topic, and what resources they had available to them. I also researched the most effective methods of teaching science to ninth grade students and examined the requirements of the Texas Essential Knowledge and Skills (TEKS) for the topic. The information gathered from the surveys and research was then used to develop an effective program that covered several

different learning styles and many of the objectives set out by the TEKS. Once the components for the program were decided, I created each of the individual components which included a narrated 3d animation covering the structure and function of organelles found in both plant and animal cells, several laboratory experiments exploring specific organelles, an interactive game in which the students perform the tasks of specific organelles in order to produce a protein, a pre-test and post-test, teacher's manual, and student handout booklet. The final objective I met was to incorporate all of these components into a portable Science Suitcase that was presented to DISD teachers and evaluated through a secondary survey. The results of this survey would determine whether the final product met the goals and objectives set forth for this project.

Discussion

The evaluations provided a very positive response to the Science Suitcase and its value as a teaching tool. A majority of the responses either agreed or strongly agreed to all of the statements, and all of the teachers indicated that they would use at least one of the components in their classroom and many of them indicated that they would use the entire suitcase.

The majority of teachers strongly agreed that the components of the suitcase would enhance their current curriculum and help students with the TEKS and TAKS. The positive survey responses indicate that the goals and objectives for this project were successfully accomplished.

Suggestions for Further Research

More thorough formative evaluations using both student and teacher input during the development of the materials would be valuable, especially under the time constraints and limitations of a master's thesis project. More investigation into different elements that could be provided in the Science Suitcase that would aid in teaching organelles and that would address different learning styles would also be helpful. There are many three-dimensional cell models available for studying organelles. More research could be done into how the models are currently being used and if an interactive activity could be created using 3D models to promote kinesthetic learning. Research could also be done into the use of web-based activities and interactive computer games for teaching high school level students. Another suggestion is to access whether the goals were met by evaluating the TAKS test scores and AP Biology enrollment after the Science Suitcase has been used in the classrooms for several years.

APPENDIX A
Preliminary Surveys

Preliminary Survey: Version 1

Thank you so much for the help. Let me give you a little background on our projects so it makes more sense why we are asking questions. We were asked to create "science suitcases" for the museum on topics that students have consistently scored poorly on during tests. These suitcases can be used for free by any teachers in the area to encourage their students to learn more and hopefully have the topics really "stick". I was chosen to create one on "enzymes" and another girl in our program, Jennifer, was chosen to work on "organelles". So the bulk of our questions revolve around the problems that teachers face trying to teach these subjects.

1. What resources do you have available from the school? (ie. computers for each student? computers that can feed into overhead projectors? lab desks with sinks?)

2. Do you teach either of these topics; enzymes and/or organelles?

3. If so, could you give us a brief description of the lessons for each topic? (ie. we let the students do a science experiment called "x", then they watch a movie called "x", then they can research on www.website.com, and then they are quizzed on chapter 3-4 from the text "x")

4. Do you notice any specific areas of these topics that students really have a hard time grasping?

5. What ways could you see ninth grade students getting engaged in these topics? (ie. 3d models, interactive "games", physical activity, etc.)

6. Do you have any wishes or ideas for teaching these topics? (ie. resources to teach them that the schools do not offer teachers)

7. Are you willing and/or able to talk further about these topics in the future? Maybe even in person?

Again, thank you so much for taking the time to answer some questions. We are really trying to make something that teachers can utilize and students can .enjoy.

Brenda Harrison
Jennifer Hulsey
UT Southwestern
Biomedical Communications Department

Preliminary Survey: Version 2

Thank you so much for offering to help. Let us fill you in on the project before getting to the questions we have. We were asked to create "science suitcases" for the Museum of Nature and Science on topics that students have consistently scored poorly on during tests. These suitcases can be used for free by any teachers in the area to encourage their students to learn more and hopefully have the topics really "stick". I was chosen to create one on "enzymes" and another girl in our program, Jennifer, was chosen to work on "organelles". So the bulk of our questions revolve around the problems that teachers face trying to teach these subjects.

1. What resources do you have available from the school? (ie. computers for each student? computers that can feed into overhead projectors? lab desks with sinks?) And are these computers capable of running a large animation?

2. Do you teach either of these topics; enzymes and/or organelles?

3. If so, could you send us a copy of your syllabus for each topic? Are there specific videos, books, handout, or models that you use? If so, could you give us names or titles?

4. How long are your class periods? And how many days do you spend on each of these topics?

5. What areas of the current curriculum and accessable tools do you find lacking? helpful?

6. Do you notice any specific areas of these topics that students really have a hard time grasping?

7. What ways could you see ninth grade students getting engaged in these topics? (ie. 3d models, interactive "games", physical activity, etc.)

8. Do you have any wishes or ideas for teaching these topics? (ie. resources to teach them that the schools do not offer teachers)

9. Are you willing and/or able to talk further about these topics in the future? Maybe even in person?

Brenda Harrison
Jennifer Hulsey
Biomedical Communications
UT Southwestern Medical Center

APPENDIX B
Preliminary Survey Responses

Sounds like an interesting project! I for one appreciate you doing this. Here are the answers to your questions.

1. What resources do you have available from the school? (ie. computers for each student? computers that can feed into overhead projectors? lab desks with sinks?)

   I teach in a high school. We have a computer lab we have limited access to where each student will have a computer. The teacher computer in every classroom feeds into a projector system. We have access to a full lab at any time with plenty of sinks.

2. Do you teach either of these topics; enzymes and/or organelles?

   Yes - I teach Biology.

3. If so, could you give us a brief description of the lessons for each topic? (ie. we let the students do a science experiment called "x", then they watch a movie called "x", then they can research on www.website.com, and then they are quizzed on chapter 3-4 from the text "x")

   Oh gosh. I'm still in summer brain mode. With organelles we do a project called "Sell a Cell Organelle" where they make up a magazine type ad and a commercial along with a paragraph describing their organelle. They try to "sell" their organelle to the class. (each group of 3-4 gets a different organelle.) We watch a video, but I can't remember what it's called about organelles as well. I give PPT notes with pictures. They'll test on it along with mitosis. For enzymes, we do a liver and apples lab where they see the effects of ph, temperature, etc. on catalase and catecholase. We do some PPT notes, we do a salivary enzyme lab where their spit is used. They'll do a review and test over it. And of course, chapter reading is assigned, but they rarely do it. And there's probably a quiz or two in there somewhere. I could tell you better if I were at school with my outline from last year in front of me. I'm just doing this from memory.

4. Do you notice any specific areas of these topics that students really have a hard time grasping?

   Optimal temperature for some is difficult. They don't always understand just how important enzymes are for life to exist. The term catalyst is difficult for them to grasp. Specificity is hard sometimes.

5. What ways could you see ninth grade students getting engaged in these topics? (ie. 3d models, interactive "games", physical activity, etc.)

   You could demonstrate by having two kids wander around the room blindfolded and see how long it takes them. Then use someone to be a catalyst and join them and see how much quicker it is. For organelles, make the cell like a factory or town or something and have them model how/what each organelle does.

6. Do you have any wishes or ideas for teaching these topics? (ie. resources to teach them that the schools do not offer teachers)

   Not that I can think of right off. Ideas for more labs maybe.

7. Are you willing and/or able to talk further about these topics in the future? Maybe even in person?

   Certainly - 214.263.0518

I hope this was somewhat helpful. Give me a call if you need more info!

Holly

I received info regarding your suitcase project....and would like to help. I just started a new job as Science Facilitator for Garland ISD after teaching 19 years in Dallas. I am also a former grad student from UTSW DCMB and especially appreciate your efforts in helping public schools with science lessons.

ALL high schools in Texas MUST teach about both organelles and enzymes. They are part of the state curriculum known as TEKS (you can view these essential knowledge and skills yourself on the Texas Education Agency website.)

Students must be able to identify organelles within the cell, relate structure to function, and identify cells (prokaryote vs eukaryote, plant vs animal) based on the presence or absence of identifying organelles. What compounds the difficulty students have in this area is that different teachers use different definitions of "organelle", some teachers and textbooks call any part of any cell an "organelle" while others more strictly use the term to define membraneous compartments. Students can usually identify plant and animal cells, while having more difficulty differentiating eukaryote/prokaryote cells. They usually can identify the structure and function of the nucleus but are much less successful with any other cell parts. In a typical lesson that I have done, students are usually shown an introductory video or powerpoint that discusses/shows examples of different cell types and associated organelles' structure and function. Then we use cell models where the students place the organelles in their appropriate locations within each cell type. Following this, we also model a virus as comparison. To end the lesson, the kids make a venn diagram comparing components of eukaryote cells, prokaryote cells, and viruses. Throughout the lesson, I have the kids color and label diagrams of each type as homework assignments. In honors classes, an added project is given - students compare a cell type of their choice to any other system (school, library, factory, etc) and make comparisons with 10 organelles; eg. the nucleus in the animal cell is like the principal's office in the school because it is the control center for the system. In my opinion, this project is what really cements the info for the kids. It also seems that kids do much better when they are presented with a wide variety of different types of activities with this content.

Enzymes are a much less important topic according to the state (fewer TEKS and much less emphasis on TAKS). Kids basically need to know that enzymes are proteins that act as catalysts, that environmental factors such as temperature and pH have an effect on reaction rates, and that enzymes aren't used up in the reaction. I usually discuss enzymes in conjunction with digestion - something most of them are familiar with. I show them video clips of enzymes and substrates, followed by a paper model lab where kids have to cut out models of enzymes and match them with their complementary shaped substrates and then predict what the product or products might look like. We also do a wet lab using catalase from both liver and potato. Kids vary the temperature (hot, room, cold) and pH (acid, neutral, basic) and compare the speed of bubbling when hydrogen peroxide is added to either the liver or potato. Bubbling speed is ranked 0-5 and the data graphed and compared. They seem to get the vocabulary confused a lot, enzyme and substrate are often reversed in their minds. They also have a hard time relating to enzymes as proteins

within cells. They think the liver IS the enzyme or the potato IS the enzyme. For homework, I have kids draw and label a diagram of an enzyme/substrate reaction showing before, during, and after the reaction has occurred. This seems to help a lot. I think a good 3D model would be a great aid for this lesson but I have not found or created one.

Well, I hope some of this info is useful to you and please feel free to email me again directly if you have other questions. Again, thanks so much for working to help these kids learn!

Karen MacVey
Science Facilitator
Sachse High School
Garland ISD

We are medical illustration students at UT Southwestern and we were given your emails from the Jeannie Han with the Stars group. We were asked to create "science suitcases" for the Museum of Nature and Science on topics that students have consistently scored poorly on during tests. These suitcases can be used for free by any teachers in the area to encourage their students to learn more and hopefully have the topics really "stick". I was chosen to create one on "enzymes" and another girl in our program, Jennifer, was chosen to work on "organelles". So the bulk of our questions revolve around the problems that teachers face trying to teach these subjects.

We were wondering if you could give us the contact information for some high school science teachers that would be willing to answer the following questions.

1. What resources do you have available from the school? (ie. computers for each student? computers that can feed into overhead projectors? lab desks with sinks?)

   Many teachers have all of these items. Many teachers now have access to In-focus machines to project animations in the classroom.

2. Do you teach either of these topics; enzymes and/or organelles?

   All teacher in the district must teach these topic. These topics are part of the required content that must be taught based on Texas State requirements called TEKS.

3. If so, could you give us a brief description of the lessons for each topic? (ie. we let the students do a science experiment called "x", then they watch a movie called "x", then they can research on www.website.com, and then they are quizzed on chapter 3-4 from the text "x")

   Many teachers the <u>organelle</u> lesson by constructing concept maps, having students create foldables with pictures and organelle functions, or matching organelles with functions on handouts, students color and label cell organelle and write functions. Many teachers have students construct 3-dimensional cell models with labeled cell organelle. Teacher may show animations of cell structure and organelle function from websites, CD Rom's that are textbook ancillaries or videos of cell organelle purchased from science vendors or from the web.

   When teaching <u>enzymes</u> teachers can show illustrations of the "lock and key model" or "induced fit" of enzyme and substrate. Again teacher handouts, videos or animations can be used. Samples of enzyme specificity and enzyme action are shown using catalase as an example. Graphs of enzyme activation energy changes are discussed and analyzed. Many other enzymes are

illustrated and taught throughout the curriculum such DNA polymerases, helicases, restriction enzymes, etc.

4. Do you notice any specific areas of these topics that students really have a hard time grasping?

   Students need a <u>complete</u> understanding of these topics to pass standardized tests required by the state.

5. What ways could you see ninth grade students getting engaged in these topics? (ie. 3d models, interactive "games", physical activity, etc.)

   All of the items mentioned above are great.

6. Do you have any wishes or ideas for teaching these topics? (ie. resources to teach them that the schools do not offer teachers)

   Each school has differences in the items available. However, hands-on manipulative models for classroom investigation are needed for both topics.

7. Are you willing and/or able to talk further about these topics in the future? Maybe even in person?

   OK

Again, thank you so much for taking the time to answer some questions. We are really trying to make something that teachers can utilize and students can enjoy.

Brenda Harrison
Jennifer Hulsey
UT Southwestern
Biomedical Communications Department

Thank you so much for offering to help. Let us fill you in on the project before getting to the questions we have. We were asked to create "science suitcases" for the Museum of Nature and Science on topics that students have consistently scored poorly on during tests. These suitcases can be used for free by any teachers in the area to encourage their students to learn more and hopefully have the topics really "stick". I was chosen to create one on "enzymes" and another girl in our program, Jennifer, was chosen to work on "organelles". So the bulk of our questions revolve around the problems that teachers face trying to teach these subjects.

1. What resources do you have available from the school? (ie. computers for each student? **NO**
   computers that can feed into overhead projectors? **ONLY SOMETIMES**
   lab desks with sinks?) **YES**
   And are these computers capable of running a large animation? **YES IF ON DISK. BETTER TO HAVE DVD OR CD.**

2. Do you teach either of these topics; enzymes and/or organelles? **BOTH**

3. If so, could you send us a copy of your syllabus for each topic? Are there specific videos, books, handout, or models that you use? If so, could you give us names or titles?

   I WILL ATTACH DOCUMENTS

4. How long are your class periods? And how many days do you spend on each of these topics?

   50 MINUTES VARIOUS TIMES WEEK OR TWO DEPENDS ON TOPIC

5. What areas of the current curriculum and accessable tools do you find lacking? helpful?

6. Do you notice any specific areas of these topics that students really have a hard time grasping?

7. What ways could you see ninth grade students getting engaged in these topics? (ie. 3d models, interactive "games", physical activity, etc.)

   STUDNETS ALWAYS LIKE GAMES, POSSIBLY MODELS

8. Do you have any wishes or ideas for teaching these topics? (ie. resources to teach them that the schools do not offer teachers)

9. Are you willing and/or able to talk further about these topics in the future? Maybe even in person?

YES I AM OVERWHELMED RIGHT NOW WITH END OF SIX WEEKS SOME QUESTION NOT ADDRESSED YET DUE TO TIME CONSTRAINTS NOW. PLEASE RESUBMIT AGAIN.

Brenda Harrison
Jennifer Hulsey
Biomedical Communications
UT Southwestern Medical Center

Mary Lou Brieger
Pre-AP/IB Biology/IPC
marybrieger@hebisd.edu
Extension #7549

Hi Brenda,

I just got back in Tuesday, and am digging my way out from email and voice mail madness. Answers are below, sorry for a delay.

10. What resources do you have available from the school? (ie. computers for each student? computers that can feed into overhead projectors? lab desks with sinks?) And are these computers capable of running a large animation?

    N/A

11. Do you teach either of these topics; enzymes and/or organelles?

    I have taught both of these topics to grades ranging from 7-12.

12. If so, could you send us a copy of your syllabus for each topic? Are there specific videos, books, handout, or models that you use? If so, could you give us names or titles?

    I do have some syllabi/activities I would be happy give you, though they're on my other computer so I'll have to send those later. Mostly I tried to perform activities that used household items (easy to do this for some topics, more difficult with others) because it's easier to work with things that are familiar to students, that way there's only one 'unknown' for them to grasp -- the concept. Activities that involve a lot of technology or unfamiliar items have two hurdles -- getting kids to know what they're working with, and also getting them to understand the concept.

13. How long are your class periods? And how many days do you spend on each of these topics?

    My class periods for labs were 1 hour and 40 minutes. Most labs I did were designed to fit into two discreet 50-minute sections so they could be adapted to more conventional teaching schedules in other schools. Sometimes I would run the two sessions back to back, other times I would run them on separate days, depending on how quickly the kids could absorb what's going on. I think allowing time for reflection, to let the procedure of the experiment "soak in" is important before going on to the next step. It also is more conducive to self-realization or discovery, rather than being told what they just learned.

    All in all, I probably dedicated about 7 to 10 days to organelles in the high school, perhaps 5 to 7 in middle school. For enzymes, I'd say about 5 to 6 days in high school, 3 to 4 days in middle school.

14. What areas of the current curriculum and accessable tools do you find lacking? helpful?

    I don't really have a good answer for this one, since I'm not entirely familiar with the DISD curriculum, and this probably pertains more to classroom teachers.

15. Do you notice any specific areas of these topics that students really have a hard time grasping?

    Organelles: the dynamic nature of the cell, where cellular materials come from, the names of the organelles (many sound/look the same), be careful in assigning colors to organelles -- when the kids see models and then look at real cells, you sometimes have to teach them all over again. I'd recommend teaching what they "really" look like at the same time as teaching the simplified model.

    Enzymes: how environmental factors influence the activity of enzymes, where enzymes come from, the variety of shapes and sizes, inhibitors, positive/negative feedback systems (very confusing for many, but very important for them to understand nature's checks-and-balances and cycles)

16. What ways could you see ninth grade students getting engaged in these topics? (ie. 3d models, interactive "games", physical activity, etc.)

    I think your idea of the interactive games is excellent. Models are very limited in their use, and very expensive/time consuming to make. I recommend staying relatively inexpensive, easy to repair/replace. 9th grade kids also like to build things; boys and girls differ slightly here. Without starting an argument (knowing my audience), girls are traditionally lagging in spatial understanding by the time they hit science in middle and high school, so they tend to avoid it. This is largely because parents buy the "assembly required" toys for the boys when they are young, not as much for girls. Anything you can do that helps correct this will be great.

17. Do you have any wishes or ideas for teaching these topics? (ie. resources to teach them that the schools do not offer teachers)

    If you can, begin to introduce some sort of technology and incorporate data collection and analysis into the lesson. We are seeing a sincere difficulty on behalf of students when it comes to asking them to analyze data -- whether they have to create the graph themselves or interpret one that is pre-

generated, this is an area of science education that they are struggling with. Anything you can do to help them gather, analyze, and present data would be very instrumental. Implementing technology into this is very helpful, too (a pH tester to analyze acid concentration during some sort of enzyme-catalyzed reaction, for example, and recording the rate of reaction along with the change in pH)...

18. Are you willing and/or able to talk further about these topics in the future? Maybe even in person?

    Of course. Let me know if there's anything else I can do.

S

APPENDIX C
Animation Script

Organelle Extravaganza Animation Script

All living things are made of **cells**. Cells are the basic units of life. Some exist as single-celled organisms while others, including humans, are multicellular and consist of many different kinds of specialized cells working together.

The cells that make up plants and animals are called **eukaryotic cells**. Eukaryotic cells have a nucleus and many structures called **organelles** that carry out specific functions within the cell.

In many ways, a eukaryotic cell is similar to a factory, with its organelles working together as a group to produce a product. In this cellular factory, each organelle carries out a specific function. The **plasma membrane** is the gatekeeper that decides what gets into and out of the cell. The **nucleus** is the main control center for the cell, and is similar to the main boss of a factory. The **ribosomes** are the many machines working to produce its product, proteins. The **rough endoplasmic reticulum** moves these proteins and other substances through the cell, much like an assembly line of a factory, and plays a role in quality control. The packaging and distribution center of the cell is the **Golgi apparatus** where the destination of each product is decided. The **smooth endoplasmic reticulum** acts as the poison control center for the factory, neutralizing the drugs and poisons. The cleanup crews are the **lysosomes** which clean up all the trash in the factory**.** The **mitochondrion** is the power source for the factory. It uses the energy stored in food to produce enough energy to power the cellular factory.

Now that we have a basic overview of each of the organelles' functions, lets look at each of them a little closer. We will begin by looking at an animal cell and then take a look at a plant cell later on.

There are several different ways you can study cells. You can study them through models such as this one. Actual organelles are not colored, except for chloroplasts and mitochondria, but color has been added to this model to make it easier to visualize. You can also observe cells through a **light microscope**, which uses lenses to produce an enlarged image. Or observe smaller organelles and cell parts through a higher powered **electron microscope** that uses **electrons** to illuminate the cell and create an enlarged image.

Lets start with the **Plasma Membrane**.
Every cell is surrounded by a plasma membrane. The main components of this membrane are **phospholipids** and **proteins**. A phospholipid is a fat that has a **polar phosphate** group on one end and two **non-polar** long fatty acid tails on the other end. The phosphate is attracted to water because water is also polar, and the fatty acids are repelled by water. The water on the inside and the outside of the cell force the fatty acid

tails to the center and the phospholipids form a double layer, or bilayer. Proteins are also embedded within the plasma membrane. The **lipid bilayer** is fluid, meaning the phospholipids can move from side to side. **Cholesterol** is another fat that is very important for the stability of membranes. It stiffens the membrane, making it less fluid.

The plasma membrane encloses the cell separating the **cytoplasm** from its surroundings. It controls what enters and leaves the cell. **Lipids** and substances that dissolve in lipids such as oxygen and carbon dioxide can pass through the plasma membrane. The proteins embedded in the lipid bilayer form channels and pumps that help move molecules across the plasma membrane that cannot cross on their own. Because the lipids and proteins allow only some things to permeate, or enter, the cell, the plasma membrane is known as **semipermeable**. Similar biological membranes surround most organelles.

Which one of the following is not present in the plasma membrane?

a) Phospholipids
b) Cholesterol
c) Cytoplasm
d) Proteins

The correct answer is:
c) Cytoplasm
The plasma membrane does not contain cytoplasm. It separates the cytoplasm from the outside of the cell.

Nucleus

In the same way that the main boss controls a large factory, the nucleus is the control center of the eukaryotic cell. It contains most of the cell's genetic material in the form of **DNA** and with it the master set of instructions for making proteins. DNA and proteins contribute to the long thin fibers within the nucleus known as **chromatin**. When the cell is dividing the chromatin fibers condense to form **chromosomes**.

The nucleus is surrounded by a double membrane called the **nuclear envelope**. Each membrane is a lipid bilayer similar to the plasma membrane. The nuclear envelope is dotted with up to thousands of **nuclear pores**, which allow material to move into and out of the nucleus.

The small dense region in the non-dividing nucleus is the **nucleolus.** This is where the assembly of ribosomes begins. Proteins are combined with **ribosomal RNA** to produce small and large **ribosomal subunits**. These subunits exit the nucleus through the nuclear pores and enter the cytoplasm.

Which structure includes all of the others listed?

a) Nucleus
b) Nucleolus
c) Chromosomes
d) DNA

The correct answer is:
a) Nucleus
Found within the nucleus is the genetic material in the form of DNA which condenses into chromosomes. The nucleolus is also found inside the nucleus.

Ribosomes
After the ribosomal subunits exit the nucleus through the nuclear pore and enter the cytoplasm, a large and small subunit assemble into a ribosome. They bind to **messenger RNA** which comes from the nucleus and contains instructions for making proteins. As the ribosomes move along the RNA they assemble small compounds known as amino acids into proteins. This process is known as **protein synthesis**.

Certain chemicals block the function of ribosomes. Which cell activity would immediately be affected by this change in ribosome function?

a) Selective permeability
b) Production of energy
c) Excretion of metabolic wastes
d) Protein synthesis

The correct answer is:
d) Protein synthesis
Ribosomes are the organelles that are responsible for protein synthesis. They make proteins from instructions that they receive from the nucleus.

Rough Endoplasmic Reticulum.
The endoplasmic reticulum, also called the ER, is a network of membranous tubules called **cisternae** that are continuous with the nuclear envelope. Ribosomes bind to a large part of the ER, giving it a rough appearance, thus this organelle is called the rough ER. If a ribosome begins making a protein that will be moved through the endoplasmic reticulum or perhaps be secreted from the cell, the ribosome will attach itself to the rough ER and channel the protein inside. The proteins are then moved through the rough ER and are packaged into small vesicles that bud off from the ER surface. The rough ER also plays a role in quality control. Proteins that are not made correctly are pushed out of the rough ER into the cytoplasm where they are disposed of.

Smooth Endoplasmic Reticulum.

The rest of the endoplasmic reticulum is called smooth ER because it lacks ribosomes and appears smooth. The smooth ER performs many different processes within the cell. The most important job of the smooth ER is the **detoxification** of drugs and poisons. It also plays a role in making **hormones** and lipids.

If organelles can increase in number in response to an increased demand, then which organelle would you expect to find more of in the liver cells of a drug addict than in a non-addicted person?

a) Rough endoplasmic reticulum
b) Smooth endoplasmic reticulum
c) Mitochondria
d) Lysosomes

The correct answer is:
b) Smooth endoplasmic reticulum
The smooth endoplasmic reticulum is responsible for the detoxification of drugs and poisons.

Golgi Apparatus.
The vesicles that contain the newly formed proteins from the rough ER are called **transport vesicles** because they transport the proteins from the ER to an organelle known as the Golgi apparatus, or just the Golgi named after its discoverer Camillo Golgi. The Golgi consists of a set of flattened membrane-bound sacs that serves as the packaging and distribution center of the cell. The Golgi faces the nucleus and ER on one side and the plasma membrane on the other side. The nuclear side acts as the receiving department and the side facing outward acts as the shipping department. Transport vesicles traveling from the ER fuse with the Golgi and deposit their proteins inside.

Enzymes inside of the Golgi apparatus modify the proteins and the Golgi then sorts its products and targets them for various parts of the cell or for secretion outside the cell. The products then bud off of the Golgi inside transport vesicles. Transport vesicles carrying products destined for secretion from the cell go on to fuse with the plasma membrane. Other vesicles go on to fuse with lysosomes or other organelles.

You would expect a cell with an extensive Golgi apparatus to

a) Make a lot of energy
b) Move actively
c) Sort a lot of material
d) Store large quantities of food

The correct answer is:
c) Sort a lot of material

The Golgi apparatus is the packaging and distribution center of the cell so if a cell has an extensive Golgi apparatus it is safe to assume that it would sort a lot of material.

Lysosomes

Every factory needs a cleanup crew. In the eukaryotic cell, lysosomes perform this task and remove the junk that might otherwise accumulate and clutter up the cell. Lysosomes are membranous bags filled with **enzymes** that break down lipids, sugars, proteins, and other waste materials into small molecules that can be used by the cell. Lysosomes also break down excess organelles that are no longer needed or are damaged and no longer functioning properly.

Cells can acquire large substances such as food particles from the outside of the cell by forming **endosomes** from the plasma membrane. These endosomes can move to the lysosome where the outside substances are broken down into more useful compounds.

The function of a lysosome is to

a) Protect the cell from the external environment
b) Synthesize proteins
c) Make energy for the cell
d) Remove cellular waste products

The correct answer is:
d) Remove cellular waste products
Lysosomes remove the wastes and break down excess organelles that could accumulate and clutter up the cell.

Mitochondria

After learning about the cell parts and the functions that they perform, it is easy to see that each of these functions requires a lot of energy. The most important form of energy that the cell can immediately use is stored in a molecule called **ATP**. Mitochondria are the organelles that provide much of this energy and are therefore known as the powerhouse of the cell. In a process known as **cellular respiration**, mitochondria convert the chemical energy found in organic compounds such as the broken down food and convert it into ATP which is more convenient for the cell to use.

A mitochondrion has two membranes. The outer membrane is smooth, while the inner membrane is highly folded inward providing a very large surface area for energy production. Mitochondria also have their own circular DNA and have their own ribosomes.

The cell organelle that would be found in cells requiring large quantities of energy is the

a. Golgi apparatus
b. Mitochondrion
c. Lysosome
d. Nucleolus

The correct answer is:
b) Mitochondrion
The mitochondrion is the cell organelle that functions in energy production. To meet the need for large quantities of energy, a cell must have large numbers of mitochondria.

Plant cells can also be compared to a factory with a couple extra workers. Plant cells contain all of the organelles mentioned so far but have several additional components. The rigid **cell wall** is much like a brick wall surrounding the fence around the factory and provides an extra layer of protection. The **chloroplasts** are the solar panels on the roof of the factory that convert the sunlight into additional energy for the factory. And finally, the **central vacuole** is the factory's storage building for storing extra materials.

Let's look at these additional components of the plant cell a little closer.

Cell wall
Plant cells have an additional line of protection, known as the cell wall, that distinguishes them from animal cells. The thick cell wall is composed of proteins and **carbohydrates** including the **polysaccharide cellulose**. The wall surrounds the plasma membrane and protects the plant cell, maintains its shape, and prevents excessive uptake of water. Most cell walls are porous enough to allow nutrients and gasses to pass through easily.

The cell wall contains all of the following except:
a) Proteins
b) Carbohydrates
c) Cholesterol
d) Cellulose

The correct answer is:
c) Cholesterol
The cell wall of a plant contains proteins, carbohydrates, and cellulose. Cholesterol is a lipid and is found in the plasma membrane.

Chloroplasts
Remember that plant cells have mitochondria to produce energy but they also have an additional power source known as chloroplasts. Chloroplasts are the biological equivalents to solar power plants because they can directly convert sunlight into energy in the form of ATP, in a process called **photosynthesis**. Chloroplasts contain the green

pigment chlorophyll that helps to harvest the light energy and are found in the leaves of plants. Much like the mitochondria, chloroplasts are surrounded by a double membrane, but they also have small interconnected discs called **thylakoids** inside where the light harvesting takes place. Surrounding the thylakoids is a fluid known as **stroma**. Found within the stroma are ribosomes and circular DNA.

Which of the following sets of features is common to both plant and animal cells?

a) Mitochondria and a plasma membrane
b) Nucleus and chloroplast
c) Plasma membrane and cell wall
d) Chloroplast and ribosome

The correct answer is:
a) Mitochondria and a plasma membrane
Both plants and animals have a plasma membrane and mitochondria. Chloroplasts and cell walls are only found in plant cells.

Central Vacuole

Every factory needs a place to store things, and plant cells contain a place for storage as well. Mature plant cells generally contain a large central vacuole that is enclosed by a membrane called the **tonoplast** and takes up most of the cell's volume. The central vacuole stores water, salts, proteins, and carbohydrates. When the central vacuole is full the pressure it exerts on the cell wall makes it possible for plants to support heavy structures such as leaves and flowers.

If you saw a plant whose stem and leaves were wilted, what could you conclude about the central vacuole:

a) The water level was too high
b) The water level was too low
c) It was filled
d) None of the above

The correct answer is:
b) The water level was too low
In order for the central vacuole to support the heavy structures of the plant it needs to be full of water and pushing against the cell wall.

The cellular factories inside our bodies are continuously working to make sure we function properly and each organelle plays an important role. Everything a living organism does can ultimately be traced back to the cell.

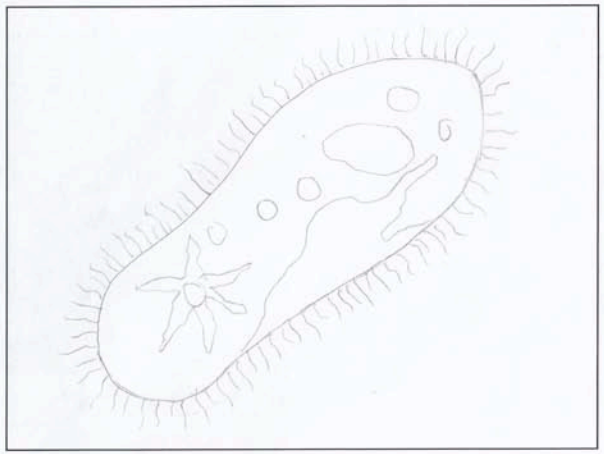
APPENDIX D
Storyboards

Project: Organelle Extravaganza

Date:

706-255-5919

3



- The cell fades into a video of the paramecium moving (video from the feeding paramecia lab)
- SCRIPT: "Some exist as single-celled organisms"

4

- SCRIPT: "while others, including humans, are multicellular and consist of many different kinds of specialized cells working together"
- Fade from paramecium movie into an image of a girl smelling a flower

gettyimages - teenage girl smelling flower

Jennifer Hulsey: UTSW Biomedical Communications

Email: JLH26@aol.com

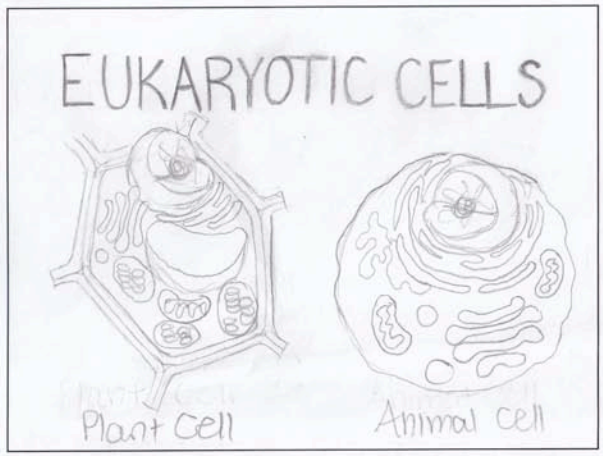
2

Project: Organelle Extravaganza

706-255-5919

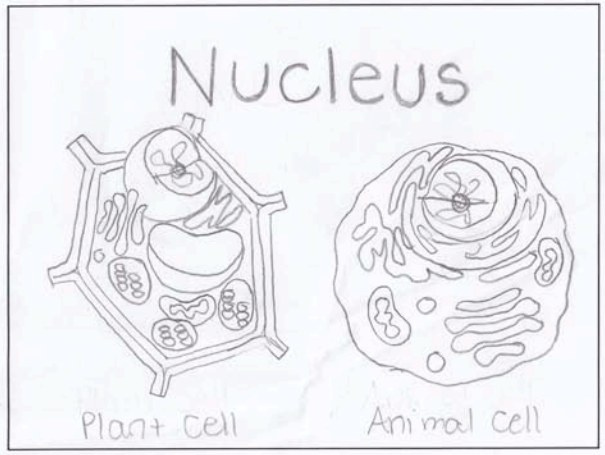
Date:

5



- Zoom into image in scene 4 to reveal a plant and animal cell with labels beneath them.
- "Eukaryotic cells" fades in above the cell models over two seconds
- SCRIPT: "The cells that make up plants and animals are called Eukaryotic cells"

6



- The nucleus of both the plant and animal cells light up
- "Eukaryotic cells" fades out and "nucleus" fades in over two seconds
- SCRIPT: "Eukaryotic cells have a nucleus and many structures called..."

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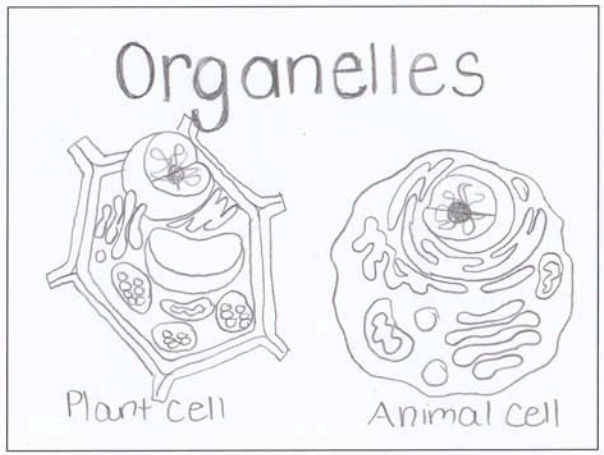
3

Project: Organelle Extravaganza

706-255-5919

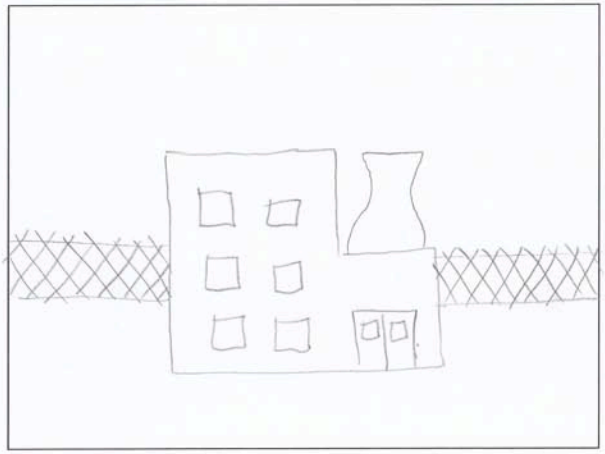
Date:

7



- "Nucleus fades away and "organelles" fades in over two seconds
- The organelles light up in both the plant and animal cells
- SCRIPT: "organelles that carry out specific functions within the cell."

8



- Zoom into animal cell and fade to an outside view of the factory
- SCRIPT: "In many ways a Eukaryotic cell is similar to a factory with its organelles working together as a group to produce a product. In this cellular factory, each organelle carries out a specific function."

Jennifer Hulsey: UTSW Biomedical Communications

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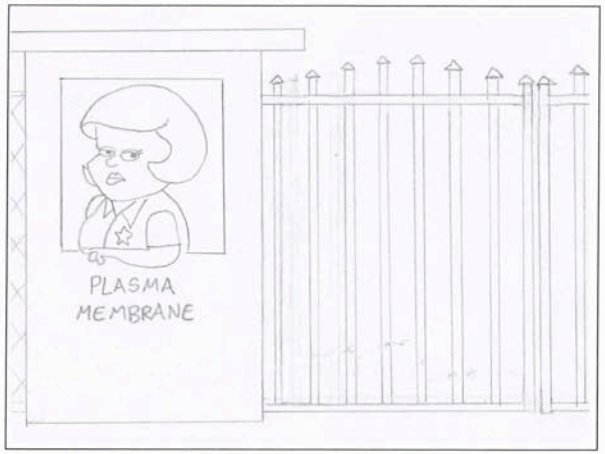
4

Project: Organelle Extravaganza

706-255-5919

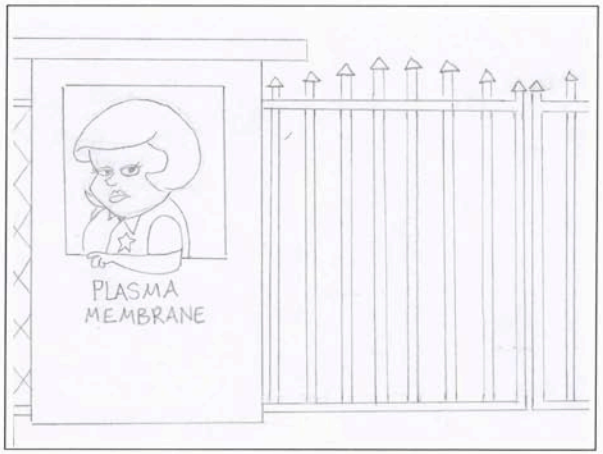
Date:

9



- Fade into a view of the security guard and gate with the factory in the background.
- SCRIPT: "The plasma membrane is the gatekeeper that decides what gets into and out of the cell."

10



- The security guard nods

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5

Project: Organelle Extravaganza

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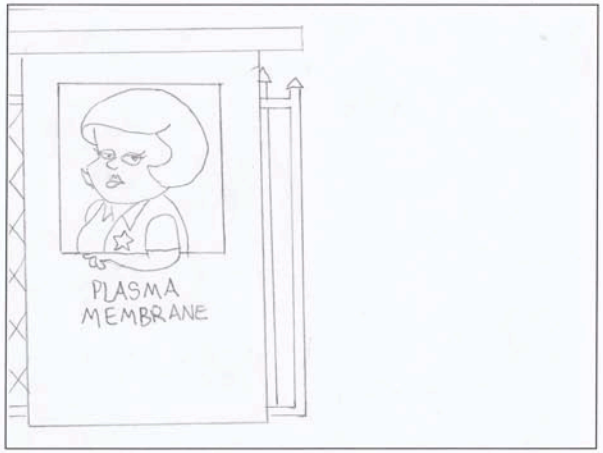
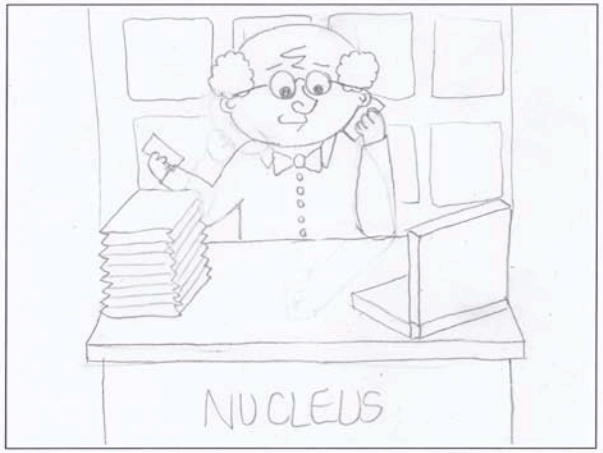
Date:

11



• The gate opens.

12



• Zoom into the factory and fade into the boss's office where the nucleus is sitting at his desk.
• SCRIPT: "The nucleus is the control center for the cell. And is similar to the main boss of a factory."

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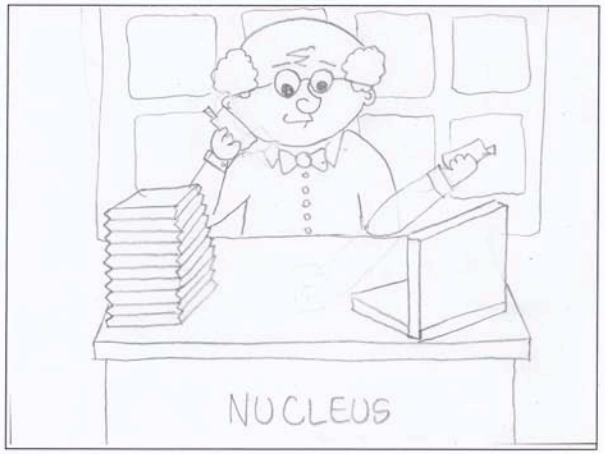
6

Project: Organelle Extravaganza

706-255-5919

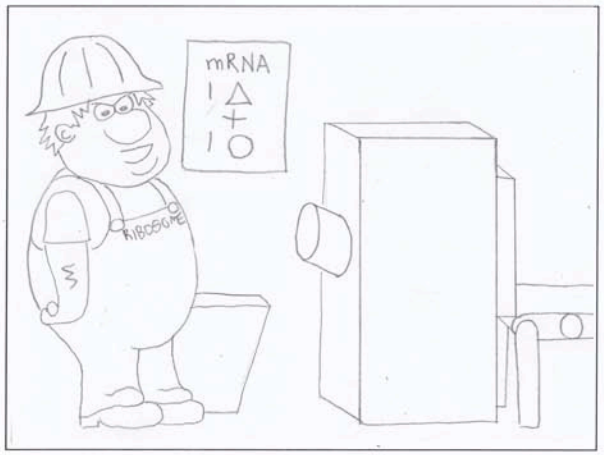
Date:

13



- The nucleus switches phones
- The characters in the tvs move.

14



- Fade from office to the ribosome worker at his machine with the mRNA instructions sign
- SCRIPT: "The ribosomes are the many machines working to produce its product."

Jennifer Hulsey: UTSW Biomedical Communications

Email: JLH26@aol.com

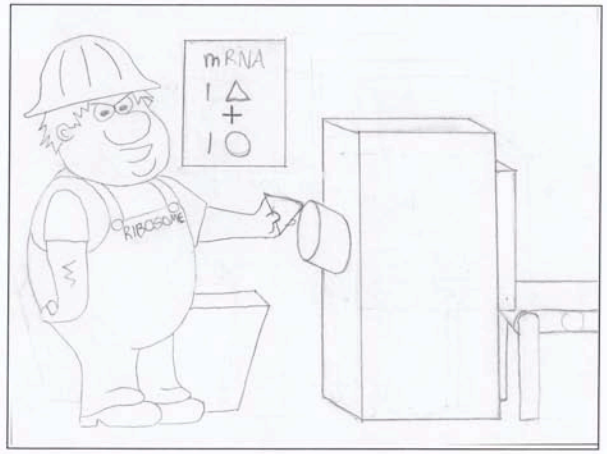
7

Project: Organelle Extravaganza

706-255-5919

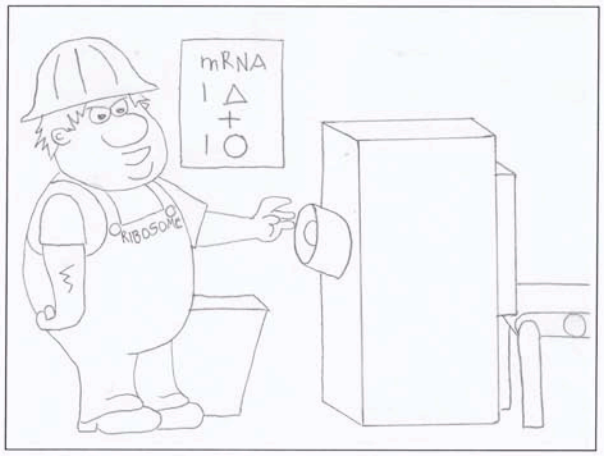
Date:

15



• The ribosome puts the blue triangle into the machine and reaches into the bin to get a red circle

16



• The ribosome puts the red circle into the machine.

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8

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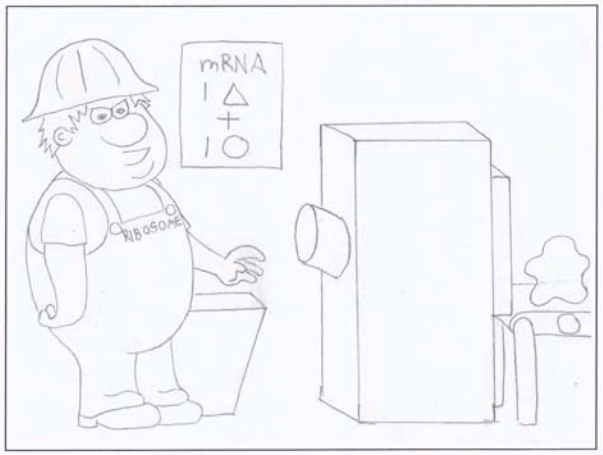
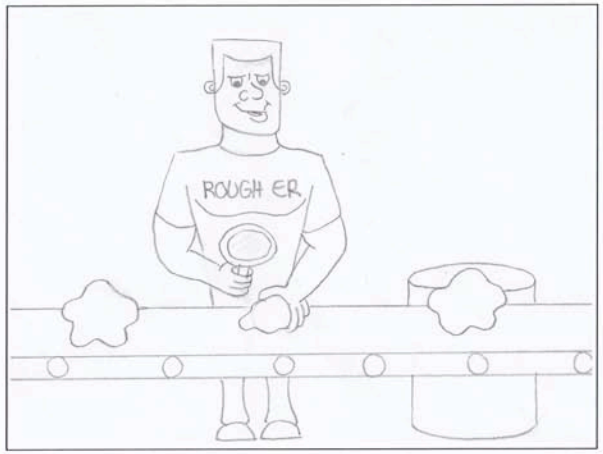
Date:

17



- The protein comes out on the other side of the machine onto the conveyer belt

18



- Fade from the ribosome into the Rough ER at his assembly line.
- SCRIPT: "The rough endoplasmic reticulum moves proteins and other substances through the cell, much like an assembly line of a factory, and plays a role in quality control

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9

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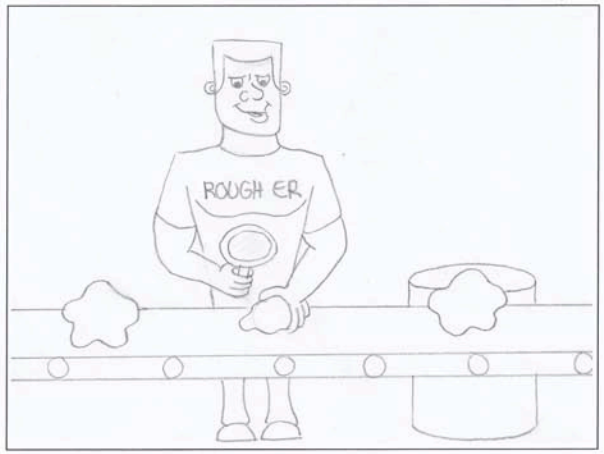
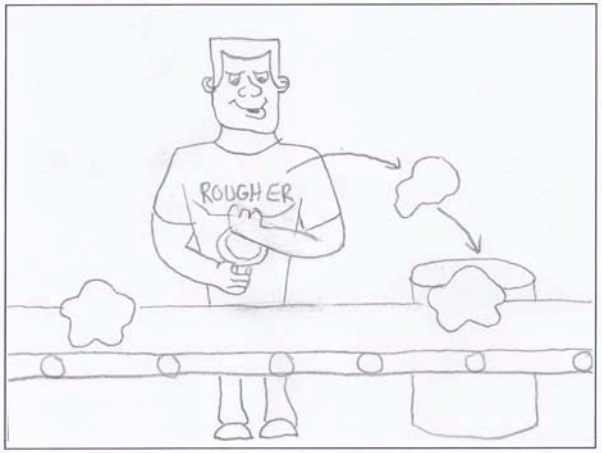
19



• The rough ER takes a green deformed protein from the assembly line

20



• He then throws the deformed protein into the trashcan.

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10

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706-255-5919

Date:

21

- Fade from rough ER into the Packaging + Distribution center where the Golgi is at a table with a box
- There are three assembly lines labeled plasma membrane, lysosome and Rough ER with boxes on them
- The boxes exit to the right.
- SCRIPT: "The packaging and distribution center of the cell is the Golgi apparatus where the destination of each product is decided."

22

- A protein comes through the opening in the wall.

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11

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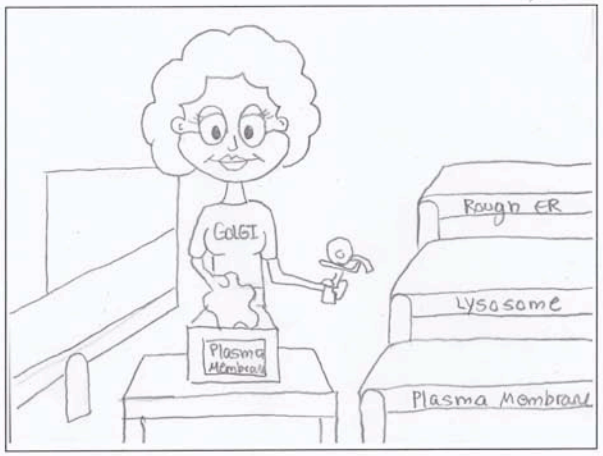

- The Golgi reaches out and grabs the protein

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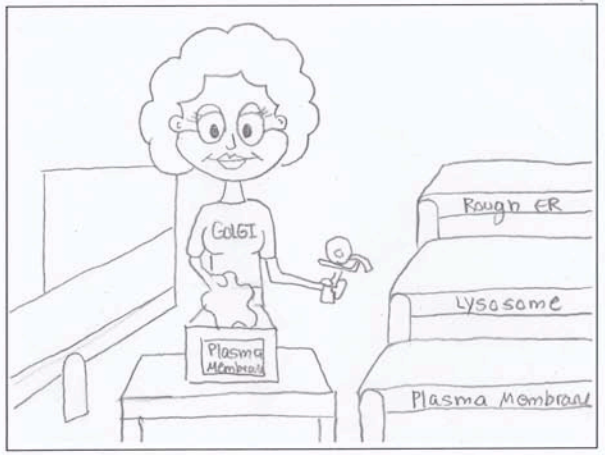
24



- The Golgi places the protein into the box labeled Plasma membrane

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12

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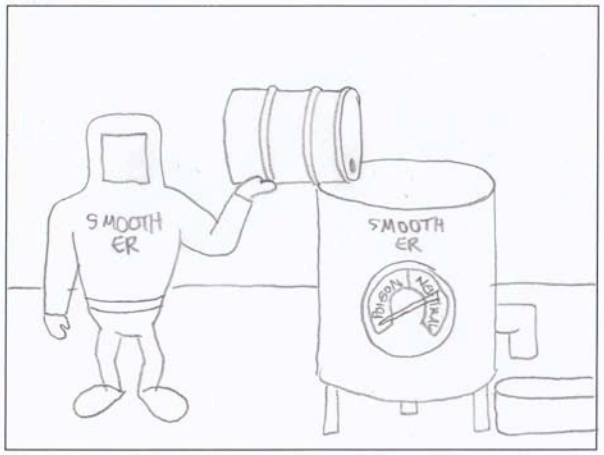
706-255-5919

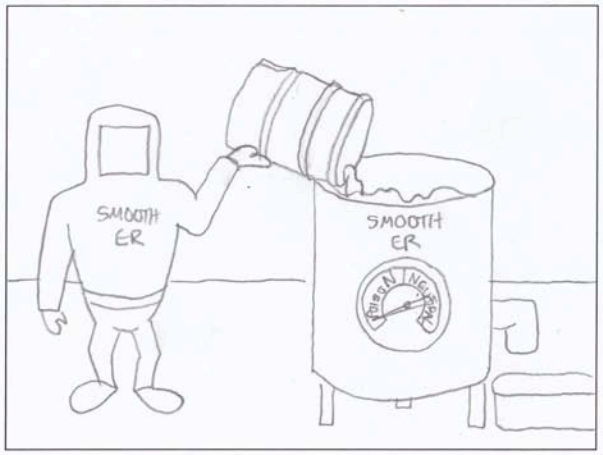
Date:

74



- Fade into the poison control room where the smooth ER is there with the smooth ER machine.
- SCRIPT: "The smooth endoplasmic reticulum acts as a poison control center for the factory, neutralizing drugs and poisons."

75



- The smooth ER pushes the barrel up and slime enters the smooth ER machine and fills

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13

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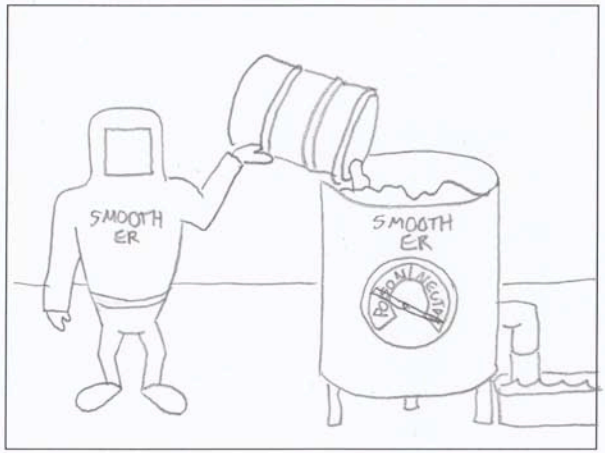
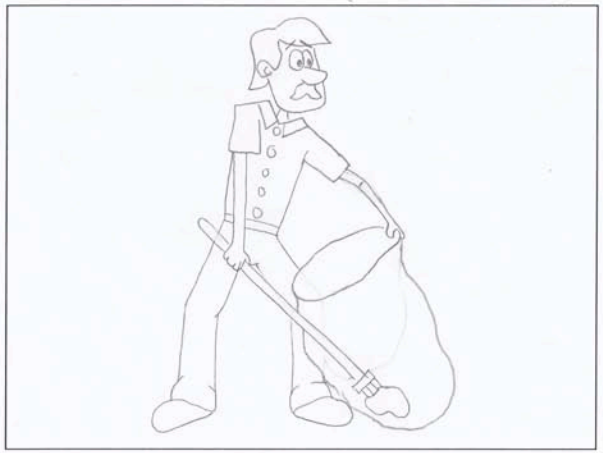
26



- The arrow on the dial moves from poison to neutral and the water pours into the trough.

27



- Fade into the lawn where the lysosome is picking up trash.
- SCRIPT: "The cleanup crew are the lysosomes which clean up all the trash in the factory.

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14

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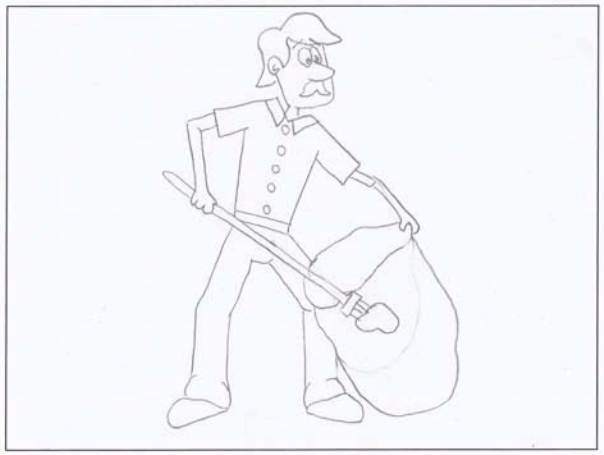
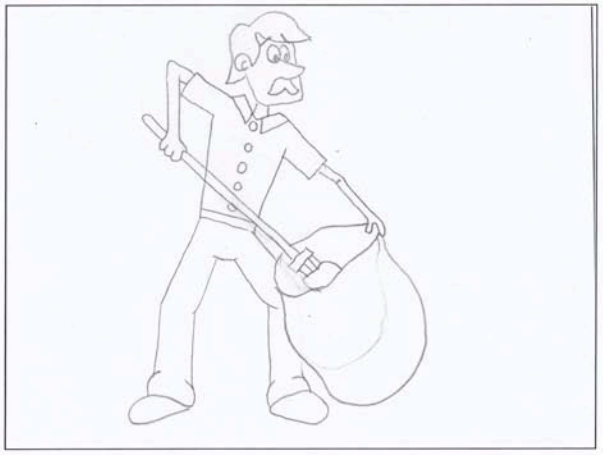
706-255-5919

Date: 7/9



• The lysosome picks up the trash

7/9



• and puts it in the bag.

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15

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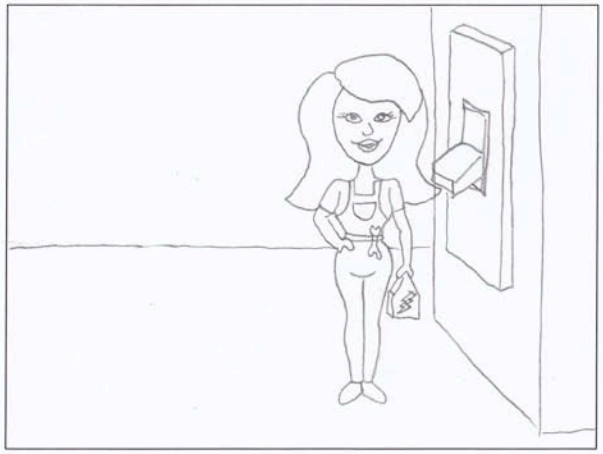
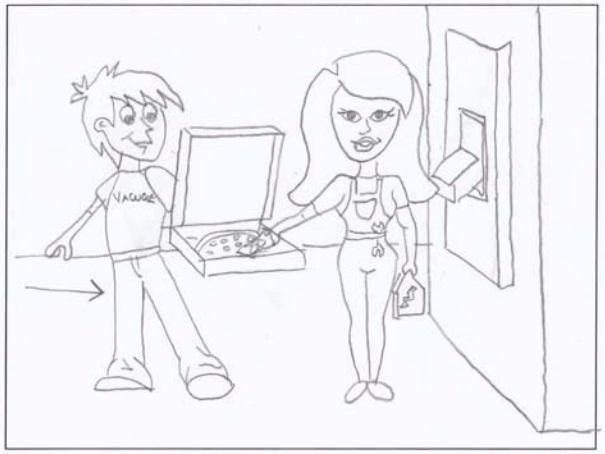
Date:

30



- Fade into the mitochondria outside of the factory
- SCRIPT: "The mitochondrion is the power source for the factory."

31



- The food vacuole slides in from the left and the mitochondria takes a piece of pizza
- SCRIPT: "It uses energy stored in food..."

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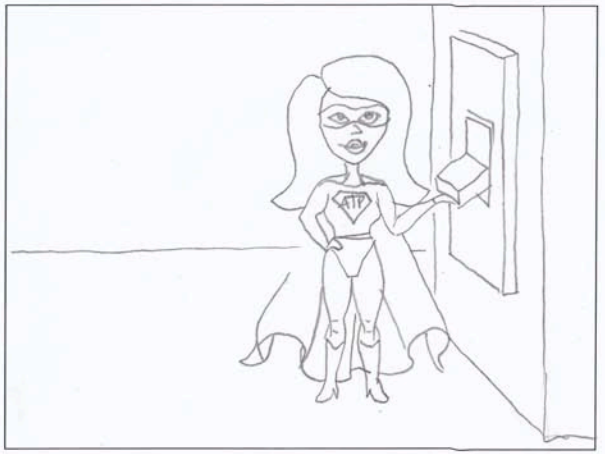
31

- The mitochondria eats the pizza

32



- There is a puff of smoke, the food vacuole disappears. The super ATP appears.

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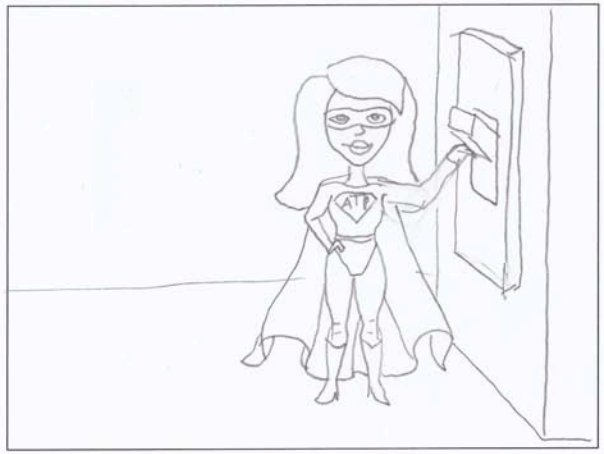
33



- The mitochondria lifts the light switch and the lights go on.
- SCRIPT: "to produce enough energy to power the cellular factory"

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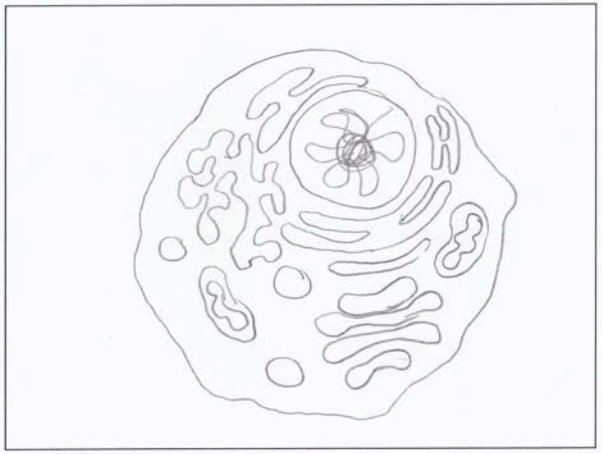
34



- Fade into an outside view of the animal cell
- SCRIPT: "Now that we have a basic overview of each of the organelles functions, let's look at each on of them a little closer. We will start with the animal cell."
"There are several different ways you can study cells. You can study them through models such as this one. Actual organelles aren't colored except for chloroplasts but color has been added to this model to make it easier to visualize

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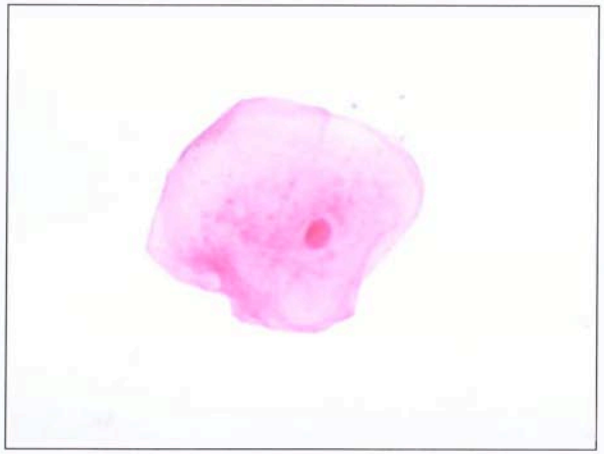
Date:

35



- Fade into the cheek cell lab picture.
- SCRIPT: "You can also observe cells through a light microscope, which uses lenses to produce an enlarged image."

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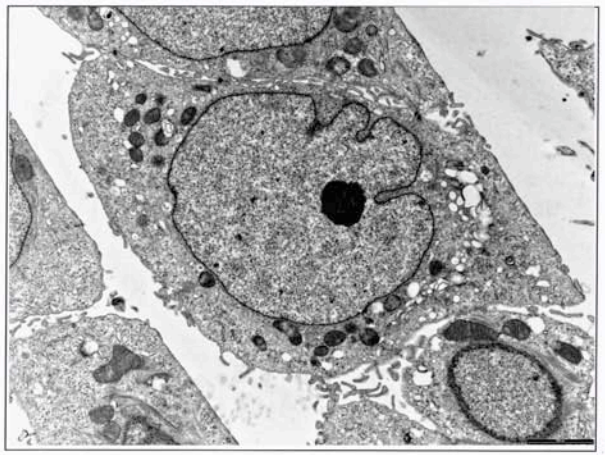
36



- Fade into an EM of the cell.
- SCRIPT: "Or observe smaller organelles and cell parts through a higher powered electron microscope that uses electrons to illuminate the cell and create an enlarged image."

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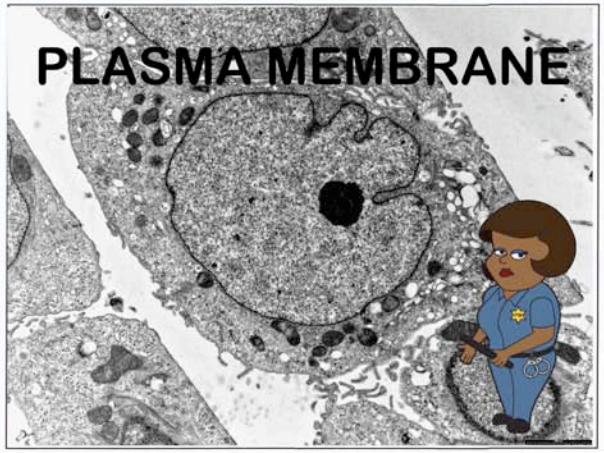
706-255-5919

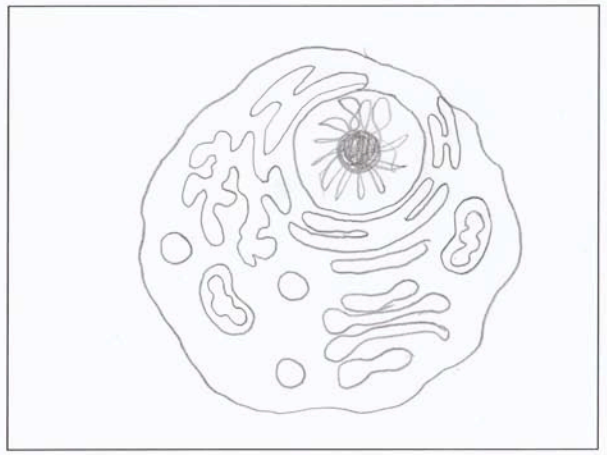
Date:

37



- Highlight the plasma membrane on the EM.
- SCRIPT: "Let's start with the plasma membrane.

38



- Fade into a view of the cut animal cell and highlight the plasma membrane
- SCRIPT: "Every cell, plant and animal, is surrounded by a plasma membrane."

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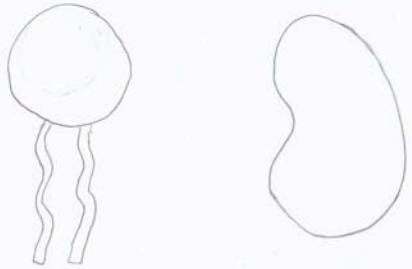
39

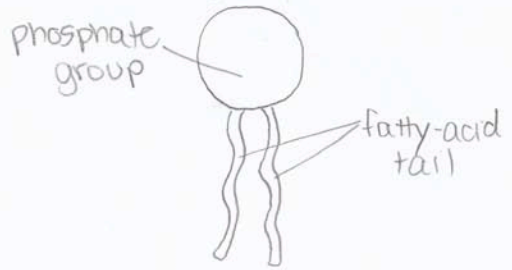
Phospholipids + Proteins



- Zoom into plasma membrane and fade into a phospholipid and protein model on a black background.
- Title "phospholipids and proteins" in white is above the models.
- SCRIPT: "The main components of this membrane are phospholipids and proteins."

40

Phospholipid



- Zoom into the phospholipid and the protein and protein title fade away
- label for the phosphate group fades in over one second and holds.
- Label for the fatty acid tails fades in over one second and holds until the end of the sentence.
- SCRIPT: "A phospholipid is a fat that has a polar phosphate group on one end and two non-polar long fatty acid tails on the other end."

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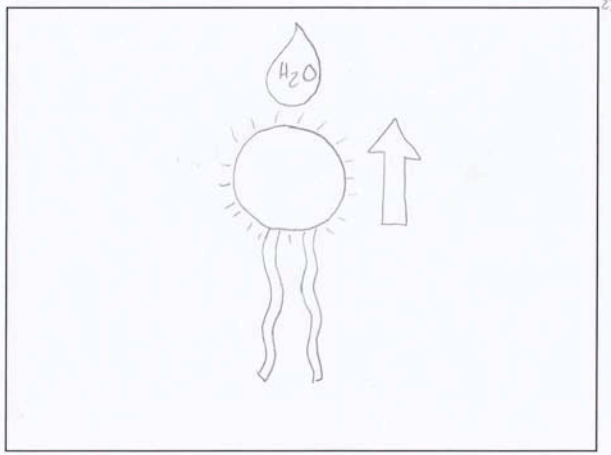
706-255-5919

Date:

41

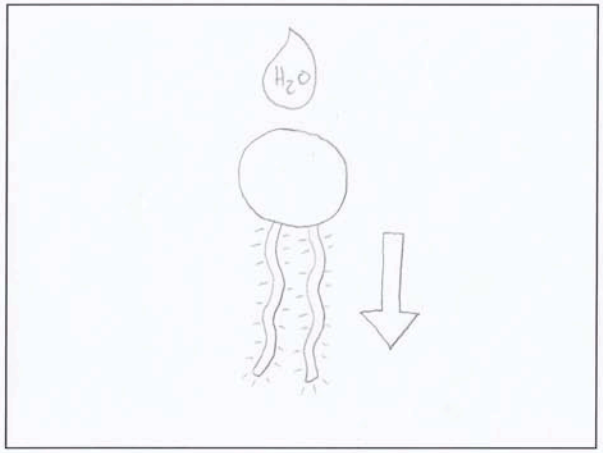
23



- Title "Phospholipid" fades away
- Water droplet fades in above the phospholipid
- The phosphate group highlights and an arrow fades in pointing towards the water and fades out after "polar"
- SCRIPT: "The phosphate group is attracted to water because water is also polar."

42

24



- The fatty acid tails highlight and an arrow fades in pointing away from the water and fades out at end of sentence
- SCRIPT: " and the fatty acids are repelled by water."

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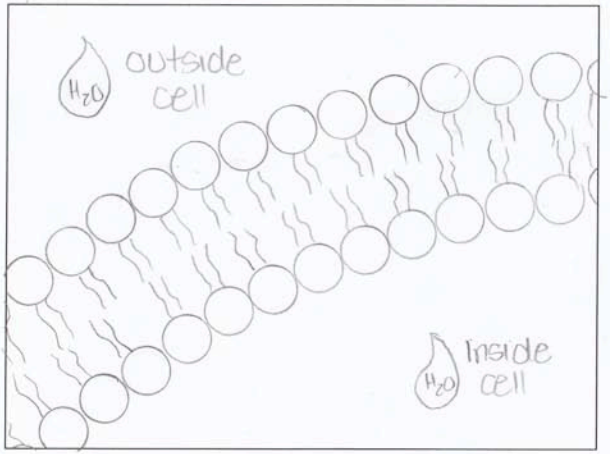
Date:

43



- Water droplet splits and moves to the upper left corner and lower right corner
- Text "outside cell" and "inside cell" fade in when water reaches corners
- Phospholipid shrinks and joins other phospholipids that fade in to form a bilayer
- SCRIPT: "The water on the inside and outside of the cell force the fatty acid tails to the center and the phospholipids form a double layer or bilayer"

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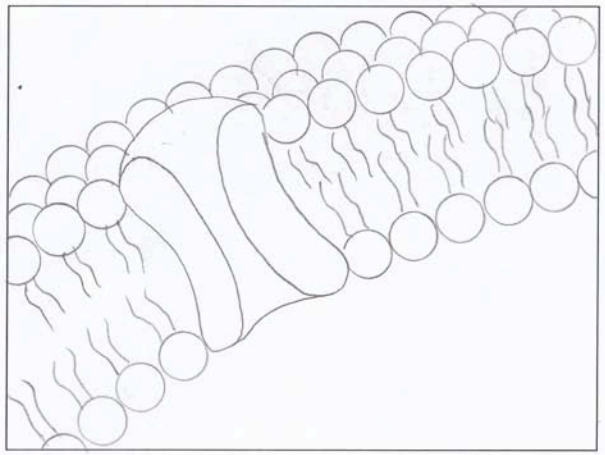
44



- The rest of the phospholipids fade in as well as the proteins.
- SCRIPT: "Proteins are also embedded within the plasma membrane"

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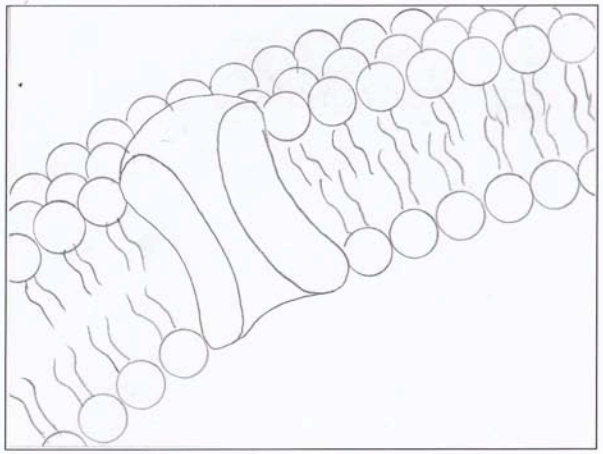
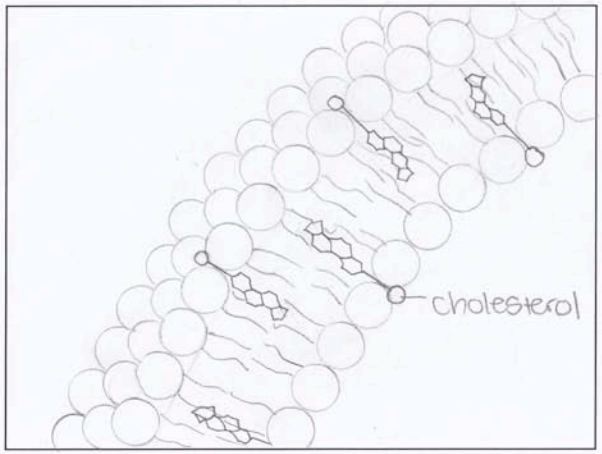
45



- The phospholipids move.
- SCRIPT: "The lipid bilayer is fluid, meaning the phospholipids can move from side to side."

46



- Zoom into the plasma membrane and show lipid bilayer moving around
- Highlight cholesterol inside the membrane and show the plasma membrane movement slowing down
- SCRIPT: "Cholesterol is another fat that is very important for the stability of membranes. It stiffens the membrane, making it less fluid"

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24

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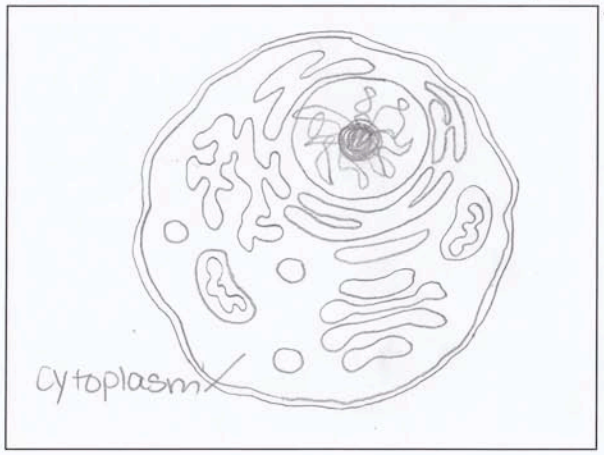
Date:

47

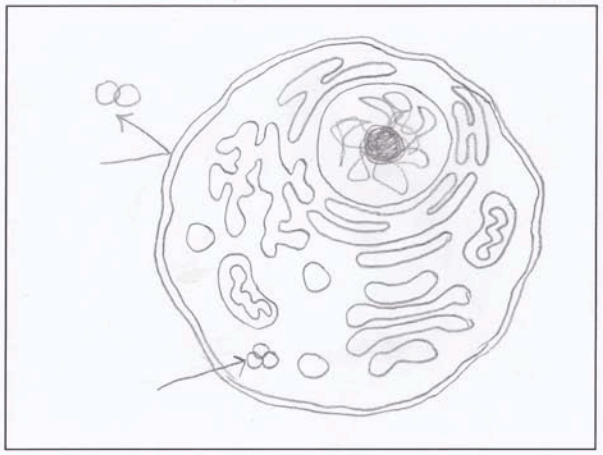
27



- The EM fades away and so does the highlight on the cell model
- The plasma membrane is cut and the cytoplasm is highlighted and labeled
- SCRIPT: "The plasma membrane encloses the cell separating the cytoplasm from its surroundings."

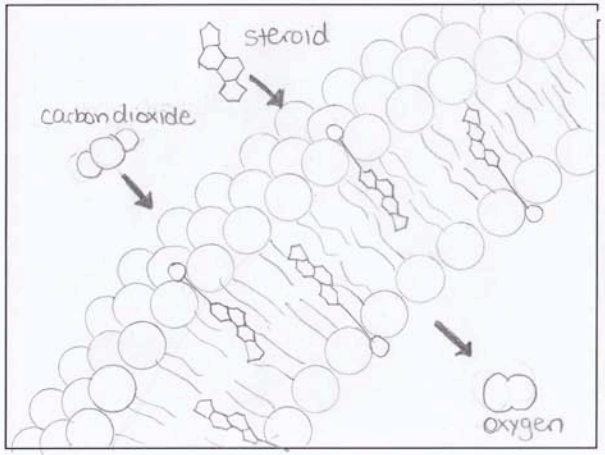
48

28



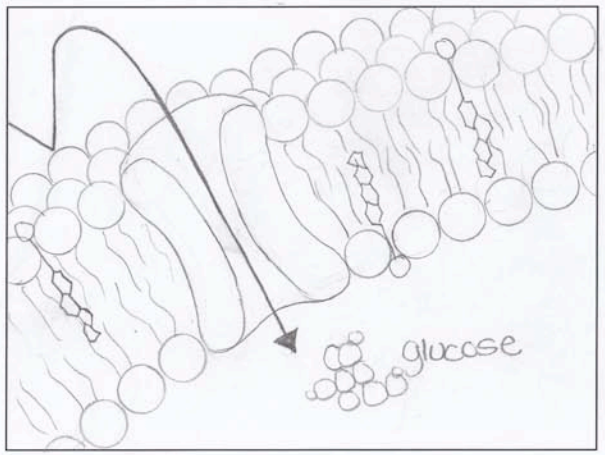
- Show a molecule entering the cell through the plasma membrane and then show another molecule bouncing off the plasma membrane
- Show a molecule exiting the cell through the plasma membrane
- SCRIPT: "It controls what enters and leaves the cell."

49



- Show oxygen, carbon dioxide, and steroids passing through the plasma membrane.
- SCRIPT: "Lipids and substances that dissolve in lipids such as oxygen, carbon dioxide and steroids can pass through the plasma membrane."

50



- Move along the membrane and stop at a protein.
- Show glucose try to enter through lipids then have gates open and the glucose pass through the channel into the cell.
- SCRIPT: "These proteins embedded in the lipid bilayer form channels and pumps that help move molecules that are just too polar and cannot cross the lipid bilayer on their own across the cell membrane."

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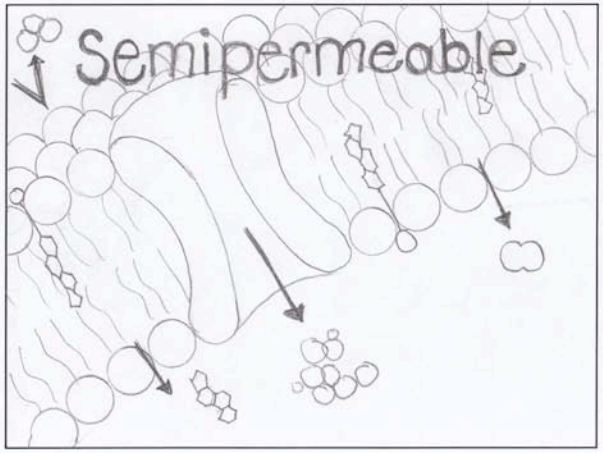
706-255-5919

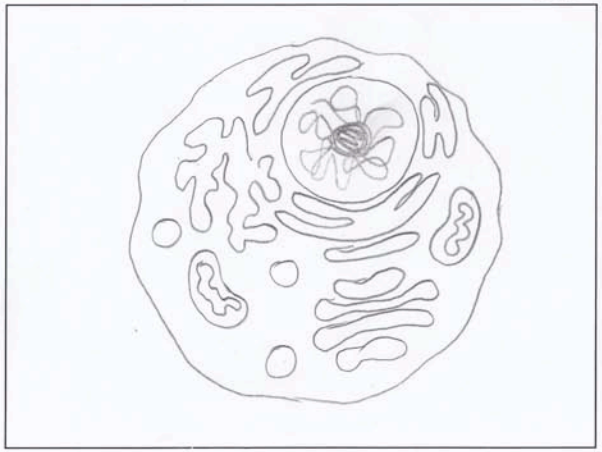
Date:

S1



- Show many different molecules trying to enter and leave the cell and only some of pass through while others are stopped.
- "Semipermeable fades in above membrane"
- SCRIPT: "Because the lipids and proteins allow only some things to permeate the cell, the plasma membrane is known as semipermeable"

S2



- Zoom back out to the entire cell and highlight other organelles with membranes (endoplasmic reticulum, golgi apparatus,
- SCRIPT: "Similar biological membranes surround many organelles

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27

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Date:

53

QUESTION 1

Which one of the following is not present in the plasma membrane?

a) Phospholipids
b) Cholesterol
c) Cytoplasm
d) Proteins

- Fade into question one with plasma membrane faded behind it
- The number one students compete to get the correct answer. The teacher can then click on the answer the student chose and it will reveal whether they are right or wrong. If wrong the next student gets to guess

706-255-5919

54

CORRECT!

The plasma membrane does not contain cytoplasm. It separates the cytoplasm from the outside of the cell.

- If the correct answer is chosen CORRECT and the reason why will fade in over the plasma membrane ghosted image.
- If the answer is wrong an x will appear over the letter and they will have to try again.

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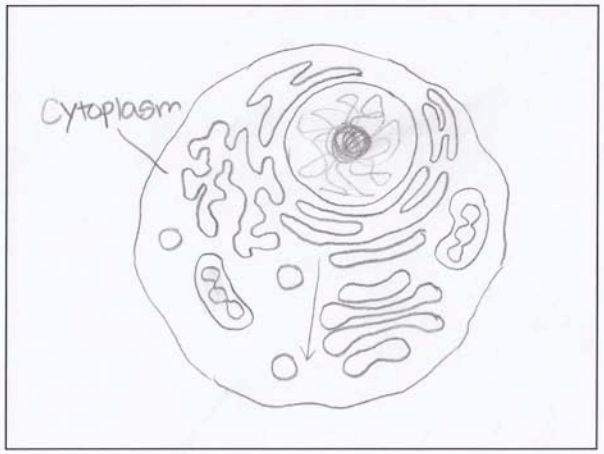
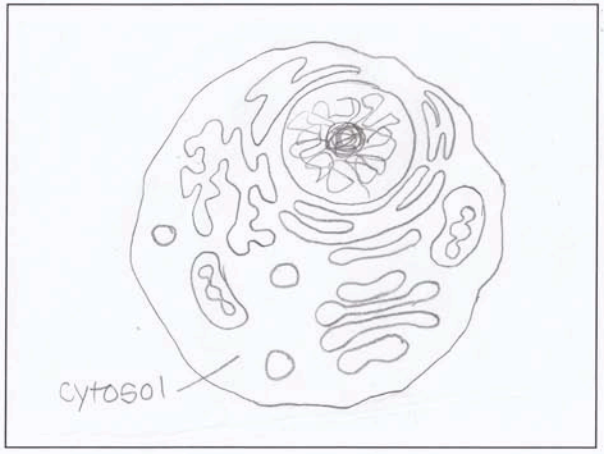
706-255-5919

Date: 55



- Fade from answer into the normal cell.
- Highlight circle grows from outside the nucleus to the plasma membra
- Cytoplasm is labeled
- SCRIPT: "The entire region between the nucleus and the plasma membrane is a watery environment called the cytoplasm."

Date: 56



- Show organelles moving around and bumping into eachother
- Label cytosol and highlights
- SCRIPT: "All the organelles within the cell are found within the cytoplasm floating in a gel-like substance known as the cytosol."

2.

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29

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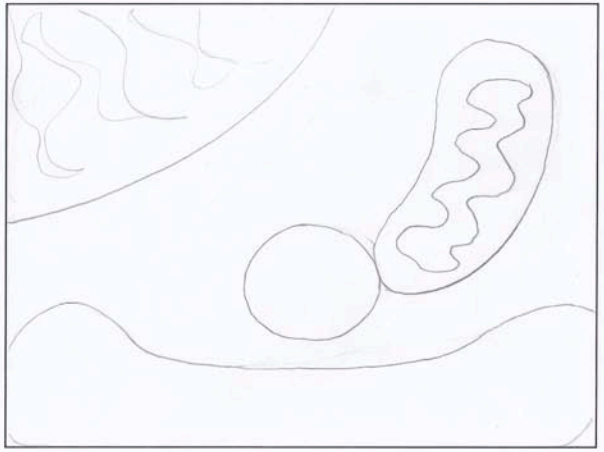
57



- Move inside the cell and show organelles bumping into each other
- SCRIPT: "The cytoplasm is a very crowded place with organelles and molecules continually bumping into each other."

58

- Zoom out to show the entire cell and highlight the cytoskeleton and label
- SCRIPT: "Found within the cytoplasm is the support system of the cell known as the cytoskeleton. The cytoskeleton consists of microscopic fibers that hold the cell together & suspend structures within the cytoplasm.

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30

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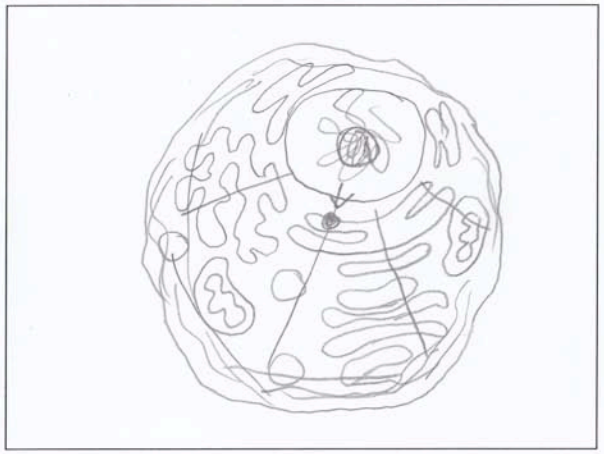
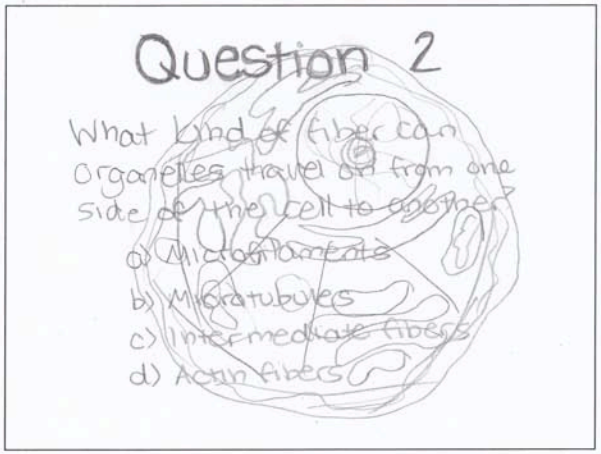
59



- Show a particle move along a microtubule from the nucleus.
- SCRIPT: "It also allows movement of particles within the cytoplasm."

60



- Fade into question two with the cytoskeleton ghosted behind it
- The number 2 students compete to get the correct answer. The teacher then clicks on the answer the student chose, and it will reveal whether they are right or wrong. If wrong the next student gets to guess.

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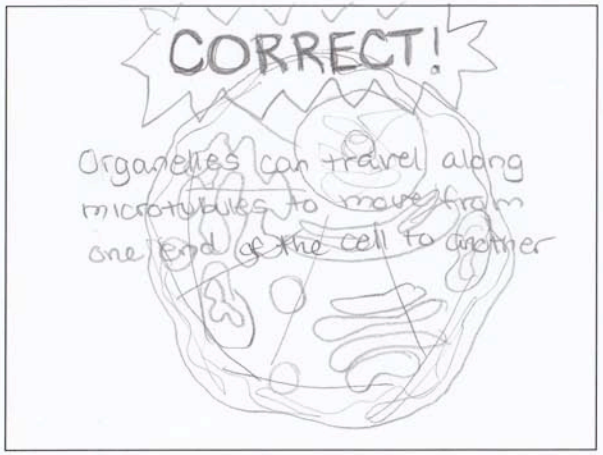
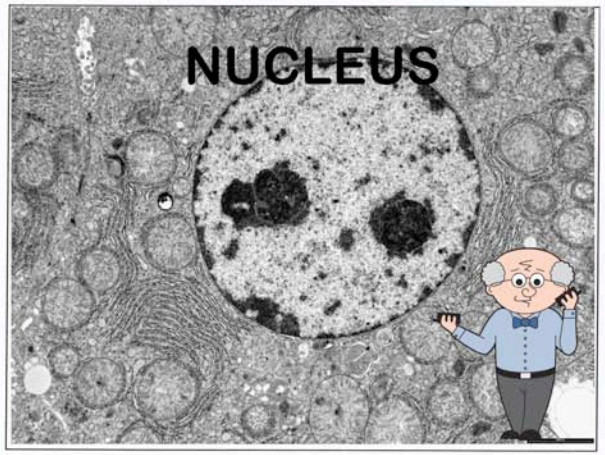
61



- If the correct answer is chosen CORRECT and the reason why will fade in over the cytoskeleton image
- If the answer is wrong an X will appear over the letter and the next student will try

Date:

62



- Fade to the EM of the nucleus with nucleus title and nucleus character
- SCRIPT: "NUCLEUS"

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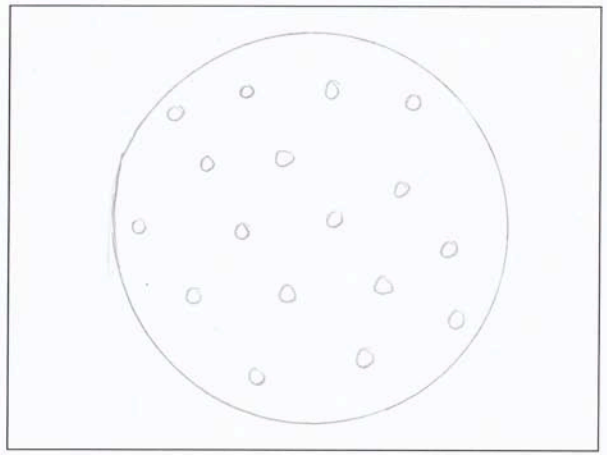
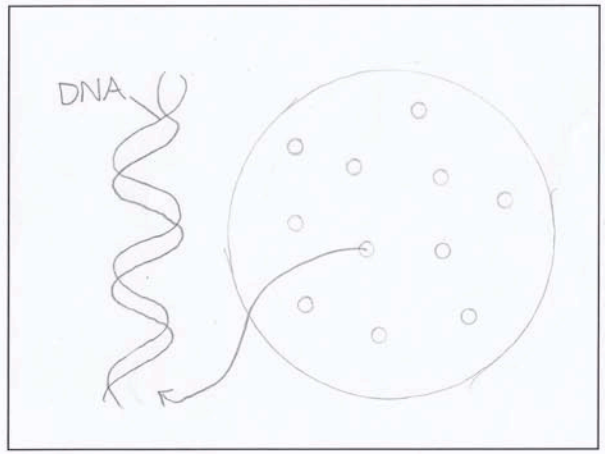
63



- Fade into a view of the nucleus
- SCRIPT: "In the same way that the main boss controls a large factory, the nucleus is the control center for the eukaryotic cell."

64



- A strand of DNA comes out of the nucleus and stops to the left of the nucleus
- The DNA is labeled
- SCRIPT: "It contains most of the cell's genetic material in the form of DNA and with it the master set of instructions for making proteins."

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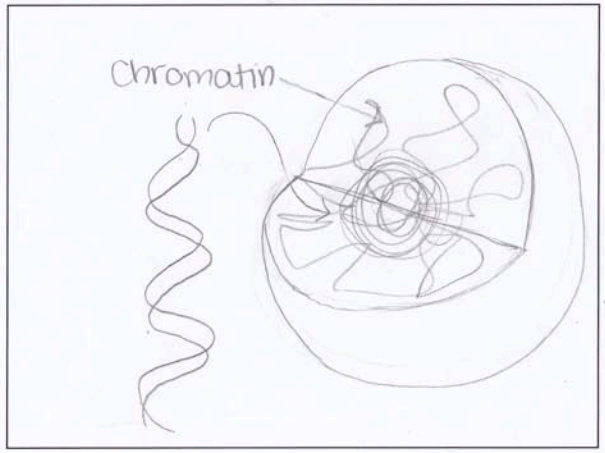
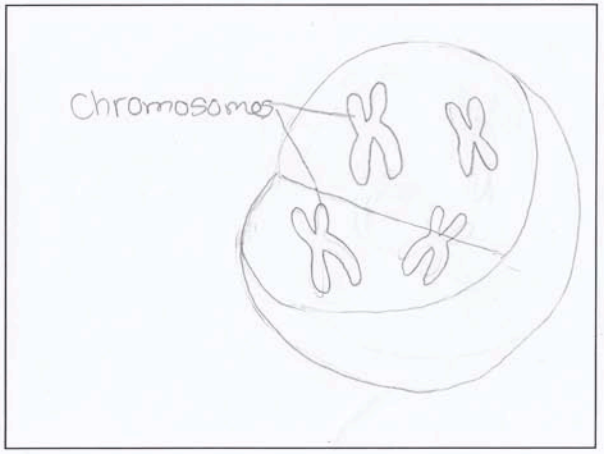
65



- The nucleus is cut to reveal the chromatin inside
- The DNA moves into the cell and fades into the chromatin
- The chromatin is labeled
- SCRIPT: "DNA and protein contribute to the long thin fibers within the nucleus. The material is known as chromatin..."

66



- The chromatin condenses into chromosomes
- The chromosomes are labeled
- SCRIPT "When the cell is dividing the chromatin fibers condense to form chromosomes"

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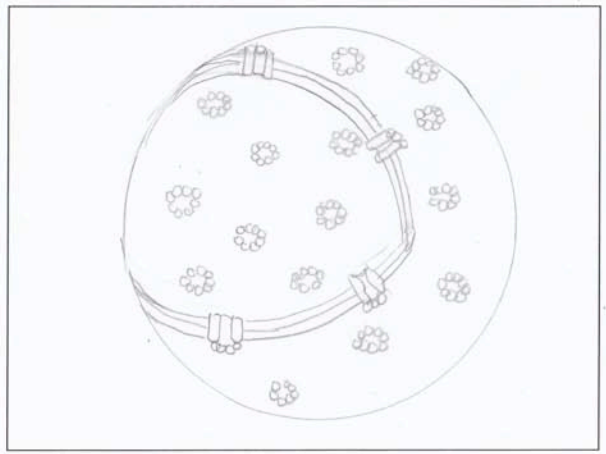
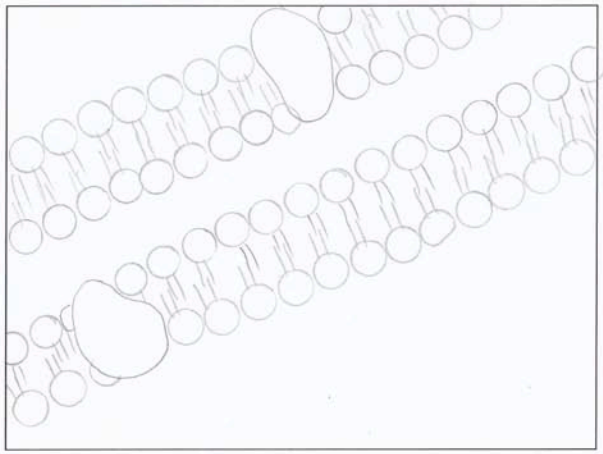
67



- The inside of the nucleus fades to reveal the shell of the nuclear envelope. + it is labeled.
- SCRIPT: "The nucleus is surrounded by a double membrane, called the nuclear envelope..."

68



- Zoom into envelope and fades into a view of the lipid bilayers which also has a lipid bilayer composition. Each of the two bilayers has a similar composition to the plasma membrane."

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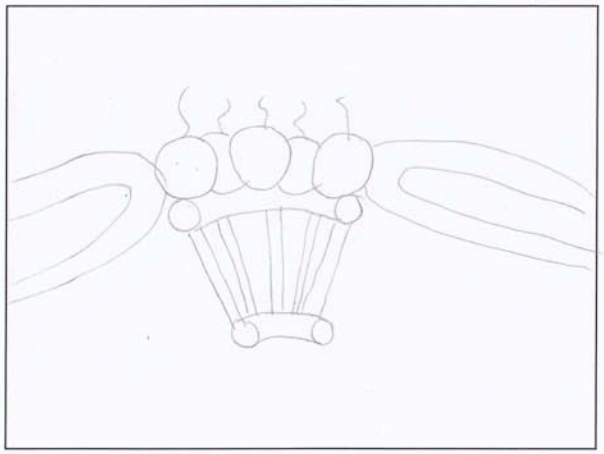
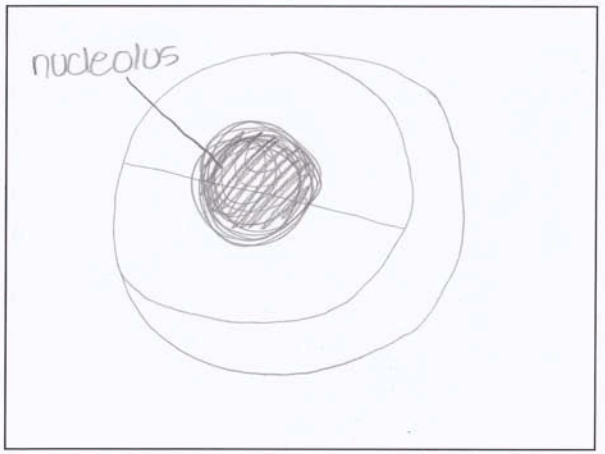
69



- Move along the nuclear envelope until you arrive at the nuclear pore.
- label "nuclear pore" and show something move through it
- SCRIPT: The nuclear envelope is dotted with thousands of nuclear pores, which allow material to move into and out of the nucleus."

70



- zoom back out and fade into the cut nucleus
- label the nucleolus
- SCRIPT: "The small dense region in the non-dividing nucleus is the nucleolus."

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36

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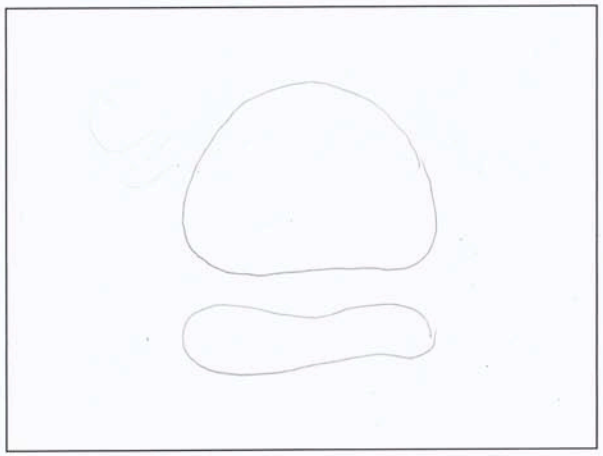
71



- Zoom into the nucleolus to see the ribosomal subunits.
- SCRIPT: "This is where the assembly of ribosomes begins."

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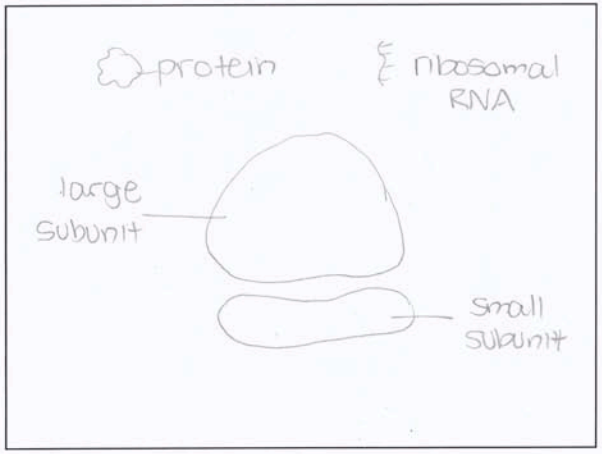
72



- A protein fades in and is labeled then a strand of ribosomal RNA fades in and is labeled.
- The protein + rRNA move to the subunits and fade away.
- The subunits are labeled "small subunit" and "large subunit."
- SCRIPT. "Proteins are combined with ribosomal RNA, or rRNA, that is created from the cell's DNA, to produce small and large ribosomal subunits."

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37

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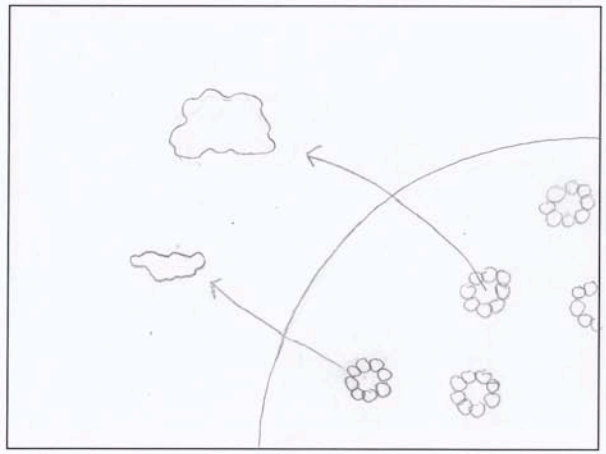
73



- Zoom out to nucleus and show ribosomal subunits exiting through the nuclear pores into the cytoplasm
- SCRIPT: "These subunits exit the nucleus through the nuclear pores and enter the cytoplasm..."

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74

Question 3

Which structure includes all of the others on this list?

a) Nucleolus
b) Nucleus
c) Chromosomes
d) DNA

- Fade into question three with nucleus image faded behind it.
- The number 3 students compete to get the correct answer. The teacher can then click on the answer the student chose and it will reveal whether they are right or wrong. If wrong the next student gets to guess.

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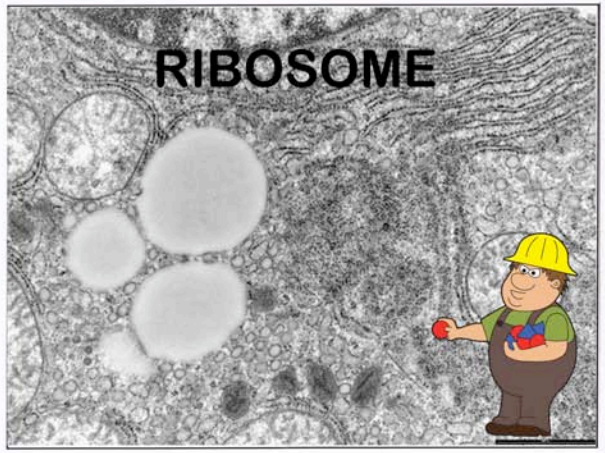
75

CORRECT!

The nucleus is the control center of the cell. Inside the nucleus is the genetic material in the form of DNA that condenses into chromosomes. The nucleolus is also found in the nucleus

- If the correct answer is chosen CORRECT and the reason why will fade in over the nucleus image.
- If the answer is wrong an X will appear over the letter and they will have to try again.

76



- On FM of a ribosome with the ribosome title across the top and the ribosome character in the bottom right corner
- SCRIPT: "Ribosome"

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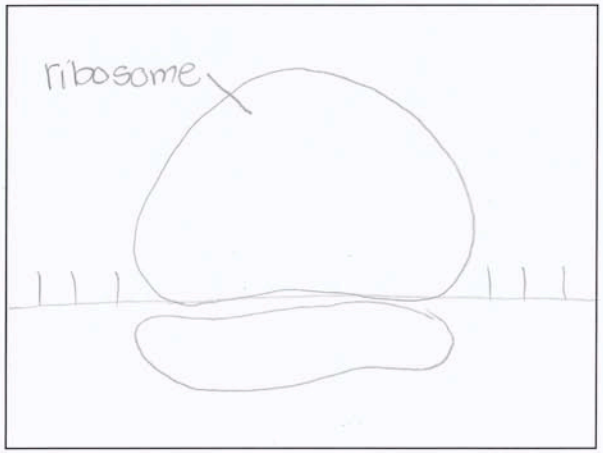
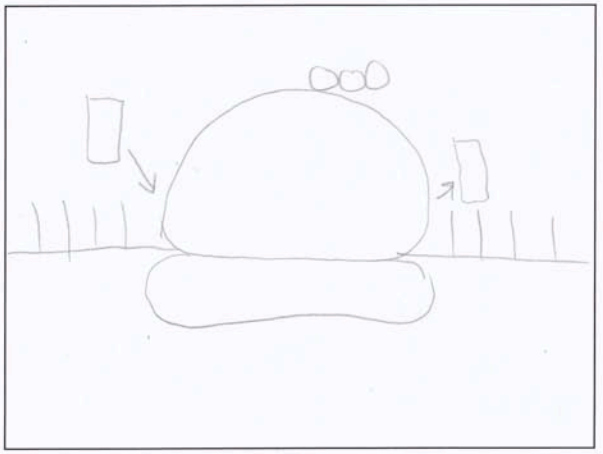
Date: 77



- Show the ribosomal subunits assembling on a strand of RNA. and label.
- SCRIPT: "After the ribosomal subunits exit the nucleus through the nuclear pore and enter the cytoplasm, a large and small subunit assemble into a ribosome

Date: 78



- Show the mRNA going through the ribosome and codons going in and out and a protein coming out of the top
- SCRIPT: "Ribosomes have one of the most important jobs carried out in the cellular factory."

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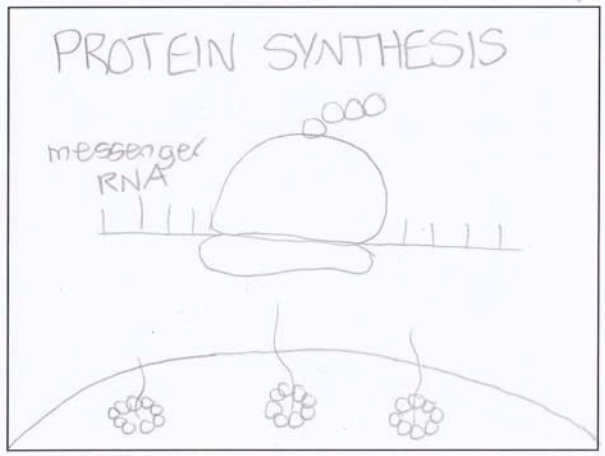
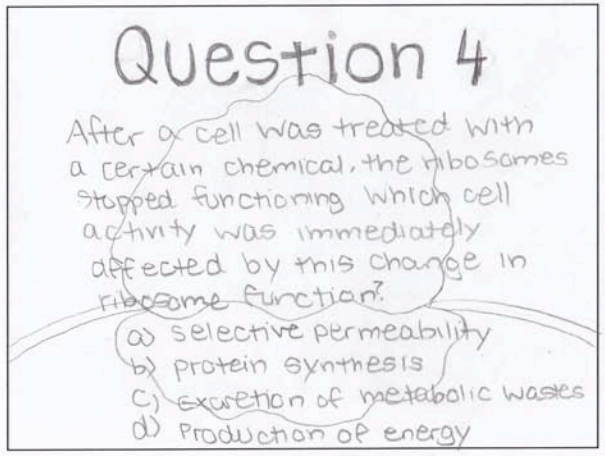
79



- Zoom out to show the mRNA coming out of the nuclear pore and show it going through the ribosome.
- "messenger RNA" is labeled
- Protein Synthesis title appears
- SCRIPT: "They use instructions enclosed in messages that come in a form of long stringy molecules call messenger RNA to make proteins. The process is known as protein synthesis."

Date: 80



- Fade into question four with a ribosome image ghosted behind it
- The number 4 students compete to get the correct answer. The teacher can then click on the answer the student chose and it will reveal whether they are right or wrong. If wrong the next student gets to guess.

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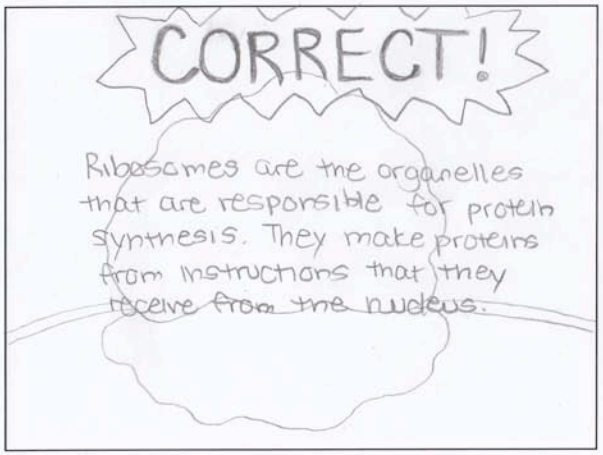
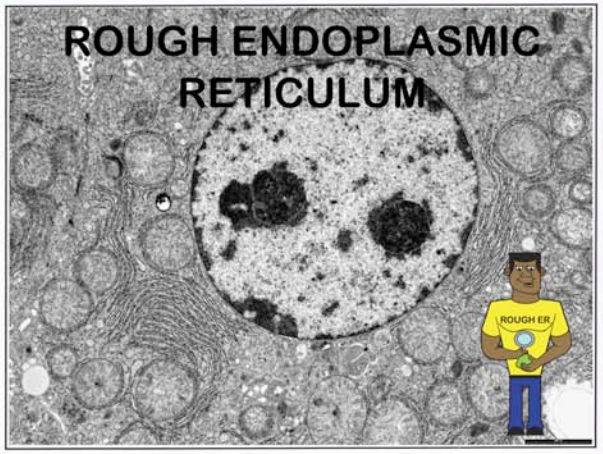
Date: 81



- If the correct answer is chosen CORRECT and the reason why will fade in over ribosome image.
- If the answer is wrong an X will appear over the letter and they will have to try again.

Date: 87



- The EM of the rough endoplasmic reticulum with the rough endoplasmic reticulum title and character fade in.
- SCRIPT: "Rough Endoplasmic Reticulum"

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47

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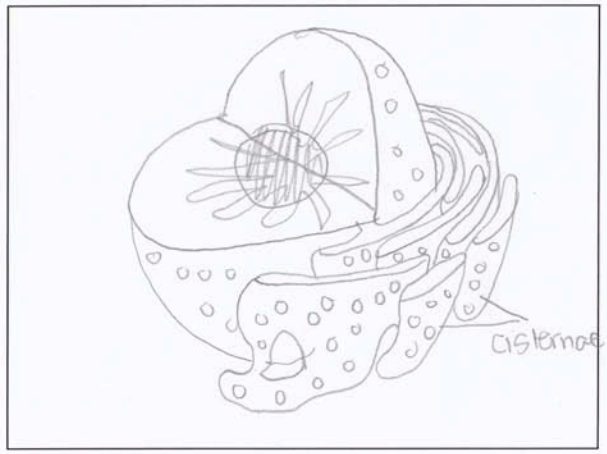
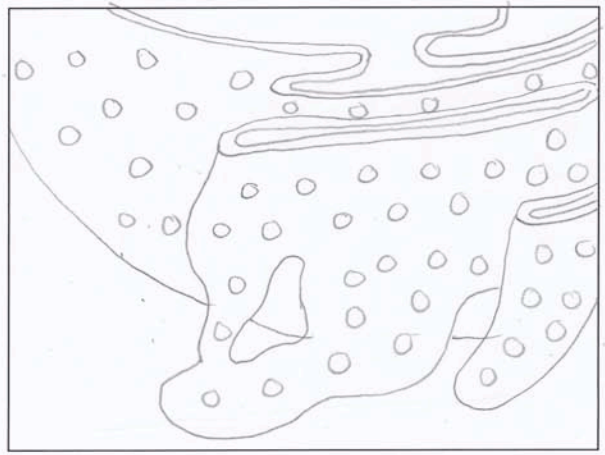
Date:

83



- Fade into the endoplasmic reticulum and label.
- label the cisternae
- SCRIPT: "The rough endoplasmic reticulum, also called the rough ER, is a network of membranous tubules called cisternae that are derived from the nuclear envelope."

84



- Zoom into a part of the rough ER to see the ribosomes better.
- SCRIPT: "Ribosomes bind to a large part of the ER, giving it a rough appearance, thus this organelle is called the rough ER."

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43

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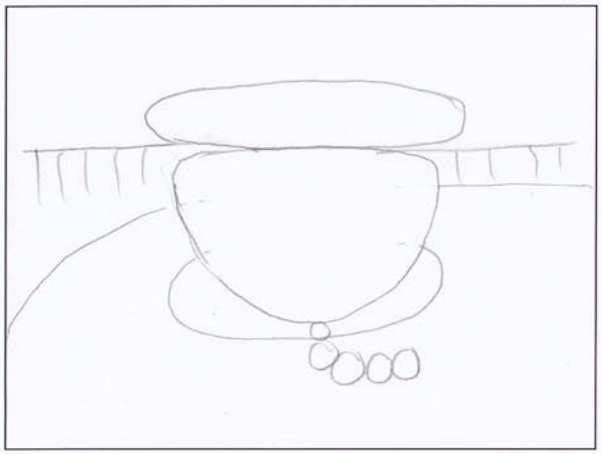
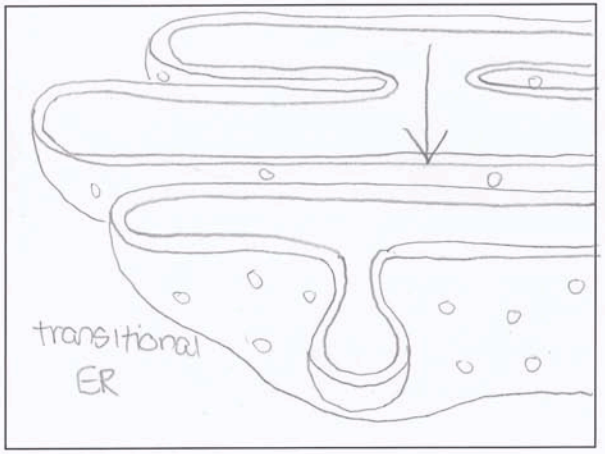
Date:

85



- Zoom into the surface and show a ribosome attach to the surface + drop its protein inside.
- SCRIPT: "If a ribosome begins making a protein that will be moved through the endoplasmic reticulum or perhaps be secreted by the cell, the ribosome will attach itself to the rough ER and channel the protein inside."

86



- Show proteins moving to the end of the rough ER and budding off
- The transitional ER is labeled.
- SCRIPT: "The proteins are then moved through the rough ER and are packaged into small vesicles that bud off from a specialized region of the endoplasmic reticulum and are packaged into small vesicles that bud off from a specialized region of the endoplasmic reticulum called transitional ER."

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44

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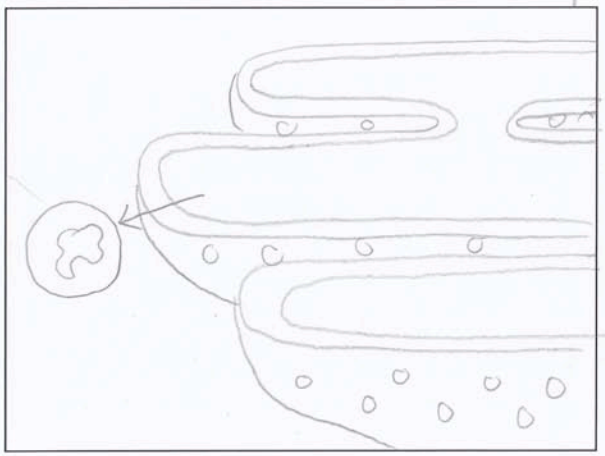
87



- Show a damaged protein pushed out of the ER into the cytoplasm and break up.
- SCRIPT: " The rough ER also plays a role in quality control. Proteins that are not quite right are pushed out of the rough ER into the cytoplasm where they are disposed of."

88

Smooth Endoplasmic Reticulum

- fade into an EM of the smooth ER the title Smooth endoplasmic reticulum on top and smooth ER character in bottom right corner
- smooth ER highlights
- SCRIPT: "Smooth Endoplasmic reticulum"

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45

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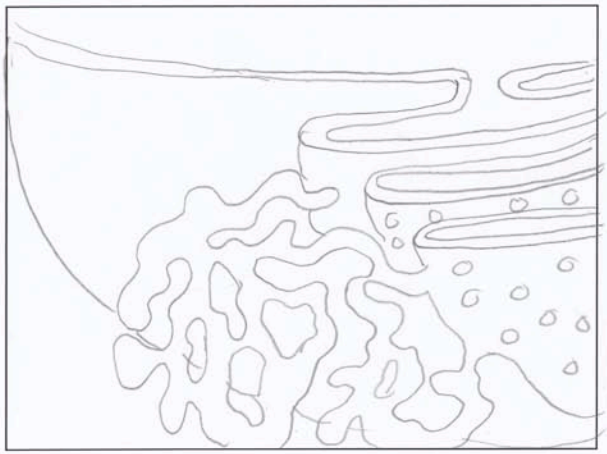
89



- Fade into smooth ER which is labeled
- SCRIPT: "The rest of the endoplasmic reticulum is called smooth ER because it lacks ribosomes and appears smooth. The smooth ER performs many different processes within the cell."

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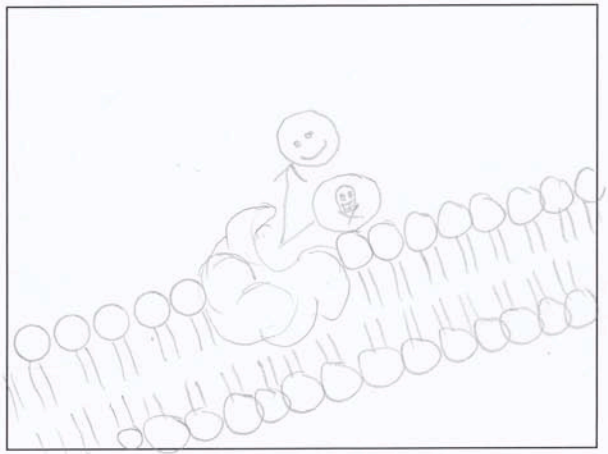
90



- Zoom into the smooth ER and fade into the membrane. With an enzyme on it.
- A poison enters and then comes out as a smiley face.
- SCRIPT: "The most important job of the smooth ER is the detoxification of drugs and poisons"

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4/6

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Date: 91

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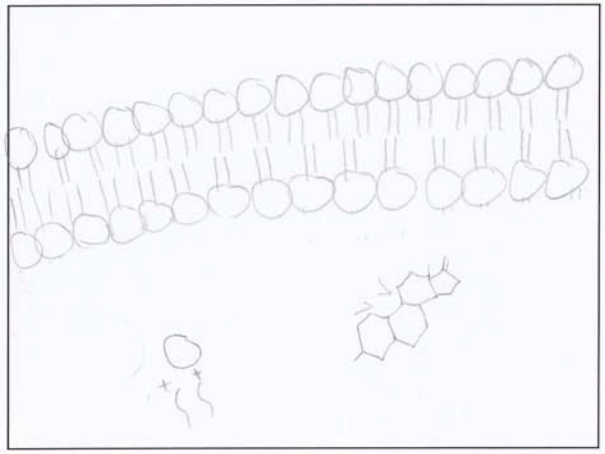
97



Question 5

If organelles can increase in number in response to an increased demand, then which organelle would you expect to find more of in the liver cells of a drug addict than in a non-addicted person?

a) Rough Endoplasmic Reticulum
b) Smooth Endoplasmic Reticulum
c) Mitochondria
d) Lysosomes

- Show a phospholipid be formed and a hormone and exit the smooth ER.
- SCRIPT: "It also plays a role in making hormones and lipids."

- Fade into question five with the ER ghosted behind it
- The number 5 students compete to get the correct answer. The teacher can then click on the answer the student chose and it will reveal whether they are right or wrong. If wrong the next student gets to guess

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47

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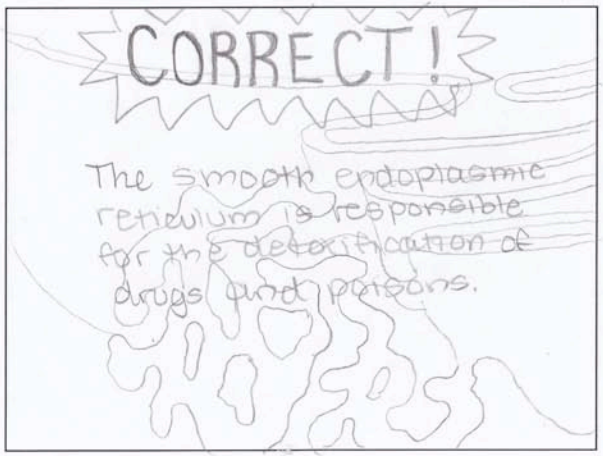
93



- If the correct answer is chosen CORRECT and the reason why will fade in over the ER image.
- If the answer is wrong an X will appear over the letter and they will have to try again.

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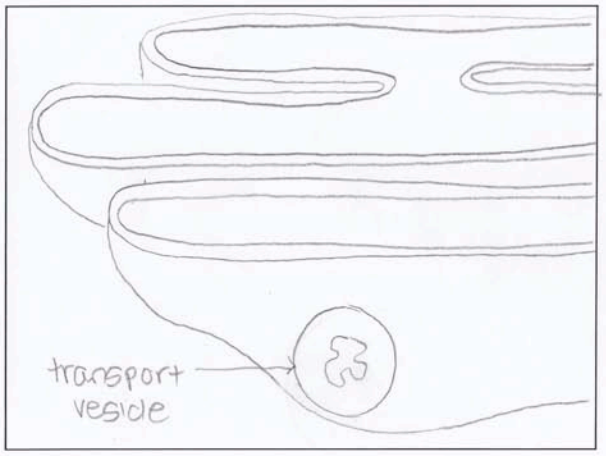
95



- fade from question five into the rough ER.
- show a vesicle bud off of the rough ER with a newly formed protein inside and label it as a transport vesicle
- The vesicle then moves to the Golgi apparatus and fuses with it
- SCRIPT: " The vesicles that contain the newly formed proteins are called transport vesicles because they transport the proteins from the ER to an organelle known as the Golgi apparatus, or just the Golgi."

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95

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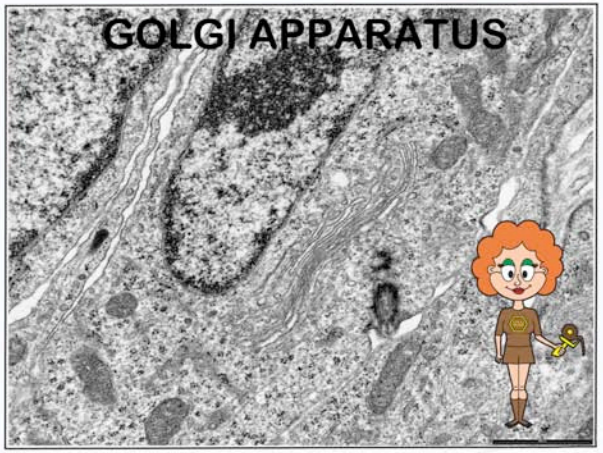
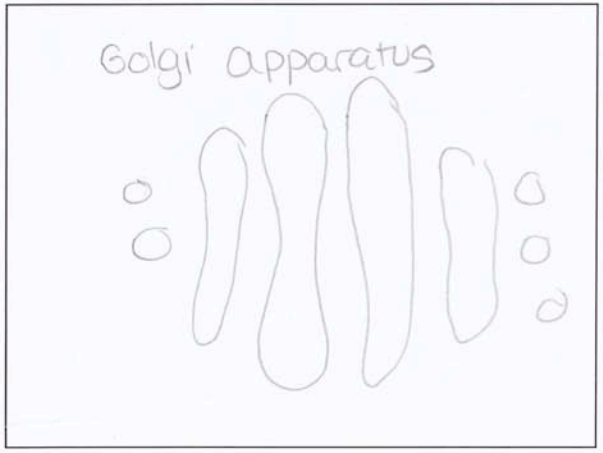
94



- An EM of the Golgi apparatus fades in with the Golgi apparatus title on top and the Golgi character in the bottom right corner
- The golgi highlights
- SCRIPT: "Golgi apparatus"

96



- Move to the Golgi apparatus
- SCRIPT: "The Golgi consists of flattened membrane sacs that serve as a packaging + distribution center of the cell."

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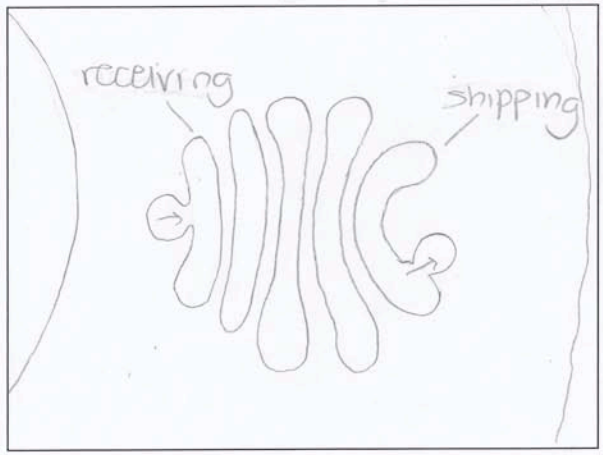
706-255-5919

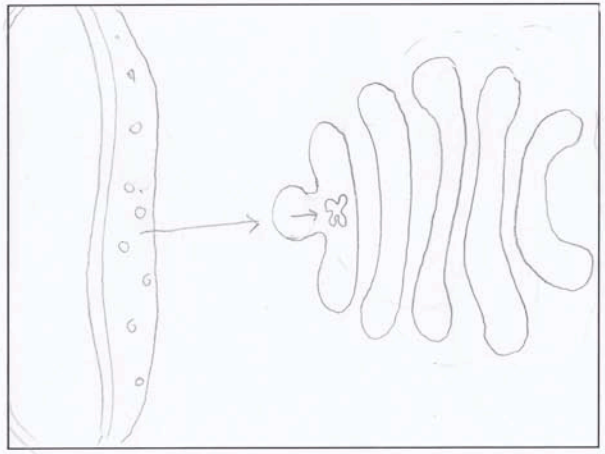
Date:

97



- The cis face is labeled and the trans face is labeled.
- A vesicle fuses with the cis face and another vesicle buds off the trans face.
- SCRIPT: "The nuclear side acts as the receiving department and the side facing outward acts as the shipping department."

98



- Zoom into the cis face of the Golgi.
- A transport vesicle coming from the ER fuses with the Golgi and the protein is deposited inside the Golgi.
- SCRIPT: "Transport vesicles traveling from the ER fuse with the cis face and deposit their proteins inside the Golgi."

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50

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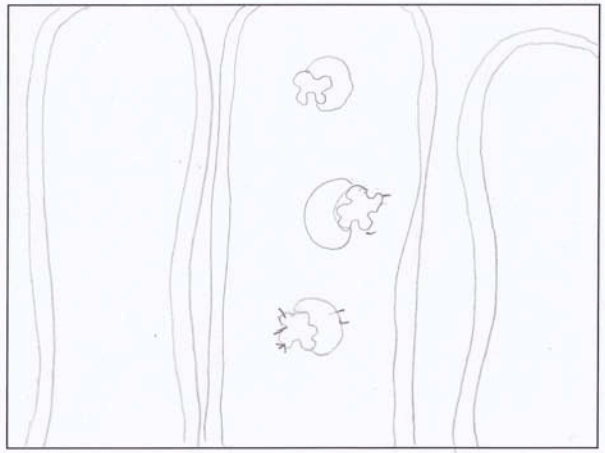
706-255-5919

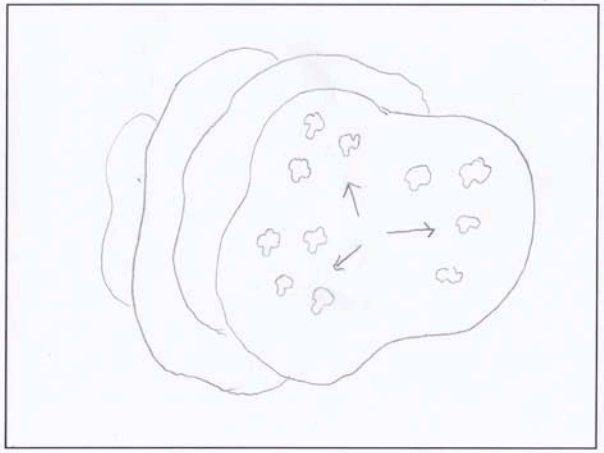
Date:

99



- Show the protein moving throughout the Golgi.
- Enzymes inside the Golgi modify the protein (changes color)
- SCRIPT: "Enzymes inside the Golgi apparatus modify the proteins"

100



- The proteins then move to different parts of the trans face
- The camera moves to the front of the trans face
- SCRIPT: "and the Golgi then sorts its products and targets them for various parts of the cell."

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51

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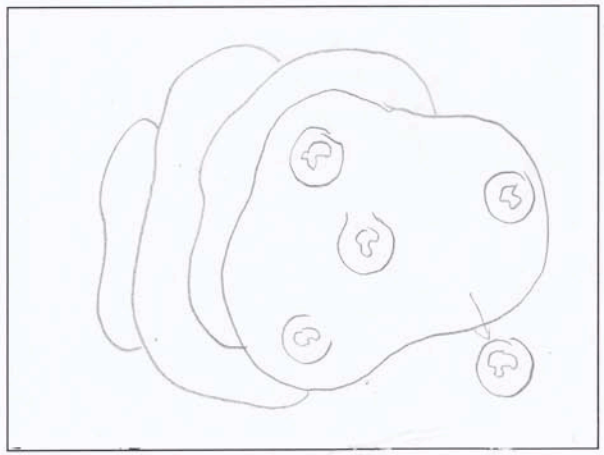
706-255-5919

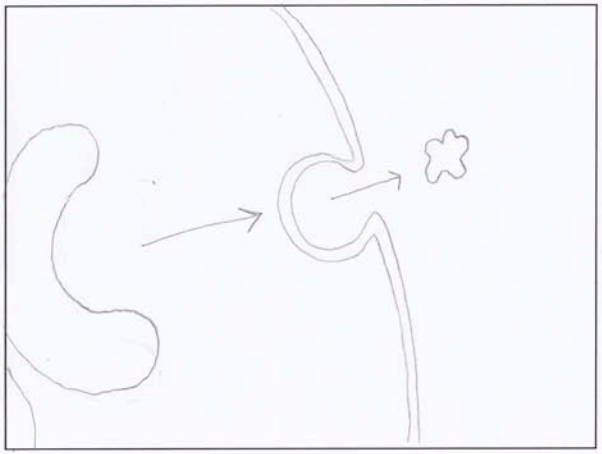
Date:

101



- A protein buds off of the trans face of the Golgi
- SCRIPT: "The products then bud off of the trans face of the golgi apparatus inside transport vesicles."

102



- The transport vesicles are then followed as they move to the cell membrane. (on microtubules?)
- The vesicle fuses with the membrane and the protein is released.
- SCRIPT: "Transport vesicles carrying products secreted from the cell go on to fuse with the plasma membrane."

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52

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706-255-5919

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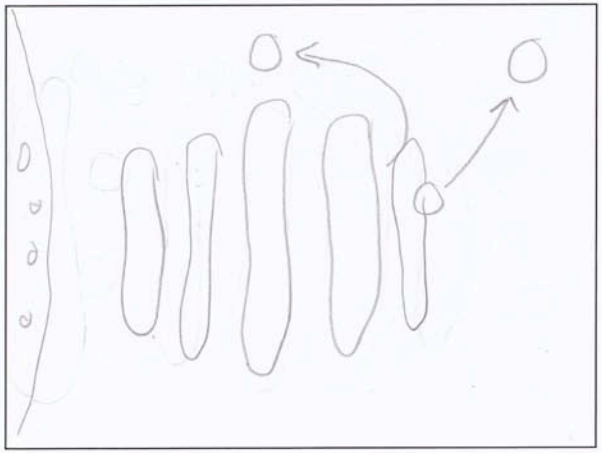
103



- Show a vesicle go to become a lysosome and one to the rough ER
- SCRIPT: "Other vesicles go on to become lysosomes or fuse with the rough ER."

104

Question 6

You would expect a cell with an extensive Golgi apparatus to

a) Make a lot of energy
b) Secrete a lot of material
c) Move actively
d) Store large quantities of food

- Fade into question six with the Golgi apparatus ghosted behind it
- The number 6 students compete to get the correct answer. The teacher then clicks on the answer the student chose and it will reveal whether they are right or wrong. If wrong the next student gets to guess.

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63

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706-255-5919

Date:

105

CORRECT!

The Golgi apparatus is the packaging and distribution center of the cell so if a cell has an extensive Golgi apparatus it is safe to assume that it would secrete a lot of material.

- If the correct answer is chosen CORRECT and the reason why will fade in over the Golgi image
- If the answer is wrong an X will appear over the letter and they will have to try again.

106

LYSOSOME

- Fade into an EM of a lysosome with the lysosome title on top and the lysosome character in the bottom right corner."
- lysosome highlights
- SCRIPT: "Lysosome

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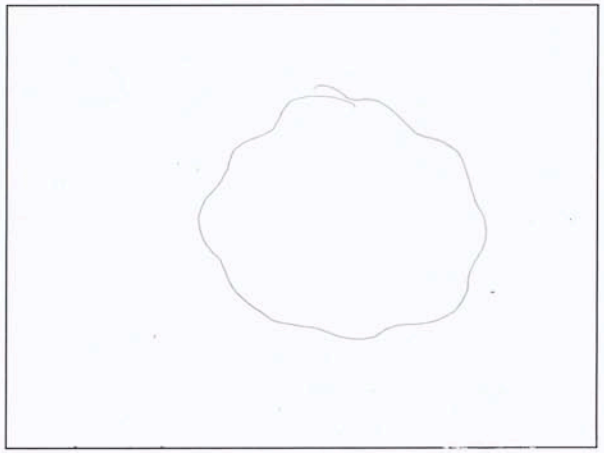
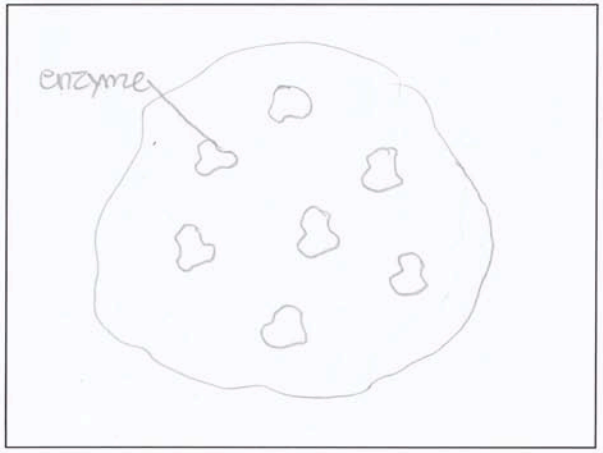
107



- Fade into the cell and move to a lysosome.
- SCRIPT: "Every factory needs a cleanup crew. In the eukaryotic cell, lysosomes perform this task and remove the junk that might otherwise accumulate & clutter up the cell."

108



- Zoom into the lysosome to show the enzymes inside
- Enzyme is labeled
- SCRIPT: "Lysosomes are membranous bags filled with enzymes"

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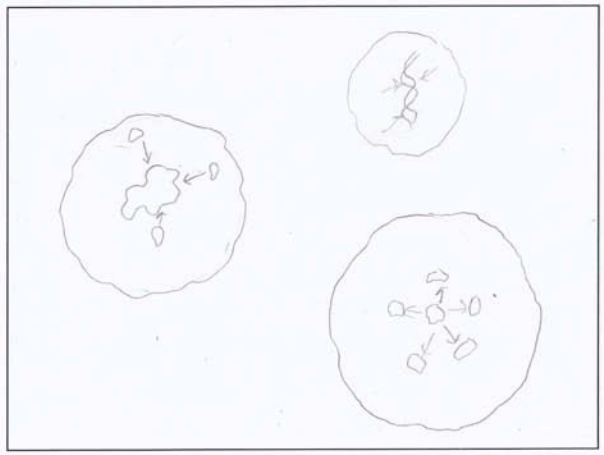
706-255-5919

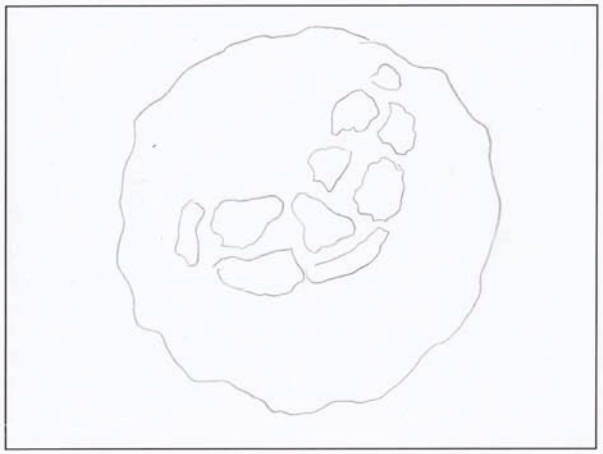
Date:

109



- Three lysosomes engulf a lipid, DNA and a protein and the enzymes break them down and release the molecules.
- SCRIPT: "that break down lipids, carbohydrates, DNA, and proteins into small molecules that can be used by the cell."

110



- Move to another part of the cell and show a lysosome engulf a mitochondria and break it down
- SCRIPT: "Lysosomes also break down excess organelles that are no longer needed or are damaged and no longer functioning properly."

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56

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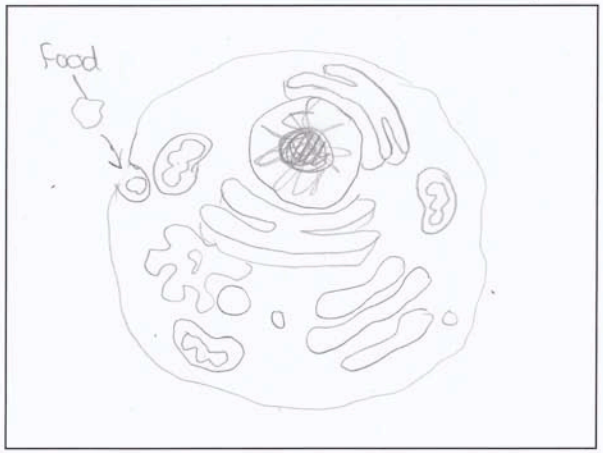
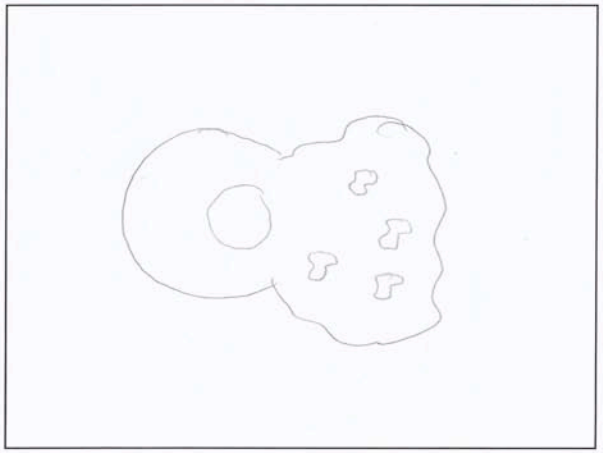
111



- Zoom out to a view of the cell
- Show a food particle enter through the plasma membrane and form a vacuole.
- label the food particle
- label the vacuole
- SCRIPT: Cells can acquire large substances such as food from the outside of the cell by forming vacuoles from the plasma membrane."

112



- Show the vacuole join with the lysosome.
- the lysosomes enzymes break down the food.
- SCRIPT: "These vacuoles can move to the lysosome where the outside substances are broken down into more useful compounds!"

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57

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706-255-5919

Date:

113

Question 7

The function of a lysosome is to

a) Synthesize proteins
b) Remove cellular waste products
c) Make energy for the cell
d) Protect the cell from the external environment

- Fade into question seven with the lysosomes ghosted behind it
- The number 7 students compete to get the correct answer. The teacher then clicks on the answer the student chose and it will reveal whether they are right or wrong. If wrong the next student gets to guess

114

CORRECT!

Lysosomes remove the wastes and break down excess organelles that could accumulate and clutter up the cell.

- If the correct answer is chosen CORRECT and the reason why will fade in over the lysosomes.
- If the answer is wrong an X will appear over the letter and they will have to try again.

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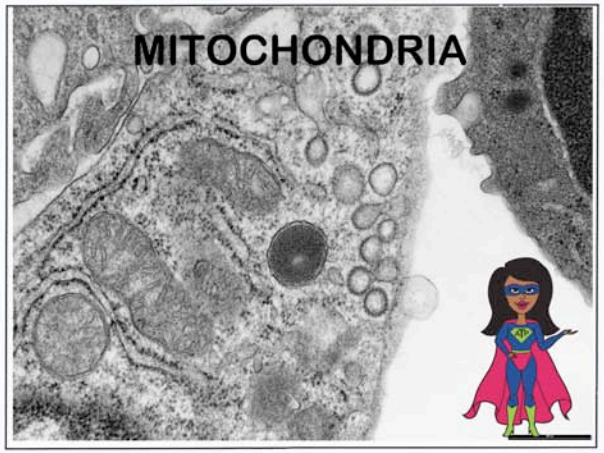
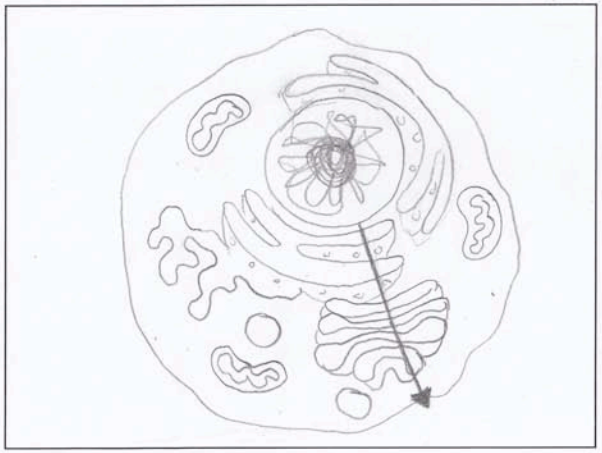
Date:

115



- An EM of the mitochondria with the mitochondria title and the mitochondria character on the bottom right corner
- The mitochondria highlight
- SCRIPT: "Mitochondria"

116



- Fade from question sentence into the entire animal cell
- Zoom into the nucleus and follow the mRNA to the ribosome on the rough ER, then follow the protein through the rough ER to the golgi and then out of the cell.
- SCRIPT: "After learning about the cell parts and the functions that they perform, it is easy to see that each of these organelles requires a lot of energy. Protein production, modification, transportation and digestion all require energy."

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59

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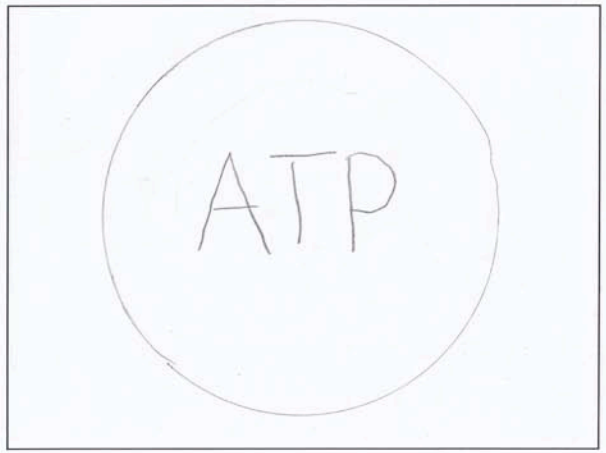
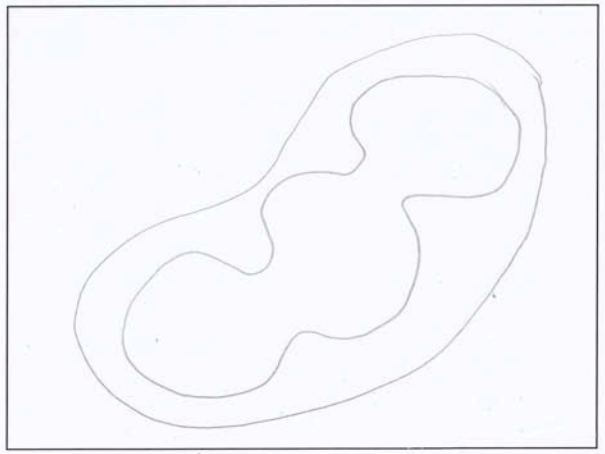
117



- Fade from protein to ATP and label
- SCRIPT: "The most important form of energy that the cell can immediately use is stored in a molecule called ATP"

118



- Fade into a mitochondrion
- SCRIPT: "Mitochondria are the organelles that provide much of the energy and are therefore known as the powerhouse of the cell."

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60

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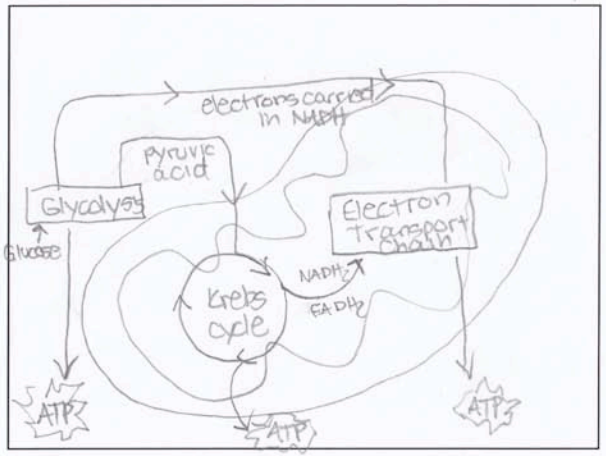
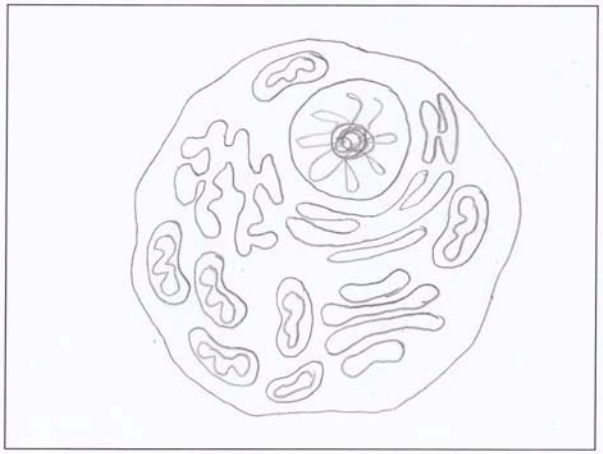
Date:

119



- Show a food particle enter the mitochondrion where it is converted to ATP which exits the mitochondrion.
- SCRIPT "In a process known as Cellular respiration, mitochondria convert the chemical energy found in organic compounds such as the broken down food and convert it into ATP which is more convenient for the cell to use."

120



- The lungs in the outline person fade away and the bicep muscle fades in
- Zoom into the muscle to reveal an animal cell with a lot of mitochondria"
- SCRIPT: "Cells that have a high energy requirement such as muscle cells can have hundreds or thousands of mitochondria."

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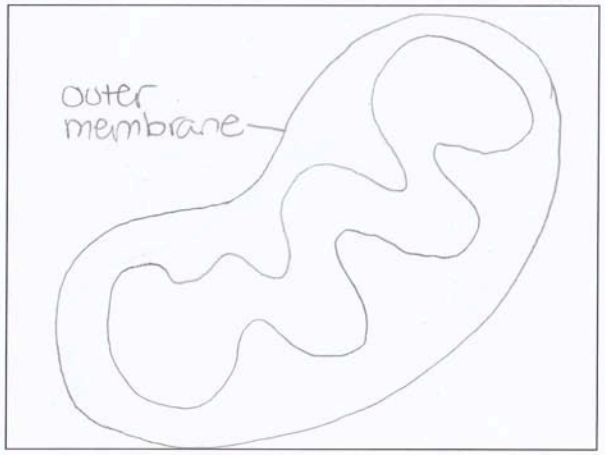
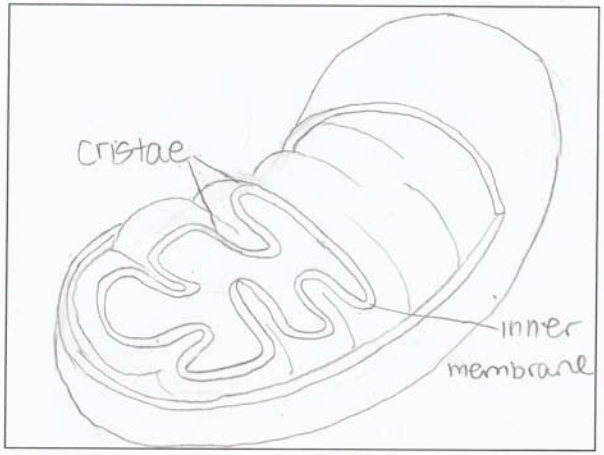
121



- Zoom into one of the mitochondrion and rotate around it.
- label the outer membrane.
- SCRIPT: "A mitochondrion has two membranes. The outer membrane is smooth..."

122



- The mitochondria's outer membrane is cut to reveal the highly folded inner membrane and label the cristae.
- SCRIPT: "While the inner membrane is highly folded inward into cristae, providing a very large surface area."

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62

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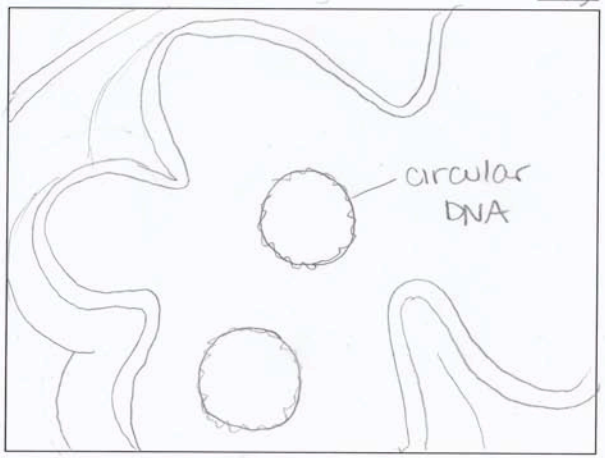
Date:

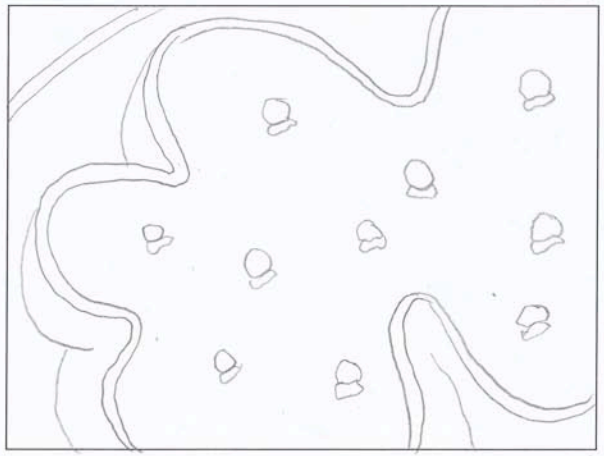
706-255-5919

123



- Move further into the mitochondria to show the circular DNA
- SCRIPT: "Mitochondria also have their own DNA."

124



- Move further into the mitochondria to show the ribosomes inside the cell.
- SCRIPT: "and have their own ribosomes."

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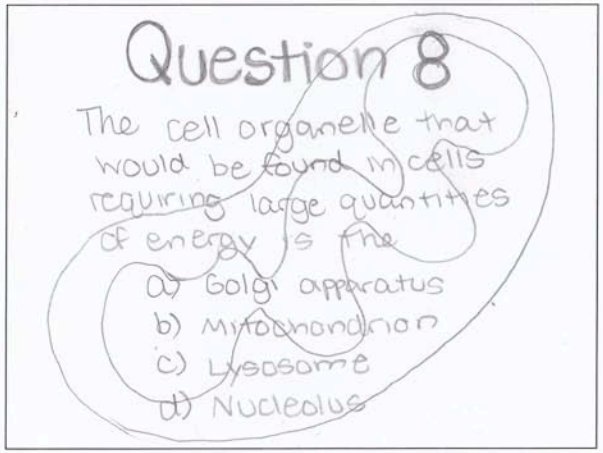
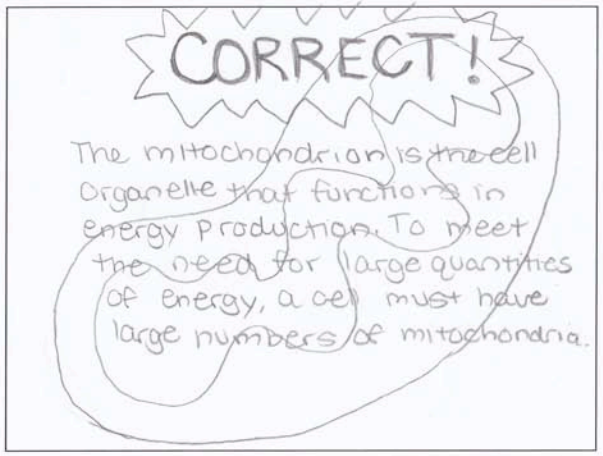
Date:

175



- Fade into question eight with the mitochondria ghosted in behind it
- The number 8 students compete to get the correct answer. The teacher then clicks on the answer the student chose and it will reveal whether they are right or wrong. If wrong the next student gets to guess.

176



- If the correct answer is chosen CORRECT and the reason why will fade in over the mitochondria.
- If the answer is wrong an X will appear over the letter and the next student will try.

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64

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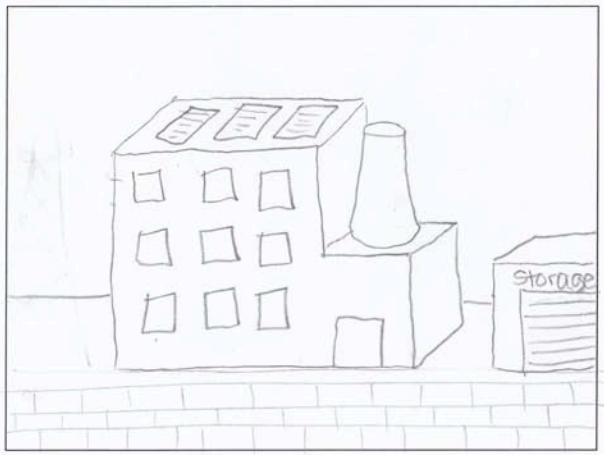
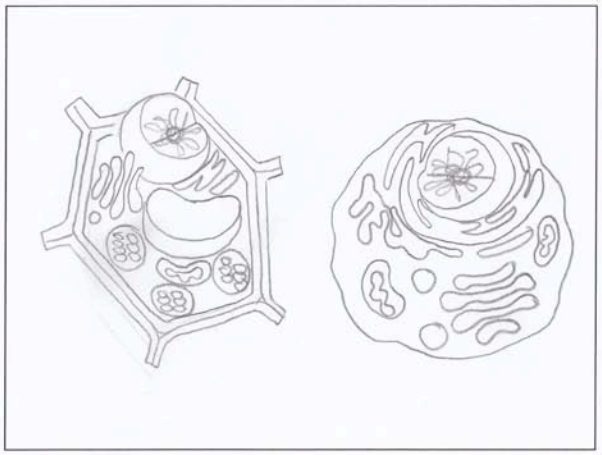
Date:

127



- Fade into the factory and have the storage building, wall, and solar panels appear.
- SCRIPT: "Plant cells can also be compared to a factory with a couple extra workers."

128



- Fade into plant and animal cell image
- Highlight the organelles that they have in common and lysosomes in red. Then highlight the cell wall, the central vacuole, and chloroplasts in the plant cell.
- SCRIPT: "Plant cells contain all of the organelles mentioned so far, except for lysosomes, but have several additional components."

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65

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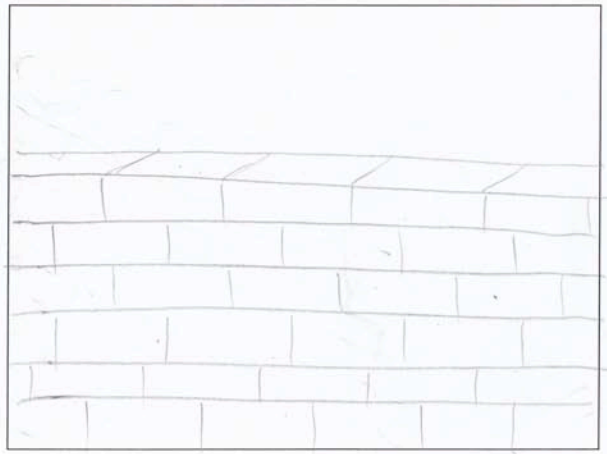
706-255-5919

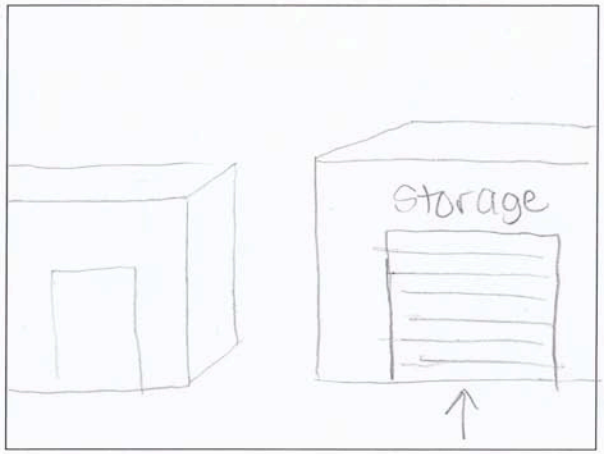
Date:

129



- Fade back into the plant factory
- Show the brick wall raise from the ground around the fence
- SCRIPT: "In the plant cell factory, the cell wall acts as a brick wall around the factory and adds an extra layer of protection."

130



- Fade into the factory and have the storage building raise from the ground to the right of it
- SCRIPT: "The central vacuole is the storage building for the factory."

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606

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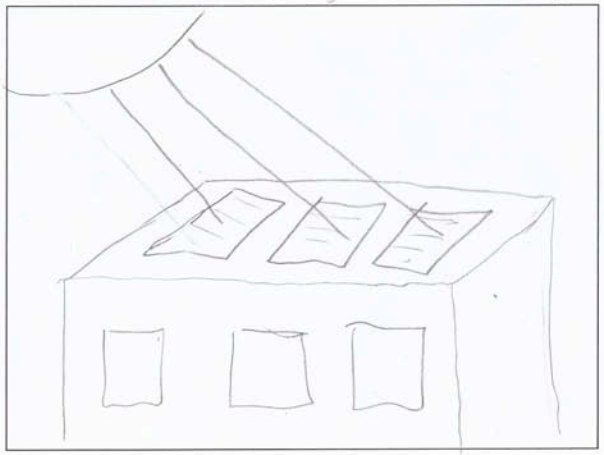
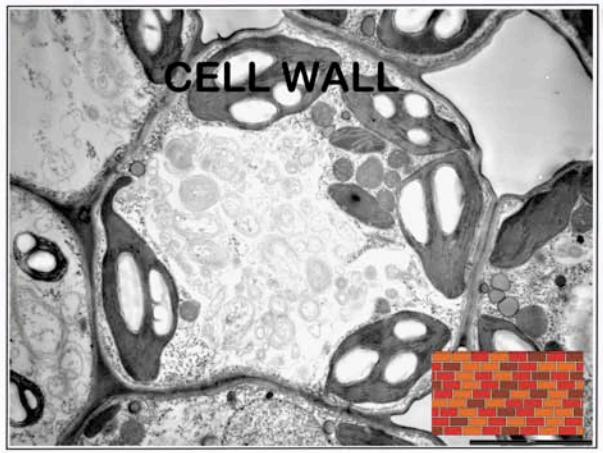
131



- Move up to the roof to show the solar panels and sun beams hitting them
- SCRIPT: "And finally the chloroplasts are like solar panels on the roof of the factory, draining energy from the sun."

132



- Fade into an EM of the cell wall with the cell wall title at the top and the cell wall character on the bottom right corner
- Highlight the cell wall
- SCRIPT: "Cell wall"

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67

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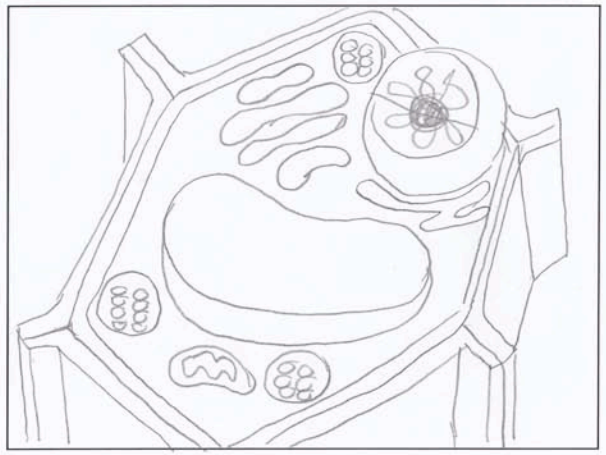
706-255-5919

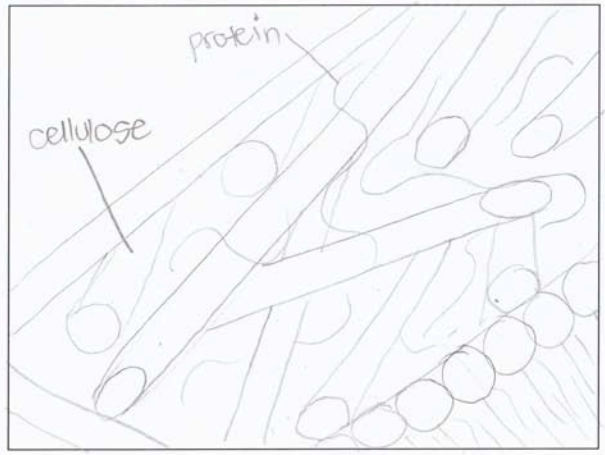
Date:

133



- Fade into the plant cell and highlight the cell wall and label
- SCRIPT: "Plant cells have an additional line of protection known as the cell wall that distinguishes them from animal cells."

134



- Zoom into the cell wall and fade into an upclose composition shot and label the parts
- SCRIPT: " The thick wall is composed of proteins and carbohydrates including the polysaccaride cellulose."

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68

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706-255-5919

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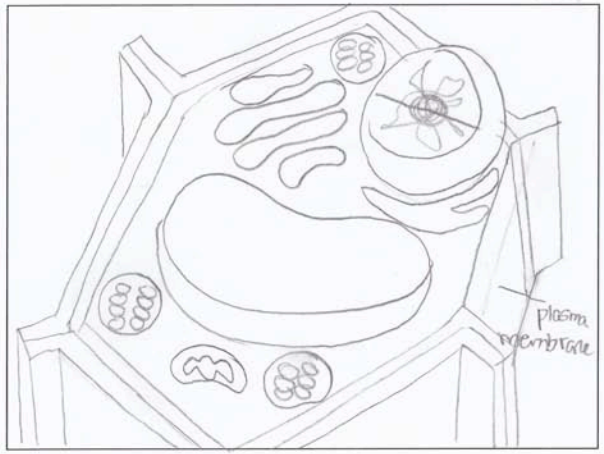
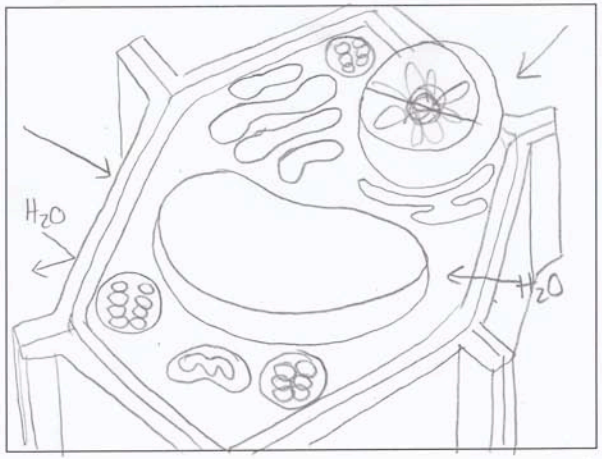
135



- Zoom back out to the whole plant cell.
- Highlight the plasma membrane and label.
- SCRIPT: "The wall surrounds the plasma membrane and protects the cell..."

136



- Show arrows pressing in on the cell and it not moving
- Then show the cell wall allowing some water in and stopping the rest
- SCRIPT: "maintains its shape, and prevents excessive uptake of water."

Jennifer Hulsey: UTSW Biomedical Communications

Email: JLH26@aol.com

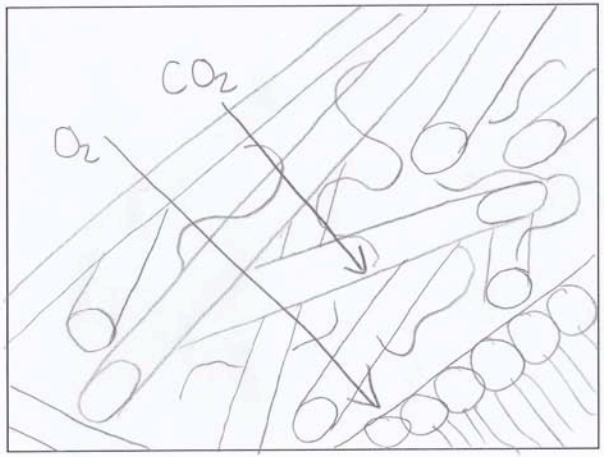
69

Project: Organelle Extravaganza

706-255-5919

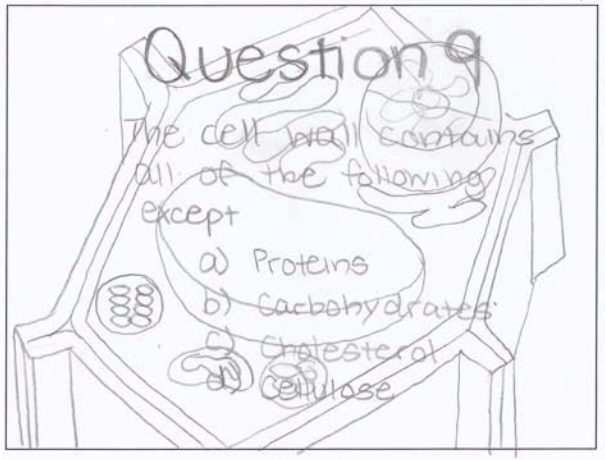
Date:

137



- Zoom into cell wall to show oxygen, carbon dioxide, and other molecules into the cell
- SCRIPT: "Most cell walls are porous enough to allow oxygen, carbon dioxide, and certain other substances to pass through easily"

138



- Fade into question nine with the plant cell faded in the background
- The number 9 students compete to get the correct answer. The teacher then clicks on the answer the student chose and it will reveal whether they are right or wrong. If wrong then the next student gets to guess.

Jennifer Hulsey: UTSW Biomedical Communications

Email: JLH26@aol.com

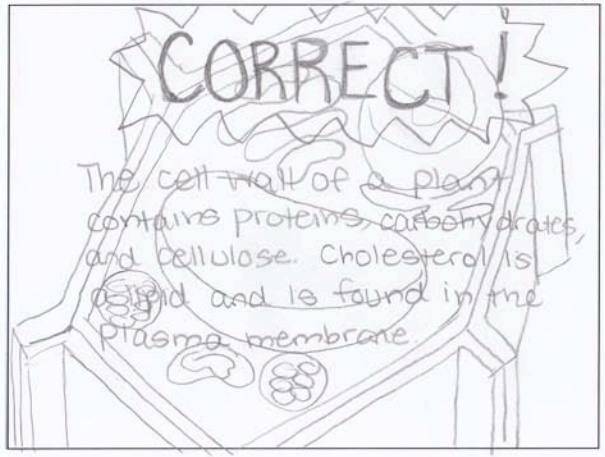
10

Project: Organelle Extravaganza

706-255-5919

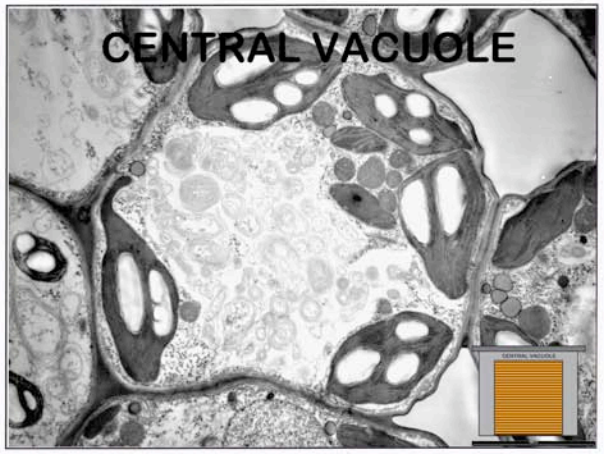
Date:

139



- If the correct answer is chosen, CORRECT and the reason why will fade in over the plant cell image
- If the answer is wrong an X will fade in over the letter and the next student will try

140



- Fade into an EM of the central vacuole with the central vacuole title on top and the central vacuole character in the bottom right corner
- The central vacuole highlights
- SCRIPT: "central vacuole"

Jennifer Hulsey: UTSW Biomedical Communications

Email: JLH26@aol.com

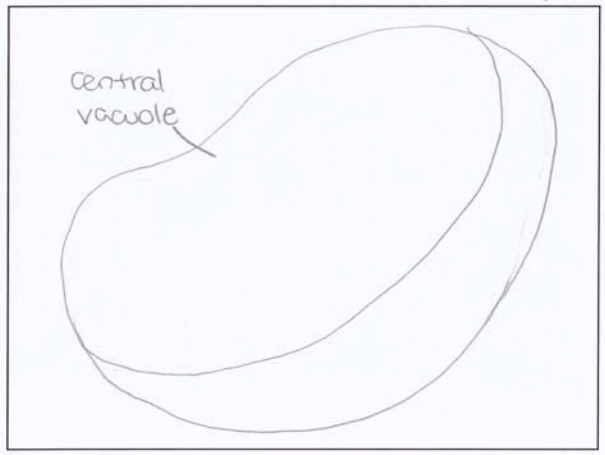
71

Project: Organelle Extravaganza

706-255-5919

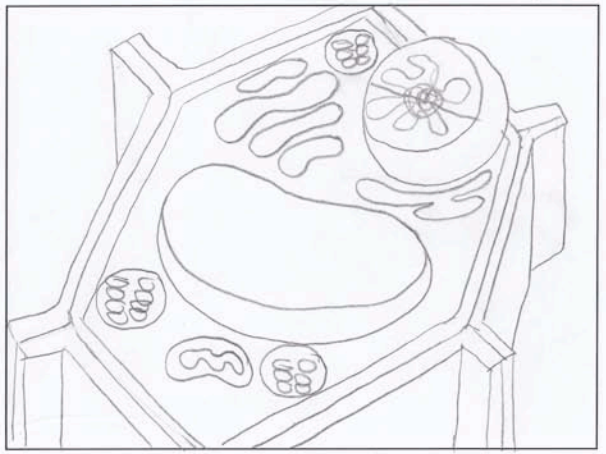
Date:

141



- Fade into the plant cell and zoom into the central vacuole and label
- SCRIPT: "Every factory needs a place to store things, and plant cells contain a place for storage as well."

142



- Label the tonoplast and zoom out to show that the central vacuole takes up most of the cell
- SCRIPT: "Mature plant cells generally contain a large central vacuole that is enclosed by a membrane called the tonoplast, and takes up most of the cell's volume."

Jennifer Hulsey: UTSW Biomedical Communications

Email: JLH26@aol.com

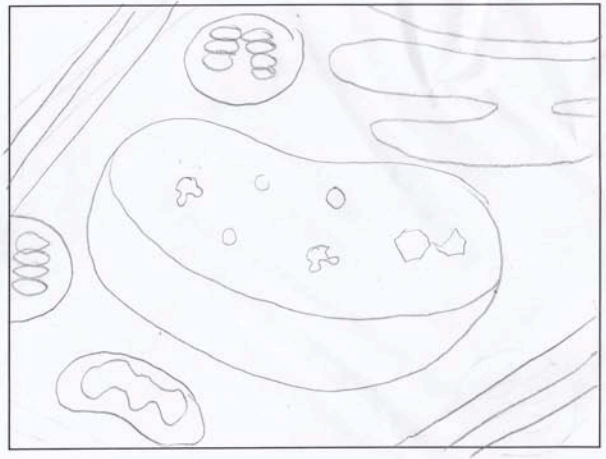
ZZ

Project: Organelle Extravaganza

706-255-5919

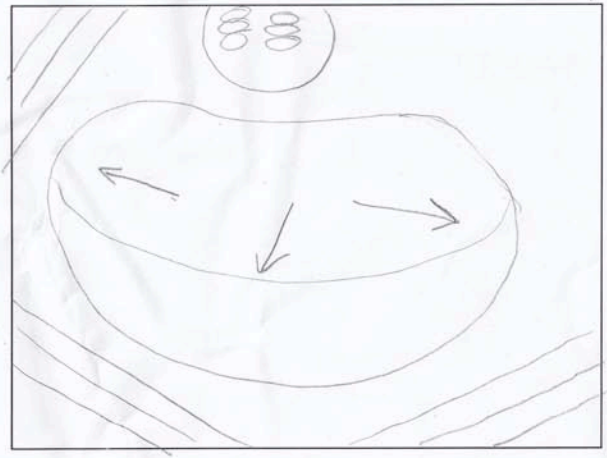
Date:

143



- Show water molecules, salt, proteins and carbohydrates floating in the central vacuole
- SCRIPT: "The central vacuole stores water, salts, proteins, and carbohydrates"

144



- Show arrows inside the central vacuole pointing out towards the cell wall
- SCRIPT: "When the central vacuole is full the pressure it exerts on the cell wall..."

Jennifer Hulsey: UTSW Biomedical Communications

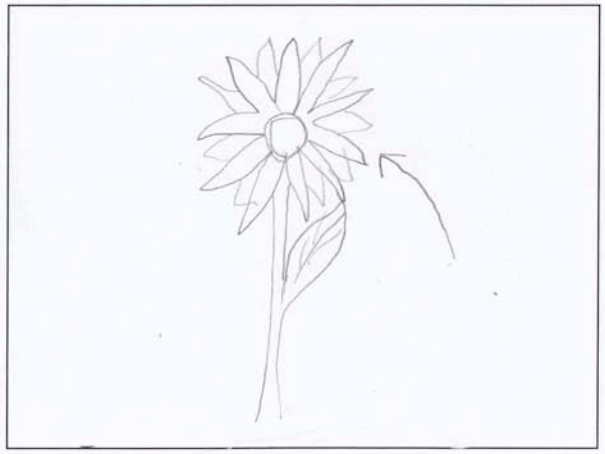
Email: JLH26@aol.com

Project: Organelle Extravaganza

706-255-5919

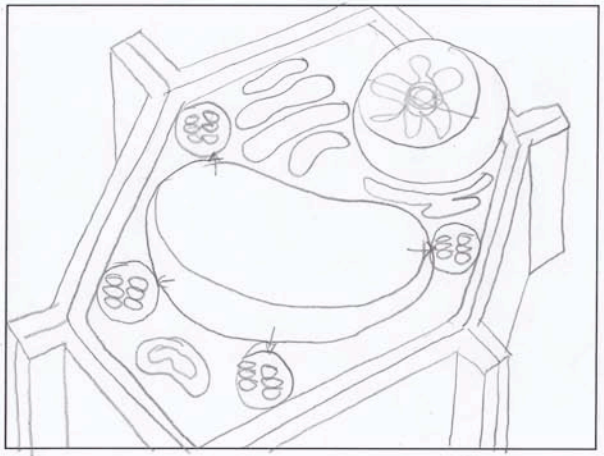
Date:

145



- Fade into an image of a flower that goes from being bent over to standing up straight
- SCRIPT: "makes it possible for plants to support heavy structures such as leaves or flowers."

146



- Show the central vacuole filling and pushing the chloroplasts closer to the cell wall.
- Show light hitting the chloroplasts.
- SCRIPT: "By pushing all contents of the cell's cytoplasm against the cellular membrane, the central vacuole also keeps the chloroplasts closer to the light."

Jennifer Hulsey: UTSW Biomedical Communications

Email: JLH26@aol.com

7

Project: Organelle Extravaganza

706-255-5919

Date:

147

Question 10

If you saw a plant whose stem and leaves were wilted, what could you conclude about the central vacuole.

a) The water level was too high
b) The water level was too low
c) It was filled
d) None of the above

- Fade into question ten with the central vacuole in the background
- The number 10 students compete to get the correct answer. The teacher then clicks on the answer the student chose and it will reveal whether they are right or wrong. If wrong then the next student gets to guess.

148

CORRECT!

The water level in the central vacuole was low. In order for the central vacuole to support the heavy structures of the plant it needs to be full of water and pushing against the cell wall.

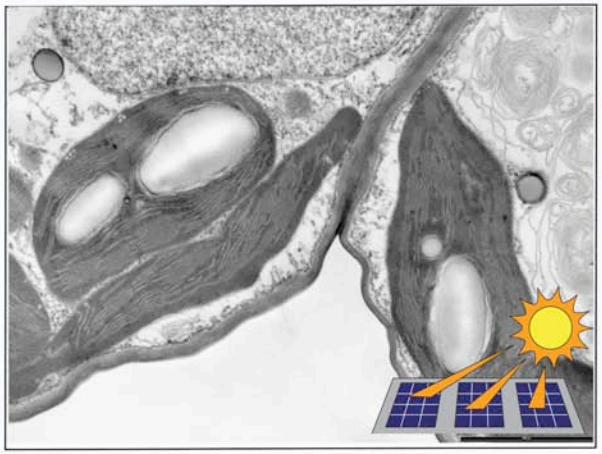
- If the correct answer is chosen then CORRECT and the reason why will fade in over the central vacuole image
- If the answer is wrong an X will fade in over the letter and the next student will get to try.

Project: Organelle Extravaganza

706-255-5919

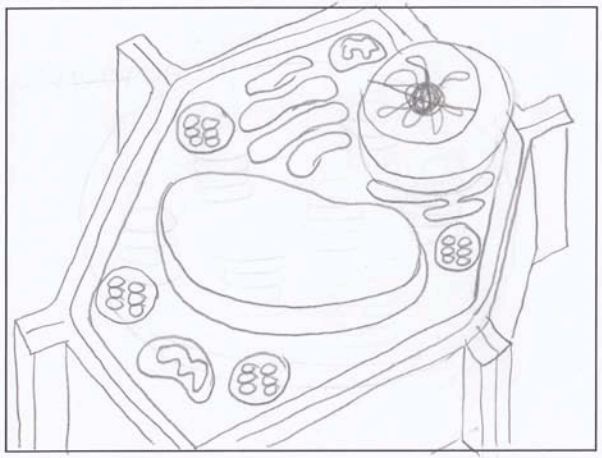
Date:

149



- Fade into an EM of the chloroplast with the chloroplast title up top and the chloroplast character in the bottom right corner
- The chloroplast highlights
- SCRIPT: "chloroplast"

150



- Fade into a view of the plant cell and highlight mitochondria
- SCRIPT: "Remember that plant cells have mitochondria to produce energy but they also have an additional power source known as chloroplasts"
- highlight chloroplast

Jennifer Hulsey: UTSW Biomedical Communications

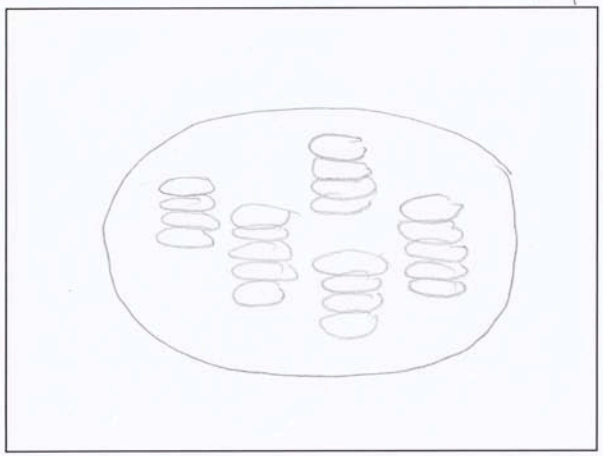
Email: JLH26@aol.com

76

Project: Organelle Extravaganza

Date:

151

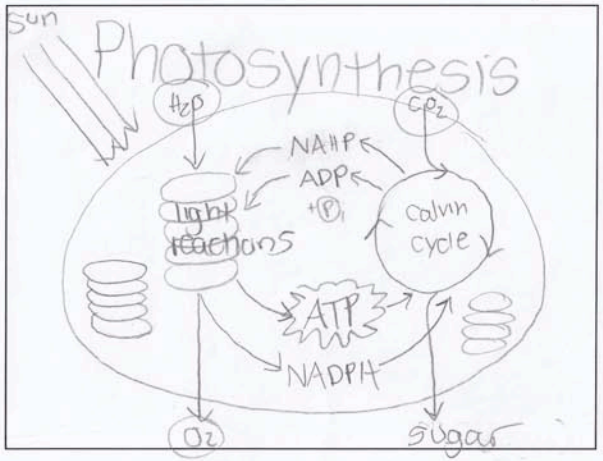


- Zoom into the chloroplast
- SCRIPT: "Chloroplasts are the biological equivalents to solar power plants ..."

706-255-5919

152

132



- Show sunlight entering the chloroplast and photosynthesis cycle producing ATP which is labeled and "photosynthesis" fades into the top of the screen
- SCRIPT: "because they can directly convert sunlight into energy in the form of ATP, in a process called photosynthesis"

Jennifer Hulsey: UTSW Biomedical Communications

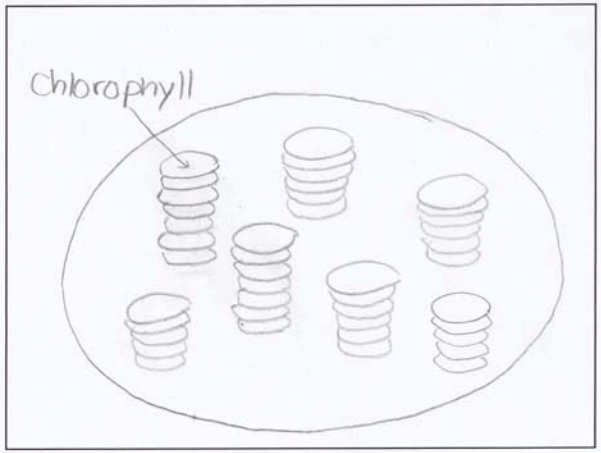
Email: JLH26@aol.com

77

Project: Organelle Extravaganza

Date:

153

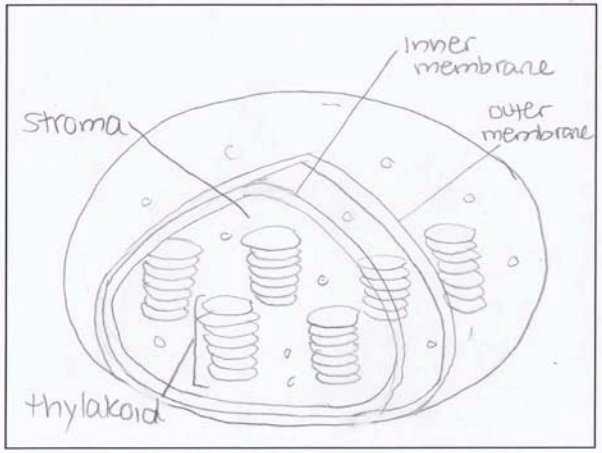


- Show the green chlorophyll inside the chloroplast, and it is labeled
- SCRIPT: "Chloroplasts contain the green pigment chlorophyll that helps harvest the light energy and are found in the leaves of plants."

Jennifer Hulsey: UTSW Biomedical Communications

706-255-5919

154



- The chloroplasts membrane is cut open to reveal the membrane and the thaylakoids.
- The thylakoids and the stroma are labeled
- SCRIPT: "Much like the mitochondria, chloroplasts are surrounded by a double membrane, but they have small interconnected membrane-enclosed discs called thylakoids inside where the light harvesting takes place. Surrounding the thylakoids is a fluid known as Stroma."

Email: JLH26@aol.com

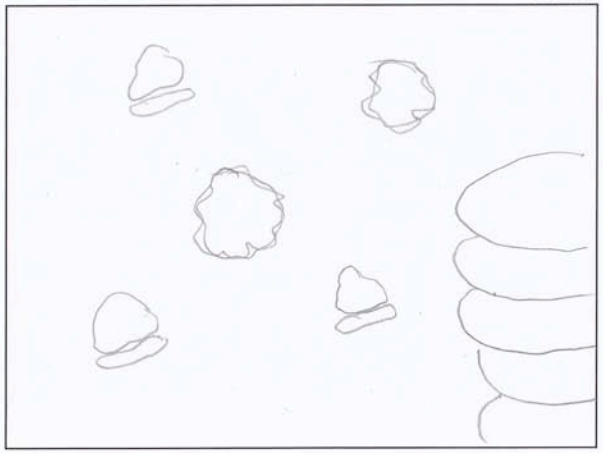
JB

Project: Organelle Extravaganza

706-255-5919

Date:

155



- Zoom into stroma to see ribosomes and circular DNA and label
- SCRIPT: "Found within the stroma are ribosomes + circular DNA"

156

Question 11

Which of the following set of features is common to both plant and animal cells?

a) Mitochondria and plasma membrane

b) Nucleus and chloroplast

c) Plasma membrane and cell wall

d) Chloroplast and ribosome

- Fade into question eleven with the chloroplasts in the background
- The number 11 students compete to get the correct answer. The teacher then clicks on the answer the student chose and it will reveal whether they were right or wrong. If wrong then the next student gets to guess.

Jennifer Hulsey: UTSW Biomedical Communications

Email: JLH26@aol.com

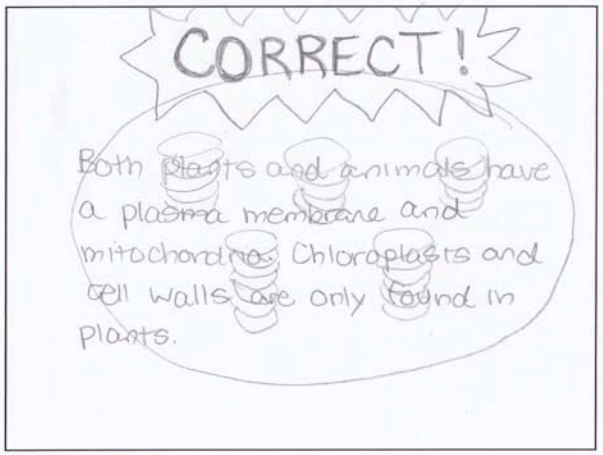
79

Project: Organelle Extravaganza

706-255-5919

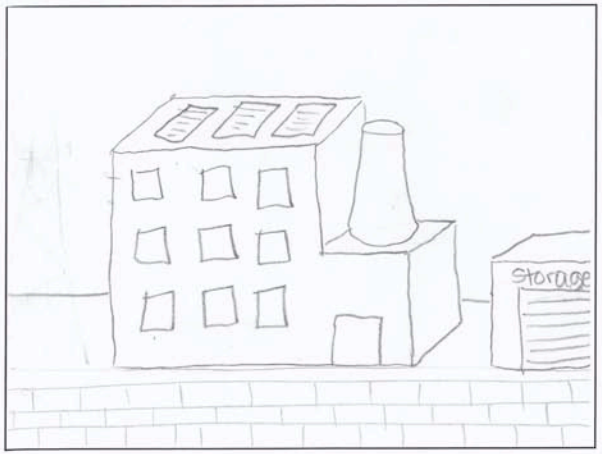
Date:

157



- If the correct answer is chosen then CORRECT and the reason why will fade in over the chloroplast image.
- If the answer is wrong an X will fade in over the letter and the next student will get to try

158



- fade into a view of the factory
- SCRIPT: The cellular factories inside our bodies are continuously working to make sure we function properly..."

Jennifer Hulsey: UTSW Biomedical Communications

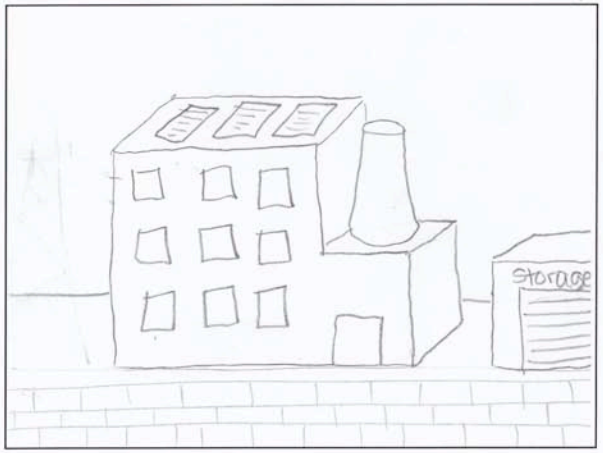
Email: JLH26@aol.com

80

Project: Organelle Extravaganza

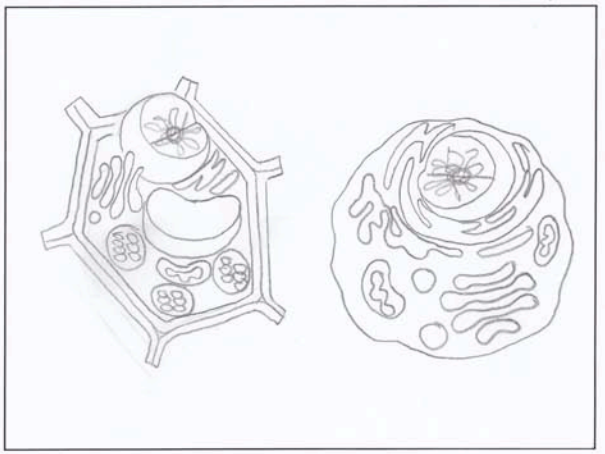
706-255-5919

Date: 5/9



- Show the factory with all of the characters in front.
- SCRIPT: "And each organelle plays an important role."

1 of 6



- Fade into a view of the cells
- SCRIPT: "Everything a living organism does can ultimately be traced back to the cell."

Jennifer Hulsey: UTSW Biomedical Communications

Email: JLH26@aol.com

5|

APPENDIX E
Permission to Use Electron Micrographs

Laurie Mueller

From: "Beth Levine" <Beth.Levine@UTSouthwestern.edu>
To: "Laurie Mueller" <Laurie.Mueller@UTSouthwestern.edu>
Cc: "Cindy Jozefiak" <Cindy.Jozefiak@UTSouthwestern.edu>; "Kailiang Jia" <Kailiang.Jia@UTSouthwestern.edu>
Sent: Thursday, July 17, 2008 10:18 PM
Subject: Re: permission to use EM images

Dear Laurie:

You are welcome to use whatever images form Kailiang or Sophie's projects would be helpful.

Best regards,

Beth Levine

Beth Levine, M.D.
Howard Hughes Medical Institute
Professor of Internal Medicine and Microbiology
Jay P. Sanford Professor in Infectious Diseases
Chief, Division of Infectious Diseases
UT Southwestern Medical Center
5323 Harry Hines Blvd.
Dallas, Texas 75390-9113
Tel. 214-648-0493
Fax. 214-648-0284
E-mail: beth.levine@utsouthwestern.edu

>>> "Laurie Mueller" <laurie.mueller@utsouthwestern.edu> 07/17/08 3:12 PM >>>
Hello Dr. Levine and Kailiang,

you probably do not recognize my name, but I am one of the technicians in Dr. Gilpin's electron microscope facility. I work with Tom Januszewski who is currently doing some high-pressure freeze work on C. elegans with you. Tom and I have taken images from several of your specimens and I would like to use them in an outreach project, but I must have your permission to do so.

The STARS program here (Science Teacher Access to Resources at Southwestern) is creating a 3D animation of the cell. The animation (and the printed, laminated original images) will be used in ninth grade biology classes in the Dallas school district, making it easier for teachers to teach this difficult material. We have been asked to provide images for the project, so I have been searching through old EM grids looking for good examples of organelles and ultrastructure. Two

Laurie Mueller

From: "Beth Levine" <Beth.Levine@UTSouthwestern.edu>
To: "Laurie Mueller" <Laurie.Mueller@UTSouthwestern.edu>
Cc: "Cindy Jozefiak" <Cindy.Jozefiak@UTSouthwestern.edu>; "Kailiang Jia" <Kailiang.Jia@UTSouthwestern.edu>
Sent: Thursday, July 17, 2008 10:18 PM
Subject: Re: permission to use EM images

Dear Laurie:

You are welcome to use whatever images form Kailiang or Sophie's projects would be helpful.

Best regards,

Beth Levine

Beth Levine, M.D.
Howard Hughes Medical Institute
Professor of Internal Medicine and Microbiology
Jay P. Sanford Professor in Infectious Diseases
Chief, Division of Infectious Diseases
UT Southwestern Medical Center
5323 Harry Hines Blvd.
Dallas, Texas 75390-9113
Tel. 214-648-0493
Fax. 214-648-0284
E-mail: beth.levine@utsouthwestern.edu

>>> "Laurie Mueller" <laurie.mueller@utsouthwestern.edu> 07/17/08 3:12 PM >>>
Hello Dr. Levine and Kailiang,

you probably do not recognize my name, but I am one of the technicians in Dr. Gilpin's electron microscope facility. I work with Tom Januszewski who is currently doing some high-pressure freeze work on C. elegans with you. Tom and I have taken images from several of your specimens and I would like to use them in an outreach project, but I must have your permission to do so.

The STARS program here (Science Teacher Access to Resources at Southwestern) is creating a 3D animation of the cell. The animation (and the printed, laminated original images) will be used in ninth grade biology classes in the Dallas school district, making it easier for teachers to teach this difficult material. We have been asked to provide images for the project, so I have been searching through old EM grids looking for good examples of organelles and ultrastructure. Two

of the specimens I looked at belong to Sophie Pattingre and I got very nice images of cells, cell division, and desmosomes from them. You can see the images at the links below. Folder 5117 is Sophie's HT29-CT-complete-media and folder 5119 is her HT29BCl-L-complete-media.

\\Mcif_tem2\images\lmueller\suitcase\5117

\\Mcif_tem2\images\lmueller\suitcase\5119

The STARS group specifically asked for an image of microfilaments and these are clearly visible in two images Tom took from the high pressure freeze C. elegans specimens that he and Kailiang did last month. Whenever possible, I use archived specimens for this project. However, I would like to send these two images to the STARS group in spite of the fact that the specimen is very current. You can see the images at the link below. This is Kailiang's C. elegans N2BEC1-day-0.

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Would you have any objections to STARS using these images for the project? If you have questions about how the images would be used, I can put you in touch with their director, Joel Goodman and with Jennifer Hulsey, the artist who is doing the animation.

Thank you very much for your time,
Laurie

Laurie Mueller
Molecular and Cellular Imaging Facility
K1.210
UT Southwestern Medical Center at Dallas
5323 Harry Hines Boulevard
Dallas, TX 75390-9039
214-648-7291

Laurie Mueller

From: "Rolf Brekken" <Rolf.Brekken@UTSouthwestern.edu>
To: "Laurie Mueller" <Laurie.Mueller@UTSouthwestern.edu>; "Shanna Arnold" <Shanna.Arnold@UTSouthwestern.edu>
Sent: Thursday, July 17, 2008 11:45 AM
Subject: Re: permission to use EM images

Laurie:
this is fine

rolf

Rolf A. Brekken, PhD
Effie Marie Cain Scholar in Angiogenesis Research
Assistant Professor
Departments of Surgery and Pharmacology
Hamon Center for Therapeutic Oncology Research
UT-Southwestern Medical Center
office, NB8.222a; lab NB8.222 & NB8.224
6000 Harry Hines Blvd.
Dallas, TX 75390-8593

TEL: 214 648 5151
FAX: 214 648 4940
rolf.brekken@utsouthwestern.edu
>>> "Laurie Mueller" <laurie.mueller@utsouthwestern.edu> 07/17/08 11:24 AM >>>
Hello Shanna and Dr. Brekken,

you will probably not recognize my name, but I am one of the technicians in the electron microscopy lab; I work with Tom Januszewski. Last year he processed a number of specimens (pancreas, liver, tumor, and brain) for you, and we have them archived here in the EM lab. I have taken some images from two of those specimens and would like to use them in an outreach project, but I must have your permission to do so.

The STARS program here (Science Teacher Access to Resources at Southwestern) is creating a 3D animation of the cell. The animation (and the printed, laminated original images) will be used in ninth grade biology classes in the Dallas school district, making it easier for teachers to teach this difficult material. We have been asked to provide the images for the project, so I have been searching through old EM grids looking for good examples of organelles and ultrastructure. Two of the specimens I looked at were yours and I got some images of very nice lipid droplets, ribosomes, clathrin vesicles, and lysosomes from them. You can see the images at the links below. Folder 7309 is your WT1156 pancreas/tumor edge and 7310 is your WT1156 liver.

\\Mcif_tem2\images\lmueller\suitcase\7309

\\Mcif_tem2\images\lmueller\suitcase\7310

I have deliberately selected specimens that are not current; presumably any images you took have already been used. I have also chosen a wild type so that there is no possibility of a new finding going out inadvertently. Would you have any objections to STARS using these images for the project? If you have questions about how the images would be used, I can put you in touch with their director, Joel Goodman and with Jennifer Hulsey, the artist who is doing the animation.

Thank you very much for your time,
Laurie

Laurie Mueller
Molecular and Cellular Imaging Facility
K1.210
UT Southwestern Medical Center at Dallas
5323 Harry Hines Boulevard
Dallas, TX 75390-9039
214-648-7291

10/23/2008

Laurie Mueller

From: "Laurie Mueller" <laurie.mueller@utsouthwestern.edu>
To: "Stephen Hammes" <Stephen.Hammes@UTSouthwestern.edu>
Sent: Monday, June 16, 2008 4:25 PM
Subject: Re: permission to use EM images

Thank you! This was a great specimen to work on with so much activity in these cells.

Laurie

----- Original Message -----
From: "Stephen Hammes" <Stephen.Hammes@UTSouthwestern.edu>
To: "Laurie Mueller" <Laurie.Mueller@UTSouthwestern.edu>; "Tamara Strauss" <Tamara.Strauss@UTSouthwestern.edu>
Sent: Friday, June 13, 2008 5:46 PM
Subject: Re: permission to use EM images

| Please feel free to use them!
|
| Steve
|
|
|
| Stephen R Hammes, M.D., Ph.D.
| Associate Professor of Internal Medicine
| University of Texas Southwestern Medical Center
| 5323 Harry Hines Blvd.
| Dallas, TX 75390-8857
|
| Phone: 214-648-3749
| Fax: 214-648-7934
| >>> "Laurie Mueller" <laurie.mueller@utsouthwestern.edu> 06/13/08 5:03
| PM >>>
| Hello Tamara and Dr. Hammes,
|
| you might not remember me from the name alone, but I am one of the
| technicians in the electron microscopy lab. Last year we prepared two
| specimens
| (mouse embryo ovaries) for you which we still have in the lab.
|
| The STARS program here (Science Teacher Access to Resources at

| Southwestern) is working on a project which will create a 3D animation
| of the cell for use in ninth grade biology classes in the Dallas school
| district. They have asked the EM facility to provide images of cells
| and organelles for this animation. The images will also be printed and
| laminated.
|
| I have been searching through old grids looking for good examples of
| structures such as Golgi, ribosomes, and microtubules. One of the
| specimens I looked at was yours and I got some images of very nice
| endoplasmic reticulum, actin filaments, Golgi, and centrioles from it.
| You can see the images at the link below:
|
| \\Mcif_tem2\images\lmueller\suitcase then select the folder "RER"
|
|
| I would like to send images 1 and 4-7 to the STARS group.
| (Images 2 and 3 were of interest to me but would not be included in
| the STARS package.) The images are from EM specimen number 7283
| and this is your 1-2EM mouse embryo ovary from 6/25/07.
|
| Would you have any objections to STARS using these images for the
| project? I have tried to use only specimens that are not current for
| this project
| and I believe you did not take any images from these grids. I also use
| the wild
| type whenever possible so that there is no possibility of a new finding
| going out
| inadvertently. However, in this case I do not know whether this is a
| wild type
| specimen or a mutant. Please take a look at the images in my folder
| "RER" and
| tell me if you would agree to let us use them. If you would like more
| information

| on the project I can put you in touch with their director,
Joel Goodman
| and with
| Jennifer Hulsey, the artist who is doing the animation.
|
| Thank you very much for your time,
| Laurie Mueller
|
|

Laurie Mueller

From: "Laurie Mueller" <laurie.mueller@utsouthwestern.edu>
To: "Shelley Dixon" <Shelley.Dixon@UTSouthwestern.edu>
Sent: Thursday, June 12, 2008 1:58 PM
Subject: Re: permission to use EM images

Shelley,

thank you so much! They are going to love these images.

Laurie

----- Original Message -----
From: "Shelley Dixon" <Shelley.Dixon@UTSouthwestern.edu>
To: "Inik Chang" <Inik.Chang@UTSouthwestern.edu>; "Laurie Mueller" <Laurie.Mueller@UTSouthwestern.edu>; "Masashi Yanagisawa" <Masashi.Yanagisawa@UTSouthwestern.edu>
Sent: Wednesday, June 11, 2008 5:24 PM
Subject: Re: permission to use EM images

| Hi Laurie,
|
| We are delighted you would like to use our images. Please proceed.
|
| Shelley
|
| Shelley A. Dixon
| Lab Manager for Dr. Masashi Yanagisawa
| Howard Hughes Medical Institute
| The University of Texas
| Southwestern Medical Center at Dallas
| 5323 Harry Hines Blvd. Room L3.116
| Dallas, Texas 75390-8584
| 214-648-5059 (ph)
| 214-648-5068 (fax)
| e-mail: Shelley.Dixon@UTSouthwestern.edu
| >>> "Laurie Mueller" <laurie.mueller@utsouthwestern.edu> 06/11/08 3:19
| PM >>>
| Hello Inik and Dr. Yanagisawa,
|
| you might not remember me from the name alone, but I am one of the
| technicians in the electron microscopy lab. Last year you did some work
| on one of our transmission microscopes. We prepared four

specimens, two
| ileum and two jejunum (wt and ko), which we still have here in
the lab.
|
|
| The STARS program here (Science Teacher Access to Resources at
| Southwestern) is working on a project which will create a 3D
animation
| of the cell for use in ninth grade biology classes in the
Dallas school
| district. They have asked the EM facility to provide images of
cells
| and organelles for this animation. The images will also be
printed and
| laminated.
|
| I have been searching through old grids looking for good
examples of
| structures such as Golgi, ribosomes, and microtubules. One of
the old
| specimens I looked at was yours and I got some images of very
nice
| nuclear pores from it. I would like to send these images to
the STARS
| group. The EM specimen number is 7321 and this is your wt
jejunum from
| 7/10/07. You can see the images at the link below...
|
| \\Mcif_tem2\images\lmueller\suitcase
then
| select the folder "nuclear pore"
|
|
| Would you have any objections to STARS using these images for
the
| project? I have deliberately selected specimens that are not
current;
| presumably any images you took have already been used. I have
also
| chosen the wild type specimen so that there is no possibility
of a new
| finding going out inadvertently. Please take a look at the
images in my
| folder "nuclear pore" and tell me if you would agree to let us
use them.
| If you would like more information on the project I can put you
in
| touch with their director, Joel Goodman and with Jennifer
Hulsey, the
| artist who is doing the animation.
|

Thank you very much for your time,
Laurie Mueller

10/23/2008

Laurie Mueller

From: "Shelley Dixon" <Shelley.Dixon@UTSouthwestern.edu>
To: "Laurie Mueller" <Laurie.Mueller@UTSouthwestern.edu>
Sent: Tuesday, September 16, 2008 3:05 PM
Subject: Re: ileum specimen

Great, Laurie!

Shelley

>>> "Laurie Mueller" <laurie.mueller@utsouthwestern.edu> 09/16/08 2:53 PM >>>
Shelley,

Thanks once again. I don't believe I mentioned in my earlier emails that, of course, proper credit will be given to labs that provided materials for the project.

Thanks so much for your help,
Laurie

----- Original Message -----
From: "Shelley Dixon" <Shelley.Dixon@UTSouthwestern.edu>
To: "Inik Chang" <Inik.Chang@UTSouthwestern.edu>; "Laurie Mueller" <Laurie.Mueller@UTSouthwestern.edu>
Sent: Monday, September 15, 2008 1:10 PM
Subject: Re: ileum specimen

| Hi Laurie,
|
| Please use these images as you like. We are happy they can help you!
|
| Shelley
|
| Shelley A. Dixon
| Lab Manager for Dr. Masashi Yanagisawa
| Howard Hughes Medical Institute
| The University of Texas
| Southwestern Medical Center at Dallas
| 5323 Harry Hines Blvd. Room L3.116
| Dallas, Texas 75390-8584
| 214-648-5059 (ph)
| 214-648-5068 (fax)
| e-mail: Shelley.Dixon@UTSouthwestern.edu
| >>> "Laurie Mueller" <laurie.mueller@utsouthwestern.edu> 09/15/08 10:21
| AM >>>

| Inik and Shelley,
|
| several months ago I took some images from your specimens and asked to
| use them in the STARS program. Well, I've taken several more images of
| microtubules, actin filaments, and junctional complexes. Would you
| allow us to use these six images also? These are from your WT ileum of
| July 2007 and they are simply the best examples I have found of
| cytoskeletal elements. You can see them at this site:
|
|
| \\Mcif_tem2\images\lmueller\suitcase\7320
|
| Thanks very much for your time and for your generosity!
|
| Laurie
|
|
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|
|
|
|
| Hi Laurie,
|
| We are delighted you would like to use our images. Please proceed.
|
| Shelley
|
| Shelley A. Dixon
| Lab Manager for Dr. Masashi Yanagisawa
| Howard Hughes Medical Institute
| The University of Texas
| Southwestern Medical Center at Dallas
| 5323 Harry Hines Blvd. Room L3.116
| Dallas, Texas 75390-8584
| 214-648-5059 (ph)
| 214-648-5068 (fax)
| e-mail: Shelley.Dixon@UTSouthwestern.edu
| >>> "Laurie Mueller" <laurie.mueller@utsouthwestern.edu> 06/11/08 3:19
| PM >>>
| Hello Inik and Dr. Yanagisawa,
|
| you might not remember me from the name alone, but I am one of the

| technicians in the electron microscopy lab. Last year you did some work
| on one of our transmission microscopes. We prepared four specimens, two
| ileum and two jejunum (wt and ko), which we still have here in the lab.
|
|
| The STARS program here (Science Teacher Access to Resources at
| Southwestern) is working on a project which will create a 3D animation
| of the cell for use in ninth grade biology classes in the Dallas school
| district. They have asked the EM facility to provide images of cells
| and organelles for this animation. The images will also be printed and
| laminated.
|
| I have been searching through old grids looking for good examples of
| structures such as Golgi, ribosomes, and microtubules. One of the old
| specimens I looked at was yours and I got some images of very nice
| nuclear pores from it. I would like to send these images to the STARS
| group. The EM specimen number is 7321 and this is your wt jejunum from
| 7/10/07. You can see the images at the link below...
|
|
\\Mcif_tem2\images\lmueller\suitcase then
| select the folder "nuclear pore"
|
|
| Would you have any objections to STARS using these images for the
| project? I have deliberately selected specimens that are not current;
| presumably any images you took have already been used. I have also
| chosen the wild type specimen so that there is no possibility of a new
| finding going out inadvertently. Please take a look at the images in my
| folder "nuclear pore" and tell me if you would agree to let us use them.
| If you would like more information on the project I can put you in

| touch with their director, Joel Goodman and with Jennifer Hulsey, the
| artist who is doing the animation.
|
| Thank you very much for your time,
| Laurie Mueller
|
|
|
|

Laurie Mueller

From: "Rita Garuti" <Rita.Garuti@UTSouthwestern.edu>
To: "Helen Hobbs" <Helen.Hobbs@UTSouthwestern.edu>; "Laurie Mueller" <LMUELL.SW108A.SWMED@UTSouthwestern.edu>
Sent: Monday, September 15, 2008 2:26 PM
Subject: Re: permission to use EM image

Hi Laurie

I have talked to Dr.Hobbs and she has no problem with you using the image for this program.

Best regards
Rita Garuti

>>> "Laurie Mueller" <laurie.mueller@utsouthwestern.edu> 09/15/08 11:06 AM >>>
Rita and Dr. Hobbs,

in case you do not recognize the name, I am one of the technicians in Dr. Gilpin's electron microscope facility. I have taken an image from one of your specimens and would like to use it in an outreach project, but I need your permission to do so.

The STARS program here (Science Teacher Access to Resources at Southwestern) is creating a 3D animation of the cell. The animation (and the printed, laminated original images) will be used in ninth grade biology classes in the Dallas school district, making it easier for teachers to teach this material. We have been asked to provide images for the project, so I have been searching through old EM grids looking for good examples of organelles and ultrastructure. One of the specimens I looked at was your "NO" control, resin-embedded for reference, from August 2007. I took an image showing Golgi elements and smooth ER which I would like to send to the STARS group. A copy of the images is attached.

Would you have any objections to STARS using this image for the project? If you have questions about how the image would be used, I can put you in touch with their director, Joel Goodman and with Jennifer Hulsey, the artist who is doing the animation.

Thank you very much for your time,
Laurie

Laurie Mueller
Molecular and Cellular Imaging Facility
K1.210
UT Southwestern Medical Center at Dallas
5323 Harry Hines Boulevard
Dallas, TX 75390-9039
214-648-7291

From: "Laurie Mueller" <laurie.mueller@utsouthwestern.edu>
To: "Jennifer Hulsey" <Jennifer.Hulsey@UTSouthwestern.edu>
Date: Monday - November 17, 2008 12:00 PM
Subject: Re: permission for nepta

Yes, you may use the nepeta images for the STARS suitcase.

Laurie

----- Original Message -----
From: "Jennifer Hulsey" <Jennifer.Hulsey@UTSouthwestern.edu>
To: "Laurie Mueller" <Laurie.Mueller@UTSouthwestern.edu>
Sent: Monday, November 17, 2008 11:55 AM
Subject: permission for nepta

| Hey Laurie,
| I was just adding the permissions into my paper and realized that I
| did not have written permission from you to use the nepta images. Would
| you mind sending me an email giving me permission to use them? Thanks
| so much.
| Jennifer
|

APPENDIX F
Various Laboratory Protocols

Organelle(s) To Study: Chloroplast

Experiment: Separation and Identification of Chloroplast Pigments (modified from - *Cambell 6th Ed. 181-183; 7th Ed. 186-188)*

Objective: Students will use Thin Layer Chromatography (TLC) to identify chloroplast pigments found in plants.

Hypothesis:

The pigments in green plants have different solubilities. Here, the least soluble pigments are the xanthophylls which will stay closest to the origin. Yellow-green chlorophyll B is more soluble than xanthophyll and is seen next up. Blue green chlorophyll A is even more soluble therefore it moves further that chlorophyll B. Carotene is the most soluble of the pigments and will end up at the top of the solvent front.

Materials:

- Method of grinding – either blender or mortar and pestle
- Spinach leaves – or plant leaf of choice (red cabbage, beet leaves, carrots (baby food), red and green peppers)
- Capillary tubes (melting pt tubes)
- Pipets, measuring devices (graduated cylinder)
- Silica plates (TLC plates) Sigma Aldrich
- Marking pencils
- Vials/jars for chromatography (covered)
- Paint thinner – hardware store (100 % mineral spirits)
- Isopropyl alcohol (99% rubbing alcohol) (drug store)
- Hexane (Fisher Scientific Co. cat#H291)

Procedure:

Teacher Recommended Setup –

1. Tear leaves into small pieces and grind with mortar and pestle (most efficient), or blender to a pulp. (This breaks down the cell walls) (Students of some levels can perform this part of the experiment)
2. Add isopropyl alcohol in small amounts with stirring until a colored solution is formed. (Caution: a concentrated solution works best.)
3. Pipet solution into a small vial (2-oz), cap and label. Solutions are sensitive to light and air. Therefore, fresh solutions give the best results (no more than 1 day old). ***Note:*** *Peppers and red cabbage show best results when crushed in blender. Blend first, then remove pulp to another container and add isopropyl alcohol to pulp to extract pigments.* ***Since most blenders are not explosion-proof do not place any solvents into them.***
4. Cut silica plates into approximately 1 cm x 8 cm strips by using a single edged razor blade. Cut on the plastic side to avoid damaging the silica coating. Only touch edges of silica plates as fingerprints will affect the separations. ***Note:*** *Since TLC plates will pick up moisture from the air, it is best to keep them in an airtight container for long-term storage.*
5. Prepare solvent solution: (Teacher)
    a. pour 100 ml of paint thinner into a jar
    b. add 7 ml of hexane to the jar
    c. add 3.5 ml of isopropyl alcohol to the jar

Note: *This solution is volatile. Keep stored in a closed container.*

6. Using plastic or glass disposable pipets, place a small amount, about 1/2 cm depth, of above solution into 4-oz jars and cap (enough jars for each student or group).
7. Distribute silica plates and 4-oz jars of solvent solution to students.

Student Procedure –

1. Using capillary tubes, spot the TLC plate with plant extract solution. Dip one end of the capillary tube into the plant extract solution (the tube will automatically draw a small amount up into the tube). Quickly touch the end of the tube to the plate to dispense a drop onto the plate.
2. Let dry and repeat a few times to get a concentrated spot. Spot the plate about 2 cm above the bottom of the plate (the spot must be above the level of the solvent in the 4-oz jar).
3. Place the spotted silica plate into the solvent solution and quickly replace the cap.
4. Observe the pigment spot as it moves up the plate with the solvent front.
5. Remove plate from jar when solvent front is approximately 1 cm from the top of the TLC plate.

Website for reference pictures: Results:

http://images.google.com/imgres?imgurl=http://regentsprep.org/Regents/biology/units/homeostasis/chromatography.jpg&imgrefurl=http://regentsprep.org/Regents/biology/units/homeostasis/processes.cfm&h=459&w=360&sz=48&hl=en&start=1&um=1&tbnid=BdNS8r6mmjhyvM:&tbnh=128&tbnw=100&prev=/images%3Fq%3Dchromatography%2Bchloroplast%2Bpigments%2B%26svnum%3D10%26um%3D1%26hl%3Den%26client%3Dsafari%26rls%3Den%26sa%3DG

Another protocol version:
http://classes.uleth.ca/200701/biol34601/06-Chloroplasts&PigmentsSp07.pdf

Optional Analysis by Spectrophotometer – also available, let me know if you'd like this information as well

---

Organelle(s) To Study: Nucleus, cell wall(onion), cell membrane(cheek) cytoplasm

Experiment: Nuclei Staining of Onion Skin Cells or Cheek Cells

Objective: To teach students the basics of how to use a microscope as well as staining for the cell membrane (cheek), cell wall (onion), cytoplasm and nucleus.

Hypothesis: Staining with either iodine or methylene blue will allow for visualization of the basic cell organelles under low magnification microscope.

Materials:

- Compound Light Microscope
- Blank Slides
- Cover Slips
- Iodine stain
- Onion skin (epithelial) tissue

If doing cheek staining

- sterile swab
- methylene blue stain
- Cheek cells (swab)

Procedure:

1. Separate the outer most layer of the onion and throw away. Remove the under layer. From this layer separate the skin from the flesh of the onion.
2. Place the skin on a microscope slide
3. Add a few drops of iodine stain
4. Cover onion with cover slip
5. View best at 40X

For Cheek Cells

1. Rinse out mouth with water
2. Take cotton swab and wipe along the cheek interior
3. Place swab across microscope slide
4. Place a few drops of methylene blue over cells
5. Cover cells with cover slip
6. Begin viewing at 40X up to 100X

Website for reference pictures:
http://images.google.com/imgres?imgurl=http://regentsprep.org/Regents/biology/units/laboratory/graphics/cheekcells.jpg&imgrefurl=http://regentsprep.org/Regents/biology/units/laboratory/indicators.cfm&h=240&w=320&sz=93&hl=en&start=2&um=1&tbnid=IA1VZouQp_JYCM:&tbnh=89&tbnw=118&prev=/images%3Fq%3Dmethylene%2Bblue%2Bdye%2Bcheek%2Bcells%26svnum%3D10%26um%3D1%26hl%3Den%26client%3Dsafari%26rls%3Den%26sa%3DG

Organelle(s) To Study: Ribosomes, Endoplasmic Reticulum, Mitochondria

Experiment: Using Electron Microscopy to study Organelles

Objective: To facilitate collaboration between area universities and high schools in a continuing effort to educate students about interesting current advances in science.

Materials: School bus
Parent Signatures
Area facility willing to cooperate

Procedure:

1. To be explained in tutorial from area facilities

Website for reference pictures:
http://images.google.com/imgres?imgurl=http://student.ccbcmd.edu/courses/bio141/lecguide/unit1/proeu/images/1537a.jpg&imgrefurl=http://student.ccbcmd.edu/courses/bio141/lecguide/unit1/proeu/dkmito.html&h=400&w=500&sz=53&hl=en&start=4&um=1&tbnid=v6JlHznRuO5agM:&tbnh=104&tbnw=130&prev=/images%3Fq%3DElectron%2Bmicrography%2Borganelle%26svnum%3D10%26um%3D1%26hl%3Den%26client%3Dsafari%26rls%3Den%26sa%3DN

Organelle(s) To Study: Nucleus

Experiment: DNA Isolation from Cheek Cells

Objective: The basic procedure for extracting DNA is the same, regardless of its source, although the specifics may vary, here is a simple protocol allowing visualization of the DNA in a test tube.

Hypothesis: DNA will be extracted from cheek cells using a basic cell lysis solution (liquid soap) and precipitated in an ionic solution (alcohol). This procedure will make it possible to visualize the DNA in the test tube.

Materials:
- NaCl

- Liquid soap
- Glass beakers
- Test tubes + stoppers
- Distilled water
- Glass rod
- Plastic cup
- Rubbing alcohol

Procedure:

1. Add 8 grams of sodium chloride (NaCl) to 92 milliliters(ml) of distilled water in beaker. (Solution A)
2. In a second beaker, combine 25 mls of liquid soap with 75 mls of distilled water. (Solution B)
3. Pour 1 ml of solution A into a large test tube.
4. Pour 10 mls of the bottled water into a plastic cup and swirl the water in your mouth for 30 seconds.
5. Spit the water back into the cup and pour the contents into the test tube containing the sodium chloride solution.
6. Add 1 ml of liquid soap to the test tube contaning solution A.
7. Cover the top of the test tube with a stopper and gently mix the contents by turning the test tube upside down and right side up.
8. Add 5 mls of the rubbing alcohol to the test tube making sure to pour it at an angle down the side of the test tube.
9. Wait for about 5 minutes and watch as the DNA floats to the surface.
10. Pour 1 ml of alcohol into the second test tube.
11. Use the glass rod to remove the DNA from the first test tube by twirling the rod in a circular motion.
12. Place the DNA into the second test tube containing the alcohol

A good follow-up for this experiment would be to run an agarose gel to visualize the DNA under a UV light. This however requires several expensive equipment pieces as well as buffers. Let me know if you would also like his protocol.

Website for alternative protocols: I chose the most simple and cheap version of the protocols, here is an example of a slightly more complicated protocol.

http://biology.arizona.edu/sciconn/lessons2/Vuturo/vuturo/dna.htm

---

Organelle(s) To Study: Nucleus

Experiment: Fluorescence analysis of nuclear localization

Objective: To educate students on a popular procedure for analyzing cell components (organelles) by fluorescence microscopy using immunohistochemistry..

Hypothesis: The nucleus of a cell can be visualized by fluorescent antibody treatment of the cells prior to microscopy.

Materials:

Note: *There are several antibodies on the marked to fluorescently label organelles. For simplicity, I will only talk about nuclear staining.*

- DAPI
- Fluorescence microscope
- (Can also use virtual scope)

Procedure:

http://www.mitosciences.com/PDF/cyto.pdf (not sure if you will even use this one for due to the expensive nature of the experiments, antibodies and microscopes)

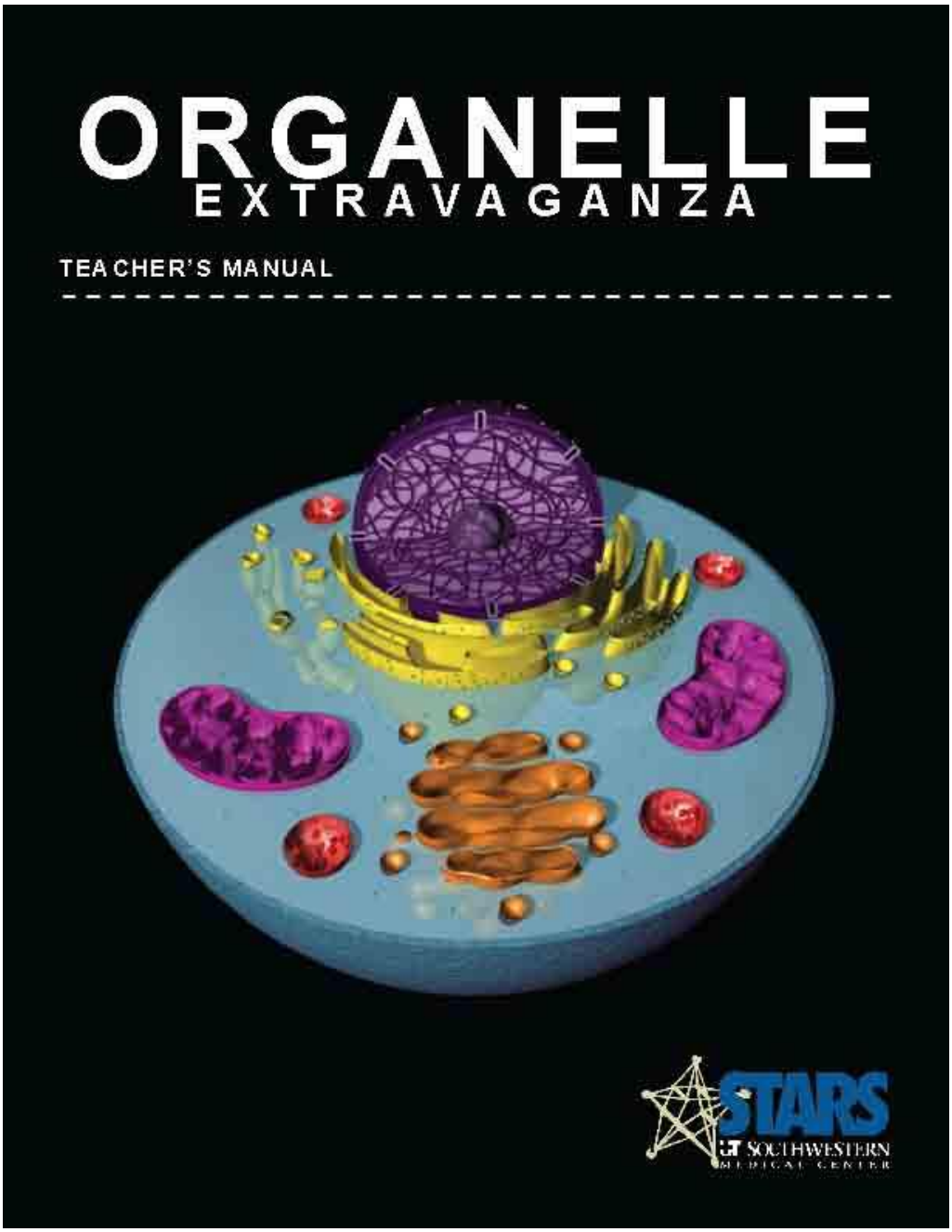
Website for reference pictures: http://en.wikipedia.org/wiki/Staining_(biology)

Organelle(s) To Study: Nucleus, Cell wall

Experiment: Identification of Cellular Distribution in different parts of plant

Website for protocols in plant sectioning:
http://www.plantbio.ohiou.edu/epb/instruct/pbio442-542/Lab%201%20-%20Laboratory%20Techniques.pdf

APPENDIX G
Teacher's Manual



ORGANELLE EXTRAVAGANZA

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS
- Table of Contents

ABOUT

ABOUT
- About the artist.

SUITCASES

SUITCASES
- Suitcase One of Two
- Suitcase Two of Two

SUITCASE CONTENTS

SUITCASE CONTENTS
- Suitcase One Contents
- Suitcase Two Contents

SUGGESTED CURRICULUM

SUGGESTED CURRICULUM
- Suggested Curriculum

PRE-TEST & POST-TEST

PRE-TEST & POST-TEST
- Pre-test and Post-test Answers

ANIMATION

ANIMATION
- Animation Container
- Animation Instructions
- Animation Script

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GAME

PROTEIN PRODUCTION GAME

- Protein Production Game Containers
- Protein Production Game Supplies
- Protein Production Game Instructions
- Prepared Origami Paper
- Cell Placement Chart
- mRNA Instructions
- Endoplasmic Reticlum Check Sheets

LAB ONE

LAB 1: ANIMAL & PLANT CELL

- Lab 1: Animal and Plant Cell Containers
- Lab 1: Animal and Plant Cell Supplies
- Lab 1: Animal and Plant Cell Instructions
- Lab 1: Animal and Plant Cell Results

LAB TWO

LAB 2: PAPER CHROMATOGRAPHY

- Lab 2: Paper Chromatography Containers
- Lab 2: Paper Chromatography Supplies
- Lab 2: Paper Chromatography Instructions
- Lab 2: Paper Chromatography Results

LAB THREE

LAB 3: FEEDING PARAMECIA

- Lab 3: Feeding Paramecia Containers
- Lab 3: Feeding Paramecia Supplies
- Lab 3: Feeding Paramecia Instructions
- Lab 3: Feeding Paramecia Results

ACKNOWLED-GEMENTS

ACKNOWLEDGEMENTS

- Acknowledgements

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ORGANELLE EXTRAVAGANZA

ABOUT THE ARTIST

JENNIFER HULSEY

Jennifer Hulsey was born in Athens Georgia. She attended the University of Georgia where she received her Bachelor's of Fine Arts in Scientific Illustration. From there she went on to attend the University of Texas Southwestern Medical Center at Dallas to pursue a Master's of Arts in Biomedical Communications.

Jennifer created this Science Suitcase as her Master's thesis project. The Science Suitcase was part of the STARS Science Triathlon that was funded by a grant from the Howard Hughes Medical Institute. If you would like to contact Jennifer or view her portfolio please visit her website at www.jenniferhulsey.com.

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ORGANELLE EXTRAVAGANZA

SUITCASE ONE OF TWO

1. Teacher's Manual, Student Handouts, Animation DVD
2. Lab 2: Paper Chromatography 6
3. Protein Production Game 1
4. Protein Production Game 2 & 3

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ORGANELLE EXTRAVAGANZA

SUITCASE TWO OF TWO

1. Lab 2: Paper Chromatography 1
2. Lab 1: Animal and Plant Cell 2 & 3
3. Lab 1: Animal and Plant Cell 1
4. Lab 2: Paper Chromatography 3
5. Lab 2: Paper Chromatography 5
6. Lab 3: Feeding Paramecia
7. Lab 2: Paper Chromatography 4
8. Disposable Pipets
9. Lab 2: Paper Chromatography 2

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ORGANELLE EXTRAVAGANZA

SUITCASE ONE CONTENTS

TEACHER'S MANUAL, STUDENT HANDOUTS, ANIMATION DVD

- Teacher's Manual
- Student Handouts Booklet
- Animation DVD
- PDF CD

LAB 2: PAPER CHROMATOGRAPHY 6

- 6 test tube racks in individual plastic bags
- 6 test tube brushes

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PROTEIN PRODUCTION GAME 1

- 1 Set of 11 name tags with green backs
- 1 Set of 11 name tags with blue backs
- 1 Set of 11 name tags with red backs

PROTEIN PRODUCTION GAME 2

- 1 envelope of 12 Endoplasmic Reticulum Check Sheets
- 1 envelope of 3 Cell Placement Charts
- 3 red DNA Folders
- 3 green DNA Folders
- 3 purple DNA Folders
- 3 blue DNA Folders
- 12 pizza pans
- 1 box of envelopes

PROTEIN PRODUCTION GAME 3

- 3 red envelopes of Food Particles
- 3 green envelopes of Food Particles
- 3 purple envelopes of Food Particles
- 3 blue envelopes of Food Particles
- 6 markers
- 1 roll of tape

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ORGANELLE EXTRAVAGANZA

SUITCASE TWO CONTENTS

LAB 2: PAPER CHROMATOGRAPHY 1

- 36 Chromatography tubes
- 36 rubber stoppers with hooks

LAB 1: ANIMAL AND PLANT CELL 2

- 3 dropper bottles of Iodine
- 6 dropper bottles of Methylene Blue

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LAB 1: ANIMAL AND PLANT CELL 3

- 3 dropper bottles of Iodine
- 6 dropper bottles of Distilled Water

LAB 1: ANIMAL AND PLANT CELL 1

- 6 boxes of colored pencils
- 10 plastic knives
- 6 curved forceps
- 1 plastic container of flat toothpicks
- 1 box of coverslips
- 1 box of 25 microscope slides
- 1 cardboard box of extra slides

LAB 2: PAPER CHROMATOGRAPHY 3

- 6 mortars
- 6 pestles

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LAB 2: PAPER CHROMATOGRAPHY 5

- 6 glass dropper bottles

LAB 3: FEEDING PARAMECIA

- 1 bottle of Congo Red Indicator
- 1 box of 12 microscope slides with wells
- 1 box of coverslips
- 1 plastic container of 30 microcentrifuge tubes
- 1 metal lab scoop
- 1 1/4 teaspoon measuring spoon
- 2 ice packs
- 6 packets of Active Dry Yeast

LAB 2: PAPER CHROMATOGRAPHY 4

- Chromatography paper
- 1 vial of capillary tubes

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DISPOSABLE PIPETS

- 50 disposable pipets

LAB 2: PAPER CHROMATOGRAPHY 2

- 6 markers
- 6 six inch plastic rulers
- 1 paper punch
- 6 rolls of label tape
- 6 pairs of scissors
- 6 boxes of colored pencils

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ORGANELLE EXTRAVAGANZA

SUGGESTED CURRICULUM

DAY ONE

Give the students the Pre-Test to see what they know about organelles before using the suitcase. Then start by introducing cells and organelles through a lecture or Powerpoint presentation. Have students read about organelles in their textbooks for homework.

DAY TWO

Watch the Organelle Extravaganza Animation. The animation runs approximately 23 minutes. The animation is divided into sections for each organelle. At the end of each section is a multiple choice question. Pause the animation at each question and hold a class discussion about which answer is correct. You can then restart the animation.

The animation can be divided over two days if you decide to spend more time discussing the questions.

DAY THREE

Play the Protein Production Game. This game works best when the students have already been exposed to the organelles and their functions.

DAY FOUR

Run the Animal and Plant Cell Lab. This lab introduces the students to animal cells in the form of their own cheek cells and plant cells in the form of onion skin cells. You will need to buy a purple onion before the lab.

DAY FIVE

Run the Paper Chromatography Lab. This lab introduces the students to the pigments contained inside chloroplasts. The solvents are not included in the suitcase. If you do not have access to Petroleum Ether, Acetone, or Isopropyl Alcohol you will need to buy them. You will also need to buy fresh spinach from the grocery store.

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DAY SIX

Run the Feeding Paramecia Lab. This lab introduces students to lysosomes. The paramecia will need to be ordered from Ward's Science before this lab. They take two to three days to arrive.

DAY SEVEN

Give the students the Post-Test to see what they know about organelles after using the suitcase.

NOTE

You do not need to use all of the elements included in the Organelle Extravaganza Science Suitcase for it to be effective. This is a suggested curriculum for using this suitcase and can be altered to best suit your needs.

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ORGANELLE EXTRAVAGANZA

PRE-TEST AND POST-TEST ANSWERS

Read each question carefully and circle the letter that best answers the question.

1. Which of these structures controls the cell's activity in most cells?

   A. Mitochondrion
   B. Plasma Membrane
   C. Nucleolus
   D. Nucleus

2. Which of the organelles listed converts the chemical energy found in food into a form of energy that can be used by the cell?

   A. Golgi apparatus
   B. Mitochondrion
   C. Rough Endoplasmic Reticulum
   D. Nucleus

3. Which one of the following is a function of the Golgi apparatus?

   A. Making proteins
   B. Storing DNA
   C. Packaging and distributing proteins
   D. Digesting and recycling cell waste

4. Which two structures are found in plant cells but are not found in animal cells.

   A. Mitochondria and the Cell Wall
   B. Chloroplast and Central Vacuole
   C. Nucleus and Ribosomes
   D. Lysosomes and Rough Endoplasmic Reticulum

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ORGANELLE EXTRAVAGANZA

ANIMATION CONTAINER

SUITCASE ONE OF TWO

1 Teacher's Manual, Student Handouts, and Animation DVD

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ORGANELLE EXTRAVAGANZA

ANIMATION INSTRUCTIONS

Time Required: Run time approximately 23 minutes.

Organelles to Study: Plasma Membrane, Nucleus, Nucleolus, Ribosome, Rough Endoplasmic Reticulum, Smooth Endoplasmic Reticulum, Golgi Apparatus, Lysosome, Mitochondrion, Cell Wall, Chloroplast, and Central Vacuole.

OBJECTIVES

1) Identify the structure and function of organelles in both plant and animal cells.
2) Compare and contrast the structures of plant and animal cells.

MATERIALS

Not Provided:

- DVD player and television

OR

- Computer with a projector

Provided in the science suitcase:

- 1 Organelle Extravaganza Animation DVD

TEACHER SETUP

1. Set up a DVD player and television or connect a projector to a computer to project the animation onto a projection screen.

2. Place the DVD into the DVD player or into the CD drive of your computer.

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1. From the main menu of the DVD, you can choose to play the full movie or choose a specific organelle using scene selection.

2. Pause the animation after each question when "Pause Now" appears on the screen. This allows time to hold a class discussion about the possible answers.

3. Once you have finished the class discussion, restart the animation to reveal the correct answer.

TEACHER CLEAN UP

1. Place the DVD back into its case and place the case into the container labeled "Teacher's Manual, Student Handouts, DVD Animation."

2. Replace the container into "Suitcase One" as shown.

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ORGANELLE EXTRAVAGANZA

ANIMATION SCRIPT

All living things are made of **cells**. Cells are the basic units of life. Some exist as single-celled organisms while others, including humans, are multicellular and consist of many different kinds of specialized cells working together.

The cells that make up plants and animals are called **eukaryotic cells**. Eukaryotic cells have a **nucleus** and many structures called **organelles** that carry out specific functions within the cell.

In many ways, a eukaryotic cell is similar to a factory, with its organelles working together as a group to produce a product. In this cellular factory, each organelle carries out a specific function. The **plasma membrane** is the gatekeeper that decides what gets into and out of the cell. The nucleus is the main control center for the cell, and is similar to the main boss of a factory. The **ribosomes** are the many machines working to produce its product, proteins. The **rough endoplasmic reticulum** moves these proteins and other substances through the cell, much like an assembly line of a factory, and plays a role in quality control. The packaging and distribution center of the cell is the **Golgi apparatus** where the destination of each product is decided. The **smooth endoplasmic reticulum** acts as the poison control center for the factory, neutralizing the drugs and poisons. The cleanup crews are the **lysosomes** which clean up all the trash in the factory. The **mitochondrion** is the power source for the factory. It uses the energy stored in food to produce enough energy to power the cellular factory.

Now that we have a basic overview of each of the organelles' functions, let's look at each of them a little closer. We will begin by looking at an animal cell and then take a look at a plant cell.

There are several different ways you can study cells. You can study them through models such as this one. Actual organelles are not colored, except for chloroplasts and mitochondria, but color has been added to this model to make it easier to visualize. You can also observe cells through a **light microscope**, which uses lenses to produce an enlarged image. Or observe smaller organelles and cell parts through a higher powered **electron microscope** that uses **electrons** to illuminate the cell and create an enlarged image.

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PLASMA MEMBRANE

Every cell is surrounded by a plasma membrane. The main components of this membrane are **phospholipids** and **proteins**. A phospholipid is a fat that has a **polar, phosphate group** on one end and two **non-polar,** long **fatty acid** tails on the other end. The phosphate is attracted to water because water is also polar, and the fatty acids are repelled by water. The water on the inside and the outside of the cell force the fatty acid tails to the center and the phospholipids form a double layer, or bilayer. Proteins are also embedded within the plasma membrane. The **lipid bilayer** is fluid, meaning the phospholipids can move from side to side. **Cholesterol** is another fat that is very important for the stability of membranes. It stiffens the membrane, making it less fluid.

The plasma membrane encloses the cell separating the **cytoplasm** from its surroundings. It controls what enters and leaves the cell. **Lipids** and substances that dissolve in lipids such as oxygen and carbon dioxide can pass through the plasma membrane. The proteins embedded in the lipid bilayer form channels and pumps that help move molecules across the plasma membrane that cannot cross on their own. Because the lipids and proteins allow only some things to permeate, or enter, the cell, the plasma membrane is known as **semipermeable**. Similar biological membranes surround most organelles.

1 Which one of the following is not present in the plasma membrane?

a) phospholipids
b) cholesterol
c) cytoplasm
d) proteins

The correct answer is:

c) cytoplasm

The plasma membrane does not contain cytoplasm. It separates the cytoplasm from the outside of the cell.

NUCLEUS

In the same way that the main boss controls a large factory, the nucleus is the control center of the eukaryotic cell. It contains most of the cell's genetic material in the form of **DNA** and with it the master set of instructions for making proteins. DNA and proteins contribute to the long thin fibers within the nucleus known as chromatin. When the cell is dividing the **chromatin** fibers condense to form **chromosomes**.

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The nucleus is surrounded by a double membrane called the **nuclear envelope**. Each membrane is a lipid bilayer similar to the plasma membrane. The nuclear envelope is dotted with up to thousands of **nuclear pores**, which allow material to move into and out of the nucleus.

The small dense region in the non-dividing nucleus is the **nucleolus**. This is where the assembly of ribosomes begins. Proteins are combined with **ribosomal RNA** to produce small and large ribosomal subunits. These subunits exit the nucleus through the nuclear pores and enter the cytoplasm.

2 Which structure includes all of the others listed?

a) nucleus
b) nucleolus
c) chromosomes
d) DNA

The correct answer is:

a) nucleus

Found within the nucleus is the genetic material in the form of DNA which condenses into chromosomes. The nucleolus is also found inside the nucleus.

RIBOSOMES

After the ribosomal subunits exit the nucleus through the nuclear pore and enter the cytoplasm, a large and small subunit assemble into a ribosome. They bind to **messenger RNA** which comes from the nucleus and contains instructions for making proteins. As the ribosomes move along the RNA they assemble small compounds known as **amino acids** into proteins. This process is known as **protein synthesis**.

3 Certain chemicals block the function of ribosomes. Which cell activity would immediately be affected by this change in ribosome function?

a) selective permeability
b) production of energy
c) excretion of metabolic wastes
d) protein synthesis

The correct answer is:

d) protein synthesis

Ribosomes are the organelles that are responsible for protein synthesis. They make proteins from instructions that they receive from the nucleus.

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ROUGH ENDOPLASMIC RETICULUM

The endoplasmic reticulum, also called the ER, is a network of membranous tubules called **cisternae** that are continuous with the nuclear envelope. Ribosomes bind to a large part of the ER, giving it a rough appearance, thus this organelle is called the rough ER. If a ribosome begins making a protein that will be moved through the endoplasmic reticulum or perhaps be secreted from the cell, the ribosome will attach itself to the rough ER and channel the protein inside. The proteins are then moved through the rough ER and are packaged into small vesicles that bud off from the ER surface. The rough ER also plays a role in quality control. Proteins that are not made correctly are pushed out of the rough ER into the cytoplasm where they are disposed of.

SMOOTH ENDOPLASMIC RETICULUM

The rest of the endoplasmic reticulum is called smooth ER because it lacks ribosomes and appears smooth. The smooth ER performs many different processes within the cell. The most important job of the smooth ER is the **detoxification** of drugs and poisons. It also plays a role in making **hormones** and lipids.

4 If organelles can increase in number in response to an increased demand, then which organelle would you expect to find more of in the liver cells of a drug addict than in a non-addicted person?

a) rough endoplasmic reticulum
b) smooth endoplasmic reticulum
c) mitochondria
d) lysosomes

The correct answer is:

b) Smooth endoplasmic reticulum

The smooth endoplasmic reticulum is responsible for the detoxification of drugs and poisons.

GOLGI APPARATUS

The vesicles that contain the newly formed proteins from the rough ER are called **transport vesicles** because they transport the proteins from the ER to an organelle known as the Golgi apparatus, or just the Golgi. The Golgi consists of a set of flattened membrane-bound sacs that serves as the packaging and distribution center of the cell. The Golgi faces the nucleus and ER on one side and the plasma membrane on the other side. The nuclear side acts as the receiving department and the side facing outward acts as the shipping department. Transport vesicles traveling from the ER fuse with the Golgi and deposit their proteins inside.

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Enzymes inside of the Golgi apparatus modify the proteins and the Golgi then sorts its products and targets them for various parts of the cell or for secretion outside the cell. The products then bud off of the Golgi inside transport vesicles. Transport vesicles carrying products destined for secretion from the cell go on to fuse with the plasma membrane. Other vesicles go on to fuse with lysosomes or other organelles.

5

You would expect a cell with an extensive Golgi apparatus to:

a) make a lot of energy
b) move actively
c) sort a lot of material
d) store large quantities of food

The correct answer is:

c) sort a lot of material

The Golgi apparatus is the packaging and distribution center of the cell so if a cell has an extensive Golgi apparatus it is safe to assume that it would sort a lot of material.

LYSOSOMES

Every factory needs a cleanup crew. In the eukaryotic cell, lysosomes perform this task and remove the junk that might otherwise accumulate and clutter up the cell. Lysosomes are membranous bags filled with **enzymes** that break down lipids, sugars, proteins, and other waste materials into small molecules that can be used by the cell. Lysosomes also break down excess organelles that are no longer needed or are damaged and no longer functioning properly.

Cells can acquire large substances such as food particles from the outside of the cell by forming **endosomes** from the plasma membrane. These endosomes can move to the lysosome where the outside substances are broken down into more useful compounds.

6

The function of a lysosome is to:

a) protect the cell from the external environment
b) synthesize proteins
c) make energy for the cell
d) remove cellular waste products

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The correct answer is:

d) remove cellular waste products

Lysosomes remove the wastes and break down excess organelles that could accumulate and clutter up the cell.

MITOCHONDRIA

After learning about the cell parts and the functions that they perform, it is easy to see that each of these functions requires a lot of energy. The most important form of energy that the cell can immediately use is stored in a molecule called **ATP**. Mitochondria are the organelles that provide much of this energy and are therefore known as the powerhouse of the cell. In a process known as **cellular respiration**, mitochondria convert the chemical energy found in organic compounds such as the broken down food and convert it into ATP which is more convenient for the cell to use.

A mitochondrion has two membranes. The outer membrane is smooth, while the inner membrane is highly folded inward providing a very large surface area for energy production. Mitochondria also have their own circular DNA and have their own ribosomes.

7 The cell organelle that would be found in cells requiring large quantities of energy is the:

a) Golgi apparatus
b) mitochondrion
c) lysosome
d) nucleolus

The correct answer is:

b) mitochondrion

The mitochondrion is the cell organelle that functions in energy production. To meet the need for large quantities of energy, a cell must have large numbers of mitochondria.

Plant cells can also be compared to a factory with a couple of extra workers. Plant cells contain all of the organelles mentioned so far but have several additional components. The rigid **cell wall** is much like a brick wall surrounding the fence around the factory and provides an extra layer of protection. The **chloroplasts** are the solar panels on the roof of the factory that convert the sunlight into additional energy for the factory. And finally, the **central vacuole** is the factory's storage building for storing extra materials.

Let's look at these additional components of the plant cell a little closer.

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CELL WALL

Plant cells have an additional line of protection, known as the cell wall, that distinguishes them from animal cells. The thick cell wall is composed of proteins and **carbohydrates** including the **polysaccharide**, **cellulose**. The wall surrounds the plasma membrane and protects the plant cell, maintains its shape, and prevents excessive uptake of water. Most cell walls are porous enough to allow nutrients and gasses to pass through easily.

The cell wall contains all of the following except:

a) proteins
b) carbohydrates
c) cholesterol
d) cellulose

The correct answer is:

c) cholesterol

The cell wall of a plant contains proteins, carbohydrates, and cellulose. Cholesterol is a lipid and is found in the plasma membrane.

CHLOROPLAST

Remember that plant cells have mitochondria to produce energy but they also have an additional power source known as chloroplasts. Chloroplasts are the biological equivalents to solar power plants because they can directly convert sunlight into energy in the form of ATP, in a process called **photosynthesis**. Chloroplasts contain the green **pigment, chlorophyll,** that helps to harvest the light energy and are found in the leaves of plants. Much like the mitochondria, chloroplasts are surrounded by a double membrane, but they also have small interconnected discs called **thylakoids** inside where the light harvesting takes place. Surrounding the thylakoids is a fluid known as **stroma**. Found within the stroma are ribosomes and circular DNA.

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9 Which of the following sets of features is common to both plant and animal cells?

a) mitochondria and a plasma membrane
b) nucleus and chloroplast
c) plasma membrane and cell wall
d) chloroplast and ribosome

The correct answer is:

a) mitochondria and a plasma membrane

Both plants and animals have a plasma membrane and mitochondria. Chloroplasts and cell walls are only found in plant cells.

CENTRAL VACUOLE

Every factory needs a place to store things, and plant cells contain a place for storage as well. Mature plant cells generally contain a large central vacuole that is enclosed by a membrane called the **tonoplast** and takes up most of the cell's volume. The central vacuole stores water, salts, proteins, and carbohydrates. When the central vacuole is full the pressure it exerts on the cell wall makes it possible for plants to support heavy structures such as leaves and flowers.

10 If you saw a plant whose stem and leaves were wilted, what could you conclude about the central vacuole?

a) the water level was too high
b) the water level was too low
c) it was filled
d) none of the above

The correct answer is:

b) the water level was too low

In order for the central vacuole to support the heavy structures of the plant it needs to be full of water and pushing against the cell wall.

The cellular factories inside our bodies are continuously working to make sure we function properly and each organelle plays an important role. Everything a living organism does can ultimately be traced back to the cell.

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GLOSSARY

ATP (Adenosine triphosphate) – one of the principal chemical compounds that living things use to store and release energy.

Amino Acid – an organic compound possessing a carboxyl and amino group and that combines with other amino acids to form proteins.

Carbohydrate – a compound that is made of carbon, hydrogen, and oxygen atoms, and that provides nutrients to the cells of living things.

Cell – the smallest unit that can perform all life processes. It is a collection of living matter that is enclosed by a barrier that separates the cell from its surroundings.

Cellular Respiration – the process by which cells produce energy in the form of ATP by breaking down glucose and other food molecules in the presence of oxygen.

Cellulose – a structural polysaccharide of cell walls in plants.

Cell wall – strong supportive layer surrounding the plasma membrane in plants, algae, and some bacteria. In plant cells, the wall is formed of cellulose fibers embedded in a protein matrix. It protects the plant cell, maintains its shape, and prevents excess uptake of water.

Central vacuole – a membranous sac in a mature plant cell. Its functions include storage of water, salts, and proteins. When it is full the pressure it exerts on the cell wall allows it to support heavy structure like leaves and flowers.

Chlorophyll – a green pigment located within the chloroplasts of plants that captures light energy.

Chloroplast – an organelle found only in plants and some other organisms that captures the energy from sunlight and converts it into chemical energy.

Cholesterol – a steroid that forms an essential component of animal cell membranes. It stiffens the plasma membrane making it less fluid.

Chromatin – the granular material found inside the nucleus of that consists of DNA tightly coiled around proteins.

Chromosome – a threadlike structure within the nucleus of a eukaryotic cell. Each chromosome consists of one very long DNA molecule and the associated proteins.

Cisternae – a flattened membrane disk that makes up the Golgi apparatus.

Cytoplasm – the entire contents of the cell within the plasma membrane that includes the cytosol, cytoskeleton, and all of the organelles excluding the nucleus.

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Cytosol – the semifluid portion of the cytoplasm excluding the membrane, cytoskeleton, and organelles.

Deoxyribonucleic acid (DNA) – a double-stranded helical nucleic acid that contains the sugar deoxyribose and nitrogenous bases adenine, cytosine, guanine, and thymine. It is capable of replicating and contains the genetic instructions of the cell.

Detoxification – the metabolic process by which the toxic qualities of a poison or toxin are reduced by the body.

Electron – a subatomic particle with a single negative charge. One or more electrons move around the nucleus of an atom.

Electron Microscope – a microscope that focuses a beam of electrons through a specimen, resulting in a magnification power a thousand times greater than a light microscope.

Endoplasmic Reticulum (ER) – an extensive membranous network found within the cytoplasm of eukaryotic cells. It is continuous with the outer nuclear membrane and composed of ribosome-studded (rough) and ribosome free (smooth) regions.

Endosome – a vesicle formed by the invagination and pinching off of the cell membrane during endocytosis, a process by which cells absorb materials such as proteins from outside the cell.

Enzyme – a protein that acts as a biological catalyst, a chemical agent that changes the rate of a reaction without being consumed by the reaction.

Eukaryote – an organism made up of cells that have a membrane-enclosed nucleus and membrane-enclosed organelles.

Fatty-acid – a long carbon chain carboxyl acid.

Golgi apparatus – an organelle in eukaryotic cells consisting of stacks of flat membranous sacks that modify, sort, and package proteins from the endoplasmic reticulum.

Hormone – a circulating chemical signal that is made in one cell or tissue and that causes a change in another target cell or tissue in a different location in the body.

Light Microscope – an optical instrument with lenses that reflect visible light to magnify images of specimens.

Lipid – one of a family of compounds including fats, phospholipids, and steroids that are insoluble in water.

Lipid bilayer – a double-layered sheet that forms the core of nearly all cell membranes.

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Lysosome – a membrane enclosed sac filled with enzymes needed to break down certain materials inside the cell. They are found within the cytoplasm.

Messenger RNA (mRNA) – a type of RNA, that carries copies of instructions for the assembly of amino acids into proteins from DNA to the rest of the cell.

Mitochondrion – a cell organelle that converts the chemical energy stored in food into compounds that are more convenient for the cell to use.

Nonpolar – pertaining to a molecule that does not exhibit polarity.

Nuclear Envelope – the double membrane that encloses the nucleus in eukaryotic cells separating it from the cytoplasm.

Nuclear pore – large protein complexes that cross the nuclear envelope. There are thousands scattered across the surface of the nuclear envelope. They allow for the transport of water soluble molecules across the nuclear envelope.

Nucleolus – a specialized structure within the nucleus that is involved in the production of ribosomes.

Nucleus – in eukaryotic cells, the structure that contains the cell's genetic material in the form of DNA and controls the cell's activities.

Organelles – specialized structures found in the cytoplasm of eukaryotic cells that perform specific functions within the cell.

Phosphate group – a functional group important in energy transfer.

Phospholipid – a molecule that is a constituent of the inner bilayer of biological membranes, having a polar hydrophilic head and a nonpolar hydrophobic tail.

Photosynthesis – the process by which plants and some other organisms use light energy to convert water and carbon dioxide into oxygen and high-energy carbohydrates such as sugars and starches.

Pigment – a light absorbing molecule.

Plasma membrane – the thin flexible membrane at the boundary of every cell that acts as a selective barrier and regulates what enters and leaves the cell.

Polar – pertaining to a compound exhibiting polarity, that is a compound having a partial positive charge on one side and a partial negative charge on the other side.

Polysaccharide – a polymer of up to over a thousand monosaccharides, formed by dehydration reactions.

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Prokaryote – an organism made up of a single cell that does not contain a nucleus or cell organelles.

Protein – an organic compound that is made of one or more chains of amino acids and that is a principal component of all cells.

Protein Synthesis – The process in which the genetic code carried by messenger RNA directs cellular organelles called ribosomes to produce proteins from amino acids.

Ribosomal RNA (rRNA) – together with proteins forms the structure of the ribosome and is responsible for ribosomal function.

Ribonucleic acid (RNA) – single-stranded nucleic acid that contains the sugar ribose and nitrogenous bases adenine, cytosine, guanine, and urasil. Functions in protein synthesis.

Ribosome – a cell organelle constructed in the nucleolus from ribosomal RNA and proteins and consists of two subunits. It functions as the site of protein synthesis. Can be found floating in the cytoplasm or attached to the rough endoplasmic reticulum.

Rough Endoplasmic Reticulum (rough ER) – the portion of the endoplasmic reticulum that is studded with ribosomes. It is responsible for moving substances throughout the cell and plays a roll in quality control.

Semipermeable – a property of biological membranes that allow some substances to cross more easily than others.

Smooth Endoplasmic Reticulum (smooth ER) – the portion of the endoplasmic reticulum that is free of ribosomes. In many cells it contains collections of enzymes that perform specialized tasks such as the synthesis of membrane lipids and hormones, and the detoxification of drugs and poisons.

Stroma – the fluid of the chloroplast surrounding the thylakoid membrane.

Thylakoids – a flattened membrane sac inside the chloroplast, used to convert light energy into chemical energy.

Tonoplast – a membrane that encloses the central vacuole in a plant cell, separating the cytosol from the contents of the central vacuole.

Transport vesicle – a tiny membranous sac in a cell's cytoplasm carrying molecules produced by the cell.

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ORGANELLE EXTRAVAGANZA

PROTEIN PRODUCTION GAME CONTAINERS

SUITCASE ONE OF TWO

1 Protein Production Game 1

2 Protein Production Game 2 & 3

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ORGANELLE EXTRAVAGANZA

PROTEIN PRODUCTION GAME SUPPLIES

PROTEIN PRODUCTION GAME 1

- 1 Set of 11 name tags with green backs
- 1 Set of 11 name tags with blue backs
- 1 Set of 11 name tags with red backs

PROTEIN PRODUCTION GAME 2

- 1 envelope of 12 Endoplasmic Reticulum Check Sheets
- 1 envelope of 3 Cell Placement Charts
- 3 red DNA Folders
- 3 green DNA Folders
- 3 purple DNA Folders
- 3 blue DNA Folders
- 12 pizza pans
- 1 box of envelopes

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PROTEIN PRODUCTION GAME 3

- 3 red envelopes of Food Particles
- 3 green envelopes of Food Particles
- 3 purple envelopes of Food Particles
- 3 blue envelopes of Food Particles
- 6 markers
- 1 roll of tape

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ORGANELLE EXTRAVAGANZA

PROTEIN PRODUCTION GAME TEACHER'S MANUAL

Time Required: One Class Period

Organelles to Study: Plasma membrane, Endosome, Nucleus, Mitochondria, Endoplasmic Reticulum, Ribosome, Lysosome, Transport Vesicles, and Golgi Apparatus.

OBJECTIVES

1) Demonstrate an understanding of basic cell functions and the role that each organelle plays by acting them out.

2) Work together as a team to produce a protein.

INTRODUCTION

This activity is designed to review and reinforce the students' understanding of cell organelles and the parts each of them play in basic cell functions. Students should already have a basic understanding of the cell organelles and of how energy is produced and proteins are synthesized and secreted.

MATERIALS

Materials for each Group:

- 1 set of organelle name tags
- 1 cell placement chart
- 4 DNA folders and corresponding mRNA instructions
- 4 envelopes of food particles (pizza pieces)
- 4 pizza pans
- 4 sheets of origami paper (copied or printed from files)
- 4 endoplasmic reticulum check sheets
- 4 envelopes
- 2 markers

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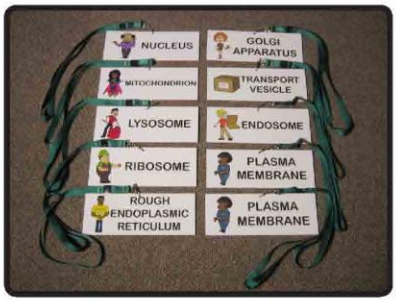
PRE-CLASS PREPARATION

1. Use a copy machine to make double-sided copies of the four prepared origami sheets provided. Copy machines vary, but you will want to make a two-sided copy from one-sided originals. Digital files can also be found on the CD provided that you can print if you have access to a printer that will print double-sided documents. Make sure you have one of each of the sheets for each group.

2. Using a paper cutter or scissors cut all of the origami sheets on the lines marked "cut here".

3. Move the desks to have as much floor space as possible and make a circle for each group on the floor using the tape provided. The students will stand inside this circles so make sure they are large enough. You can have the students do this step if you would like.

4. Place one set of organelle name tags in the center of each circle. (Each set has a different color on the back and will have 1 nucleus, 1 mitochondrion, 1 lysosome, 1 ribosome, 1 endoplasmic reticulum, 1 Golgi apparatus, 1 transport vesicle, 1 endosome, and 2 plasma membrane name tags. You can give extra students plasma membrane name tags if needed). The name tags are color coded so it will be easier to keep them separated.



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5 Also place 4 plastic envelopes of food particles (one of each color: red, green, purple, and blue), 4 DNA folders with corresponding mRNA Instructions inside (red, green, purple, and blue), 4 sheets of copied origami paper (proteins 1 - 4), 4 endoplasmic reticulum check sheets (1 - 4), 1 cell placement chart, 4 envelopes, and 2 markers in the center of each circle.

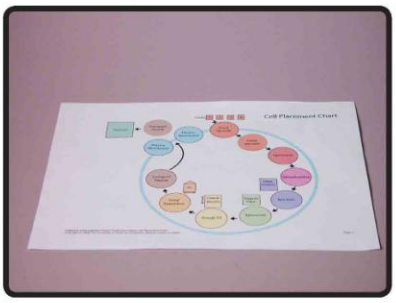
SETUP

1 Divide the class into several groups of eight to ten depending on class size. The suitcase has enough materials for three groups. (A group of 10 includes two plasma membranes. If you have less than 30 students the groups can have one plasma membrane instead of two or you can choose not to use the plasma membranes at all. You can also add extra plasma membranes if you have an uneven number of students.)

2 Explain that each group is going to form a cell with each student acting as a different cell part.

3 Instruct the students to each choose an organelle name tag and place it around their neck.

4 Tell the nucleus of each group to use the Cell Placement Chart to arrange the group members into the correct positions inside the cell and to give each group member the correct game pieces.



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5 Once the groups are settled and in the correct positions, explain that this is a relay race with the groups competing to create energy, make proteins, and secrete them from the cell.

Alternatives: The game does not have to be a relay race if you feel like the speed would be an issue for your class.

You can also have the students alternate organelles after each round.

6 Read the STORY aloud to your class.

7 After you have read the STORY, run through a practice round with the students by reading the DIRECTIONS and having the students follow along.

8 Once you run through the game ask if the students have any questions.

9 Tell the students that the first group to successfully complete three proteins and give them to you in the correctly addressed envelopes wins. Explain that they must complete the proteins in order. There are numbers on the envelopes of food particles, the DNA folders, and the endoplasmic reticulum check sheets.

10 Start the game.

Organelle Extravaganza Protein Production Game Teacher's Manual
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STORY

Each group is a hypothetical cell that produces and secretes animal shaped proteins. In order for a cell to produce a protein it needs to have energy. A food particle must enter the cell through the **plasma membrane** by forming an **endosome** and be broken down into smaller particles by a **lysosome**. The smaller food particles can then be used by the **mitochondrion** to produce energy in the form of ATP and distribute it within the cell.

Now that the cell has energy it can produce a protein. The instructions for making the protein come from the DNA inside the **nucleus** in the form of mRNA. The **ribosome** uses the mRNA instructions to produce a protein. The **rough endoplasmic reticulum** then checks that the protein is made correctly and moves it through the cell to the **Golgi apparatus**. The Golgi apparatus then packages and distributes the protein to the outside of the cell through the plasma membrane in **transport vesicles**.

DIRECTIONS

In order to create a protein each group should follow these steps:

1. The **endosome** reaches outside of the cell from its position on the **plasma membrane** and grabs the red envelope of food particles labeled "Food Particles - Practice Round".

2. The **endosome** enters the cell with the envelope of food particles.

3. The **endosome** gives the envelope of food particles to the **lysosome** and returns to its position on the **plasma membrane.**

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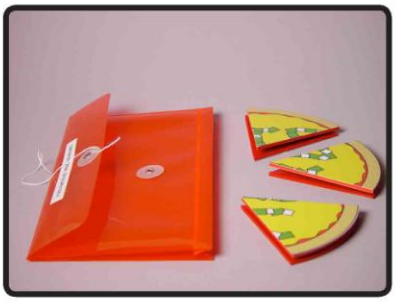
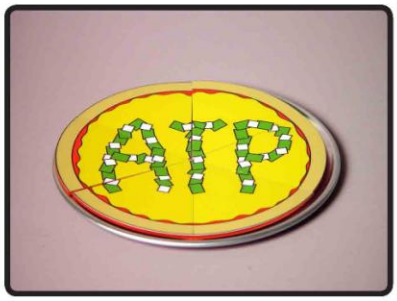
4 The **lysosome** opens the envelope of food particles and takes them out.



5 The **lysosome** breaks the food particles into smaller pieces by pulling them apart..

6 The **lysosome** gives the broken down food particles to the **mitochondrion**.

7 The **mitochondrion** arranges the food particles inside the pizza pan to form a pizza. The toppings must spell out ATP to move forward.



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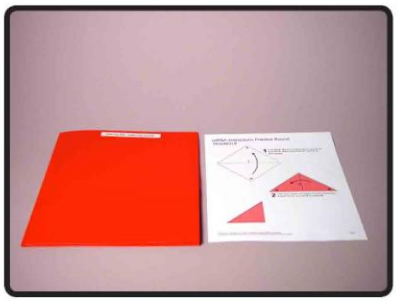
8 When a full pizza spelling ATP is formed, the **mitochondrion** signals to the **nucleus** to start.

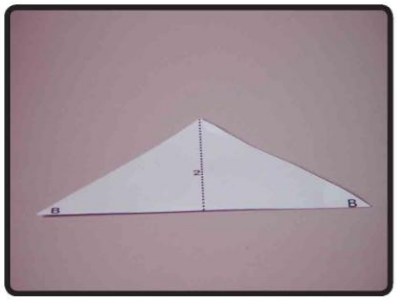
Now that we have energy:

9 After receiving the signal from the **mitochondrion**, the **nucleus** opens the red DNA folder labeled "DNA Folder - Practice Round" and takes out the mRNA Instructions. These are the instructions for making the protein.



10 The **nucleus** reads the mRNA Instructions aloud to the **ribosome**.

11 The **ribosome** uses the origami paper labeled "Practice Protein" to fold an animal protein following the instructions read by the **nucleus**.



12 The **ribosome** gives the folded protein to the **rough endoplasmic reticulum**.

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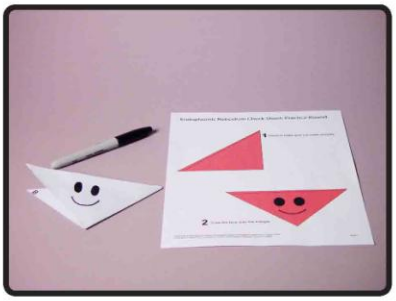
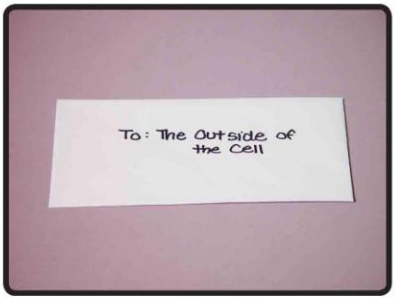
13 The **rough endoplasmic reticulum** uses the Endoplasmic Reticulum Check Sheet labeled "Endoplasmic Reticulum Check Sheet - Practice Round" to check that the protein is made correctly and uses the marker to draw the face.



14 The **rough endoplasmic reticulum** gives the protein to the **Golgi apparatus**.

15 The **Golgi apparatus** places the protein into an envelope and uses the marker to address it TO: The Outside of the Cell.



16 The **Golgi apparatus** gives the envelope to the **transport vesicle**.

17 The **transport vesicle** goes to the **plasma membrane**.

18 The **plasma membrane** opens and lets the **transport vesicle** out of the cell.

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19 The **transport vesicle** takes the envelope to the teacher and returns to its original place inside the cell.

20 Once the **transport vesicle** is back in the cell you can start making the next protein.

CLEAN UP

1 Have the students return all their supplies and name tags to the center of the circle the way they found them.

- The **lysosome** and **endosome** need to reattach the pizza pieces and place them into their color coordinated envelopes.
- The **mitochondrion** needs to stack the empty pizza pans.
- The **nucleus** needs to place the mRNA Instructions into their color coordinated DNA Folders and return the Cell Placement Chart to the center of the circle.

2 Gather the materials and check to make sure the food particles are attached together in pairs and in the color coordinated "Food Particles" envelope.

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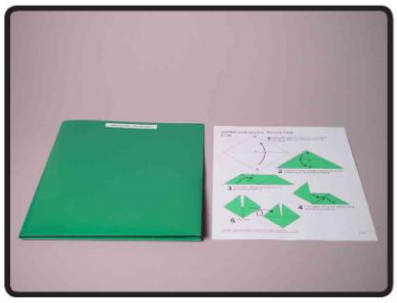
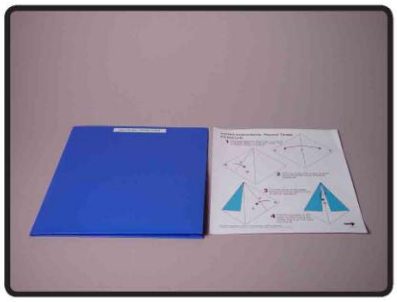
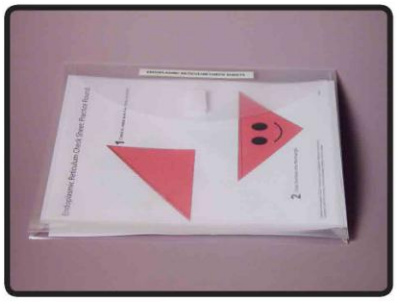
3 Also check that the mRNA Instructions are in their corresponding DNA Folders.





4 Place the Endoplasmic Reticulum Check Sheets and the Cell Placement Charts into the correct clear plastic envelopes.



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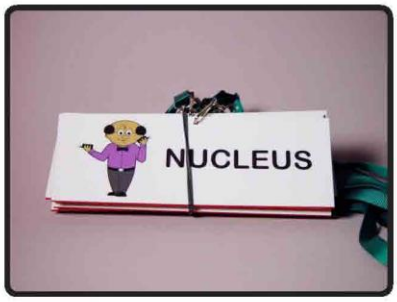
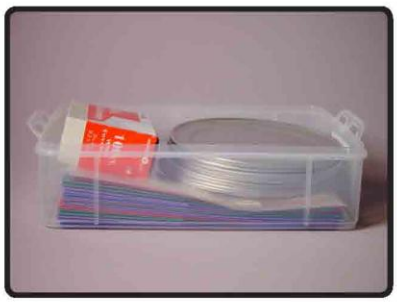
5 Wrap a large black rubber band around each group of colored name tags as shown.



6 Place the name tags into the box labeled "Protein Production Game 1" as shown.

7 Place the DNA folders, Endoplasmic Reticulum Envelope, Cell Placement Chart Envelope, and box of envelopes into the box labeled "Protein Production Game 2"



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8 Place the "Food Particles" envelopes, markers, and tape into the box labeled "Protein Production Game 3" as shown.

9 Place the lid onto the box labeled "Protein Production Game 2" and stack it on top of the box labeled "Protein Production Game 3" as shown.

7 Replace the boxes into "Suitcase One" as shown.

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REVIEW QUESTIONS

1. Describe what happens when a large food particle enters the cell making sure to name each of the organelles involved and state their functions.

When a large food particle enters the cell it forms an endosome from the plasma membrane. The endosome fuses with a lysosome and breaks the food particle into smaller pieces which can enter the cytoplasm. The smaller food particles can then be used by the mitochondrion to produce energy in the form of ATP. The ATP is then used to power the cell.

2. Which organelle is necessary to transform food into energy for the cell?

The mitochondrion transforms food into energy in the form of ATP.

3. Describe how proteins are produced making sure to name each of the organelles in the process.

The directions for the protein come from the DNA inside the nucleus in the form of mRNA. The ribosome uses the mRNA directions to produce a protein. The endoplasmic reticulum then checks that the protein is made correctly and moves it through the cell to the Golgi apparatus. The Golgi apparatus packages and distributes the protein to the outside of the cell through transport vesicles.

4. What is the purpose of the nucleus?

The nucleus controls all of the cell's activities. It contains the DNA which is transcribed into mRNA that is used to make proteins.

5. What happens to a cell if its mitochondria fail?

The mitochondria produce the energy needed for a cell to function, so without mitochondria the cell would fail.

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6 Which organelle were you? And what part did you play in the game?

***Endosome**: Brought the food particles into the cell and gave them to the lysosome to be broken down.*

***Lysosome**: Broke the food particles into smaller pieces to be used by the mitochondrion to produce energy.*

***Mitochondria**: Used the food particles to produce energy in the form of ATP to power the cell.*

***Nucleus**: Instructed the ribosome how to make a protein and was the leader of the cell.*

***Ribosome**: Made a protein using instructions from the nucleus.*

***Endoplasmic Reticulum**: Checked that the protein was made correctly and moved the protein through the cell to the Golgi apparatus.*

***Golgi Apparatus**: Packaged the protein and labeled it for distribution outside of the cell.*

***Transport Vesicle**: Transported the protein out of the cell.*

***Plasma Membrane**: Surrounded the cell and regulated what entered and left the cell.*

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GLOSSARY

Cell – the smallest unit that can perform all life processes. It is a collection of living matter that is enclosed by a barrier that separates the cell from its surroundings.

Cellular Respiration – the process by which cells produce energy in the form of ATP by breaking down glucose and other food molecules in the presence of oxygen.

Endoplasmic Reticulum (ER) – an extensive membranous network found within the cytoplasm of eukaryotic cells. It is continuous with the outer nuclear membrane and composed of ribosome-studded (rough) and ribosome free (smooth) regions.

Endosome – a vesicle formed by the invagination and pinching off of the plasma membrane during endocytosis, a process by which cells absorb materials such as proteins from outside the cell.

Golgi apparatus – an organelle in eukaryotic cells consisting of stacks of flat membranous sacks that modify, sort, and package proteins from the endoplasmic reticulum.

Lysosome – a membrane enclosed sac filled with enzymes needed to break down certain materials inside the cell. They are found within the cytoplasm.

Messenger RNA (mRNA) – a type of RNA, that carries copies of instructions for the assembly of amino acids into proteins from DNA to the rest of the cell.

Mitochondrion – a cell organelle that converts the chemical energy stored in food into compounds that are more convenient for the cell to use.

Nucleus – in eukaryotic cells, the structure that contains the cell's genetic material in the form of DNA and controls the cell's activities.

Organelles – specialized structures found in the cytoplasm of eukaryotic cells that perform specific functions within the cell.

Plasma membrane – the thin flexible membrane at the boundary of every cell that acts as a selective barrier and regulates what enters and leaves the cell.

Protein – an organic compound that is made of one or more chains of amino acids and that is a principal component of all cells.

Protein Synthesis – The process in which the genetic code carried by messenger RNA directs cellular organelles called ribosomes to produce proteins from amino acids.

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Ribosome – a cell organelle constructed in the nucleolus from ribosomal RNA and proteins and consists of two subunits. It functions as the site of protein synthesis. Can be found floating in the cytoplasm or attached to the rough endoplasmic reticulum.

Rough Endoplasmic Reticulum (rough ER) – the portion of the endoplasmic reticulum that is studded with ribosomes. It is responsible for moving substances throughout the cell and plays a roll in quality control.

Smooth Endoplasmic Reticulum (smooth ER) – the portion of the endoplasmic reticulum that is free of ribosomes. In many cells it contains collections of enzymes that perform specialized tasks such as the synthesis of membrane lipids and hormones, and the detoxification of drugs and poisons.

Transport vesicle – a tiny membranous sac in a cell's cytoplasm carrying molecules produced by the cell.

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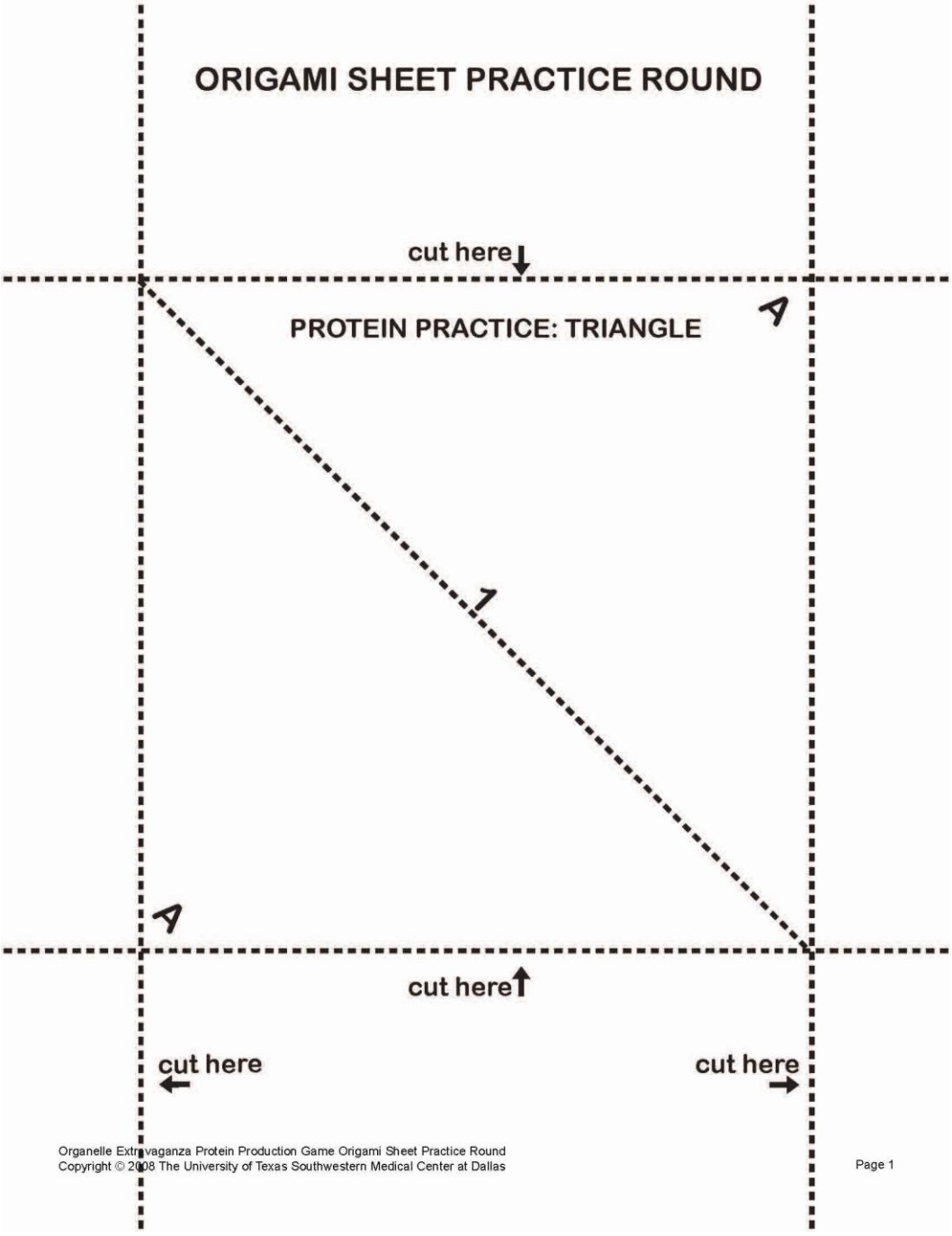
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Organelle Extravaganza Protein Production Game Origami Sheet Practice Round
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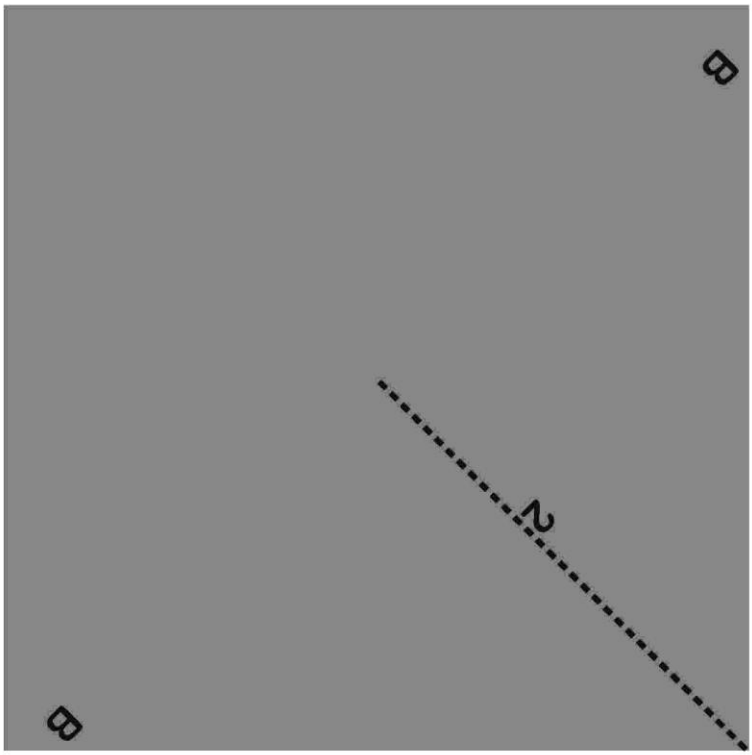
Page 1



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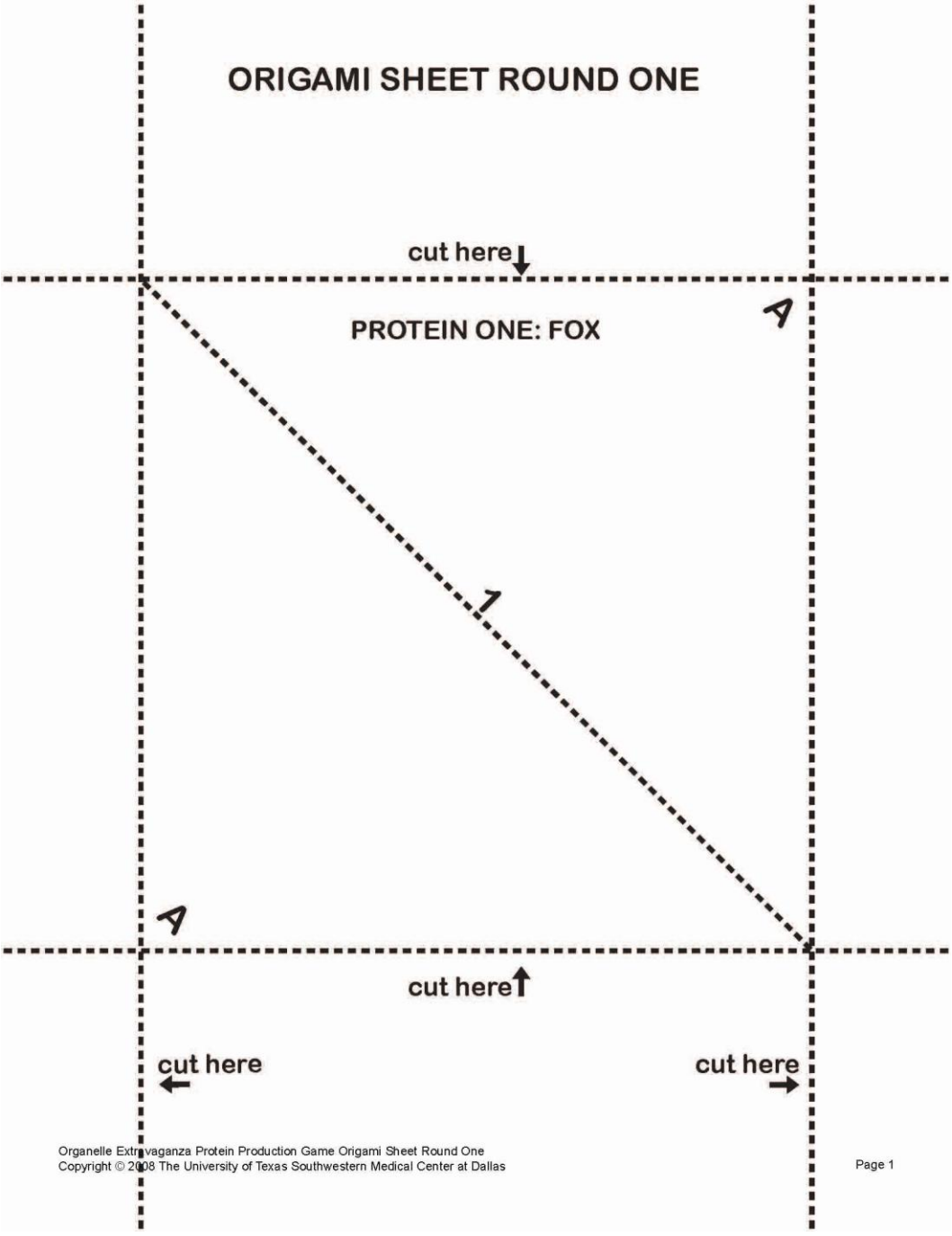
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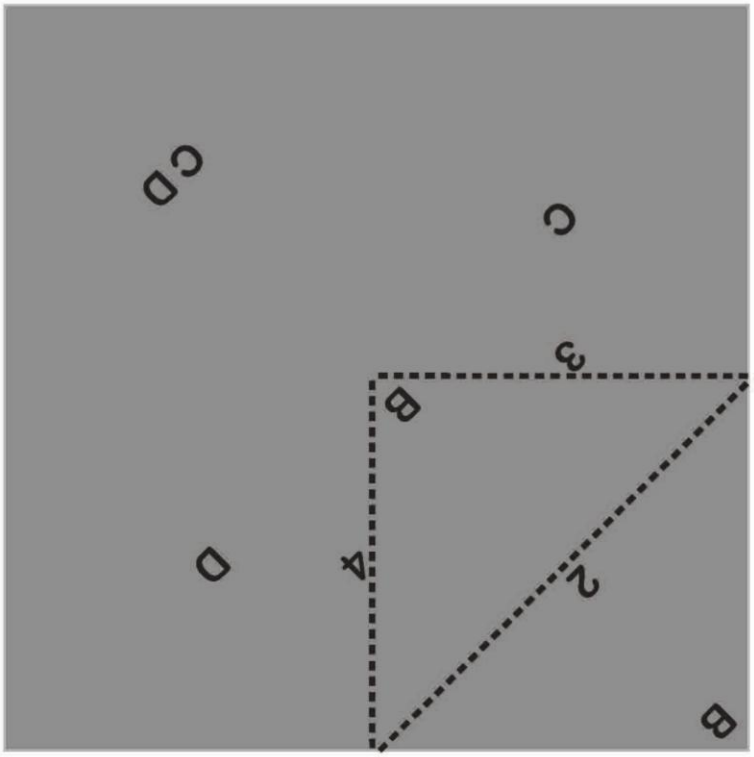
Page 1



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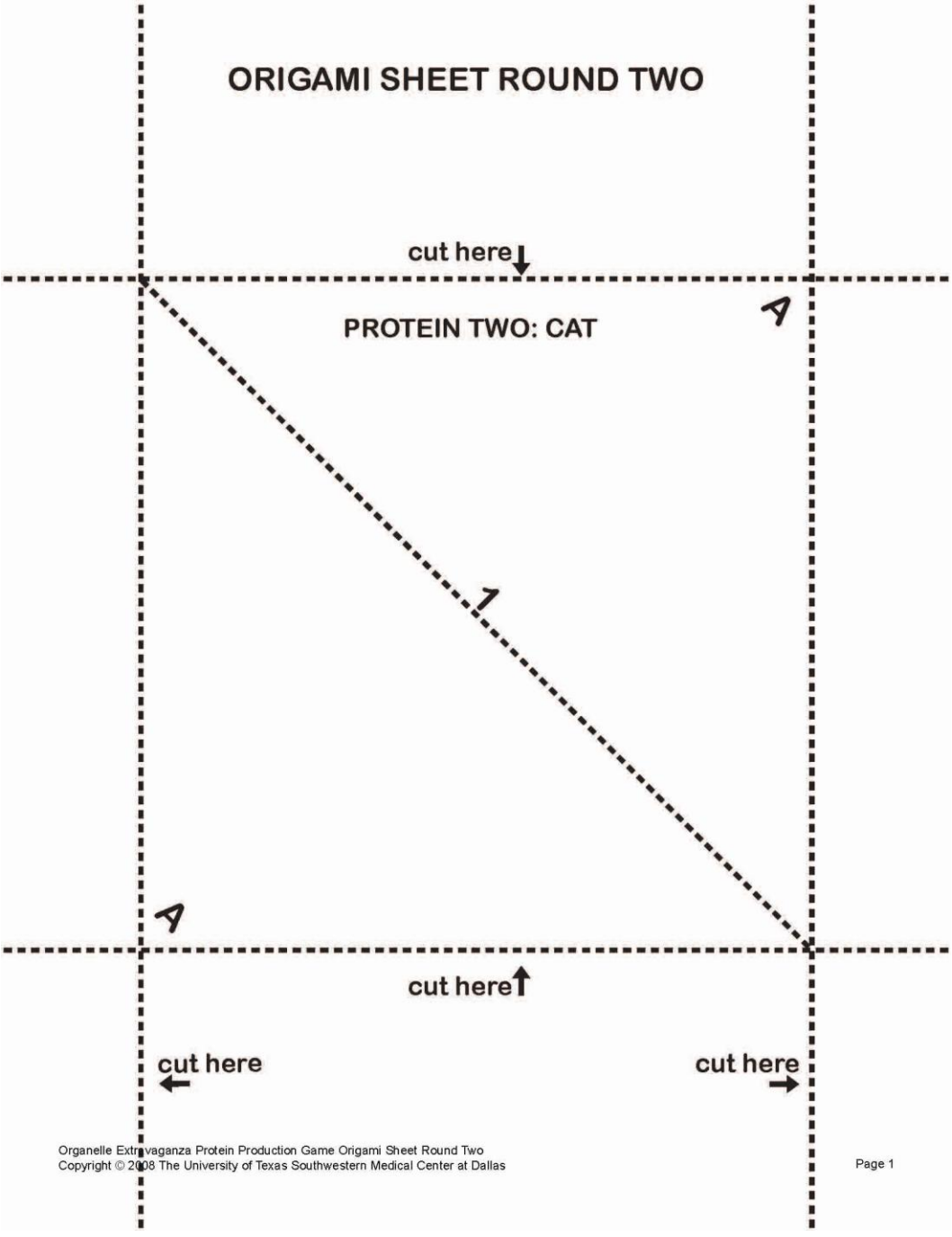

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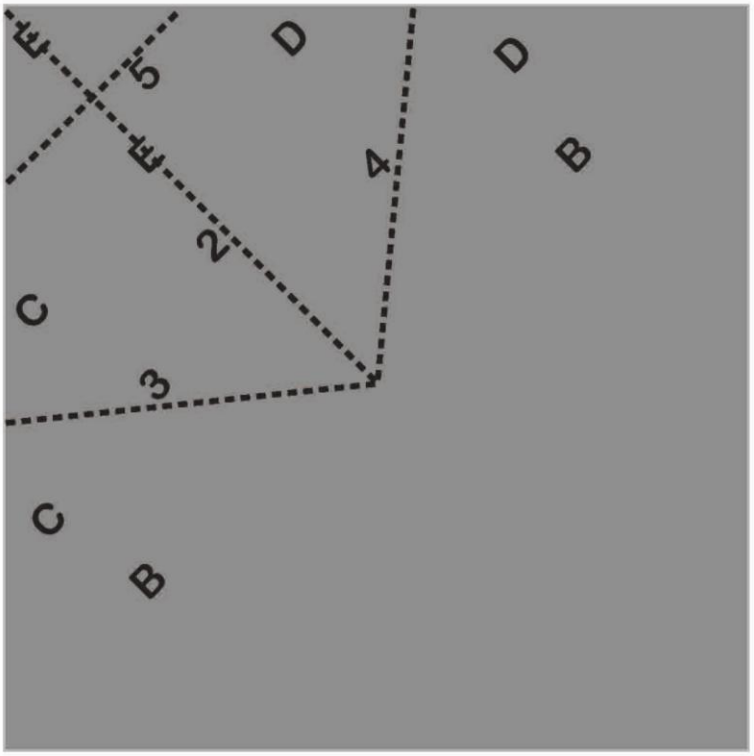

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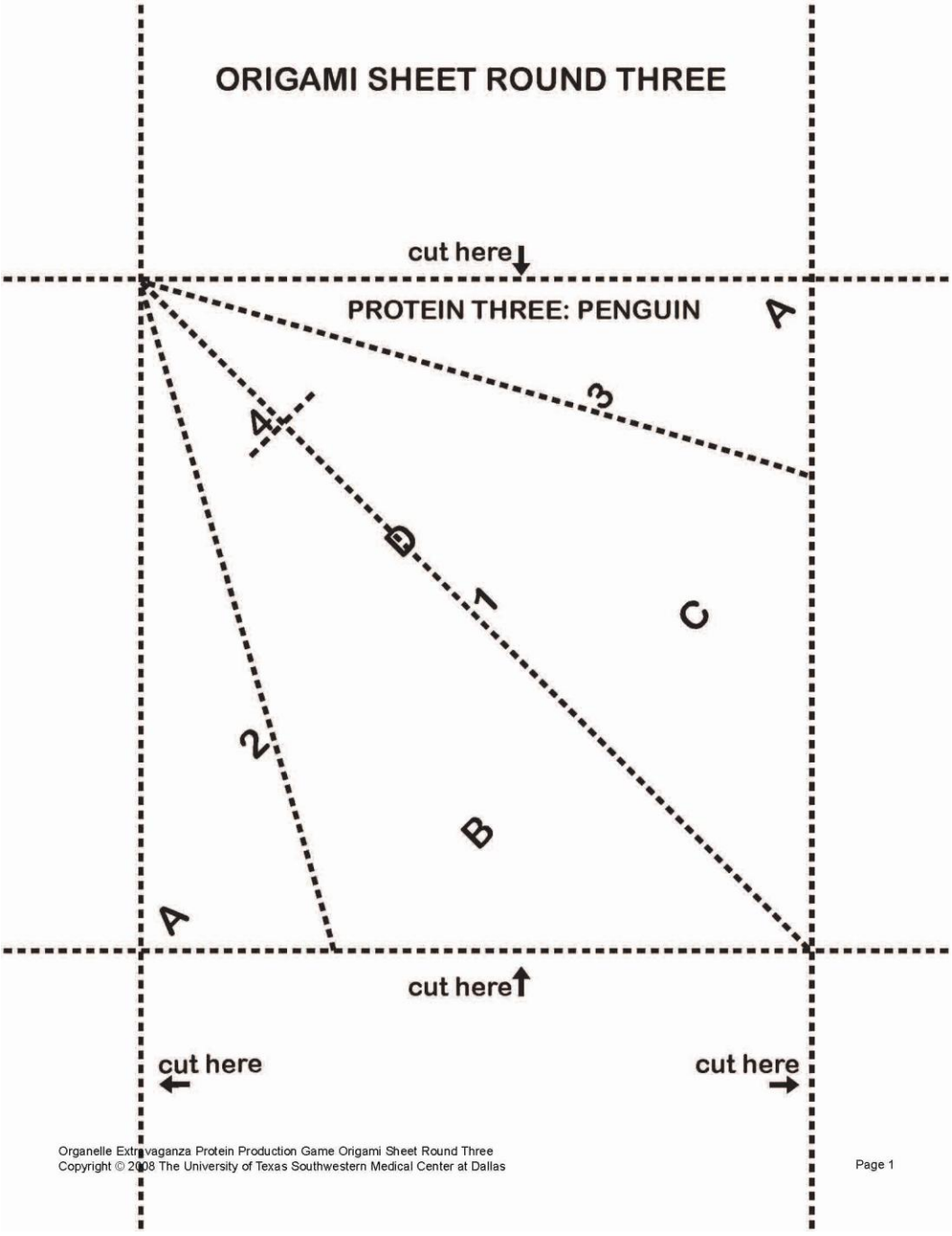
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PROTEIN THREE: PENGUIN
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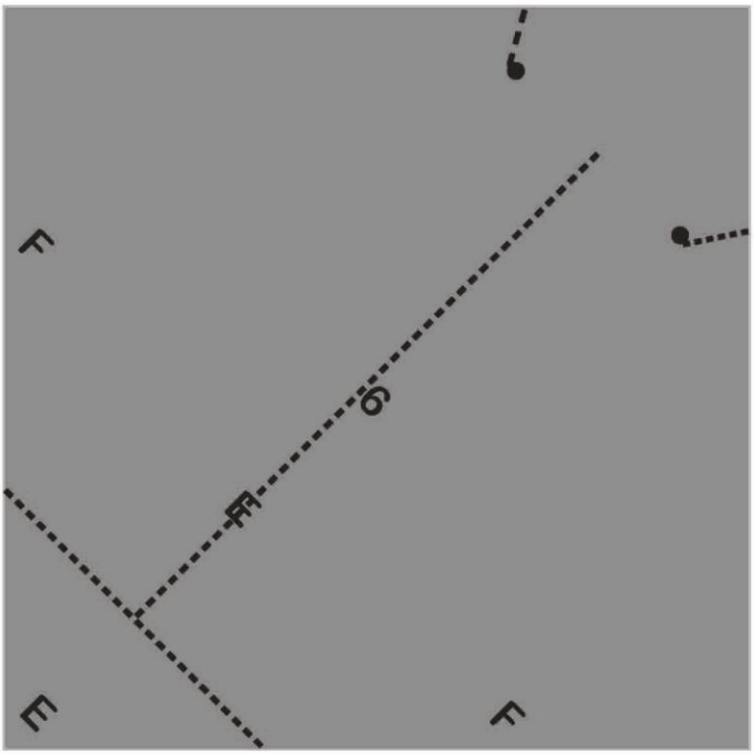
Page 1



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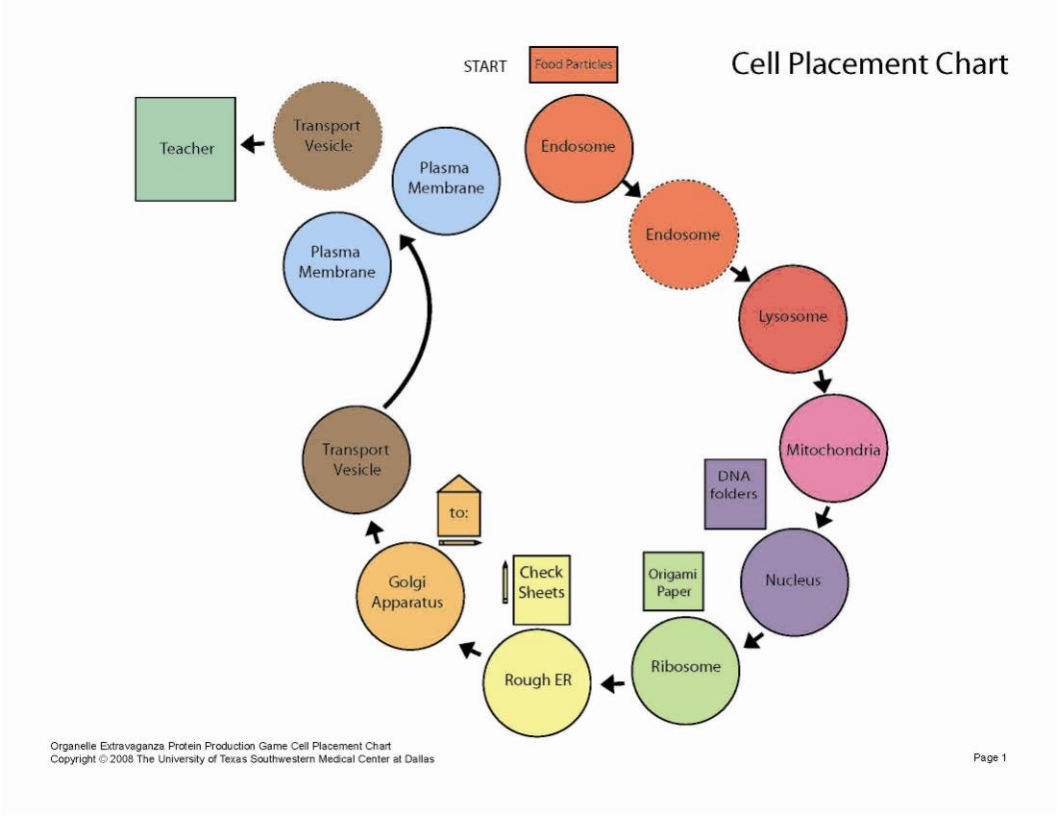
Cell Placement Chart
START
Food Particles
Endosome
Endosome
Lysosome
Mitochondria
DNA folders
Nucleus
Origami Paper
Ribosome
Rough ER
Check Sheets
Golgi Apparatus
to:
Transport Vesicle
Plasma Membrane
Plasma Membrane
Transport Vesicle
Teacher
Organelle Extravaganza Protein Production Game Cell Placement Chart
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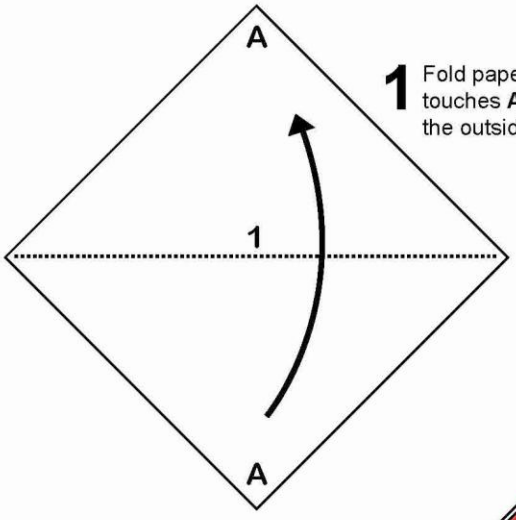
Page 1

mRNA Instructions Practice Round: TRIANGLE



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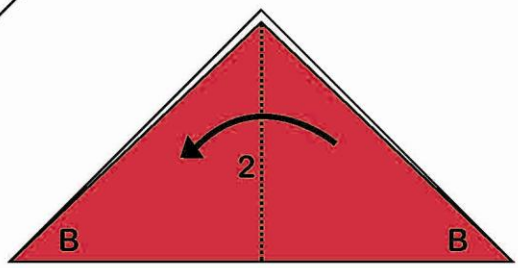
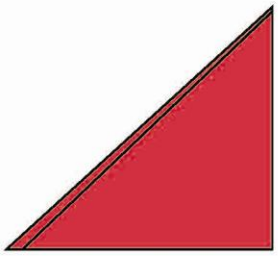


2 Fold both layers of paper forward along the dotted line **2**, so that **B** touches **B**.



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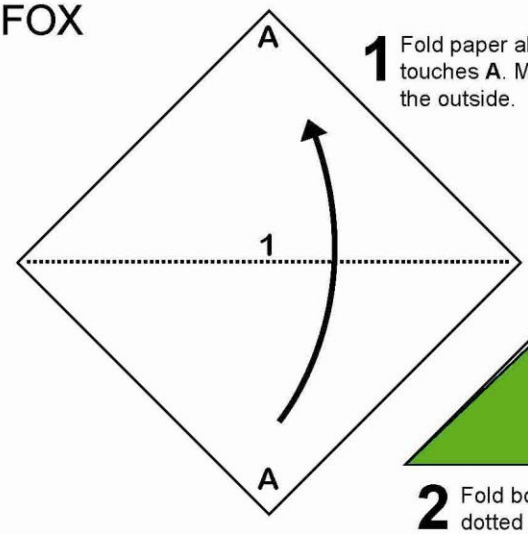
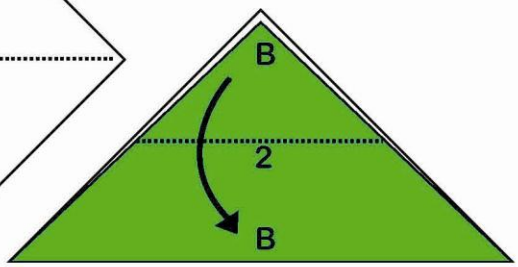
mRNA Instructions: Round One

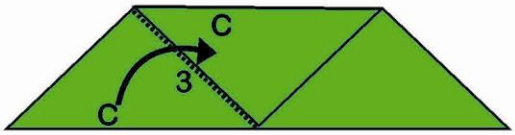
FOX



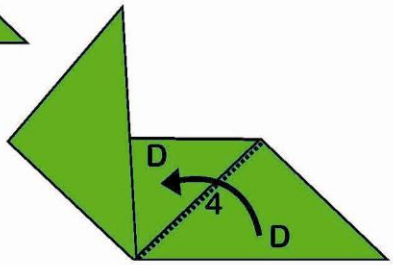
1 Fold paper along the dotted line **1,** so that **A** touches **A**. Make sure that the color is on the outside.



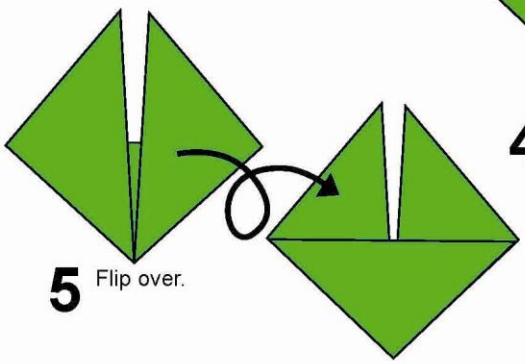
2 Fold both layers of paper forward along the dotted line **2**, so that **B** touches **B**.



3 Fold paper along the dotted line **3**, so that **C** touches **C**.



4 Fold paper along the dotted line **4**, so that **D** touches **D**.



5 Flip over.

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mRNA Instructions: Round Two

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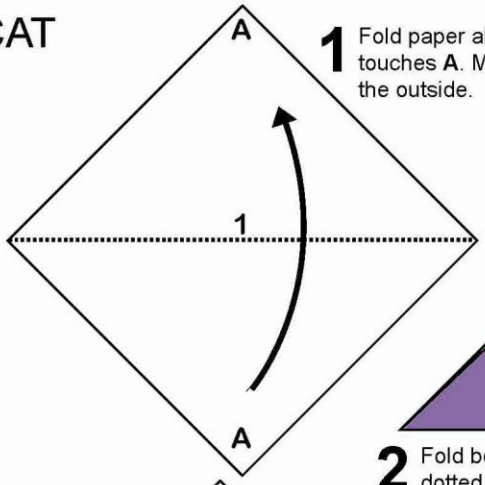

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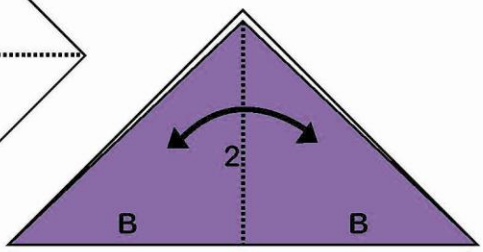
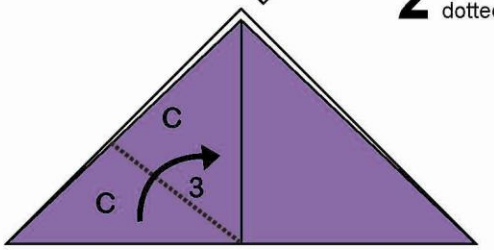
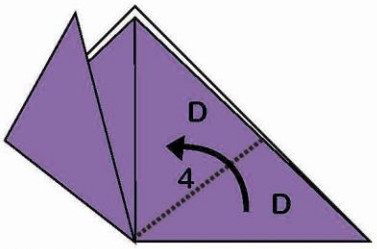


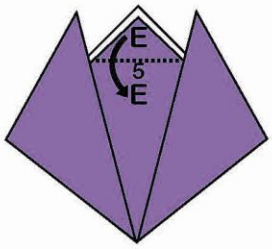
2 Fold both layers of paper forward along the dotted line **2**, so that **B** touches **B**, and unfold.



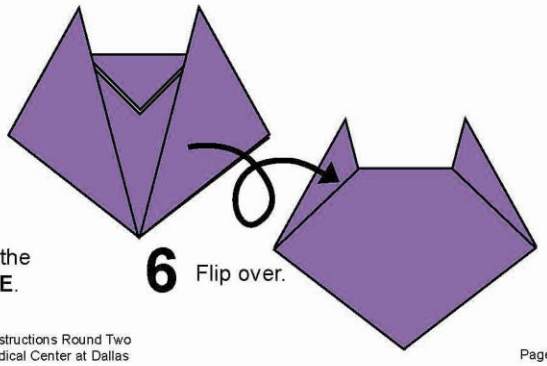
3 Fold paper along the dotted line **3**, so that **C** touches **C**.



4 Fold paper along the dotted line **4**, so that **D** touches **D**.



5 Fold both layers of paper along the dotted line **5**, so that **E** touches **E**.



6 Flip over.

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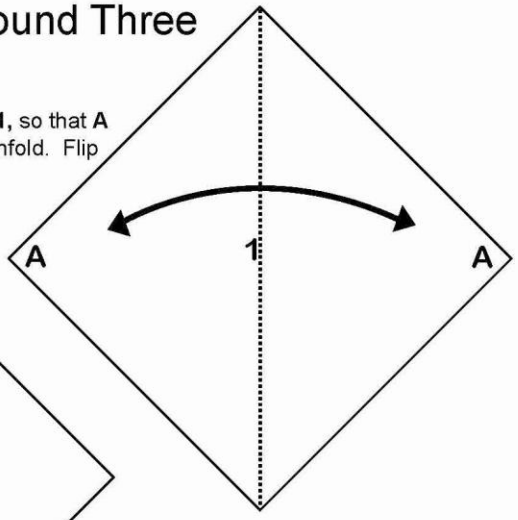
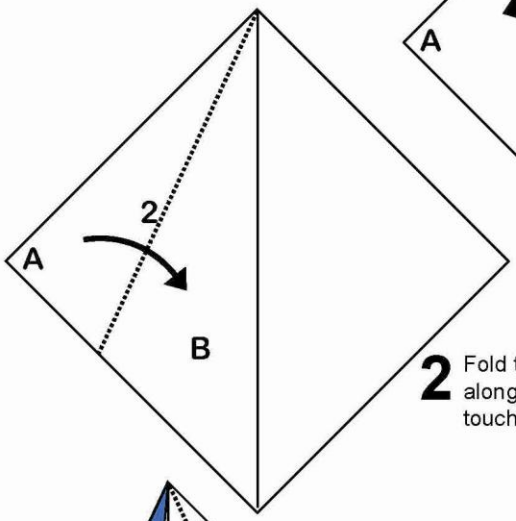
mRNA Instructions: Round Three
PENGUIN

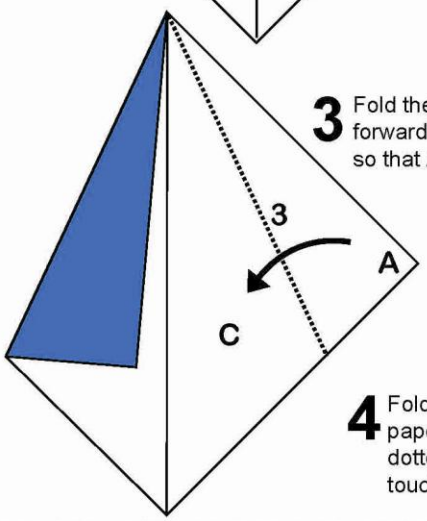
1 Fold paper along the dotted line **1,** so that **A** touches **A**. Make a crease and unfold. Flip so that the crease is vertical.

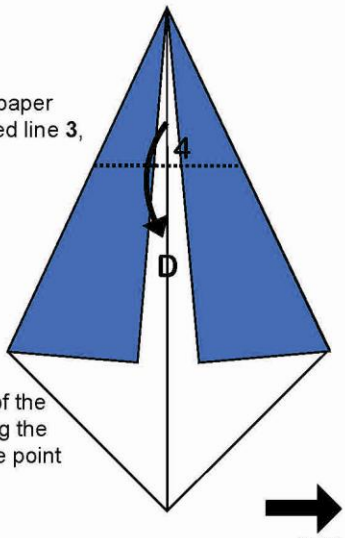




2 Fold the corner of the paper forward along the dotted line **2**, so that **A** touches **B**.

3 Fold the corner of the paper forward along the dotted line **3**, so that **A** touches **C**.





4 Fold the top point of the paper forward along the dotted line **4**, so the point touches **D**.

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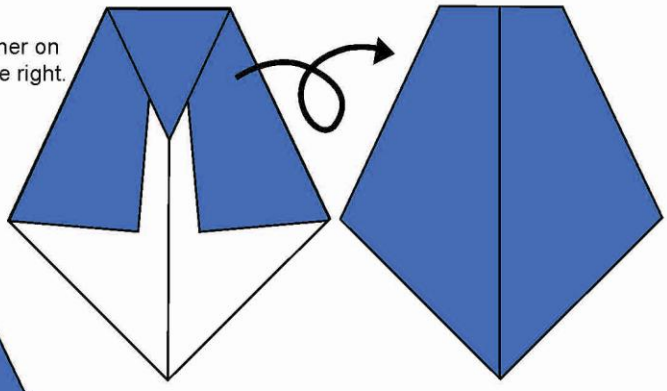
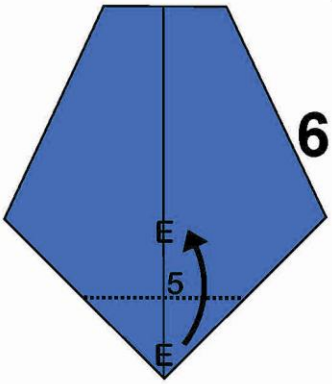
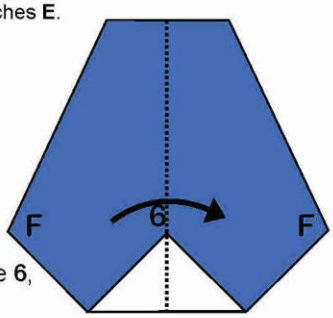
mRNA Instructions: Round Three
PENGUIN

5 Flip over so the corner on the left is now on the right.

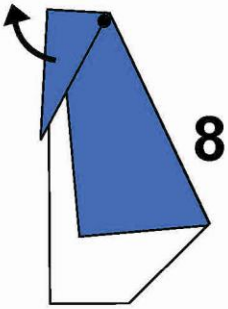




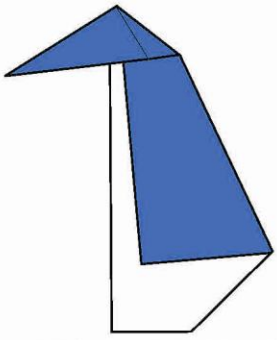
6 Fold the paper forward along the dotted line **5**, so that **E** touches **E**.



7 Fold along the dotted line **6**, so that **F** touches **F**.



8 Lift the head up and pinch at the dot.



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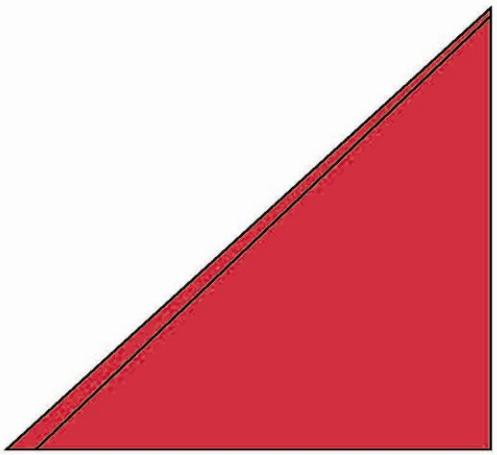
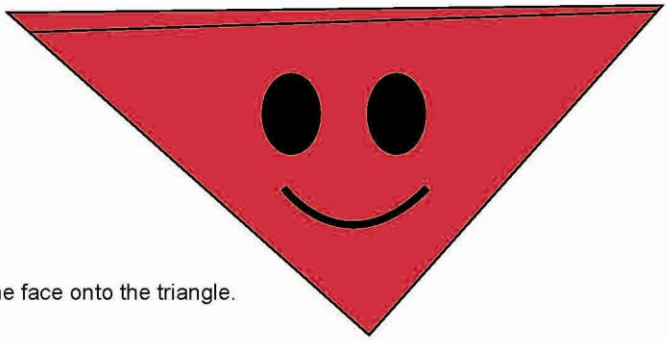
Endoplasmic Reticulum Check Sheet: Practice Round



1 Check to make sure it is made correctly.



2 Draw the face onto the triangle.

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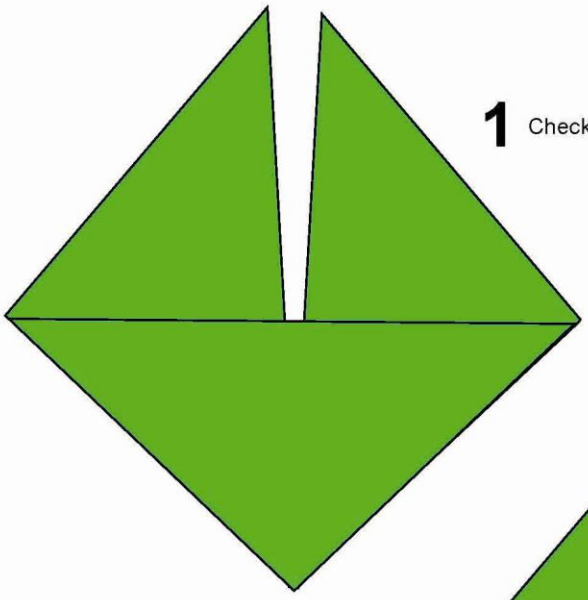
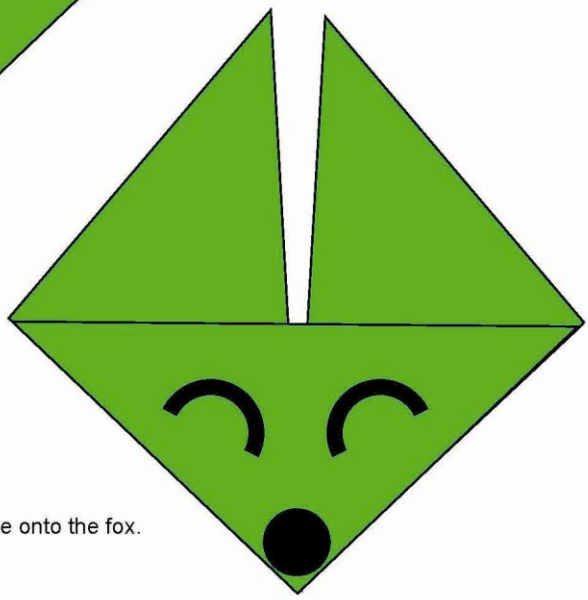
Endoplasmic Reticulum Check Sheet: Round One



1 Check to make sure it is made correctly.



2 Draw the face onto the fox.

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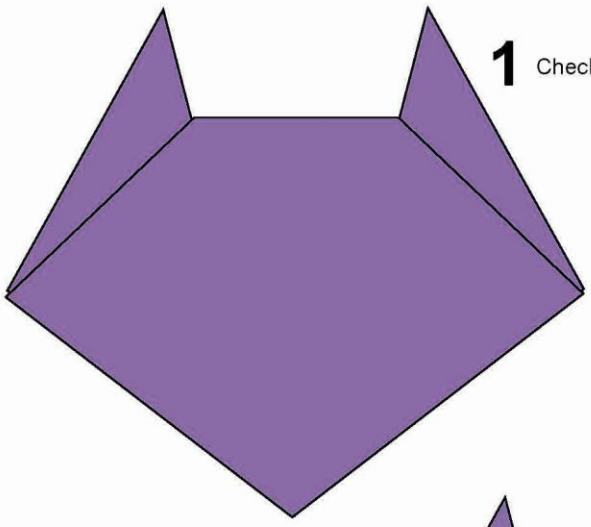
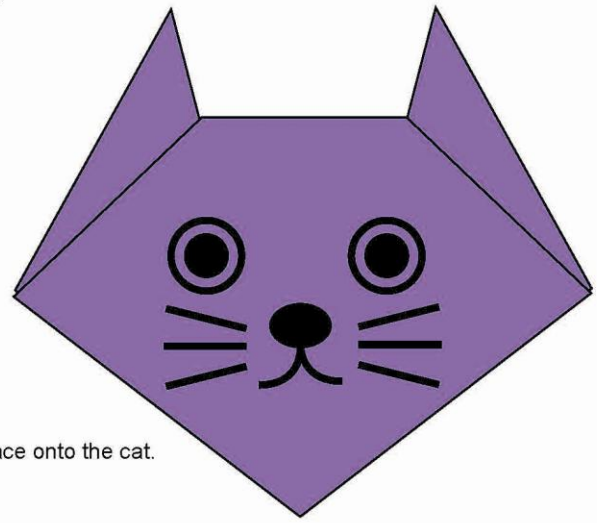
Endoplasmic Reticulum Check Sheet: Round Two



1 Check to make sure it is made correctly.



2 Draw the face onto the cat.

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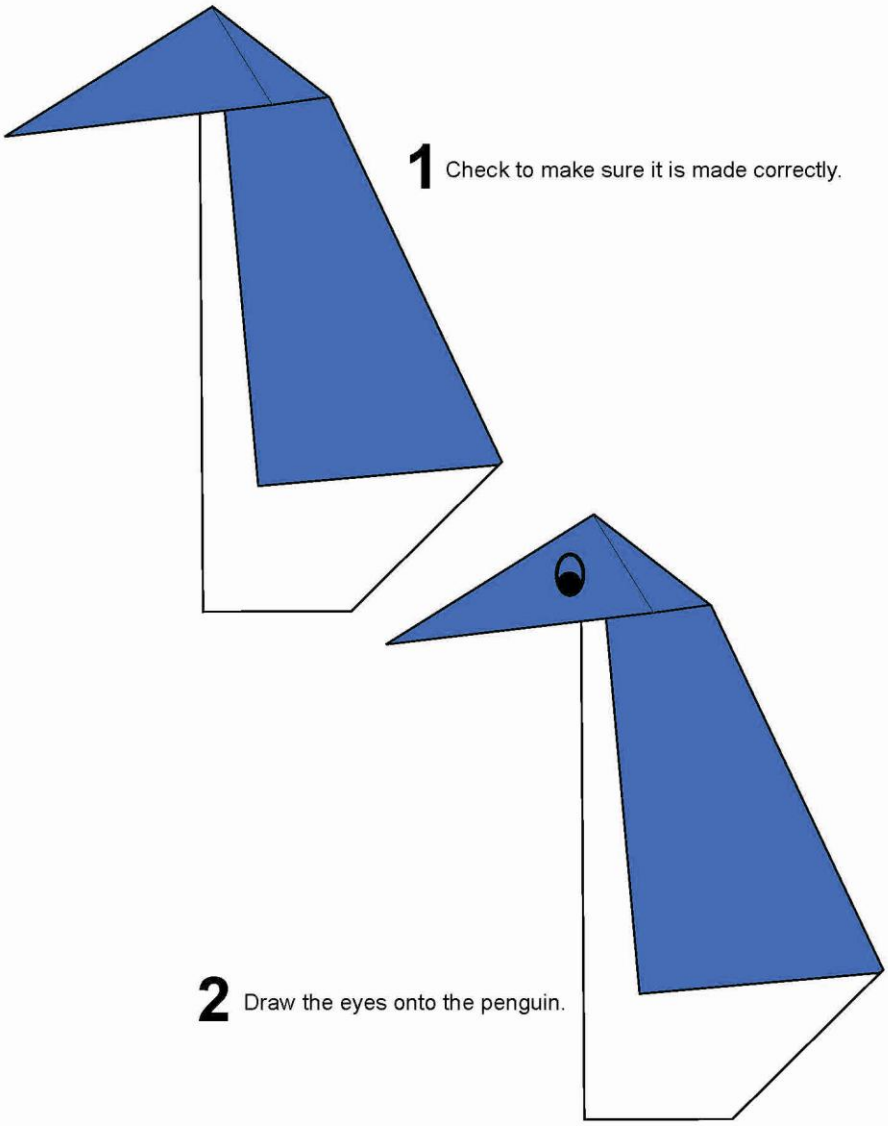
Endoplasmic Reticulum Check Sheet: Round Three



1 Check to make sure it is made correctly.

2 Draw the eyes onto the penguin.

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ORGANELLE EXTRAVAGANZA

LAB 1: ANIMAL AND PLANT CELL CONTAINERS

SUITCASE TWO OF TWO

1 Lab 1: Animal and Plant Cell 1

2 Lab 1: Animal and Plant Cell 2 & 3

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ORGANELLE EXTRAVAGANZA

LAB 1: ANIMAL AND PLANT CELL SUPPLIES

LAB 1: ANIMAL AND PLANT CELL 1

- 6 boxes of colored pencils
- 10 plastic knives
- 6 curved forceps
- 1 plastic container of flat toothpicks
- 1 box of coverslips
- 1 box of 25 microscope slides
- 1 cardboard box of extra slides

LAB 1: ANIMAL AND PLANT CELL 2

- 3 dropper bottles of Iodine
- 6 dropper bottles of Methylene Blue

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LAB 1: ANIMAL AND PLANT CELL 3

- 3 dropper bottles of Iodine
- 6 dropper bottles of Distilled Water

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ORGANELLE EXTRAVAGANZA

LAB 1: ANIMAL AND PLANT CELL TEACHER'S MANUAL

Time Required: One Class Period

Organelles to Study: Nucleus, Nucleolus, Cytoplasm, Plasma Membrane (cheek), Cell Wall (onion), and Central Vacuole (onion)

OBJECTIVES

1) Identify the structures you can see in animal and plant cells.
2) Compare and contrast the structures of plant and animal cells.

Students should have a basic understanding of how to use a compound light microscope before performing this lab.

INTRODUCTION

Most cells are too small to be seen with the naked eye. With the aid of a **compound light microscope,** however, you can see the cells as well as their parts. In animal cells, such as your cheek cells, the **cytoplasm**, **plasma membrane**, **nucleus,** and **nucleolus** can be seen. In plant cells, such as onion skin cells, the **cell wall**, **cytoplasm**, **nucleus**, **nucleolus**, and sometimes the **central vacuole** can be seen.

In this lab, **stains** will be added to both the animal cell and plant cell to add color and contrast to the cell parts and make them more visible through the compound light microscope. You will be able to view the cells at several different magnifications and observe the differences in plant cell and animal cell structure.

MATERIALS

Need to be bought ahead of time:

- 1 Red onion per class

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Not Provided:

- Safety goggles
- Lab aprons
- Compound light microscopes (one per lab group)

Provided in the science suitcase:

- Slides in slide box (100)
- Cover slips
- Plastic knives (7 - one per group and one for teacher)
- Iodine stain in a dropper bottle (6 - one per lab group)
- Methylene blue stain in a dropper bottle (6 - one per lab group)
- Distilled water in a dropper bottle (6 - one per lab group)
- Curved forceps (6 - one per lab group)
- Flat toothpicks (12 - two per lab group)
- Colored pencils (6 boxes - on per lab group)

PRE-LAB PREPARATION

- Buy one fresh red onion per class at the grocery store before the lab. A fresh onion provides better results.

TEACHER SETUP

1

Set up six lab stations. At each lab station place one compound light microscope, one dropper bottle of methylene blue, one dropper bottle of iodine, one dropper bottle of distilled water, a box of colored pencils, and a pair of rounded forceps.

The suitcase provides enough materials for six lab stations. If you do not have six compound light microscopes available you can have fewer stations.

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2 Setup a teacher's station with the box of microscope slides, cover slips, and toothpicks for the lab groups to pick up.

Note: There are extra slides provided in case a slide breaks.

3 Setup a cleaning station by the sink. Have a glass disposal container and trash can available. Place several towels beside the sink to dry the slides, coverslips, and forceps on.

4 Separate the outer most layer of the onion and throw it away. Cut the onion into quarters using the plastic knife provided and give each lab group one layer of the onion.

5 Ask if any of the students have an iodine allergy. If so, they should not come into contact with the iodine stain at any time.

TEACHER CLEAN UP

1 Dispose of any remaining onion in the trash can.

2 Make sure all of the slides, coverslips, forceps, and knives are clean and dried completely.

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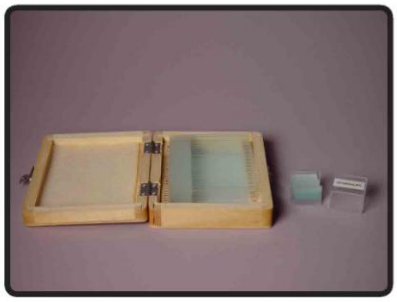
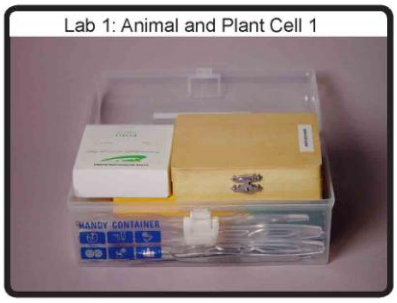
3 Make sure the slides and coverslips are clean and completely dry, and place them back into their containers.



4 Replace all materials into the lab boxes as shown.

Lab 1: Animal and Plant Cell 1



Lab 1: Animal and Plant Cell 2 and 3

5 Wrap a large black rubber band around each of the blue lab boxes as shown.

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6 Replace the lab boxes into "Suitcase Two" as shown.

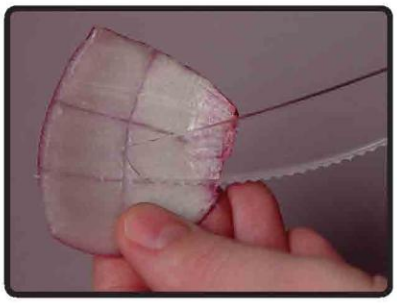
PROCEDURE

1 Start by putting on your safety goggles and lab apron.

2 Have one member of the group go to the teacher's station and get four blank slides, four cover slips, and two toothpicks.

PROCEDURE: ONION SKIN CELLS

1 Take a small piece of onion given to you by the teacher. Score the underside of the onion dividing it into squares.



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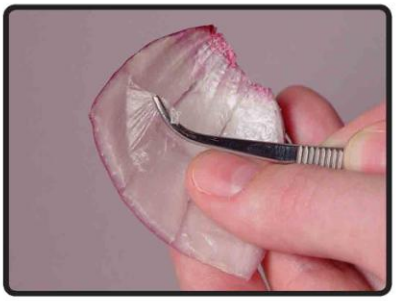
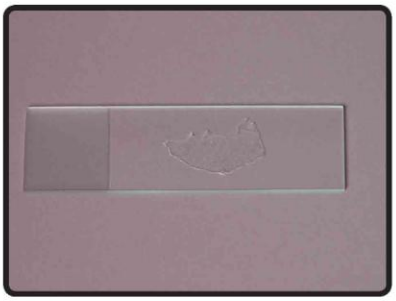
2 Use the flat end of the curved forceps starting at a corner to peel off the skin from the inside surface (the rough white side) of the onion. Throw the rest of the onion piece away in a trash can.



3 Carefully lay a small piece of onion skin flat in the center of two blank microscope slides. Make sure to flatten the onion skin while it is still wet. Try to have as few folds and wrinkles as possible.

Note: You can place a drop of distilled water on the slide to help smooth it out.



4 Find the dropper bottle labeled "**Distilled Water**". Use the dropper to draw up a small amount of distilled water from the bottle.

5 Add one drop of the distilled water on top of the onion skin on one of the slides.

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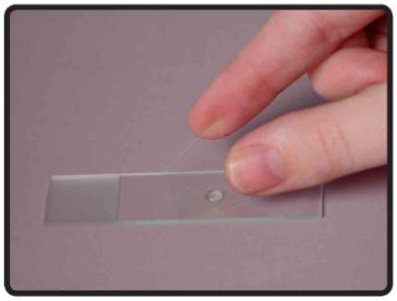
6 Stand a cover slip on its edge near the onion skin on your slide. Slowly lower the other side of the cover slip until it covers the onion skin completely. If there are any air bubbles, gently tap on the glass to remove them.



7 Find the dropper bottle labeled "**Iodine**". Use the dropper to draw up a small amount of iodine stain from the bottle.

8 Add one drop of iodine stain on top of the onion skin on your second slide.

9 Stand a cover slip on its edge near the onion skin on your slide. Slowly lower the other side of the cover slip until it covers the onion skin completely. If there are any air bubbles, gently tap on the glass to remove them.

10 Make sure the 4x objective is in place above the stage and the microscope light is turned on. Place the slide with distilled water onto the stage. (It will be clear.) Look through the eyepiece (you can remove your safety goggles for this part) and turn the coarse focus knob (the large knob) until the image is in focus. You can use the fine focus knob (the small knob) to focus the image further.

Try to find an area where the onion skin is not folded and you can see the cells clearly.

11 Remove the slide with distilled water and place the slide stained with iodine onto the stage. Look through the eyepiece and turn the coarse focus knob until the image is in focus. You can use the fine focus knob to focus the image further. You should be able to identify the cell wall and cytoplasm and possibly the nucleus at this power.

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12 Draw a picture of what you see in the circle labeled "Onion Skin Cell 4x" on the page provided and compare it to the diagram of a plant cell in your textbook. Label the parts that you can see.

13 Rotate the lens to the 10x objective making sure to look from the side and not through the eyepiece. Use ONLY the fine focus knob if you need to focus. You may see a small dot in the middle of each cell. This is the nucleus.

14 Rotate the lens to the 40x objective. Again, use the fine focus knob if you need to focus the image. You should be able to see the nucleus clearly at this magnification. It should appear as a dark spot in the middle of the cell. You might also see the nucleolus at this magnification.

15 Draw a picture of what you see in the circle labeled "Onion Skin Cell 40x" on the page provided and compare it to the diagram of a plant cell in your textbook. Label the parts that you can see.

16 Switch to the 4x objective and remove the slide. Set the slide aside while you view the cheek cells.

PROCEDURE: CHEEK CELL

1 Put on your safety goggles.

2 Find the dropper bottle labeled "Distilled Water". Use the dropper to draw up a small amount of distilled water from the bottle.

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3 Add one drop of distilled water onto the center of one of your unused slides.

4 Find the dropper bottle labeled "**Methylene Blue**". Use the dropper to draw up a small amount of methylene blue stain from the bottle.

5 Add one drop of methylene blue stain onto the center of a second slide.

6 Choose one student in the group to gently rub the flat end of a toothpick on the inside of their cheek. Do not rub too hard, you are trying to get cells not blood.

7 Gently stir the toothpick in the drop of distilled water and then throw the toothpick away.

8 Repeat Step 6 using a clean toothpick.

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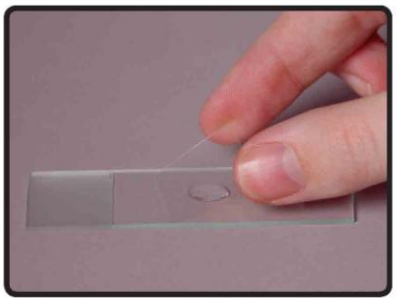
9 Gently stir the toothpick in the drop of methylene blue and then throw the toothpick away.

10 Stand a glass cover slip on its edge near the drop of distilled water. Slowly lower the other side of the cover slip until it completely covers the distilled water. If there are any air bubbles present, gently tap the cover slip to remove them. Repeat for both slides.



11 Make sure the 4x objective is in place above the stage. Place the slide with distilled water onto the stage (It will be clear.) Look through the eyepiece (you can remove your safety goggles for this part) and turn the coarse focus knob (the large knob) until the image is in focus. You can use the fine focus knob (the small knob) to focus the image further.

It should look like small nearly clear purplish blobs scattered on the slide. Move the slide around until you find a section of the slide where the cells are not clustered together.

12 Remove the slide with distilled water and place the slide stained with methylene blue onto the stage. Look through the eyepiece and turn the coarse focus knob until the image is in focus. You can use the fine focus knob to focus the image further. You should be able to identify the plasma membrane and cytoplasm and possibly the nucleus at this power.

It should look like small purplish blue blobs scattered on the slide. Move the slide around until you find a section of the slide where the cells are not clustered together.

13 Draw a picture of what you see in the circle labeled "Human Cheek Cell 4x" on the page provided and compare it to the diagram of an animal cell in your textbook. Label the parts that you can see.

14 Rotate the lens to the 10x objective making sure to look from the side and not through the eyepiece. Use ONLY the fine focus knob if you need to focus. You may see a small dot in the middle of each cell. This is the nucleus.

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15 Now rotate the lens to the 40x objective. Again you may need to use the fine focus knob to focus the image. You should be able to see the nucleus clearly at this magnification. It should appear as a dark spot in the middle of the cell. You might also be able to see the nucleolus.

16 Draw a picture of what you see in the circle labeled "Human Cheek Cell 40x" on the page provided and compare it to the diagram of an animal cell in your textbook. Label the parts that you can see.

17 Switch to the 4x objective and remove the slide.

18 You can continue to compare the two slides to see differences in plant and animal cells.

CLEAN UP

1 Dispose of the toothpicks and piece of onion in the trash can.

2 Place any broken glass in the appropriate container as instructed by your teacher.

3 Clean the slides, coverslips, and curved forceps in the sink using warm soapy water. Dry them with paper towels. Place the slides, coverslips, and curved forceps on the towels near the sink to finish drying.

4 Make sure the tops on all of the dropper bottles are screwed on tightly.

5 Clean your workstation.

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ANALYSIS

1. What was the purpose of using stains to view these cells? What difference do you see between the slides with water and the slides with stain?

Stains are used to provide color and contrast to the cells so the cell structure can be seen more clearly through the compound light microscope.

The slides with water do not have as much contrast and the structures are more difficult to distinguish.

2. What structures did you observe in the onion skin cell? In the cheek cell? What are the functions of each of these structures?

The onion skin cell has a cell wall and a nucleus that can both be seen with the iodine stain. Students may be able to see dark spots outside the nucleus. These are other organelles. They may also be able to see the central vacuole.

The cheek cell has a plasma membrane and nucleus. Students may be able to see dark spots outside the nucleus. These are other organelles.

Cell walls provide support and protect the plant cell. The nucleus is where genetic material is stored and is the main control center of the cell directing all cell activities. The central vacuole stores water, salts, and other materials. The plasma membrane regulates what enters and leaves the cell.

3. The compound light microscope used in this lab is not powerful enough to view other organelles in these cells. Name two organelles in the plant cell and two organelles in the animal cell that were not visible.

Animal Cell: Rough Endoplasmic Reticulum, Smooth Endoplasmic Reticulum, Ribosomes, Golgi Apparatus, Lysosome, and Mitochondria.

Plant Cell: Rough Endoplasmic Reticulum, Smooth Endoplasmic Reticulum, Ribosomes, Golgi Apparatus, Lysosome, Mitochondria, and Chloroplast.

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4 Describe the shape of the plant cell. Describe the shape of the animal cell. From what you can see through the compound light microscope how are plant and animal cells similar in structure? How are they different?

Onion cells are generally rectangular in shape.

Cheek cells are roughly circular and flat in shape.

Both plant and animal cells have plasma membranes and nuclei.

Plant cells however have cell walls and central vacuoles and animal cells do not.

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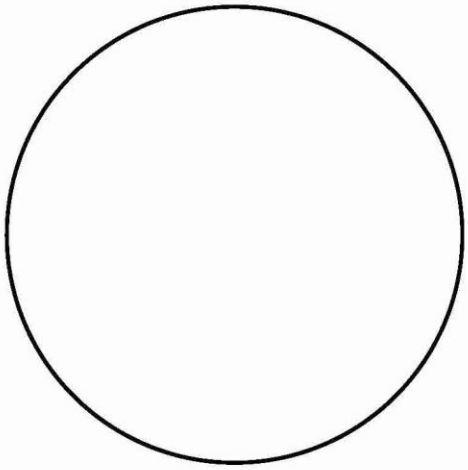
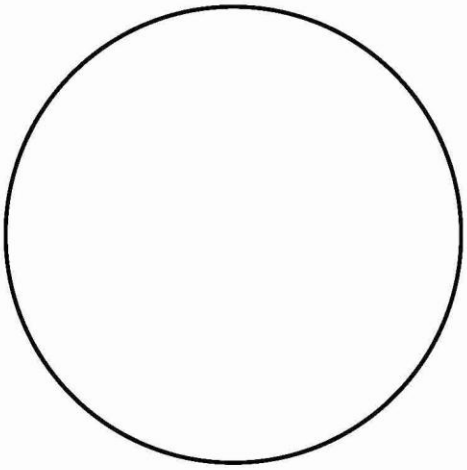
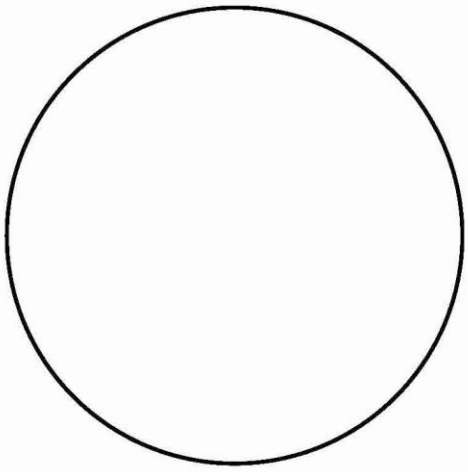
PLANT AND ANIMAL CELL DRAWINGS



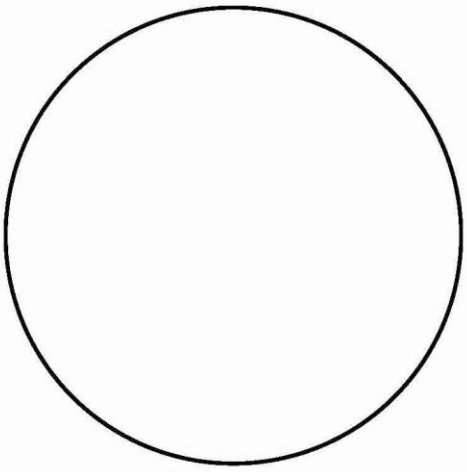
Onion Skin Cell 4x



Onion Skin Cell 40x



Human Cheek Cell 4x



Human Cheek Cell 40x

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GLOSSARY

Central vacuole – a membranous sac in a mature plant cell. Its functions include storage of water, salts, and proteins. When it is full the pressure it exerts on the cell wall allows it to support heavy structure like leaves and flowers.

Compound Light Microscope – an optical instrument with lenses that reflect visible light to magnify images of specimens.

Cytoplasm – the entire contents of the cell within the plasma membrane that includes the cytosol, cytoskeleton, and all of the organelles excluding the nucleus.

Distilled water – water which has had all impurities and minerals removed in a process known as distillation.

Iodine – a stain used to detect polysaccharides such as cellulose, in which potassium iodide reacts with starch to produce a blue color.

Methylene blue – a dye that forms a deep blue solution when dissolved in water and is used as a biological stain in microscopy.

Nucleolus – a specialized structure within the nucleus that is involved in the production of ribosomes.

Nucleus – in eukaryotic cells, the structure that contains the cell's genetic material in the form of DNA and controls the cell's activities.

Stain – a dye or mixture of dyes used in microscopy to make small or transparent structures visible, to differentiate between tissue segments or to produce specific chemical reactions.

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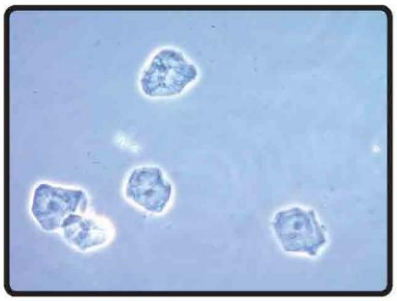
ORGANELLE EXTRAVAGANZA

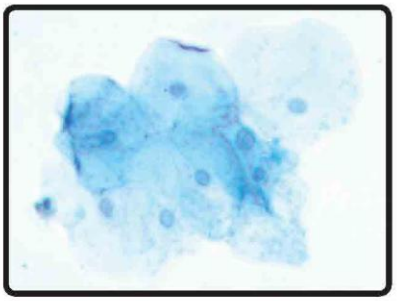
LAB 1: ANIMAL AND PLANT CELL RESULTS

CHEEK CELL

1 Cheek cell unstained



2 Cheek cell stained with Methylene Blue



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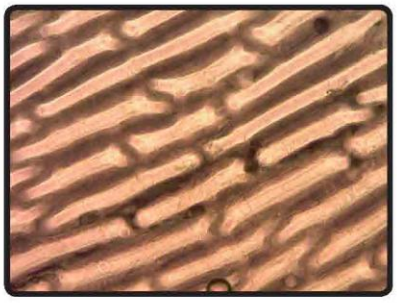
ONION SKIN CELL

1 Onion skin cell unstained



2 Onion skin cell stained with Iodine

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ORGANELLE EXTRAVAGANZA

LAB 2: PAPER CHROMATOGRAPHY CONTAINERS

SUITCASE TWO OF TWO

1. Lab 2: Paper Chromatography 1
2. Lab 2: Paper Chromatography 2
3. Lab 2: Paper Chromatography 3
4. Lab 2: Paper Chromatography 4
5. Lab 2: Paper Chromatography 5
6. Disposable Pipets

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SUITCASE ONE OF TWO

1 Lab 2: Paper Chromatography 6

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ORGANELLE EXTRAVAGANZA

LAB 2: PAPER CHROMATOGRAPHY SUPPLIES

LAB 2: PAPER CHROMATOGRAPHY 1

- 36 Chromatography tubes
- 36 rubber stoppers with hooks

LAB 2: PAPER CHROMATOGRAPHY 2

- 6 markers
- 6 six inch plastic rulers
- 1 paper punch
- 6 rolls of label tape
- 6 pairs of scissors
- 6 boxes of colored pencils

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LAB 2: PAPER CHROMATOGRAPHY 3

- 6 mortars
- 6 pestles

LAB 2: PAPER CHROMATOGRAPHY 4

- Chromatography paper
- 1 vial of capillary tubes

LAB 2: PAPER CHROMATOGRAPHY 5

- 6 glass dropper bottles

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LAB 2: PAPER CHROMATOGRAPHY 6

- 6 test tube racks in individual plastic bags
- 6 test tube brushes

DISPOSABLE PIPETS

- 50 disposable pipets

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ORGANELLE EXTRAVAGANZA

LAB 2: PAPER CHROMATOGRAPHY TEACHER'S MANUAL

Time Required: One Class Period

Organelle to Study: Chloroplast

OBJECTIVES

1) Identify the pigments found in chloroplasts.
2) Provide an introduction to paper chromatography.

INTRODUCTION

Plants use **chloroplasts** found inside their leaves to capture light that is used in **photosynthesis** to produce energy. Light is composed of different **wavelengths**. The efficiency of plants at capturing light is increased by the variety of light absorbing **pigments** found inside the chloroplasts. By having several different pigments the plant can absorb a wider range of wavelengths of light.

There are several different groups of pigments. **Chlorophylls** are green pigments that are most effective in driving photosynthesis. There are two types of chlorophyll pigments. **Chlorophyll B** is yellow-green, while **chlorophyll A** is blue-green. **Carotenoids** are **accessory pigments** that can drive photosynthesis but some carotenoids also function as **photoprotectors** by absorbing and scattering excessive light energy that would otherwise damage the chlorophyll. Of the carotenoids, **xanthophylls** are yellow and **carotenes** are orange-yellow. Chlorophyll typically hides these other pigments until the fall, when the chlorophyll breaks down revealing xanthophyll and carotene.

The different pigments present in a leaf can be separated into bands of color using a technique known as **paper chromatography**. In paper chromatography the individual components of a mixture are separated based on their **solubility**. The pigments in plants have different solubilities and will separate depending on their attraction for a **stationary phase** (the filter paper) or a **mobile phase** (the solvent). The pigments will separate as the **solvent** moves up the filter paper and will show up as colored streaks. Pigments with a stronger attraction to the filter paper than to the solvent will move more slowly than the pigments with a strong attraction to the solvent and will separate first.

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MATERIALS

Need to be bought ahead of time:

- Fresh spinach leaves

Not Provided:

- Safety goggles
- Lab aprons
- Chromatography Solvent
  - Acetone 10
  - Petroleum Ether 90
- Isopropyl Alcohol (rubbing alcohol found at drug stores)
- Graduated Cylinders (2)
- Beaker

Provided in the science suitcase:

- Disposable pipets (2 for the teacher setup)
- Test tubes (36 - one per student)
- Rubber stoppers with hooks for hanging (36 - one per student)
- Test tube racks that hold six (6 - one per lab group)
- Test tube brush (6 - one per group)
- Mortar and pestle (6 - one per lab group)
- Filter paper cut into 1 cm x 15 cm strips
- Glass dropper bottles for isopropyl alcohol (6 - one per lab group)
- Capillary tubes (15 - one for every two students)
- Colored tape (6 - one roll per lab group)
- Markers (6- one per lab group)
- Colored pencils (6- one box per lab group)
- Scissors (6 - one per lab group)
- Rulers (12 - two per lab group)
- Paper punch (1 for the teacher setup)

PRE-LAB PREPARATION

- Buy fresh spinach leaves at the grocery store.
- Order or pick up acetone (you can use nail polish remover), petroleum ether, and isopropyl alcohol (rubbing alcohol) if you do not have available at your school.

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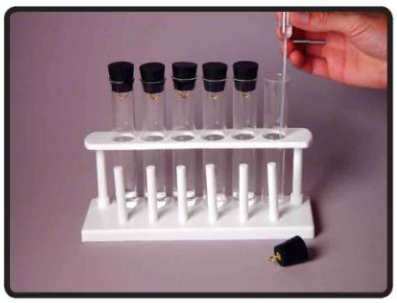
TEACHER SETUP

1. Prepare chromatography solvent using graduated cylinders and a beaker (make enough solvent for each student to have 5 mL. (200 mL for 40 students):
   - 1 part acetone (20 mL for 200 mL of solvent)
   - 9 parts petroleum ether (180 mL for 200 mL of solvent)

Note: Chromatography solvents are flammable and toxic. Have no open flames; maintain good ventilation; avoid inhaling fumes. Keep stored in a closed container. Preparing the solvent under a fume hood is recommended.

2. Using a disposable pipet, transfer approximately 5 mL of chromatography solvent into enough test tubes for each student to have one and insert a rubber stopper to seal. Place six test tubes into each test tube rack.



3. Using a different disposable pipet, transfer a small amount of isopropyl alcohol into enough glass dropper bottles labeled "Isopropyl Alcohol" for each lab group to have one.

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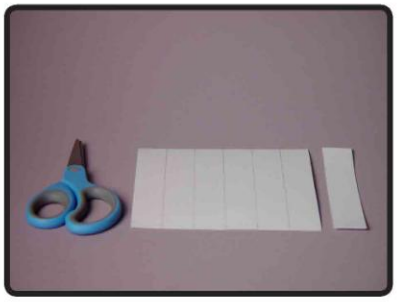
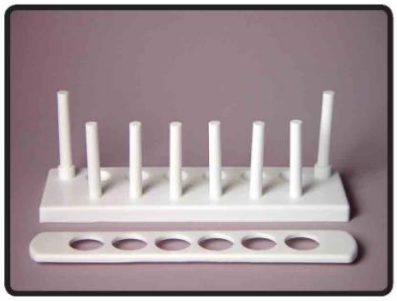
4 Cut a sheet of chromatography paper into seven strips (2 cm x 12 cm). Cut enough for each student to have one and have a few extras for mistakes.



5 Use the paper punch to punch a hole close to the top edge of each strip of filter paper.

6 Assemble the test tube racks found inside the black zippered bag. Take the plastic rods out from the underside of the large plastic piece. Place the rods into the holes on the top of the large plastic piece. Position the smaller plastic piece onto the rods to complete the test tube rack.



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7 Set up six lab stations. (The suitcase provides enough materials for six lab stations. You can set up fewer stations if you have fewer students.)

At each lab station, place a filled rack of test tubes containing chromatography solvent (6), a dropper bottle of isopropyl alcohol, a mortar and pestle, 6 strips of filter paper, 3 capillary tubes, a box of colored pencils, a pair of scissors, a roll of label tape, and a ruler.

8 Set up a cleaning station by the sink. Have a place to dispose of broken glass, a place to dispose of chemicals, and a trash can available. Make sure to have the test tube brushes available. Place several towels beside the sink for the student to place their test tube racks, rubber stoppers, and mortars and pestles.

9 Divide the students into groups of six and have them go to a lab station. Once the students are at their lab stations, give each group a small handful of spinach leaves.

TEACHER CLEAN UP

1 Dispose of any remaining solvent and isopropyl alcohol into an appropriate waste container.

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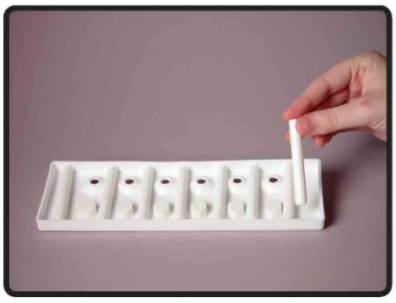
2 Gently wash the glass dropper bottles with warm soapy water and allow them to air dry. Make sure they are completely dry before storing them.

3 Make sure the test tubes, stoppers, test tube racks, and mortars and pestles are all clean and dried completely.

4 Place the rubber stoppers back into the test tubes for storage.

5 Disassemble the test tube racks. Place the rods back into the underside of the large plastic piece as shown. Place all of the pieces of each test tube rack into individual zippered plastic storage bags.



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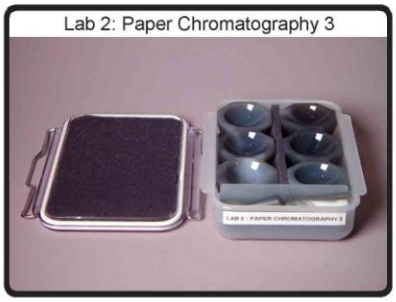
6 Replace all materials into the correct lab boxes as shown.

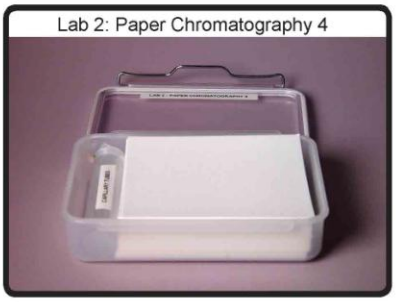
Lab 2: Paper Chromatography 1

Lab 2: Paper Chromatography 2

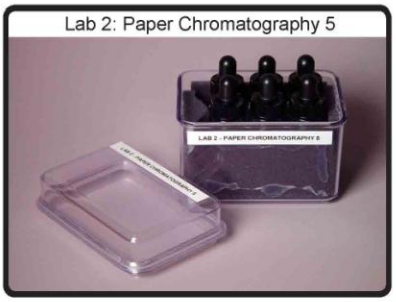
Lab 2: Paper Chromatography 3



Lab 2: Paper Chromatography 4



Lab 2: Paper Chromatography 5



Lab 2: Paper Chromatography 6

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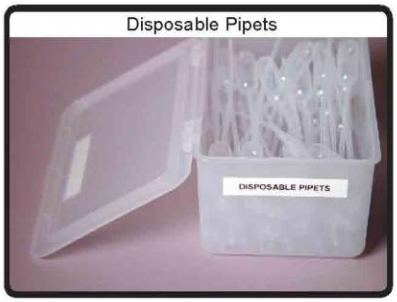

7 Place the white band around the white box labeled "Lab 2: Paper Chromatography 1" as shown.

8 Replace the lab boxes into the suitcases as shown.

Organelle Extravaganza Lab 2: Paper Chromatography Teacher's Manual
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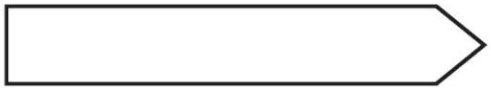
PROCEDURE

1. Start by putting on your safety goggles and lab apron.

2. Cut a point at one end of your piece of filter paper. Try to touch the paper only on the edges to avoid transferring oils from your skin onto the paper.



3. Using a pencil, lightly draw a fine line across your paper about 1 cm from the point.

4. As a group, tear one or two spinach leaves into small pieces disposing of the stems.

5. Place the spinach pieces into the mortar and grind the leaves with the pestle, using a circular motion. This breaks down the **cell walls** and releases the pigment.

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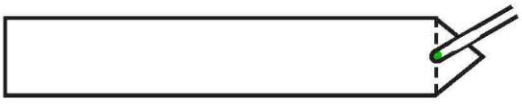
6 Use the dropper from the glass dropper bottle labeled "Isopropyl Alcohol" to add small amounts of isopropyl alcohol into the mortar one drop at a time as you grind the leaves until a finely ground colored solution is formed. (Do not use more than three drops of isopropyl alcohol). This solution is called the **pigment extract.**

7 Take turns using the capillary tubes. Dip one end of the capillary tube into the plant extract solution (the tube will automatically draw a small amount of liquid up into the tube).

Note: Do not pick up any of the leaf pieces on your capillary tube. You just need the liquid.

8 Quickly and gently touch the end of the capillary tube to the center of the pencil line on your filter paper strip as shown. The pigment extract will make a small colored spot on your paper.



Note: Do not puncture your filter paper with the capillary tube.

9 Be sure to let the drop dry. Repeat 15 to 20 times to build up the pigment spot until it is dark green. Make sure to let the spot dry after each drop is added. This keeps the pigment spot from spreading out too much and will provide you with a much better result.

10 Choose a test tube from the rack. Write your name on a piece of tape provided and attach it to your test tube. Remove the rubber stopper from your test tube and carefully attach your filter paper to the hook .

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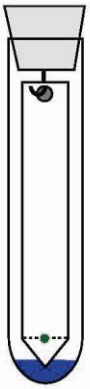
11 Place the paper and cork assembly inside your test tube as shown. Adjust it so the paper point just touches the solvent and the paper does not touch the sides of the test tube. The pigment dot must be above the level of the solvent for the experiment to work.



12 Observe the solvent as it moves up the filter paper. The solvent will carry the pigment with it as it moves and the pigments will separate out in colored bands.

13 Remove the paper when the solvent is approximately 1 cm from the top of the filter paper (you want the top 1 cm of the filter paper to be dry). Before the solvent evaporates, quickly draw a pencil line across the filter paper where the **solvent front** ends (the uppermost edge of the solvent).

Note: The solvent front will be the line between wet paper and dry paper.

14 Using a small dot, mark the center of each pigment band on the original filter paper. The colors fade quickly, so you should make your observations immediately.

(Remember carotenes are orange-yellow, xanthophylls are yellow, chlorophyll a is blue-green and chlorophyll b is yellow-green). Look for subtle differences in color.

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15 While the filter paper is drying (2 or 3 minutes), sketch your results using the colored pencils provided. The location (height) and color of each of the pigment bands should be recorded.

16 Use the ruler to measure the distance in cm from the starting point (original pencil line) to the center of each pigment band to determine the distance moved by each solute. Then measure the entire distance traveled by the solvent (from the original pencil line to the uppermost edge of the solvent).

Pigment	Distance Traveled from Starting Point
Chlorophyll B	
Chlorophyll A	
Xanthophyll	
Carotene	
Solvent	

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17 Each pigment has an **Rf (ratio-factor) value**, the speed at which it moves up the filter paper compared to the speed of the solvent.

$$Rf = \frac{\text{distance moved by the solute (pigment)}}{\text{distance moved by the solvent}}$$

Use these values from the data table above to calculate and record the Rf value for each of the pigments in the data table below.

Pigment	Color	Rf Value
Chlorophyll B	yellow green	
Chlorophyll A	blue green	
Xanthophyll	yellow	
Carotene	orange-yellow	

CLEAN UP

1 When your observations are complete, dispose of your filter paper in the trash can.

2 Discard any remaining solvent in the appropriate container as instructed by your teacher.

3 Remove the tape from your test tube and throw it away. Gently wash your test tube with warm soapy water using the brush provided.

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4 Place your test tube upside down on the pegs of your test tube rack to dry and place the test tube rack on the towel beside the sink.

5 Also wash the rubber stopper with warm soapy water, dry, and place on a towel beside the sink.

6 Rinse the mortar and pestle thoroughly using a small amount of isopropyl alcohol to remove any remaining pigment, then wash with soap and water and dry. Place on the towel beside the sink to finish drying.

7 Dispose of your capillary tube in the appropriate container as instructed by your teacher.

8 Clean your workstation and return the glass dropper bottle to your teacher.

ANALYSIS

1 Pigments with a strong attraction to the filter paper will move more slowly than the pigments with a strong attraction to the solvent and will separate from the point of origin first. Which pigment has the strongest attraction to the filter paper? Which pigment has the strongest attraction to the solvent? Why?

Chlorophyll B has the strongest attraction to the filter paper because it is the first pigment to separate.

Carotene has the strongest attraction to the solvent because it is the last pigment to separate.

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2 Why did you grind the spinach leaves with the mortar and pestle?

Grinding the leaves breaks down the cell walls of the spinach leaves and releases the pigment.

3 What two characteristics could be used to identify an unknown pigment?

The pigment's color and ratio factor can both be used to identify an unknown pigment.

4 Why do plants need more than one pigment?

The efficiency of plants at capturing light is increased by the variety of light absorbing pigments found inside the chloroplasts. By having several different pigments the plant can absorb a greater range of wavelengths of light.

5 Why do green leaves turn yellow and orange in the fall?

The accessory pigments are usually hidden by the chlorophylls until the fall, when the chlorophyll breaks down revealing xanthopyll which is yellow and carotene which is orange-yellow.

EXTENSION

Now that you have performed this experiment with spinach leaves, now run the same experiment using red cabbage, beet leaves, green peppers, or carrots (baby food) to determine which pigments are present in other plants.

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GLOSSARY

Accessory pigment – any pigment that can absorb light energy and pass the electrons along to the primary pigment, chlorophyll A, which starts the process of photosynthesis.

Carotene – an orange photosynthetic pigment important for photosynthesis. It contributes to photosynthesis by transmitting the light energy it absorbs to chlorophyll.

Carotenoids – an accessory pigment, either yellow or orange, in the chloroplasts of plants. By absorbing wavelengths of light that chlorophyll cannot, carotenoids broaden the spectrum of color that can drive photosynthesis.

Cell wall – strong supportive layer surrounding the plasma membrane in plants, algae, and some bacteria. In plant cells, the wall is formed of cellulose fibers embedded in a protein matrix. It protects the plant cell, maintains its shape, and prevents excess uptake of water.

Chlorophyll – a green pigment located within the chloroplasts of plants that captures light energy.

Chlorophyll A – a type of blue-green photosynthetic pigment that participates directly in the light reactions.

Chlorophyll B – a type of yellow-green photosynthetic pigment that transfers energy to chlorophyll a.

Chloroplast – an organelle found only in plants and some other organisms that captures the energy from sunlight and converts it into chemical energy.

Mobile phase – the phase which moves in a definite direction. The moving phase consists of the sample being separated/analyzed and the solvent that moves the sample through the column. The moving phase moves through the chromatography column (the stationary phase) where the sample interacts with the stationary phase and is separated.

Paper Chromatography – an analytical technique for separating and identifying mixtures that are or can be colored especially pigments.

Photoprotector – protects chlorophyll from being damaged by absorbing and scattering excessive light energy.

Photosynthesis – the process by which plants and some other organisms use light energy to convert water and carbon dioxide into oxygen and high-energy carbohydrates such as sugars and starches.

Pigments – a light absorbing molecule.

Pigment extract – the solution of isopropyl alcohol and pigments after the spinach leaves have been ground up.

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Ratio-factor (Rf) value – a measurement based on the relative distance traveled by the sample of a substance in a particular procedure. It is the distance moved by the solute divided by the distance moved by the solvent.

Solubility – the ability of a given substance, the solute, to dissolve in a solvent.

Solute – a solid, liquid, or gas dissolved into a solvent resulting in a solution. The sample components in partition chromatography.

Solvent – a liquid of gas that dissolves a solid, liquid, or gaseous solute, resulting in a solution.

Solvent front – the wet moving edge of the solvent that progresses along the surface where the separation of the pigments is occurring.

Stationary phase – the substance which is fixed in place for the chromatography procedure.

Wavelength – the distance between crests of waves, such as those of the electromagnetic spectrum. Our eyes are sensitive to light which lies in a very small region of the electromagnetic spectrum labeled "visible light".

Xanthophyll – a yellow photosynthetic pigment. They are involved in photosynthesis along with green chlorophyll, which typically covers up the yellow, except in autumn when the chlorophyll is denatured by the cold.

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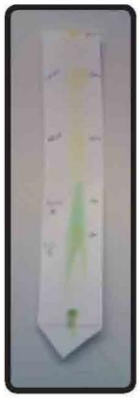
ORGANELLE EXTRAVAGANZA

LAB 2: PAPER CHROMATOGRAPHY RESULTS

CHROMATOGRAM

1 Filter paper after running the experiment and the pigment bands have been marked.



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ORGANELLE EXTRAVAGANZA

LAB 3: FEEDING PARAMECIA CONTAINERS

SUITCASE TWO OF TWO

1 Lab 3: Feeding Paramecia

2 Disposable Pipets

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ORGANELLE EXTRAVAGANZA

LAB 3: FEEDING PARAMECIA SUPPLIES

LAB 3: FEEDING PARAMECIA

- 1 bottle of Congo Red Indicator
- 1 box of 12 microscope slides with wells
- 1 box of coverslips
- 1 plastic container of 30 microcentrifuge tubes
- 1 metal lab scoop
- 1 1/4 teaspoon measuring spoon
- 2 ice packs
- 6 packets of Active Dry Yeast

DISPOSABLE PIPETS

- 50 disposable pipets

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ORGANELLE EXTRAVAGANZA

LAB 3: FEEDING PARAMECIA TEACHER'S MANUAL

Time Required: One Class Period

Organelles and Cell Parts to Study: Anal Pore, Cilia, Contractile Vacuole, Food Vacuole, Gullet, Pellicle, Lysosome, Macronucleus, Micronucleus, and Oral Groove

OBJECTIVES

1) See how Paramecia move using actin based cell movement.
2) Observe how the Paramecia form food vacuoles to enclose the yeast, and watch as the lysosomes fuse with the vacuoles and release enzymes that digest the yeast.

INTRODUCTION

Paramecia are unicellular, or one-celled, organisms that are found in freshwater environments. They are shaped like slippers with a rounded front end and a pointed tail end. The paramecium is covered by an outer membrane called a **pellicle**. The pellicle protects the cell and keeps unwanted things out and is covered with hair-like projections called **cilia**. The cilia are used in movement. When they move at an angle backwards the paramecium moves forward. Cilia also line the **oral groove** which is similar to a mouth and are used in feeding to sweep food inside. The paramecium has one large nucleus known as the **macronucleus** that is used in normal cell functions and a smaller nucleus known as the **micronucleus** that is used in reproduction. The paramecium also has a **contractile vacuole** that controls the amount of water in the cell.

Yeast is a type of fungi and is a good food source for the paramecia. When fed yeast cells, they will enter the paramecium through its oral groove. From the oral groove, the food will enter into the **gullet**, which is similar to a stomach. When enough food has accumulated in the gullet, **food vacuoles** are formed. The food vacuoles move throughout the cell, going towards the tail first. As they move throughout the cell, **lysosomes** that are found in the cytoplasm fuse with the food vacuoles and release their **enzymes**. These enzymes digest the food and release it into the cytoplasm. When the food vacuole reaches the **anal pore** any remaining undigested food is removed.

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In this lab, the yeast cells are stained with Congo Red which appears red at a pH of 5 and various shades of blue at lower pHs. The yeast cells can be observed as they move from the oral groove into the gullet and are enclosed in food vacuoles. You can see the food vacuoles change color as the lysosomes fuse with them and release their enzymes digesting the food and lowering the pH.

MATERIALS

Need to be bought ahead of time:

- Live *Paramecium caudatum* culture

Not Provided:

- Safety goggles
- Lab aprons
- Compound light microscopes (one per lab group)
- Hot plate
- Heat resistant beaker

Provided in the science suitcase:

- Active Dry Yeast packets
- Congo Red indicator
- Lab scoop
- Ice packs
- Disposable pipets (three for teacher and one per group)
- Microcentrifuge tubes (one per lab group)
- Microscope slides with two wells (one per lab group)
- Coverslips (two per lab group)

PRE-LAB PREPARATION

- Order a live *Paramecium caudatum* Living Specimen Culture for 35 students from: **www.wardsci.com** (Item # 87 V 1310)
- The *Paramecium caudatum* culture comes with an ice pack and a Living Materials Care Sheets CD.
- The order takes two to three days to arrive. I suggest ordering the paramecia culture on Monday for a Friday lab. The paramecia will survive in their container if they are kept in a cool dark place, but there is a better chance of having large specimens if you use them shortly after you receive them.

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TEACHER SETUP

1. Place the ice packs into the freezer so that they will be frozen for your class.

2. Prepare the yeast suspension in a heat resistant beaker by adding approximately 1/4 tsp of the Active Dry Yeast to 200 mL of room temperature water and allowing it to soak for two to three minutes.

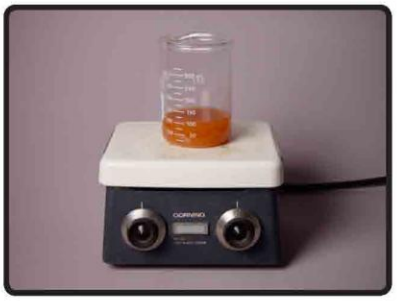
   Note: Save the remaining yeast for use with your other classes.

3. Add a pinch of Congo Red Indicator to the yeast mixture using the metal lab scoop provided. It should be a bright red color.

   Note: Where rubber gloves and use caution when handling the Congo Red Indicator because the indicator will stain skin and clothing.

4. Bring the yeast mixture to a gentle boil over a hot plate for 5 minutes. Cool before using in the experiment.

   The yeast mixture does not have to be heated but the results are better when it is heated.



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5 Using a disposable pipet place a small amount of the yeast suspension into enough microcentrifuge tubes for each lab group to have one.

6 Set up six lab stations. At each lab station place a compound light microscope, a tube of yeast suspension, and a disposable pipet.

The suitcase provides enough materials for six lab stations. If you do not have six compound light microscopes available you can have fewer stations.

7 Set up a teacher's station with the box of microscope slides with two wells, coverslips, two disposable pipets, the *Paramecium caudatum* culture, and the ice packs.

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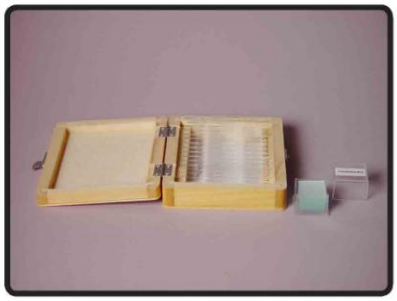
8 Set up a cleaning station by the sink. Have a glass disposal container and trash can available. Place several towels next to the sink for the students to dry their slides and coverslips.

TEACHER CLEAN UP

1 Dispose of disposable pipets used with the paramecia.

2 Clean the laboratory scoop with warm soapy water and make sure it is dried thoroughly before storage.

3 Make sure the slides and coverslips are clean and completely dry and place them back into their containers.



4 Replace all materials into the lab box labeled "Lab 3: Feeding Paramecia". Replace any unused pipets into the lab box labeled "Disposable Pipets."

Lab 3: Feeding Paramecia

Disposable Pipets

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5 Replace the lab boxes into "Suitcase Two" as shown.

PROCEDURE: OBSERVING PARAMECIA

1 Start by putting on your safety goggles and lab apron.

2 One member of the group should go to the teacher's station and get a microscope slide, and 2 coverslips.

3 Use one of the disposable pipets provided near the paramecium culture. Gently squeeze the pipet before you lower it into the paramecium culture so that you do not introduce bubbles.

4 Gently lower the pipet into the culture and draw up a small amount of fluid. Try to pull from the bottom of the culture.

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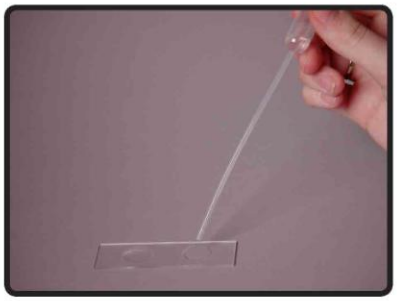
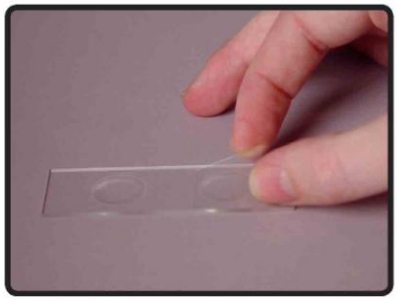
5 Use the pipet to transfer one or two drops of the paramecium culture into each of the wells in the microscope slide. You should have enough fluid to fill your well but not overflow. Return the remaining fluid back to the culture.



6 Place a coverslip over both of the wells. Make sure to stand the coverslip on its edge beside the well and gently lower it. If there are air bubbles under the coverslip you can gently tap on the surface to force them out.



7 Carefully take the slide back to your lab station being careful not to spill any of the fluid.

8 Make sure the low magnification (4x) objective is in place above the stage and the microscope light is turned on.

9 Place the slide onto the microscope stage.

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10 Look through the eyepiece (you can remove your safety goggles for this part) and turn the coarse focus knob (the large knob) until the image is in focus. You can use the fine focus knob (the small knob) to focus the image further. They should look like the image to the right.

11 Move your slide around to observe how the paramecium moves at 4x magnification. They will be moving pretty quickly.

Note: If you see bubbles moving across your slide, it is probably a paramecium that is swimming out of focus. Use your fine focus knob to focus.

12 If the paramecia are moving too fast for you to observe them, you can return to the teacher's station, and place your slide on the ice pack for about a minute to lower the temperature and slow the paramecia down.

13 Switch to the 10x objective and observe the cilia along the outside of the paramecium's body. Note how they help it to move. The macronucleus, micronucleus, and pellicle should also be visible. You may also be able to see the oral groove and the pulsating contractile vacuole.

Note: You may need to look at several paramecia to observe all of these structures.

PROCEDURE: FEEDING PARAMECIA

1 Put on your safety goggles.

2 Remove the slide from the microscope stage and remove the coverslip from one of the wells. Do not throw the coverslip away because you will need to use it again later.

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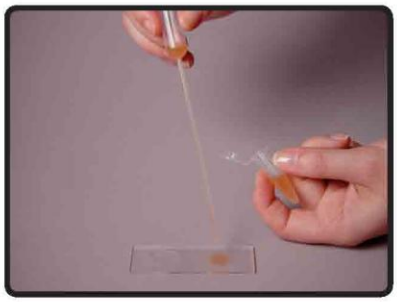
3 Find the tube of the yeast suspension that has been stained with **Congo Red Indicator** and use a disposable pipet to transfer a small drop of yeast suspension to the paramecia. Replace the coverslip over the well.

Note: Congo Red is a pH indicator which will change as the pH changes. It is red at pH 5 and is various shades of blue at lower pHs.



4 Make sure the low magnification (4x) objective is in place and place the slide onto the microscope stage.

5 Move your slide around until you find a paramecium that has stopped to eat. You might be able to find a paramecium eating alone or they could be in groups like the one in the picture.

6 Observe the paramecium as it ingests some of the yeast cells through its oral groove into its gullet and forms food vacuoles to enclose it. This should occur very quickly, perhaps within 10 seconds of adding the yeast.

7 The food vacuoles will be red at first and then eventually turn blue, as the lysosomes fuse with the food vacuole and release enzymes to digest the yeast. This color change will take approximately 10 minutes.

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CLEAN UP

1. Dispose of your disposable pipets, toothpicks, and yeast tubes into the trash can.

2. Place any broken glass in the appropriate container as instructed by your teacher.

3. Clean the slides and coverslips in the sink using warm soapy water. Dry them with paper towels. Place the slides on a towel near the sink to finish drying and the coverslips on a separate towel.

4. Clean your workstation.

ANALYSIS

1. How does the paramecium move?

   The paramecium uses the cilia found on the outside of its body to move. As the cilia move backward at an angle, it propels the paramecium forward.

2. How did the yeast cells get to the inside of the paramecium?

   The yeast cells enter the paramecium through its oral groove. The food goes through the oral groove and into the gullet, which is similar to a stomach, and accumulates there.

3. What color were the yeast cells when they entered the paramecium? Why?

   When the yeast cells first enter the paramecium they are red because of the Congo Red Indicator.

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4 After ingestion, what changes occurred to the yeast cells inside the paramecium? Explain each of these changes.

Once ingested, food goes through the oral groove and into the gullet, which is similar to a stomach. When enough food has accumulated in the gullet, then food vacuoles are formed. The food vacuoles move throughout the cell, going towards the tail first. As the food vacuole moves throughout the cell, lysosomes that are found in the cytoplasm fuse with the food vacuoles and release their enzymes. These enzymes digest the food. The vacuoles get smaller as they move throughout the cell because the digested food is released into the cytoplasm. When the food vacuole reaches the anal pore any remaining undigested food is removed.

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GLOSSARY

Anal pore – the physical exit area for undigested food.

Cilia – tail-like projections extending outwards from the cell body.

Congo red indicator – a brownish-red powder used as a biological stain.

Contractile vacuole – a sub-cellular structure involved in regulating water levels. It pumps excess water out of the cell and is found in freshwater protozoans.

Enzyme – biomolecules that catalyze chemical reactions.

Food vacuole – a small vesicle that is formed inside a protozoan cell and within which food particles are ingested by the cell, are contained, and then digested.

Gullet – an invagination of the proplasm in various protozoans that sometimes functions in the intake of food.

Lysosome – a membrane enclosed sac filled with enzymes needed to break down certain materials inside the cell. They are found within the cytoplasm.

Micronucleus – the smaller nucleus in most ciliate protozoans that is used in reproduction.

Macronucleus – the larger type of nucleus in most ciliate protozoans. It is involved in the nonreproductive functions such as feeding and metabolism.

Oral groove – a depression leading to the mouth of some invertebrates.

Paramecia – a unicellular ciliate found in freshwater environments.

Pellicle – a thin layer supporting the cell membrane in various protozoa.

Protozoa – unicellular eukaryotic organisms.

Yeast – growth form of eukaryotic microorganisms classified in the kingdom Fungi. Yeasts are unicellular.

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ORGANELLE EXTRAVAGANZA

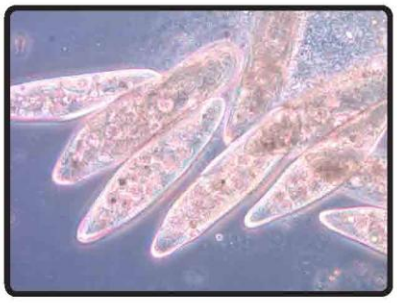
LAB 3: FEEDING PARAMECIA RESULTS

OBSERVING PARAMECIA

1 *Paramecia caudatum*

OBSERVING PARAMECIA

1 Paramecia eating yeast stained with Congo Red Indicator



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ORGANELLE EXTRAVAGANZA

ACKNOWLEDGMENTS

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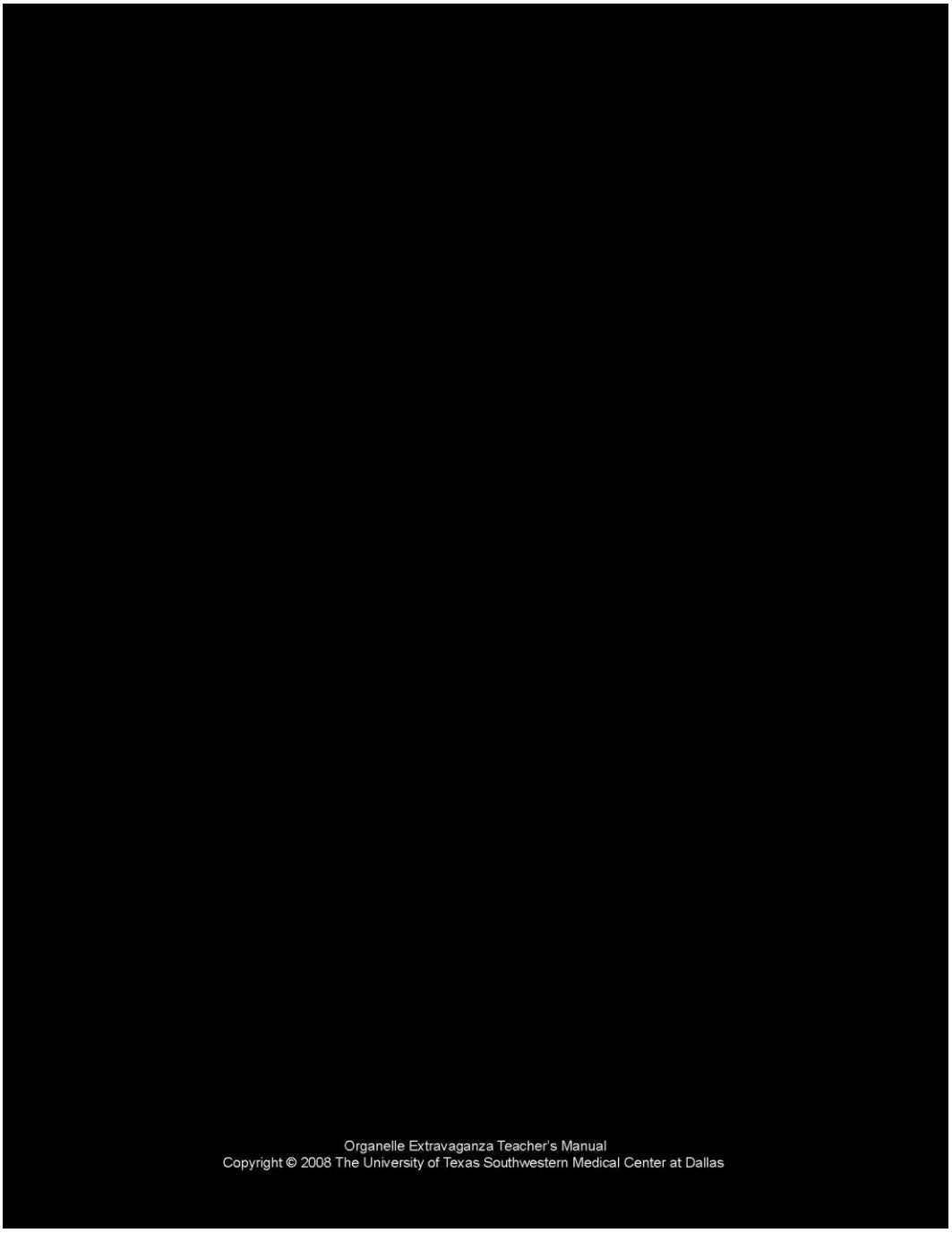

Organelle Extravaganza Teacher's Manual
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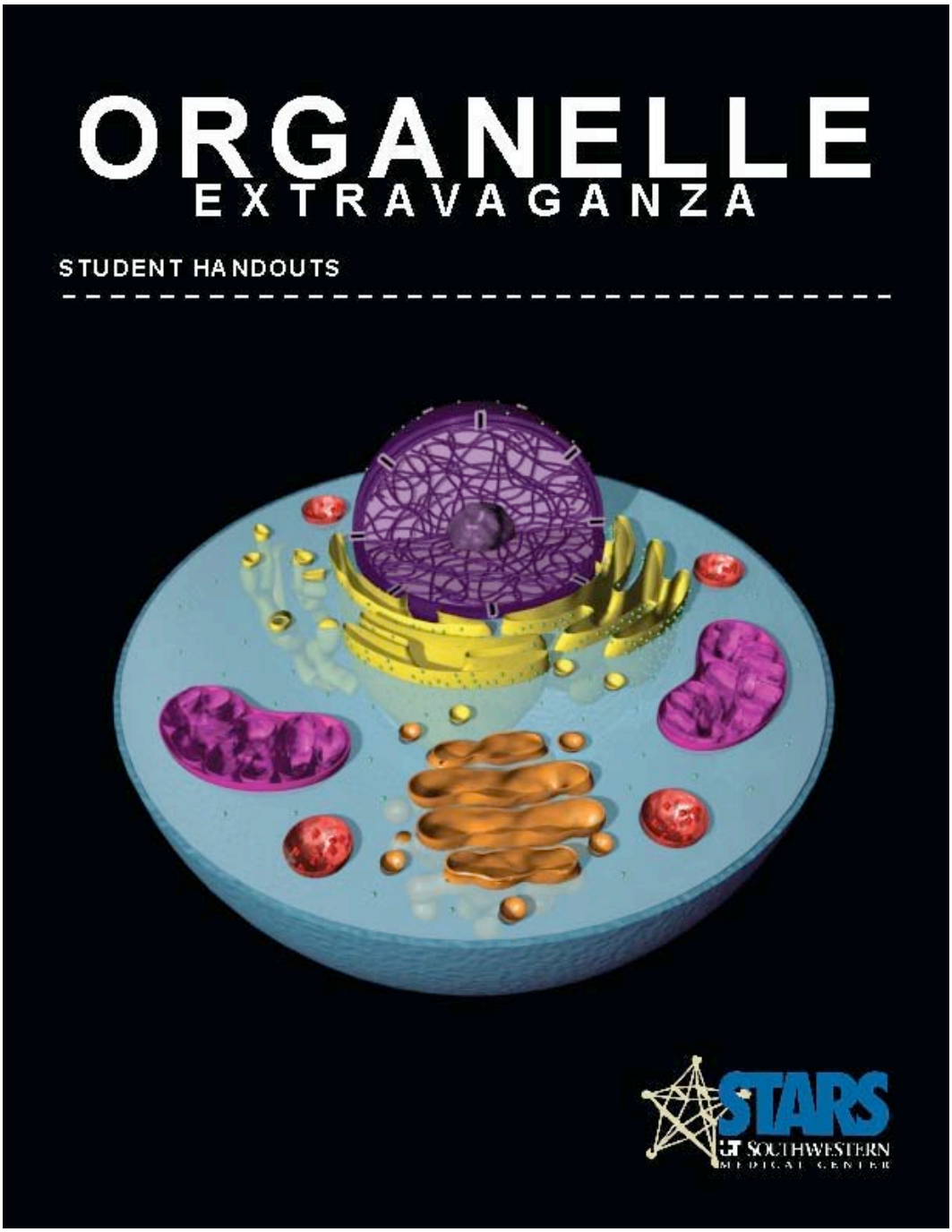
APPENDIX H
Student Handouts Booklet



ORGANELLE EXTRAVAGANZA

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS
• Table of Contents

PRE-TEST

PRE-TEST
• Pre-test

POST-TEST

POST-TEST
• Post-test

ANIMATION

ANIMATION
• Animation Script

GAME

PROTEIN PRODUCTION GAME
• Protein Production Game Instructions

LAB ONE

LAB 1: ANIMAL & PLANT CELL
• Lab 1: Animal and Plant Cell Instructions

LAB TWO

LAB 2: PAPER CHROMATOGRAPHY
• Lab 2: Paper Chromatography Instructions

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LAB THREE

LAB 3: FEEDING PARAMECIA

• Lab 3: Feeding Paramecia Instructions

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PRE-TEST

Read each question carefully and circle the letter that best answers the question.

1. Which of these structures controls the cell's activity in most cells?

   A. Mitochondrion
   B. Plasma Membrane
   C. Nucleolus
   D. Nucleus

2. Which of the organelles listed converts the chemical energy found in food into a form of energy that can be used by the cell?

   A. Golgi apparatus
   B. Mitochondrion
   C. Rough Endoplasmic Reticulum
   D. Nucleus

3. Which one of the following is a function of the Golgi apparatus?

   A. Making proteins
   B. Storing DNA
   C. Packaging and distributing proteins
   D. Digesting and recycling cell waste

4. Which two structures are found in plant cells but are not found in animal cells.

   A. Mitochondria and the Cell Wall
   B. Chloroplast and Central Vacuole
   C. Nucleus and Ribosomes
   D. Lysosomes and Rough Endoplasmic Reticulum

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ORGANELLE EXTRAVAGANZA

POST-TEST

Read each question carefully and circle the letter that best answers the question.

1. Which of these structures controls the cell's activity in most cells?

   A. Mitochondrion
   B. Plasma Membrane
   C. Nucleolus
   D. Nucleus

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ORGANELLE EXTRAVAGANZA

ANIMATION SCRIPT

All living things are made of **cells**. Cells are the basic units of life. Some exist as single-celled organisms while others, including humans, are multicellular and consist of many different kinds of specialized cells working together.

The cells that make up plants and animals are called **eukaryotic cells**. Eukaryotic cells have a **nucleus** and many structures called **organelles** that carry out specific functions within the cell.

In many ways, a eukaryotic cell is similar to a factory, with its organelles working together as a group to produce a product. In this cellular factory, each organelle carries out a specific function. The **plasma membrane** is the gatekeeper that decides what gets into and out of the cell. The nucleus is the main control center for the cell, and is similar to the main boss of a factory. The **ribosomes** are the many machines working to produce its product, proteins. The **rough endoplasmic reticulum** moves these proteins and other substances through the cell, much like an assembly line of a factory, and plays a role in quality control. The packaging and distribution center of the cell is the **Golgi apparatus** where the destination of each product is decided. The **smooth endoplasmic reticulum** acts as the poison control center for the factory, neutralizing the drugs and poisons. The cleanup crews are the **lysosomes** which clean up all the trash in the factory. The **mitochondrion** is the power source for the factory. It uses the energy stored in food to produce enough energy to power the cellular factory.

Now that we have a basic overview of each of the organelles' functions, let's look at each of them a little closer. We will begin by looking at an animal cell and then take a look at a plant cell.

There are several different ways you can study cells. You can study them through models such as this one. Actual organelles are not colored, except for chloroplasts and mitochondria, but color has been added to this model to make it easier to visualize. You can also observe cells through a **light microscope**, which uses lenses to produce an enlarged image. Or observe smaller organelles and cell parts through a higher powered **electron microscope** that uses **electrons** to illuminate the cell and create an enlarged image.

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PLASMA MEMBRANE

Every cell is surrounded by a plasma membrane. The main components of this membrane are **phospholipids** and **proteins**. A phospholipid is a fat that has a **polar, phosphate group** on one end and two **non-polar,** long **fatty acid** tails on the other end. The phosphate is attracted to water because water is also polar, and the fatty acids are repelled by water. The water on the inside and the outside of the cell force the fatty acid tails to the center and the phospholipids form a double layer, or bilayer. Proteins are also embedded within the plasma membrane. The **lipid bilayer** is fluid, meaning the phospholipids can move from side to side. **Cholesterol** is another fat that is very important for the stability of membranes. It stiffens the membrane, making it less fluid.

The plasma membrane encloses the cell separating the **cytoplasm** from its surroundings. It controls what enters and leaves the cell. **Lipids** and substances that dissolve in lipids such as oxygen and carbon dioxide can pass through the plasma membrane. The proteins embedded in the lipid bilayer form channels and pumps that help move molecules across the plasma membrane that cannot cross on their own. Because the lipids and proteins allow only some things to permeate, or enter, the cell, the plasma membrane is known as **semipermeable**. Similar biological membranes surround most organelles.

1 Which one of the following is not present in the plasma membrane?

a) phospholipids
b) cholesterol
c) cytoplasm
d) proteins

The entire region between the nucleus and the plasma membrane is the **cytoplasm**. All the organelles within the cell are found inside the cytoplasm floating in a gel-like substance known as the **cytosol**. The cytoplasm is a very crowded place with organelles and molecules continually bumping into each other.

Found within the cytoplasm is the support system of the cell known as the **cytoskeleton**. The cytoskeleton consists of microscopic fibers that hold the cell together and suspend structures within the cytoplasm. It also allows movement of particles within the cytoplasm.

NUCLEUS

In the same way that the main boss controls a large factory, the nucleus is the control center of the eukaryotic cell. It contains most of the cell's genetic material in the form of **DNA** and with it the master set of instructions for making proteins. DNA and proteins contribute to the long thin fibers within the nucleus known as chromatin. When the cell is dividing the **chromatin** fibers condense to form **chromosomes**.

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The nucleus is surrounded by a double membrane called the **nuclear envelope**. Each membrane is a lipid bilayer similar to the plasma membrane. The nuclear envelope is dotted with up to thousands of **nuclear pores**, which allow material to move into and out of the nucleus.

The small dense region in the non-dividing nucleus is the **nucleolus**. This is where the assembly of ribosomes begins. Proteins are combined with **ribosomal RNA** to produce small and large ribosomal subunits. These subunits exit the nucleus through the nuclear pores and enter the cytoplasm.

2 Which structure includes all of the others listed?

a) nucleus
b) nucleolus
c) chromosomes
d) DNA

RIBOSOMES

After the ribosomal subunits exit the nucleus through the nuclear pore and enter the cytoplasm, a large and small subunit assemble into a ribosome. They bind to **messenger RNA** which comes from the nucleus and contains instructions for making proteins. As the ribosomes move along the RNA they assemble small compounds known as **amino acids** into proteins. This process is known as **protein synthesis**.

3 Certain chemicals block the function of ribosomes. Which cell activity would immediately be affected by this change in ribosome function?

a) selective permeability
b) production of energy
c) excretion of metabolic wastes
d) protein synthesis

ROUGH ENDOPLASMIC RETICULUM

The endoplasmic reticulum, also called the ER, is a network of membranous tubules called **cisternae** that are continuous with the nuclear envelope. Ribosomes bind to a large part of the ER, giving it a rough appearance, thus this organelle is called the rough ER. If a ribosome begins making a protein that will be moved through the endoplasmic reticulum or perhaps be secreted from the cell, the ribosome will attach itself to the rough ER and channel the protein inside. The proteins are then moved through the rough ER and are packaged into small vesicles that bud off from the ER surface. The rough ER also

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plays a role in quality control. Proteins that are not made correctly are pushed out of the rough ER into the cytoplasm where they are disposed of.

SMOOTH ENDOPLASMIC RETICULUM

The rest of the endoplasmic reticulum is called smooth ER because it lacks ribosomes and appears smooth. The smooth ER performs many different processes within the cell. The most important job of the smooth ER is the **detoxification** of drugs and poisons. It also plays a role in making **hormones** and lipids.

4 If organelles can increase in number in response to an increased demand, then which organelle would you expect to find more of in the liver cells of a drug addict than in a non-addicted person?

a) rough endoplasmic reticulum
b) smooth endoplasmic reticulum
c) mitochondria
d) lysosomes

GOLGI APPARATUS

The vesicles that contain the newly formed proteins from the rough ER are called **transport vesicles** because they transport the proteins from the ER to an organelle known as the Golgi apparatus, or just the Golgi. The Golgi consists of a set of flattened membrane-bound sacs that serves as the packaging and distribution center of the cell. The Golgi faces the nucleus and ER on one side and the plasma membrane on the other side. The nuclear side acts as the receiving department and the side facing outward acts as the shipping department. Transport vesicles traveling from the ER fuse with the Golgi and deposit their proteins inside.

Enzymes inside of the Golgi apparatus modify the proteins and the Golgi then sorts its products and targets them for various parts of the cell or for secretion outside the cell. The products then bud off of the Golgi inside transport vesicles. Transport vesicles carrying products destined for secretion from the cell go on to fuse with the plasma membrane. Other vesicles go on to fuse with lysosomes or other organelles.

5 You would expect a cell with an extensive Golgi apparatus to:

a) make a lot of energy
b) move actively
c) sort a lot of material
d) store large quantities of food

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LYSOSOMES

Every factory needs a cleanup crew. In the eukaryotic cell, lysosomes perform this task and remove the junk that might otherwise accumulate and clutter up the cell. Lysosomes are membranous bags filled with **enzymes** that break down lipids, sugars, proteins, and other waste materials into small molecules that can be used by the cell. Lysosomes also break down excess organelles that are no longer needed or are damaged and no longer functioning properly.

Cells can acquire large substances such as food particles from the outside of the cell by forming **endosomes** from the plasma membrane. These endosomes can move to the lysosome where the outside substances are broken down into more useful compounds.

6 The function of a lysosome is to:

a) protect the cell from the external environment
b) synthesize proteins
c) make energy for the cell
d) remove cellular waste products

MITOCHONDRIA

After learning about the cell parts and the functions that they perform, it is easy to see that each of these functions requires a lot of energy. The most important form of energy that the cell can immediately use is stored in a molecule called **ATP**. Mitochondria are the organelles that provide much of this energy and are therefore known as the powerhouse of the cell. In a process known as **cellular respiration**, mitochondria convert the chemical energy found in organic compounds such as the broken down food and convert it into ATP which is more convenient for the cell to use.

A mitochondrion has two membranes. The outer membrane is smooth, while the inner membrane is highly folded inward providing a very large surface area for energy production. Mitochondria also have their own circular DNA and have their own ribosomes.

7 The cell organelle that would be found in cells requiring large quantities of energy is the:

a) Golgi apparatus
b) mitochondrion
c) lysosome
d) nucleolus

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Plant cells can also be compared to a factory with a couple of extra workers. Plant cells contain all of the organelles mentioned so far but have several additional components. The rigid **cell wall** is much like a brick wall surrounding the fence around the factory and provides an extra layer of protection. The **chloroplasts** are the solar panels on the roof of the factory that convert the sunlight into additional energy for the factory. And finally, the **central vacuole** is the factory's storage building for storing extra materials.

Let's look at these additional components of the plant cell a little closer.

CELL WALL

Plant cells have an additional line of protection, known as the cell wall, that distinguishes them from animal cells. The thick cell wall is composed of proteins and **carbohydrates** including the **polysaccharide**, **cellulose**. The wall surrounds the plasma membrane and protects the plant cell, maintains its shape, and prevents excessive uptake of water. Most cell walls are porous enough to allow nutrients and gasses to pass through easily.

8 The cell wall contains all of the following except:

a) proteins
b) carbohydrates
c) cholesterol
d) cellulose

CHLOROPLAST

Remember that plant cells have mitochondria to produce energy but they also have an additional power source known as chloroplasts. Chloroplasts are the biological equivalents to solar power plants because they can directly convert sunlight into energy in the form of ATP, in a process called **photosynthesis**. Chloroplasts contain the green **pigment, chlorophyll,** that helps to harvest the light energy and are found in the leaves of plants. Much like the mitochondria, chloroplasts are surrounded by a double membrane, but they also have small interconnected discs called **thylakoids** inside where the light harvesting takes place. Surrounding the thylakoids is a fluid known as **stroma**. Found within the stroma are ribosomes and circular DNA.

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9 Which of the following sets of features is common to both plant and animal cells?

a) mitochondria and a plasma membrane
b) nucleus and chloroplast
c) plasma membrane and cell wall
d) chloroplast and ribosome

CENTRAL VACUOLE

Every factory needs a place to store things, and plant cells contain a place for storage as well. Mature plant cells generally contain a large central vacuole that is enclosed by a membrane called the **tonoplast** and takes up most of the cell's volume. The central vacuole stores water, salts, proteins, and carbohydrates. When the central vacuole is full the pressure it exerts on the cell wall makes it possible for plants to support heavy structures such as leaves and flowers.

10 If you saw a plant whose stem and leaves were wilted, what could you conclude about the central vacuole?

a) the water level was too high
b) the water level was too low
c) it was filled
d) none of the above

The cellular factories inside our bodies are continuously working to make sure we function properly and each organelle plays an important role. Everything a living organism does can ultimately be traced back to the cell.

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GLOSSARY

ATP (Adenosine triphosphate) – one of the principal chemical compounds that living things use to store and release energy.

Amino Acid – an organic compound possessing a carboxyl and amino group and that combines with other amino acids to form proteins.

Carbohydrate – a compound that is made of carbon, hydrogen, and oxygen atoms, and that provides nutrients to the cells of living things.

Cell – the smallest unit that can perform all life processes. It is a collection of living matter that is enclosed by a barrier that separates the cell from its surroundings.

Cellular Respiration – the process by which cells produce energy in the form of ATP by breaking down glucose and other food molecules in the presence of oxygen.

Cellulose – a structural polysaccharide of cell walls in plants.

Cell wall – strong supportive layer surrounding the plasma membrane in plants, algae, and some bacteria. In plant cells, the wall is formed of cellulose fibers embedded in a protein matrix. It protects the plant cell, maintains its shape, and prevents excess uptake of water.

Central vacuole – a membranous sac in a mature plant cell. Its functions include storage of water, salts, and proteins. When it is full the pressure it exerts on the cell wall allows it to support heavy structure like leaves and flowers.

Chlorophyll – a green pigment located within the chloroplasts of plants that captures light energy.

Chloroplast – an organelle found only in plants and some other organisms that captures the energy from sunlight and converts it into chemical energy.

Cholesterol – a steroid that forms an essential component of animal cell membranes. It stiffens the membrane making it less fluid.

Chromatin – the granular material found inside the nucleus of that consists of DNA tightly coiled around proteins.

Chromosome – a threadlike structure within the nucleus of a eukaryotic cell. Each chromosome consists of one very long DNA molecule and the associated proteins.

Cisternae – a flattened membrane disk that makes up the Golgi apparatus.

Cytoplasm – the entire contents of the cell within the plasma membrane that includes the cytosol, cytoskeleton, and all of the organelles excluding the nucleus.

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Cytosol – the semifluid portion of the cytoplasm excluding the membrane, cytoskeleton, and organelles.

Deoxyribonucleic acid (DNA) – a double-stranded helical nucleic acid that contains the sugar deoxyribose and nitrogenous bases adenine, cytosine, guanine, and thymine. It is capable of replicating and contains the genetic instructions of the cell.

Detoxification – the metabolic process by which the toxic qualities of a poison or toxin are reduced by the body.

Electron – a subatomic particle with a single negative charge. One or more electrons move around the nucleus of an atom.

Electron Microscope – a microscope that focuses a beam of electrons through a specimen, resulting in a magnification power a thousand times greater than a light microscope.

Endoplasmic Reticulum (ER) – an extensive membranous network found within the cytoplasm of eukaryotic cells. It is continuous with the outer nuclear membrane and composed of ribosome-studded (rough) and ribosome free (smooth) regions.

Endosome – a vesicle formed by the invagination and pinching off of the cell membrane during endocytosis, a process by which cells absorb materials such as proteins from outside the cell.

Enzyme – a protein that acts as a biological catalyst, a chemical agent that changes the rate of a reaction without being consumed by the reaction.

Eukaryote – an organism made up of cells that have a membrane-enclosed nucleus and membrane-enclosed organelles.

Fatty-acid – a long carbon chain carboxyl acid.

Golgi apparatus – an organelle in eukaryotic cells consisting of stacks of flat membranous sacks that modify, sort, and package proteins from the endoplasmic reticulum.

Hormone – a circulating chemical signal that is made in one cell or tissue and that causes a change in another target cell or tissue in a different location in the body.

Light Microscope – an optical instrument with lenses that reflect visible light to magnify images of specimens.

Lipid – one of a family of compounds including fats, phospholipids, and steroids that are insoluble in water.

Lipid bilayer – a double-layered sheet that forms the core of nearly all cell membranes.

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Lysosome – a membrane enclosed sac filled with enzymes needed to break down certain materials inside the cell. They are found within the cytoplasm.

Messenger RNA (mRNA) – a type of RNA, that carries copies of instructions for the assembly of amino acids into proteins from DNA to the rest of the cell.

Mitochondrion – a cell organelle that converts the chemical energy stored in food into compounds that are more convenient for the cell to use.

Nonpolar – pertaining to a molecule that does not exhibit polarity.

Nuclear Envelope – the double membrane that encloses the nucleus in eukaryotic cells separating it from the cytoplasm.

Nuclear pore – large protein complexes that cross the nuclear envelope. There are thousands scattered across the surface of the nuclear envelope. They allow for the transport of water soluble molecules across the nuclear envelope.

Nucleolus – a specialized structure within the nucleus that is involved in the production of ribosomes.

Nucleus – in eukaryotic cells, the structure that contains the cell's genetic material in the form of DNA and controls the cell's activities.

Organelles – specialized structures found in the cytoplasm of eukaryotic cells that perform specific functions within the cell.

Phosphate group – a functional group important in energy transfer.

Phospholipid – a molecule that is a constituent of the inner bilayer of biological membranes, having a polar hydrophilic head and a nonpolar hydrophobic tail.

Photosynthesis – the process by which plants and some other organisms use light energy to convert water and carbon dioxide into oxygen and high-energy carbohydrates such as sugars and starches.

Pigment – a light absorbing molecule.

Plasma membrane – the thin flexible membrane at the boundary of every cell that acts as a selective barrier and regulates what enters and leaves the cell.

Polar – pertaining to a compound exhibiting polarity, that is a compound having a partial positive charge on one side and a partial negative charge on the other side.

Polysaccharide – a polymer of up to over a thousand monosaccharides, formed by dehydration reactions.

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Prokaryote – an organism made up of a single cell that does not contain a nucleus or cell organelles.

Protein – an organic compound that is made of one or more chains of amino acids and that is a principal component of all cells.

Protein Synthesis – The process in which the genetic code carried by messenger RNA directs cellular organelles called ribosomes to produce proteins from amino acids.

Ribosomal RNA (rRNA) – together with proteins forms the structure of the ribosome and is responsible for ribosomal function.

Ribonucleic acid (RNA) – single-stranded nucleic acid that contains the sugar ribose and nitrogenous bases adenine, cytosine, guanine, and urasil. Functions in protein synthesis.

Ribosome – a cell organelle constructed in the nucleolus from ribosomal RNA and proteins and consists of two subunits. It functions as the site of protein synthesis. Can be found floating in the cytoplasm or attached to the rough endoplasmic reticulum.

Rough Endoplasmic Reticulum (rough ER) – the portion of the endoplasmic reticulum that is studded with ribosomes. It is responsible for moving substances throughout the cell and plays a roll in quality control.

Semipermeable – a property of biological membranes that allow some substances to cross more easily than others.

Smooth Endoplasmic Reticulum (smooth ER) – the portion of the endoplasmic reticulum that is free of ribosomes. In many cells it contains collections of enzymes that perform specialized tasks such as the synthesis of membrane lipids and hormones, and the detoxification of drugs and poisons.

Stroma – the fluid of the chloroplast surrounding the thylakoid membrane.

Thylakoids – a flattened membrane sac inside the chloroplast, used to convert light energy into chemical energy.

Tonoplast – a membrane that encloses the central vacuole in a plant cell, separating the cytosol from the contents of the central vacuole.

Transport vesicle – a tiny membranous sac in a cell's cytoplasm carrying molecules produced by the cell.

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ANSWERS

1 **c) cytoplasm**

The plasma membrane does not contain cytoplasm. It separates the cytoplasm from the outside of the cell.

2 **a) nucleus**

Found within the nucleus is the genetic material in the form of DNA which condenses into chromosomes. The nucleolus is also found inside the nucleus.

3 **d) protein synthesis**

Ribosomes are the organelles that are responsible for protein synthesis. They make proteins from instructions that they receive from the nucleus.

4 **b) smooth endoplasmic reticulum**

The smooth endoplasmic reticulum is responsible for the detoxification of drugs and poisons.

5 **c) sort a lot of material**

The Golgi apparatus is the packaging and distribution center of the cell so if a cell has an extensive Golgi apparatus it is safe to assume that it would sort a lot of material.

6 **d) remove cellular waste products**

Lysosomes remove the wastes and break down excess organelles that could accumulate and clutter up the cell.

7 **b) mitochondrion**

The mitochondrion is the cell organelle that functions in energy production. To meet the need for large quantities of energy, a cell must have large numbers of mitochondria.

8 **c) cholesterol**

The cell wall of a plant contains proteins, carbohydrates, and cellulose. Cholesterol is a lipid and is found in the plasma membrane.

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9 **a) mitochondria and a plasma membrane**

Both plants and animals have a plasma membrane and mitochondria. Chloroplasts and cell walls are only found in plant cells.

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10 **b) The water level was too low**

In order for the central vacuole to support the heavy structures of the plant it needs to be full of water and pushing against the cell wall.

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ORGANELLE EXTRAVAGANZA

PROTEIN PRODUCTION GAME

Time Required: One Class Period

Organelles to Study: Plasma membrane, Endosome , Nucleus, Mitochondria, Endoplasmic Reticulum, Ribosome, Lysosome, Transport Vesicles, and Golgi Apparatus.

OBJECTIVES

1) Demonstrate an understanding of basic cell functions and the role that each organelle plays by acting them out.

2) Work together as a team to produce a protein.

MATERIALS

- 1 set of organelle name tags
- 1 cell placement chart
- 4 DNA folders and corresponding mRNA instructions
- 4 envelopes of food particles (pizza pieces)
- 4 pizza pans
- 4 sheets of origami Paper
- 4 endoplasmic reticulum check sheets
- 4 envelopes
- 2 markers

STORY

Each group is a hypothetical cell that produces and secretes animal shaped proteins. In order for a cell to produce a protein it needs to have energy. A food particle must enter the cell through the **plasma membrane** by forming an **endosome** and be broken down into smaller particles by a **lysosome**. The smaller food particles can then be used by the **mitochondrion** to produce energy in the form of ATP and distribute it within the cell.

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Now that the cell has energy it can produce a protein. The instructions for making the protein come from the DNA inside the **nucleus** in the form of mRNA. The **ribosome** uses the mRNA instructions to produce a protein. The **rough endoplasmic reticulum** then checks that the protein is made correctly and moves it through the cell to the **Golgi apparatus**. The Golgi apparatus then packages and distributes the protein to the outside of the cell through the plasma membrane in **transport vesicles**.

DIRECTIONS

In order to create a protein each group should follow these steps:

1. The **endosome** reaches outside of the cell from its position on the **plasma membrane** and grabs the red envelope of food particles labeled "Food Particles- Practice Round".

2. The **endosome** enters the cell with the envelope of food particles.

3. The **endosome** gives the envelope of food particles to the **lysosome** and returns to its position on the **plasma membrane.**

4. The **lysosome** opens the envelope of food particles and takes them out.

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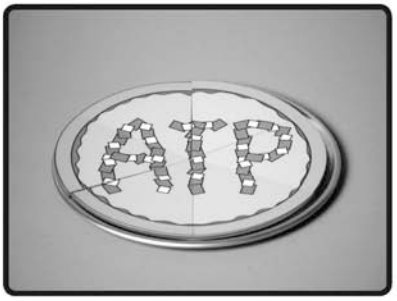
5 The **lysosome** breaks the food particles into smaller pieces by pulling them apart..

6 The **lysosome** gives the broken down food particles to the **mitochondrion**.

7 The **mitochondrion** arranges the food particles inside the pizza pan to form a pizza. The toppings must spell out ATP to move forward.



8 When a full pizza spelling ATP is formed, the **mitochondrion** signals to the **nucleus** to start.

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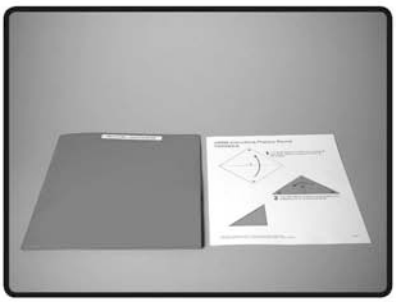
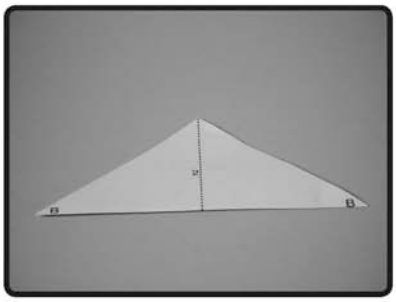
Now that we have energy:

9 After receiving the signal from the **mitochondrion**, the **nucleus** opens the red DNA folder labeled "DNA Folder- Practice Round" and takes out the mRNA Instructions. These are the instructions for making the protein.



10 The **nucleus** reads the mRNA Instructions aloud to the **ribosome**.

11 The **ribosome** uses the origami paper labeled "Practice Protein" to fold an animal protein following the instructions read by the **nucleus**.



12 The **ribosome** gives the folded protein to the **rough endoplasmic reticulum**.

Organelle Extravaganza Protein Production Game
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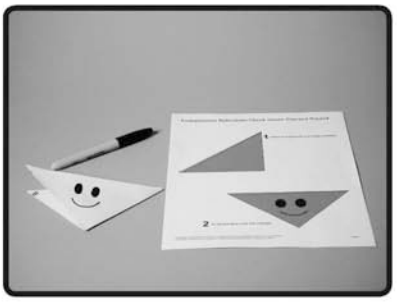
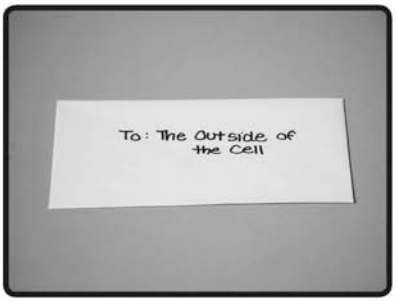
13 The **rough endoplasmic reticulum** uses the Endoplasmic Reticulum Check Sheet labeled "Endoplasmic Reticulum Check Sheet- Practice Round" to check that the protein is made correctly and uses the marker to draw the face.



14 The **rough endoplasmic reticulum** gives the protein to the **Golgi apparatus**.

15 The **Golgi apparatus** places the protein into an envelope and uses the marker to address it TO: The Outside of the Cell.



16 The **Golgi apparatus** gives the envelope to the **transport vesicle**.

17 The **transport vesicle** goes to the **plasma membrane**.

18 The **plasma membrane** opens and lets the **transport vesicle** out of the cell.

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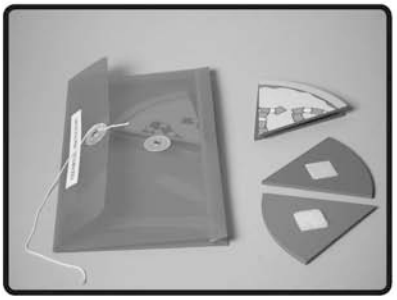
19 The **transport vesicle** takes the envelope to the teacher and returns to its original place inside the cell.

20 Once the **transport vesicle** is back in the cell you can start making the next protein.

CLEAN UP

1 L**ysosome** and **endosome:** reattach the pizza pieces and place them into their color coordinated envelopes.



2 M**itochondrion:** stack the empty pizza pans.

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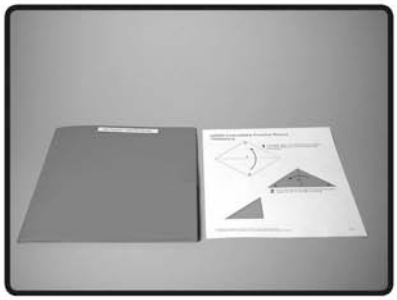
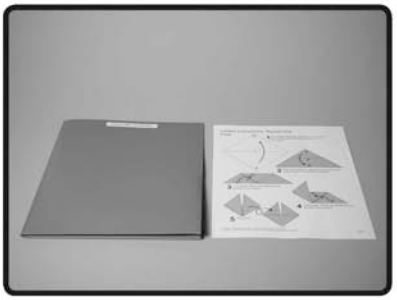
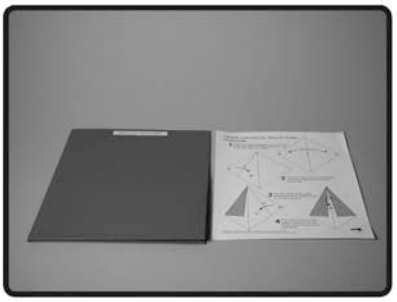
3 **Nucleus:** place the mRNA Instructions into their color coordinated DNA Folders and return the Cell Placement Chart to the center of the circle.



4 Return all materials to the center of the circle the way you found them.

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REVIEW QUESTIONS

1. Describe what happens when a large food particle enters the cell making sure to name each of the organelles involved and state their functions.

2. Which organelle is necessary to transform food into energy for the cell?

3. Describe how proteins are produced making sure to name each of the organelles in the process.

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4 What is the purpose of the nucleus?

5 What happens to a cell if its mitochondria fail?

6 Which organelle were you? And what part did you play in the game?

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GLOSSARY

Cell – the smallest unit that can perform all life processes. It is a collection of living matter that is enclosed by a barrier that separates the cell from its surroundings.

Cellular Respiration – the process by which cells produce energy in the form of ATP by breaking down glucose and other food molecules in the presence of oxygen.

Endoplasmic Reticulum (ER) – an extensive membranous network found within the cytoplasm of eukaryotic cells. It is continuous with the outer nuclear membrane and composed of ribosome-studded (rough) and ribosome free (smooth) regions.

Endosome – a vesicle formed by the invagination and pinching off of the cell membrane during endocytosis, a process by which cells absorb materials such as proteins from outside the cell.

Golgi apparatus – an organelle in eukaryotic cells consisting of stacks of flat membranous sacks that modify, sort, and package proteins from the endoplasmic reticulum.

Lysosome – a membrane enclosed sac filled with enzymes needed to break down certain materials inside the cell. They are found within the cytoplasm.

Messenger RNA (mRNA) – a type of RNA, that carries copies of instructions for the assembly of amino acids into proteins from DNA to the rest of the cell.

Mitochondrion – a cell organelle that converts the chemical energy stored in food into compounds that are more convenient for the cell to use.

Nucleus – in eukaryotic cells, the structure that contains the cell's genetic material in the form of DNA and controls the cell's activities.

Organelles – specialized structures found in the cytoplasm of eukaryotic cells that perform specific functions within the cell.

Plasma membrane – the thin flexible membrane at the boundary of every cell that acts as a selective barrier and regulates what enters and leaves the cell.

Protein – an organic compound that is made of one or more chains of amino acids and that is a principal component of all cells.

Protein Synthesis – The process in which the genetic code carried by messenger RNA directs cellular organelles called ribosomes to produce proteins from amino acids.

Ribosome – a cell organelle constructed in the nucleolus from ribosomal RNA and proteins and consists of two subunits. It functions as the site of protein synthesis. Can be found floating in the cytoplasm or attached to the rough endoplasmic reticulum.

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Rough Endoplasmic Reticulum (rough ER) – the portion of the endoplasmic reticulum that is studded with ribosomes. It is responsible for moving substances throughout the cell and plays a roll in quality control.

Smooth Endoplasmic Reticulum (smooth ER) – the portion of the endoplasmic reticulum that is free of ribosomes. In many cells it contains collections of enzymes that perform specialized tasks such as the synthesis of membrane lipids and hormones, and the detoxification of drugs and poisons.

Transport vesicle – a tiny membranous sac in a cell's cytoplasm carrying molecules produced by the cell.

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ORGANELLE EXTRAVAGANZA

LAB 1: ANIMAL AND PLANT CELL

Time Required: One Class Period

Organelles to Study: Nucleus, Nucleolus, Cytoplasm, Plasma Membrane (cheek), Cell Wall (onion), and Central Vacuole (onion)

OBJECTIVES

1) Identify the structures you can see in animal and plant cells.
2) Compare and contrast the structures of plant and animal cells.

Students should have a basic understanding of how to use a compound light microscope before performing this lab.

INTRODUCTION

Most cells are too small to be seen with the naked eye. With the aid of a **compound light microscope,** however, you can see the cells as well as their parts. In animal cells, such as your cheek cells, the **cytoplasm**, **plasma membrane**, **nucleus,** and **nucleolus** can be seen. In plant cells, such as onion skin cells, the **cell wall**, **cytoplasm**, **nucleus**, **nucleolus**, and sometimes the **central vacuole** can be seen.

In this lab, **stains** will be added to both the animal cell and plant cell to add color and contrast to the cell parts and make them more visible through the compound light microscope. You will be able to view the cells at several different magnifications and observe the differences in plant cell and animal cell structure.

MATERIALS

- Safety goggles
- Lab aprons
- Compound light microscope
- Slides

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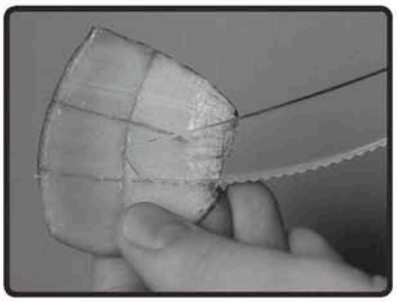
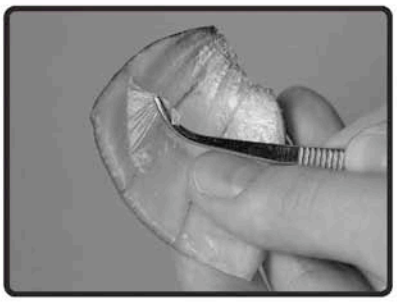
- Red Onion
- Plastic Knife
- Iodine stain in a dropper bottle
- Methylene blue stain in a dropper bottle
- Distilled water in a dropper bottle
- Curved forceps
- Flat toothpicks
- Colored pencils

PROCEDURE: ONION SKIN CELLS

1 Take a small piece of onion given to you by the teacher. Score the underside of the onion dividing it into squares.



2 Use the flat end of the curved forceps starting at a corner to peel off the skin from the inside surface (the rough white side) of the onion. Throw the rest of the onion piece away in a trash can.



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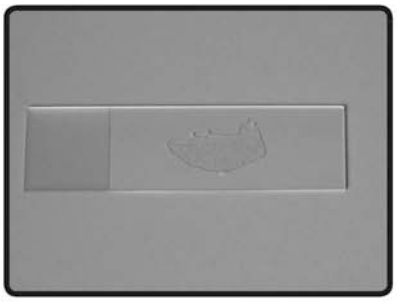
3 Carefully lay a small piece of onion skin flat in the center of two blank microscope slides. Make sure to flatten the onion skin while it is still wet. Try to have as few folds and wrinkles as possible.

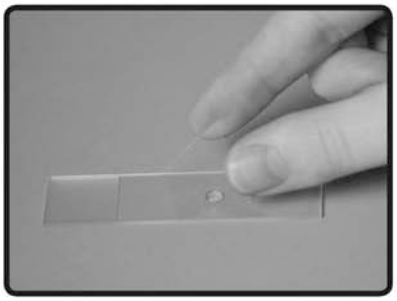
Note: You can place a drop of distilled water on the slide to help smooth it out.



4 Find the dropper bottle labeled "**Distilled Water**". Use the dropper to draw up a small amount of distilled water from the bottle.

5 Add one drop of the distilled water on top of the onion skin on one of the slides.

6 Stand a cover slip on its edge near the onion skin on your slide. Slowly lower the other side of the cover slip until it covers the onion skin completely. If there are any air bubbles, gently tap on the glass to remove them.



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7 Find the dropper bottle labeled "**Iodine**". Use the dropper to draw up a small amount of iodine stain from the bottle.

8 Add one drop of iodine stain on top of the onion skin on your second slide.

9 Stand a cover slip on its edge near the onion skin on your slide. Slowly lower the other side of the cover slip until it covers the onion skin completely. If there are any air bubbles, gently tap on the glass to remove them.

10 Make sure the 4x objective is in place above the stage and the microscope light is turned on. Place the slide with distilled water onto the stage. (It will be clear.) Look through the eyepiece (you can remove your safety goggles for this part) and turn the coarse focus knob (the large knob) until the image is in focus. You can use the fine focus knob (the small knob) to focus the image further.

Try to find an area where the onion skin is not folded and you can see the cells clearly.

11 Remove the slide with distilled water and place the slide stained with iodine onto the stage. Look through the eyepiece and turn the coarse focus knob until the image is in focus. You can use the fine focus knob to focus the image further. You should be able to identify the cell wall and cytoplasm and possibly the nucleus at this power.

12 Draw a picture of what you see in the circle labeled "Onion Skin Cell 4x" on the page provided and compare it to the diagram of a plant cell in your textbook. Label the parts that you can see.

13 Rotate the lens to the 10x objective making sure to look from the side and not through the eyepiece. Use ONLY the fine focus knob if you need to focus. You may see a small dot in the middle of each cell. This is the nucleus.

14 Rotate the lens to the 40x objective. Again, use the fine focus knob if you need to focus the image. You should be able to see the nucleus clearly at this magnification. It should appear as a dark spot in the middle of the cell. You might also see the nucleolus at this magnification.

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15 Draw a picture of what you see in the circle labeled "Onion Skin Cell 40x" on the page provided and compare it to the diagram of a plant cell in your textbook. Label the parts that you can see.

16 Switch to the 4x objective and remove the slide. Set the slide aside while you view the cheek cells.

PROCEDURE: CHEEK CELL

1 Put on your safety goggles.

2 Find the dropper bottle labeled "Distilled Water". Use the dropper to draw up a small amount of distilled water from the bottle.

3 Add one drop of distilled water onto the center of one of your unused slides.

4 Find the dropper bottle labeled "**Methylene Blue**". Use the dropper to draw up a small amount of methylene blue stain from the bottle.

5 Add one drop of methylene blue stain onto the center of a second slide.

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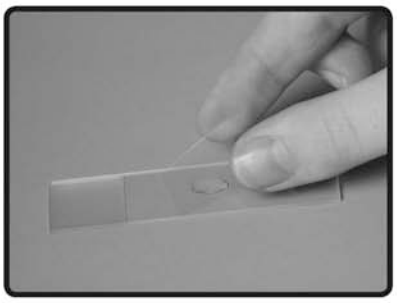
6 Choose one student in the group to gently rub the flat end of a toothpick on the inside of their cheek. Do not rub too hard, you are trying to get cells not blood.

7 Gently stir the toothpick in the drop of distilled water and then throw the toothpick away.

8 Repeat Step 6 using a clean toothpick.

9 Gently stir the toothpick in the drop of methylene blue and then throw the toothpick away.

10 Stand a glass cover slip on its edge near the drop of distilled water. Slowly lower the other side of the cover slip until it completely covers the distilled water. If there are any air bubbles present, gently tap the cover slip to remove them. Repeat for both slides.



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11 Make sure the 4x objective is in place above the stage. Place the slide with distilled water onto the stage (It will be clear.) Look through the eyepiece (you can remove your safety goggles for this part) and turn the coarse focus knob (the large knob) until the image is in focus. You can use the fine focus knob (the small knob) to focus the image further.

It should look like small nearly clear purplish blobs scattered on the slide. Move the slide around until you find a section of the slide where the cells are not clustered together.

12 Remove the slide with distilled water and place the slide stained with methylene blue onto the stage. Look through the eyepiece and turn the coarse focus knob until the image is in focus. You can use the fine focus knob to focus the image further. You should be able to identify the plasma membrane and cytoplasm and possibly the nucleus at this power.

It should look like small purplish blue blobs scattered on the slide. Move the slide around until you find a section of the slide where the cells are not clustered together.

13 Draw a picture of what you see in the circle labeled "Human Cheek Cell 4x" on the page provided and compare it to the diagram of an animal cell in your textbook. Label the parts that you can see.

14 Rotate the lens to the 10x objective making sure to look from the side and not through the eyepiece. Use ONLY the fine focus knob if you need to focus. You may see a small dot in the middle of each cell. This is the nucleus.

15 Now rotate the lens to the 40x objective. Again you may need to use the fine focus knob to focus the image. You should be able to see the nucleus clearly at this magnification. It should appear as a dark spot in the middle of the cell. You might also be able to see the nucleolus.

16 Draw a picture of what you see in the circle labeled "Human Cheek Cell 40x" on the page provided and compare it to the diagram of an animal cell in your textbook. Label the parts that you can see.

17 Switch to the 4x objective and remove the slide.

18 You can continue to compare the two slides to see differences in plant and animal cells.

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CLEAN UP

1. Dispose of the toothpicks and piece of onion in the trash can.

2. Place any broken glass in the appropriate container as instructed by your teacher.

3. Clean the slides, coverslips, and curved forceps in the sink using warm soapy water. Dry them with paper towels. Place the slides, coverslips, and curved forceps on the towels near the sink to finish drying.

4. Make sure the tops on all of the dropper bottles are screwed on tightly.

5. Clean your workstation.

ANALYSIS

1. What was the purpose of using stains to view these cells? What difference do you see between the slides with water and the slides with stain?

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2 What structures did you observe in the onion skin cell? In the cheek cell? What are the functions of each of these structures?

3 The compound light microscope used in this lab is not powerful enough to view other organelles in these cells. Name two organelles in the plant cell and two organelles in the animal cell that were not visible.

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4 Describe the shape of the plant cell. Describe the shape of the animal cell. From what you can see through the compound light microscope how are plant and animal cells similar in structure? How are they different?

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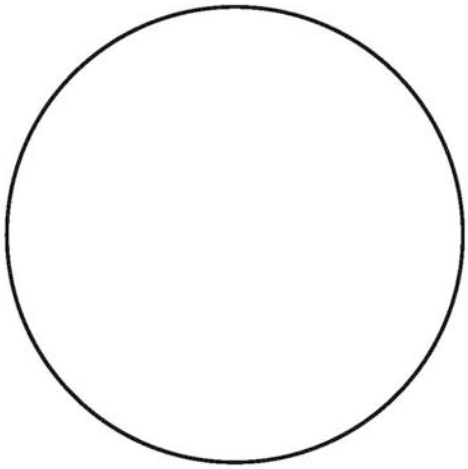
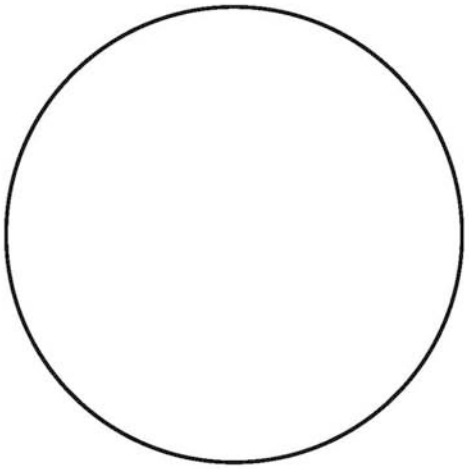
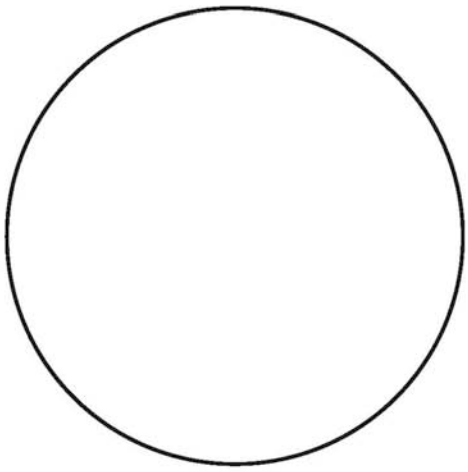
PLANT AND ANIMAL CELL DRAWINGS



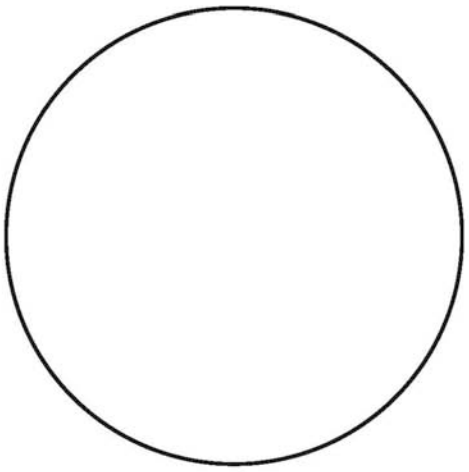
Onion Skin Cell 4x



Onion Skin Cell 40x



Human Cheek Cell 4x



Human Cheek Cell 40x

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GLOSSARY

Central vacuole – a membranous sac in a mature plant cell. Its functions include storage of water, salts, and proteins. When it is full the pressure it exerts on the cell wall allows it to support heavy structure like leaves and flowers.

Compound Light Microscope – an optical instrument with lenses that reflect visible light to magnify images of specimens.

Cytoplasm – the entire contents of the cell within the plasma membrane that includes the cytosol, cytoskeleton, and all of the organelles excluding the nucleus.

Distilled water – water which has had all impurities and minerals removed in a process known as distillation.

Iodine – a stain used to detect polysaccharides such as cellulose, in which potassium iodide reacts with starch to produce a blue color.

Methylene blue – a dye that forms a deep blue solution when dissolved in water and is used as a biological stain in microscopy.

Nucleolus – a specialized structure within the nucleus that is involved in the production of ribosomes.

Nucleus – in eukaryotic cells, the structure that contains the cell's genetic material in the form of DNA and controls the cell's activities.

Stain – a dye or mixture of dyes used in microscopy to make small or transparent structures visible, to differentiate between tissue segments or to produce specific chemical reactions.

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ORGANELLE EXTRAVAGANZA

LAB 2: PAPER CHROMATOGRAPHY

Time Required: One Class Period

Organelle to Study: Chloroplast

OBJECTIVES

1) Identify the pigments found in chloroplasts.
2) Provide an introduction to paper chromatography.

INTRODUCTION

Plants use **chloroplasts** found inside their leaves to capture light that is used in **photosynthesis** to produce energy. Light is composed of different **wavelengths**. The efficiency of plants at capturing light is increased by the variety of light absorbing **pigments** found inside the chloroplasts. By having several different pigments the plant can absorb a wider range of wavelengths of light.

There are several different groups of pigments. **Chlorophylls** are green pigments that are most effective in driving photosynthesis. There are two types of chlorophyll pigments. **Chlorophyll B** is yellow-green, while **chlorophyll A** is blue-green. **Carotenoids** are **accessory pigments** that can drive photosynthesis but some carotenoids also function as **photoprotectors** by absorbing and scattering excessive light energy that would otherwise damage the chlorophyll. Of the carotenoids, **xanthophylls** are yellow and **carotenes** are orange-yellow. Chlorophyll typically hides these other pigments until the fall, when the chlorophyll breaks down revealing xanthophyll and carotene.

The different pigments present in a leaf can be separated into bands of color using a technique known as **paper chromatography**. In paper chromatography the individual components of a mixture are separated based on their **solubility**. The pigments in plants have different solubilities and will separate depending on their attraction for a **stationary phase** (the filter paper) or a **mobile phase** (the solvent). The pigments will separate as the **solvent** moves up the filter paper and will show up as colored streaks. Pigments with a stronger attraction to the filter paper than to the solvent will move more slowly than the pigments with a strong attraction to the solvent and will separate first.

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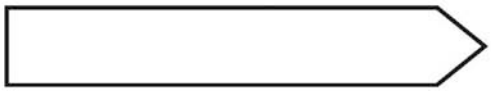
MATERIALS

- Safety goggles
- Lab aprons
- Chromatography tubes filled with solvent
- Graduated Cylinders (2)
- Mortar and pestle
- Filter paper strips
- Glass dropper bottle of isopropyl alcohol
- Capillary tubes
- Colored tape
- Marker
- Colored pencils
- Scissors
- Rulers

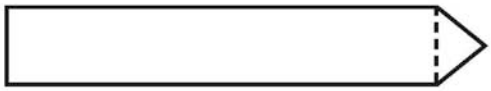
PROCEDURE

1. Start by putting on your safety goggles and lab apron.

2. Cut a point at one end of your piece of filter paper. Try to touch the paper only on the edges to avoid transferring oils from your skin onto the paper.



3. Using a pencil, lightly draw a fine line across your paper about 1 cm from the point.



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4 As a group, tear one or two spinach leaves into small pieces disposing of the stems.

5 Place the spinach pieces into the mortar and grind the leaves with the pestle, using a circular motion. This breaks down the **cell walls** and releases the pigment.

6 Use the dropper from the glass dropper bottle labeled "isopropyl alcohol" to add small amounts of isopropyl alcohol into the mortar one drop at a time as you grind the leaves until a finely ground colored solution is formed. (Do not use more than three drops of isopropyl alcohol). This solution is called the **pigment extract.**

7 Take turns using the capillary tubes. Dip one end of the capillary tube into the plant extract solution (the tube will automatically draw a small amount of liquid up into the tube).

Note: Do not pick up any of the leaf pieces on your capillary tube. You just need the liquid.

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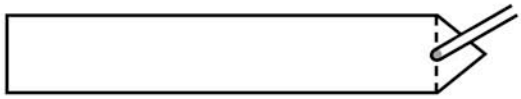
8 Quickly and gently touch the end of the capillary tube to the center of the pencil line on your filter paper strip as shown. The pigment extract will make a small colored spot on your paper.

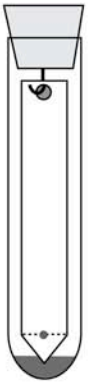


Note: Do not puncture your filter paper with the capillary tube.

9 Be sure to let the drop dry. Repeat 15 to 20 times to build up the pigment spot until it is dark green. Make sure to let the spot dry after each drop is added. This keeps the pigment spot from spreading out too much and will provide you with a much better result.

10 Choose a test tube from the rack. Write your name on a piece of tape provided and attach it to your test tube. Remove the rubber stopper from your test tube and attach your filter paper to the hook.

11 Place the paper and cork assembly inside your test tube as shown. Adjust it so the paper point just touches the solvent and the paper does not touch the sides of the test tube. The pigment dot must be above the level of the solvent for the experiment to work.



12 Observe the solvent as it moves up the filter paper. The solvent will carry the pigment with it as it moves and the pigments will separate out in colored bands.

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13 Remove the paper when the solvent is approximately 1 cm from the top of the filter paper (you want the top 1 cm of the filter paper to be dry). Before the solvent evaporates, quickly draw a pencil line across the filter paper where the **solvent front** ends (the uppermost edge of the solvent).

Note: The solvent front will be the line between wet paper and dry paper.

14 Using a small dot, mark the center of each pigment band on the original filter paper. The colors fade quickly, so you should make your observations immediately.

(Remember carotenes are orange-yellow, xanthophylls are yellow, chlorophyll a is blue-green and chlorophyll b is yellow-green). Look for subtle differences in color.

15 While the filter paper is drying (2 or 3 minutes), sketch your results using the colored pencils provided. The location (height) and color of each of the pigment bands should be recorded.

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16 Use the ruler to measure the distance in cm from the starting point (original pencil line) to the center of each pigment band to determine the distance moved by each solute. Then measure the entire distance traveled by the solvent (from the original pencil line to the uppermost edge of the solvent).

Pigment	Distance Traveled from Starting Point
Chlorophyll B	
Chlorophyll A	
Xanthophyll	
Carotene	
Solvent	

17 Each pigment has an **Rf (ratio-factor) value**, the speed at which it moves up the filter paper compared to the speed of the solvent.

$$Rf = \frac{\text{distance moved by the solute (pigment)}}{\text{distance moved by the solvent}}$$

Use these values from the data table above to calculate and record the Rf value for each of the pigments in the data table below.

Pigment	Color	Rf Value
Chlorophyll B		
Chlorophyll A		
Xanthophyll		
Carotene		

CLEAN UP

1 When your observations are complete, dispose of your filter paper in the trash can.

2 Discard any remaining solvent in the appropriate container as instructed by your teacher.

3 Remove the tape from your test tube and throw it away. Gently wash your test tube with warm soapy water using the brush provided.

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4 Place your test tube upside down on the pegs of your test tube rack to dry and place the test tube rack on the towel beside the sink.

5 Also wash the rubber stopper with warm soapy water, dry, and place on a towel beside the sink.

6 Rinse the mortar and pestle thoroughly using a small amount of isopropyl alcohol to remove any remaining pigment, then wash with soap and water and dry. Place on the towel beside the sink to finish drying.

7 Dispose of your capillary tube in the appropriate container as instructed by your teacher.

8 Clean your workstation and return the glass dropper bottle to your teacher.

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ANALYSIS

1. Pigments with a strong attraction to the filter paper will move more slowly than the pigments with a strong attraction to the solvent and will separate from the point of origin first. Which pigment has the strongest attraction to the filter paper? Which pigment has the strongest attraction to the solvent? Why?

2. Why did you grind the spinach leaves with the mortar and pestle?

3. What two characteristics could be used to identify an unknown pigment?

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4 Why do plants need more than one pigment?

5 Why do green leaves turn yellow and orange in the fall?

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GLOSSARY

Accessory pigment – any pigment that can absorb light energy and pass the electrons along to the primary pigment, chlorophyll A, which starts the process of photosynthesis.

Carotene – an orange photosynthetic pigment important for photosynthesis. It contributes to photosynthesis by transmitting the light energy it absorbs to chlorophyll.

Carotenoids – an accessory pigment, either yellow or orange, in the chloroplasts of plants. By absorbing wavelengths of light that chlorophyll cannot, carotenoids broaden the spectrum of color that can drive photosynthesis.

Cell wall – strong supportive layer surrounding the plasma membrane in plants, algae, and some bacteria. In plant cells, the wall is formed of cellulose fibers embedded in a protein matrix. It protects the plant cell, maintains its shape, and prevents excess uptake of water.

Chlorophyll – a green pigment located within the chloroplasts of plants that captures light energy.

Chlorophyll A – a type of blue-green photosynthetic pigment that participates directly in the light reactions.

Chlorophyll B – a type of yellow-green photosynthetic pigment that transfers energy to chlorophyll a.

Chloroplast – an organelle found only in plants and some other organisms that captures the energy from sunlight and converts it into chemical energy.

Mobile phase – the phase which moves in a definite direction. The moving phase consists of the sample being separated/analyzed and the solvent that moves the sample through the column. The moving phase moves through the chromatography column (the stationary phase) where the sample interacts with the stationary phase and is separated.

Paper Chromatography – an analytical technique for separating and identifying mixtures that are or can be colored especially pigments.

Photoprotector – protects chlorophyll from being damaged by absorbing and scattering excessive light energy.

Photosynthesis – the process by which plants and some other organisms use light energy to convert water and carbon dioxide into oxygen and high-energy carbohydrates such as sugars and starches.

Pigments – a light absorbing molecule.

Pigment extract – the solution of isopropyl alcohol and pigments after the spinach leaves have been ground up.

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Ratio-factor (Rf) value – a measurement based on the relative distance traveled by the sample of a substance in a particular procedure. It is the distance moved by the solute divided by the distance moved by the solvent.

Solubility – the ability of a given substance, the solute, to dissolve in a solvent.

Solute – a solid, liquid, or gas dissolved into a solvent resulting in a solution. The sample components in partition chromatography.

Solvent – a liquid of gas that dissolves a solid, liquid, or gaseous solute, resulting in a solution.

Solvent front – the wet moving edge of the solvent that progresses along the surface where the separation of the pigments is occurring.

Stationary phase – the substance which is fixed in place for the chromatography procedure.

Wavelength – the distance between crests of waves, such as those of the electromagnetic spectrum. Our eyes are sensitive to light which lies in a very small region of the electromagnetic spectrum labeled "visible light".

Xanthophyll – a yellow photosynthetic pigment. They are involved in photosynthesis along with green chlorophyll, which typically covers up the yellow, except in autumn when the chlorophyll is denatured by the cold.

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ORGANELLE EXTRAVAGANZA

LAB 3: FEEDING PARAMECIA

Organelles and Cell Parts to Study: Anal Pore, Cilia, Contractile Vacuole, Food Vacuole, Gullet, Pellicle, Lysosome, Macronucleus, Micronucleus, and Oral Groove

OBJECTIVES

1) See how Paramecia move using actin based cell movement.
2) Observe the Paramecia form food vacuoles to enclose the yeast, and watch as the lysosomes fuse with the vacuoles and release enzymes that digest the yeast.

INTRODUCTION

Paramecia are unicellular, or one-celled, organisms that are found in freshwater environments. They are shaped like slippers with a rounded front end and a pointed tail end. The paramecium is covered by an outer membrane called a **pellicle**. The pellicle protects the cell and keeps unwanted things out and is covered with hair-like projections called **cilia**. The cilia are used in movement. When they move at an angle backwards the paramecium moves forward. Cilia also line the **oral groove** which is similar to a mouth and are used in feeding to sweep food inside. The paramecium has one large nucleus known as the **macronucleus** that is used in normal cell functions and a smaller nucleus known as the **microneucleus** that is used in reproduction. The paramecium also has a **contractile vacuole** that controls the amount of water in the cell.

Yeast is a type of fungi and is a good food source for the paramecia. When fed yeast cells, they will enter the paramecium through its oral groove. From the oral groove, the food will enter into the **gullet**, which is similar to a stomach. When enough food has accumulated in the gullet, **food vacuoles** are formed. The food vacuoles move throughout the cell, going towards the tail first. As they move throughout the cell, **lysosomes** that are found in the cytoplasm fuse with the food vacuoles and release their **enzymes**. These enzymes digest the food and release it into the cytoplasm. When the food vacuole reaches the **anal pore** any remaining undigested food is removed.

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In this lab, the yeast cells are stained with Congo Red which appears red at a pH of 5 and various shades of blue at lower pHs. The yeast cells can be observed as they move from the oral groove into the gullet and are enclosed in food vacuoles. You can see the food vacuoles change color as the lysosomes fuse with them and release their enzymes digesting the food and lowering the pH.

MATERIALS

- Safety goggles
- Lab apron
- Compound light microscopes
- Live *Paramecium caudatum* culture
- Disposable pipet
- Tube filled with stained yeast
- Microscope slides with two wells
- Coverslips

PROCEDURE: OBSERVING PARAMECIA

1. Start by putting on your safety goggles and lab apron.

2. One member of the group should go to the teacher's station and get a microscope slide, and 2 coverslips.

3. Use one of the disposable pipet provided near the paramecium culture. Gently squeeze the pipette before you lower it into the paramecium culture so that you do not introduce bubbles.

4. Gently lower the pipet into the culture and draw up a small amount of fluid. Try to pull from the bottom of the culture

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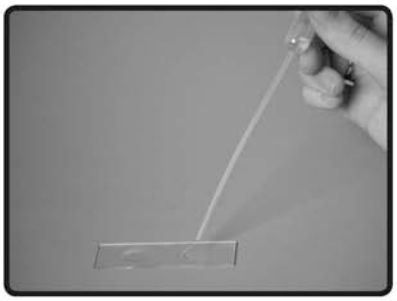
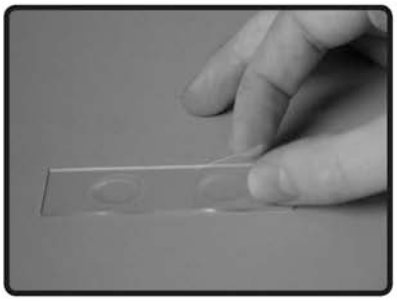
5 Use the pipet to transfer one or two drops of the paramecium culture into each of the wells in the microscope slide. You should have enough fluid to fill your well but not overflow. Return the remaining fluid back to the culture.



6 Place a coverslip over both of the wells. Make sure to stand the coverslip on its edge beside the well and gently lower it. If there are air bubbles under the coverslip you can gently tap on the surface to force them out.



7 Carefully take the slide back to your lab station being careful not to spill any of the fluid.

8 Make sure the low magnification (4x) objective is in place above the stage and the microscope light is turned on.

9 Place the slide onto the microscope stage.

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10 Look through the eyepiece (you can remove your safety goggles for this part) and turn the coarse focus knob (the large knob) until the image is in focus. You can use the fine focus knob (the small knob) to focus the image further. They should look like the image to the right.

11 Move your slide around to observe how the paramecium moves at 4x magnification. They will be moving pretty quickly.

Note: If you see bubbles moving across your slide, it is probably a paramecium that is swimming out of focus. Use your fine focus knob to focus.

12 If the paramecia are moving too fast for you to observe them, you can return to the teacher's station, and place your slide on the ice pack for about a minute to lower the temperature and slow the paramecia down.

13 Switch to the 10x objective and observe the cilia along the outside of the paramecium's body. Note how they help it to move. The macronucleus, micronucleus, and pellicle should also be visible. You may also be able to see the oral groove and the pulsating contractile vacuole.

Note: You may need to look at several paramecia to observe all of these structures.

PROCEDURE: FEEDING PARAMECIA

1 Replace your safety goggles.

2 Remove the slide from the microscope stage and remove the coverslip from one of the wells. Do not throw the coverslip away because you will need to use it again later.

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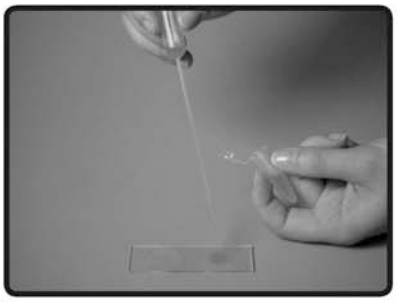
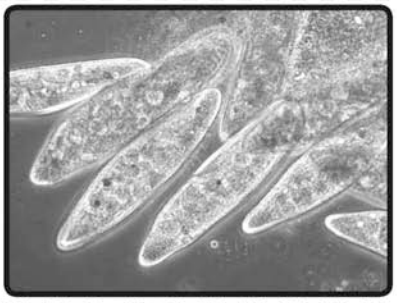
3 Find the tube of the yeast suspension that has been stained with **Congo Red Indicator** and use a disposable pipet to transfer a small drop of yeast suspension to the paramecia. Replace the coverslip over the well.

Note: Congo Red is a pH indicator which will change as the pH changes. It is red at pH 5 and is various shades of blue at lower pHs.



4 Make sure the low magnification (4x) objective is in place and place the slide onto the microscope stage.

5 Move your slide around until you find a paramecium that has stopped to eat. You might be able to find a paramecium eating alone or they could be in groups like the one in the picture.



6 Observe the paramecium as it ingests some of the yeast cells through its oral groove into its gullet and forms food vacuoles to enclose it. This should occur very quickly, perhaps within 10 seconds of adding the yeast.

7 The food vacuoles will be red at first and then eventually turn blue, as the lysosomes fuse with the food vacuole and release enzymes to digest the yeast. This color change will take approximately 10 minutes.

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CLEAN UP

1. Dispose of your disposable pipets, toothpicks, and yeast tubes into the trash can.

2. Place any broken glass in the appropriate container as instructed by your teacher.

3. Clean the slides and coverslips in the sink using warm soapy water. Dry them with paper towels. Place the slides on a towel near the sink to finish drying and the coverslips on a separate towel.

4. Clean your workstation.

ANALYSIS

1. How does the paramecium move?

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2 How did the yeast cells get to the inside of the paramecium?

3 What color were the yeast cells when they entered the paramecium? Why?

4 After ingestion, what changes occurred to the yeast cells inside the paramecium? Explain each of these changes.

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GLOSSARY

Anal pore – the physical exit area for undigested food.

Cilia – tail-like projections extending outwards from the cell body.

Congo red indicator – a brownish-red powder used as a biological stain.

Contractile vacuole – a sub-cellular structure involved in regulating water levels. It pumps excess water out of the cell and is found in freshwater protozoans.

Enzyme – biomolecules that catalyze chemical reactions.

Food vacuole – a small vesicle that is formed inside a protozoan cell and within which food particles are ingested by the cell, are contained, and then digested.

Gullet – an invagination of the proplasm in various protozoans that sometimes functions in the intake of food.

Lysosome – a membrane enclosed sac filled with enzymes needed to break down certain materials inside the cell. They are found within the cytoplasm.

Micronucleus – the smaller nucleus in most ciliate protozoans that is used in reproduction.

Macronucleus – the larger type of nucleus in most ciliate protozoans. It is involved in the nonreproductive functions such as feeding and metabolism.

Oral groove – a depression leading to the mouth of some invertebrates.

Paramecia – a unicellular ciliate found in freshwater environments.

Pellicle – a thin layer supporting the cell membrane in various protozoa.

Yeast – growth form of eukaryotic microorganisms classified in the kingdom Fungi. Yeasts are unicellular.

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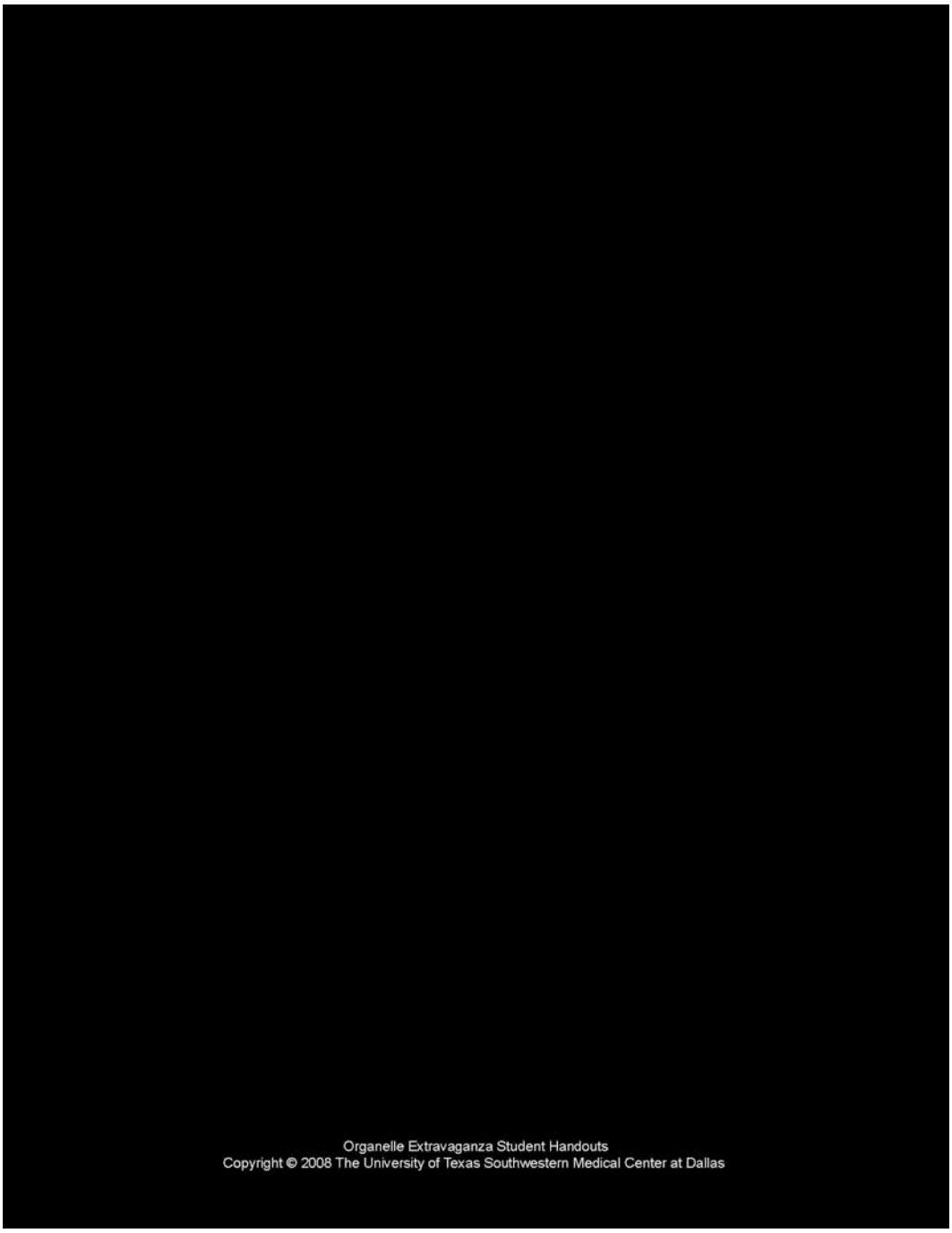
Organelle Extravaganza Student Handouts
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APPENDIX I
Evaluation Survey

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: Teacher Administrator Other: _____

2. Do you currently teach Biology? Yes No
   If yes, what grade? _____

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? Yes No

4. Do you have access to light microscopes for student use? Yes No
   If yes, how many? _____

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

APPENDIX J
Evaluation Survey Responses

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9th, 10th

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? 6

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments: It looks easy to follow

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

Page 1

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(✓) Animation

(✓) Protein Production Game

(✓) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

(✓) Animation

(✓) Protein Production Game

(✓) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

(✓) Paper Chromatography Lab

(✓) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9th

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? 1 per student

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(X) Animation

(X) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

(X) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

( ) Animation

(X) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

?

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9th

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? 1 per 2 students

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments: didn't get to see

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments: seem to be

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments: didn't get to see

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments: better than asking students to make analogy to organelles & city - that they may not be familiar w)

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments: NA to our school

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(✓) Animation

(✓) Protein Production Game

(✓) Animal and Plant Cell Lab

(✓) Paper Chromatography Lab

(✓) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments: labs look standard - I have done all but last.

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

The real test is always with students. What seems great to teachers doesn't always work as well with students. It looks very promising and deserves to be tested

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 12th AP. Bio

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? _____

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

(✓) Animation

(✓) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

Not sure yet?

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 10th

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? 12 for 28 students

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments: on ppt.

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments: on ppt →

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments: what I observed in gamet

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments: Same kinds of expts as generally done, few organelles in expt

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments: well done with LM + EM!

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments: Some will appreciate more than others

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments: Seemed to be.

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab already do this

( ) Paper Chromatography Lab would do w/ PS.

( ) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

( ) Animation

(✓) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

(✓) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9, 11, 12

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? _____

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
(1)	2	3	4	(5)

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

(✓) Animation

( ) Protein Production Game

(✓) Animal and Plant Cell Lab

(✓) Paper Chromatography Lab

(✓) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

(✓) Feeding Paramecia Lab

Comments: You have to order Paramecia for the lab which is time-consuming

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9th

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? 7

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments: Very good!

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments: Very good

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(✓) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

(✓) Feeding Paramecia Lab

Comments: The game seems a little confuse.

2. Which component is most effective?

(✓) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Don't know I need to use it first

Comments:

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: full time sub this year (1/2 of only in Science)

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 10th
   taught Biology 7 yrs mostly 10th some 9-12

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? Yes No

4. Do you have access to light microscopes for student use? (Yes) No not all in good working condition
   If yes, how many? 1/2 students

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments: good pic of onion skin retrieval technique!

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments: cute! Especially the components pic!

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

This is the analogy I used in class. (Last year a "city analogy" was also included for a different approach for students.)

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4) →	(5)

Comments: It's tough but can be done!!

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5) !

Comments: Excellent

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4) →	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments: ESP the envelope taking it outside the cell!

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments: usually

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4) <->	(5)

Comments: any analogy that is effective

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments: Absolutely!!!

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments: the envelope idea drives home visual Kinesthetic & of course verbaling's story (auditory) good ideas Jennifer!

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments: we talked it up (the virtual microscope suitcase) Testing organelles is a great idea TAKS & all over the comprehension of these organelle functions!!

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(✓) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab great ideas!!

Comments: super visual

2. Which component is most effective?

( ) Animation
( ) Protein Production Game
( ) Animal and Plant Cell Lab
( ) Paper Chromatography Lab
( ) Feeding Paramecia Lab

all of these I think need to be given = applause

Comments:

3. Which component is least effective?

( ) Animation possibly the animation would be least as compared to doing for the 6 I kids however visual is still necessary as a valuable component to tie in all labs animation game
( ) Protein Production Game
( ) Animal and Plant Cell Lab
( ) Paper Chromatography Lab
( ) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 10

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? class set

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
(1)	2	3	4	(5)

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
(1)	2	3	4	(5)

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	(5)

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(✓) Animation

(✓) Protein Production Game

(✓) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

( ) Animation

(✓) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

(✓) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9-12

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? 14

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments: well explained

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments: good analogies & good use of humor

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

(X) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9-11 HS.

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? _____

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

love this!

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(✓) Animation

(✓) Protein Production Game

(✓) Animal and Plant Cell Lab

(✓) Paper Chromatography Lab

(✓) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9th

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? _____

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments: a little boring

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? _____

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? _____

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	(2)	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(✓) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

(√) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

(√) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

The game requires students to follow verbal instructions, work with a group and manipulatives. I think this is too much for students to coordinate. Also protein production is taught in more depth and I don't feel captures the the true concepts and details that a high school class addresses.

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9-12

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? class set

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

( ) Animation

(✓) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

(✓) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9th

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? 20

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(X) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

(X) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

(X) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

(X) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments: None

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 10th

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? 4

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	(5)

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(✓) Animation

( ) Protein Production Game

(✓) Animal and Plant Cell Lab

(✓) Paper Chromatography Lab

(✓) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

(✓) Animation

( ) Protein Production Game

(✓) Animal and Plant Cell Lab

(✓) Paper Chromatography Lab

(✓) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

(✓) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

This depends on the profile of the class.

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9-12

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? Class Set

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	(4)	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

12. The game is effective in teaching the functions of the different organelles in the production of a protein.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

13. The use of teamwork and competition will keep students involved and interested in the game.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

14. The factory analogy is effective in tying the animation and game together.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

15. The suitcases are easy to transport.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

16. The components of the suitcase are appropriate for the target audience (high school Biology students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

(/) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

(/) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

ORGANELLE EXTRAVAGANZA

A Portable Science Suitcase for High School Biology Students

INSTRUCTIONS

Please circle the answer that best applies to you.

1. Are you a: (Teacher) Administrator Other: _____

2. Do you currently teach Biology? (Yes) No
   If yes, what grade? 9th

3. Do you have access to a DVD player or a projector to play a DVD in your classroom? (Yes) No

4. Do you have access to light microscopes for student use? (Yes) No
   If yes, how many? ~20

INSTRUCTIONS

Please circle the number that most closely corresponds with your attitude toward the statement. Space for additional comments is available after each statement.

1. The Teacher's Manual is clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

2. The Student Handouts are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	(3)	4	5

Comments:

3. The instructions for the labs are clear, concise and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

4. The photographs are beneficial to the lab instructions.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

5. The lab experiments are beneficial in teaching students about organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

6. The animation clearly explains organelle structure and function.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

7. The use of the factory analogy is effective

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

8. The integration of a cellular model, electron micrographs, and the factory cartoon clearly explains organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

9. The questions throughout the video are helpful in keeping the students engaged.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

10. The animation appeals to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

11. The game instructions are clear and easy to follow.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
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15. The suitcases are easy to transport.

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Comments:

17. The components of the suitcase will fit into my current curriculum.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

18. The components of the suitcase will enhance my current curriculum for teaching organelles.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

19. The components of the suitcase will help students with the TEKS and TAKS.

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Comments:

20. I would recommend this Science Suitcase to other teachers.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Comments:

INSTRUCTIONS

Please mark all that apply.

1. Which component(s) would you most likely use in your classroom?

(√) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

(√) Feeding Paramecia Lab

Comments:

2. Which component is most effective?

(√) Animation

( ) Protein Production Game

( ) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

3. Which component is least effective?

( ) Animation

( ) Protein Production Game

(√) Animal and Plant Cell Lab

( ) Paper Chromatography Lab

( ) Feeding Paramecia Lab

Comments:

THANK YOU FOR YOUR TIME

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