Model Organisms:

Their Use in Biomedical Research

A Unit for High School Biology

by Rebecca Wheeler

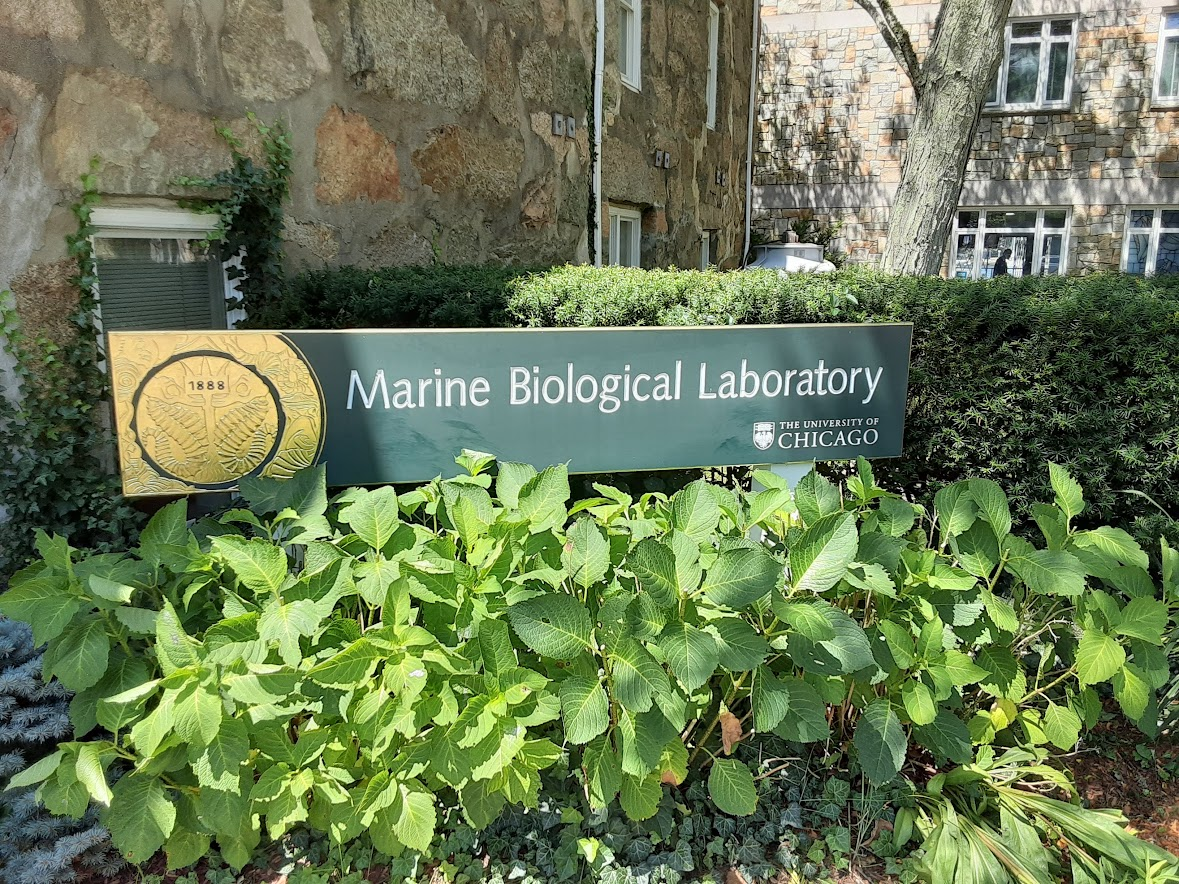


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# Curriculum Overview

| Stage 1: Desired Results | |
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| Standards   * [Massachusetts High School Science and Engineering Practices](https://www.doe.mass.edu/frameworks/scitech/2016-04.pdf) (pages 72-73 and Appendix 1) * [NGSS Science and Engineering Practices](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf) * [NGSS Nature of Science Understandings](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf) | Essential Questions   * How are model organisms used in scientific research? * How can humans benefit from biomedical research? * How is proper scientific research conducted? |
| Enduring Understandings   * Model organisms are an essential component of biomedical research * Biomedical research leads to improvements in human health * The scientific method is the foundation of biomedical research |
| Transfer  *At the end of this unit, students will be able to…*   * Critically analyze scientific research * Develop and conduct an independent scientific investigation |

| Stage 2: Evidence | | |
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| Formative Assessments:   * Lesson 1:   + Student Notes from Table Talk/Think-Pair-Share   + Wrap-Up Padlet * Lesson 2:   + Notes from Warmup Activity (Facts about the MBL)   + Sticky Note Evaluations * Lesson 3:   + Outline of Experiment/Study * Lesson 4:   + Pre-Lab Questions/Experimental Procedure   + Rough Draft of Lab Report | | Summative Assessments:   * Lesson 1:   + “What is a Model Organism?” Handout * Lesson 2:   + MBL Model Organism Poster * Lesson 3:   + “Jigsaw Activity” Handout * Lesson 4:   + Final Lab Report |

| Stage 3: Learning Plan | | | | |
| --- | --- | --- | --- | --- |
| Lesson Number | Lesson Name | Brief Description | Time | Standards |
| 1 | Introduction to Model Organisms | Students make observations of photos of typical model organisms. They then find information about why model organisms are used in scientific research. | One 50 minute class period  (50 min total) | * [Massachusetts High School Science and Engineering Practices](https://www.doe.mass.edu/frameworks/scitech/2016-04.pdf) (pages 72-73 and Appendix 1) * [NGSS Science and Engineering Practices](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf) * [NGSS Nature of Science Understandings](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf) |
| 2 | Model Organisms of the MBL | Students learn about the Marine Biological Laboratory (MBL) and the particular model organisms utilized in its facilities. In small groups, students then research one of these species and create a poster based on their findings. | Three 50 minute class periods  (150 min total) |
| 3 | Research with Model Organisms | Students analyze specific studies/experiments that involve model organisms. They share their findings with their peers through a jigsaw activity. | Two 50 minute class periods (100 min total) |
| 4 | Yeast and Caffeine Lab | In small groups, students create their own experiment to determine the effects of caffeine on the model organism of yeast. Each student writes a lab report based upon their experimental findings. | Four 50 minute class periods (200 min total) |

# Lesson 1: Introduction to Model Organisms

| Lesson 1: Overview | |
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| Lesson Overview:  This lesson serves as an introduction to the concept of a model organism. First, students view photos of various model organisms commonly used in biomedical research. They make visual observations about the organisms and respond to questions posed by the teacher. They then view Internet resources to answer questions about model organisms. To conclude the lesson, each student posts a response in a Padlet as an “exit ticket.” | Lesson Objectives:  *At the end of the unit, students will be able to…*   * Explain the purpose/use of a model organism in scientific research * Summarize the characteristics of an ideal model organism * Discuss the pros and cons of using model organisms |
| Standards:   * [Massachusetts High School Science and Engineering Practices](https://www.doe.mass.edu/frameworks/scitech/2016-04.pdf) (pages 72-73 and Appendix 1) * [NGSS Science and Engineering Practices](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf) * [NGSS Nature of Science Understandings](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf) | Timing:   * One 50 minute class period (50 min total) |
| Materials:   * Computer and Internet access * Large board or screen (i.e. SMART Board) * “Table Talk/Think-Pair-Share” document * Student notebooks * “What is a Model Organism?” handout | Assessment:  *How will the teacher know that the lesson objectives have been met?*   * Each student will verbally communicate with their partner or group. * Each student will write responses in their notebook. * Each student will submit an accurate, completed handout. * Each student will contribute a response to the assigned Padlet. |

| Lesson 1: Activities | | | |
| --- | --- | --- | --- |
| *Time* | *Activity* | *Teacher is…* | *Students are…* |
| Period #1  10 min | Table Talk / Think-Pair-Share | * Displaying photos of model organisms on board/screen for students to view * Audibly posing questions to the class * Walking around the classroom to listen to and encourage student conversations | * Working as a table or with a partner to discuss answers to the teacher’s questions * Writing down answers to questions in notebooks |
| Period #1  5 min | Class Discussion | * Asking students to volunteer answers to their questions * Revealing the species name of each organism pictured | * Volunteering answers * Listening to their peers’ responses |
| Period #1  25 min | “What is a Model Organism?” Handout | * Providing each student with a paper copy of the “What is Model Organism?” handout * Stating the directions for completing this handout * Checking in on each student’s progress as they complete the handout | * Completing the “What is a Model Organism?” handout with their table or partner   + Reading the Internet articles   + Writing answers to the questions based on these articles |
| Period #1  10 min | Wrap-Up: Padlet | * Asking each student to respond to these two prompts using the Padlet app:   + “Describe the most interesting fact you learned about model organisms.”   + “What is one further question you have about model organisms, or what are you curious about?” * Sharing the link to the Padlet with students * Displaying the class’s Padlet on the board | * Responding to the teacher’s prompts using the Padlet app |

# Lesson 2: Model Organisms of the MBL

| Lesson 2: Overview | |
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| Lesson Overview:  This lesson allows for an in-depth exploration of model organisms. Students learn about the Marine Biological Laboratory (MBL) and its utilization of model organisms. Then students research one of these species and with a partner/small group create a poster showcasing its characteristics. Posters are presented to the class. | Lesson Objectives:  *At the end of the unit, students will be able to…*   * Explain the role of the Marine Biological Laboratory (MBL) in the scientific community * Identify the species of model organisms found at the MBL * Describe the unique characteristics of a specific MBL model organism and how it has contributed to biomedical research |
| Standards:   * [Massachusetts High School Science and Engineering Practices](https://www.doe.mass.edu/frameworks/scitech/2016-04.pdf) (pages 72-73 and Appendix 1) * [NGSS Science and Engineering Practices](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf) * [NGSS Nature of Science Understandings](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf) | Timing:   * Three 50 minute class periods (150 minutes total) |
| Materials:   * Student notebooks * Computer and Internet access * Poster boards * Colored pencils and/or markers * “Poster Project” handout * Sticky notes | Assessment:  *How will the teacher know that the lesson objectives have been met?*   * Each student will respond to the warmup activity in their notebook * In groups, students will create a poster that fulfills specific criteria * In groups, students will present their posters to their classmates * Each student will complete an evaluation for every group |

| Lesson 2: Activities | | | |
| --- | --- | --- | --- |
| *Time* | *Activity* | *Teacher is…* | *Students are…* |
| Period #2  10 min | Warmup: Fast Facts About the MBL | * Directing students to the Marine Biological Laboratory (MBL) website * Asking students to individually write down 5 facts about the MBL using the website as a resource * Walking around the room to check on individual student progress | * Viewing the Marine Biological Laboratory (MBL) website * Finding facts and writing them down in their notebook |
| Period #2  10 min | Overview of the MBL and its Model Organisms | * Asking students to volunteer their facts * Discussing the [basics of the MBL](https://www.mbl.edu/about) and then focusing on its [Marine Resource Center](https://www.mbl.edu/research/resources-research-facilities/marine-resources-center) * Showing [“Amazing Organisms Found at the MBL”](https://vimeo.com/688475848) video | * Volunteering their facts to the class * Listening to their peers’ facts * Listening to the teacher’s introduction to the MBL * Viewing the video on the screen |
| Period #2  10 min | Introduction to the Poster Project | * Explaining directions for the MBL Model Organism Poster project * Providing students with the “Poster Project” handout | * Reviewing the “Poster Criteria” handout * Choosing an organism that is listed on the handout |
| Period #2  20 min | Poster Project Research | * Walking around the room to check on student progress * Offering suggestions and guiding student research | * Researching their model organism and recording findings into their notebook |
| Period #3  15 min | Recap and Finish Research | * Summarizing the previous period’s activities * Offering suggestions and guiding student research | * Finishing research * Checking in with the teacher to determine if they have fulfilled the research requirements |
| Period #3  40 min | Poster Work | * Providing students with materials to create their posters * Checking in with groups to evaluate progress | * Working on the poster (writing and drawing) |
| Period #4  30 min | Recap, Presentations, and Sticky Note Evaluations | * Summarizing the previous period’s activities * Pass out several sticky notes to each student * Explaining theSticky Note Evaluations procedure:   + During each group’s presentation, each student will write down the following on a sticky note:     - One thing the group did well     - One thing the group could improve     - One question for the group * Moderating presentations * Reminding students to fill out a sticky note for each group * At the conclusion of the presentations, direct students to give their sticky notes to the appropriate groups | * With their partner/group students will verbally present their poster to the class (discussing their findings and showcasing the drawing of their organism) * Filling out sticky notes while listening/watching the other groups’ presentations * When directed by the teacher, students will give their sticky notes to the groups |
| Period #4  20 min | Review Evaluations and Discussion | * Asking the groups to read through the sticky note evaluations they have received from their peers * Asking volunteers from each group to attempt to answer the questions posed by other students | * With their partner/group students will read through and discuss the evaluations * Answer questions from their peers |

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# Lesson 3: Research with Model Organisms

| Lesson 3: Overview | |
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| Lesson Overview:  This lesson enables students to connect their knowledge of the scientific method with real, current research involving model organisms. In a jigsaw activity, students learn about several experiments/studies. First, students are placed into groups of four. Each student in the group reads a different article about a particular experiment/study and completes a written outline. Next, they meet with others who were assigned the same article and together they create a summary of the experiment/study. Finally, students reconvene with their original group and share their summaries. | Lesson Objectives:  *At the end of the unit, students will be able to…*   * Explain the steps of the scientific method * Summarize the use of model organisms in real scientific experiments or studies * Analyze a real scientific experiment or study in terms of the scientific method * Evaluate the criteria for a successful scientific experiment or study |
| Standards:   * [Massachusetts High School Science and Engineering Practices](https://www.doe.mass.edu/frameworks/scitech/2016-04.pdf) (pages 72-73 and Appendix 1) * [NGSS Science and Engineering Practices](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf) * [NGSS Nature of Science Understandings](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf) | Timing:   * Two 50 minute class periods (100 min total) |
| Materials:   * Student notebooks * “The Scientific Method Overview” Handout * Paper copies of the 4 different articles * “Jigsaw Activity” handout * Blank paper (for the first part of Jigsaw Activity) | Assessment:  *How will the teacher know that the lesson objectives have been met?*   * Each student will complete a written outline of an experiment/study * Each student will contribute to their “home” and “expert” groups * Each student will complete and submit the “Jigsaw Activity” handout |

| Lesson 3: Activities | | | |
| --- | --- | --- | --- |
| *Time* | *Activity* | *Teacher is…* | *Students are…* |
| Period #5  15 min | Warmup: Review of the Scientific Method | * Requesting that each student respond to this prompt in their notebook: “List anything you can remember about the scientific method.” * Walking around the room to ensure students are writing * After 5 min, asking students to share their response with the person sitting next to them * Passing out “The Scientific Method Overview” handout to each student * Verbally reviewing the handout with the class and clarifying any confusion | * Writing their response to the teacher’s prompt in their notebooks * Sharing their response with the person next to them * Reading “The Scientific Method Overview” handout * Listening to the the teacher’s lecture and asking any questions they may have about the content |
| Period #5  5 min | Instructions and Formation of Home Groups | * Passing out the “Jigsaw Activity” handout and blank paper to each student * Randomly assigning students into “home” groups of four (one method: counting off) * Explaining the first part of the Jigsaw Activity, which is to read an article and complete a written outline (blank paper may be used) | * Listening to the teacher’s instructions and reading through the “Jigsaw Activity” handout * Writing down the names of their group members |
| Period #5  30 min | Article Analysis (Individual) | * Making sure each student knows their assigned article * Checking in with each student as they complete the outline and answering any questions that arise | * Reading their assigned article * Completing the written outline |
| Period #6  5 min | Instructions and Formation of Expert Groups | * Explaining the second part of the Jigsaw Activity, which is to meet with their “expert” group (those who were assigned the same article) * Explaining that the expert group will discuss the article and compose a written summary of the experiment/study * Ensuring that the groups are properly arranged | * Listening to the teacher’s instructions * Finding their expert group members and sitting in a designated area with them |
| Period #6  20 min | Work with Expert Group | * Observing the progress of the expert groups and offering suggestions | * Discussing their article within expert groups * Contributing to the summary of the experiment/study |
| Period #6  25 min | Instructions and Work with Home Group | * Requesting that students meet with their original home group to complete the last part of the Jigsaw Activity, which is to share summaries and answer analysis questions together * Observing the progress of the home groups and offering suggestions * Collecting the “Jigsaw Activity” handout from each student | * Finding their home group members and sitting in a designated area with them * Completing the final part of the Jigsaw Activity with their home group * Handing in their completed “Jigsaw Activity” handout |

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# Lesson 4: Yeast and Caffeine Lab

| Lesson 4: Overview | |
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| Lesson Overview:  The purpose of this lesson is to allow students to practice the scientific method and work with an actual model organism. In small groups, students develop an experimental procedure to determine the effect of caffeine on yeast population growth. The teacher provides materials, background information, and demonstrations. With teacher approval, each group conducts their experiment. Finally, each individual student completes a written lab report based upon their group’s findings. | Lesson Objectives:  *At the end of the unit, students will be able to…*   * Develop and conduct a scientific experiment utilizing a model organism * Analyze data to answer an experimental question * Identify limitations and sources of error encountered during experiments * Relate experimental results to the broader themes of biomedical research and human health |
| Standards:   * [Massachusetts High School Science and Engineering Practices](https://www.doe.mass.edu/frameworks/scitech/2016-04.pdf) (pages 72-73 and Appendix 1) * [NGSS Science and Engineering Practices](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf) * [NGSS Nature of Science Understandings](https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf) | Timing:   * Four 50 minute class periods (200 min total) |
| Materials:   * “Yeast and Caffeine Lab” handout * Lab materials (see handout) * Student notebooks * Computer access (for writing lab reports) | Assessment:  *How will the teacher know that the lesson objectives have been met?*   * Students will work with their lab groups to answer Pre-Lab Questions and develop an experimental procedure * Each student will actively participate in their group’s procedure * Each student will complete and submit a written lab report |

| Lesson 4: Activities | | | |
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| *Time* | *Activity* | *Teacher is…* | *Students are…* |
| Period #7  5 min | Introduction to the Lab | * Distributing the “Yeast and Caffeine Lab” handout * Requesting that students silently read through the handout * Arranging students into groups of 3 or 4 | * Reading the “Yeast and Caffeine Lab” handout * Meeting with their lab group members |
| Period #7  15 min | Review of Materials and Demonstrations | * Verbally reviewing the handout * Showing students materials that may be used in their experiments * Demonstrating how to use the digital scale, make solutions, and prepare microscope slides * Reviewing lab safety | * Listening to and watching the demonstrations * Asking questions about lab equipment and procedures |
| Period #7  30 min | Pre-Lab Questions | * Explaining that each student needs to complete the Pre-Lab Questions with their group * Checking in with each group to answer any questions/provide clarification | * Working with their group members to complete the Pre-Lab Questions * Writing answers to the Pre-Lab Questions in their notebooks |
| Period #8  20 min | Consultation with Teacher | * Meeting with each group to read through their Experimental Procedure and providing feedback | * Meeting with the teacher to gain approval of their group’s Experimental Procedure * Revising their group’s Experimental Procedure if needed |
| Period #8  15 min | Setup of Experiment | * Assisting groups with experimental setup | * Working with their group members to gather materials |
| Period #8  15 min | Data Collection | * Checking in with each group to monitor progress | * Collecting and recording initial data |
| Period #9  50 min | Data Collection | * Checking in with each group to monitor progress | * Collecting and recording data |
| Period #10  25 min | Data Collection | * Checking in with each group to monitor progress | * Collecting and recording data |
| Period #10  5 min | Review of the Lab Report Format | * Verbally discussing the Lab Report Format described in the “Yeast and Caffeine Lab” handout | * Reading the Lab Report Format on the handout * Listening to the teacher and asking clarifying questions |
| 20 min | Work on Lab Report | * Instructing students to work on the rough draft of their lab report | * Individually writing a rough draft of the lab report * Consulting with lab group members |

# Resources For Teachers

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| Lesson 1: |
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| Jane AlfredIan T Baldwin (2015) The Natural History of Model Organisms: New opportunities at the wild frontier eLife 4:e06956.<https://elifesciences.org/articles/06956>Ankeny, R., & Leonelli, S. (2021). Model Organisms (Elements in the Philosophy of Biology). Cambridge: Cambridge University Press. doi:10.1017/9781108593014<https://www.cambridge.org/core/elements/model-organisms/F895B26EAC0373BCA5A138835AC73AEA>Hu, C. (2023) Of mice and model organisms, Cold Spring Harbor Laboratory.<https://www.cshl.edu/of-mice-and-model-organisms/>Why Do Scientists Use Model Organisms? (Video): <https://www.youtube.com/watch?v=ljKZiaEn_BA>4 Weird Lab Animals (Video): <https://www.youtube.com/watch?v=v4ePpLoS6xw> |
| Lesson 2: |
| [About the Marine Biological Laboratory](https://www.mbl.edu/about) (from the MBL website)[The Marine Resources Center of the MBL](https://www.mbl.edu/research/resources-research-facilities/marine-resources-center) (from the MBL website)[“Amazing Organisms Found at the MBL”](https://vimeo.com/688475848) (video from the MBL website)[Creature Feature: MBL Organisms](https://www.mbl.edu/news/creature-feature-mbl-organisms) (links to videos and specific lab websites, from the MBL website)[“To Solve Old Problems, Study New Species,”](https://www.ted.com/talks/alejandro_sanchez_alvarado_to_solve_old_problems_study_new_species?_ga=2.71977683.1543607731.1691181534-521204225.1688676074) A TED Talk from MBL Fellow Alejandro Sánchez Alvarado about looking beyond the typical model organisms |
| Lesson 3: |
| [Science Journal For Teens](https://www.sciencejournalforkids.org/) (the source for the articles used in Lesson 3)[Jigsaw Activities](https://www.bell-foundation.org.uk/eal-programme/guidance/effective-teaching-of-eal-learners/great-ideas/jigsaw-activities/#:~:text=What%20are%20jigsaw%20activities%3F,then%20become%20the%20experts%20in.) (general instructions from the Bell Foundation) |
| Lesson 4: |
| [Using Yeast in Biology](https://www.yourgenome.org/stories/using-yeast-in-biology/) (from the yourgenome.org website)Goudsouzian, L.K., McLaughlin, J.S., and Slee, J.B. 2017. Using Yeast to Make Scientists: A six-week student-driven research project for the Cell Biology laboratory. CourseSource. <https://doi.org/10.24918/cs.2017.4>Garlock, Caitlyn. Yeast Population Lab. <http://msgarlock.weebly.com/uploads/2/8/1/7/28176599/ahs_bio14_ecology_yeastlab.pdf> |