Survey of Biology

Lab Manual

WICHE
Western Interstate Comission
for Higher Education

NANSLO
NORTH AMERICAN NETWORK
OF SCIENCE LABS ONLINE

2016

NANSLO

NANSLO Overview Lab Manual

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NANSLO Mission

NANSLO provides a consortium approach to the development and deployment of high-quality, modular, openly licensed courseware integrating learner-centered and immersive web-based labs using software, video, and robotics for the study of science courses.

The North American Network of Science Labs Online (NANSLO) provides students the ability to conduct lab activities with state-of-the-art science equipment using robotics, software, and web cams over the Internet. From any computer, students can log into a lab interface and manipulate the controls to conduct real-time experiments. The interface also allows participants to communicate with lab partners, ask for assistance from a knowledgeable lab technician, and collect data and images for their assignments.

How NANSLO works

1. Faculty use the centralized scheduling system to reserve a block of time for students to perform assigned NANSLO lab activities.

2. When a reservation is made, a unique URL and PIN are generated. Faculty give their students this information, and students use it to access the scheduling system and select a day and time within the reserved block to complete the lab activity.

3. Once connected to the NANSLO lab, students have access to real scientific lab equipment that lets them:
   - Engage in authentic instrumental experimentation;
   - Collect real-time data and capture it electronically;
   - Experiment with different settings to see the impact on the data being observed and collected;
   - Generate graphs and data to insert into lab reports;
   - Capture high-resolution images;
   - Collaborate with classmates and lab personnel through voice conferencing.

NANSLO Laboratory Locations

The NANSLO network's hub is based at the Western Interstate Commission for Higher Education (WICHE) in Boulder, CO. Currently, the network includes two laboratories.

- North Island College (NIC), Courtenay, British Columbia

- Great Falls College Montana State University (GFCMSU), Great Falls, Montana

Lab Equipment

Each lab that you will be conducting uses robotics that you control to complete the experiment. The robotics are attached to scientific equipment that correspond to each specific experiment.

Measurement

- Controllable camera
- Fish tank
- Measuring Tools
- Video camera

Introduction to Microscopy

- Compound microscope
- Auto slide loader
- Letter “e” whole mount slide
- Colored threads slide
- Video camera

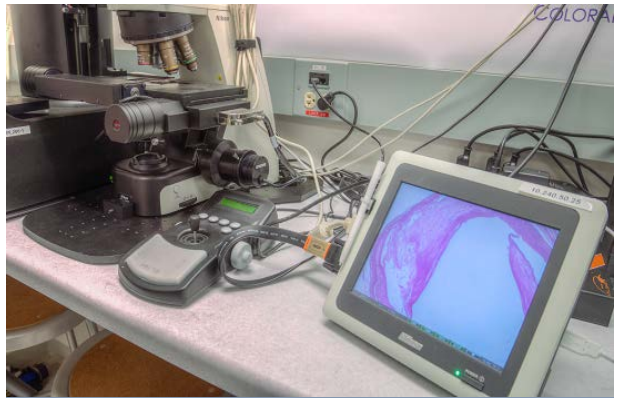
Cell Type Comparison

- Compound microscope
- Auto slide loader
- Elodea leaf whole mount slide
- Frog skin slide
- Bacteria forms smear slide
- Mixed Protozoa whole mount slide
- Video camera

Lab Equipment

Each lab that you will be conducting uses robotics that you control to complete the experiment. The robotics are attached to scientific equipment that correspond to each specific experiment.

Mitosis & Meiosis

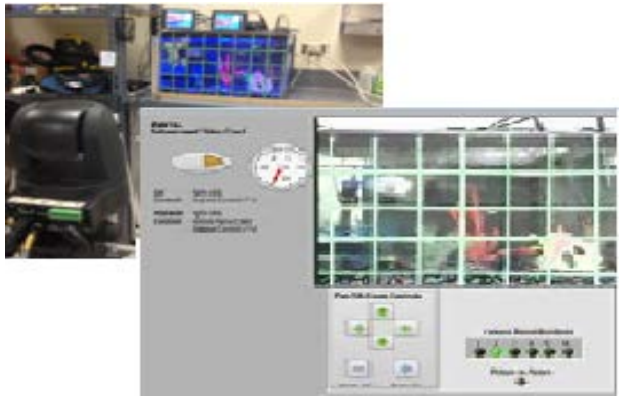


- Compound microscope
- Auto slide loader
- Whitefish blastula slide
- Onion root tip slide
- Video camera

Photosynthesis

- Terrarium
- Gas probe (oxygen and CO_2)
- Temperature probe
- Heat exchanger
- Plant material
- Grow lights
- Video camera

Ecology

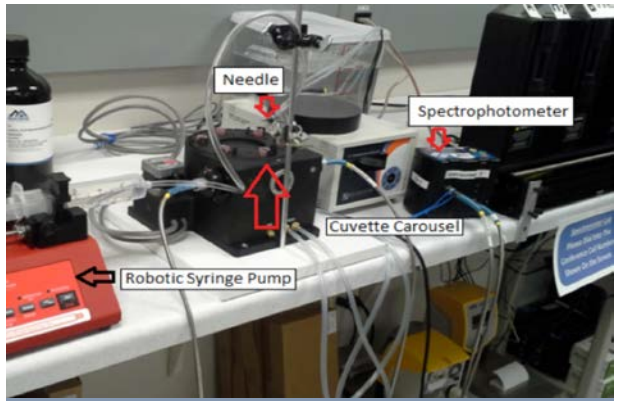


- Fish tank with plant and animal organisms
- Sensors: temperature, pH, dissolved oxygen, nitrates
- Video camera

Lab Equipment

Each lab that you will be conducting uses robotics that you control to complete the experiment. The robotics are attached to scientific equipment that correspond to each specific experiment.

Membrane Diffusion

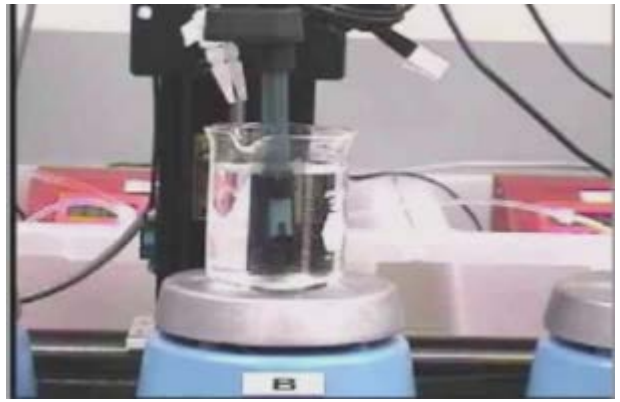


- Spectrophotometer
- Heating unit
- Cuvettes
- Cuvette carousel
- Starch solution
- Iodine solution
- Stir-bar
- Robotic syringe pump
- Video camera

Osmosis

- Compound microscope
- Slide of cell of a red onion leaf
- Slide of blood
- Hypotonic blood solution slide
- Hypertonic blood solution slide
- 20% salt solution
- Video camera

Acid/Base Titration



- Probe assembly
- Solutions in beakers
- Rinse beaker
- Acid solution (tank A)
- Base solution (tank B)
- Burettes
- pH and temperature sensors
- Heating unit
- Video camera

Lab Equipment

Reaction Rate

- Beakers
- Alka-Seltzer tablets
- Water
- Measuring device
- Video camera

Background Information for Instructor

Materials contained in this section:

- Using this Lab Manual
- NANSLO Network Scheduling System
- Scheduling a Lab
- Faculty Scheduling System Dashboard
- Preparation Tips
- Preparing Students for Success
- Reports and Assessment
- Getting Support
- Instructor Checklist

Using this Lab Manual

	Designed for
NANSLO Overview provides general information about NANSLO, the capabilities it offers to you and your students, our laboratory locations, and the equipment used for the NANSLO lab activities included in this lab manual.	*instructors but may be shared with students*
Background Information for Instructors provides general information for scheduling your assigned NANSLO lab activities; technical tips; things to consider in preparing students for success in these lab activities; reports available for use in determining student completion of lab activities; and a general checklist that can be used in preparing for assigned lab activities.	*instructor use only*
Instructions for Students provides general information for students to use in preparing for each NANSLO lab activity; technical requirements; instructions for making an appointment based on the times you have reserved; functions available on the scheduling system student dashboard; general instructions for completing assigned labs; and a general checklist that can be used in preparing for each assigned lab activity. *NOTE: This complete section should be given to students as it is applicable to all NANSLO lab activities in this lab manual.*	*student use only*
Survey of Biology Lab Activities contains ten lab activities. Each lab activity is complete. It contains a description of the lab activity; its purpose; essential question(s) to be answered; lab activity objectives; pre- and post-lab questions; background information; its applicability in real life and the work place; equipment setup; the control panel and instructions on how to use this web-enabled interface; a lab day checklist; information, observations, and activities to be completed while connected to the NANSLO Laboratory; an area to use in documenting data collected and images captured; analysis questions and procedures; reviewing results; and conclusions and reflections. Each lab activity has been written using an inquiry-based format. *NOTE: This section can be given to students as their lab manual or can be provided in modules as the student is assigned to each lab activity.*	*student use only*

NANSLO Network Scheduling System

In order to use these NANSLO lab activities through a NANSLO laboratory, your Institution must have an agreement with NANSLO to use its services and have a NANSLO Scheduling System Account.

Institution Administrator: Each Institution using NANSLO has appointed an Institution Administrator who enters course and faculty information into the system (see scheduler.nanslo.org for more information about this system.) This centralized system allows institutions from across the country and the world to provide students with access to NANSLO's laboratories and NANSLO lab activities through the Internet.

Username and Password: Your Institution Administrator is responsible for determining who will have access to this scheduling system. Once a faculty member record is entered into the scheduling system by the Institution Administrator, a unique username and password is generated and an email is sent to the primary email address entered.

Faculty Dashboard: If you have been given a username and password by your Institution Administrator, you have access to a Faculty Dashboard. Through that dashboard, you can make reservations, update reservations, send email notification to students who have made appointments for assigned NANSLO lab activities, and view student reports.

Have Questions?

- Is your Institution using NANSLO?
- Who is your Institution Administrator?
- Need more information on using your Faculty Dashboard or making a reservation?

Send your questions to schedulerhelp@nanslo.org. Please include your contact name and number and information on the topic you need help on.

Scheduling a Lab

Ten reservations are required as a reservation is made by you or your Scheduling System Institution Administrator for each lab activity in this Lab Manual. Each reservation generates a unique URL and PIN number that you will provide to your students to enable them to make appointments during the block of time reserved. The information entered for each reservation is:

1. The name of the NANSLO lab activity.
2. A range of dates when that NANSLO lab activity is assigned to your students.
3. The number of students who are assigned to that NANSLO lab activity.
4. The number of students who will work together online. Typically 4 or 5 students work together and use a teleconferencing capability to collaborate.
5. The number of laboratory sessions needed for that reservation are computed (number of students/team size.) Select the number of laboratory sessions needed from the list of available time blocks during the selected date range.
6. Upon completion of a reservation, an email is automatically generated to you if you are associated to the

Lab Usage and Capacity

- NANSLO laboratories offer flexible hours (days and evenings)
- NANSLO laboratories are usually open on Saturday
- Multiple laboratory stations allow large numbers of students to be served at the same time
- Each student group can access different scientific equipment at the same time through the NANSLO laboratory

Faculty Dashboard

If you have been given a username and password by your Scheduling System Institution Administrator, you will have access to a customized dashboard. Use the Faculty Dashboard to:

1. Add reservations and update reservations you have already made.
2. Access Student Rosters to determine which students have and have not made appointments to complete each of these assigned NANSLO lab activities.
3. Access Student Reports to determine which students accessed the NANSLO laboratory, how long they remained online, and viewing any comments appended to individual student records.
4. Review information on reservations made.
5. Edit your profile.
6. Assign a Section ID to your course if not done by the Institution Administrator.

If you have been given a Username and Password by your Scheduling System Institution Administrator, go to scheduler.nanslo.org, select the "I am a faculty or administrator" button, and enter your username and password to access the Faculty Dashboard. Need to know who your Institution Administrator is? Send an email to schedulerhelp@nanslo.org.

Preparation Tips

Unique URL and PIN for Each Reservation: Remember to give students the unique URL and PIN for each reservation made for each NANSLO lab activity.

Try It Out Before Assigning it to Students: NANSLO encourages faculty to try out NANSLO before assigning students a NANSLO lab activity. It helps you answer your student's questions about how to set up an appointment, how to use the equipment, and other basic questions. The measurement activity is a good one to use.

Computer Equipment: Currently NANSLO lab activities cannot be performed on cell phones and tablets. We're working on it. So students need to use a computer for these activities.

Technical Issues and Internet Connectivity: Most students have had very little technical difficult when accessing NANSLO laboratories. However, very slow connections may impact your student's experience especially when viewing the video stream on the NANSLO control panel showing the equipment and activity as it is performed.

Access to NANSLO Control Panel: We are moving toward delivering our control panel using HTML 5; however, in some instances, your students may be required to download a piece of software (Citrix receiver) to their computers.

Campus Firewalls: On occasion, accessing the NANSLO laboratory through campus computers my be an issue. If you are demonstrating a NANSLO lab activity to students, it is a good idea to test it out in advance.

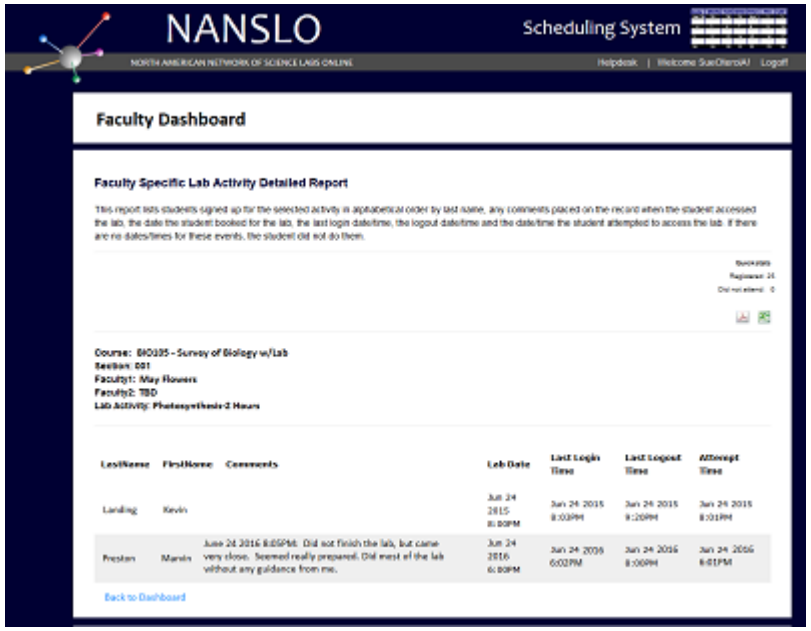
We're Here to Help: Email NANSLO at schedulerhelp@nanslo.org

Preparing Students for Success

- Review the lab information, objectives, and essential questions to identify questions your students may have or to make changes you see appropriate for your course.
- Recommend students make appointments as soon as possible (window for making appointments begins two weeks before the reservation start date) if specific days of the week or times of the day are needed.
- Access your Faculty Dashboard, review your Roster, and remind students that have not made an appointment to do so.
- Discuss or demonstrate how students access the NANSLO laboratory before the start date of the assigned NANSLO lab activity.
- Show students how to capture images on their computer and paste them into a document and how to use a spreadsheet to document data that has been collected.
- Provide additional resources that assist students in understanding the concepts they will be learning in the assigned NANSLO lab activity.
- Share samples of lab reports with your students.
- Encourage students to review tutorials and other material to prepare themselves before connecting to the NANSLO laboratory.
- Remind students to connect to the teleconferencing capability as soon as they connect to the NANSLO laboratory to collaborate with team members and NANSLO lab technicians.
- Let students know that lab technicians are online and available to help them with technical issues.
- After the lab, provide time for students to share and compare results, discuss challenges, and reflect on learning.
- Facilitate group discussions on how these NANSLO lab activities complement everyday life and work experiences.

Reports and Assessment

Student Activity Reports: Several reports are available through your Faculty Dashboard you can use determine if students have made an appointment for an assigned NANSLO lab activity and the time spent working through the activity.



Detailed Student Reports provide information about:

- Who made an appointment for an assigned lab.
- Who made an appointment and didn't show up for the lab.
- Who attempted to access the lab on the selected date and time and were unable to log into the lab station computer.
- What time a student logged in and logged out, allowing faculty to determine time spent in the laboratory.
- Notes appended to individual student records by lab technicians.

Student Roster

- Lists the names, contact information, and date and time selected by those students to access the NANSLO laboratory and perform the NANSLO lab activity.

Assessments: The lab objectives and essential questions serve to guide the outcomes for each lab. Look for pre- and post-quizzes, guiding questions, data analysis, and lab reports to assess learning. Rubrics may also be associated with labs to assist in scoring.

Getting Help

Provide information on who to contact

Instructor Checklist

- ❑ Preview lab, watch tutorials
- ❑ Test software
- ❑ Schedule lab
- ❑ Introduce concepts and lab to students
- ❑ Guide students by assigning tutorials on NANSLO and lab
- ❑ Preview lab with students and conduct a Q & A session
- ❑ Show examples of same lab procedure done in person
- ❑ Clarify your expectations for outcomes
- ❑ Review Student Activity Reports, and contact students as needed
- ❑ Conduct discussions to review results, challenges, and questions
- ❑ Encourage student reflection and self-assessment for learning
- ❑ Assess outcomes and student learning

Instructions for Students

Material contained in this section:

- Preparing for Each Lab
- Technical Requirements
- Scheduling a Lab Appointment
- Student Dashboard
- Completing a Lab
- Getting Help
- Student Checklist

Preparing for Each Lab

There are ten NANSLO lab activities within this manual. Your instructor will provide dates when each activity will be completed by you and other details on turning in your work and a unique URL and PIN number for EACH activity.

Here are your steps for success.

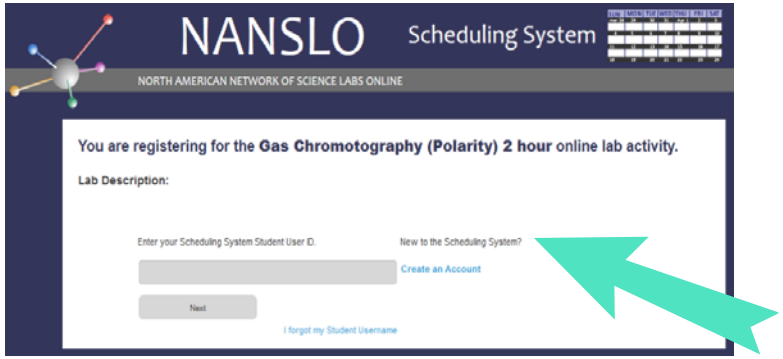
1. Carefully review the entire NANSLO lab activity.
2. Watch any accompanying videos or tutorials one or more times so you have a strong understanding of the content and experiment you will be conducting.
3. Copy any lab report sheets, as necessary, or create the digital documents and spreadsheets you will be using during the experiment.
4. Review the technical requirements for the lab and make sure you have access to a computer, Internet connection, and software that meets these requirements. (see p. XX)
5. Once you receive the unique URL and PIN from your instructor for this NANSLO lab activity, schedule your appointment as soon as possible (the appointment window begins two weeks before the start date of this NANSLO lab activity.) (see p. xx)

Technical Requirements

To prepare for a NANSLO lab activity, you must have:

- An Internet connection.
- Sufficient bandwidth (for example, your Internet Service Provider download speed is 5MB per second). If you have very slow Internet access, it will have an impact on your ability to view the images being transmitted to your computer.
- A computer (Mac or PC) — currently the NANSLO lab activities do not run on iPads, notepads, or cell phones.
- Sufficient knowledge on how to use a computer, e.g., how to use the right and left mouse buttons, capture images using those buttons, open software such as Word to paste images captured, where you have saved files on your computer.
- The appropriate browser to access the NANSLO lab activity. Currently, Google Chrome seems to be most effective; however, you can use Internet Explorer and Mozilla Firefox. Irrespective of the browser you use to access the NANSLO lab activity, the NANSLO web interface opens in Internet Explorer.

Scheduling a Lab Appointment



Using the NANSLO Network Scheduling System

This centralized system allows you to access NANSLO's laboratories and your assigned NANSLO lab activities through the Internet from across the country and the world.

Making your appointment:

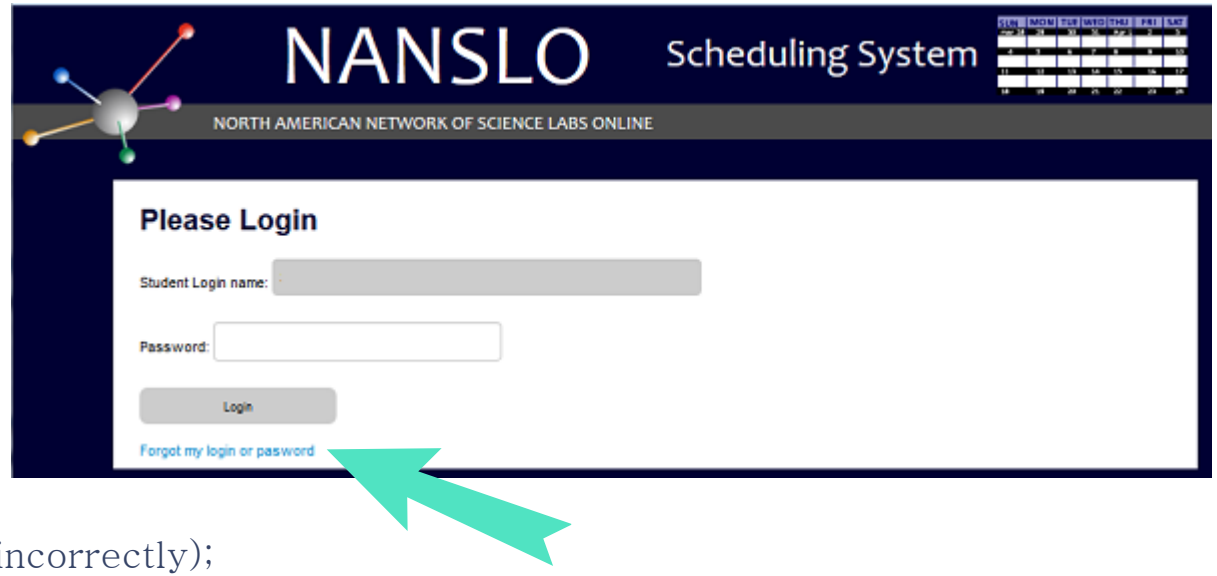
- Your instructor reserves a block of time (dates and times) for you to perform each assigned NANSLO lab activity.
- You will be provided with a unique URL and PIN number for each of these NANSLO lab activities.
- Enter that unique URL and PIN number to schedule an appointment within the specified block of time reserved.
- The system is set up on a first come, first serve basis so make your appointment early. The appointment window begins two weeks before the start date of your assigned lab (the first date selected by your instructor for his/her reservation.)
- An email notification is automatically sent out to you when an appointment is made providing more detailed information about your appointment and the NANSLO lab activity.
- The first time you use the scheduling system, you will also set up your scheduling system account. A username and password is automatically generated for you.
- Write down your scheduling system USERNAME and PASSWORD so you can access your Student Dashboard.
- Use your Student Dashboard to update your appointments and click on the links to those NANSLO lab activities you've made appointments posted on that dashboard to access the NANSLO lab activity on the date/time selected you selected for that appointment.
- See Scheduling a Lab – Students for information on how to set up an appointment, setting up your scheduling system account, and scheduling additional appointments.

Student Dashboard

After creating an account in the scheduling system and making an appointment, you have access to a student dashboard. To access your student dashboard, go to http://scheduler.nanslo.org. Select "I am a student." Enter your username and password.*

Forgot Your Username or Password?

If you have forgotten your username or password, select "Forgot my login or password." The information will be sent to your primary email address.

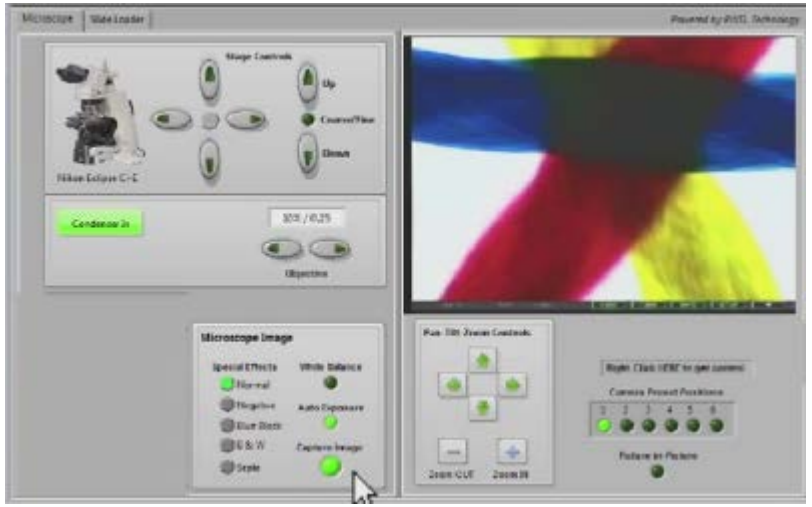


Your Student Dashboard is used to:

- Access your scheduled NANSLO lab activities on the dates and times selected;
- Modify your profile (including your email address, if it has changed or was entered incorrectly);
- Reschedule an appointment when needed;
- Resend the appointment confirmation email; and
- Perform other miscellaneous activities.

YOU DO NOT MAKE APPOINTMENTS through this dashboard.

Completing a Lab



Typically, NANSLO lab activities reference tutorials used to walk you through the specific functions on the NANSLO web interface used to control the scientific equipment for that activity.

Steps for Success:

- Study available NANSLO tutorials prior to the lab.
- Use the control panel to conduct the experiments.
- Record data using the functions available to collect data, create graphs, and take images.
- Copy these elements to the clipboard and then paste them into your lab reports, spreadsheets, or documents prepared for this lab.
- On the day and time of your lab appointment, use your Student Dashboard to access the link to your appointment.
- Use the Voice Conferencing tools to dial in and communicate with team members as soon as you connect to the laboratory. .
- Talk to the lab technicians to answer questions or help with technical issues as they are there to assist you.
- Once you have completed the steps in the laboratory, be sure you have copied and saved your data, graphs, and images for your reports to your computer (not the lab computer.)

You are now ready to review and analyze your results more deeply. Follow the lab and your instructor's directions to conclude the lab report and reflect on your learning.

Getting Help

Provide information on who to contact

Student Checklist

- ❑ Preview lab, watch tutorials, videos, and pre-lab activities
- ❑ Test software
- ❑ Schedule lab appointment
- ❑ Participate in discussions to prepare for lab
- ❑ Prepare documents needed to record lab work
- ❑ Review tutorials and support materials
- ❑ Complete lab at appointed time
- ❑ Participate in discussions through voice conferencing
- ❑ Analyze data and results and complete assignment
- ❑ Self-assess your learning

NANSLO

Survey of Biology

Lab Activities

NANSLO Survey of Biology Introduction

Survey of Biology introduces students to basic biology concepts. Students learn how to use scientific measurements, convert measurements, connect real world applications to biology principles learned, use the scientific method tin forming hypotheses, collecting data, interpreting data, and validating and modifying hypotheses, use basic laboratory equipment that supports theoretical principles presented, and prepare laboratory reports.

The NANSLO lab activities included here build on the skills introduced in the Survey of Biology course by providing students an opportunity to demonstrate competency in these areas.

Objectives:

- Use scientific measurements and convert measurements.
- Apply the scientific method when completing lab activities.
- Use the scientific equipment appropriately when working on lab activities.
- Demonstrate improvement in learning through pre- and post-lab questions.
- Connect how lab activities performed are used in real world applications by reviewing the examples provided.

Lab Descriptions

The Survey of Biology Lab Manual contains ten lab activities for you to complete all included in this Survey of Biology Lab Activities section of this Manual. As a guide, the icons shown here appear on all pages applicable to material included for each of these lab activity.

Measurement

Pages: 34-52

- In this lab, you will study the different types of measurements commonly used in labs, conversion between the metric and English systems, and how scientific notation is used to express large numbers. You will also learn to apply this understanding by taking remote measurements of temperature and volume of a fish tank.

Introduction to Microscopy

Pages: 53-75

- Microscopes have extended the eyes of biologists for centuries. In this lab, you will learn how to operate a typical compound lab microscope by virtually controlling and adjusting the mechanisms to bring specimens into focus at different magnifications. You will also explore how the image is positioned relative to changes in directional controls and explore the changes in depth of field and field of view relative to different lenses.

Cell Type Comparison

Pages: 76-95

- This lab allows you to study and compare different cell types, which are the foundation for most biological studies and research.

Lab Descriptions

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Mitosis

Pages: 96-118

- Mitosis is the process where new cells are generated from existing cells. In this lab, you will learn about the different stages in this process and make observations of plant and animal cells preserved during the different mitosis stages.

Photosynthesis

Pages: 119-136

Photosynthesis is a complex process essential in the study of biology, as it is the basis of all food chains and life on the planet. In this lab, you will use gas sensors to measure the amount and rate of oxygen produced and carbon dioxide consumed. From this data, you will plot the rate of photosynthesis over time as a function of the intensity of the light. You will also test your predictions on how different light wavelengths affect the rate of photosynthesis.

Ecology

Pages: 137-157

Ecology is the study of the interactions between organisms and their environment. Ecosystems are complex, dynamic systems which include all of the organisms within that community. In this lab, you will use both qualitative data and quantitative data to make observations and measurements around a defined ecosystem—in this case a fish tank.

Lab Descriptions

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Diffusion

Pages: 158-178

This laboratory activity will focus on the transport of molecules across a barrier via diffusion. Diffusion is the movement of things from a high concentration to a low concentration. In this lab, you will be using a spectrophotometer to quantitatively measure diffusion at different temperatures.

Osmosis

Pages: 179-198

Osmosis is a process where molecules move across cell membranes due to changing concentration gradients. This lab consists of two exercises to observe how cells change due to osmosis in plant and animal cells..

Acid/Base Titration

Pages: 199-215

A titration is a procedure to analyze a substance for a particular compound and can be used to find out the amount of chemical in a solution. In this lab activity, you will determine the concentration of an acid in a sample by adding a known quantity of a base.

Lab Descriptions

Reaction Rates

Pages: 216-229

The rate of a chemical reaction is the time it takes for a given amount of a reactant (what you start with) to change into the product (what you end with). Rate is affected by several factors. For this lab, you will observe how reaction conditions and surface area of matter change the rate of reaction in an Alka-Seltzer tablet and water mixture.

Measurement in Biology

Lab Description:

In this lab, you will study the different types of measurements commonly used in labs, conversion between the metric and English systems, and how scientific notation is used to express large numbers. You will also learn to apply this understanding by taking remote measurements of temperature and volume of a fish tank.

Purpose:

To practice measuring volume and temperature, and apply measurement unit conversion and scientific notation to collected data.

Essential Question:

How is measurement used to record data in biology?

Objectives:

At the completion of this lab, you should be able to:

1. Identify units of measurement for temperature, volume, mass, and length in metric and English (Imperial) systems.
2. Convert measurements between the metric and English units.
3. Use the NANSLO lab equipment to take length and temperature measurements.
4. Calculate volume in both metric and standard units.
5. Convert temperature between metric and standard units.
6. Express numbers using scientific notation.

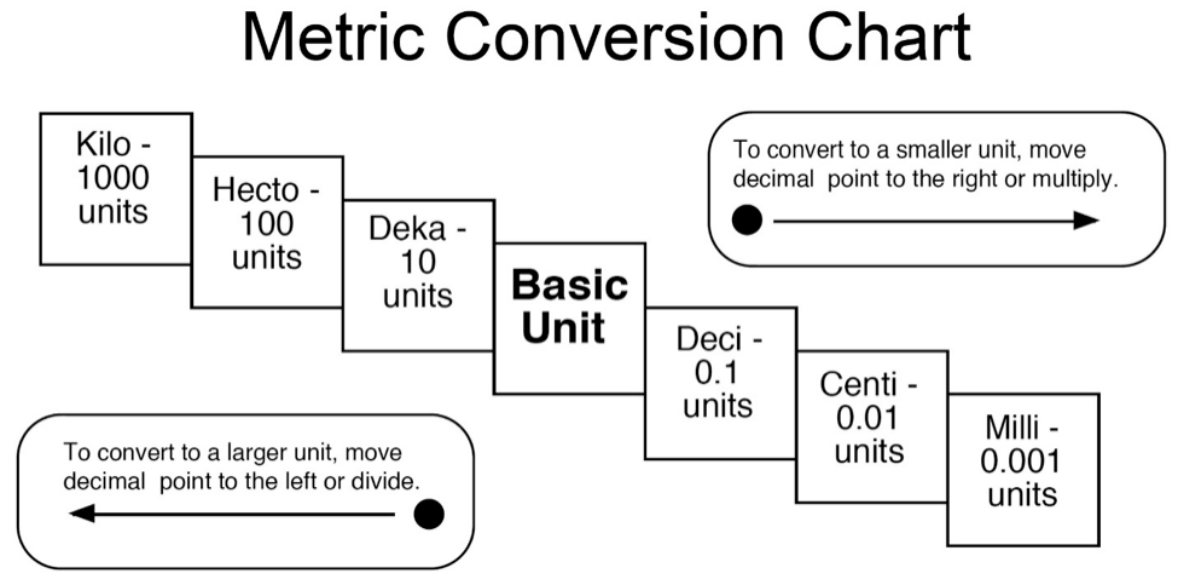
Pre-Lab Questions

These pre-lab questions are to help you think about the measurement lab and self-assess what you know and what you want to know about the topic. By the end of the lab, you should be able to answer these questions in more detail. Compare your answers to see what you have learned.

1. What is the difference between the metric and English (Imperial) system of measurement?
2. Why is the metric system applied to science investigations?
3. How are units converted between the two systems?
4. How is volume measured?
5. What is the difference between mass and weight?
6. What is scientific notation and how is it used?

Background Information

There are four basic types of measurements: length, volume, temperature, and mass. There are two main systems of measurement: the **English** (or **Imperial**) **system** and the **metric system**. The US and the UK are the main users of the English system, while the rest of the world primarily uses the metric system. You will need to become comfortable with conversions within and between the two systems. Since the metric system is a base 10 system, you can make conversions by moving the decimal to the left or right. If you know the prefix and the base unit, you can multiply or divide. For instance, to convert from centimeters to meters, jump two to the left: 360 centimeters is equal to 3.6 meters.



Background Information

The English (or Imperial) system is not as user friendly. To convert from one unit to another, you need to know the conversion factor. For instance, to convert inches to feet you need to know that there are 12 inches in 1 foot. So, to convert 360 inches to feet, use the conversion factor of 12 inches = 1 foot.

$$\frac{360\ \cancel{inches}}{\square} X \frac{1\ foot}{12\ \cancel{inches}} = 3\ feet$$

Conversions between the two systems can also be made. For instance there are 2.54 cm in 1 inch.

$$\frac{360\ \cancel{inches}}{\square} X \frac{2.54\ cm}{1\ \cancel{inches}} = 914.4\ cm$$

Measuring Length: In the metric system, length has a base unit of meter (m).

Measuring Volume: The base unit for volume is liter. One liter is equivalent to 1 cubic decimeter, which is 1 decimeter x 1 decimeter x 1 decimeter. Volume is a combination of 3 measurements (length x width x height).

Measuring Temperature: Temperature can be measured in Fahrenheit °F or Celsius °C. In most science labs, temperature is measured using the Celsius scale. It is called a centigrade thermometer because there are 100 (centi) divisions, i.e., degrees, between freezing of water at 0° C and the boiling point of water at 100° C. In Fahrenheit, freezing is 32° F and boiling is 212° F, which is 180 divisions.

To convert between °F and °C, do the following:

From °F to °C: 1) Subtract 32° from °F. 2) Multiply by 5. 3) Divide by 9.

From °C to °F: 1) Multiply °C by 9. 2) Divide by 5. 3) Add 32.

Background Information

Measuring Mass:

Grams are the base units of mass in the metric system, and mass measures the amount of matter in an object. Mass does not change. Weight, on the other hand, which is commonly mistaken for mass, varies based on gravity. A person's weight is less on the moon than on earth because of gravitational forces, while the mass is always the same. Typically, a digital balance or a triple weight balance is used to measure mass. A digital scale works by tarring, or starting, at zero point and then weighing the object that is placed on the top of the detector. A triple weight balance works by using counterbalance to find the weight that corresponds to the object being measured. The metric base unit of weight is gram (g) while the SI base unit is pound (lb) or ounce (oz).

Scientific notation is a way to refine very large or very small numbers. It makes data easier to record and compare to other numbers. For instance, the number 320000033994 is a very long number that would take you a minute to say accurately. Adding commas helps — 320,000,033,994 — but it would still probably take a minute to come up with "three hundred and twenty quadrillion, thirty-three thousand, nine hundred and ninety-four." If we were collecting data and had to compare two of these numbers, say 444430000 to 320000033994, would that be an easy task to do? It can be done, but it takes some time. At a quick glance, it would be tough to say which one is bigger or smaller. Scientific notation can help. 4.44×10^{9} vs. 3.2×10^{11} is easier to compare. Scientific notation is not difficult, but it does have a set of steps that you will need to follow.

Background Information

Writing Numbers Using Scientific Notation

1. Rewrite your number and put a decimal after the first non-zero digit.
    1. 1234567 will become 1.234567
    2. 0.000000098765 becomes 9.8765
2. Add a "x 10" to the end of the digits.
    1. 1.234567 becomes 1.234567 x 10
    2. 9.8765 becomes 9.8765 x 10
3. Count how many place values the decimal has moved from its original placement to its current spot. Write that number as your exponent.
    1. If the number becomes smaller when you move the decimal, the exponent will be positive.
4. 1.234567×10^{6}
    1. If the number becomes bigger when you move the decimal, the exponent will be negative.
5. 9.8765×10^{-8}

Background Information

Important Terms

English or Imperial system – the measurement system used in only a few countries, including the United States, using feet, pounds, quarts, and seconds as standards of measurement

mass – the property of a body that is a measure of its inertia; commonly taken as a measure of the amount of material it contains and causes it to have weight in a gravitational field

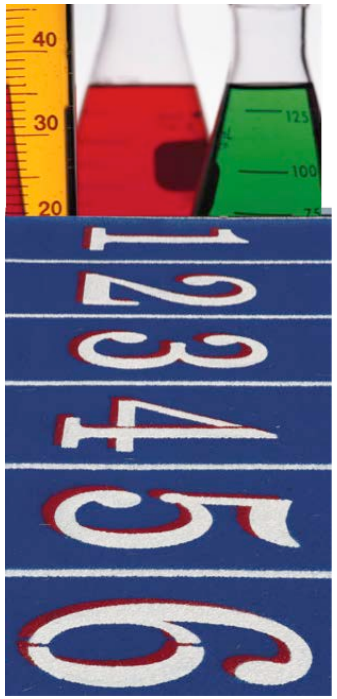
metric system – any decimal system of units based on the meter; for scientific purposes, the Système International d'Unités (SI units)

scientific notation – a method for expressing a given quantity as a number having significant digits necessary for a specified degree of accuracy, multiplied by 10 to the appropriate power, as 1385.62 written as 1.386×10^3

unit conversion – a multi-step process that involves multiplication or division by a numerical factor and selection of the correct number of significant digits

volume – the amount of space occupied by a three-dimensional object, as measured in cubic units (quarts or liters)

weight – the force with which a body is attracted to the earth or a celestial body by gravity and which is equal to the product of the mass and the local gravitational acceleration



Resources

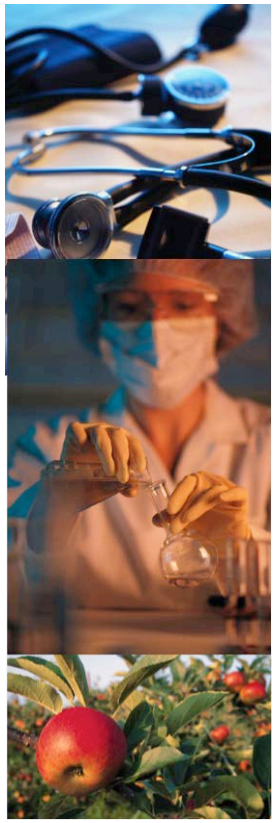
Scientific Notation. Math is Fun. https://www.mathsisfun.com/numbers/scientific-notation.html
Mass vs. Weight. NASA. http://education.ssc.nasa.gov/massvsweight.asp
The Metric System: Units, Definitions, and History. Science Made Simple. http://www.sciencemadesimple.com/metric_system.html
Volume Formulas. Math.com. http://www.math.com/tables/geometry/volumes.htm

Measurement in Biology

Measurement is an important part of any science. In biology, it is important to accurately measure to ensure data is representative of what is actually happening. Scientists depend on accurate data to analyze results, make predictions, and calculate for solutions.

A few examples of measurement in biology include measuring the:

- levels of oxygen and carbon dioxide in a water ecosystem
- average length of different species of fish
- amount of pollen produced by a specific species of plant
- rise in water temperature due to eutrophication
- amount of water moving through an organ
- soil temperature that maximizes germination of a particular plan
- the fluctuation of blood pressure during stress
- changing climate conditions including precipitation, temperature, and biomass



Resources
Vital Statistics and Measuring. Monarch Lab, University of Minnesota.
http://monarchlab.org/biology-and-research/biology-and-natural-history/vital-statistics-measuring/
National Measurement Institute.
http://www.lgcgroup.com/our-science/national-measurement-institute/#.VtZHmCmslho
Measuring Biological Attributes. UK Marine SACs Project.
http://www.ukmarinesac.org.uk/communities/intertidal-reef/ir6_3.htm

Measurement Lab

Purpose:
To measure and collect quantitative data.

For this lab, measurements will be collected on a remote fish tank housed at a NANSLO lab.

https://www.flickr.com/photos/21708387@N02/

This ecological system has been equipped with sensors to detect:

- dissolved oxygen
- temperature
- pH

You will be viewing measurement of the tank itself, as well as recording the temperature of the water.

Pre-Lab Problems

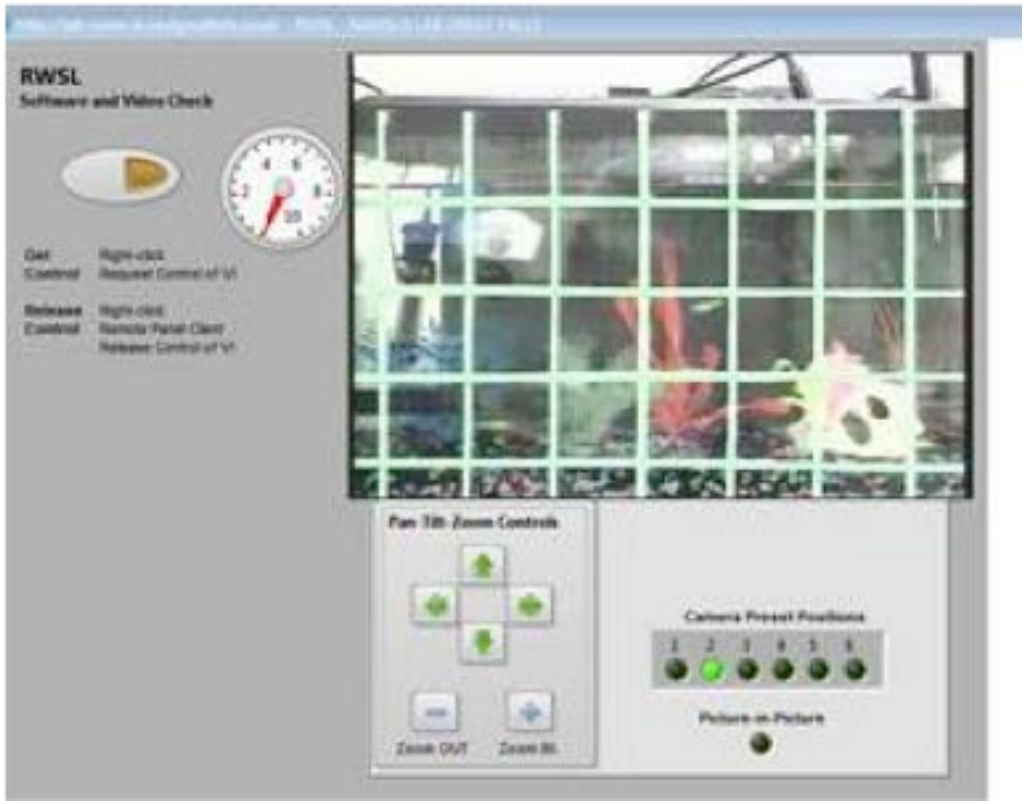
1. Convert 12 inches (in) to centimeters (cm).
2. Convert 400000 milliliters (mL) to kiloliters (kL).
3. What is the temperature in °C if the outside temperature is 43° F?
4. Evaluate your answer to #3. Is it smaller or bigger than 43? Does this make sense?
5. Find a food product in your house and record the weight on the label (should be in ounces). Convert the weight to grams.
6. Convert the food weight in #5 to kilograms.
7. Compare your answers for #5 and #6. Do these make sense?
8. Write the following in scientific notation:
   - 1345635000
   - 477777.00000000000
   - 4570000
   - 0.00000000567
9. Convert the following from scientific notation to full number (i.e., normal):
   - 6.789×10^{5}
   - 9.112×10^{-4}
   - 4.56×10^{7}
   - 8.43×10^{-2}

Control Panel

The Control Panel is where you access the equipment controls, collect data, and communicate with others participating at the same time as you.

In this experiment, you will use a video camera to view and zoom into different areas of the aquarium.

You will also use the controls to monitor the sensors that will allow you to record temperature.



Variables and Controls:

1. Temperature reading
2. pH reading
3. Dissolved oxygen reading
4. Message screen
5. Camera image
6. Camera view
7. Camera controls
8. Voice conference

Measurement Apparatus Tutorial

This tutorial introduces you to the measurement lab. You will see how the equipment is set up as well as the view you will have from your control panel. For this lab, you will be using the video camera to record measurements of the tank and take digital and analog readings of temperature.

The demonstration shows how to control the equipment, read the settings, collect data, and collaborate with others. Watch the tutorial a second time, immediately before your lab appointment, to refresh your memory about the function and purpose of the different features in this lab setup.

- Add link when available

Things to Notice / Questions:

1. What does each of the sensors monitor?
2. How will you measure the volume of the tank?
3. How will you capture and record your data?
4. How will you measure the temperature?

Measurement Lab Procedure

Exercise 1: Measuring length and volume

1. Using the NANSLO lab equipment, you will log in and take the indicated measurements and observations at the times you are scheduled to take the lab.
2. Connect to the voice conferencing tool to talk with teammates and the lab technician. Look for the controls and sensor data.
3. Use the video camera to zoom in and record the following measurements:
    - What is the length of the fish tank in inches?
    - What is the length of the fish tank in cm?
    - What is the height of the fish tank in cm?

Exercise 2: Measuring temperature

1. Use the video camera to zoom in and read the analog thermometer in the fish tank. What is the temperature and what are the units?
2. Use the video camera to zoom in and read the digital thermometer in the fish tank. What are the units on the digital thermometer?

Lab Day Checklist

On the day of your scheduled lab, review the items on this checklist to make sure you are prepared before logging into NANSLO.

- ❑ Read and review all lab materials
- ❑ Prepare and organize lab charts and recording materials
- ❑ Watch the lab tutorial again as a review before the lab
- ❑ Log in to your lab session – two options:
  - ❑ Retrieve your email from the scheduler with your appointment info or
  - ❑ Log in to the student dashboard and join your session by going to http://scheduler.nanslo.org
- ❑ NOTE: You cannot log in to your session before the date and start time of your appointment. Use Internet Explorer or Mozilla Firefox.

Measurement Lab Report

Exercise 1: Measuring length and volume

Use the video camera to zoom in and record the following measurements:

1. What is the length of the fish tank in inches?

2. What is the length of the fish tank in cm?

3. What is the height of the fish tank in cm?

Exercise 2: Measuring temperature

1. Use the video camera to zoom in and read the analog thermometer in the fish tank. What is the temperature and what are the units?

2. Use the video camera to zoom in and read the digital thermometer in the fish tank. What are the units on the digital thermometer?

Measurement Lab Analysis

Exercise 1

1. Convert your answer to #1 to cm.
2. Convert your answer to #2 to inches.
3. Do your conversions match your measurements above? Why or why not?
4. What is the volume of the fish tank if the width (i.e., depth) is 20 cm?
5. Convert the volume to liters and gallons.
6. Write your answer in scientific notation.

Exercise 2

1. Convert your answer to #1 to °F.
2. Go back through and convert all of your measurements and your analysis to scientific notation. Put these next to your original answers.
3. Imagine you have been made the ruler of a new island and your first mandate is to pick a units system to adopt for your new nation. Which system would you choose and why?

Reviewing Results

1. How accurate was the data you collected? How do you know?

2. How might an accurate record of temperature be important in a fish tank?

1. What other types of measurements would a biologist be interested in collecting in a fish tank ecosystem? List at least six.
    1.
    2.
    3.
    4.
    5.
    6.

Conclusion and Reflection

Write a thoughtful conclusion to the lab, answering the essential question: How is measurement used to record data in biology?

Post-Lab Questions

Answer the following questions as completely as possible. Use evidence from your lab to help support answers where possible. Use these questions to demonstrate your learning. You may want to review your pre-lab answers and see what you have gained in understanding.

1. What is the difference between the metric and English (Imperial) systems of measurement?
2. Why is the metric system applied to science investigations?
3. How are units converted between the two systems?
4. How is volume measured?
5. What is the difference between mass and weight?
6. What is scientific notation and how is it used?

Introduction to Microscopy

Lab Description:

Microscopes have extended the eyes of biologists for centuries. In this lab, you will learn how to operate a typical compound lab microscope by virtually controlling and adjusting the mechanisms to bring specimens into focus at different magnifications. You will also explore how the image is positioned relative to changes in directional controls and explore the changes in depth of field and field of view relative to different lenses.

Purpose:

To gain experience using the microscope and explore how different magnifications affect what you see.

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Essential Question:

How can microscopy enhance our ability to study biology?

Objectives:

At the completion of this lab, you should be able to:

1. Identify and label the basic parts of a compound microscope.
2. Select, position, and focus slides to view in the NANSLO microscope.
3. Calculate the total magnification when switching objective lenses.
4. Record accurate observations of what you see through the microscope.
5. Chart the field of view for each objective lens and explain how this changes.
6. Relate the lab exercises to biological research and study.

Pre-Lab Questions

These pre-lab questions are to help you think about the microscopy lab and self-assess what you know and what you want to know about the topic. By the end of the lab, you should be able to answer these questions in more detail. Compare your answers to see what you have learned.

1. How do microscopes magnify a specimen?
2. What are the main parts of a microscope?
3. How is a slide brought into focus?
4. How do you change magnification?
5. What is depth of field?
6. How is this different from field of view?
7. How does field of view change with different magnification?
8. How can microscopy enhance our ability to study biology?

History of the Microscope

There are few things that have impacted the development of modern biology more than the development of the microscope. In the 1300s, around the same time that people began to use lenses for eyeglasses, biologists began to use them to magnify specimens. These early devices were single lens microscopes and had limited magnification ability.

In 1665, a scientist named Robert Hooke published a work entitled *Micrographia*, which contained the first recorded use of the word "cell." Dutch scientist Antonie van Leeuwenhoek designed high-powered single lens microscopes in the 1670s. The pinnacle of this simple type of microscope was van Leeuwenhoek's discovery of "bacteria" in 1673. His single lens microscopes could magnify up to 270x. Single lens microscopes remained popular well into the 1830s.

The addition of more lenses led to the creation of the compound microscope. The compound microscope provided a much higher degree of magnification than the earlier scopes, however the images were fuzzy due to image distortion at higher magnifications.

In the mid-1900s, electron microscopes came into use. Electron microscopes use beams of electrons rather than light, and are capable of much higher magnifications. These microscopes are expensive and require special controlled environments and trained technicians to operate them.

Resources

Milestones in Light Microscopy Timeline. Nature Publishing Group. http://www.nature.com/milestones/milelight/timeline.html
Different Types of Microscopes. MicrobeHunter Microscopy Magazine. http://www.microbehunter.com/different-types-of-microscopes/

Background Information

For the last several decades, the development of modern microscopes has been focused on the resolution limit. The ability to differentiate small things that are close together is known as resolution. From far away, a car at night with its headlights on will look as if it has only one headlight. As it approaches, the resolution improves and you can tell that there are two lights. The point at which you can clearly see two is the resolution limit of the lens (or lenses) you are using — in this case, your eyes.

In 1873, Ernst Abbe showed that the theoretical resolution limit of a diffraction microscope was half the wavelength of the light being used. Therefore, the resolution limit of an optical microscope is about 190 nm to 350 nm.

The resolving power of a microscope also indicates how much magnification you theoretically have; different types of microscopes have different magnifications. A compound microscope has a magnification range of 40x to 2000x. This is a useful range for looking at cells, large cellular organelles (compartments in a cell) and bacteria, and other specimens in the range of 200 nm to 5 mm. With compound microscopes, the specimen must also be thin enough that light can shine through it.

It is important to remember that the sample you are looking at in your microscope is a three-dimensional object. It has height, width, and depth. In microscopy, we refer to these dimensions as the X, Y, and Z axes. When you are examining a sample under the microscope, you need to know both how much of the sample is visible and what part of it you are viewing. You determine how much of the sample you are viewing based on the amount visible to the ocular, or the camera. This area is called the field of view.

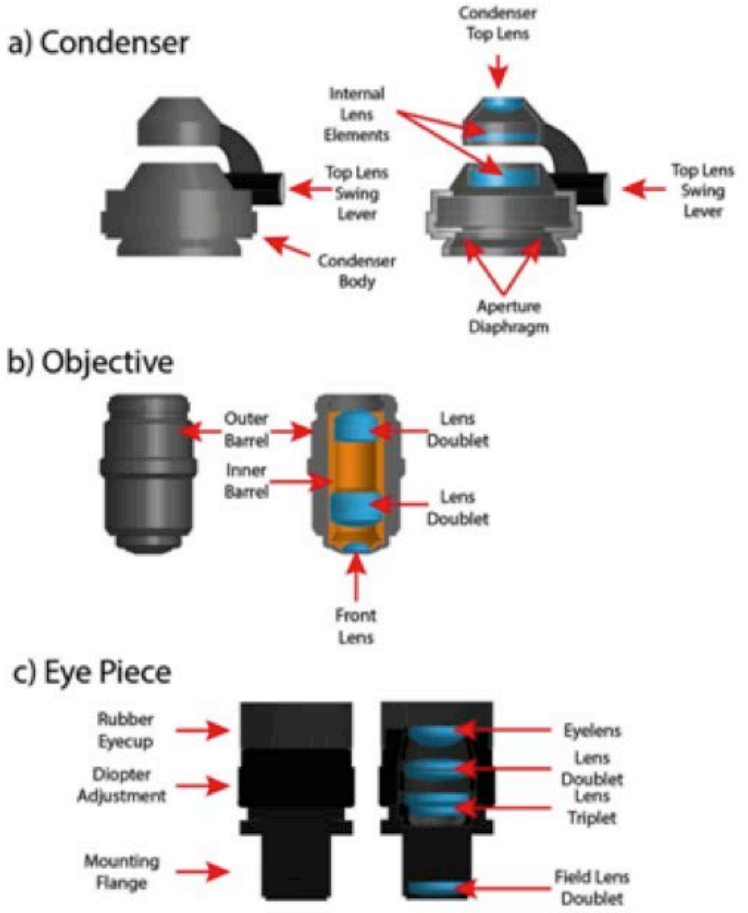
Parts of the Microscope

In a modern compound microscope, there are three main optical components. They are the condenser, the objective, and the eye piece.

The **condenser** focuses the light from the light source onto the underside of the sample.

The **objective** contains a complex series of lenses that correct chromatic aberration and image distortion which occur because of flaws in the glass. The objective also provides part of the microscope's total magnification. The objectives are mounted into a rotating wheel that allows the user to select which objective they wish to use. Often if an objective is longer, it will be able to magnify the image more. Another reason the objectives are different lengths is so that the microscope will be parfocal at all magnifications, which means that the object that is in focus at 10x will also be in focus at 20x, 40x, 60x, etc.

The **eye piece** provides the final part of the magnification. The total magnification of a microscope is determined by multiplying the objective by the eye piece. As an example, if you're using a 10x eyepiece and 20x objective, your total magnification will be 10 x 20 = 200x.



Modern Microscopy in Biology

Histology

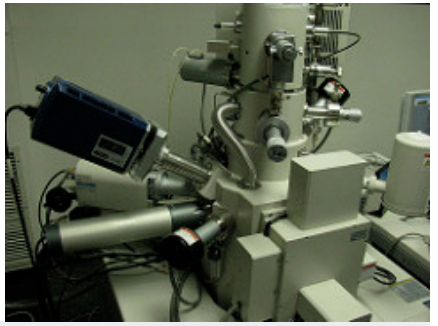
Histology is a field in biology that involves the study of tissues. A histologist uses a microscope to collect information on how tissues function in humans and animals. This knowledge helps with important discoveries concerning the cells and body systems.

Virus Research

Microscopy is used in viral diagnoses and viral pathogenesis studies. It is an important tool for both diagnostic work and research. It is also particularly valuable in the surveillance of emerging diseases. Cryo-electron microscopy has been useful for studying live tissues at reduced temperatures.

Multiphoton Microscope

A powerful new microscope called the multiphoton microscope is also used to examine living tissues at the cellular and molecular levels. Scientists have used this microscope to study how the body fights tumors and infectious diseases, as well as responds to drug and other treatments.



Laser Microscopes

Researchers are continually improving the way microscopes operate. Laser based microscopes are in development. They allow you to see cells and tissues without the use of dyes which can disrupt results.

Resources

New Microscope Provides Breakthrough for Cancer Treatment and Drug Discovery. University of Strathclyde Glasgow. https://www.strath.ac.uk/ricas/news/microscope/

Modern Uses of Electron Microscopy for Detection of Viruses. Clinical Microbiology Reviews. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2772359/

Microscopy Lab

This lab includes two exercises.

The first exercise is to gain experience in manipulating the controls of the microscope, and to observe how these changes relate to the orientation and view of the specimen. You will look at a simple printed letter “e” and observe how this image changes using 10x, 20x, and 60x objective lenses. You will also gain experience focusing and adjusting the slide position, as you switch between magnifications.

In the second exercise, you will determine the size of the field of view (the visible area). To do this, you will use a stage micrometer, which is a microscope slide that has a small ruler on it. You will measure the field of view for each objective on the microscope.

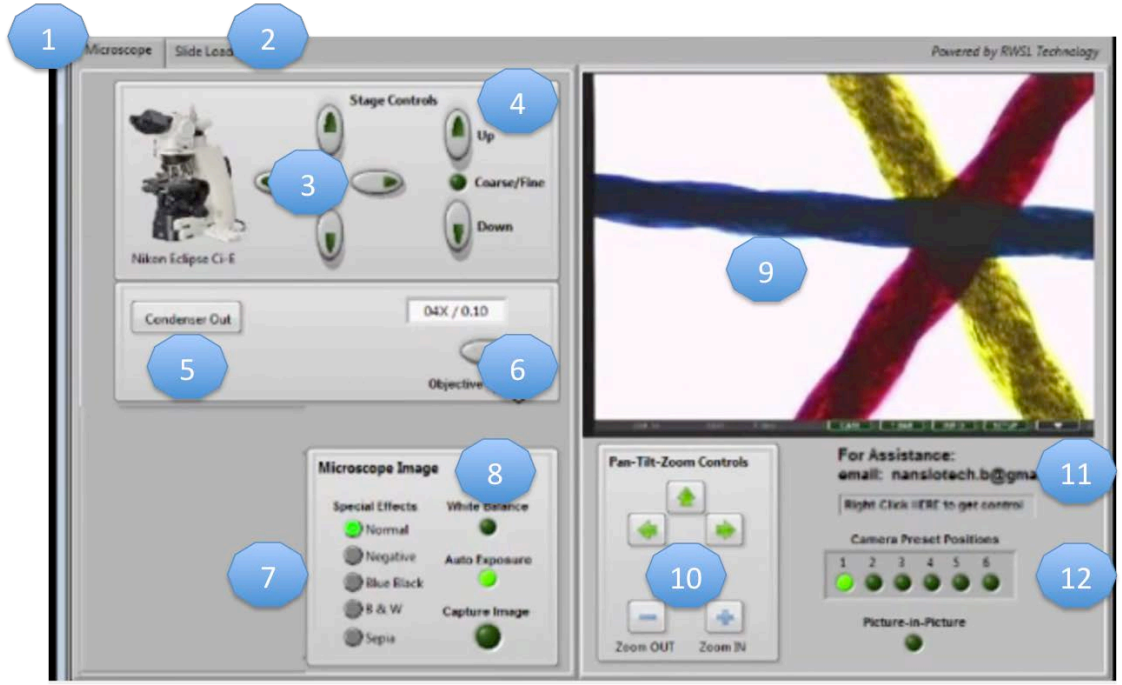
These labs will also give you experience using the camera to capture images to include in your lab reports.

https://www.flickr.com/photos/rueful/

Control Panel

The Microscopy Control Panel is where you access the equipment controls, collect data, and communicate with others participating at the same time as you.

In this experiment, you will manipulate the controls of the microscope remotely to view slides and make observations.



Variables and Controls:

1. Microscope tab
2. Slide loader tab
3. Stage direction controls
4. Stage up and down controls
5. Condenser button
6. Objective lens selector
7. Special effects
8. Image adjustments/capture image
9. Image screen
10. Camera controls
11. User controls
12. Camera preset positions

Microscope Tutorial

This tutorial introduces you to the remote microscope, which you will use in several labs. You will see how the equipment is set up as well as the view you will have from your control panel. The demonstration shows how to control the equipment, read the settings, collect data, and collaborate with others. Watch the tutorial a second time, immediately before your lab appointment, to refresh your memory about the function and purpose of the different features in this lab setup.

- http://www.wiche.edu/nanslo/lab-tutorials#microscope

Things to Notice / Questions:

1. How do you select a microscope slide?
2. How do you ask the lab technician for assistance?
3. What do you need to do to select a new slide?
4. What is the highest magnification you can use to view an object?
5. What do you do if you can't see the object when you change magnification?
6. When do you select the condenser?

Microscopy Lab Procedure

Using the NANSLO lab equipment, you will log in and take the indicated measurements at the time you are scheduled to take the lab.

Exercise 1: Operating a compound microscope: Magnification and stage movement

1. Look for the controls to gain voice access to the lab technician and your lab partners.
2. Identify how to access and hand over controls on the right side of the control panel beneath the viewing screen.
3. Use the slide selector to select the letter “e” whole mount slide from the microscope interface.
4. Use the microscope controls to place the letter “e” in the center of the field of view and focus on it with the 10x objective.
5. On the lab report page, find the diagram of the slide as it is currently loaded on the microscope. In the box, draw the letter “e” as you see it in the microscope.
6. Observe the differences between the observed letter “e” and the letter “e” mounted on the microscope in your lab report.

Microscopy Lab Procedure

7. Change to the 20x objective and capture an image of the letter “e.” (If you can’t see any part of the “e,” move the slide.) Capture and save this image in your lab report.
8. Change to the 60x objective and capture an image of the letter “e.” (If you can’t see any part of the “e,” move the slide.) Capture and save this image in your lab report.
9. Change back to 10x objective. Using the microscope controls, click on the top button, which moves the stage in (towards the body of the microscope, if you are observing through the PTZ camera) so that the “e” moves slightly. How does the “e” move with respect to the direction the stage moves? Record your observations in your lab report.
10. This time, press the left stage control button. This will move the stage to the left (towards the slide loader, if you are observing through the PTZ camera) so that the “e” moves slightly. How does the “e” move with respect to the direction the stage moves? Record your observations in your lab report.
11. Return the “e” slide to the cassette.

Microscopy Lab Procedure

Exercise 2: Depth of field and field of view

The field of view is a plane parallel to the slide (X and Y axes) that can be easily calculated using a ruler. The ruler that is used with a microscope is called a stage micrometer.

While it might seem obvious that the part of the sample you see is the part that is in focus, or the focal point, you need to remember that there may be parts of the sample either above or below the focal point that are not visible. The amount of the sample that is in the focal point is called the depth of field (the Z axis). The depth of field is perpendicular to the field of view. However, depth of field is much harder to measure than field of view, so you will only be dealing with depth of field qualitatively in this lab. Both field of view and depth of field are related to and affected by the magnification of the objectives. In this section, you will explore the relationship between the objective's magnification and the field of view and depth of field.

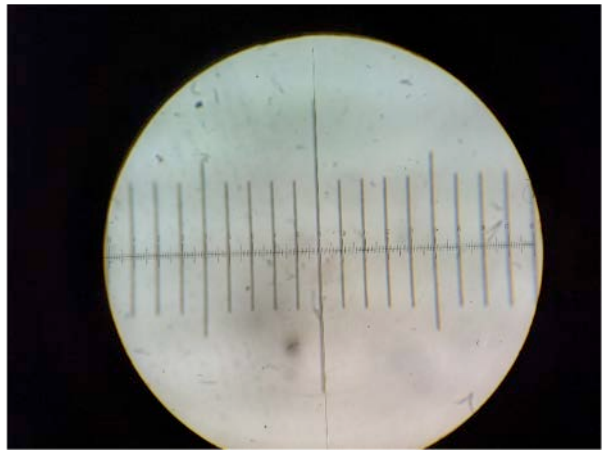
To make measurements on the microscope, you first need to determine the size of the field of view. To do this, you will use a stage micrometer, which is a microscope slide that has a small ruler drawn on it. You will use the stage micrometer to measure the field of view (the visible area) for each objective on the microscope. The micrometer you will be using is 1 mm in total length with 100 divisions.

Microscopy Lab Procedure

Compete the following steps, and record your observations and images in your lab report.

Depth of field

1. Select the Colored Threads slide from the slide loader tab.
2. Examine the slide with the 10x objective and describe what you see in your lab report.
3. How many of the threads can you get in focus using the 10x objective? Which of the threads is on top, in the middle, and on the bottom? Capture an image and insert it in your lab report. Label the top, middle, and bottom threads.
4. Change to the 20x objective. How many of the threads can you get in focus simultaneously? Record your observations.
5. Capture and save, and insert your image in the lab report. Return slide to cassette.



Field of view

6. Select the Stage Micrometer slide from the slide loader tab, center, and focus the micrometer in the field of view. Create a table to record the diameter of the field of view for each of the objectives.

Lab Day Checklist

On the day of your scheduled lab, review the items on this checklist to make sure you are prepared before logging into NANSLO.

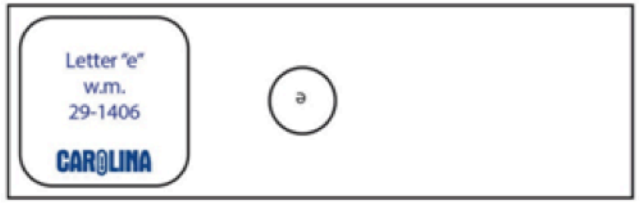
- ❑ Read and review all lab materials
- ❑ Prepare and organize lab charts and recording materials
- ❑ Watch the lab tutorial again as a review before the lab
- ❑ Log in to your lab session – two options:
  - ❑ Retrieve your email from the scheduler with your appointment info or
  - ❑ Log in to the student dashboard and join your session by going to http://scheduler.nanslo.org
- ❑ NOTE: You cannot log in to your session before the date and start time of your appointment. Use Internet Explorer or Mozilla Firefox.

Lab Report

Exercise 1

10x Objective: In the box, draw the letter "e" as you see it in the microscope.

a) Slide



b) Drawing

1. What are the differences between the observed letter "e" and the letter "e" mounted on the microscope? (Hint: There are two differences.)
2. Change to the 20x objective and capture an image of the letter "e." (If you can't see any part of the "e," move the slide.) Capture and save this image.

Lab Report

Lab Images (student insert)

3. Change to the 60x objective and capture an image of the letter "e." (If you can't see any part of the "e," move the slide.) Capture and save this image.

4. Change back to 10x objective. Using the microscope controls, click on the top button, which moves the stage in (towards the body of the microscope, if you are observing through the PTZ camera) so that the "e" moves slightly. How does the "e" move with respect to the direction the stage moves? Record your observations.

5. This time, press the left stage control button. This will move the stage to the left (towards the slide loader, if you are observing through the PTZ camera) so that the "e" moves slightly. How does the "e" move with respect to the direction the stage moves? Record your observations.

Lab Report

Lab Images (student insert)

Exercise 2:
Depth of field

1. Select the Colored Threads slide from the slide loader tab. Examine the slide with the 10x objective and describe what you see:

2. How many of the threads can you get in focus using the 10x objective? Which of the threads is on top, in the middle, and on the bottom?

3. Capture an image and insert. Label the top, middle, and bottom thread.

4. Change to the 20x objective. How many of the threads can you get in focus simultaneously? Record your observations. Capture and save, and insert your image in the lab report. Return slide to cassette.

Lab Report

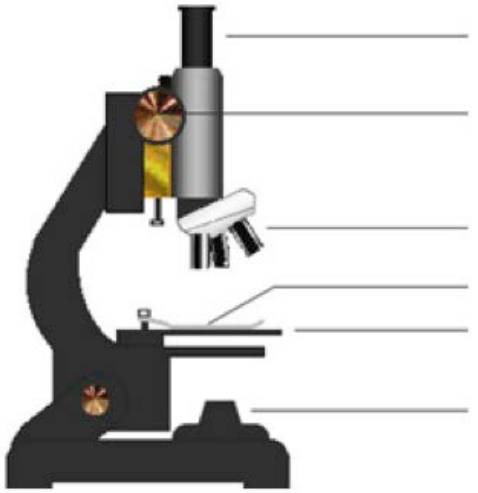
6. Label the diagram with the correct microscope parts.

Exercise 2:
Field of view

5. Select the Stage Micrometer slide from the slide loader tab, center, and focus the micrometer in the field of view. Create a table to record the diameter of the field of view for each of the objectives.

Microscopic Objective	Total Magnification		Diameter Field of View
	10x Eye Piece	20x Eye Piece	
10x			
20x			
40x			
60x			

6. Label the diagram with the correct microscope parts.

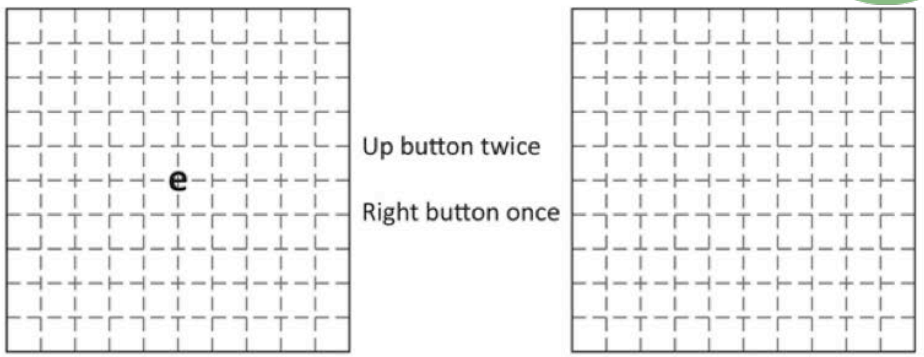


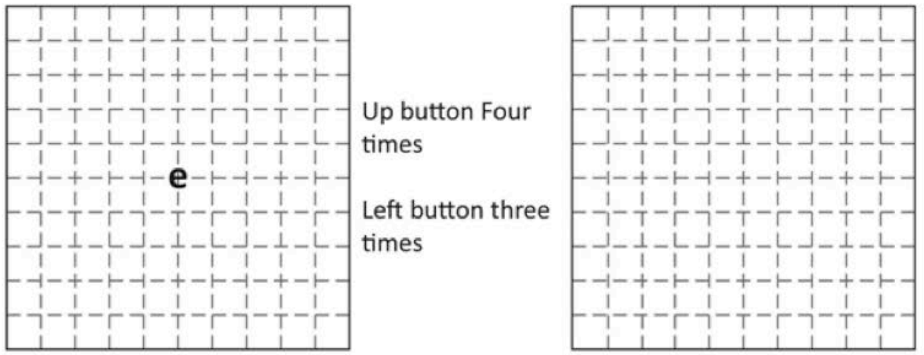
Lab Report

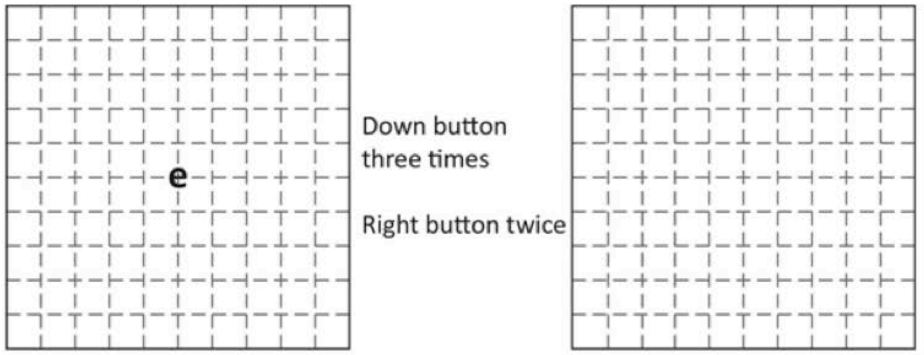
Describe the difference in your observations of the black lines that make up the letter “e” using the 20x and 60x objectives.

In the these diagrams, assume that each dashed line represents the distance the stage will move with a single click of the microscope control buttons.

Using the sequence of buttons, draw where the “e” will be after the button clicks.





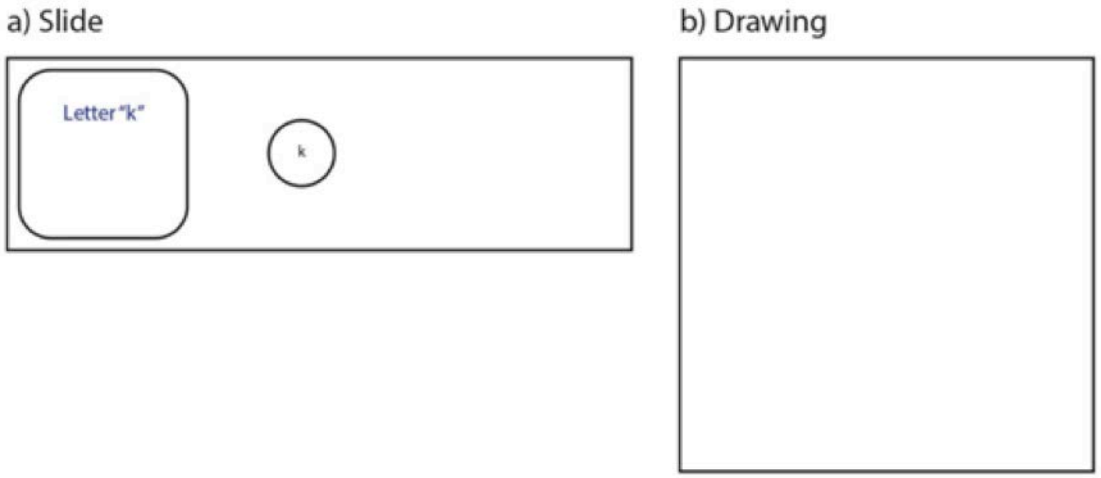


Lab Report

You are looking at a sample at 10x. When you increase the magnification to 40x, the sample is no longer in the field of view. What might cause this to happen, and how would you correct it?

Explain why sometimes when you change from the 10x or 20x object to the 60x object, the sample is not in focus.

Given the following slide, draw how the sample would appear while looking through the microscope.



Reviewing Results

Write a review of your explorations with the microscope. Include your findings and an explanation of your results for each of the exercises.

Conclusion and Reflection

Write a thoughtful conclusion to the lab, answering the essential question: How can microscopy enhance our ability to study biology?

Post-Lab Questions

Answer the following questions as completely as possible. Use evidence from your lab to help support answers where possible. Use these questions to demonstrate your learning. You may want to review your pre-lab answers and see what you have gained in understanding.

1. How do microscopes magnify a specimen?
2. What are the main parts of a microscope?
3. How is a slide brought into focus?
4. How do you change magnification?
5. What is depth of field?
6. How is this different from field of view?
7. How does field of view change with different magnifications?
8. How can microscopy enhance our ability to study biology?

Cell Type Comparison

Lab Description:

This lab allows you to study and compare different cell types, which are the foundation for most biological studies and research.

Purpose:

To observe and compare different cell types in order to better understand their structure and identify their differences and similarities.

Essential Question:

What are the main comparisons of prokaryotic and eukaryotic cells, and how is cell study related to biology?

Objectives:

At the completion of this lab, you should be able to:

1. Describe the characteristics of prokaryotic cells.
2. Describe the characteristics of eukaryotic cells.
3. Identify and label the main parts of each type of cell.
4. Use the microscope to view slides at different magnifications.
5. Capture and insert microscope images in lab reports.
6. Calculate and compare the size of different types of cells.
7. Apply scientific terminology in lab analysis and conclusions.
8. Explain the importance of studying cells in the field of

Pre-Lab Questions

These pre-lab questions are to help you think about the cell type comparison lab and self-assess what you know and what you want to know about the topic. By the end of the lab, you should be able to answer these questions in more detail. Compare your answers to see what you have learned.

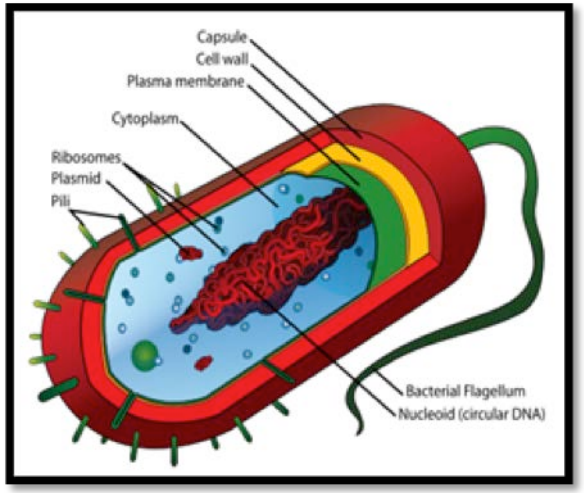
1. What is the definition of a cell?
2. In what ways are all cells the same?
3. What are the characteristics of prokaryotic cells?
4. What are the characteristics of eukaryotic cells?
5. Which group of cells are the most abundant on Earth?
6. What are the main parts of a prokaryotic cell?
7. What are the main parts of a eukaryotic cell?
8. Using a microscope, how can you tell a prokaryotic cell from a eukaryotic cell?

Background Information

All living things are composed of one or more cells. A single cell possesses all of the requirements for life. Therefore, to begin the study of biology, one must have a good understanding of a cell.

The **cell theory** describes the basic concepts that we understand about cells. Historically, it stems from work done in the mid 1800s in Germany. Scientists working independently came up with the following:

1. All animals are composed of cells.
2. All plants are composed of cells.
3. All cells come from pre-existing cells.

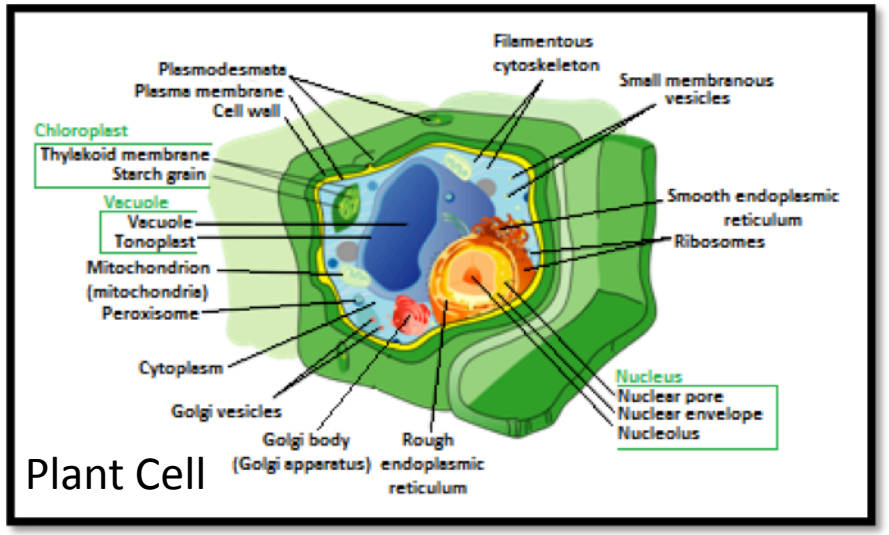


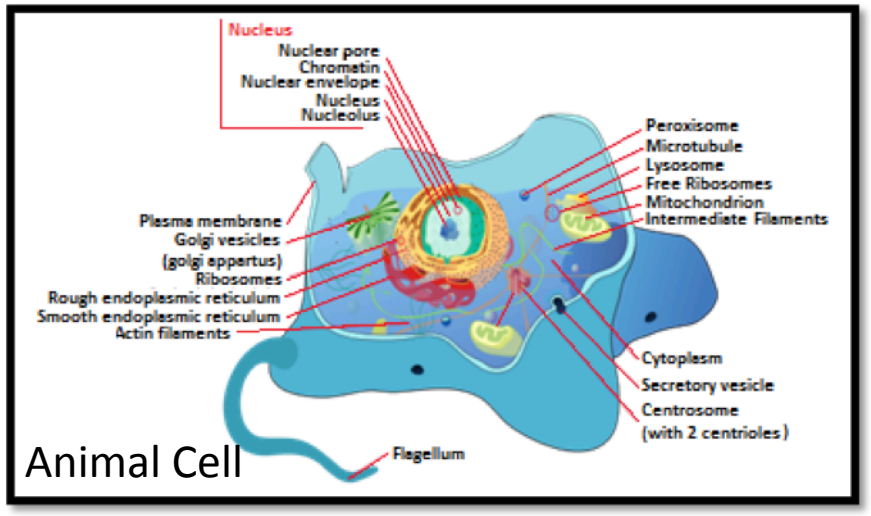
Cells are broken into two main groups: ***prokaryotic*** and ***eukaryotic***. The most primitive cells are prokaryotic cells. *Pro* as a prefix means "before" and *karyon* refers to nucleus (kernel). Therefore, a prokaryotic cell is one without a nucleus or "pre-nucleus." These cells are considered to be the simplest life forms because they lack membrane-bound organelles. Prokaryotic cells were the first life forms on Earth and the only living things for about 2 billion years. Today, they are still the most abundant organisms on Earth.

Background Information

Eukaryotic cells are found in plants, animals, protists, and fungi. All eukaryotic cells have internal organelles. Each organelle has a specific function that relates to the overall function of the cell. This complexity has led to greater specialization, allowing this group of cells to have success in both single and multi-cellular organisms. With a greater understanding of the specific function of each organelle, scientists can start to see structure-function relationships inherent in biology.

The following terms describe the different types of organelles and other structures in a cell. Make note of those that are unique to eukaryotic plant or animal cells.





Background Information

Important Terms

cell wall – Plant, fungal cells, and some bacterial cells have a rigid wall surrounding the plasma membrane. The cell walls are composed of complex carbohydrates and serve a variety of functions from protecting the cell to regulating the life cycle of the plant organism.

centrioles – Centrioles are self-replicating organelles made up of microtubules. Found only in animal cells, they have a role in cell division.

chloroplasts – The chloroplast is a sac-like organelle that contains chlorophyll, a green pigment that carries out photosynthesis. Chloroplasts are found in plants.

cilia and flagella – Cilia and flagella are microtubule-based structures that function in the locomotion of single-celled organisms. In multi-cellular organisms, cilia can function to move fluid or materials.

cytoplasm – Also known as cytosol, this is the fluid portion of the cell. It is found in all cell types. In a eukaryotic cell, it is between the nuclear membrane and the plasma membrane. In a prokaryotic cell, it is found inside the plasma membrane.

endoplasmic reticulum – Extending from the outside of the nucleus into the cytoplasm, the ER is a system of internal membranes within the cytoplasm of the cell. Some parts of the ER are covered with protein-making ribosomes. The presence of ribosomes is a characteristic of the rough ER. Smooth ER does not have ribosomes that attach to the surface; it is involved in the chemical activities of fat metabolism and the detoxification of toxic substances (alcohol and drugs).

Golgi apparatus – The Golgi apparatus is the distribution and shipping department for the cell's chemical

Background Information

intermediate filaments, microfilaments, and microtubules – These are long protein structures that provide a framework for the inside of the cell membrane — the cytoskeleton. They provide the cell with shape, support, and the ability to move around the cytoplasm. They also serve to transport materials from place to place. Additionally, these fibers help with the process of cell division by contracting together in the middle of the cell.

lysosomes – Lysosomes break down macromolecules. They digest worn-out cell components to make way for new ones. These organelles also eliminate particles the cell has taken in. For example, white blood cells engulf pathogens such as bacteria that cause disease. The presence of lysosomes in plant cells is being debated.

mitochondria – Mitochondria have a unique double-membrane structure and their own DNA. The membrane systems function in a complex series of reactions to extract energy from organic molecules (i.e., food.). They are the site of cell metabolism.

nucleus – Like the mitochondria, the nucleus has a double membrane structure. It contains the genetic material of the cell (DNA) and separates the nucleoplasm from the cytoplasm.

plasma membrane – All living cells (both prokaryotic and eukaryotic) have plasma membranes that enclose their contents. These membranes regulate the passage of molecules into and out of the cells.

ribosomes – All living cells contain ribosomes constructed from two oddly-shaped subunits which serve to manufacture proteins. Cells that produce large amounts of protein have great numbers of free and attached ribosomes.

vacuole – A vacuole is a membrane-bound storage cavity in a cell. In a plant cell, it is a large, single central organelle that stores compounds, helps in plant growth, and plays an important structural role for the plant. In other organisms, it can function for storage of ingestion, digestion, excretion, and expulsion of excess water

Background Information

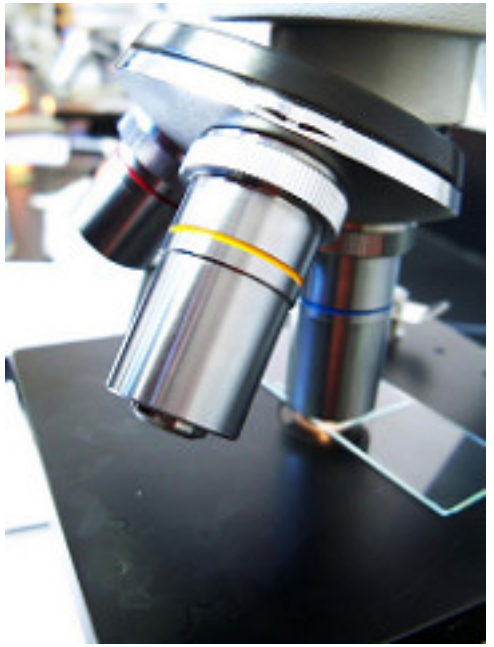
Review the following resources for additional background information:

- Cells Alive!
  http://cellsalive.com/
- Prokaryotic and Eukaryotic Cells. Khan Academy.
  https://www.khanacademy.org/science/biology/structure-of-a-cell/prokaryotic-and-eukaryotic-cells/v/prokaryotic-and-eukaryotic-cells
- Characteristics of Prokaryotic Cells. *Boundless Biology*. Boundless.
  https://www.boundless.com/biology/textbooks/boundless-biology-textbook/cell-structure-4/prokaryotic-cells-59/characteristics-of-prokaryotic-cells-312-11445/

Explore Cell Type Applications

The study of cells essentially includes all areas of biology. Take a look at the following resources and videos that demonstrate how the study of cells is essential for understanding:

- how organisms live and grow
- the interrelationships of organisms within a body
- the function of the cell
- research into using cells to regenerate other cells (stem cell research)
- the variety and evolving life forms
- how cells function within themselves
- how cells function within a system
- what happens when cells dysfunction
- identification of disease and treatment responses in cells



Comparing Cell Types Lab

In this lab, you will compare cell types using the NANSLO microscope. The lab report, analysis, and conclusion pages will support and guide you to make conclusions based on the data you have collected and observed.

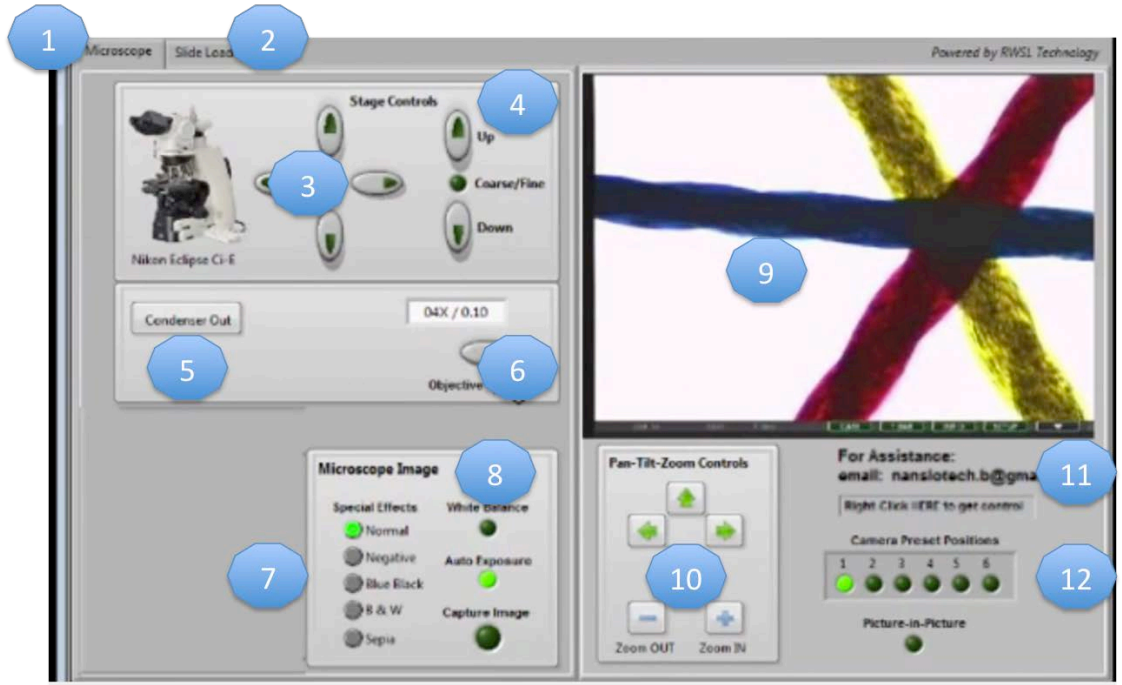
Resources

Stem Cell Research. NOVA.
http://www.pbs.org/wgbh/nova/body/stem-cells-research.html
The Stem Cell Divide. National Geographic.
http://science.nationalgeographic.com/science/health-and-human-body/human-body/stem-cell-divide/
How Many Cells Are In Your Body? National Geographic.
http://phenomena.nationalgeographic.com/2013/10/23/how-many-cells-are-in-your-body/
Cancer: Rogue Cells. National Geographic.
http://phenomena.nationalgeographic.com/2013/10/23/how-many-cells-are-in-your-body/

Control Panel

The Microscope Control Panel is where you access the equipment controls, collect data, and communicate with others participating at the same time as you.

In this lab, you will manipulate the controls of the microscope remotely in order to view slides and make observations.



Variables and Controls:

1. Microscope tab
2. Slide loader tab
3. Stage direction controls
4. Stage up and down controls
5. Condenser button
6. Objective lens selector
7. Special effects
8. Image adjustments/capture image
9. Image screen
10. Camera controls
11. User controls
12. Camera preset positions

Microscope Tutorial

This tutorial introduces you to the remote microscope, which is used in several labs. You will see how the equipment is set up as well as the view you will have from your control panel. The demonstration shows how to control the equipment, read the settings, collect data, and collaborate with others. Watch the tutorial a second time, immediately before your lab appointment, to refresh your memory about the function and purpose of the different features in this lab setup.

- http://www.wiche.edu/nanslo/lab-tutorials#microscope

Things to Notice / Questions:

1. How do you select a microscope slide?
2. How do you ask the lab technician for assistance?
3. What do you need to do to select a new slide?
4. What is the highest magnification you can use to view an object?
5. What do you do if you can't see the object when you change magnification?
6. When do you select the condenser?

Cell Type Comparison Lab Procedure

Log into the NANSLO lab at the time you are scheduled to take the lab and connect to voice conferencing.

You will be viewing slides of different cells to make comparisons. For each of the slides, you will complete the following steps.

1. Select the slide from the slide selector.
2. Use the 10x objective and bring the sample into position and focus.
3. Change to the 40x objective and bring the sample into position and focus. Capture an image at 40x to include in your lab report.
4. Change to the 60x objective and bring the sample into position and focus. Capture an image at 40x to include in your lab report.
5. You will capture two images for each sample, one at 40x and one at 60x to include in your lab report and use for analysis.

Slides to View:

- Elodea leaf
- Frog skin
- Bacteria Forms Smear
- Mixed Protozoa Whole Mount (capture an image of several different types of protists)

Lab Day Checklist

On the day of your scheduled lab, review the items on this checklist to make sure you are prepared before logging into NANSLO.

- ❑ Read and review all lab materials
- ❑ Prepare and organize lab charts and recording materials
- ❑ Watch the lab tutorial again as a review before the lab
- ❑ Log in to your lab session – two options:
  - ❑ Retrieve your email from the scheduler with your appointment info or
  - ❑ Log in to the student dashboard and join your session by going to http://scheduler.nanslo.org
- ❑ NOTE: You cannot log in to your session before the date and start time of your appointment. Use Internet Explorer or Mozilla Firefox.

Lab Report

Lab Images (student insert)

Elodea leaf 40x
(Include observations and image)

Elodea leaf 60x
(Include observations and image)

Frog skin 40x
(Include observations and image)

Frog skin 60x
(Include observations and image)

Lab Report

Lab Images (student insert)

Bacteria 40x
(Include observations and image)

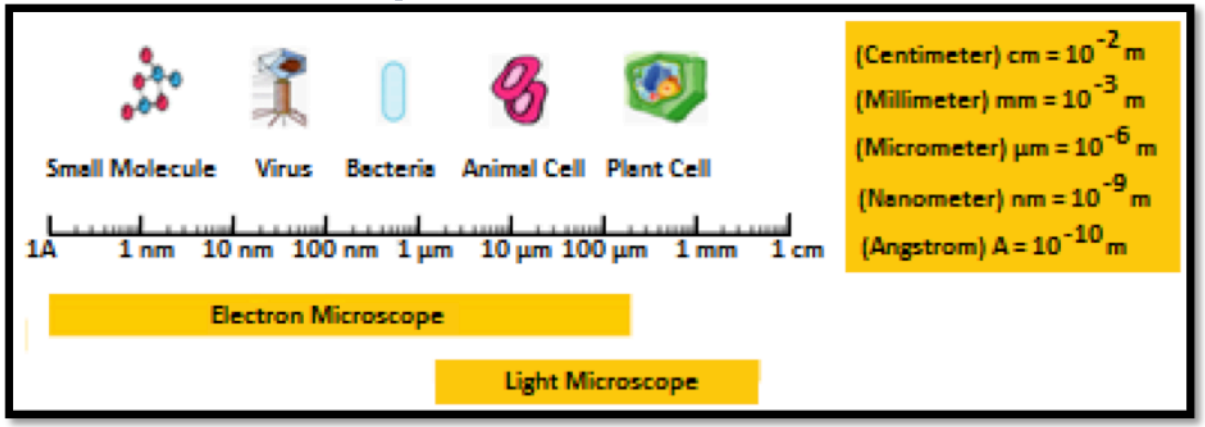
Bacteria 60x
(Include observations and image)

Protozoa 40x
(Include observations and image)

Protozoa 60x
(Include observation notes and image)

Cell Comparison Lab Analysis

Most cells are microscopic. While cells can vary in size, they generally range from 10 to 100 micrometers. The chart below shows the relative sizes of the different types of cells and the components that they are made up of. Prokaryotic cells are smaller than eukaryotic cells. The diameter of a prokaryotic cell is usually between 1–10 µm, whereas a typical eukaryotic cell is between 10–100 µm. The smallest bacteria, called mycoplasmas, can be as little as 0.1 µm in diameter.

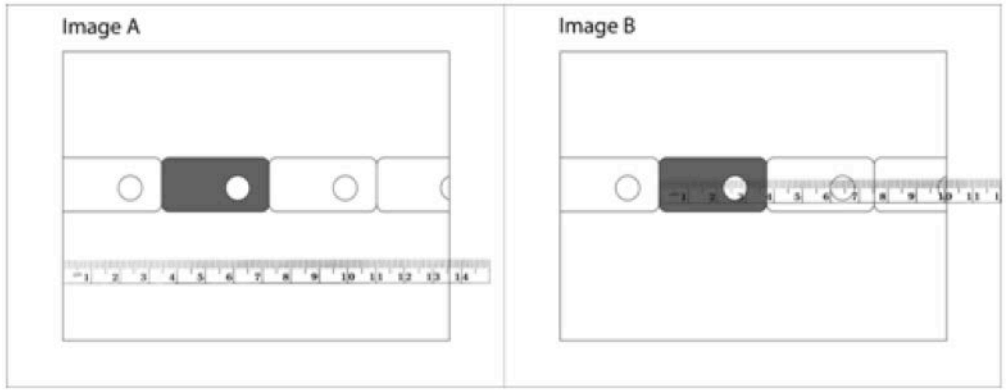


Measure the size of each type of cell. To determine the size of the cells, we are going to use the ratio method.

You will need one piece of information, which is the width of your field of view. On these microscopes, the field of view is 305 µm at 40x magnification and 205 µm at 60x magnification.

Cell Comparison Lab Analysis

Using the image in the figure below as an example, we can see that the total width of the field of view is 13.6 cm or
136 mm (Image A). The cell (gray) is 3.7 cm or 37 mm (Image B).



Dividing 37 mm / 136 mm = 0.272, which we multiply by the total length of the field of view: 0.272 * 305 µm = 82.96 µm (40x) or 0.272 * 205 µm = 55.76 µm (60x). Then round for significant figures for a cell size of 83 µm (40x) or 56 µm (60x).

Using the images you collected, measure and then calculate the size of each type of cell.

Elodea cell

Frog cell

Bacterial cell

Protozoa cell image of a bacterial cell and a ruler

Cell Comparison Lab Analysis

Using the elodea image you captured, label all the structures you can identify (nucleus, cell membrane, cytoplasm, cell wall, etc.). You can do this in a Word or PowerPoint program by drawing arrows and inserting text boxes.

Repeat the above for a frog skin cell, bacterial cell, or protozoa cell (just pick one).

Reviewing Results

Write a review of your experiment. Include your findings and an explanation of your results.

- Explain what you observed.
- Based on your images, which cells were prokaryotic? Use your observations to support your claim.
- Based on your images, which cells were eukaryotic? Use your observations to support your claim.

Conclusion and Reflection

Write a thoughtful conclusion to the lab, answering the essential question: What are the main comparisons of prokaryotic and eukaryotic cells, and how is cell study related to biology?

Post-Lab Questions

Answer the following questions as completely as possible. Use evidence from your lab to help support answers where possible. Use these questions to demonstrate your learning. You may want to review your pre-lab answers and see what you have gained in understanding.

1. What is the definition of a cell?
2. In what ways are all cells the same?
3. What are the characteristics of prokaryotic cells?
4. What are the characteristics of eukaryotic cells?
5. Which group of cells are the most abundant on Earth?
6. What are the main parts of a prokaryotic cell?
7. What are the main parts of a eukaryotic cell?
8. Using a microscope, how can you tell a prokaryotic cell from a eukaryotic cell?

Cell Mitosis Lab

Lab Description:

Mitosis is the process where new cells are generated from existing cells. In this lab, you will learn about the different stages in this process and make observations of plant and animal cells preserved during the different mitosis stages.

Purpose:

To observe the phases of mitosis in prepared plant and animal cell slides.

Essential Question:

What is mitosis and how does it relate to plant and animal life?

Objectives:

At the completion of this lab, you should be able to:

1. Define mitosis and describe its purpose in plant and animal life forms.
2. Describe and sequence the stages of mitosis.
3. Use the NANSLO microscope to load slides, focus, and change magnification of specimens.
4. Observe, identify, and describe mitosis phases in plant cell samples.
5. Observe, identify, and describe mitosis phases in animal cell samples.
6. Make comparisons between mitosis in plant and animal cells.
7. Calculate an estimated duration of each stage of the cell cycle in

Pre-Lab Questions

These pre-lab questions are to help you think about the measurement lab and self-assess what you know and what you want to know about the topic. By the end of the lab, you should be able to answer these questions in more detail. Compare your answers to see what you have learned.

1. What is the purpose of mitosis and how does it relate to the cell cycle?
2. What are the stages a cell goes through during mitosis?
3. How are chromosomes involved in mitosis?
4. What do you look for to identify the stage of mitosis in a cell?
5. What is the difference between mitosis in an animal and a plant cell?
6. How is the study of mitosis important in biology?

Important Terms

anaphase – the stage of mitosis and meiosis in which the chromosomes move toward the poles of the spindle

blastula – an early metazoan embryo typically having the form of a hollow, fluid-filled rounded cavity bound by a single layer of cells

chromatid – one of the usually paired and parallel strands of a duplicated chromosome joined by a single centromere

chromatin – a complex of nucleic acid and basic proteins usually dispersed in the interphase nucleus and condensed into chromosomes in mitosis and meiosis

chromosome – the part of a cell that contains the genes, which control how an animal or plant grows and what it becomes

cytokinesis – cleavage of the cytoplasm into daughter cells following nuclear division

interphase – the interval between the end of one mitotic or meiotic division and the beginning of another

meiosis – the cellular process that results in the number of chromosomes in gamete-producing cells being reduced to one half; it involves a reduction division in which one of each pair of homologous chromosomes passes to each daughter cell, and a mitotic division

meristem – a formative plant tissue usually made up of small cells capable of dividing indefinitely and giving rise to similar cells or to cells that differentiate to produce the definitive tissues and organs

metaphase – the stage of mitosis and meiosis in which the chromosomes become arranged in the equatorial plane of the spindle

Important Terms

mitosis – a process that takes place in the nucleus of a dividing cell; it typically involves a series of steps consisting of prophase, metaphase, anaphase, and telophase, and results in the formation of two new nuclei, each having the same number of chromosomes as the parent nucleus

mitotic spindle – the spindle-shaped fibers that form during mitosis and pull the chromatids apart toward opposite poles

morphology – the study of the form and structure of animals and plants

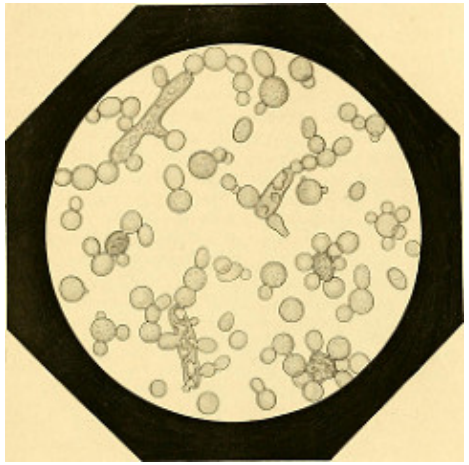
prophase – the initial stage of mitosis and of the mitotic division of meiosis characterized by the condensation of chromosomes consisting of two chromatids, disappearance of the nucleolus and nuclear membrane, and formation of mitotic spindle

telophase – the final stage of mitosis and of the second division of meiosis, in which the spindle disappears and the nuclear envelope reforms around each set of chromosomes

Background Information

Cells undergo a process of growth and division called the **cell cycle**. You and I each started as a single cell. Thanks to many iterations of the cell cycle, we now consist of trillions of cells. The term "cell" was first used by Robert Hooke in 1665, when he looked at a piece of cork under a microscope and observed that the units of the cork looked like little rooms that monks lived in. The Latin name for those rooms is "cella."

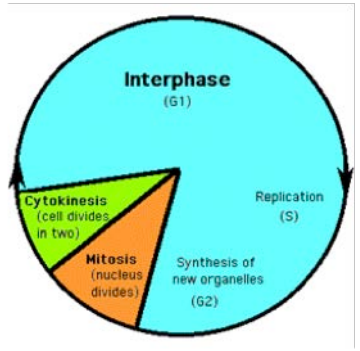
The invention of better microscopes continued to allow scientists to look at smaller and smaller objects, and in 1862 Louis Pasteur used an experiment called the swan neck flask to show that microbial life was not spontaneously generated. He showed that for bacteria to grow, cells had to be present.



This lab will discuss how new cells come from pre-existing cells. There are two processes involving the production of new cells. The first is called **mitosis** and is used for growth and to replace old or dead cells. The second is called **meiosis** and is used to produce gamete (egg and sperm) cells that are used for sexual reproduction. In this lab, we will explore mitosis in plant and animal cells.

Background Information

The cell cycle is comprised of three major stages: **interphase**, **mitosis**, and **cytokinesis**.



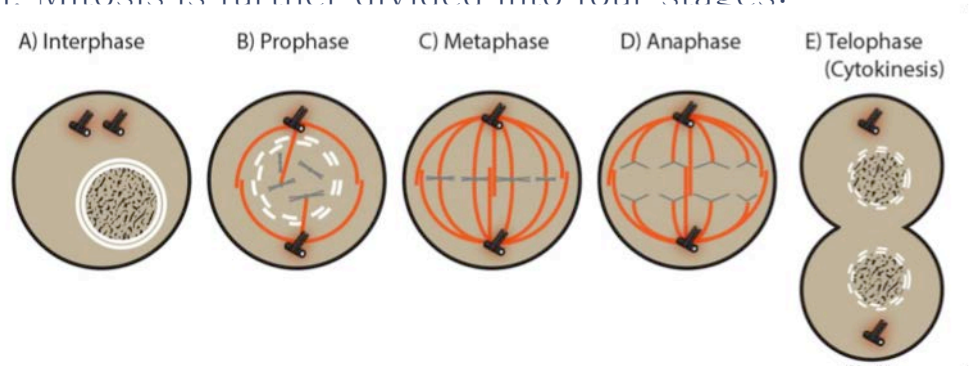
Most of a cell's life is spent in interphase. During interphase, the cell grows and, when getting prepared to divide, the cell's DNA replicates.

Interphase has three parts:

- Growth 1 (G1) where the cell grows and performs normal cellular functions
- Synthesis (S) where DNA is replicated
- Growth 2 (G2) where the cellular organelles are replicated

The next phase is mitosis, during which the replicated genetic material divides into two separate nuclei. Mitosis is further divided into four stages:

1. Prophase
2. Metaphase
3. Anaphase
4. Telophase



Two identical nuclei result from mitosis.

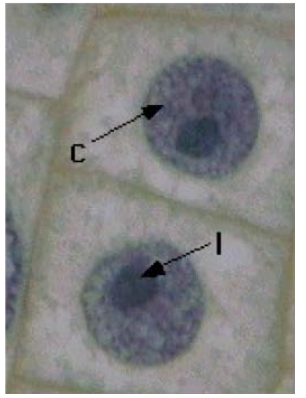
Background Information

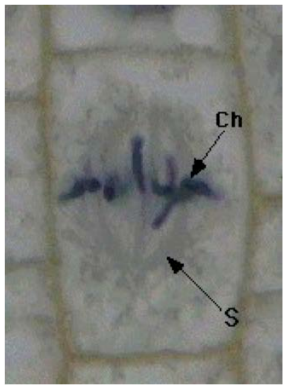
The different stages of the cell cycle can be identified by looking at the chromosomes and the shape of a cell. The study of cell shape is known as **morphology**.

During **interphase** there is a clearly defined nucleus with dispersed chromosomes. This is the phase of normal cell activity. During interphase, individual chromosomes cannot be distinguished. Instead, they collectively appear as a dark mass of material called **chromatin** (label C). The DNA of each chromosome replicates toward the end of this stage. Note the nucleus with one or more dark-stained nucleoli (label I) filled with chromatin.

Once the cell enters the **prophase**, the nuclear membrane breaks down and the chromosomes condense and form what are called **mitotic spindles**. In this stage, the chromatin appears as a mass of thick threads. These threads are the replicated chromosomes, which have coiled up and shortened. Each chromosome now consists of a pair of **chromatids** (called sister chromatids), which are duplicates of the original chromosome. The chromatids are held together by a centromere. In late prophase, the nuclear membrane and nucleoli cannot be seen, but the chromosomes are distinctly visible as pairs of sister chromatids in the central region of the cell.

In **metaphase**, the chromosomes line up across the equator of the cell (label Ch, also called the metaphase plater). A mass of fibers called a spindle (label S) has fully-formed between the poles of the cell. The spindle is attached to each chromosome and is responsible for moving them to the equator of the cell. At this point, each chromosome is still comprised of a pair of sister chromatids.



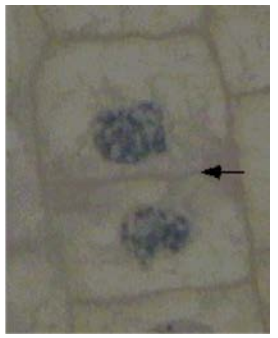


Background Information

During **anaphase**, the centromere splits and the chromosome is divided, pulling half to each side of the cell. In this stage, the two sister chromatids that comprise a chromosome are split apart. The chromatids move along the spindle fibers in opposite directions — toward the poles of the cell. This ensures that after the cell divides, each of the resulting daughter cells receives one copy of each chromosome.

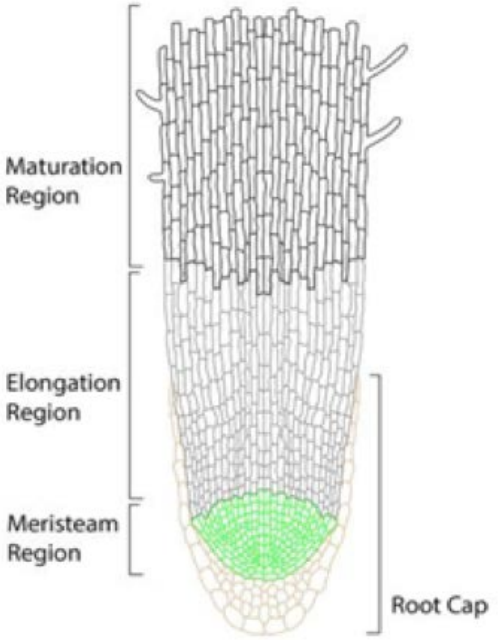
In **telophase**, the chromosomes become less condensed and two nuclei form. In this stage, the chromatids (now called chromosomes) have formed distinctive clumps at each pole. A new nuclear membrane forms around each clump of chromosomes, which uncoil and return to the chromatin network seen in interphase. The nucleoli reappear. In plants, the new cell walls (the arrows in both pictures) grow to form the two new, identical daughter cells.

Cytokinesis, the last stage, is the division of the cell cytoplasm. It results in two newly formed daughter cells which are genetically identical to the parent cell.



Background Information

New cells are produced in animals and plants by the division of old cells. The new cells often are used when tissue is growing or when dead or damaged cells need to be replaced. Onion root tips are a great way to visualize this. An onion root tip is divided into 4 sections based on the behavior and function of the cells. The root cap is the region that protects the growing root, and inside the root cap is the **meristem** region, which is a region of mitotically active cells — so lots of dividing cells. The elongation region is where cells are growing, and the maturation is the region where cells are fully mature.



Another useful model specimen to look at for mitosis is the whitefish blastula. Whitefish blastula are cells that are in early stages of embryonic development. By adding a fixative agent to these cells, we can freeze the cells in place.

The duration of each stage of the cell cycle can be estimated by determining the proportion of cells arrested, i.e., frozen at each stage of mitosis with respect to the number of cells in interphase. See lab analysis for more information on how to

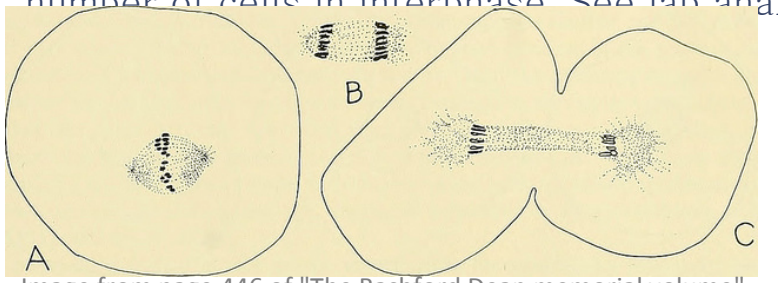


Image from page 446 of "The Bashford Dean memorial volume" (1930)

Resources

The Cell Cycle & Mitosis Tutorial. The Biology Project, University of Arizona. http://www.biology.arizona.edu/cell_bio/tutorials/cell_cycle/cells3.html

Phases of Mitosis. Khan Academy https://www.khanacademy.org/science/biology/cellular-molecular-biology/mitosis/a/phases-of-mitosis

Video: https://www.khanacademy.org/science/biology/cellular-molecular-biology/mitosis/v/mitosis

NOVA: Mitosis. PBS & WGBH Educational Foundation. http://www.pbslearningmedia.org/resource/tdc02.sci.life.stru.dnadivide/mitosis/

Louis Pasteur. Biography.

Explore Mitosis in Current Research

Cancer Research

Unregulated cell division can lead to cancer.

Cell-cycle checkpoints normally ensure that DNA replication and mitosis occur only when conditions are favorable and the process is working correctly. However, mutations in genes can lead to unregulated growth, resulting in tumor formation and invasion of cancerous cells to other organs. Researchers study mitosis to understand these processes and track cell cycle abnormalities.

The study and development of new treatments and interactions of drugs on cells depend on gaining an in-depth understanding of the response to the cell cycle.

Learn more about mitosis in research at these sites:

Mitosis in the Spotlight: Another Step to New Therapies for Uncontrolled Cell Division. IBMC. https://www.ibmc.up.pt/science-in-society/news-and-media/mitosis-spotlight-another-step-new-therapies-uncontrolled-cell

What Makes Cell Division Accurate? ScienceDaily. https://www.sciencedaily.com/releases/2014/01/140123125532.htm

New Key Mechanism in Cell Division Discovered. ScienceDaily. https://www.sciencedaily.com/releases/2012/05/120518132804.htm

Mitosis Lab Exercises

You will complete two mitosis lab exercises using the NANSLO microscope.

Exercise 1: Mitosis in plant cells

In this first exercise, you will observe onion cells at different magnifications to view the and identify the different stages of mitosis. You will manipulate the controls of the microscope to observe these cells with the 10x and 60x objective lenses. You will also capture images at both magnifications to include for further study and to insert into your lab report.

Exercise 2: Mitosis in animal cells

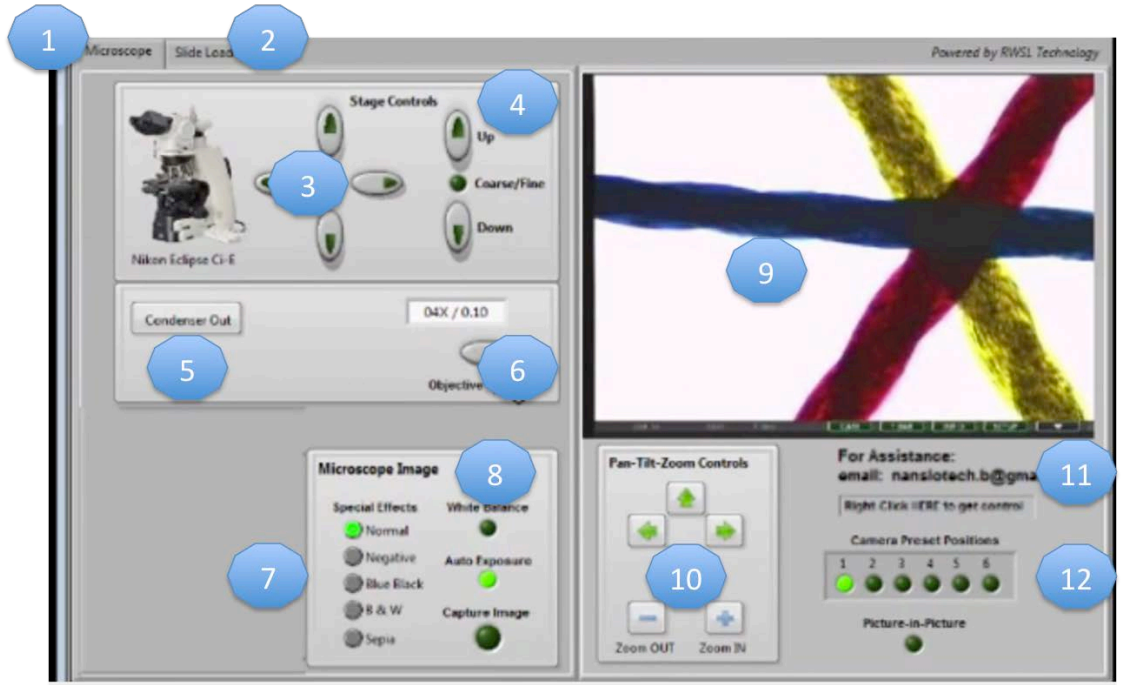
In this exercise you will observe the cells of whitefish blastula. You will observe the cells using the 10x and 60x lenses, recording observations and capturing images for each magnification.

The lab report, analysis, and conclusion pages will support and guide you to make conclusions based on the data you have collected and observed.

Control Panel

The Microscope Control Panel is where you access the equipment controls, collect data, and communicate with others participating at the same time as you.

In this lab, you will manipulate the controls of the microscope remotely in order to view slides and make observations.



Variables and Controls:

1. Microscope tab
2. Slide loader tab
3. Stage direction controls
4. Stage up and down controls
5. Condenser button
6. Objective lens selector
7. Special effects
8. Image adjustments/capture image
9. Image screen
10. Camera controls
11. User controls
12. Camera preset positions

Microscope Tutorial

This tutorial introduces you to the remote microscope, which is used in several labs. You will see how the equipment is set up as well as the view you will have from your control panel. The demonstration shows how to control the equipment, read the settings, collect data, and collaborate with others. Watch the tutorial a second time, immediately before your lab appointment, to refresh your memory about the function and purpose of the different features in this lab setup.

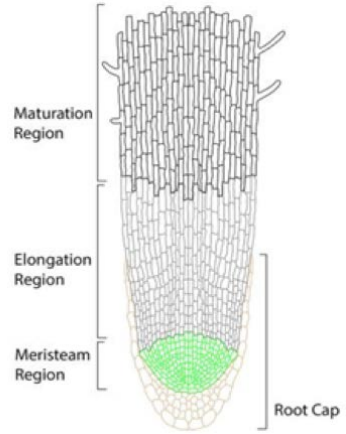
- http://www.wiche.edu/nanslo/lab-tutorials#microscope

Things to Notice / Questions:

1. How do you select a microscope slide?
2. How do you ask the lab technician for assistance?
3. What do you need to do to select a new slide?
4. What is the highest magnification you can use to view an object?
5. What do you do if you can't see the object when you change magnification?
6. When do you select the condenser?

Procedure

Exercise 1: Mitosis in plant cells

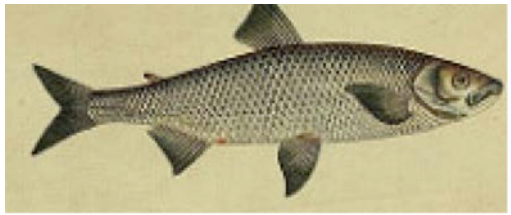


1. Using the NANSLO lab equipment, log in at the time you scheduled to take the la
2. Connect to voice conferencing.
3. Select the prepared slide of the onion root tip.
4. Locate and focus the cells at 10x and increase the magnification to 60x.
5. Locate and focus the onion root tip in the meristem region. Capture an image and save it.
6. Move the slide around and take a minimum of two more images (so three, total).
7. Move to the elongation region and capture another image.
8. Find regions where you can see multiple stages of mitosis. Make sure you have a cell in each phase of mitosis.
9. Return slide to cassette.

Procedure

Exercise 2: Mitosis in animal cells

1. Select the prepared slide of the whitefish blastula.
2. Locate and focus the blastula at 10x and then increase the magnification to 60x. Find a region on the slide where you can see multiple stages of mitosis on one image. Capture image and save for analysis.
3. Move the slide around and take a minimum of two more images (so three, total).
4. Return slide to cassette.



Resource

Mitosis in Whitefish Blastula Cells. JBS Science Department.
http://science.jburroughs.org/resources/mitosis/printanimaldiagram.html

Lab Day Checklist

On the day of your scheduled lab, review the items on this checklist to make sure you are prepared before logging into NANSLO.

- ❑ Read and review all lab materials
- ❑ Prepare and organize lab charts and recording materials
- ❑ Watch the lab tutorial again as a review before the lab
- ❑ Log in to your lab session – two options:
  - ❑ Retrieve your email from the scheduler with your appointment info or
  - ❑ Log in to the student dashboard and join your session by going to http://scheduler.nanslo.org
- ❑ NOTE: You cannot log in to your session before the date and start time of your appointment. Use Internet Explorer or Mozilla Firefox.

Lab Report: Exercise 1

Onion Root Tip Cells

Include three observation notes and images. Label images with location of cells, magnification, and stage of mitosis.

Observation notes 1

Image 1

Observation notes 2

Image 2

Observation notes 3

Image 3

Lab Report: Exercise 2

Whitefish Blastula Cells

Include three observation notes and images. Label images with location of cells, magnification, and stage of mitosis.

Observation notes 1

Image 1

Observation notes 2

Image 2

Observation notes 3

Image 3

Lab Analysis

1. What happens during cytokinesis?

2. Describe the shape of the chromosomes as they are pulled to the poles in anaphase.

3. At the completion of cytokinesis, in what phase are the two daughter cells?

4. How does mitosis differ in plant and animal cells?

5. Which phase of mitosis shows the greatest difference between animal and plant cells? Explain your choice.

6. What role do you think mitosis plays in living things? Justify your answer.

Lab Analysis

7. Provide an image that you captured using the NANSLO remote microscope for each stage of mitosis, for **either** animal **or** plant cells. Make sure to clearly label what stage each of your images represents, and whether it is animal or plant.

The duration of each stage of the cell cycle can be estimated by determining the proportion of cells arrested, i.e., frozen, at each stage of mitosis with respect to the number of cells in interphase. Look at a slide where you can see 100 cells that have been arrested or frozen in place by fixation. If you count the number in each phase and divide by the total, you will get a percentage. If you know how much time it takes a cell to divide (a whitefish blastula = 24 hours), you can predict the percentage of time a cell is in each phase. For example, if we have 100 cells and we count 10 as being in prophase, we can estimate that 10 / 100 x 100 = 10% of the cells are in prophase and 10% of 24 hours = 2.4 hours, so whitefish blastula cells will be in prophase for ~2.4 hrs.

8. Pick one of your images and calculate the percentage of cells that are in interphase, metaphase, and anaphase.

Reviewing Results

Write a review of your experiment. Include your findings and an explanation of your results.

- Explain what you observed in terms of mitosis.
- Use the vocabulary on the Important Terms page to help you explain what you observed.
- Explain why mitosis is an important cell function.

Conclusion and Reflection

Write a thoughtful conclusion to the lab, answering the essential question: What is mitosis and how does it relate to plant and animal life?

Post-Lab Questions

Answer the following questions as completely as possible. Use evidence from your lab to help support answers where possible. Use these questions to demonstrate your learning. You may want to review your pre-lab answers and see what you have gained in understanding.

1. What is the purpose of mitosis and how does it relate to the cell cycle?
2. What are the stages a cell goes through during mitosis?
3. How are chromosomes involved in mitosis?
4. What do you look for to identify the stage of mitosis in a cell?
5. What is the difference between mitosis in an animal and a plant cell?
6. How is the study of mitosis important in biology?

Photosynthesis Lab

Lab Description:

Photosynthesis is the basis for life on our planet. It is the process used by plants to convert carbon dioxide and water to oxygen and sugars through the energy of sunlight. Plants not only provide the oxygen needed for respiration, they are the basis for the food chain and absorb the carbon that is attributed to climate change. This lab explores an aspect of this truly phenomenal biological process by observing the effects of different wavelengths and intensity of light on plants and how these effects on photosynthesis.

Purpose:

To determine the effect of temperature and light wavelength (intensity) on photosynthesis.

Essential Question:

How can photosynthesis be measured and what can be gained from collecting and analyzing this data?

Objectives:

At the completion of this lab, you should be able to:

1. State the photosynthetic equation and explain the relationships between the variables.
2. Determine what to measure to monitor photosynthesis.
3. Describe how altering a variable such as light intensity or wavelength will impact photosynthesis.
4. Collect, graph, and interpret quantitative data on photosynthesis at different wavelengths of light.
5. Describe how photosynthesis data is used to study important global issues.

Pre-Lab Questions

These pre-lab questions are designed to help you think about the photosynthesis lab and self-assess what you know and what you want to know about the topic. By the end of the lab, you should be able to answer these questions in more detail. Compare your answers to see what you have learned.

1. What are the main conditions necessary for photosynthesis to take place?
2. How does the wavelength of light impact the process of photosynthesis?
3. What color (wavelength) of light do you think will enhance photosynthesis?
4. Do you think temperature affects the rate of photosynthesis? Explain.
5. In what ways is photosynthesis related to the study of climate change?

Background Information

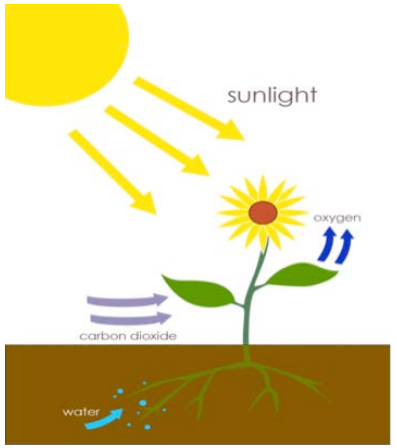
Photosynthesis is a process carried out by green plants to convert carbon dioxide and water to oxygen and glucose through the energy of sunlight. The glucose molecule is used as a chemical energy source for plants and the organisms that consume them. The energy captured by plants through the process of photosynthesis provides the basis for the food chain and energy for all life forms. The oxygen produced is released into the atmosphere and is essential for plant and animal respiration.

The balanced equation for photosynthesis is:

$$6\ CO_2\ +\ 12\ H_2O\ +\ \text{light energy} \rightarrow C_6H_{12}O_6\ (\text{glucose})\ +\ 6\ O_2$$

The same time as photosynthesis is taking place, plants are also undergoing cellular respiration. This process is actually the reverse of photosynthesis because it will release carbon dioxide and water while consuming glucose and oxygen, as you can see in the simplified equation: $C_6H_{12}O_6$ (glucose) + 6 O_2 → 6 CO_2 + 12 H_2O + ATP.

Approximately 1% of the sun's energy that reaches Earth is captured by plants and other photosynthetic organisms.

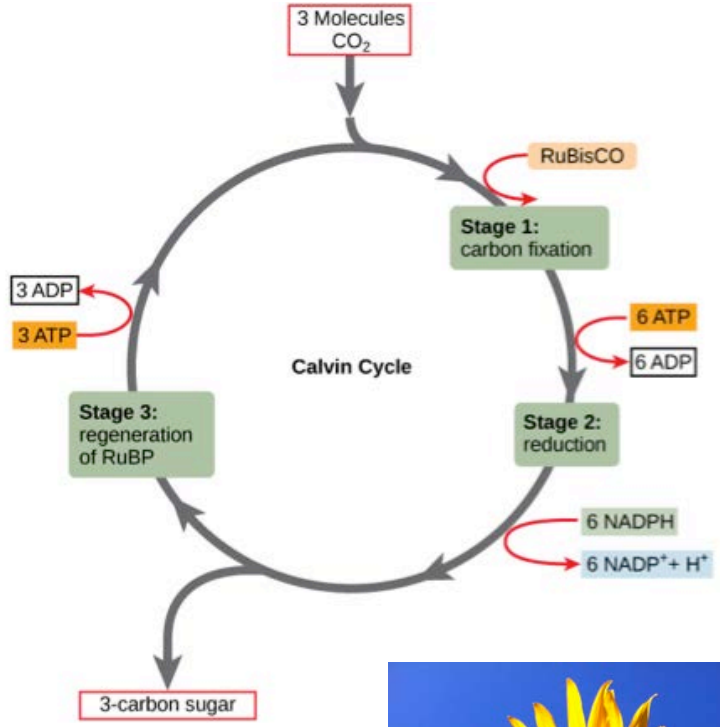


Photosynthesis takes place primarily in leaves, but any plant structure with chloroplasts has the ability to undergo photosynthesis.

Background Information

A plant in the light will be undergoing the process of photosynthesis and will be giving off oxygen. By using an O_2 gas sensor to measure the amount of gas present, we can determine if oxygen is being produced and at what rate. We can also monitor how much carbon dioxide is being consumed and at what rate. From this, we can plot the rate of photosynthesis over time as a function of the intensity of the light. As you conduct this lab, recognize there are other metabolic processes that can be affecting these gases.

Temperature will also be measured to explore the impact on photosynthesis. Keep in mind that photosynthesis is a complex process that requires the function of enzymes and chemicals in the plant cell during the process. Learn more about the detailed parts and function of the plant cell and chemical process of photosynthesis by reviewing the following resources:



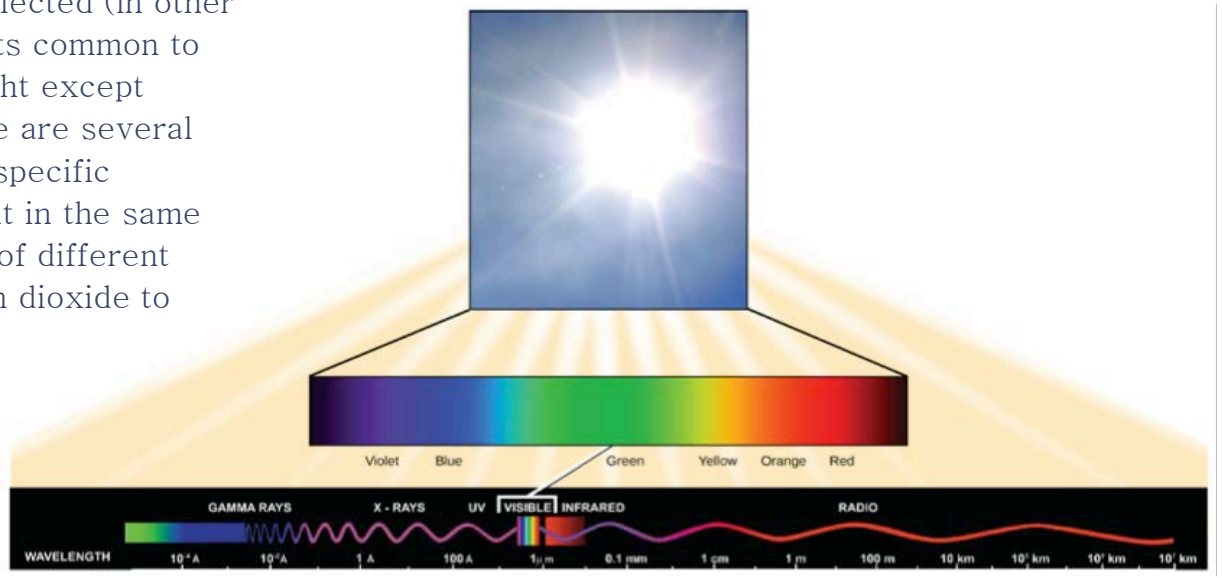
Benckiser, Reckitt. Rate of Photosynthesis: Limiting Factors. RSC. http://www.rsc.org/learn-chemistry/content/filerepository/CMP/00/001/068/Rate%20of%20photosynthesis%20limiting%20factors.pdf
Alberts B, Johnson A, Lewis J, et al. Chloroplasts and Photosynthesis. In: Molecular Biology of the Cell. 4th ed. Garland Science. http://www.ncbi.nlm.nih.gov/books/NBK26819/

Background Information

Light and Photosynthesis

Light from the sun is emitted as electromagnetic radiation or solar energy. When referring to all of the forms of electromagnetic radiation, it is called the electromagnetic spectrum. Visible light is the range of the electromagnetic spectrum that we can see. Light energy travels in and is measured in waves. Each wave is measured from crest to crest and has a specific length called the wavelength. Different wavelengths correspond to different amounts of energy carried. A long wavelength carries less energy than a short wavelength. If you look at the figure below, you can see that the high energy waves, like X-rays and UV rays, are shorter in length and the lower energy waves, like radio waves, are longer in length. The visible light range is made up of wavelengths that are intermediate in length. As a group, these wavelengths are considered to be white light but if you were to separate these wavelengths, you would see the rainbow of colors.

Plants contain pigments such as chlorophylls that absorb light. The color of the pigment we see comes from the wavelengths of light reflected (in other words, those not absorbed). Chlorophylls, the green pigments common to all photosynthetic cells, absorb all wavelengths of visible light except green, which they reflect and is detected by our eyes. There are several different pigments in plants and each pigment will absorb a specific wavelength of light, so not all wavelengths of light will result in the same photosynthetic rate. In this lab, you will explore the effects of different wavelengths of light on the production of oxygen and carbon dioxide to determine the rate of photosynthesis.



Explore Photosynthesis

Exploring Photosynthesis from Space

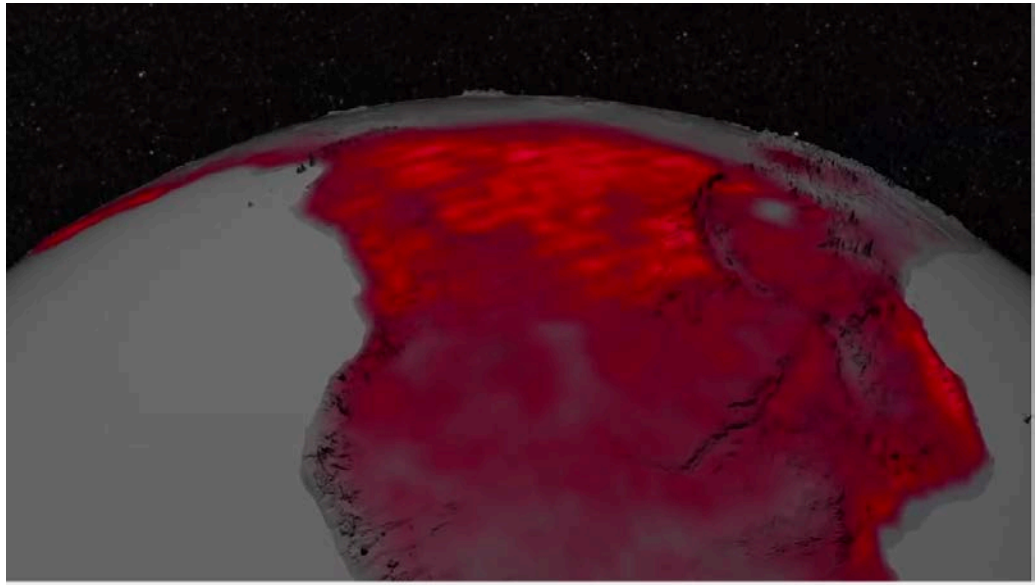
When plants convert light to energy through photosynthesis, the chlorophyll also emits traces of light as a fluorescent glow (solar induced fluorescence [SIF]). This can be seen with satellite imagery from space. SIF can determine what locations on the planet have the most photosynthetic activity and productivity, as well as where this activity is decreasing.

Photosynthesis and Climate Change

The study of photosynthesis contributes to climate change information. Through photosynthesis plants convert carbon, removing it from the atmosphere and water.

Photosynthesis at Sea

Phytoplankton are tiny plant organisms that are the basis of the ocean food chain. Since carbon dioxide is consumed during photosynthesis, phytoplankton play an important role in absorbing carbon, the main cause of climate change.



NASA | Seeing Photosynthesis from Space

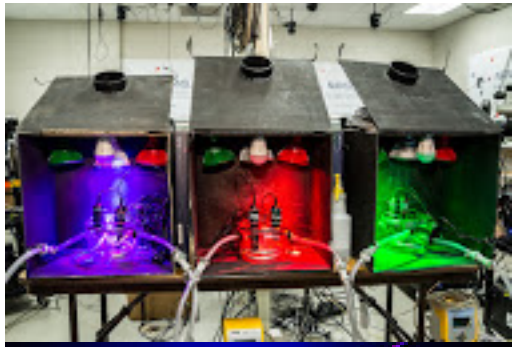
https://www.youtube.com/watch?v=1XilneV3cJI

Resources

Stoller-Conrad J. Tracking Photosynthesis from Space. Caltech. https://www.caltech.edu/news/tracking-photosynthesis-space-46627
Lindsey R, Scott M. What are Phytoplankton? NASA Earth Observatory. http://earthobservatory.nasa.gov/Features/Phytoplankton

Photosynthesis Experiments

Purpose:
To determine the effect of temperature and light wavelength (intensity) on photosynthesis.



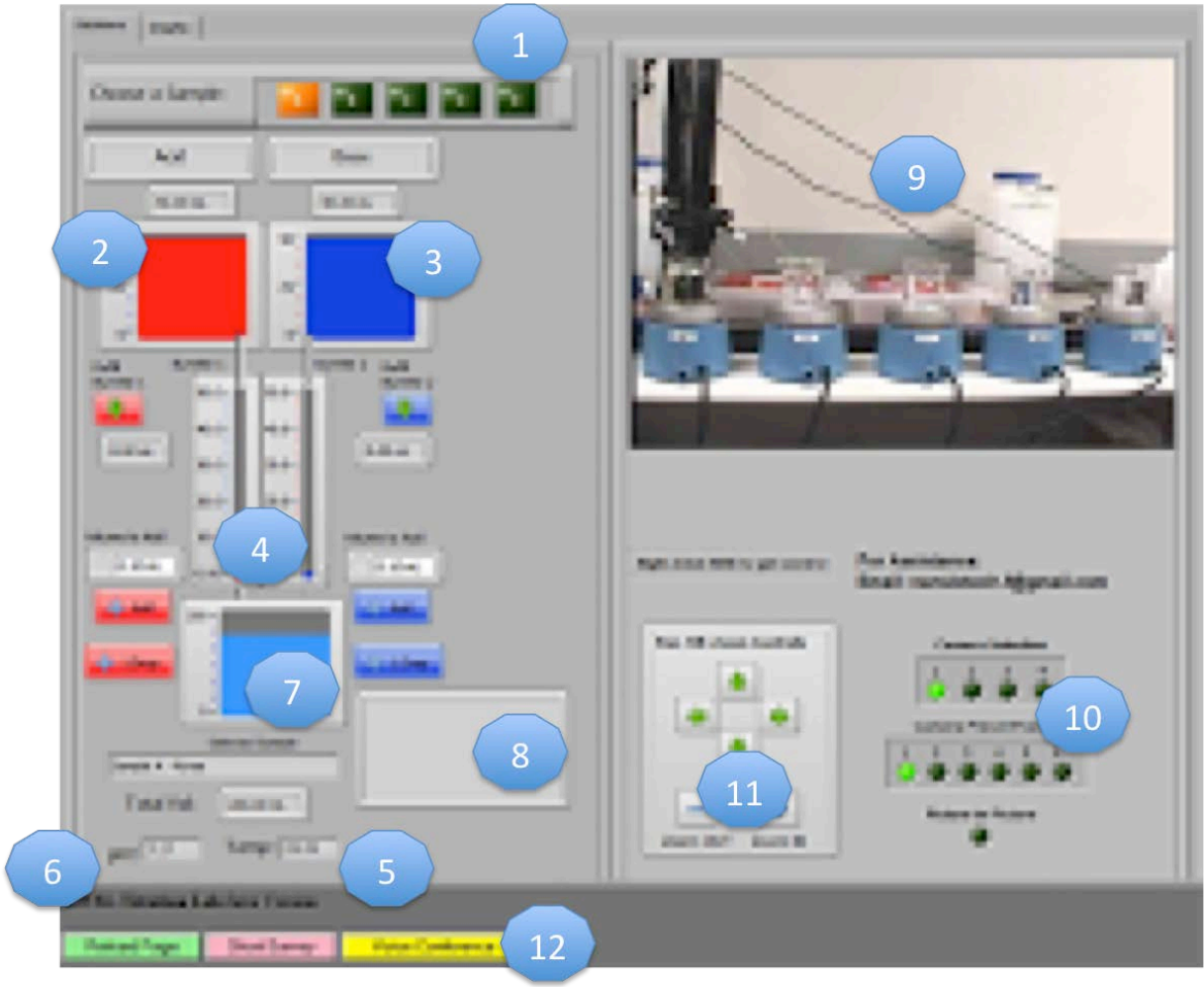
The photosynthesis lab equipment allows you to choose different wavelengths of light to measure their effects on oxygen and carbon dioxide produced by the plant specimens. The wavelengths appear as different colors, as seen in the lab setup.

This image shows a close-up of the apparatus which has two gas probes and a temperature probe within the plant chamber with a purple light source.

Control Panel

The Photosynthesis Lab Control Panel is where you access the equipment controls, collect data, and communicate with others participating at the same time as you.

In this experiment, you will monitor the oxygen and carbon dioxide of plant samples by setting up different conditions of temperature and light.



Variables and Controls:

1. Light source
2. Temperature reading
3. Oxygen reading
4. Carbon dioxide reading
5. Graph
6. Graph controls
7. Camera view
8. Camera controls
9. Voice conference
10. User control selection

Photosynthesis Tutorial

This tutorial introduces you to the apparatus used for this lab. You will see how the equipment is set up as well as the view you will have from your control panel. The demonstration shows how to control the equipment, read the settings, collect data, and collaborate with others. Watch the tutorial a second time, immediately before your lab appointment, to refresh your memory about the function and purpose of the different features in this lab setup.

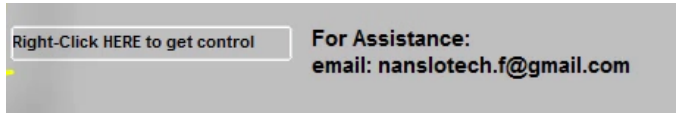
http://www.wiche.edu/nanslo/lab-tutorials#photosynthesis

Things to Notice / Questions:

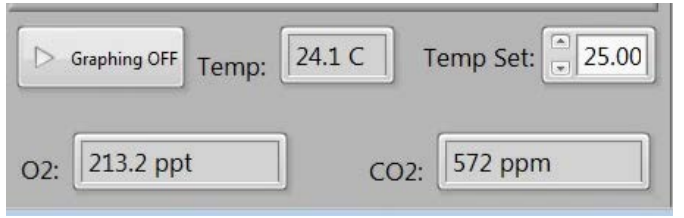
1. How do you create a graph of your results?
2. What are the three types of probes measuring?
3. Where is the plant material located?
4. What are the variables you will be testing?
5. How do you give someone else the controls for the experiment?

Photosynthesis Lab Procedure

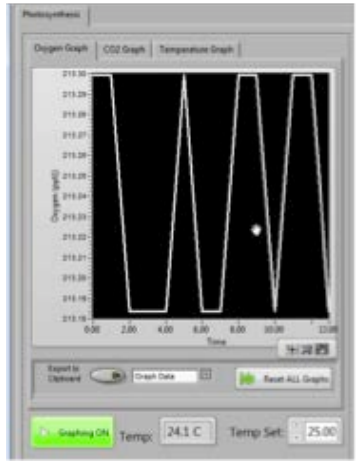
Using the NANSLO lab equipment, you will log in and take the indicated measurements at the time you are scheduled to take the lab.

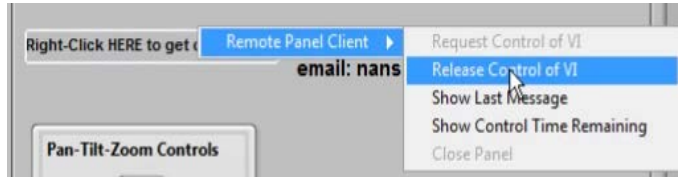


Exercise 1: How temperature affects the rate of photosynthesis



1. Click the Temperature tab and set the temperature to 27° C. Wait for the temperature to stabilize.
2. Click the Graph tab; click the start recording button for the gas probes.
3. Record your data for 10 minutes.
4. Record the light intensity.
5. Click the light source tab and turn on the “normal” light (record the time you turn on the light).
6. Record your data for another 10 minutes.
7. Record the light intensity.
8. Click the Graph tab; click the Stop Recording button for the gas probes.
9. Click the Export Data button to export the gas and temperature data.
10. Repeat steps 1–6 with a temperature below 27° C.
11. Repeat steps 1–6 with a temperature above 27° C.
12. Repeat steps 1–6 with a different temperature above 27° C.
13. If working with a group, be sure to share controls.

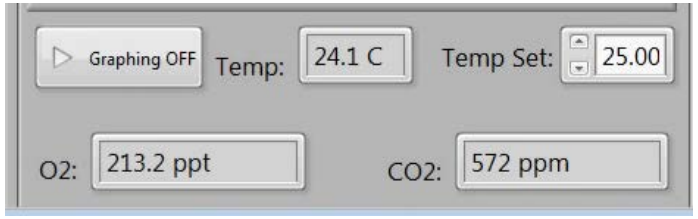


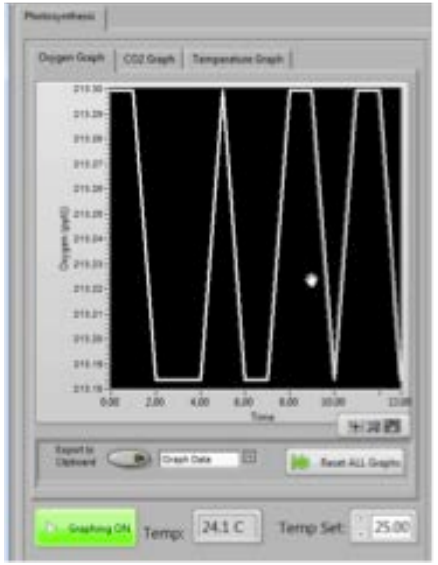


Photosynthesis Lab Procedure

Exercise 2: The effect of light on photosynthesis

1. Click the Temperature tab and set the temperature to 27° C. Wait for the temperature to stabilize.
2. Click the Graph tab; click the Start Recording button for the gas probes.
3. Click the Light Source tab and turn on the "normal" light (record the time you turn on the light).
4. Record your data for 10 minutes.
5. Record the light intensity.
6. Click the Graph tab; click the Stop Recording button for the gas probes.
7. Click the Export Data button to export the gas and temperature data.
8. Click the Light Source tab and select the Green light; repeat steps 2-7.
9. Click the Light Source tab and select the Red light; repeat steps 1-7.
10. Click the Light Source tab and select the Yellow light; repeat steps 1-7.
11. Click the Light Source tab and select the Blue light; repeat steps 1-7.
12. If working with a group, be sure to share controls.





Lab Day Checklist

On the day of your scheduled lab, review the items on this checklist to make sure you are prepared before logging into NANSLO.

- ❑ Read and review all lab materials
- ❑ Prepare and organize lab charts and recording materials
- ❑ Watch the lab tutorial again as a review before the lab
- ❑ Log in to your lab session – two options:
  - ❑ Retrieve your email from the scheduler with your appointment info or
  - ❑ Log in to the student dashboard and join your session by going to http://scheduler.nanslo.org
- ❑ NOTE: You cannot log in to your session before the date and start time of your appointment. Use Internet Explorer or Mozilla Firefox.

Photosynthesis Lab Report

Exercise 1

Lab Observations and Data
Exercise 1: How temperature affects the rate of photosynthesis
Hypothesis:

Time			
Temperature			
Light			
Oxygen			
Carbon Dioxide			

Observation Notes:

Lab Images (student insert)
Insert data graphs for the control and four trials here. Label each graph. If you want, you can also add data to a chart as in the example.

Photosynthesis Lab Report

Exercise 2

Lab Observations and Data
Exercise 2: How wavelength affects photosynthesis
Hypothesis:

Time		
Temperature	27° C	
Light Intensity	normal	
	green	
	red	
	yellow	
	blue	

Observation Notes:

Lab Images (student insert)
Insert data graphs for the control and four trials here. Label each graph. If you want, you can also add data to a chart as in the example.

Photosynthesis Lab Analysis

Exercise 1: How temperature affects the rate of photosynthesis

Insert student table

Essential Question: How can photosynthesis be measured and what can be gained from collecting and analyzing this data?

Use the following equation to calculate the rate of photosynthesis for each of your trials.

Photosynthesis rate = change in CO_2 or O_2 ÷ time

Trial 1:

Trial 2:

Trial 3:

Trial 4:

1. Do you have evidence that photosynthesis occurred? Explain.
2. Did either the oxygen or carbon dioxide levels change depending on the temperature? Explain.

Photosynthesis Lab Analysis

Exercise 2: The effect of light on photosynthesis

Essential Question: How can photosynthesis be measured and what can be gained from collecting and analyzing this data?

Use the following equation to calculate the rate of photosynthesis for each of your trials.

Photosynthesis rate = change in CO_2 or O_2 ÷ time

Trial 1:

Trial 2:

Trial 3:

Trial 4:

Trial 5:

From your data table, plot a graph that shows the rate of O_2 production vs. time at the different wavelengths of light.

1. If the rate of O_2 production is low, what does that tell you about the effectiveness of that wavelength of light?
2. What if the rate of O_2 production is high?

Insert student table/ graph

Conclusion and Reflection

Write a thoughtful conclusion to the lab, answering the essential question: How can photosynthesis be measured and what can be gained from collecting and analyzing this data?

Post-Lab Questions

Answer the following questions as completely as possible. Use evidence from your lab to help support answers where possible. Use these questions to demonstrate your learning. You may want to review your pre-lab answers and see what you have gained in understanding.

1. What are the main conditions necessary for photosynthesis to take place?
2. What will enhance the rate of photosynthesis? How do you know?
3. How does the wavelength of light impact the process of photosynthesis? How do you know?
4. What color (wavelength) of light enhances photosynthesis the most? Explain with evidence.
5. Do you think temperature impacts the rate of photosynthesis? Explain with evidence.
6. In what ways is photosynthesis related to the study of climate change?

Ecology

Lab Description:

In this lab, you will study the components and interactions of the physical and living elements within a fish tank ecosystem. You will access the lab at least three times in the assigned week. Through the lab interface, you will make observations, create data tables, and analyze your results to look for patterns/trends within this ecological system.

Purpose:

To use quantitative and qualitative data to make observations and study the interactions in a fish tank ecological system.

Essential Question:

How can a fish tank be used to study ecology and how can this study relate to larger ecosystems?

Objectives:

At the completion of this lab, you should be able to:

1. Define the study of ecology.
2. Describe how a fish tank is a complex ecological system.
3. Collect, organize, chart/graph qualitative and quantitative data.
4. Analyze and interpret data for patterns and changes.
5. Discuss how the data provides insights into the dynamics of a healthy freshwater ecosystem.
6. Apply the ecology lab process to other applications in biology.

Pre-Lab Questions

These pre-lab questions are to help you think about the ecology lab and self-assess what you know and what you want to know about the topic. By the end of the lab, you should be able to answer these questions in more detail. Compare your answers to see what you have learned.

1. What is ecology and how does it relate to biology?
2. How is a fish tank a complex ecological system?
3. What type of data can be collected from observing a fish tank ecosystem?
4. How can qualitative and quantitative data provide insights into the dynamics of a healthy and balanced ecosystem?
5. How does the study of a fish tank ecosystem apply to biological sciences?

Background Information

Ecology is the study of the interactions among organisms and their environment. It is an interdisciplinary field that covers everything from Earth science to biology to zoology. An ecological environment can be large or small and is limited only by the observer. For instance, the entire Earth is one ecological system and a small pond is another. By examing each defined ecological system, we can make observations, detect trends or patterns, and make predictions.

Ecologists seek to explain:

- Life processes, including interactions and adaptations
- Movement of materials and energy through communities
- The development and progression of ecosystems
- The distribution of organisms and the biodiversity in a system

Resources

International Society of Behavioral Ecology. http://www.behavecol.com/pages/society/welcome.html

Spatial Ecology and Conservation. Nature Education. http://www.nature.com/scitable/knowledge/library/spatial-ecology-and-conservation-13900969

Temporal Ecology Lab. http://temporalecology.org/

Systems Ecology. Chesapeake Biological Laboratory: University of Maryland Center for Environmental Science. http://www.umces.edu/cbl/systems-ecology

Background Information

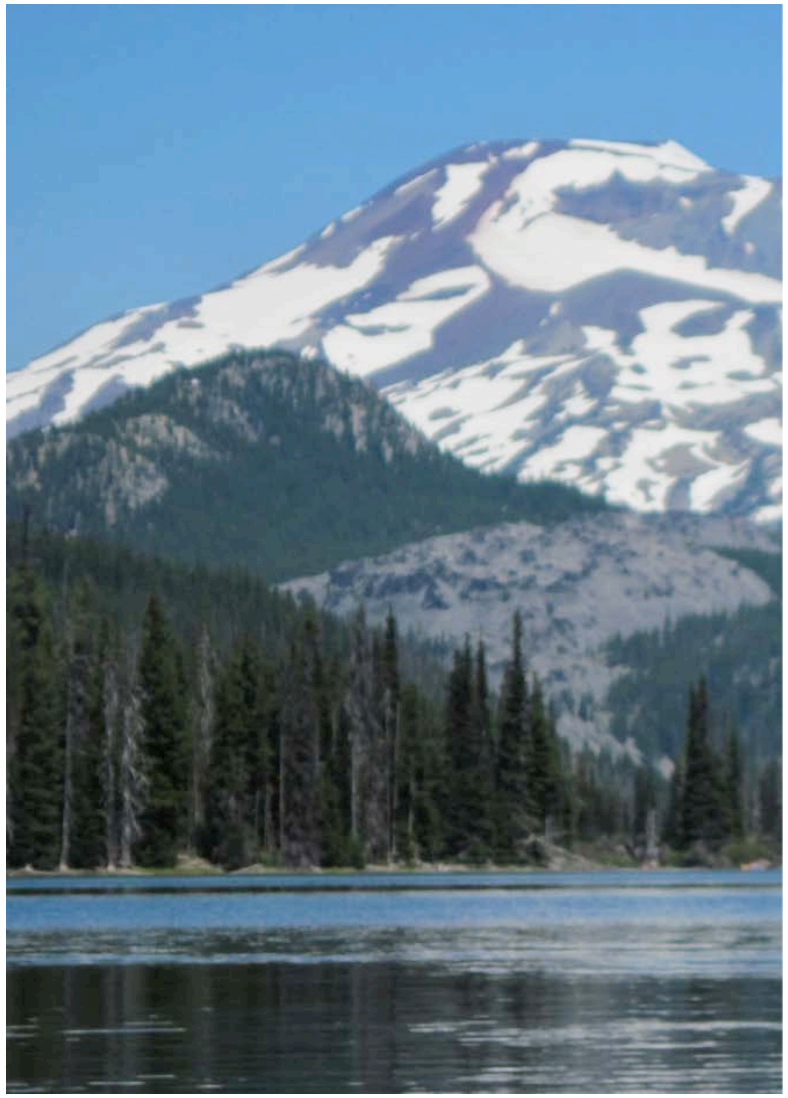
Ecological systems are biologically complex. The biocomplexity comes from the many ecological processes that are occurring simultaneously. They can be grouped into numerous distinct types, including spatial, temporal, structural, and behavioral.

- Spatial ecology is concerned with looking at how organisms are distributed throughout the defined environment, i.e., where they are located. This is very dynamic, as most things are not fixed but in constant motion, so spatial ecology looks at a snapshot, or moment, in time.
- Temporal ecology is how an ecosystem changes over time. For instance, changing patterns, such as the seasonal colors of leaves or the rings indicating the ages of trees.
- Structural ecology involves the physical arrangement of the environment, e.g., the terrain, structures, and configuration.
- Behavioral ecology looks at the behavior of the organisms.
- Systems ecology focuses on the interactions and transactions within and between biological and ecological systems, and is especially concerned with the ways in which the functioning of ecosystems can be influenced by human interventions.

How Biology and Ecology Relate

While biology is the study of living things, ecology is the science of the interconnectedness of living things and the environment. Biologists draw on ecology studies and research to study complex interactions related to the specific life forms they are studying. Ecologists benefit from biology research by gaining a better understanding of the organisms that make up the ecosystems.

Background Information



Important Terms

behavioral ecology – a branch of ecology concerned with the relationship between an animal's behavior and the conditions of its environment

biocomplexity – the study of complex interactions of living things

ecology – a branch of science concerned with the interrelationship of organisms and their environments

habitat – the place, or type of place, where a plant or animal naturally or normally lives or grows

invasive species – a species of plant or animal that is introduced to an ecosystem that is not its natural habitat

limiting factor – a factor present in an environment that controls a process, particularly the growth abundance or distribution of a population of organisms in an ecosystem

spatial ecology – a specialization of ecology and geography that is concerned with the identification of spatial patterns and their relationships to ecological events

structural ecology – an ecological feature of an ecosystem that can be measured, and subsequently evaluated, against a set of criteria

systems ecology – a branch of ecology that focuses on interactions and transactions within and between biological and ecological systems, and is especially concerned with the ways in which the functioning of ecosystems can be influenced by human interventions

temporal ecology – the study of an ecological system through time

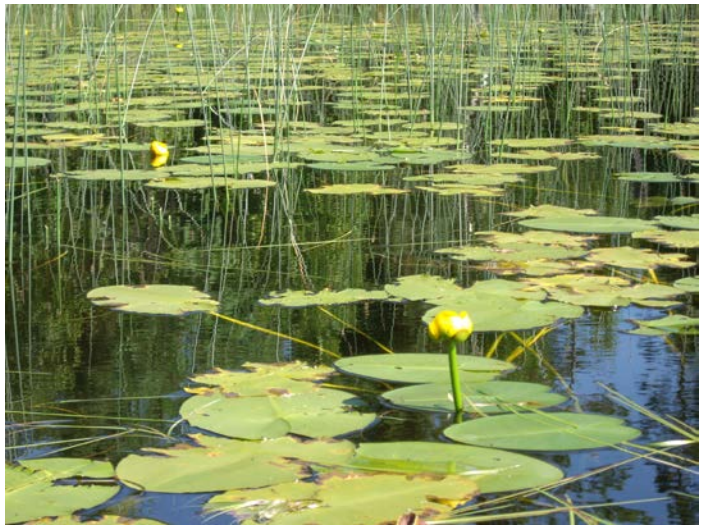
Explore Ecology

Ecology is the study of ecosystems and how life forms interrelate with each other and the environment. There is a delicate balance within any ecosystem that includes a complex exchange of energy. Food chains are interconnected to form food webs within an ecosystem. When a species is introduced or removed, the entire balance of the ecosystem is altered.

A healthy ecosystem is considered balanced. The natural nutrient cycles and exchange of energy take place to maintain the continued functioning of the life forms in the environment.

In the example of this photo, the balance could be disturbed by:

- overfishing
- overstocking fish
- pollution from boats and human waste
- runoff from farms or industries
- invasive species
- disease
- drought or flooding



Through the study of ecology, scientists gain understanding about how ecosystems work and what factors are involved in keeping each system balanced. Take a look at these resources to review examples of ecology research.

Resources

Ecology Global Network. Ecology Communications Group. http://www.ecology.com/

Ecology News. ScienceDaily. http://www.sciencedaily.com/news/earth_climate/ecology/

Ecology Lab

Purpose:
To use quantitative and qualitative data to make observations and study the interactions in a fish tank ecological system.

For this lab, our ecological system is a fish tank housed at a NANSLO lab. In order for organisms to survive in a tank setting, environmental conditions such as temperature, dissolved oxygen, pH, nitrite level, and algae levels need to be kept in balance. When these items aren't in an optimum range, the environment can become toxic to the inhabitants.

This ecological system has been equipped with sensors to detect:

- dissolved oxygen
- temperature
- pH

You will also evaluate the turbidity of the water by a visual scan of how far into the tank you can view.

https://www.flickr.com/photos/21708387@N02/

Ecology Lab

Dissolved Oxygen: Dissolved oxygen (DO) is the measure of oxygen available in water. It is commonly expressed in milligrams per liter (mg/L). Oxygen in water is required for respiration of aquatic life and is a measurement used to analyze the health of a water ecosystem. If the DO is too low, animals will die off, e.g., when there is a fish kill in a lake. Different species require different amounts of optimal DO. For instance, trout typically require a higher amount of dissolved oxygen, so habitats typically include colder water or streams with higher levels of DO. Factors that affect DO levels are temperature, water clarity, photosynthesis, bacteria, and the amount of organic material.

Temperature: The water temperature has a direct correlation to the amount of dissolve oxygen. Cold water can hold more dissolved oxygen than warm water. In natural systems, seasonal cycles, and even daily cycles, impact the amount of oxygen present in the water. In winter and early spring, when the water temperature is low, the dissolved oxygen concentration is high. In summer and fall, when the water temperature is high, the dissolved oxygen concentration is low.

pH: pH is a measure of the acid/base of a solution; it uses a scale from 0–14, with 7 being neutral. A pH less than 7 indicates acidity, while a pH greater than 7 indicates a base. pH is logarithmic, which means each number on the scale represents a 10-fold change in the acidity/basicity of the water. Water with a pH of 4 is 10-times more acidic than water with a pH of 3. The pH of water determines the solubility. This has important consequences depending on what compounds are available and the degree they are available or toxic to aquatic life.

Turbidity: Turbidity is the measure of water clarity. It is related to the amount of suspended particles in the water, such as clay, silt, algae, organic compounds, plankton, and other microscopic organisms. This can occur naturally or as a form of pollution. Turbid waters can suffocate fish; reduce the light reaching water plants which decreases photosynthesis; and cause a rise in water temperature, thereby decreasing the available oxygen. The particles also increase stagnation and provide conditions for an increase in bacteria. For

Resources

Water Properties and Measurements. USGS Water Science School. http://water.usgs.gov/edu/waterproperties.html
Understanding: Water Quality. Water on the Web. http://www.waterontheweb.org/under/waterquality/index.html
Water Research Center. http://www.water-research.net/
Live Aquaria. Petco Wellness. http://www.liveaquaria.com/
Rate My Fish Tank. http://www.ratemyfishtank.com/blog/properly-aerating-your-aquarium

Fish Tank Visible Organisms

Multiple species live in this habitat. A grid has been constructed on the front of the apparatus to allow location data to be recorded. You will observe and take photos of the organisms you view during the lab.

Please note that the plants and animals visible will vary depending on when you access the lab and what fish tank you are viewing. Below are some of the most common organisms you may observe. Use the provided resources and your own research to identify and access key details about the requirements of these organisms.

Fish Tank Aquatic Plant and Animal Life

Echinodorus
https://www.flickr.com/photos/40282089@N06/

Generic Guppies
https://www.flickr.com/photos/best/

Emerald Catfish Cory Dora
https://www.flickr.com/photos/7718908@N04/

Danio Glo Fish-Zebra Fish
https://www.flickr.com/photos/48380660@N04/

Resources

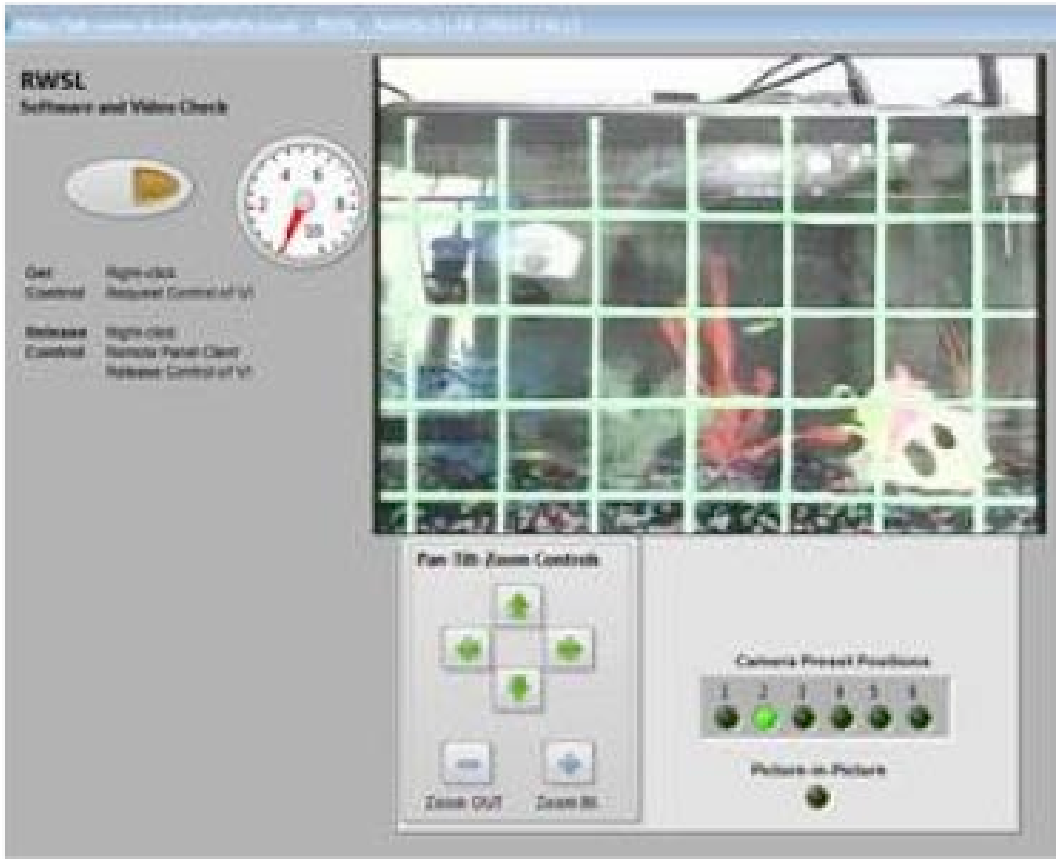
Plant Profiles - Echinodorus. The Planted Tank. http://www.plantedtank.net/forums/myPlants.php?do=homepage&cat=2&page=0
Identifying Creatures in Your Pond. Freshwater Habitats Trust. http://freshwaterhabitats.org.uk/habitats/pond/identifying-creatures-pond/
Key to Life in the Pond. Wisconsin's Citizen-Based Water Monitoring Network. http://watermonitoring.uwex.edu/pdf/level1/pondkey.pdf
Small Freshwater Organisms. Fun Science Gallery. http://www.funsci.com/fun3_en/guide/guide1/micro1_en.htm
Life in a Pond Study Guide. Douglas-Hart Nature Center. http://www.dhnature.org/uploads/2/5/7/0/25708496/life_in_a_pond_study_guide.pdf

Control Panel

The Ecology Lab Control Panel is where you access the equipment controls, collect data, and communicate with others participating at the same time as you.

In this experiment, you will use a video camera to view and zoom in on different areas of the aquarium. This allows you to identify, observe, and count the organisms visible with the naked eye. The grid on the tank allows you to record the quadrant where the organism is located.

You will also use the controls to monitor the sensors that allow you to record the levels of dissolved oxygen, temperature, and pH.



Variables and Controls:

1. Temperature reading
2. pH reading
3. Dissolved oxygen reading
4. Message screen
5. Camera image
6. Camera view
7. Camera controls
8. Voice conference

Ecology Apparatus Tutorial

This tutorial introduces you to the ecology lab. You will see how the equipment is set up as well as the view you will have from your control panel. The demonstration shows how to control the equipment, read the settings, collect data, and collaborate with others. Watch the tutorial a second time, immediately before your lab appointment, to refresh your memory about the function and purpose of the different features in this lab setup.

- Add link when available

Things to Notice / Questions:

1. What does each of the sensors monitor?
2. How is the grid on the tank used for recording observations?
3. How will you capture and record your data?
4. What comparisons will you make each time you log into and access the lab?

Ecology Lab Procedure

Using the NANSLO lab equipment, you will log in and take the indicated measurements and make observations at the times you are scheduled to take the lab. You will need to log in at least three times this week to collect your data and make your observations, but feel free to access the lab as many times as you would like. Should you encounter an issue, please notify the lab.

1. Connect to the voice conferencing tool to talk with teammates and the lab technician. Look for the controls and sensor data.
2. Record the date, time, temperature, pH, and dissolved oxygen content in your lab report.
3. Use the video camera to zoom in and make observations in the tank. Here are some things to look for:

    - Turbidity of water, or visual description of clarity of water (How far into the tank do you estimate you can see?)
    - Estimated amount of plant material
    - Identification of observable plant types/species
    - Estimated or actual population of different plant types
    - Spatial observations using the tank grid to identify the area of the tank where plants are located
    - Types/species of animals present
    - Estimated or actual population of different animals
    - Interactions between animals
    - Interactions between plants and animals
    - Other behavioral observation
    - Spatial observations using the tank grid to identify the area of the tank where animals are located

4. Take images of the different organisms to help you identify them later and to use in your lab report. Use the camera feature or take screen shots of your views. Use the fish tank grids to record the location of each photo.
5. Use the images you take to identify as many types of organisms as are available — this could be fish or plants. If your image from step 1 does not let you do this, zoom in on different parts of the fish tank grids.

Recording Information

Numerical data versus observational characteristics should be presented differently. Present this data so it is easy to interpret.

Tips for recording information

Record data, add images, and write observations for each of the three (or more) lab viewing sessions. Be as accurate as possible, including detailed observations in your qualitative data, as well as quantitative data provided by the sensors. A structure is provided in the lab report pages, but it will be the quality and organization of your observations that will inform your collection of data and its usefulness for analysis.

Lab Day Checklist

On the day of your scheduled lab, review the items on this checklist to make sure you are prepared before logging into NANSLO.

- ❑ Read and review all lab materials
- ❑ Prepare and organize lab charts and recording materials
- ❑ Watch the lab tutorial again as a review before the lab
- ❑ Log in to your lab session – two options:
  - ❑ Retrieve your email from the scheduler with your appointment info or
  - ❑ Log in to the student dashboard and join your session by going to http://scheduler.nanslo.org
- ❑ NOTE: You cannot log in to your session before the date and start time of your appointment. Use Internet Explorer or Mozilla Firefox.

Lab Report #1

Date:

Time:

Sensor Data: Temperature_____ Dissolved Oxygen _____ pH _____ Turbidity_____

Record of Species (include descriptions, names, numbers, and location in the tank)

Plants (include photos and observation notes):

Animals (include photos and observation notes):

Interaction Observation:

Lab Report #2

Date:

Time:

Sensor Data: Temperature_____ Dissolved Oxygen _____ pH _____ Turbidity_____

Record of Species (include descriptions, names, numbers, and location in the tank)

Plants (include photos and observation notes):

Animals (include photos and observation notes):

Interaction Observation:

Lab Report #3

Date:

Time:

Sensor Data: Temperature_____ Dissolved Oxygen _____ pH _____ Turbidity_____

Record of Species (include descriptions, names, numbers, and location in the tank)

Plants (include photos and observation notes):

Animals (include photos and observation notes):

Interaction Observation:

Ecology Lab Analysis

Graph the results of your data observations over time.

From your data, can you identify any trends that would affect the environmental ecology of the fish tank? Explain.

Using online sources, find typical ranges for 1) temperature, 2) pH, and 3) nitrate levels for a typical freshwater household fish tank. Cite your sources.

Ecology Review Results

Write a review of your experiment. Include your findings and an explanation of your results. Use the following prompts to guide you.

1. How accurate was the data you collected? How do you know?
2. Was temperature a factor in the ecological balance of the fish tank? Explain.
3. What factors impact pH in a fish tank?
4. Why is it important to study not only the individual species, but their interactions as a part of ecology?
5. Do you feel the fish tank is a “healthy” ecosystem? Explain using specific reasons and evidence from your lab.

Conclusion and Reflection

Write a thoughtful conclusion to the lab, answering the essential question: How can a fish tank be used to study ecology and how can this study relate to larger ecosystems?

Post-Lab Questions

Answer the following questions as completely as possible. Use evidence from your lab to help support answers where possible. Use these questions to demonstrate your learning. You may want to review your pre-lab answers and see what you have gained in understanding.

1. What is ecology and how does it relate to biology?
2. How is a fish tank a complex ecological system?
3. What type of data can be collected from observing a fish tank ecosystem?
4. How can qualitative and quantitative data provide insights into the dynamics of a healthy and balanced ecosystem?
5. How does the study of a fish tank ecosystem apply to the ecology of natural lakes and ponds?
6. How does the study of a fish tank ecosystem apply to biological sciences?

Membrane Diffusion

Lab Description:

Diffusion is a process where molecules disperse from areas of high concentration to areas of low concentration to establish equilibrium. In this lab, you will experiment with the rate of diffusion across a membrane. A spectrophotometer will be used to track the diffusion of iodine across a membrane. This is accomplished by measuring the light absorbed by the dark color of iodine as it reacts in the starch solution on the other side of the membrane. You will be setting up trials using different temperatures to find the impact of heat on the rate of diffusion.

Purpose: To determine the rate of diffusion related to increasing temperature.

Essential Question: How can diffusion be measured to better understand the movement of molecules?

Objectives: At the completion of this lab, you should be able to:

1. Define diffusion and identify the conditions necessary for it to occur.
2. Determine what is being measured in a spectrophotometer, and explain the basics of spectrophotometry.
3. Collect quantitative data on the rate of diffusion at different temperatures.
4. Graph the data collected and interpret the data.
5. Explain how temperature impacts molecular movement.
6. Determine the effect of temperature on the diffusion rate of iodine through a dialysis tube membrane.
7. Apply diffusion concepts to the field of biology with specific examples.

Pre-Lab Questions

These pre-lab questions are to help you think about the diffusion lab and self-assess what you know and what you want to know about the topic. By the end of the lab, you should be able to answer these questions in more detail. Compare your answers to see what you have learned.

1. What is diffusion and how does it apply to biology?
2. What are the conditions necessary for diffusion to occur?
3. What is a method for determining the rate of diffusion?
4. How does temperature relate to the rate of diffusion in liquids?
5. In what circumstances might it be important to know the rate of diffusion in the field of biology?

Background Information

Diffusion is the movement of things from a high concentration to a low concentration. Imagine you are adding cream to your coffee. The spot where the cream hits the milk is highly concentrated and it diffuses out to areas of low concentrations. Perfume works the same way but in the air. Someone wearing the scent is highly concentrated and you can smell it as it diffuses across the room and hits your nose.

Atoms and molecules are in constant motion. Even in a solid state, the molecules exhibit vibrational movement as they move against each other in position. When molecules are in a liquid state, they can be farther apart than in a solid, but not nearly as far apart as in a gas.

Because molecules are in constant motion, the molecules are colliding with each other. This type of motion is called Brownian movement. As a substance heats up, the motion becomes faster and molecules collide more frequently. Think for a minute about a drop of food coloring in a glass of water. If the water is hot, the water molecules will be moving faster and the collisions with the food coloring molecules will be more frequent, causing the food coloring to diffuse more rapidly. On the other hand, ice water will have the opposite effect. Simple diffusion relies on Brownian motion and temperature.

There is an interesting simulation here if you want to learn more: http://phet.colorado.edu/en/simulation/states-of-matter-basics

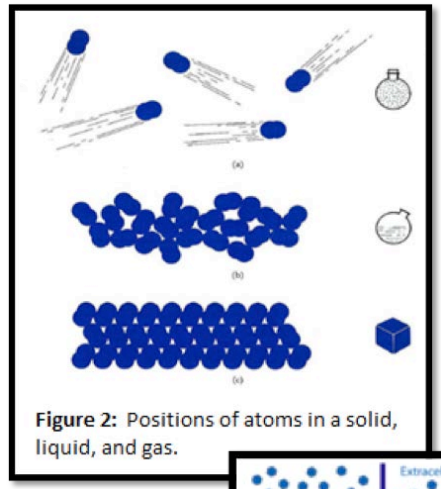


Figure 2: Positions of atoms in a solid, liquid, and gas.

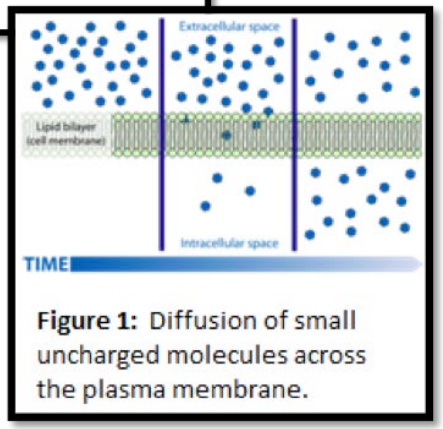


Figure 1: Diffusion of small uncharged molecules across the plasma membrane.

Resource

Diffusion and Osmosis. Khan Academy. https://www.khanacademy.org/science/biology/membranes-and-transport/diffusion-and-osmosis/v/diffusion-and-osmosis https://www.youtube.com/watch?v=aubZU0iWtgI

Background Information

The life of a cell is dependent on efficiently moving molecules into and out of the cell. A factor of this movement is the cell membrane. Molecules in living things move in a variety of ways, but for the purposes of this lab the focus will be on simple diffusion. Small, uncharged molecules are able to move easily across the cell membrane in a process known as simple diffusion. The process of simple diffusion relies on the inherent nature of molecules to move from high concentration to lower concentration. This laboratory activity will focus on the transport of molecules across a barrier via diffusion, which can be applied to the diffusion process in other situations.

The difference between the highly concentrated substance and the lower concentrated substance is called the **concentration gradient.** Diffusion can only happen if there is a concentration gradient present. When there is no longer a net movement, **equilibrium** is reached.

There are both qualitative and quantitative methods that can be used to record and observe diffusion. Qualitative data are based on the five senses and observations. Imagine the perfume example. As you get closer to the person, i.e., the concentrated sample, your nose gets overwhelmed, and as you walk away it goes away. Quantitative data, on the other hand, are measured and numerical, and are not subjective to our individual senses. In this lab, we will be using a **spectrophotometer** to quantitatively measure diffusion.

Important Terms

absorbance – the measure of the quantity of light absorbed by a sample

Brownian movement – the irregular motion of small particles suspended in a liquid or a gas, caused by the bombardment of the particles by molecules of the medium

concentration gradient – the gradual difference in concentration of a dissolved substance in a solution between a region of high density and one of lower density

cuvette – a straight-sided, optically clear container for holding liquid samples in a spectrophotometer or other instrument

diffusion – an intermingling of molecules, ions, etc., resulting from random thermal agitation

equilibrium – a state of rest or balance

equivalence point – the point at which chemically equivalent of concentration, the number of moles of solute per liter of solution

solute – the substance dissolved in a given solution

solution – a homogeneous, molecular mixture of two or more substances

solvent – a substance that dissolves another to form a solution

spectrophotometer – an apparatus for measuring the intensity of light in a part of the spectrum, especially as transmitted or emitted by particular substances

Explore Diffusion in Biology

Dialysis

The process of dialysis involves passing through a tube made of a semipermeable material. On the other side is a liquid of a certain concentration. The blood is passed over the membrane and materials diffuse into or out of the bloodstream.

Pheromones

Pheromones are chemicals released by animals that are dispersed by diffusion for the purpose of attracting a mate.

Smoke Diffusion

The study of how smoke diffuses through air is used to determine health risks from forest fires and second-hand smoke.

Botany

Many functions of a plant use diffusion as a way to exchange and distribute molecules for necessary life processes. For example, carbon dioxide diffuses from the air spaces between mesophyll cells in a leaf to the chloroplast.

Animal Physiology- Human Health

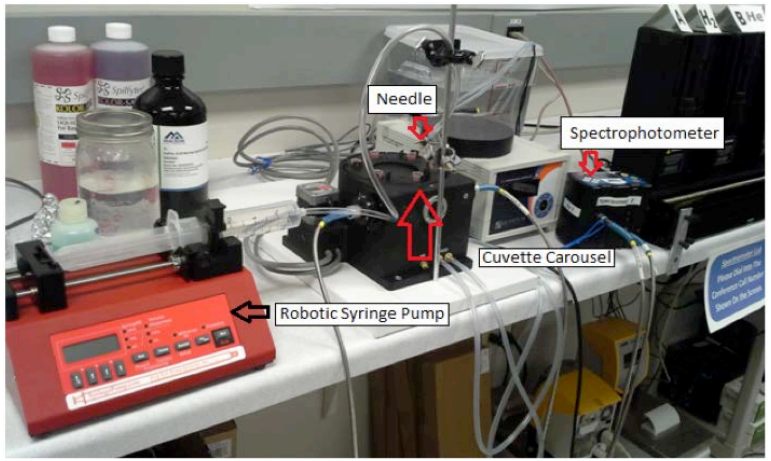
Digestion: particles of food diffuse in the colon. Respiration: exchange of oxygen and carbon dioxide diffuses between the lungs and bloodstream. Food molecules and oxygen diffuse from the mother's blood to the fetus's blood supply through the placenta.

Resources

How Does a Kidney Dialysis Machine Work? HowStuffWorks. http://science.howstuffworks.com/innovation/everyday-innovations/question17.htm
Pheromones in Insects. Smithsonian. http://www.si.edu/Encyclopedia_SI/nmnh/buginfo/pheromones.htm
Diffusion. Biocyclopedia. http://www.biocyclopedia.com/index/introduction_to_botany/diffusion.php

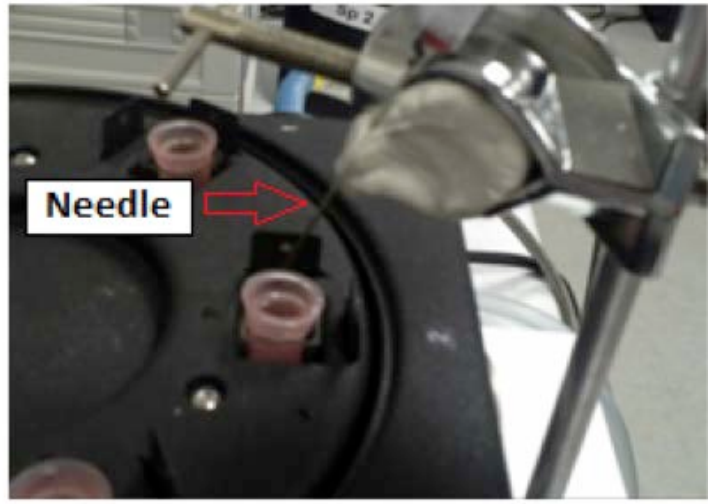
Diffusion Experiment

Purpose:
To determine the rate of diffusion related to increasing temperature.



The diffusion lab is set up with the equipment shown here.

This image shows a close-up of a cuvette that contains a starch solution. Each cuvette includes a diffusion membrane insert you will be filling with an iodine solution. The iodine will be added in small amounts using a syringe controlled by a robotic pump.



Diffusion Experiment

How a spectrometer measures diffusion:

When light is directed at a colored liquid, a certain amount of light is absorbed. The more color that is present, the more light gets absorbed. If we watch for a color change as something moves from one liquid to another, we can measure that change by looking at how much light gets absorbed.

[Rate of Diffusion = Change in Absorbance/Time]

The independent variable in this experiment will be time. You will have three temperature variables. In the cuvette will be a starch solution; an iodine solution will be in the diffusion membrane insert. The bottom of the pink cup has a permeable barrier that will allow the iodine to pass through. The iodine will be added in small amounts using a syringe controlled by a robotic pump.

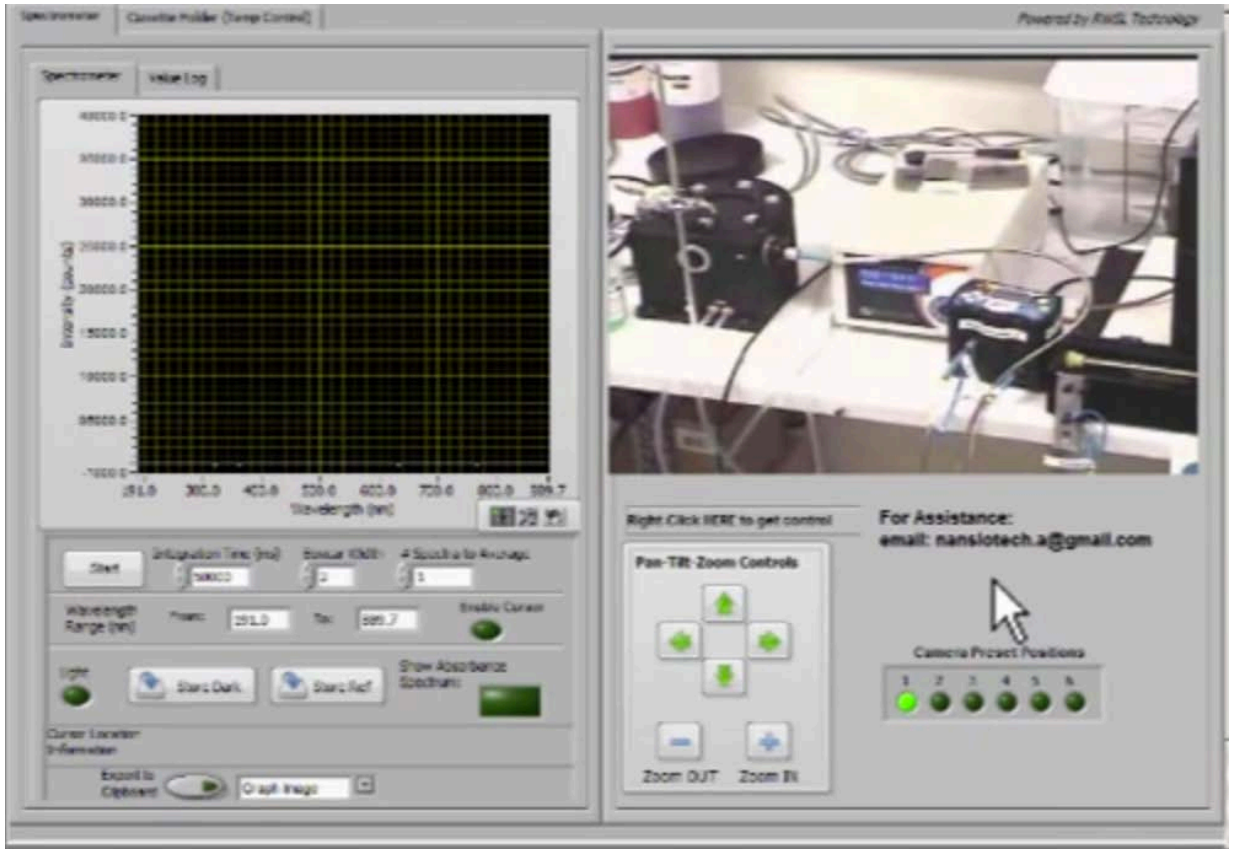
When iodine and starch interact, they form a dark pigment as iodine diffuses. The rate of diffusion can be measured by how much pigment is present. More color equals more iodine, indicating more has diffused.

The cuvettes will be pre-loaded with starch solution (clear) and a small stir-bar to stir the solution. You will be able to select a cuvette by rotating the carousel. You will deliver a small, pre-measured amount of iodine solution (red-brown) with the robotic syringe pump, and it will begin moving through the diffusion membrane into the starch solution and will react chemically with the starch to form a starch-iodine complex (blue-black). You will be able to control the temperature of the cuvette carousel so you can see how different temperatures affect the rate of diffusion. There are six cuvettes in the carousel, so you will have up to six opportunities to measure diffusion rates.

Control Panel

The Diffusion Lab Control Panel is where you have access to the equipment controls, collect data, and communicate with others participating at the same time as you.

In this experiment, you will control the temperature as diffusion occurs. You will be able to track and save the data on the graphs.



Diffusion Apparatus Tutorial

This tutorial introduces you to the spectrophotometer, which is used for several labs. You will see how the equipment is set up as well as the view you will have from your control panel. The demonstration shows how to control the equipment, read the settings, collect data, and collaborate with others. Watch the tutorial a second time, immediately before your lab appointment, to refresh your memory about the function and purpose of the different features in this lab setup.

http://www.wiche.edu/nanslo/lab-tutorials#beerlambert

Things to Notice / Questions:

1. How do you store a dark spectrum? Why is this stored?
2. What is the timer used for?
3. Why do you think stirring is used in this lab?
4. What are you measuring and how does it relate to diffusion?
5. How will the graphs help you understand the results?

Diffusion Lab Procedure

Using the NANSLO lab equipment, you will log in and take the indicated measurements at the time you scheduled to take the lab.

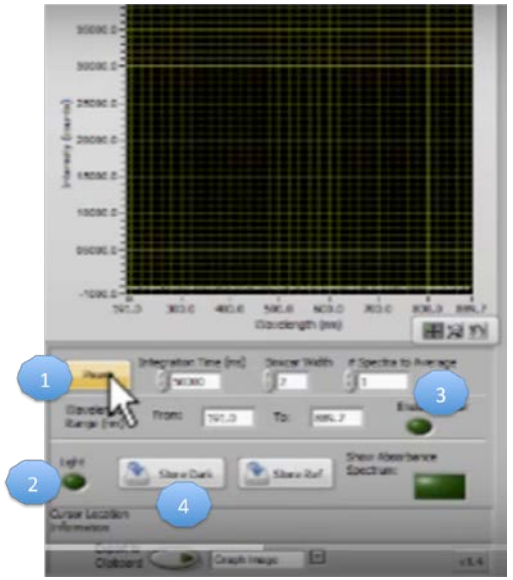
Exercise 1: Diffusion

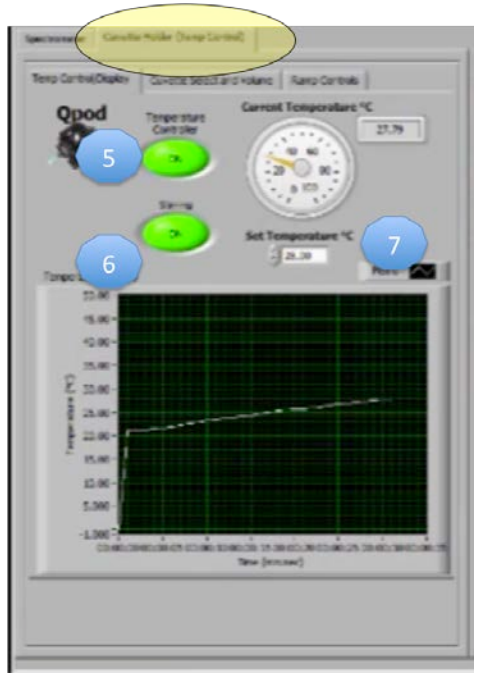
From the Spectrometer tab

1. Click on the Start button to start the spectrophotometer data feed.
2. Ensure that the spectrophotometer light is turned off.
3. Set # Spectra to Average to a value of 20.
4. Store a dark spectrum.

From the Cuvette Holder/Temp Control/Display Tab

5. Turn on the Temperature Controller and select an initial temperature of 20° C.
6. Ensure that the stirrer is turned on so the solutions are being mixed. Use camera preset 2 to verify that the Cuvette Holder controller screen says "Stir On."
7. Wait until the temperature has been stable for at least 2 minutes.





Diffusion Lab Procedure

From the Spectrometer Tab

8. Turn on the spectrophotometer light.

9. Store a reference spectrum.

10. Select the Show Absorbance Spectrum button to view the absorbance spectrum and Zoom Out on the graph.

11. Turn on the cursor and drag it to 351.8 nm. This is where an absorbance peak will appear when the starch-iodine complex forms.

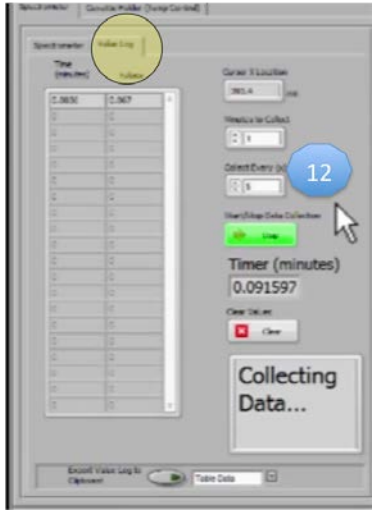
From the Spectrometer/Value Log Tab

12. Ensure that Minutes to Collect is set to 10 minutes and Collect Every (x) Seconds is set to 30 seconds.

From the Cuvette Holder/Cuvette Select and Volume Tab

13. Select Pump #1 and ensure that Volume to be Added is set to 0.25 mL.

14. Click the Add Volume button and observe the volume in the cuvette increasing from 3.75 to 4.0 mL as the iodine solution is added.



Diffusion Lab Procedure

From the Spectrometer/Value Log Tab

15. Click Start.
16. Time and Absorbance data will now be collected every 30 seconds for 10 minutes.
17. You can watch the absorbance peak grow on the Spectrometer tab.
18. Value Log data to the clipboard and paste it into a document.

From the Cuvette Holder/Cuvette Select and Volume Tab

19. Select another cuvette on the Cuvette Selector tab to start with a clean starch solution.
20. Another student should take control of the control panel at this point (right click to release your control, or take control).
21. Set the temperature to 30° C.
22. Start over with step 2 and collect another set of data.
23. Another student should now take control and set the temperature to any setting between 30° C and 50° C.
24. Start over with step 2 and collect another set of data.
25. If there are students who haven't collected any data, and there is time remaining in your lab period, collect more data sets if you would like. Do not exceed 50° C!

Lab Day Checklist

On the day of your scheduled lab, review the items on this checklist to make sure you are prepared before logging into NANSLO.

- ❑ Read and review all lab materials
- ❑ Prepare and organize lab charts and recording materials
- ❑ Watch the lab tutorial again as a review before the lab
- ❑ Log in to your lab session – two options:
  - ❑ Retrieve your email from the scheduler with your appointment info or
  - ❑ Log in to the student dashboard and join your session by going to http://scheduler.nanslo.org
- ❑ NOTE: You cannot log in to your session before the date and start time of your appointment. Use Internet Explorer or Mozilla Firefox.

Diffusion Lab Report

Lab Observations and Data
Cuvette 1
Data:

Observation notes:

Lab Observations and Data
Cuvette 2
Data:

Observation notes:

Lab Images (student insert)

Diffusion Lab Report

Lab Observations and Data
Cuvette 3
Data:

Observation notes:

Lab Observations and Data
Cuvette 4
Data:

Observation notes:

Lab Images (student insert)

Diffusion Lab Report

Lab Observations and Data
Cuvette 5
Data:

Observation notes:

Lab Observations and Data
Cuvette 6
Data:

Observation notes:

Lab Images (student insert)

Diffusion Lab Analysis

Using the Value Log data, create a graph. On the graph you will plot time as the independent variable and absorbance as the dependent variable. You should have three different lines for the three temperature variables (or more if you collected more data).

Analyze the graph by relating the shape of the curve to an underlying mechanism that might govern the phenomenon being studied. Discuss factors involved in diffusion that might cause this curve shape to be true.

Calculate the rate of absorbance change for each of the temperatures with the following equation: *Rate of Diffusion = Change in Absorbance/Time*, and add these values to your data table.

Insert student graph

Diffusion Lab Analysis

With your graphed data, calculate the slope of the line for the last 5 minutes of the data collected at each temperature. Slope is calculated by first choosing two points on the graph, then determining the change in the horizontal points and the change in the vertical points.

For example, if your coordinates on the graph at point #1 are 0.5 (X axis) and 6 (Y axis) and at point #2 the coordinates are 4 (X axis) and 12 (Y axis), the vertical change is 12 – 6 and the horizontal change is 4 – 0.5, or vertical change = 6 and horizontal change = 3.5. To find the slope, you would divide the vertical change by the horizontal change. 6/3.5 for a slope of 1.7. ***The slope is the rate of diffusion.*** Be sure to include the correct units for your data. Show your calculations, and then plot on a graph the diffusion rate (slope of the last 5 minutes worth of data) vs. temperature. What information can you get from this graph?

On your initial time vs. absorbance graph, interpolate what the absorbance curve would look like at 25° C. On the highest temperature absorbance curve that you graphed, extrapolate out to 40 minutes – what do you think the absorbance would be at that point? Would the values continue to increase linearly?

Membrane systems often have folds in the membrane which function to increase surface area. Based on what you know about molecular movement, explain why it is important for cells to have an increased surface area.

Insert student graph

Reviewing Results

Write a review of your experiment. Include your findings and an explanation of your results. Then answer the following questions.

1. How accurate was the data you collected? How do you know?
2. Was temperature a factor in the diffusion rate? Explain.
3. How do the graphs show the equivalency point?

Conclusion and Reflection

Write a thoughtful conclusion to the lab, answering the essential question: How can diffusion be measured to better understand the movement of molecules?

Post-Lab Questions

Answer the following questions as completely as possible. Use evidence from your lab to help support answers where possible. Use these questions to demonstrate your learning. You may want to review your pre-lab answers and see what you have gained in understanding.

1. What is diffusion and how does it apply to biology?
2. What are the conditions necessary for diffusion to occur?
3. What is a method for determining the rate of diffusion?
4. How does temperature relate to the rate of diffusion in liquids?
5. In what circumstances might it be important to know the rate of diffusion in the field of biology?

Osmosis Lab

Lab Description:

Osmosis is a process in which molecules move across cell membranes due to changing concentration gradients. This lab consists of two exercises that observe how cells change due to osmosis in plant and animal cells.

Purpose:

To observe the conditions and effects of osmosis in plant and animal cells.

Essential Question:

What is osmosis and how does it impact the transport of water in and out of cells?

Objectives:

At the completion of this lab, you should be able to:

1. Define osmosis and the basic conditions for water transport in and out of cells.
2. Describe how cells change in a hypertonic solution.
3. Describe how cells change in a hypotonic solution.
4. Use the microscope to view slides at different magnifications.
5. Capture and insert microscope images in lab reports.
6. Explain how solutes impact the direction of water in or out of the cell.
7. Apply scientific terminology in lab analysis and conclusions.
8. Explain the importance of studying osmosis in the field of biology.

Pre-Lab Questions

These pre-lab questions are to help you think about the osmosis lab and self-assess what you know and what you want to know about the topic. By the end of the lab, you should be able to answer these questions in more detail. Compare your answers to see what you have learned.

1. What conditions need to exist for water to enter a plant cell through osmosis?
2. What conditions need to exist for water to leave a plant cell through osmosis?
3. What do you think you will see in animal cells in an isotonic solution?
4. What will happen to animal blood cells in a hypertonic solution?
5. What will happen to animal blood cells in a hypotonic solution?
6. How is the study of osmosis important in biology?

Important Terms

concentration gradient – the difference in the concentration of a substance on two sides of a permeable barrier

crenation – a process resulting from osmosis in which red blood cells, in a hypertonic solution, undergo shrinkage and acquire a notched or scalloped surface

hypotonic – a solution having a lower concentration of solute than another solution, hence exerting less osmotic pressure than that solution

hypertonic – having an osmotic pressure greater than that of the solution with which it is compared; pertaining to a solution that causes cells to shrink

isotonic – having equal tension; denoting solutions possessing the same osmotic pressure; more specifically, limited to solutions in which cells neither swell nor shrink

osmosis – the movement of a solvent, usually water, due to osmotic pressure

osmotic pressure – pressure caused by a difference in concentration between solutions on the two sides of a selectively permeable membrane; the result is movement of the solvent in the direction of higher solute concentration

semipermeable – partially, but not freely or wholly, permeable; permeable to some, usually small, molecules but not to other, usually large, particles

solute – the substance dissolved in a solvent

solvent – the dissolving medium of a solution

tonicity – the state of tissue tension; the effective osmotic pressure equivalent

turgid – swollen from liquid

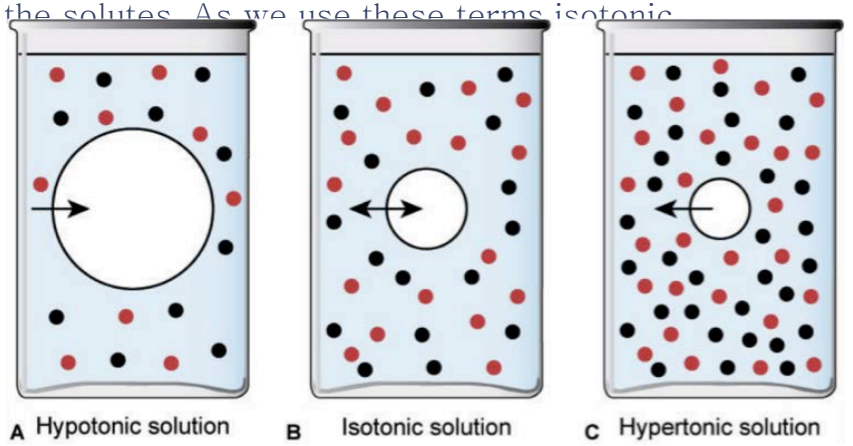
turgor pressure – a measure of the tendency of a cell to push water out of the cell, usually a positive value

Background Information

The life of a cell is dependent on efficiently moving molecules into and out of the cell. **Osmosis** is a special type of diffusion that describes the movement of water molecules through the **semipermeable** cell membrane. Osmosis is caused by the unequal distribution of **solutes** on the two sides of the membrane known as the **concentration gradient.** Water will move from the side with more solute to the side with lower solute. Solutes themselves are often too big or too charged to cross the semipermeable membrane. To maintain balance, water will move to the side of higher concentration. Water is "drawn" toward the side of the membrane with the higher solute concentration by **osmotic pressure** caused by the differences in the concentration of the solutions.

In a **hypotonic** environment, a solution has a lesser amount of non-penetrating solutes outside of the cell. Based on a concentration gradient, the net movement of water is into the cells. As a result, the cells swell. This is known as **turgor** and is responsible for plant cells being turgid or "full." In an animal cell there is no cell wall, so the cell will swell and burst. In a **hypertonic** condition, a solution has a greater amount of non-penetrating solutes outside of the cell. Based on a concentration gradient, the net movement of water is out of the cells. As a result, the cells shrink. This is called **crenation**. In an **isotonic** state, the concentrations and pressures are equal, resulting in no net movement.

It is important to note that concentration is typically given for the non-penetrating solute not the **solvent**. This means that in order to determine which direction the water molecules will move, you need to be able to calculate the percentage of water. For example, in a 5% glucose solution there is 95% water. In the figure shown below, you can see the three tonic solutions and how the movement of the free water across a plasma membrane changes as a result of the concentration of the solutes. As we use these terms isotonic, hypertonic, and hypotonic, we are referring the solution, not the cell.



Resources

How Osmosis Works [HD Animation].
https://vimeo.com/128464245

Diffusion and Osmosis | Membranes and Transport | Biology. Khan Academy.
https://www.youtube.com/watch?v=aubZU0iWtgI

Explore Osmosis in Biology

Biofuels

NASA scientists are working on a process that uses osmosis to meet the rising demand of algae used to produce biofuel. The concept is to grow freshwater algae in ocean water by using bags made of semipermeable membranes. With saltwater on the outside and freshwater on the inside, the membrane prevents salt from diluting the freshwater. The algae will feed on the nutrients in the sewage. Through osmosis, the bag will absorb carbon dioxide from the air and release oxygen and freshwater. In the process, biofuels will be produced.
Read more: NASA Envisions "Clean Energy" From Algae Grown in Waste Water. NASA.
http://www.nasa.gov/centers/ames/news/features/2009/clean_energy_042209.html


https://www.flickr.com/photos/jurvetson/

Aquaporins

Aquaporins are membrane proteins that act as water channels to help water molecules travel across cell membranes during the process of osmosis. Aquaporins were discovered in 1992 by Peter Agre, and earned him the 2003 Nobel Prize in Chemistry. An aquaporin transports water, one molecule at a time, at the rate of about 3 billion water molecules per second, allowing cells to regulate volume and osmotic pressure.

Aquaporins are essential to life processes. Their functioning is an important element in the study of diseases that affect parts of the body that require water transport, such as the kidneys, lungs, skeletal muscle, digestive system, and skin.
Read more: Aquaporins. University of Minnesota Medical School Duluth.
http://www.d.umn.edu/~jfitzake/Lectures/DMED/IonChannelPhysiology/IonChannelProperties/Aquaporins.html


https://www.flickr.com/photos/104257326@N05/

Resource

Osmosis – Real-Life Applications. Science Clarified. http://www.scienceclarified.com/everyday/Real-Life-Chemistry-Vol-2/Osmosis-Real-life-applications.html

Osmosis Lab Exercises

You will complete two osmosis lab exercises using the NANSLO microscope.

Exercise 1: Osmosis in plant cells

In this first exercise, you will observe osmosis as it affects the plant cells. You will view a slide of live red onion cells that the lab technician will prepare and place on the microscope stage. You will manipulate the controls of the microscope to observe these cells with the 10x and 40x objective lenses. You will also capture images at both magnifications to include for further study and to insert into your lab report.

Next, the lab technician will add a drop of 20% salt solution to the slide as you are viewing. You will make observation notes and capture images of what you are viewing to include in your lab report.

Exercise 2: Osmosis in animal cells

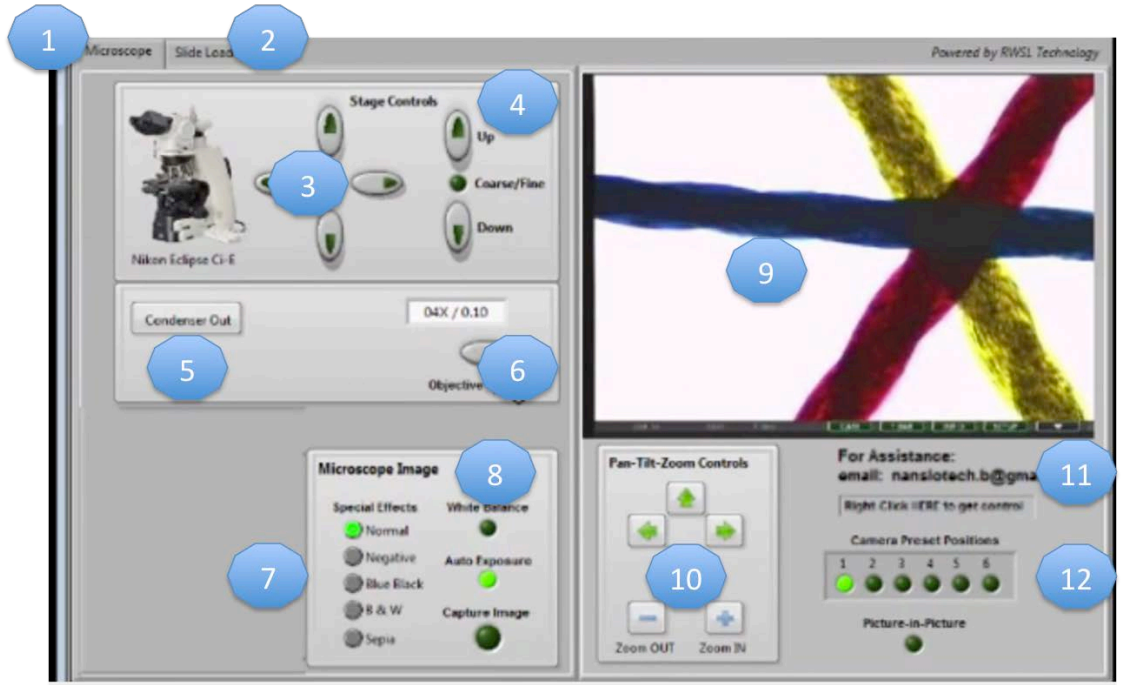
This time, you will ask the technician to load a slide of blood on the microscope stage. You will observe the blood cells using the 10x, 40x, and 60x lenses, recording observations and capturing images for each magnification. You will then change to the hypotonic blood solution slide and repeat your observations. Finally, you will view the hypertonic blood solution slide at each magnification, recording your images and notes for study and comparisons.

The lab report, analysis, and conclusion pages will support and guide you to make conclusions based on the data you have collected and observed.

Control Panel

The Microscope Control Panel is where you access the equipment controls, collect data, and communicate with others participating at the same time as you.

In this lab, you will manipulate the controls of the microscope remotely in order to view slides and make observations.



Variables and Controls:

1. Microscope tab
2. Slide loader tab
3. Stage direction controls
4. Stage up and down controls
5. Condenser button
6. Objective lens selector
7. Special effects
8. Image adjustments/capture image
9. Image screen
10. Camera controls
11. User controls
12. Camera preset positions

Microscope Tutorial

This tutorial introduces you to the remote microscope, which is used for several labs. You will see how the equipment is set up as well as the view you will have from your control panel. The demonstration shows how to control the equipment, read the settings, collect data, and collaborate with others. Watch the tutorial a second time, immediately before your lab appointment, to refresh your memory about the function and purpose of the different features in this lab setup.

- http://www.wiche.edu/nanslo/lab-tutorials#microscope

Things to Notice / Questions:

1. How do you select a microscope slide?
2. How do you ask the lab technician for assistance?
3. What do you need to do to select a new slide?
4. What is the highest magnification you can use to view an object?
5. What do you do if you can't see the object when you change magnification?
6. When do you select the condenser?

Procedure

Exercise 1: Osmosis in plant cells

1. Using the NANSLO lab equipment, log in at the time you scheduled to take the lab.
2. Connect to voice conferencing.
3. Request the lab technician make a slide of a leaf of red onion cells and place it on the microscope.
4. Observe your slide at 10x. Record what you see and capture an image to include in your lab report.
5. Increase magnification to 40x, adjust the focus, and record observations and an image in your lab report.
6. While watching the screen, ask the lab technician to add a drop of a 20% salt solution.
7. Observe the process for a few minutes. Then describe and take a picture of the cells exposed to the salt solution.

Procedure

Exercise 2: Osmosis in animal cells

1. Ask the lab technician to put a slide of blood on the microscope.

2. Observe your slide at 10x. Record observations and an image in your lab report.

3. Increase magnification to 60x. Record observations and an image in your lab report.

4. Change to the **hypotonic blood solution** slide and repeat steps 2 and 3, recording observation notes and images for both magnifications.

5. Change to the **hypertonic blood solution** slide and repeat steps 2 and 3, recording observation notes and images for both magnifications in your lab report.

Lab Day Checklist

On the day of your scheduled lab, review the items on this checklist to make sure you are prepared before logging into NANSLO.

- ❑ Read and review all lab materials
- ❑ Prepare and organize lab charts and recording materials
- ❑ Watch the lab tutorial again as a review before the lab
- ❑ Log in to your lab session – two options:
  - ❑ Retrieve your email from the scheduler with your appointment info or
  - ❑ Log in to the student dashboard and join your session by going to http://scheduler.nanslo.org
- ❑ NOTE: You cannot log in to your session before the date and start time of your appointment. Use Internet Explorer or Mozilla Firefox.

Lab Report: Exercise 1

Red Onion Cells

Include three observation notes and images.

Red onion cells (10x) observations Image 1

Red onion cells (40x) observations Image 2

Red onion cells exposed to 20% salt solution observations Image 3

Lab Report: Exercise 2

Blood Cells

Include six observation notes and images.

Blood cells (10x) observations Image 1

Blood cells (60x) observations Image 2

Hypotonic blood solution (10x) observations Image 3

Lab Report: Exercise 2

Hypotonic blood solution (60x) observations	Image 4
Hypertonic blood solution (10x) observations	Image 5
Hypertonic blood solution (60x) observations	Image 6

Lab Analysis

Exercise 1: Osmosis and plant cells

What did you notice about the cell membranes and cell structure using the 10x objective lens?

What did you notice when you used the 40x objective lens?

Describe what happened when the salt solution was added to the slide.

Insert and label an image as evidence of your observations.

Lab Analysis

Use the vocabulary included in the Important Terms and Background Information pages in this lab to describe what was happening as the salt solution was added to the slide. Include not only what happened visually, but describe the process in terms of osmosis, osmotic pressure, and concentration gradient. Describe the conditions as hypertonic, hypotonic, or isotonic.

Explain the role of the cell wall with regard to a plant's ability to control its internal **turgor pressure**?

Did the data support your hypothesis? Write a statement that uses your data to either support or reject your hypothesis.

Lab Analysis

Exercise 2: Osmosis in animal cells

What did you notice about the blood cell structure using the 10x objective lens?

What did you notice when you used the 60x objective lens?

What did you notice about the hypotonic blood cell structure using the 10x objective lens?

What did you notice when you used the 60x objective lens?

What did you notice about the hypertonic blood cell structure using the 10x objective lens?

What did you notice when you used the 60x objective lens?

Reviewing Results

Write a review of your experiment. Include your findings and an explanation of your results.

- Explain what you observed in terms of osmosis.
- Use the vocabulary on the Important Terms page to help you explain what you observed.
- Explain why osmosis is an important cell function.

Conclusion and Reflection

Write a thoughtful conclusion to the lab, answering the essential question: What is osmosis and how does it impact the transport of water in and out of cells?

Post-Lab Questions

Answer the following questions as completely as possible. Use evidence from your lab to help support answers where possible. Use these questions to demonstrate your learning. You may want to review your pre-lab answers and see what you have gained in understanding.

1. What conditions need to exist for water to enter a plant cell through osmosis?
2. What conditions need to exist for water to leave a plant cell through osmosis?
3. What do you think you will see in animal cells in an isotonic solution?
4. What will happen to animal blood cells in a hypertonic solution?
5. What will happen to animal blood cells in a hypotonic solution?
6. How is the study of osmosis important in biology?

Acid/Base Titration

Lab Description:

A titration is a procedure to analyze a substance for particular compounds and their concentrations. In this lab, you will use remote acid/base titration lab equipment to determine the concentration (molarity) of acid in the sample solution.

Purpose:

To determine the concentration of an acid in a sample by adding a known quantity of a base through the process of titration.

Essential Question:

How can titration be used to calculate unknown concentrations of acids in a solution, and how does this apply to biology?

Objectives:

At the completion of this lab, you should be able to:

1. Define titration and explain how and why it is used.
2. Explain the process of acid/base titration.
3. Complete acid/base titrations using virtual equipment.
4. Create graphs from collected data and interpret for completing calculations.
5. Calculate the concentration (molarity) of an acid using experiment data.
6. Describe an application of titration in biology.

Pre-Lab Questions

These pre-lab questions are to help you think about the titration lab and self-assess what you know and what you want to know about the topic. By the end of the lab, you should be able to answer these questions in more detail. Compare your answers to see what you have learned.

1. What is titration?
2. How does pH help determine how acidic or alkaline a solution is?
3. How does pH relate to acid/base titration?
4. In what circumstances might it be important to know the concentration of acid of a solution in the field of biology?

Background Information

Important Terms

acid – a compound with a pH less than 7, that in a solution donates hydrogen ions and is able to accept an unshared pair of electrons from a base

base – a compound with a pH greater than 7, that in a solution accepts hydrogen ions; also known as alkaline

equivalence point – the point at which chemically equivalent amounts of reactants have reacted to cancel each other out

ion – an atom or group of atoms that has a positive or negative electric charge from losing or gaining one or more electrons

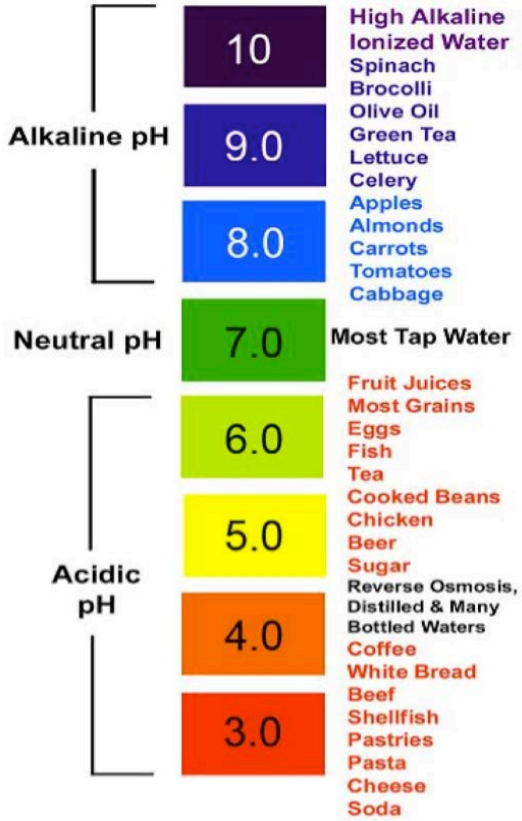
molarity (M) – a measure of concentration, the number of moles of solute per liters of solution

mole (m) – the amount of pure substance containing the same number of chemical units as there are atoms in exactly 12 grams of carbon-12

neutral – an even number of hydrogen ions (+) and hydroxide ions (–) so the solution is neutral; a substance that is neutral has a pH of 7

pH – a number between 0 and 14 that indicates if a chemical is an acid or a base

reagent – a solution with a known chemical makeup and concentration



Some common substances' pH values are shown in the chart above. A pH of 7 is neutral. Substances above 7 are alkaline and substances below 7 are acidic. Take a look at the pH of some common foods. Any surprises?

Explore Titration in Biology

Medical Uses

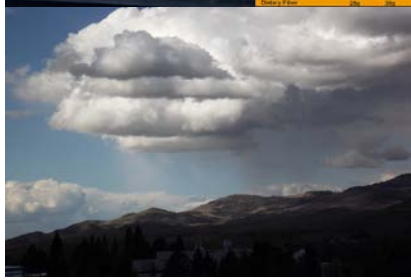
- Titration is used for analyzing samples of blood and urine to measure the concentration of different chemicals.
- Acids and bases are important in living things to maintain the proper pH for enzymes to work.
- New drugs are tested and analyzed using the process of titration.
- It is used to determine the correct proportion of different medicines in an intravenous drip.
- Titration is also used to monitor blood glucose levels in patients with diabetes, as well as in pregnancy tests and other applications of urinalysis.

Food Industry

- Titration helps identify fat and water content and the presence of vitamins in foods.
- It is used to test for the amount of salt or sugar, and proteins.
- Titration is also used in wine and cheese production to meet standards, test for acidity, and determine product readiness.

Biodiesel

- Titration is used to determine the acidity of waste vegetable oil, one of the primary ingredients in biodiesel production.



Ecology – Water Protection

- Titration is used to test the underwater environment in fresh water and marine water.
- It is used to monitor aquarium pH and other chemical concentrations.
- Titration is a precise method for the determination of the acidity in rain or snow samples associated with acid rain.

Resources
Titratable Acidity. Iowa State University Extension and Outreach. http://goo.gl/tA9Iog
Tinnesand M. The Big Reveal: What's Behind Nutrition Labels. American Chemical Society. http://goo.gl/rycf8f
Acid–Base Titrations. Spark Notes. http://www.sparknotes.com/chemistry/acidsbases/titrations/section1.rhtml

Titration Experiment

Purpose:

To determine the concentration of an acid in a sample by adding a known quantity of a base through the process of titration.

The titration experiment is set up with five beakers and burettes you control virtually to add solutions with precise measurements.

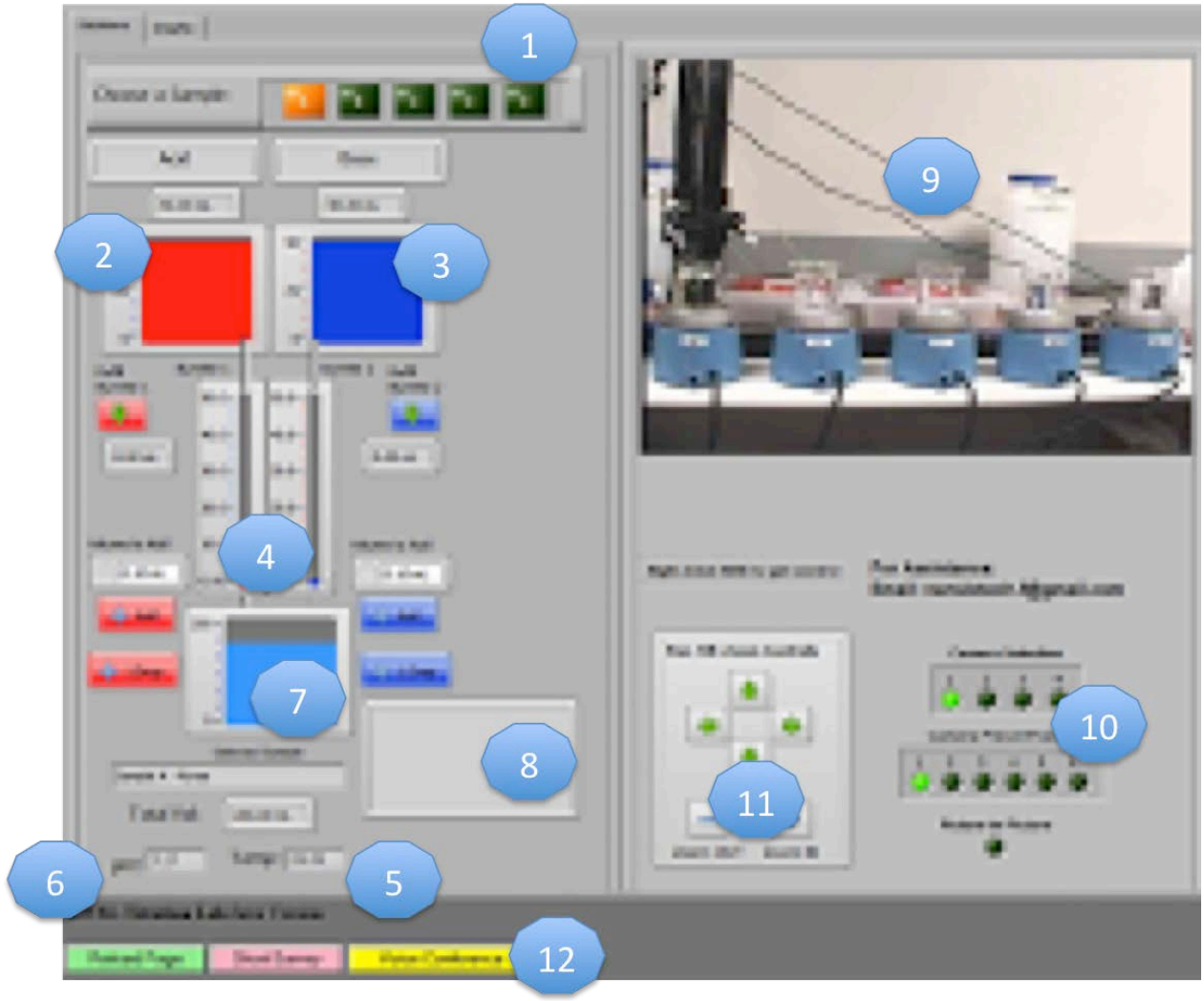
This image shows a close-up of the double burettes that add amounts you specify, or drops of solution, to the beaker.

Control Panel

The Titration Lab Control Panel is where you access the equipment controls, collect data, and communicate with others participating at the same time as you.

In this experiment, you will have five beakers labeled A–E. Beaker A is filled with clear water to sterilize the probe after each use.

Each of the other four beakers contains an acidic solution. Your job will be to use titration to determine the concentration in each of these beakers.



Variables and Controls:

1. Selection of beaker
2. Acid tank
3. Base tank
4. Burettes
5. Temperature reading
6. pH reading
7. Volume
8. Message screen
9. Camera image
10. Camera view
11. Camera controls
12. Voice conference

Titration Apparatus Tutorial

This tutorial introduces you to the titration apparatus, which is used for several labs. You will see how the equipment is set up as well as the view you will have from your control panel. The demonstration shows how to control the equipment, read the settings, collect data, and collaborate with others. Watch the tutorial a second time, immediately before your lab appointment, to refresh your memory about the function and purpose of the different features in this lab setup.

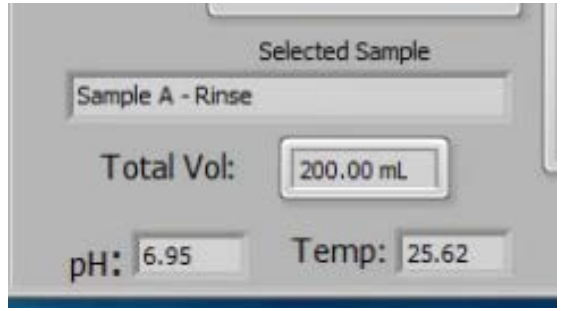
http://www.wiche.edu/nanslo/lab-tutorials#titration

Things to Notice / Questions:

1. Why should you rinse the probe off in beaker A between samples?
2. What might be some reasons why you can't add solution to a beaker?
3. When is it a good idea to switch to using the drop feature?
4. How will you know when you have added enough base solution?
5. How will creating a graph help you visualize your data?

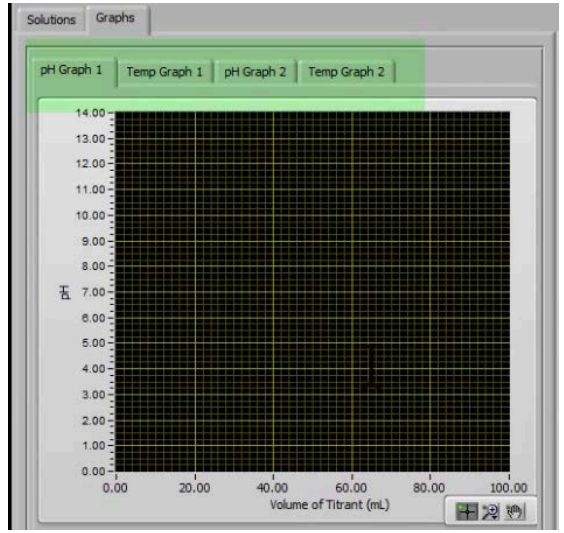
Titration Lab Procedure

Using the NANSLO lab equipment, you will log in and take the indicated measurements at the time you are scheduled to take the lab.



Exercise 1: Qualitative measurement

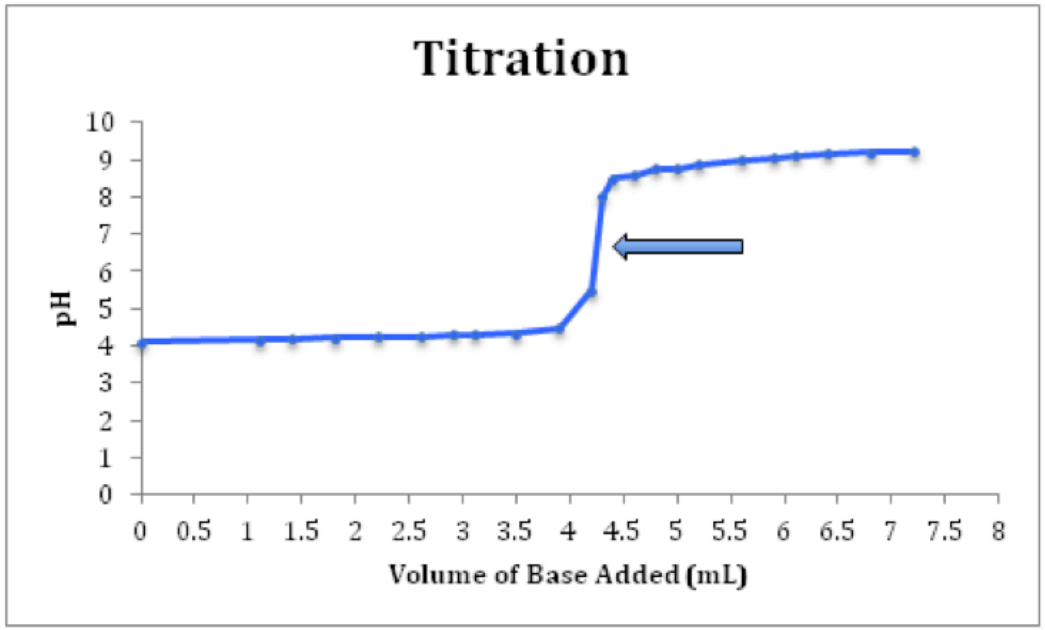
1. The first titration is qualitative, where you will make observations about how the acid in the beaker reacts with the base you add from the dropper.
2. Slowly add a small amount of base to beaker B. Keep track of the volume and pH changes by adding data points to a graph.
3. Try adding different volumes and see what happens. For instance, try a tenth of a milliliter up to a few milliliters.
4. See if you can determine the equivalence point. Use the interface to add the volumes. Save the titration graph/data for this run and move on to the next one.
5. If you have lab partners, trade off adding fluid.



Procedure

Exercise 2: Quantitative measurement

1. From your first measurement, you should have a good guess as to what volume you need to add to reach the equivalent point.
2. This time, try to get close to that and then add volume slowly around that volume.
3. You have three more titrations to try this.
4. Save the titration graph for each titration to use for your analysis.



Recording Information

Tips for recording information:

- Keep a record of each step you take in the experiment to refer to after you are finished.
- Make a chart and record the volume, temperature, and pH of the acidic solution in each beaker before adding the base.
- Record the amount you add and wait for the solution to stabilize before recording the change in temperature, volume, and pH.
- Start a graph and add the data point.
- Continue adding information to your own records and to the computer generated data/graph. This way, you will have two sources of information.

Example:

Lab Day Checklist

On the day of your scheduled lab, review the items on this checklist to make sure you are prepared before logging into NANSLO.

- ❑ Read and review all lab materials
- ❑ Prepare and organize lab charts and recording materials
- ❑ Watch the lab tutorial again as a review before the lab
- ❑ Log in to your lab session – two options:
  - ❑ Retrieve your email from the scheduler with your appointment info or
  - ❑ Log in to the student dashboard and join your session by going to http://scheduler.nanslo.org
- ❑ NOTE: You cannot log in to your session before the date and start time of your appointment. Use Internet Explorer or Mozilla Firefox.

Lab Report

Sample B (modify these charts as needed)

Start volume	Start pH	Volume added	pH	Temperature change

Observation Notes:

Sample C

Start volume	Start pH	Volume added	pH	Temperature change

Observation Notes:

Lab Images (student insert)

Titration Lab Report

Sample B (modify these charts as needed)

Start volume	Start pH	Volume added	pH	Temperature change

Observation Notes:

Sample C

Start volume	Start pH	Volume added	pH	Temperature change

Observation Notes:

Lab Images (student insert)

Titration Lab Analysis

The purpose of the acid/base titration is to determine the concentration (molarity) of acid in the beaker. Taking a look at the data, you will see there are some constants and some variables. Using the following equation, information, and your data, you will be able to solve for the unknown M of the acid.

Molarity (concentration) of Acid (MA) x the Volume of Acid (VA) is equivalent to Molarity of Base (MB) x the Volume of Base (VB) or

$$MA \times VA = MB \times VB$$

Constants and Variables

Each beaker contained 5.0 mL of HCL acid of unknown concentration and 0.1 M NaOH was added to the beaker to a volume you determined doing the titration.

Use your graphs to find the equivalency point in which the solution was neutralized by reaching a pH of 7. Find the Volume of Base added at this point on each of your four trials.

MA = concentration of acid, solving for this unknown

VA = volume of acid, 5.0 mL

MB = concentration of base, 0.1 M

VB = volume of base; use your data to find volume of base added to reach equivalency point

Calculate the Molarity of the Acid for all four of the titrations you performed.

Titration 1 MA=

Titration 2 MA=

Titration 3 MA=

Titration 4 MA=

Reviewing Results

Write a review of your experiment. Include your findings and an explanation of your results. Use the following questions as prompts to include in your review and learning reflection.

1. Were your results consistent for each sample? If not, what might have been the reason?
2. How accurate was the data you collected? How do you know?
3. How do the graphs show the equivalency point?
4. Was temperature a factor in the titration? Explain.
5. How do the graphs show the equivalency point?

Conclusion and Reflection

Write a thoughtful conclusion to the lab, answering the essential question: How can titration be used to calculate unknown concentrations of acids in a solution, and how does this apply to biology?

Post-Lab Questions

Answer the following questions as completely as possible. Use evidence from your lab to help support answers where possible. Use these questions to demonstrate your learning. You may want to review your pre-lab answers and see what you have gained in understanding.

1. What is titration?
2. Why is determining volume important in titration?
3. How does pH relate to acid/base titration?
4. In what circumstances might it be important to know the concentration of acid of a solution in the field of biology?

Reaction Rates

Lab Description:

The rate of a chemical reaction is the time it takes for a given amount of a reactant to change into the product. For this lab, you will observe how reaction conditions change the rate of reaction in an Alka-Seltzer tablets and water mixture.

Purpose:

To determine how surface area affects the reaction rate of Alka-Seltzer and water.

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Essential Question:

What are some of the factors affecting reaction rates and how is this applicable to biology?

Objectives:

At the completion of this lab, you should be able to:

1. Define reaction rate and explain how and why it is measured.
2. Explain the process of determining reaction rate.
3. Complete reaction rate experiments using virtual equipment.
4. Use collected data to make calculations.
5. Analyze and compare results.
6. Describe an application of reaction rates in biology.

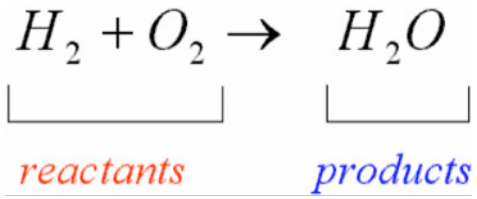
Pre-Lab Questions

These pre-lab questions are to help you think about the reaction rate lab and self-assess what you know and what you want to know about the topic. By the end of the lab, you should be able to answer these questions in more detail. Compare your answers to see what you have learned.

1. What is a reaction rate? Provide an example.
2. What are four factors that affect reaction rate?
3. How does an increased surface area of the reactants affect reaction rate?
4. In what circumstances might it be important to understand reaction rates in biology? Give an example.

Background Information

In a chemical reaction you start with reactants, which are changed in some fashion to become products. Reactants are to the left of the arrow and products are shown on the right of the arrow.



The rate of a chemical reaction is the time it takes for a given amount of a reactant (what you start with) to change into the product (what you end with). Rate is affected by several factors, including:

1) Reactant concentration

2) Temperature

3) Pressure

4) Catalysts

5) Physical state of reactants

In this lab, you will be examining how one of the physical states of the reactants (surface area) affects reaction rate.

Important Terms

catalyst – a substance that causes a chemical reaction to happen more quickly

enzymes – proteins that speed up the rate of a reaction by lowering the amount of energy required for a reaction to take place

equilibrium – a state in which opposing forces or actions are balanced so that one is not stronger or greater than the other

ion – an atom, or group of atoms, that has a positive or negative electric charge from losing or gaining one or more electrons

molarity (M) – a measure of concentration, the number of moles of solute per liters of solution

mole (m) – the amount of pure substance containing the same number of chemical units as there are atoms in exactly 12 grams of carbon-12

products – the resulting substances of a chemical reaction

reactant – a solution with a known chemical makeup and concentration

reaction rate – a measure of the change in the concentration of reactants or products over time in a chemical reaction

Reaction Rates in Biology

Chemical Reactions in Cells

Reaction rate applies to biology, since all living cells carry out continuous cycles of chemical reactions to keep functioning. The reaction rates of these processes are interdependent and complex.

Metabolism

The series of reactions needed to keep an organism alive is called metabolism. It is imperative that most of these reactions occur at a rapid rate. Since increasing temperature would be detrimental to the cells and body structures, enzymes are used as catalysts.

Medical Applications

Many diseases and conditions can be detected by studying enzymes, including diseases affecting the heart, liver, kidney, pancreas, blood, and digestive tract.

Food Industry

Enzymes are used to control the process of making many different foods, such as:

- Ice cream
- Coffee
- Juice
- Wine
- Beer
- Cheese

USDA 20150320-OSEC-LSC-0098

Resources

Digestive Enzymes. Biology Online. http://www.biology-online.org/articles/digestive_enzymes.html
The Central Role of Enzymes as Biological Catalysts. In: The Cell: A Molecular Approach. 2nd ed. NCBI. http://www.ncbi.nlm.nih.gov/books/NBK9921/

Reaction Rate Experiment

Purpose:
To determine how surface area affects the reaction rate of Alka-Seltzer and water.

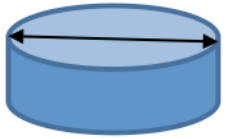
For this lab, you will observe how reaction conditions change the rate of reaction in an Alka-Seltzer tablet and water mixture. The main ingredients of Alka-Seltzer tablets are aspirin, citric acid, and sodium bicarbonate ($NaHCO_3$). When sodium bicarbonate dissolves in water, it splits apart, or dissociates, into sodium (Na^+) and bicarbonate (HCO_3^-).

The bicarbonate reacts with hydrogen ions (H^+) from the citric acid to form water and carbon dioxide, which is a gas that can be seen by the bubbles produced. This reaction is shown below:

$$C_6H_8O_7 + 3NaHCO_3 \rightarrow 3H_2O + 3CO_2 + Na_3C_6H_5O_7$$

Contact area, also known as surface area, can affect a chemical reaction. Alka-Seltzer is commonly packaged as one large tablet with a set surface area. As the tablet is crushed or broken up, the total surface area increases. Instead of one big tablet, we got lots of little tablets, and this affects the rate of the reaction.

Reaction Rate Experiment



Diameter = 1 inch
Height = 0.25 inch

Diameter = 0.5 inch
Height = 0.1 inch

The volume or space of one tablet that is 1 inch across and 0.25 inch tall is the same as ten tablets that are 0.5 inch across and 0.1 inch tall. The surface area, which is the contact area with the environment, however, is very different between the two.

Pre-Lab Questions and Calculations:

$$C_6H_8O_7 + 3NaHCO_3 \rightarrow 3H_2O + 3CO_2 + Na_3C_6H_5O_7$$

1. What are the products for the above reaction?
2. What are the reactants for the above reaction?
3. Calculate the surface area for the unbroken, big Alka-Seltzer tablet shown above on the left.
4. Calculate the surface area for ten smaller tablets with the given dimensions: Diameter = 0.5 inch and Height = 0.1 inch.
5. Predict whether a crushed tablet (i.e., more surface area) will react faster or slower than a non-crushed tablet.

Control Panel

The Reaction Rate Control Panel is where you access the equipment controls, collect data, and communicate with others participating at the same time as you.

In this experiment, you will observe and measure the reaction rates of Alka-Seltzer tablets with different surface areas.

Add full image of control panel when available

Reaction Rate Apparatus Tutorial

This tutorial introduces you to the Reactions Rate lab. You will see how the equipment is set up as well as the view you will have from your control panel. For this lab, you will be adding water to different beakers to observe reactions and track changes.

The demonstration shows how to control the equipment, read the settings, collect data, and collaborate with others. Watch the tutorial a second time, immediately before your lab appointment, to refresh your memory about the function and purpose of the different features in this lab setup.

Add link when available

Things to Notice / Questions:

1. How do you join the voice conference?
2. What steps will you take to add water to a beaker?
3. How will you change from Beaker 1 to Beaker 2?
4. How can you view a close-up of each beaker?
5. How and when will you capture an image?

Reaction Rate Lab Procedure

Using the NANSLO lab equipment, you will log in and take the indicated measurements at the time you scheduled to take the lab.

1. In this experiment, two compounds will be mixed, and you will predict what will happen. Record your observations on the Lab Report chart.

2. Using the NANSLO interface, zoom in on the first beaker. Make observations about what is in the beaker. Take note of the ruler next to the beaker.

3. Make a prediction of what will happen in this beaker before you continue.

4. Add 10 mL of water to the beaker. Start your timer and see how long it takes for the fizzing to stop. Also watch the height of the bubbles/liquid and record the highest point that the bubbles reach.

5. Repeat with beakers 2, 3, and 4.

Lab Day Checklist

On the day of your scheduled lab, review the items on this checklist to make sure you are prepared before logging into NANSLO.

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- ❑ Log in to your lab session – two options:
  - ❑ Retrieve your email from the scheduler with your appointment info or
  - ❑ Log in to the student dashboard and join your session by going to http://scheduler.nanslo.org
- ❑ NOTE: You cannot log in to your session before the date and start time of your appointment. Use Internet Explorer or Mozilla Firefox.

Lab Report

Beaker	Pre-lab Observations	Pre-lab Predictions	Reaction Time	Height of Bubbles	Observation Notes and Questions
1					
2					
3					
4					

Reviewing Results

Write a review of your experiment. Include your findings and an explanation of your results. Use the following prompts to guide you.

1. Which beaker had the fastest reaction?
2. Which beaker had the slowest reaction?
3. Which beaker had the most bubbles?
4. Which beaker generated the least bubbles?
5. Speculate on why your answer to #1 had the fastest reaction. Support your answer with evidence.
6. What other measurement would have been useful?
7. Beakers 3 and 4 had seemingly the same conditions, but one was faster than the other. Explain why?

Conclusion and Reflection

Write a thoughtful conclusion to the lab, answering the essential question: What are some of the factors affecting reaction rates and how is this applicable to biology?

Post-Lab Questions

Answer the following questions as completely as possible. Use evidence from your lab to help support answers where possible. Use these questions to demonstrate your learning. You may want to review your pre-lab answers and see what you have gained in understanding.

1. What is reaction rate? Provide an example.
2. What are four factors that affect reaction rate?
3. How does an increased surface area of the reactants affect reaction rate?
4. In what circumstances might it be important to understand reaction rates in biology? Give an example.