Exploring Stem Cells: the Role of Stem Cells in Immune System Function (Educational Unit)

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Table of Contents

Teacher Guide

Overview
Students will learn about embryonic and adult stem cells and the role the immune system plays in the function of some adult stem cells.

Students will learn about the tendency of Systemic Lupus Erythematosus (SLE) patients to develop premature cardiovascular disease, specifically atherosclerosis. The unit will explore how the body's immune system, through the production of interferon α may interfere with the normal development of endothelial progenitor cells (EPCs). Interferons are cytokines that are involved in immune system regulation and the inflammatory response. EPCs are bone marrow-derived stem cells which circulate in the bloodstream and participate in endothelial repair of the lining of blood vessels of the cardiovascular system.

This 5-6 day unit may be taught after students have attained mastery of immune system concepts. It is also a good unit for showing relevance in students' lives. It includes pedagogical strategies such as Internet treasure hunts, online interactive tutorials, cooperative group activities, problem solving, and hands-on activities. Students will gain real-world laboratory experience by working with micropipettes during a hands-on activity. They will learn how following proper protocol with minute samples is essential for accuracy and precision.

Pedagogy Used

Student-centered
☒ Data analysis, collection, interpretation
☒ Laboratory experiment
☒ Hypothesis development and testing
☒ Real-world laboratory experience
☒ Active learning/discovery learning
☒ Cooperative learning/small group instruction

Teacher-centered
☒ Data analysis, collection, interpretation
☒ Class/group discussion
☒ Demonstrations
☒ Verbal tests

Assessment Ideas
☒ Critical analysis/Critical thinking
☒ Hands-on learning
☒ Inquiry-based learning
☒ Peer teaching
☒ Peer evaluation
☒ Performance-based assessment (e.g. lab reports or presentations)
☒ Self-evaluation

Grade Level
Grades 9-12

Including All Students (Diversity and Equity Strategies)
Teams will be assigned to ethnic and gender-diverse groups. Assemble the teams so there are students with varied learning styles (visual, auditory, kinesthetic) in each team.

National Science Education Standards Addressed in This Curriculum

K-12 Unifying Concepts and Processes:

☒ Systems, order, and organization
☒ Evidence, models, and explanation
☒ Change, constancy, and measurement
☒ Form and function

Grades 9-12

Science as Inquiry:
☒ Abilities necessary to do scientific inquiry
☒ Understandings about scientific inquiry

Life Science:
☒ The cell

☒ Matter, energy, and organization in living systems
☒ Behavior of organisms

Science and Technology:
☒ Understanding about science and technology

Science in Personal and Social Perspectives:
☒ Sci. & tech. in local, natl. & global challenges

History and Nature of Science:
☒ Science as a human endeavor
☒ Nature of scientific knowledge
☒ Historical perspective

Michigan Science Standards

Standard B1: Inquiry, Reflection, and Social Implications

B1.1 Scientific Inquiry

Scientifically literate graduates make observations about the natural world, identify patterns in data, and propose explanations to account for the patterns. Scientific inquiry involves the collection of relevant data, the use of logical reasoning, and the application of imagination in devising hypotheses to explain patterns in data. Scientific inquiry is a complex and time-intensive process that is iterative rather than linear. Habits of mind—curiosity, openness to new ideas, informed skepticism—are part of scientific inquiry. This includes the ability to read or listen critically to assertions in the media, deciding what evidence to pay attention to and what to dismiss, and distinguishing careful arguments from shoddy ones. Thus, Scientific Inquiry depends on the practices described above—Identifying Science Principles and Using Science Principles

Content Expectations: B1.1A, B1.1B, B1.1C, B1.1D, B1.1E, B1.1f, B1.1g, B1.1h, B1.1i

B1.2 Scientific Reflection and Social Implications

The integrity of the scientific process depends on scientists and citizens understanding and respecting the "Nature of Science." Openness to new ideas, skepticism, and honesty are attributes required for good scientific practice. Scientists must use logical reasoning during investigation design, analysis, conclusion, and communication. Science can produce critical insights on societal problems from a personal and local scale to a global scale. Science both aids in the development of technology and provides tools for assessing the costs, risks, and benefits of technological systems. Scientific conclusions and arguments play a role in personal choice and public policy decisions. New technology and scientific discoveries have had a major influence in shaping human history. Science and technology continue to offer diverse and significant career opportunities.

Content Expectations: B1.2B, B1.2C, B1.2D, B1.2E, B1.2f

Standard B2: Organization and Development of Living Systems

Students describe the general structure and function of cells. They can explain that all living systems are composed of cells and that organisms may be unicellular or multicellular. They understand that cells are composed of biological macromolecules and that the complex processes of the cell allow it to maintain a stable internal environment necessary to maintain life. They make predictions based on these understandings.

Content Expectations: B2.1x, B2.1D, B2.2, B2.2C, B2.2D, B2.2f, B2.3B, B2.3C, B2.3f, B2.r6b, B2.r6c, L2.p1d, B2.5

Standard B4 Genetics

Students recognize that the specific genetic instructions for any organism are contained within genes composed of DNA molecules located in chromosomes. They explain the mechanism for the direct production of specify c proteins based on inherited DNA. Students diagram how occasional modifications in genes and the random distribution of genes from each parent provide genetic variation and become the raw material for evolution. Content Statements, Performances, and Boundaries

Content Expectations: L4.p2A, B4.1B, B4.2D, B4.3g, B4.4c

Science Background

Exploring Stem Cells: the Role of Stem Cells in Immune System Function is an educational unit developed for high school life science courses. Students will learn about embryonic and adult stem cells and the role the immune system plays in the function of some adult stem cells.

Students will learn about the tendency of Systemic Lupus Erythematosus (SLE) patients to develop premature cardiovascular disease, specifically atherosclerosis. The unit will explore how the body's immune system, through the production of interferon-alpha (α) may interfere with the normal development of endothelial progenitor cells (EPCs). Interferons are cytokines that are involved in immune

system regulation and the inflammatory response. EPCs are bone marrow-derived stem cells which circulate in the bloodstream and participate in endothelial repair of the lining of blood vessels of the cardiovascular system.

This 5-6 day unit includes pedagogical strategies such as Internet Treasure Hunts, online interactive tutorials, cooperative group activities, problem solving, and hands-on activities. Students will gain real-world laboratory experience by working with micropipettes during a hands-on activity. They will learn how following proper protocol with minute samples is essential for accuracy and precision.

Stem Cell Background

Stem cells have the remarkable potential to develop into many different cell types in the body. Serving as a sort of repair system for the body, they can theoretically divide without limit to replenish other cells as long as the organism is alive. When a stem cell divides, each new cell has the potential to either remain a stem cell or become another type of cell with a more specialized function, such as a muscle cell, a red blood cell, or a brain cell.

Research on stem cells is advancing knowledge about how an organism develops from a single cell and how healthy cells replace damaged cells in adult organisms. Stem cells are one of the most fascinating areas of life science today. But like many expanding fields of scientific inquiry, research on stem cells raises scientific questions as rapidly as it generates new discoveries.

Stem cells have two important characteristics that distinguish them from other types of cells. First, they are unspecialized cells that renew themselves for long periods through cell division. The second is that under certain conditions, they can be induced to become cells with special functions such as the beating cells of the heart muscle or the insulin- producing cells of the pancreas.

Scientists primarily work with two kinds of stem cells from animals and humans: **embryonic stem cells** and **adult stem cells**, which have different functions and characteristics. Scientists discovered ways to obtain or derive stem cells from early mouse embryos more than 20 years ago. Many years of detailed study of the biology of mouse stem cells led to the discovery, in 1998, of how to isolate stem cells from human embryos and grow the cells in the laboratory.

These are called **human embryonic stem cells**. The embryos used in these studies were created for infertility purposes through *in vitro* fertilization (IVF) procedures and when they were no longer needed for that purpose, they were donated for research with the informed consent of the donor. Stem cells are important for living organisms for many reasons. In the 3- to 5-day-old embryo, called a blastocyst, stem cells in developing tissues give rise to the multiple specialized cell types that make up the heart, lung, skin, and other tissues. In some adult tissues, such as bone marrow, muscle, and brain, discrete populations of adult stem cells generate replacements for cells that are lost through normal wear and tear, injury, or disease.

Adult stem cells typically produce the cell types of the tissue in which they reside. A blood-forming adult stem cell in the bone marrow, for example, normally gives rise to the many types of blood cells such as red blood cells, white blood cells and platelets. Until recently, it had been thought that a blood-forming cell in the bone marrow - which is called a **hematopoietic stem cell** - could not give rise to the cells of a very different tissue, such as nerve cells in the brain. However, a number of experiments over the last several years have raised the possibility that stem cells from one tissue may be able to give rise to cell types of a completely different tissue, a phenomenon known as plasticity.

For a more comprehensive primer on stem cells and the issues surrounding stem cell research, please see the **References and Resources** section of this activity (pg. 13). I have provided the website links students will use during the Internet Treasure Hunt portion of this activity as well as many excellent websites that will provide you with extensive, easily understandable information on stem cells. I have included many links from The Center for Stem Cell Biology at the University of Michigan. Some websites are interactive, using Flash technology, and some have short video segments from biomedical researchers who do an excellent job of explaining the stem cells and the controversial issues surrounding stem cell lines.

Background on:

- **Immune System Function related to Systemic Lupus Erythematosus (SLE) through the possible etiology (causes or origin) of the disease;**
    - **Interferon-alpha (**Be prepared to help students distinguish between the body's production of Interferon-alpha (α) and the use of Interferon-alpha for cancer and immune system disorders.)
    - **Endothelial progenitor cells (EPCs)**

When I am teaching about the immune system I describe it as being our best friend or our worst enemy.

- **Best Friend**: Your body's immune system protects you from disease and infection.

- **Worst Enemy**: In the case of people afflicted with autoimmune disorders, such as lupus, rheumatoid arthritis, diabetes mellitus, HIV/AIDS, or any of the other 80 types of autoimmune diseases, your immune system attacks healthy cells in your body by mistake. Autoimmune diseases can affect many parts of the body. These diseases tend to run in families. Women - particularly African-American, Hispanic-American, and Native-American women - have a higher risk for some autoimmune diseases.[1]

I was very fortunate to participate in Dr. Mariana Kaplan's laboratory during my 2008-2009 John H. Wallace fellowship, which I received from the American Association of Immunologists (AAI). Dr. Kaplan is a member of AAI and served as my mentor during my summer of research. Her lab is studying the role interferon-alpha (α) may play in patients, suffering from systemic lupus erythematosus (SLE), who develop premature cardiovascular disease, specifically atherosclerosis. Individuals with systemic lupus erythematosus (SLE) have up to a 50-fold increase in the incidence of cardiovascular disease (CVD) when compared with age- and sex-matched controls.[2]

The types of stem cells that students will be learning about in this activity are endothelial progenitor cells (EPCs). This stem cell is bone marrow-derived, circulates in the blood, and develops into endothelial cells that line the interior surface of blood vessels. Endothelial dysfunction, or the loss of proper endothelial function, is a hallmark for vascular diseases, and often leads to atherosclerosis. In the case of lupus patients, atherosclerosis occurs prematurely.

Research in Dr. Kaplan's lab as well as other biomedical research labs worldwide may have begun with questions such as "What pathway is the immune system interfering with? Why are there less EPCs circulating in the circulatory system of lupus patients? What is annihilating the EPCs? Why are these

[1] *Autoimmune Diseases*, Medline Plus, a service of the US National Library of Medicine and the National Institutes of Health, http://www.nlm.nih.gov/medlineplus/autoimmunediseases.html

[2] *Premature morbidity from cardiovascular and cerebrovascular diseases in women with systemic lupus erythematosus*. Ward, MM. **Arthritis Rheum**. 1999;42:338–346.

hematopoietic stem cells not developing into endothelial cells which are so critical in the repair of blood vessels? What role is the inflammatory response playing?"

As it turns out, interferon-alpha (IFN-α), one of our body's great protectors, seems to be the culprit. (Recall what I mentioned earlier about Best Friend/Worst Enemy.) Apparently, interferon-alpha is at the center of the immunologic abnormalities observed in systemic lupus erythematosus. IFN-α and IFN-β are secreted by many cell types including lymphocytes (NK cells, B-cells and T-cells), macrophages, fibroblasts, endothelial cells, osteoblasts and others. They stimulate both macrophages and NK (natural killer) cells to elicit an anti-viral response, and are also active against tumors.[3]

Our immune system works by distinguishing self from non-self, so that it attacks foreign microbes. Interferon-alpha is normally a helpful molecule in this regard, leading the fight against invading viruses. Genes producing high levels of interferon-alpha have probably been selected over time to help fight infection. But high levels of interferon-alpha in some individuals may also confuse the immune system so that it doesn't know self from non-self anymore, turning and attacking its own tissue as in SLE. As far back as the 1970s, doctors had known that a characteristic of patients with SLE, who are mainly women in their childbearing years, was an abnormally high blood level of interferon-alpha.[4]

Interferons are a type of protein called cytokines, which are diverse and potent chemical messengers that can trigger the immune system to attack invading pathogens. In humans, there are three classes of interferon, alpha, beta and gamma. Interferon alpha and beta are produced by many cell types, including the infection-fighting T-cells and B-cells in the blood, and are an important component of the anti-viral response. Interferon signals neighboring cells into action and also interferes with how foreign cells grow and multiply. The IFN-α proteins are produced by leukocytes. They are mainly involved in innate immune response against viral infection. They come in 14 subtypes of genes for these IFN-α molecules and they are located together in a cluster on chromosome 9.

To end this background section, I am including the complete abstract of the 2007 published article by graduate student and post-doctoral researchers in Dr. Kaplan's laboratory. I am also including the authors' conclusions and have left their article references hyperlinked. The abstract describes the research that reveals the possible mechanisms of the immune system that lead to premature atherosclerosis in SLE patients. If you wish to read the entire publication, it may be accessed at PubMed - http://www.ncbi.nlm.nih.gov/pubmed/17638846. Click on either of the "Free" Icons at the top-right of the abstract to download the full article from **Blood** or PubMed.

> Michael F. Denny,[1] Seth Thacker,[1,2] Hemal Mehta,[1] Emily C. Somers,[1] Todd Dodick,[1] Franck J. Barrat,[3] W. Joseph McCune,[1] and Mariana J. Kaplan[1]
> [1]Division of Rheumatology, Department of Internal Medicine and
> [2]Graduate Program in Immunology, University of Michigan Medical School, Ann Arbor;
> [3]Dynavax Technologies, Berkeley, CA, *Interferon-alpha promotes abnormal vasculogenesis in lupus: a potential pathway for premature atherosclerosis.* **Blood.** 2007 Oct 15;110(8):2907-15. Epub 2007 Jul 16
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> Individuals with systemic lupus erythematosus (SLE) have a striking increase in premature atherosclerosis of unclear etiology. Accelerated endothelial cell apoptosis occurs in SLE and

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[3] **Interferon type I, *Wikipedia, the free encyclopedia, http://en.wikipedia.org/wiki/Interferon_type_I#Sources_and_functions***

[4] *High serum IFN-α activity is a heritable risk factor for systemic lupus erythematosus,* T B Niewold[1], J Hua[1], T J A Lehman[1], J B Harley[2] and M K Crow[1,1]Mary Kirkland Center for Lupus Research, Hospital for Special Surgery, New York, NY, [2]Oklahoma Medical Research Foundation, Oklahoma City, OK, **Genes and Immunity** (2007) 8, 492–502; doi:10.1038/sj.gene.6364408. Epub 2007 June 21

correlates with endothelial dysfunction. Endothelial progenitor cells (EPCs) and myelomonocytic circulating angiogenic cells (CACs) are crucial in blood vessel repair after vascular damage, and decreased levels or abnormal function of EPCs/CACs are established atherosclerosis risk factors. We investigated if vascular repair is impaired in SLE. We report that SLE patients display abnormal phenotype and function of EPCs/CACs. These abnormalities are characterized by significant decreases in the number of circulating EPCs (310 +/- 50 EPCs/mL of blood in SLE versus 639 +/- 102 in controls) and significant impairments in the capacity of EPCs/CACs to differentiate into mature ECs and synthesize adequate levels of the proangiogenic molecules vascular endothelial growth factor (VEGF) and hepatic growth factor (HGF). These abnormalities are triggered by interferon-alpha (IFN-alpha), which induces EPC and CAC apoptosis and skews myeloid cells toward nonangiogenic phenotypes. Lupus EPCs/CACs have increased IFN-alpha expression and their supernatants promote higher induction of IFN-inducible genes. Importantly, neutralization of IFN pathways restores a normal EPC/CAC phenotype in lupus. SLE is characterized by an imbalance between endothelial cell damage and repair triggered by type I IFNs, which might promote accelerated atherosclerosis.

Our study reports the following findings.

(1) BM EPCs are decreased in the circulation of lupus patients despite the previous evidence of accelerated EC damage[3] (a factor that should normally enhance BM EPC release).[46] Since EPCs can lead to a mature endothelium after EC damage, EPC decreases may significantly affect vascular repair. Our results confirm a recent study in which a small number of SLE patients in clinical remission were found to have decreased circulating EPCs.[47]

(2) Lupus EPCs and CACs have impaired function characterized by an inability to form adequate numbers of mature ECs under proangiogenic stimulation and incorporate into vascular structures.

(3) Lupus EPCs/CACs have a decreased capacity to synthesize proangiogenic factors in vitro and, likely, in vivo. It is possible that these decreases may impair BM EPC release and their proper homing into damaged vasculature to repair blood vessels.

(4) Importantly, we have found for the first time that IFN-α promotes the abnormal vasculogenesis observed in SLE by inducing apoptosis of cells involved in blood vessel function and, possibly, by skewing monocytes and other myeloid angiogenic precursors toward nonangiogenic myelomonocytic cells (like DCs). Supporting our results, other studies have reported a toxic role of IFN-α in APCs, including macrophages.[48] Since different cells produce IFN-α in response to various stimuli, including pDCs, macrophages, B cells, and BM progenitors, it is possible that both EPCs and CACs are involved in type I IFN production in SLE monolayers.

To put their findings in layman's terms, here is what they found:

1. Bone-marrow derived endothelial progenitor cells (EPCs) are decreased in lupus patients, even though with cardiovascular damage, there should be an increase in the number of EPCs released.
2. With impaired function of EPCs (and CACs), leads to a decrease of the number of endothelial cells produced under proangiogenic activity (growth of new blood vessels from pre-existing vessels).

3. This impaired function prevents the repair of damaged blood vessels.
4. Interferon-alpha promotes the abnormal vasculogenesis (growth of new blood vessels where there were no pre-existing vessels) observed in SLE by inducing apoptosis (cell death) of cells involved in blood vessel function.

With this occurring, is it any wonder that the patients develop premature atherosclerosis?

Micropipette Background:

Micropipettes are the workhorses of all biomedical laboratories and are manufactured by several biomedical suppliers. They are used to measure minute amounts, usually under 1milliliter (mL). One mL = 1,000 microliters (mL). There are several sizes of micropipettes, usually a "P-10" (for 0.5 to 10 mL), P-50" (for 10 to 50 mL), a "P-200" (for 40 to 200 mL), and a "P-1000" (for 200 to 1000 mL). Micropipettes range in cost from about $100 to much, much more. The micropipettes I use in my classes are relatively inexpensive. However, I treat the equipment like it is made of gold so that students will follow suit. They are very sensitive and must be used correctly or will very quickly become inaccurate in measurement.

There are many videos on YouTube.com that you can view so that you are comfortable in the use of the equipment. If YouTube is blocked at your school, you can also conduct a simple Google search and will get lots of good information. If you have previously used micropipettes, you could simply read over the instructions in the Student section (pg. 17) to reacquaint yourself with proper protocol.

If YouTube.com is blocked, this video can be viewed on Google Video:
http://video.google.com/videoplay?docid=-3882495709218457245&ei=DCGzSZe3CpaEqQPfk4HpAw&q=micropipette&hl=en&emb=1

Using a Pipette: http://www.youtube.com/watch?v=NGJ5spD8Evk&feature=related

Using a Micropipette:
http://www.youtube.com/watch?v=qmhrS_SlQLM&playnext_from=PL&feature=PlayList&p=DE2FC7DA364C501E&playnext=1&index=6

Very humorous video clip on how to NOT use a micropipettes on YouTube:
http://www.youtube.com/watch?v=4eHczFh1yig&feature=related

Student Outcomes

Guided Internet Treasure Hunt

In the computer lab - use the Guided Internet Treasure Hunt forms to gain knowledge about the following information/issues. (See Attached Internet Treasure Hunt forms).

Students will investigate the following inquiries:

- What are embryonic and adult stem cells and what role do adult stem cells play in the Immune System's function?
- Students will demonstrate knowledge of the implications of stem cell research.
- Students will demonstrate knowledge of stem cells.
- Students will be able to state and support an opinion on one or more stem cell issues.
- What is Systemic Lupus Erythematosus (SLE)?
- What is atherosclerosis?

- What are endothelial progenitor cells (EPCs)?
- What is Interferon-alpha (α)?
- How do I use a micropipette?
- What is the difference between the terms *accuracy* and *precision*?

Students will learn about the tendency of Systemic Lupus Erythematosus (SLE) patients to develop premature cardiovascular disease, specifically atherosclerosis. The unit will explore how the body's immune system, through the production of interferon α may interfere with the normal development of endothelial progenitor cells (EPCs). Interferons are cytokines that are involved in immune system regulation and the inflammatory response. EPCs are bone marrow-derived stem cells which circulate in the bloodstream and participate in endothelial repair of the lining of blood vessels of the cardiovascular system.

This 5-6 day unit may be taught after students have attained mastery of immune system concepts. It is also a good unit for showing relevance in students' lives. It includes pedagogical strategies such as Internet treasure hunts, online interactive tutorials, cooperative group activities, problem solving, and hands-on activities. Students will gain real-world laboratory experience by working with micropipettes during a hands-on activity. They will learn how following proper protocol with minute samples is essential for accuracy and precision.

Learning Objectives

Upon completion of this activity, student teams will be able to:

1. Conduct guided Internet treasure hunts.
2. Demonstrate safe use of laboratory equipment, specifically micropipettes.
3. Demonstrate an understanding of the role of stem cells (embryonic and adult types) play in the survival of organisms.
4. Gain an understanding of the debate about the use of stem cells in research.
5. Collect and analyze data.

Time Requirements

- For single class periods (50-55 minutes), about 6 days will be needed to complete this lesson.
- For block scheduling (75-90 minute periods), about 3-4 days will be needed to complete this lesson.

Suggestions for Each Day

Day 1:

- Assemble lab materials and have them on display.
- Assign students to teams, keeping in mind different learning styles and diversity. The teams should reach consensus on who will be doing which duty during the activities. There should be a recorder, materials collector, timer, reader, or whatever role(s) you deem appropriate. Once you have selected teams, encourage the recorder to create a list of the materials.
- Distribute copies of the Student Section of this lab activity to the teams. Go through the sheet with them and answer any questions they may have about what they will accomplish each day.

Day 2-3:

In the computer lab – Distribute the Guided Internet Treasure Hunt sheets to teams for them to become familiar with and gain knowledge about relevant content, listed below: (See Attached Internet Treasure Hunt sheets).

Day 2:

- What are stem cells?
- What are the issues surrounding the use of stem cells?

Day 3:
- What is Atherosclerosis?
- What is Systemic Lupus Erythematosus (SLE)?
- What are endothelial progenitor cells (EPCs)?
- What is Interferon-alpha (α)?
- How do I use a micropipette?
- What is the difference between the terms *accuracy* and *precision*?

Day 4
- Students will conduct the Techniques Lab: Manipulating Small Volumes

Day 5:
- Teams will work in a computer lab and/or out of class-time to develop their PowerPoint presentations. Alternately, they could design a poster instead of developing a PowerPoint.

Day 6:
- Teams will present their findings to the class.
- Team members will anonymously grade other members using the Team Participation Rubric. I have found this activity to be very successful - the students who work during the activity have an opportunity to grade those members who may not have been as diligent. And, the idle student(s) know they will be graded by their peers and often, they get more involved in the project.

Advance Preparation
- See Materials and Equipment below
- Mix Solutions I-V by putting 2-3 drops of the food dye in 25-50 ml of water for each solution.
  - Solution I, red colored water
  - Solution II, yellow colored water
  - Solution III, green colored water
  - Solution IV, blue colored water
  - Solution V, blue colored water (large tube)
- Approximate preparation time is approximately 30 minutes for making solutions and setting up lab stations.

Teacher Tips
All websites the student teams will be exploring during the Internet Treasure Hunts are listed in the References and Resources section of this unit. There are many more websites that you could choose to explore. However, I picked websites that addressed relevant information and presented it in a balanced approach.

In addition to authentic assessment, providing feedback throughout the activity is very important for the teams. They may doubt their ability to "do" scientific inquiry and thinking. It is our job as educators to help them see that they can achieve anything they put their mind to. There are several ways to accomplish this: pre-lab questioning and discussions; post-lab debriefing; evaluating team-assessment rubrics; and feedback on drafts of team posters and presentations, as well as final evaluation.

Materials and Equipment
- Vegetable food dye in standard colors of red, yellow, blue and green

- P-20 micropipette and tips (1 micropipette and about 40 tips per team)
- P-100 (or P-200) micropipette and tips (1 micropipette and about 40 tips per team)
- Supply of 1.5 mL Eppendorf tube (commonly called an epitube) (15-20 for each team member)
- Rack for epitubes (1 per team)
- Container for waste tips (1 per team)
- Container for liquid waste (1 per team)
- Fine-tip permanent marker (1 per team)
- Wax paper (1-2 sheets per team)
- Microcentrifuge (also called a microfuge - may be shared between teams)
- Safety gear such as gloves and goggles

- Estimated cost of materials - here is a list of materials to purchase and possible sources - yo may be able to find them even cheaper - just run a Google search for the item.
    - A 5-pack of epitube racks (item # 30128-282) can be purchased from VWRLabshop.com for $25-30 (http://vwrlabshop.com/vwr-80-place-storage-system/p/0007216/)
    - 1.5 ml Epitubes - bag of 500 (item # 89000-028) can be purchased from VWRLabshop.com for $20-25 (http://vwrlabshop.com/vwr-disposable-microcentrifuge-tubes/p/0007184/)
    - Wax paper and food dye - grocery store or your cupboards
    - Micropipette tips bags of 500-1,000 cost about $15-20 from enasco.com http://www.enasco.com/product/SB39112M
    - Micropipette can run from $100 to $2,000. The inexpensive ones are fine for this lab. Here is a set of a 20 µl and 200 µl for $137 http://www.enasco.com/product/SB45962M
    - Microcentrifuges cost from about $350-1,000.

Safety

Students should exercise caution. Remind students of the following procedures and warnings:

- Some products used in lab activities may be poisonous and/or caustic.
- Do not ingest, allow solution to get on skin, or look directly into a heated test tube.
- Practice good lab safety procedures, including the use of goggles and lab coats/aprons and washing hand carefully before and after the lab.

Student Prior Knowledge and Skills

Students should have already participated in lab safety activities and signed a lab safety contract. They should be familiar with using common lab equipment such as handling test tubes, making accurate measurements, hot water baths, etc., as well as using the Internet to search for credible information. They also will conduct a measurement lab experiment to become familiar with the use of micropipettes.

Additionally, students should be familiar with:

- Basic cellular structure and functions of the plasma membrane
- DNA replication
- Protein synthesis
- Immune system basics
- Be prepared to address possible preconceptions students may possess regarding adult and embryonic stem cells, particularly stem cell research.

What is Expected From Students

- Analysis of researched information
- Concept map of adult and embryonic stem cells
- Presentation (PowerPoint or Poster)
- Correct procedures when using laboratory equipment (micropipettes)

Anticipated Results

- During the micropipette activity, how *accurate* were your attempts?
- How *precise* were your measurements?

Classroom Discussion

- Stem Cell Issues:
    - What is a stem cell?
    - What are some different types of stem cells?
    - What is the goal of stem cell research?
    - What are some issues in stem cell research?
    - Where are stem cells found?
    - Are all stem cells the same?

- Immune System Diseases and Atherosclerosis Research during Internet Treasure Hunt:
    - What are the symptoms of the disease?
    - In what part of the body does this disease occur?
    - The specific types of immune cells that are causing the problem?
    - What causes this problem?
    - Who is afflicted by the diseases (risk factors, genetic pre-disposition, etc)?

- Research during Internet Treasure Hunt on the following issues:
    - What are endothelial progenitor cells (EPCs) and what role do they play in the overall physical condition of the cardiovascular system?
    - What role does Interferon-alpha (α) play in the Immune System and the deterioration of blood vessel endothelial cells?

Assessment

- Verbal and/or written tests, authentic assessment of individual laboratory skills, two rubrics - performance-based assessment (presentation); and for team members to anonymously grade each others' contribution to the laboratory activity.

References and Resources

Techniques Lab: Manipulating Small Volumes, This lab activity on the use of using a micropipette is adapted from an activity from Access Excellence, a program of the National Health Museum, http://www.accessexcellence.org/AE/AEPC/geneconn/smallvol/

5E Instructional Model The Biological Sciences Curriculum Study (BSCS) developed a 5E Instructional Model. For more information and a full report about the origins, effectiveness, and applications of the model, see http://www.bscs.org/library/BSCS_5E_Model_Full_Report2006.pdf

Rubistar4teachers, http://rubistar.4teachers.org/index.php Rubrics made easy. RubiStar is a free tool to help teachers create quality rubrics. Registration is free and simple. You may create your own rubrics or search for ones that have been produced by teachers and posted to the website.

For Internet Treasure Hunts:

Stem Cells Explained: An Interactive Tutorial, Life Science at Michigan, University of Michigan, http://www.lsi.umich.edu/files/stemcells.swf

Creating Stem Cells for Research, Genetic Science Learning Center (GSLC), University of Utah,

http://teach.genetics.utah.edu/content/tech/stemcells/color_label_learn_stemcells.pdf

Five Things You Should Know About Stem Cell Research, University of Michigan, http://www.umich.edu/stemcell/video/stemcells101_flash.php

*Pros & Cons of Embryonic Stem Cell Research***,** Deborah White, www.About.com, http://usliberals.about.com/od/stemcellresearch/i/StemCell1.htm

Judge Rules Against Stem-Cell Research Critics, The Associated Press, January 16, 2009 http://www.kansascity.com/news/local/story/984192.html

*Micropipetting and Microfuge Activity***,** East Bay Biotechnology Education Program (EBBEP) includes more than 120 high school science teachers at 60 schools throughout Alameda, Contra Costa and Solano counties. http://www.ebbep.org/docs/basics/pipettestudent.pdf

Skill Building Activities 1: Manipulating Small Volumes, COSEE-West, (Centers for Ocean Sciences Education Excellence) the west coast hub for the National Science Foundation, located at The University of Southern California, http://www.usc.edu/org/cosee-west/Jun07Resources/PipetteUsetraining.pdf

What is Atherosclerosis? American Heart Association, Inc, http://www.americanheart.org/presenter.jhtml?identifier=4440

What Is Atherosclerosis? The National Heart, Lung, and Blood Institute (NHLBI) and The National Institutes of Health (NIH), http://www.nhlbi.nih.gov/health/dci/Diseases/Atherosclerosis/Atherosclerosis_WhatIs.html

Systemic lupus erythematosus, National Library of Medicine, and The National Institutes of Health (NIH) http://www.nlm.nih.gov/medlineplus/ency/article/000435.htm

Systemic lupus erythematosus, New York Times Health Guide, March 6, 2009, http://health.nytimes.com/health/guides/disease/systemic-lupus-erythematosus/complications.html

What Interferon is and how it works, Center for Immune Research, http://www.naturalinterferon.com/

Interferon, Wikipedia, the free encyclopedia*, http://en.wikipedia.org/wiki/Interferon-alpha*

Endothelial progenitor cells could serve as biological marker for cardiovascular disease, Emory University School of Medicine, http://www.innovations-report.de/html/berichte/biowissenschaften_chemie/bericht-16446.html

Endothelial progenitor cell, Wikipedia, the free encyclopedia, http://en.wikipedia.org/wiki/Endothelial_progenitor_cell

Accuracy and Precision. They mean slightly different things, Mathisfun.com *http://www.mathsisfun.com/accuracy-precision.html*

The Science of Measurement: Accuracy vs. Precision, RCBrill, Honolulu Community College, http://honolulu.hawaii.edu/distance/sci122/SciLab/L5/accprec.html

Stem Cells Interactive Websites:

Life Sciences Institute, University of Michigan, Ann Arbor, Michigan, © 2009 Regents of the University of Michigan. The Life Sciences Institute is a hub for collaboration among outstanding scientists from a variety of life sciences disciplines focusing on the biological problems of human health.

1. *Stem Cells Explained: An Interactive Tutorial*, http://www.lsi.umich.edu/files/stemcells.swf

2. Four Flash Videos - each segment is about 4-6 minutes in length: *Embryonic Stem Cell Research*:, A question and answer session with Dr. Sean Morrison, Director of the University of Michigan Center for Stem Cell Biology
   What the Science Really Says http://www.umich.edu/stemcell/video/morrison_part_1_flash.php
   What is at Stake in Michigan? http://www.umich.edu/stemcell/video/morrison_part_2_flash.php
   The Facts About Science http://www.umich.edu/stemcell/video/morrison_part_3_flash.php
   Ethics & Morality http://www.umich.edu/stemcell/video/morrison_part_4_flash.php

3. Laboratory website of Dr. Sean Morrison, Director of the Center for Stem Cell Biology at the Life Sciences Institute, Associate Professor of Molecular Medicine & Genetics in the Medical School, and Investigator, Howard Hughes Medical Institute, http://www.umich.edu/stemcell/

4. *Five Things You Should Know About Stem Cell Research*, University of Michigan, http://www.umich.edu/stemcell/video/stemcells101_flash.php

5. *Proposal 2 Opens The Door To Cures*, http://www.med.umich.edu/taubmaninstitute/News/p2.htm

6. *Stem Cell Image Gallery*, University of Michigan, http://www.umich.edu/stemcell/gallery/

7. *Stem Cell Research Experts*, University of Michigan, http://www.umich.edu/stemcell/experts/

Stem Cell Information (FAQs), The National Institutes of Health resources for stem cell research, http://stemcells.nih.gov/info/faqs.asp

Michigan Ballot Takes On Stem Cell Research, National Public Radio, *Talk of the Nation,* October 31, 2008 http://www.npr.org/templates/story/story.php?storyId=96392644

Key Moments in the Stem-Cell Debate, National Public Radio, November 20, 2007 http://www.npr.org/templates/story/story.php?storyId=5252449

Ethical Questions Follow Stem Cell Advances, National Public Radio, *All Things Considered,* April 15, 2008, http://www.npr.org/templates/story/story.php?storyId=89661664

Stem Cells, an Education Project of the Michigan Catholic Conference, http://www.youtube.com/watch?v=e-BD7fbwGRE&feature=channel_page

*Pros & Cons of Embryonic Stem Cell Research***,** Deborah White, www.About.com http://usliberals.about.com/od/stemcellresearch/i/StemCell1.htm

Judge Rules Against Stem-Cell Research Critics, The Associated Press, January 16, 2009 http://www.kansascity.com/news/local/story/984192.html

Student Section

Guided Internet Treasure Hunt
In the computer lab - use the Guided Internet Treasure Hunt forms provided by your teacher to gain knowledge about the following information/issues.

You will investigate the following inquiries:

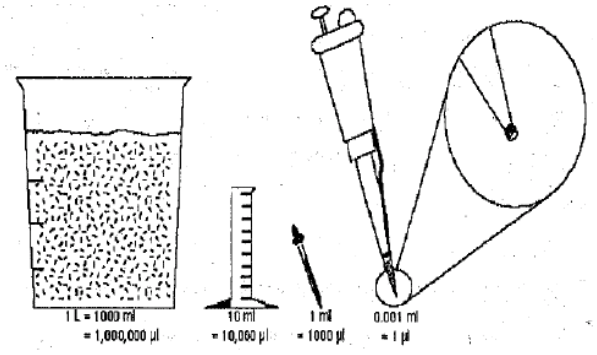
- What are embryonic and adult stem cells and what role do adult stem cells play in the Immune System's function?
- How do I use a micropipette?
- What is Systemic Lupus Erythematosus (SLE)?
- What is Atherosclerosis?
- What are endothelial progenitor cells (EPCs)?
- What is Interferon-alpha (α)?
- What is the difference between the terms *accuracy* and *precision*?

Techniques Lab: Manipulating Small Volumes[5]

Rationale
This laboratory activity introduces micropipetting technique. As with all fine motor skills, learning how to use a micropipette takes practice and determination. You will be rewarded with excellent laboratory results.

Introduction
A forensic scientist extracts a miniscule amount of DNA from a dime-sized drop of blood left at the scene of a crime. A cystic fibrosis patient inhales a fine mist containing "good" copies of a gene he did not inherit. When the chemist, the genetic engineer, and the criminologist perform laboratory procedures involving tiny amounts of DNA and chemicals, each utilizes an instrument known as a micropipette.

A micropipette is a kind of fancy eyedropper – one that comes in many different models and volume ranges. But while an eyedropper dispenses drops, micropipettes transfer microliters of fluid. Recall that 'micro-' is a prefix in the metric system which means "one-millionth" of the base unit (in this case, a liter, "L"). It may be easier for you to picture one milliliter (mL or ml) of water. If you mentally subdivide that milliliter of water into 1000 tiny equal-sized volumes, each volume is one microliter (abbreviated µL or µl).



Materials per team

[5] Adapted from http://www.accessexcellence.org/AE/AEPC/geneconn/smallvol/

Solution I, red colored water
Solution II, yellow colored water
Solution III, green colored water
Solution IV, blue colored water
Solution V, blue colored water (large tube)
P-20 micropipette and tips
P-100 (or P-200) micropipette and tips
Supply of 1.5 mL Eppendorf tube (commonly called an epitube)
Rack for epitubes
Container for waste tips
Container for liquid waste
Fine-tip permanent marker
Wax paper
Microcentrifuge (microfuge - may be shared between teams)

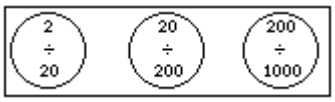
Procedure

PART 1

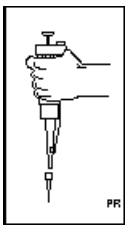
READ ALL INSTRUCTIONS BEFORE JUMPING IN YOU NEED TO KNOW WHERE YOU ARE GOING BEFORE YOU PUT ON THE SAFETY GLASSES, APRON/LAB COAT AND GLOVES

Directions for Using Micropipettes

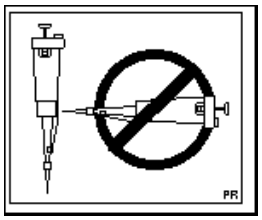
CAUTIONS



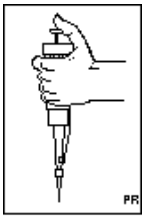
- Set pipette volume only within the range specified for that micropipette. Do not attempt to set a volume beyond the pipette's minimum or maximum values.



- When using a micropipette, first apply a tip. Forgetting to do this would cause liquid leakage into the nose cone. Since a micropipette works by air displacement, its internal mechanism must remain dry.



- Always keep a micropipette in a vertical position when there is fluid in the tip. Do not allow liquid to accidentally run back into the nose cone



- Use your thumb to control the speed at which the plunger rises after taking up or ejecting fluid. Releasing the plunger too abruptly will cause liquid to pop up into the nose cone.

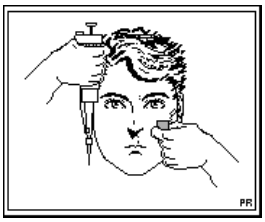
Setting and Preparing the Micropipette

1. Check that you have the right micropipette. There may be four sizes in the lab – a "P-20" (for 2 to 20 µL), a "P-100" (for 20-100 µL) a "P-200" (for 20-200 µL) and a "P-1000" (for 200-1000 µL). Check the disk on top of the plunger to see which micropipette you have.

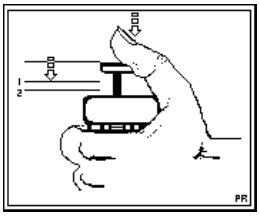
2. Dial the desired volume. Do you understand how to read the scale? If not – ASK

3. Push the end of the pipette into the proper size tip.

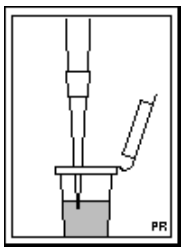
How to Take Up Sample with a Micropipette



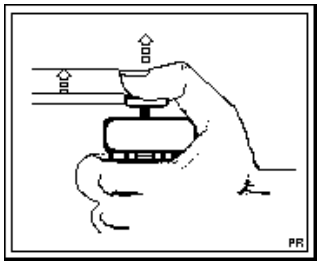
4. Before picking up the micropipette, open the cap or lid of the epitube from which you are taking fluid. (or have your lab partner do this).
5. Hold the micropipette in one hand, almost vertical; hold the epitube in your other hand. Both should be at almost eye-level.



6. Depress the plunger of the micropipette to the first stop and hold it in this position, then...

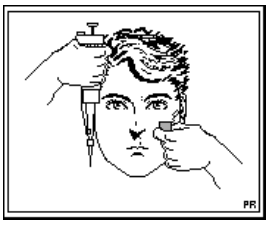


7. ...dip the tip into the solution to be pipetted.

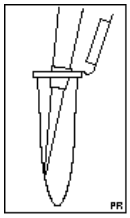


8. Draw fluid into the tip by slowly releasing the plunger without taking the tip out of the fluid.

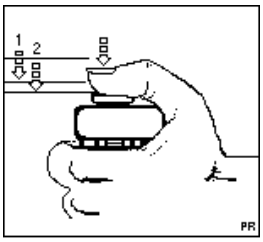
How to Expel a Sample From the Micropipette



9. With your other hand (or, have your lab partner do this), open the cap or lid of the epitube into which you are ejecting the fluid.
10. Hold the micropipette in one hand, almost vertical; hold the epitube in your other hand. Both should be at about eye-level.



11. Touch the micropipette tip to the inside wall of the epitube into which you want to expel the sample. This creates a tiny surface-tension effect which helps eject fluid out of the tip.



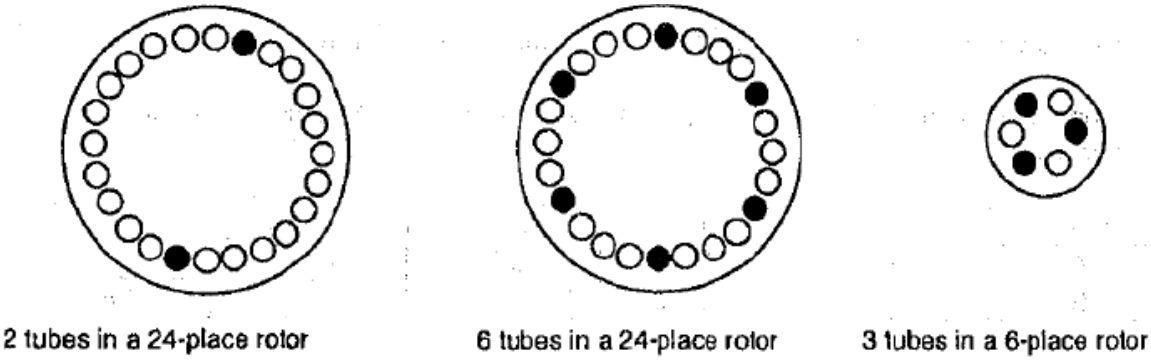
12. Slowly depress the plunger of the micropipette to the first stop. Then, continue to the second stop to expel the last bit of fluid, and hold the plunger in this position.
13. Slowly remove the pipette out of the epitube, keeping the plunger depressed to avoid sucking any liquid back into the tip.
14. Always change tips for each new reagent you need to pipette. To eject a tip, depress the other large button on the top or side of the micropipette.

Part 2

Centrifuge Instructions

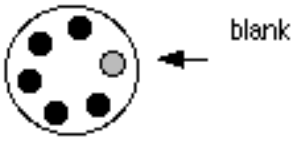
1. When you are adding several reagents to one epitube, release each drop of reagent onto a new location on the inside wall of the epitube. This will help you keep track of what you've added.
2. Tightly close the caps on all the tubes to be placed in the microcentrifuge (also called microfuge).
3. The microfuge rotor must always be balanced – you cannot, for example, insert one epitube into a microfuge. Spinning in an unbalanced arrangement like this would damage the motor of the instrument.
4. The amount of liquid in the epitube should be similar, otherwise the rotor will spin unevenly (like wet towels spinning out of balance in a washing machine). You can always prepare a "blank" tube with the appropriate volume of liquid with which to balance a single tube.

Samples of balanced rotor configurations:



5. After you have replaced the metal top (if your type of microfuge has a rotor top) and secured the lid of the microfuge, give the epitube a 1-2 second pulse. This will mix and pool all the reagents into a droplet in the bottom of each tube.

Question: What do you do if you only have 5 tubes?
You must put in one extra (a blank) tube blank with equal volume.



NOTE: REVIEW SECTIONS OF INSTRUCTIONS AS NEEDED AS YOU PROCEED TO PRACTICE MICROPIPETTING

Team Names: _____

Prelab Questions

1. Complete the following conversions:

a. 1 µL = _____ mL

b. _____ µL = 1.5 mL

c. 100 µL = _____ mL

d. _____ µL = 0.06 mL

e. 250 µL = _____ mL

f. _____ µL = 0.003 mL

2. Put the following volumes in order from largest to smallest.

a. 2.5 mL, 250 µL, 0.025 mL, 2.5 µL: _____, _____, _____, _____

b. 100 µL, 0.01 mL, 250 µL, 0.015 mL: _____, _____, _____, _____

3. Explain the reason for each of the following rules:

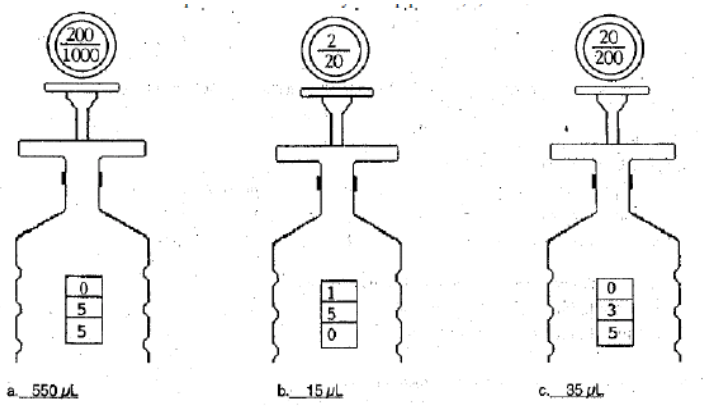
a. Always set the micropipette within its designated range.

b. Always use a micropipette with a tip.

c. Always hold a loaded micropipette in a vertical position.

d. Always release the micropipette plunger slowly.

e. Observe the volume of liquid that is measured by micropipettes a, b, and c.



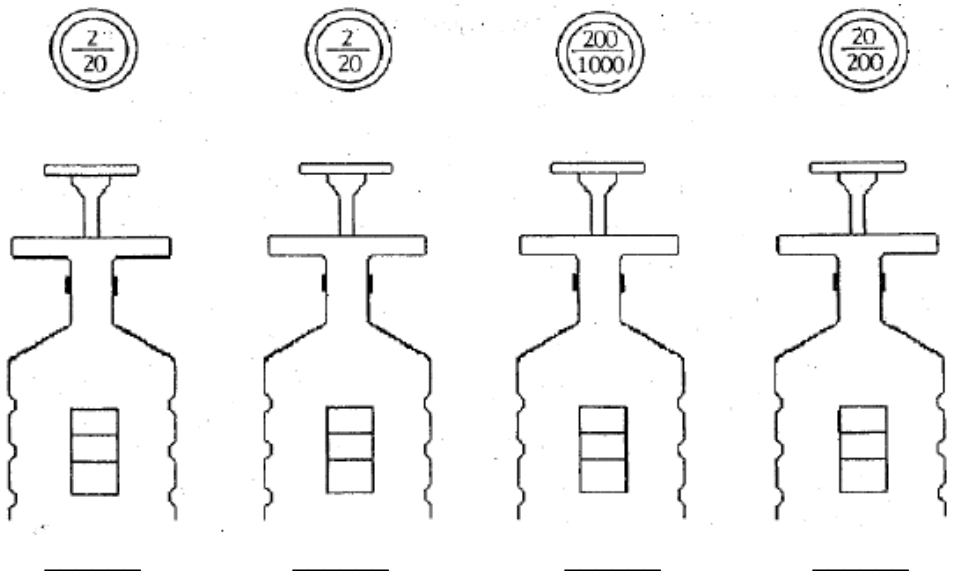
Which micropipette (a, b, or c) is the P-20? ____ What is its range? _____

Which micropipette (a, b, or c) is the P-200? ____ What is its range? _____

Which micropipette (a, b, or c) is the P-1000? ____ What is its range? _____

4. Select the appropriate micropipette and write what the dial should read to measure each of the following amounts of liquid. Write the letter and the amount on the lines below the micropipettes.

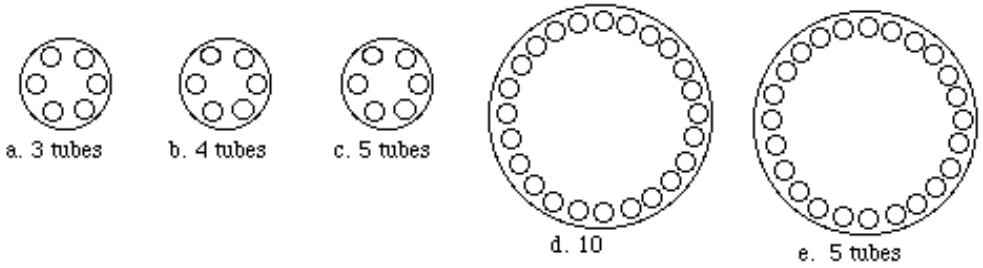
a. 150 µL b. 2.5 µL c. 300 µL d. 7 µL



_____ _____ _____ _____

5. Why is it important to balance a centrifuge before turning it on?

6. On the figures below, indicate how you would arrange the following tubes to balance the microfuge. If you decide you need to add or remove tubes to balance, explain.



OBSERVATION:

7. What is the approximate volume of a reaction tube? _____

Data Collection

Micropipette Mastery Exercises

Use a P-20 micropipette. Change tips each time you pipette.

1. Practice setting the micropipette to the following settings. Team members check each other's settings.
   2µl 4.2µl 5µl 8µl 11.5µl

2. Remove 2 µl (each team member) from an epitube and deposit liquid on plastic/waxed paper. Practice several times until you can consistently make all the drops the same size.

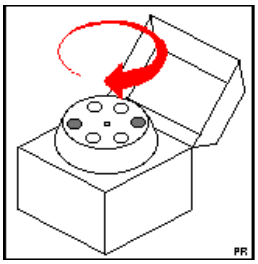
3. Remove 8 µl (each team member) from an epitube and deposit liquid on plastic/waxed paper. Practice several times until you can consistently make all the drops the same size.

4. Label two empty epitubes A and B with a permanent ink marker.

5. Add the amounts of solutions I, II, III and V to tubes A and B as shown in the table below.

Epitube	I	II	III	IV	V
A	4 µl	5 µl	2 µl		
B	6.5 µl	2.5 µl			2 µl

6. Spin tubes A and B in the microcentrifuge for 3-4 seconds to pool the solutions.



7. Add up the volume of liquid in epitibe A. As a check of your technique, set the micropipette to that volume and withdraw all of the liquid in epitube A. The contents should *just* fill the tip – no air space at the bottom of the tip; no leftover fluid in the tube. Discard liquid and tip into the waste beaker.

8. How much should be in epitube B? _____. Check your technique by setting the micropipette to this amount and repeat step 7.

Use a P-200 micropipette. Change tips each time you pipette.

9. Label an empty epitube C and D with a permanent ink marker.

10. Add the amounts of solutions I, II, III and IV as shown in the table below

Epitube	I	II	III	IV	V
C	20 µl	40 µl		25 µl	
D		35 µl	47 µl	22 µl	

11. Spin tubes C and D for 3-4 seconds.

12. How much should be in epitube C? _____. Check your technique by setting the micropipette to this amount and repeat step 7.

13. How much should be in epitube D? _____. Check your technique by setting the micropipette to this amount and repeat step 7.

Practice with both micropipettes. Change tips each time you pipette.

1. Label an empty epitube E with a permanent ink marker.

2. Complete the following data table, Indicate on the "P-_____" the appropriate micropipette to be used for each sample. Then write in the three boxes below each line, the numbers that you dialed to produce the indicated volume.

Epitube E	I	II	III	IV	V
Volume	15 µl	105 µl	12 µl	38 µl	150 µl
Micropipette setting					

Upon completion of this lab

- Remove liquid from all reaction tubes A-E and the assessment tube.
- Dispose of designated materials as outlined by your instructor.
- Leave equipment as you found it.
- Check that your work station is in order.
- Hand in your four-page Lab Activity worksheets.
- Wash your hands.

Discussion/Analysis

- During the micropipette activity, how *accurate* were your attempts?
- How *precise* were your measurements?
- If you had challenges with these two very important parts of the protocol, how can you improve your efforts?
- Why is accuracy and precision so important in biomedical research?

Micropipette Technique Assessment

1. Prepare an epitube with 40 µL of water.
2. One at a time, each student in a group of 2 should withdraw 18 µL of water and expel the 18 µL as one drop on a piece of waxed paper. When each student has had a turn, compare the four drops. Are the drops the same size? If yes, continue to step 3.
3. If not, why not? Try again, carefully coaching each other.
4. The teacher then will withdraw the last 4 µL.

Forms, Keys, and Rubrics

Guided Internet Treasure Hunt Forms

Internet Treasure Hunt: Stem Cell Basics

This web info search will help you find information about adult and embryonic stem cells. You will be looking at pre-selected websites to answer each question. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

Question #1: What are Adult and Embryonic Stem Cells?		
	Site 1	*Site 2*
Website Title:	*Stem Cells Explained: An Interactive Tutorial*, http://www.lsi.umich.edu/files/stemcells.swf	*Creating Stem Cells for Research,* http://teach.genetics.utah.edu/content/tech/stemcells/color_label_learn_stemcells.pdf
Who created this web site (organization, etc.)?		
Why did they create it? (check all that apply)	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure
How credible (accurate) do you think the info is?	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure
Important Information from this website		

Internet Treasure Hunt: Stem Cell Societal Issues

This web info search will help you find information about societal issues regarding stem cells. You will be looking at pre-selected websites to answer each question. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

Question #1: What are the issues surrounding the use of stem cells?		
	Site 1	*Site 2*
Website Title:	*Pros & Cons of Embryonic Stem Cell Research*, Deborah White, www.About.com http://usliberals.about.com/od/stemcellresearch/i/StemCell1.htm	*Judge Rules Against Stem-Cell Research Critics*, The Associated Press, January 16, 2009 http://www.kansascity.com/news/local/story/984192.html
Who created this web site (organization, etc.)?		
Why did they create it? (check all that apply)	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure
How credible (accurate) do you think the info is?	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure
Important Information from this website		

Internet Treasure Hunt: Using a Micropipette

This web info search will help you find information the protocol for using a micropipette. You will be looking at pre-selected websites to answer each question. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

Question #1: How do I use a micropipette?		
	Site 1	*Site 2*
Website Title:	*Micropipetting and Microfuge Activity*, http://www.ebbep.org/docs/basics/pipettestudent.pdf	*Skill Building Activities 1: Manipulating Small Volumes,* http://www.usc.edu/org/cosee-west/Jun07Resources/PipetteUsetraining.pdf
Who created this web site (organization, etc.)?		
Why did they create it? (check all that apply)	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure
How credible (accurate) do you think the info is?	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure
Important Information from this website		

Internet Treasure Hunt: Atherosclerosis

This web info search will help you find information about atherosclerosis. You will be looking at pre-selected websites to answer each question. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

Question #1: What is Atherosclerosis?		
	Site 1	*Site 2*
Website Title:	*What is Atherosclerosis?,* http://www.americanheart.org/presenter.jhtml?identifier=4440	*What Is Atherosclerosis?*, http://www.nhlbi.nih.gov/health/dci/Diseases/Atherosclerosis/Atherosclerosis_WhatIs.html
Who created this web site (organization, etc.)?		
Why did they create it? (check all that apply)	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure
How credible (accurate) do you think the info is?	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure
Important Information from this website		

Internet Treasure Hunt: Systemic Lupus Erythematosus (SLE)

This web info search will help you find information about Systemic Lupus Erythematosus (SLE). You will be looking at pre-selected websites to answer each question. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

Question #1: What is Systemic Lupus Erythematosus (SLE)?		
	Site 1	*Site 2*
Website Title:	*Systemic lupus erythematosus*, http://health.nytimes.com/health/guides/disease/systemic-lupus-erythematosus/complications.html	*Systemic lupus erythematosus,* http://www.nlm.nih.gov/medlineplus/ency/article/000435.htm
Who created this web site (organization, etc.)?		
Why did they create it? (check all that apply)	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure
How credible (accurate) do you think the info is?	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure
Important Information from this website		

Internet Treasure Hunt: Interferon-alpha (α)?

This web info search will help you find information about interferon-alpha (α). You will be looking at pre-selected websites to answer each question. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

Question #1: What is Interferon-alpha (α)?		
	Site 1	*Site 2*
Website Title:	*What Interferon is and How it Works*, http://www.naturalinterferon.com/	*Interferon*, Wikipedia, the free encyclopedia, *http://en.wikipedia.org/wiki/Interferon-alpha*
Who created this web site (organization, etc.)?		
Why did they create it? (check all that apply)	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure
How credible (accurate) do you think the info is?	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure
Important Information from this website		

Internet Treasure Hunt: What are endothelial progenitor cells (EPCs)?

This web info search will help you find information about endothelial progenitor cells (EPCs). You will be looking at pre-selected websites to answer each question. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

Question #1: What are endothelial progenitor cells (EPCs)?		
	Site 1	*Site 2*
Website Title:	*Endothelial progenitor cells could serve as biological marker for cardiovascular disease*, http://www.innovations-report.de/html/berichte/biowissenschaften_chemie/bericht-16446.html	*Endothelial progenitor cell*, Wikipedia, the free encyclopedia, http://en.wikipedia.org/wiki/Endothelial_progenitor_cell
Who created this web site (organization, etc.)?		
Why did they create it? (check all that apply)	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure
How credible (accurate) do you think the info is?	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure
Important Information from this website		

Internet Treasure Hunt: Accuracy and Precision

This web info search will help you find information about the terms *accuracy* and *precision*. You will be looking at pre-selected websites to answer each question. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

Question #1: What is the difference between the terms *accuracy* and *precision*?		
	Site 1	*Site 2*
Website Title:	*Accuracy and Precision. They mean slightly different things,* *http://www.mathsisfun.com/accuracy-precision.html*	*The Science of Measurement: Accuracy vs. Precision*, http://honolulu.hawaii.edu/distance/sci122/SciLab/L5/accprec.html
Who created this web site (organization, etc.)?		
Why did they create it? (check all that apply)	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure
How credible (accurate) do you think the info is?	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure
Important Information from this website		

Presentation Rubric: Exploring Stem Cells

Student Name: _____

CATEGORY	4	3	2	1
Project Requirements	All requirements are met and exceeded.	All requirements are met.	One requirement was not completely met.	More than one requirement was not completely met.
Oral Presentation	Interesting, well-rehearsed with smooth delivery that holds audience attention.	Relatively interesting, rehearsed with a fairly smooth delivery that usually holds audience attention.	Delivery not smooth, but able to hold audience attention most of the time.	Delivery not smooth and audience attention lost.
Attractiveness	Makes excellent use of font, color, graphics, effects, etc. to enhance the presentation.	Makes good use of font, color, graphics, effects, etc. to enhance to presentation.	Makes use of font, color, graphics, effects, etc. but occasionally these detract from the presentation content.	Use of font, color, graphics, effects etc. but these often distract from the presentation content.
Mechanics	No misspellings or grammatical errors.	Three or fewer misspellings and/or mechanical errors.	Four misspellings and/or grammatical errors.	More than 4 errors in spelling or grammar.
Content	Covers topic in-depth with details and examples. Subject knowledge is excellent.	Includes essential knowledge about the topic. Subject knowledge appears to be good.	Includes essential information about the topic but there are 1-2 factual errors.	Content is minimal OR there are several factual errors.
Originality	Product shows a large amount of original thought. Ideas are creative and inventive.	Product shows some original thought. Work shows new ideas and insights.	Uses other people's ideas (giving them credit), but there is little evidence of original thinking.	Uses other people's ideas, but does not give them credit.
Permissions	All permissions to use graphics "borrowed" from web pages or scanned from books have been requested, received, printed and saved for future reference.	All permissions to use graphics "borrowed" from web pages or scanned from books have been requested and received.	Most permission to use graphics "borrowed" from web pages or scanned from books have been requested and received.	Permissions were not requested for several graphics "borrowed" from web pages or scanned from books.

Collaborative Work Skills Rubric: Team Member Participation

(I will be the only one seeing this sheet - your team member will not see it.)

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Name of team member you are evaluating: _____

Your name (if you wish): _____

CATEGORY	4	3	2	1
Working with Others	Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working well together.	Usually listens to, shares, with, and supports the efforts of others. Does not cause "waves" in the group.	Often listens to, shares with, and supports the efforts of others, but sometimes is not a good team member.	Rarely listens to, shares with, and supports the efforts of others. Often is not a good team player.
Focuses on the Task	Consistently stays focused on the task and what needs to be done. Very self-directed.	Focuses on the task and what needs to be done most of the time. Other group members can count on this person.	Focuses on the task and what needs to be done some of the time. Other group members must sometimes nag, prod, and remind to keep this person on-task.	Rarely focuses on the task and what needs to be done. Lets others do the work.
Quality of Work	Provides work of the highest quality.	Provides high quality work.	Provides work that occasionally needs to be checked/redone by other group members to ensure quality.	Provides work that usually needs to be checked/redone by others to ensure quality.
Contributions	Routinely provides useful ideas when participating in the group and in classroom discussion. A definite leader who contributes a lot of effort.	Usually provides useful ideas when participating in the group and in classroom discussion. A strong group member who tries hard	Sometimes provides useful ideas when participating in the group and in classroom discussion. A satisfactory group member who does what is required.	Rarely provides useful ideas when participating in the group and in classroom discussion. May refuse to participate.
Attitude	Never is publicly critical of the project or the work of others. Always has a positive attitude about the task(s).	Rarely is publicly critical of the project or the work of others. Often has a positive attitude about the task(s).	Occasionally is publicly critical of the project or the work of other members of the group. Usually has a positive attitude about the task(s).	Often is publicly critical of the project or the work of other members of the group. Often has a negative attitude about the task(s).
Problem-solving	Actively looks for and suggests solutions to problems.	Refines solutions suggested by others.	Does not suggest or refine solutions, but is willing to try out solutions suggested by others.	Does not try to solve problems or help others solve problems. Lets others do the work.
Time-Management	Routinely uses time well throughout the project to ensure things get done on time. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Usually uses time well throughout the project, but may have procrastinated on one thing. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Tends to procrastinate, but always gets things done by the deadlines. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Rarely gets things done by the deadlines AND group has to adjust deadlines or work responsibilities because of this person's inadequate time management.