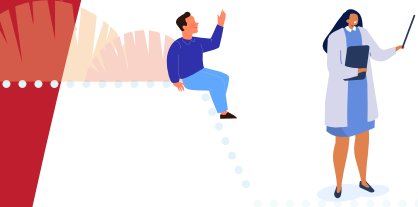
VEIN TO VEIN:

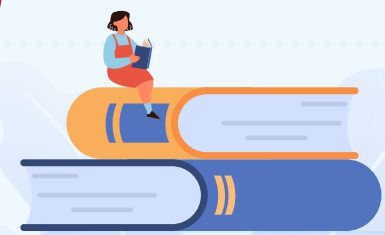
THE SCIENCE OF

BLOOD DONATION

INSIDE YOU'LL FIND:



- A comprehensive education program
- Integration ideas and student activities
- Educational video
- Teacher preparation guide
- Extensive facts, glossary, and resources surrounding the science of blood donation



How can we ensure that blood is available for all those in need and create a safe and sustainable blood supply for our nation?

This effort starts with you! As a high school educator, you are working directly with students at the exact time they are able to start their journey to becoming a lifelong blood donor. Each section is designed to provide you with turnkey resources to integrate into your curriculum.

Throughout this program, you will find references to the Next Generation Science Standards that these lessons address, making it easier for you to complete your lesson plans.

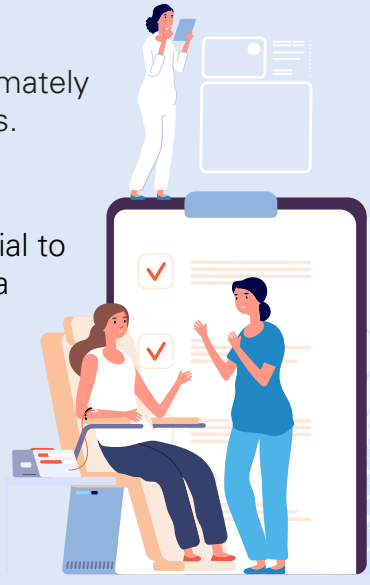
Through this program, your students will develop leadership skills and a growing interest to support our nation's blood supply.

TABLE OF CONTENTS

SECTION 1: RATIONALE FOR *VEIN TO VEIN*

Why is it so critical to educate high school students on the importance of blood donation?

1. There is no substitute for blood.
2. The average age of the current blood donor base is increasing at an alarming rate.
    - Currently, about 60 percent of blood donations are made by people over 40 years old, and of these, 75 percent come from people over the age of 50.
    - Blood donors under the age of 30 donate less than half as frequently as older donors. In fact, many donors under the age of 22 only donate once a year (compared to an average of 2.6 times annually for donors over the age of 35).
    - Young blood donors are needed to establish the foundation of the future donor pool.
    - Blood donors are especially needed from communities of color to meet the transfusion needs of an increasingly diverse population in the U.S.
3. The need for blood is constant. Red blood cells must be transfused within 42 days of collection; platelets have an even shorter shelf life of five to seven days.
4. Blood is needed for a wide variety of patients including those with acute injuries and conditions from a car accident or a bleeding pregnant mother and those with chronic conditions/diseases such as cancer or sickle cell anemia.
5. Every two seconds someone needs blood, with approximately 41,000 units of blood used each day in the United States.
6. Only three percent of the U.S. population gives blood.
    - Maintaining and increasing this percentage is essential to satisfy not only our current needs but also to create a strong base of younger donors.



SECTION 2: SCIENCE STANDARDS

The science standards below can be addressed (fully or partially) with a study of the structure and function of blood, diseases/disorders of blood, genetics of blood types and diseases/disorders, and the connection between homeostasis and blood volume/blood health.

NEXT GENERATION SCIENCE STANDARDS

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

SECTION 3: INTEGRATION IDEAS

Each of the ideas suggested here can be used independently or in conjunction with one another.

VIDEO—Share this video with your students. It explains the great need for young people to begin and continue donating blood and is the primary resource of this project. You could use the video as an anticipatory/engagement activity, to spark in class or online discussions, as part of a project (ideas below), or in any other way you see fit. Even if you cannot adjust your curriculum much, this could be shared via announcements or on social media outlets.

ESSENTIAL QUESTIONS—Focus your unit of study on Essential Questions related to the structure and function of blood and the need for transfusions to maintain homeostasis. This would likely require just a few minor tweaks to the lessons that you already use in your class and possibly the addition of a few activities. In doing this, you will bring awareness to the need and value of blood donation. Answers to these questions can be found in Appendix A.

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

- What happens to your body when you have an injury/condition that causes massive blood loss?
- What happens to your body when you have a chronic disease that causes the body to not produce enough blood or causes the right mix of cells in the blood or blood cells to not function properly?

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

- How is blood volume related to homeostasis?
- What happens to your blood donation after you donate to be sure it is safe to transfuse to a patient?
- What happens to your body after you donate blood? How does it restore homeostasis?
- How does a transfusion help a patient restore homeostasis?
- How does a low number of platelets in the blood disrupt homeostasis?

- What type of homeostatic disruption is caused by a sickle cell crisis?
- How would receiving an incompatible blood type cause a disruption in homeostasis?

HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

- How is blood type passed from one generation to the next?
- How can DNA help us understand why some populations have a higher incidence of developing blood disorders?
- What are some of the most common inherited blood disorders that require blood transfusions?

HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

- Is one blood type more common than another?
- Does race/gender appear to influence these statistics?
- How do blood group antigens contribute to the diversity of the blood supply? How does matching blood group antigens help ensure the safety of transfusions for patients with chronic illness, such as those with sickle cell anemia and antibodies?

Go a bit deeper by adding one or more of the other ideas shared below as they support the Essential Questions.

SOCRATIC SEMINAR—A Socratic Seminar is purposeful, structured, and rigorous discourse between students regarding a set topic for which they have completed prior research or reading. All dialogue is supported by facts from prior research/reading. This can be done in your science class, or you could collaborate with your ELA/Social Studies partners. Some possible topics for discussion/debate/investigation include:

- Should donor centers incentivize (free gifts) blood donors?
- How does altruism incentivize blood donors?
- Are blood transfusions a right or privilege? Should donating blood be mandated?

SURVEY/DATA ANALYSIS—Have students conduct a digital survey using social media on topics related to blood donation and then analyze the data to determine trends based on set parameters such as age, gender, political affiliation, religion, race, etc. Some questions could include:

- Have you ever donated blood?
- Have you ever received a blood transfusion or do you know someone who has?
- Do you feel donating blood is important?
- Do you know what happens to your blood after donation and before it is transfused into a patient?
- Would you be more likely to donate blood if you received a gift for it?
- Share some statistics from the resources in this project or from your local blood center and ask if they have ever heard of them or if they feel they are true or false.

A survey of this nature will provide students with the opportunity to both collect and analyze data as well as to educate and bring awareness to this issue in the community.

Here is a link to a sample survey in Google Forms:
https://forms.gle/Ku2vgRMAGfDUCWrB9

COMMERCIAL—Have students create a commercial asking for members of the community (fellow students, faculty, and/or larger community) to donate blood. This could easily be done in conjunction with the survey described above. This is a great way to integrate technology skills and support ELA standards in your class. Consider using a tool such as FlipGrid or iMovie depending on your district access.

You (or students) could select the best commercial and you could reach out to your local TV station to air it during a newscast or share it on their social media outlets. It could also be shared on morning announcements if your school has that capability.

SOCIAL MEDIA BLAST—Consider giving students bonus points for making social media posts that educate and create awareness of the need for blood donors. This would be a nice tie in to a digital citizen lesson/focus on quality/effective/safe social media usage.

BLOOD DRIVE—Work with your students to organize a school or community blood drive. Students can take on different roles in preparation, such as:

- Advertising – print, digital, social media
- Education – research data to use for persuading community, members to donate and to educate those who do so that they might become repeat donors
- Volunteers – be present on the day of the event to welcome and thank donors
- Media – have students present on the day of the event to take photos and interview donors and workers (with permission and as allowed by the blood donation center on site)

Blood centers in your area may even have staff dedicated to supporting you in your planning.

TOUR OF A BLOOD CENTER—Take a field trip to your local blood center. This would work well in conjunction with a focus on careers (see below) or as a form of research in preparation for many of the other suggested ideas above. While it may not be practical to bring several classes at once, you could select a few students from each class to attend and present back to the class.

CAREERS—If you choose to utilize any of the above ideas, you could add a look at the types of careers surrounding blood and blood donation. Some examples are linked below (many links have interactive modules to learn about the science and job skills needed):

- Blood Bank Technology Specialist
- Donor Recruiter
- Genetic Counselor
- Marketing
- Medical Laboratory Scientist/Technician
- Nurse
- Phlebotomist
- Public Relations

Consider providing students with a purpose for exploring one or more of these careers.

WEBQUEST—Create an asynchronous project for students to complete during a study of the standards above. This would work nicely if you are unable to adjust your curriculum. Select ideas suggested here (or any of your own) that are most relevant to you and your community and put them together to make a webquest. Students could work on the project throughout the unit as homework, when a substitute is needed, or for extra credit.

TWO TRUTHS AND A LIE—following the Claim, Evidence, Reasoning format provide students with three statements or facts pertinent to your unit of study and blood donation, where two statements are true and one is false. Students should make a claim as to which statement they feel is false and should provide evidence and reasoning to support their claim. You could also ask students to justify why they feel the other statements are true using evidence in the same format for a more rigorous task. Some facts are included in the resources below and in Appendix B.

Section 5 has an activity you may use as is or as a template to create your own. The format is a modification of the traditional Two Truths and a Lie.

RESOURCES—there are a lot of great lessons and resources available that can help you integrate instruction on blood donation into your classroom. Below are a few:

https://www.cdc.gov/bloodsafety/basics.html
- Facts about blood safety from the CDC.

https://serendipstudio.org/exchange/waldron/bloodtests
- Were the Babies Switched? The Genetics of Blood Types – this is a full laboratory activity.

https://alex.state.al.us/lesson_view.php?id=34638
- ABO Blood Groups and How They Contribute to Blood Transfusions – this is a full laboratory activity.

https://educationalgames.nobelprize.org/educational/medicine/bloodtypinggame/index.html
- This is a blood typing interactive game.
- Here is an example of a lesson that includes the game: https://betterlesson.com/lesson_print/637946

https://ed.ted.com/lessons/why-do-blood-types-matter-natalie-s-hodge#watch
- TedEd video with assessments and discussion topics.

http://www.bozemanscience.com/blood-types
- Video discussing the importance of blood types in blood transfusions.

www.americasblood.org
- A wealth of information about donating blood.

www.donatingblood.com
- Includes social media graphics, videos, and more.

SECTION 4: SAMPLE UNIT OVERVIEW

TEACHER PREPARATION

When you are ready to begin a unit with standards that relate to a study of blood:

1. Select an essential question (or a few) from *Vein to Vein* that best connects to the content you will be teaching.
2. Select a task for Integration #1.
3. Plan for how you will ask students to reflect on Essential Questions for Integration #2.
4. Select a task for Integration #3.

Standards: Select standards relevant to your unit of study.

Essential question(s): Select one or more from the program or create one yourself.

UNIT OVERVIEW:

INTEGRATION #1 (30–60 MINUTES)—Depending on the type of lesson plan you utilize, this activity can serve as the anticipatory set, hook, or engage phase (5E model) of your lesson.

- Share this video on the first day of your unit. To ensure maximum student engagement with the video, select a task for students, such as a KWL chart or a video response form like this example: http://www.cte.iup.edu/preinduction/HO_Video%20Note%20Taking%20Worksheet.pdf.
- After the video and task are complete, ask students to share with a partner and fill in any missing information. Finally, hold a whole-class discussion around the task you selected (think-pair-share instructional strategy). As the discussion concludes, hold a brief brainstorming session where you ask students what they think they need to learn about in science class in order to understand what they heard about in the video.
- Introduce the essential question(s) you selected and have students record it/them in their science notebook. Explain that students should think about these questions throughout the unit and that you will revisit them for a final project/assessment at the end of the unit.

INTEGRATION #2 (5–10 MINUTES PERIODICALLY THROUGHOUT THE UNIT)— Teach your unit as you normally would, being sure to revisit the essential question(s) when appropriate to allow students time to reflect on the connection between the questions and the class content. This reflection could take the form of journal writing or small group discussions. Be sure to have students record their thoughts/understandings for use at the end of the unit. If you are able, adjust your unit to have a more direct focus on blood donation. This could be done by using blood donation as a real-world scenario/phenomenon to focus your instruction.

ASSESSMENT/APPLICATION:

INTEGRATION #3 (1–4 DAYS)— Depending on the type of lesson plan you utilize, these activities could serve as the performance task, the summative assessment, the final project, or the elaborate phase (5E model) of your lesson. Choose one of the tasks below.

1. Survey and Commercial (3–4 days)
2. Survey and Socratic Seminar (3–4 days)
3. Survey and Social Media Blast (2–3 days)
4. Two Truths and a Lie (1 day)

SURVEY— Students should use social media to conduct a survey of people aged 16 and older on various topics related to blood donation—you can target this survey to the content you are focused on in class. A sample survey is here—https://forms.gle/LRMKJz34v9ibLoDT8. You can use this survey, create one as a class, or have students/groups create their own.

Once the survey results are in, dedicate a class to data analysis. While the analysis will be based on the questions you decide to use, this is how it could be done with the sample survey from above:

- Look at the data categorically—how did respondents reply based on their age, gender, race, etc.
- Speak with the math teacher at your grade level as this is a great time to support content they are teaching. If the timing allows, you might also consider having the math teacher do the data analysis with the students. Some example high school math standards related to this activity include:
    - Make inferences and justify conclusions from sample surveys, experiments, and observational studies.
        - 3. Recognize the purposes of and differences among surveys, experiments, and observational studies. Explain how randomization relates to each.
        - 6a. Use the tools of statistics to draw conclusions from numerical summaries.
        - 6b. Use the language of statistics to critique claims from informational texts. For example, causation vs correlation, bias, measures of center, and spread.

To tie everything together, hold a class discussion and help students make the connections between the Essential Questions, the course content, and the survey results. Move forward with either a Socratic Seminar, commercial, or social media blast to allow students to show their understanding.

SOCRATIC SEMINAR—A Socratic Seminar is purposeful, structured and rigorous discourse between students regarding a set topic for which they have completed prior research or reading. All dialogue is supported by facts from prior research/reading. This can be done in your science class or you could collaborate with your ELA/Social Studies partners. Some possible topics for discussion/debate/investigation include:

- Should donor centers incentivize (free gifts) blood donors for their blood?
- How does altruism incentivize blood donors?
- Does blood type affect any other medical issues?
- Are blood transfusions a right or privilege? Should donating blood be mandated?

COMMERCIAL—Have students create a commercial asking for members of the community to donate blood. Consider using a tool such as FlipGrid or iMovie depending on your district access.

You or your students could select the best commercial and you could reach out to your local TV station to air it during a newscast. It could also be shared on morning announcements if your school has that capability. (See example in Section 5)

SOCIAL MEDIA BLAST—Students, either individually or in pairs, should create a social media post that educates and create awareness of the need for blood donors. The post should include scientific content from the unit, data from the survey and/or video and possibly address the Essential Questions. This is a great place to integrate digital citizen into your classroom.

TWO TRUTHS AND A LIE—Provide students with three statements pertinent to your unit of study and blood donation, where two statements are true and one is false. Using the strategy Claim-Evidence-Reasoning, students should make a claim as to which statements are true and which one is false. They should use evidence from the unit to support their claim with scientific reasoning. (See example in Section 5)

SECTION 5: SAMPLE CLASS ACTIVITIES

Blood Donation Survey

Thank you for participating in our class survey. Your responses will help us learn more about what the public knows and thinks about donating blood. We will also be learning to statistically analyze data. All responses are anonymous.

Mrs. Erythrocyte's Grade 10 Biology Class

Sample questions to include in a Google/Microsoft Form for electronic distribution.

- Have you ever donated blood?
- Do you know your blood type?
- Have you ever received a blood transfusion or do you know someone who has?
- Do you know what happens to blood after it is donated and before it is transfused into a patient?
- Do you know why people receive blood donations? List any reasons that come to mind.
- Would you be more likely to donate blood if you were incentivized for it?
- Do you think the following statement is true or false? An estimated 5 million people need blood transfusions each year throughout the U.S.
- Do you think the following statement is true or false? Shortages of blood often occur during the winter holidays and summer.
- Do you think the following statement is true or false? Only 3 percent of the U.S. population gives blood.
- Do you think the following statement is true or false? Blood cannot be synthetically made.
- Age, gender, ethnicity: Look for trends in the data…Do you see any common responses based on a person's age? Gender? Ethnicity?

Lights! Camera! Action!

As the Manager of Donor Recruitment and Marketing at SaveALife Blood Center, you are responsible for public outreach and donor solicitation. A 30-second, primetime commercial slot has been purchased by your company in an attempt to increase the percentage of donors aged 17–25 in your community.

TASK: Make a commercial that appeals to and will persuade the young adult demographic to donate blood.

What makes a good commercial?

- Slogans, jingles, music, images, special effects, dialogue
- Dialogue should be succinct and impactful; it can be within the recording or done in a voice over style
- Content should appeal to the viewers' emotions, grab their attention
- Facts, statistics, and organization names make a message more believable

**You must submit a written script/storyboard to your teacher for approval before you begin the final product.

Teachers: This task has been left open to allow you the opportunity to integrate any technology that you have access to. You might consider iMovie, Flipgrid or even PowerPoint with screen recording. If technology integration is not possible, the written script/storyboard is sufficient, and you could have students "perform" their commercial for the class. This task also offers a unique opportunity to make connections to the ELA standards at your grade level, specifically persuasive writing.

Career Exploration

Visit the websites linked below and explore some careers related to blood donation.

- Blood Bank Technology Specialist
- Donor Recruiter
- Genetic Counselor
- Marketing
- Medical Laboratory Scientist/Technician
- Nurse
- Phlebotomist
- Public Relations

On a separate piece of paper, answer the following questions:

1. Which job interests you the most? Why?
2. Which job interests you the least? Why?
3. Choose one job to look at more closely:
    - Describe what a person with this job does.
    - What is a typical salary?
    - What is the job outlook?
    - What schooling is required? Do any local schools offer this major or certification?
    - What science have we learned during this unit that would help you in these jobs?

Career Exploration

You have recently been hired in the human resources department of SaveALife Blood Center. Your main responsibility is to advertise for open positions, review resumes, and interview candidates.

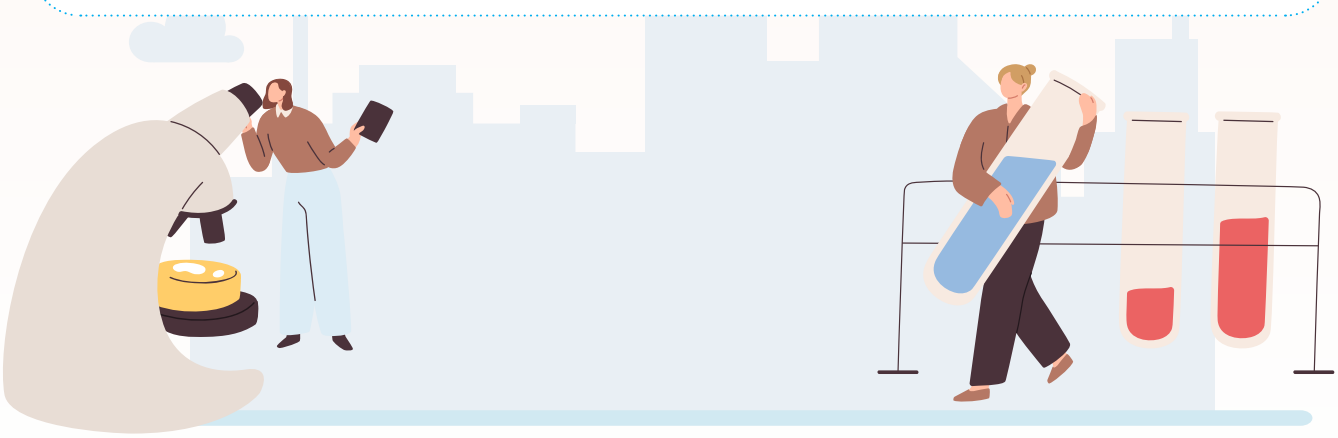
Visit the websites linked below and explore some careers related to blood donation:

- Blood Bank Technology Specialist
- Donor Recruiter
- Genetic Counselor
- Marketing
- Medical Laboratory Scientist/Technician
- Nurse
- Phlebotomist
- Public Relations

TASK: Create a help wanted ad/job posting for one of the careers above. You may use any technology tool of your choosing. Be sure to address the following:

- A description of the responsibilities of the position
- Skills required, both professional and interpersonal
- Required education and experience
- Salary
- Make the add/posting visually appealing to attract candidates
- Information about your company/why candidates would want to work for you

In addition to the links above, you could take a look at current job postings here: https://americasblood.org/membership/careers/



Two Lies and A Truth

Read this scenario and the statements that follow. *Juanita just arrived at the hospital with a broken arm. The break is extensive and will require surgery. While taking her health history, the surgeon was made aware that Juanita has sickle cell anemia and a B- blood type. The surgeon asked the hospital to have several pints of blood available as Juanita may need a transfusion during surgery. Unfortunately, blood donations have been minimal and only a few pints of blood with the following blood types are currently available: AB-, B+, and O-.*

One of the statements below is true. Use your knowledge of science to find the truth.

Statement 1: Juanita cannot have surgery because people with sickle cell anemia cannot receive blood transfusions.
Statement 2: Juanita cannot have surgery because, if she needs a transfusion, the available blood does not match her blood type.
Statement 3: Juanita can have the surgery and a blood transfusion if needed.

Claim: Which statement is the truth? _____

Write a paragraph that justifies your claim. Be sure to include the following:

- Scientific reason why you believe the statement is true.
- Scientific reason why you believe each of the other two statements are false.

If you are unfamiliar with the Claim-Evidence-Reasoning strategy, view this video from Bozeman Science.

These are two great resources from Model Teaching 2019 for implementing a Claim-Evidence-Reasoning task:

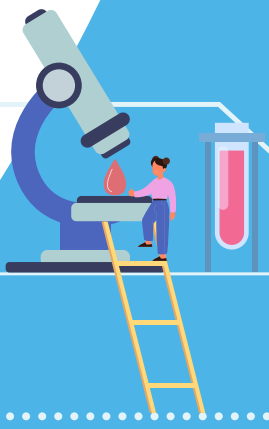
- CER Checklist
- CER Student Graphic Organizer



APPENDICES





APPENDIX A: TEACHER BACKGROUND INFORMATION

The below information is designed to provide teacher's with background information on the Essential Questions listed in Section 3 of this program.

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

What happens to your body when you have an injury/condition that causes massive blood loss?

Massive blood loss results in a severe disruption in an individual's stable internal environment. During massive bleeding, the individual loses large quantities of red blood cells and plasma which results in 1) an insufficient amount of available oxygen for the body's vital functions and 2) intravascular fluid (plasma) loss which is essential to maintaining normal blood pressure. Red cells contain hemoglobin which is the molecule which carries oxygen. Inadequate levels of plasma rob the body of needed water, salts, and vital proteins such as coagulation factors, hormones, and enzymes. For example, sufficient coagulation factors are key to an individual's ability to form clots and thereby stop the bleeding. Loss of plasma proteins in the vascular system also causes fluids to shift out of the blood vessels as a result of changes in osmotic pressure, resulting in low intravascular volume and inability to maintain normal blood pressure. In addition, massive blood loss results in the body not having enough platelets to start one of the initial stages of stopping blood loss—the formation of a platelet plug which is needed to temporarily block a tear in the skin.

What happens to your body when you have a chronic disease that causes the body to not produce enough blood or the right mix of cells in the blood or blood cells which don't function properly?

Homeostasis is absolutely critical for a body to function normally. For example, if a child does not have enough red blood cells, the body's cells will not receive enough oxygen for metabolism. If the cells are unable to metabolize nutrients properly, then the child will not grow properly. If an individual's platelet count is normal, but the platelets don't function properly, then the individuals can have difficulties forming a strong clot which can lead to the resumption of bleeding from a wound.

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

How is blood volume related to homeostasis?

Blood volume, which is determined by the number of red blood cells and plasma, is the total volume of blood in an individual's blood stream. In order to maintain homeostasis in the human body, an individual's blood volume must remain within a certain range. If it does not remain within this range, the body's internal systems will not function properly. For example, if a patient has lost a lot of blood, they might need a red blood cell transfusion to maintain the proper amount of oxygen in the body to supply its needs. With the help of a transfusion, blood volume is restored bringing the body back to homeostasis.

What happens to your blood donation after you donate to be sure it is safe to transfuse to a patient?

The nation's blood supply is extremely safe as a result of stringent screening and testing protocols mandates by the U.S. Food and Drug Administration (FDA). All *blood donations are tested for various infectious diseases such as HIV, Hepatitis B and C, and West Nile Virus, which can all be transmitted by a blood transfusion to a patient potentially resulting in the patient becoming sick with that disease. In addition, prior to every blood donation, blood donors are required to answer a donor history questionnaire that helps to determine if the donor is at risk of having a disease that could transmitted by their blood donation. This questionnaire, in addition to the donor's mini-physical, are reviewed and certified to ensure the donor meets all the safety requirements.*

In addition to infectious disease testing, blood specimens are collected during the blood donation process to conduct blood typing (i.e. determination of ABO and Rh groups) and red blood cell antibody screening, which ensures the patient receives the best transfusion match. Donor blood typing and red blood cell antibody testing is essential to help prevent patient transfusion reactions. During a transfusion reaction, the patient's immune system generates red blood cell antibodies against the donor's red blood cells because it sees them as foreign or "non-self." This leads to the destruction of the donor's red blood cells by the patient's red cell antibodies and potentially very serious health consequences for the patient, including death. By carefully matching the donor blood to the patient's blood, the patient's immune system is more likely to accept the donor red cells and not see them as "foreign".

Because sickle cell patients are frequently transfused, they have a greater chance of forming red blood cell antibodies against the donor cells, which are considered foreign. As mentioned above, the better the match between the donor and patient, the less likely the patient will form additional red blood cell antibodies. After many transfusions, the best match for a patient with multiple red blood cell antibodies is a red blood cell from a rare donor, i.e. a donor who lacks the antigens to the numerous antibodies the patient had developed.

What happens to your body after you donate blood? How does it restore homeostasis?

When you donate blood, your body loses a certain amount of red blood cells, plasma, and platelets. Your body senses this loss after you donate and starts to restore homeostasis by sending hormones to the bone marrow, for example, to speed up red blood cell and platelet production. For the average donor who eats a healthy diet, it takes an average of 4–6 weeks to restore the red blood cells it has lost, while it normally takes an average of 24–48 hours to return plasma to its routine level. The body replaces platelets within 72 hours of donation.

How does a transfusion help a patient restore homeostasis?

A transfusion helps the body restore homeostasis by replacing the blood components which are in low amounts and causing the body to not be at equilibrium. A transfusion can provide needed red cells to increase oxygen delivery to the body, plasma to restore clotting factors and maintain fluid balance, and/or platelets to help stabilize the bleeding.

How does a low number of platelets in the blood disrupt homeostasis?

Each individual has a certain number of platelets in their blood, known as a normal range, in order to maintain homeostasis. If the platelets are too low, the body's stable internal environment is no longer in balance and can then be further disrupted by bleeding. For example, if an individual with trauma is severely bleeding from their injuries, they might not have enough platelets to start one of the initial stages of stopping blood loss—the formation of a platelet plug, which is needed to temporarily block a tear in the skin. The patient can receive a platelet transfusion in order to return the platelets to the normal range, which helps stop bleeding thereby returning the body to homeostasis.

What type of homeostatic disruption is caused by a sickle cell crisis?

Red blood cells which contain Hemoglobin S, unlike red blood cells with normal Hemoglobin A, are deformed, sticky, and not as flexible when moving through the blood vessels. When a red blood cell with Hemoglobin S releases its oxygen to the body's cells, the cells form a "sickle" or "crescent" shape. These sickle shaped cells get stuck in blood vessels more easily and stick together forming blockages which prevent normal blood flow, resulting in a sickle cell crisis. These cells prevent oxygen-carrying red blood cells from moving freely into the tissues and blood vessels of the chest, arms, and legs. Without enough oxygen, tissues can die, thereby disrupting the body's internal balance.

For example, the lungs can be severely damaged by these blockages as not enough healthy tissue is available to oxygenate blood and deliver it to the rest of the body's tissues. Sickle cells can also get trapped in the brain, in clots that can cause a stroke and significant tissue damage or resulting death. Other organs and tissues can also be severely damaged by clots and a lack of oxygenated blood. The body does its best to remove sickle cells from the blood stream through the action of the spleen. Because the sickle cells must be cleared in order for the body to restore some equilibrium, they survive only 10 to 20 days. In contrast, red blood cells with normal hemoglobin are available in the blood stream for up to 120 days. Because of the shortened red blood cell life span, individuals with sickle cell disease face the dangers of chronic anemia and therefore constant homeostatic disruption.

How would receiving an incompatible blood type lead to a disruption in homeostasis?

If a patient receives an incompatible blood type, it can cause a major disruption in homeostasis. The body's red blood cell antibodies will recognize the incompatible (foreign) red blood cell antigens, causing the antigen and antibodies to combine into complexes, followed by the breakdown of the antigen/antibody complexes into pieces in the bloodstream. This breakdown causes a major disruption in the body's oxygen carrying capacity.

These red blood cell pieces can form clots and get trapped in vital organs such as the lungs, the brain, and the kidneys. In the brain, these clots can cause a stroke and significant damage to the tissues. In the lungs, these clots can result in devastating damage as they are trapped in the lung tissues and prevent blood from being oxygenated. The kidneys are unable to function properly because red cell pieces are trapped in its narrow

capillaries. The body does its best to clear the pieces of broken red blood cells through the spleen but might not be able to restore equilibrium and resolve such an extensive disruption in homeostasis.

One way to help prevent frequently transfused patients from receiving incompatible red blood cells is by increasing the blood supply diversity, thereby improving the chances of finding rare units that will more precisely match the patient's blood. These rare units can then be used for those patients who rely on compatibility beyond the routine donor.

HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

How is blood type passed from one generation to the next?

Blood type is passed from one generation to the next on Chromosome 9. Blood type is determined by two genes one from each biological parent. There are three versions of the blood type genes: A, B, and O with A and B being the dominant and O is the recessive.

How can DNA help us understand why some populations have a higher incidence of developing blood disorders?

The DNA in genes controls the expression of an individual's traits. Certain genes originated in some populations resulting in a gene which produces an atypical hemoglobin, such as Hemoglobin S. This gene is passed from one generation to the next. For example, if both parents carry the Hemoglobin S gene, the child will have sickle cell anemia. If only one parent carries the Hemoglobin S gene, then the child will have sickle cell trait.

What are some of the most common inherited blood disorders which require blood transfusions?

Some of the most common inherited blood disorders are sickle cell disease and thalassemia. Sickle cell disease patients in particular require regular blood transfusions throughout their lives as they live in a state of chronic anemia. The body does its best to remove sickle cells from the blood stream through the action of the spleen. Sickle cells must be cleared to restore some equilibrium so they survive only 10 to 20 days in circulation. In contrast, red blood cells with normal hemoglobin are available in the blood stream for up to 120 days. Because of the shortened red blood cell life span, individuals with sickle cell disease face the dangers of chronic anemia and therefore require regular transfusion.

HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Is one blood type more common than another?

Yes, depending on your race, one blood type can be more common than another. In the U.S., the approximate percentage of ABO phenotypes by race/ethnicity is as follows:

Race or ethnicity	Type O	Type A	Type B	Type AB
White non-Hispanic	45	40	11	4
Hispanic	57	31	10	3
African-American non-Hispanic	50	26	20	4
Asian	40	28	25	7
North American Indian	55	35	8	3
All donors	47	37	12	4

**Percentages may not equal 100 percent because of rounding. Original source includes additional information on race/ethnicities.*

Does race/gender appear to influence these statistics?

Race does influence blood type statistics. Blood types are more common in some races than others. For example, 26 percent of African-Americans have a B blood type while 11 percent of Caucasians have type B blood. If a patient's blood type is B, they are more likely to find a match in someone who is African-American which highlights the importance of recruiting blood donors from diverse ethnic groups.

How do blood group antigens contribute to the diversity of the blood supply?

Some blood group antigens are more common in certain races than others. The many various combinations of these different antigens result in the antigen variation among donors which thereby leads to a diverse blood supply. A diverse blood supply must be available to match the antigens of an increasingly diverse population and helps ensure successful transfusions.

How does matching blood group antigens and antibodies help ensure the safety of transfusions for patients with chronic illness, such as those with sickle cell anemia?

The hospital transfusion service helps ensure the safety of transfusions for patients with chronic illness by testing the patient's blood with a sample from the blood donor. The procedure involves testing the donor's red blood cell antigens with the red blood cell antibodies in the patient's plasma to verify they match as closely as possible. This matching helps prevent an incompatible blood transfusion so that the patient's internal equilibrium can be maintained.

If the patient receives red blood cells that are not well matched, they can form red blood cell antibodies against the foreign antigens on the donor's red blood cells. In later transfusions, these new red blood cell antibodies can attack the new donor's red blood cells as they enter the body, causing a transfusion reaction and resulting in loss of patient homeostasis.

References:

Garratty G, Glynn SA, McEntire R; Retrovirus Epidemiology Donor Study. ABO and Rh(D) phenotype frequencies of different racial/ethnic groups in the United States. Transfusion. 2004 May;44(5):703-6. doi: 10.1111/j.1537-2995.2004.03338.x. PMID: 15104651.

Additional Teacher Resources:

Harmening, Denise M. "Modern Blood Banking & Transfusion Practices". 7thEd. Chicago: F.A. Davis Company, 2019.

U.S. Food and Drug Administration (FDA)

U.S. Centers for Disease Control and Prevention (CDC)

National Heart, Lung, and Blood Institute (NHLBI), National Institutes of Health (NIH)

Sickle Cell Disease | Johns Hopkins Medicine

Sickle Cell Disease Association of America

American Society for Hematology – Sickle Cell Disease

APPENDIX B: FACTS ON BLOOD DONATION

General Information:

1. Blood cannot be synthetically made—there is no substitute.
2. Because it takes 24–36 hours for a blood donation to be ready for patient transfusion, there must already be enough blood ready for any expected or emergency situation.
3. Shortages of blood can occur at any time and are especially prevalent during the winter holidays and summer.
4. Red blood cells can be stored for up to 42 days. Platelets have a shelf life of only 5–7 days.
5. An average adult has approximately 10 pints of blood in his or her body.
6. One standard "unit" of blood is equal to 1 pint (about 2 cups) and weighs about 1 pound.

Blood Donors:

1. Only three percent of the U.S. population gives blood.
2. On average, individuals donate 1.8 times per year.
3. Individuals 16 to 18 years old give 11 percent of all blood donations each year. Approximately 51 percent of all blood donors are male and 49 percent are female.
4. Donors with type O negative blood (only 9 percent of people) are universal donors, meaning their blood can be given to people of all blood types.
5. Forty-seven percent of people in the U.S. have type O (+/-) blood.
6. Increasing the diversity of the donor base is essential to meeting the clinical needs of transfusion-dependent patients. In 2019, approximately 2.1 million blood donations were made by ethnic or racial minority donors (including African-American, Pacific Islander, American Indian, and Hispanic donors), accounting for nearly 20 percent of all donations.

Blood Donor Eligibility:

1. In most states, you must be 17 years or older to donate, but many states allow a 16-year-old to donate blood with parental consent. You must weigh at least 110 pounds and be in good health. Certain medications, medical conditions, travel histories, and personal histories may defer your eligibility.

2. Individuals can donate whole blood every 56 days, up to 6 times a year. If you are donating platelets, you can donate every seven days, up to 24 times a year.

Blood Utilization:

1. Every two seconds someone needs blood.
2. 1 in 7 people entering a hospital will need blood.
3. Approximately 45,000 units of blood are used each day in the U.S. totaling more than 15 million units of blood each year.
4. More than 5 million people need blood transfusions each year throughout the U.S.
5. Red cells are the most needed blood component – more than 10 million units are transfused every year in the U.S.
6. The average red blood cell transfusion is approximately three pints.
7. There are more than 12,000 units of platelets and plasma transfused every day.

Patient Needs:

1. Premature infants and children undergoing heart surgery or treatment for cancer require blood from donors of all types, especially type O.
2. Patients with anemia need blood transfusions to increase their oxygen-carrying capacity.
3. A patient with sickle cell diseases may require regular transfusions throughout their lifetime. Approximately 100,000 Americans have sickle cell disease. One (1) in 365 African-American newborns has sickle cell disease and one (1) in 13 are born with sickle cell trait. Sickle cell disease also affects people of Mediterranean, Middle Eastern, Latin American, and Indian descent.
4. The rarest blood type is the one not on the shelf when it's needed by patients confronting cancer, a transplant, or other trauma. In addition, people undergoing procedures like open-heart surgery may require red blood cell and platelet transfusions to survive.
5. More than 1.9 million people are diagnosed with a new cancer each year; many of them will need blood during their chemotherapy treatment.
6. Blood transfusions are needed in one out of every 83 childbirths.

APPENDIX C: GLOSSARY

Antigen: substances found on the red blood cell membrane. Two examples of these substances in humans are the A and B antigens. These substances are determined by an individual's genes.

Antibody: protein substance produced in response to an antigen.

Blood Typing: determination of ABO and Rh groups.

Blood Volume: total volume of blood in an individual's blood stream which is determined by the number of red blood cells and plasma.

Dominant Gene: version of a gene which expresses itself more strongly than its corresponding recessive version.

Hemoglobin: molecule which carries oxygen in red blood cells.

Homeostasis: denotes stable internal environment (equilibrium) within the human body.

Osmotic Pressure: pressure required to stop the flow of solvent molecules from a dilute solution to a more concentrated one though a semipermeable membrane.

Plasma: known as intravascular fluid. It makes up 55 percent of your blood and is more than 90 percent water. Plasma also contains, salts, coagulation proteins, hormones, and enzymes.

Platelet: cell which is responsible for the initial stages of stopping blood loss, the formation of a platelet plug which is needed to temporarily block a tear in the skin.

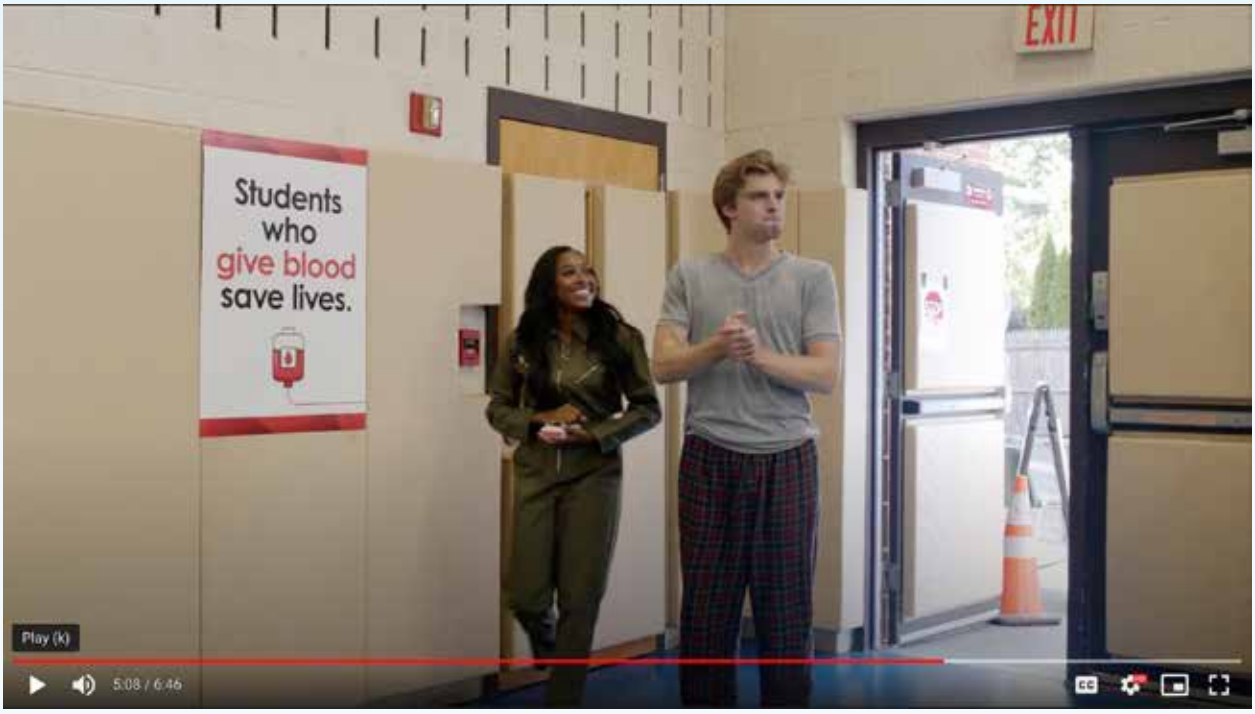
Recessive Gene: version of a gene which does not express itself except in the absence of its corresponding dominant version.

Red Blood Cell: cell that transports oxygen throughout the body.

Whole Blood: term for blood from a standard blood donation. It is blood without any of the components removed or separated. Whole blood consists of red blood cells, plasma, and platelets.

APPENDIX D: EDUCATION VIDEO

VIDEO—Share this video with your students. It explains the great need for young people to begin and continue donating blood and is the primary resource of this project. You could use the video as an anticipatory/engagement activity, to spark in class or online discussions, as part of a project (ideas starting on page 5), or in any other way you see fit. Even if you cannot adjust your curriculum much, this could be shared via announcements or on social media outlets.



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