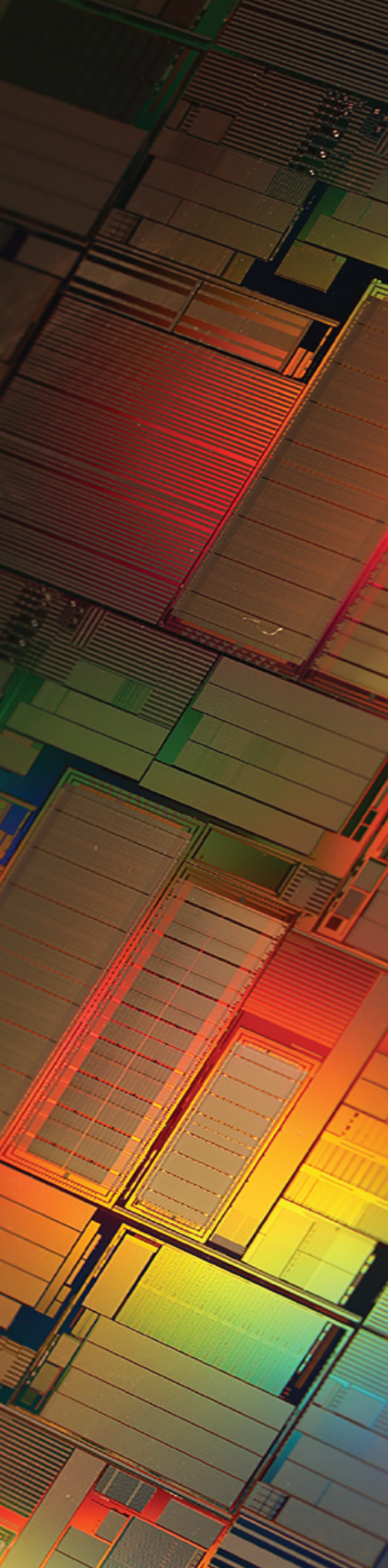

Learning About Semiconductor Technology

COMPONENTS OF A CELL PHONE

HIGH SCHOOL CHEMISTRY
HIGH SCHOOL PHYSICS
HIGH SCHOOL ENVIRONMENTAL SCIENCE

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For more information on SEMI and SEMI Foundation, visit: https://www.semi.org

Components of a Cell Phone

Lesson Overview	Career Highlight
Students will learn about elements on the periodic table and which of the Conflict Minerals are used in their cell phones and other electronic devices. Students will learn the basic internal components of cell phones and how semiconductors are used to make cell phones work.	Cellular Phone Technician Manufacturing Engineer Materials/Supply Management Specialist Quality Assurance Technician Chemical Engineer

STEM Course Connections	21st Century Skills	CTE Alignment
High School Chemistry High School Physics High School Environmental Science	Problem Solving Critical Thinking	Manufacturing and Product Development Sector

Engineering Activity	
Science and Engineering Practice #7	Students will participate in a cell phone tear down lab, where they will learn about the internal components of a cell phone and practice their recently developed decontamination protocols. Students will design options for recycling old electronic devices, and discuss alternatives to earth mining to not only alleviate the pressures on finite environmental resources, but also on geo-political pressures.

Materials

- Donated old cell phones
- Elements Around the World Student Roles
- Elements of a Cell Phone
- Elements of the World Script
- iFixit Kits (or small eyeglass repair kit)
- Mini Socratic Seminar Score Sheet
- Student Handout
- Yarn roll

Essential Questions

1. What are the major components of a cell phone?
2. What chemical elements make up the components of a cell phone?
3. Where are these elements mined and what are potential alternatives for these resources?

Prior Knowledge

Students should have a rote understanding of clean rooms and decontamination procedures, as well as a general understanding of silicon-based electronics components. Recommended HTU lessons include: What are Semiconductors?; Semiconductor Career Research

Engage

Cell Phone Reflection (15 mins)

- Students will begin with a writing prompt: *Imagine how different life would be today if there was no access to cell phones.*
- In Section A of the Student Handout, students will respond to the following questions during independent writing time:
  - *How different would your life be in a world without cell phones?*
  - *What would your interactions with your friends be like?*
  - *How would it affect your access to information?*
- After 10 minutes of writing time, allow students to share their answers with a partner or the whole class.

Explore

Cell Phone Tear Down (45 mins)

- *Teacher Note: This activity involves a hands-on component for students to learn how to take apart a cell phone, learn the components of a phone, and put it back together. It is NOT recommended to use working cell phones to do this activity. The best way to get used cell phones (or other electronic devices) is to ask students to go to their families or neighbors to find donations. Some local e-waste organizations may also provide donations to schools, particularly if the devices no longer work. A full class set of materials is not necessary, as students could work on this activity in small groups at the same time as the rest of the students who are working on either the Engage or Explain sections. For example, if only five cell phones are donated, there could be five students working on the Tear Down at a time. Adult supervision is recommended for the Tear Down activity.*
- Students should each work on tearing down their own device and their own fixit kit. Most of the tools necessary to take apart a cell phone can be found in an eyeglass repair kit.
- In Section B of the Student Handout, students will research what iFixit is. *iFixit is a Creative Commons licensed community that promotes the repair movement.*
  - How is iFixit working to eliminate eWaste?
  - What is the Right to Repair?
- Students will first determine the type of device they are working with and look for the Tear Down Guide on the iFixit website. *iFixit is a Creative Commons licensed community that promotes the repair movement.*
- With adult supervision, students will use their fixit kit to take apart the cell phone, examine the internal and external components, and put the device back together.
- *Teacher Note*: *Instruct students to go through this process slowly, and carefully. Students should remember the steps that they take to deconstruct their phone so that they can put it back together for the next student.*
- In Section C of the Student Handout, students will draw and label the components of the cell phone they tear down.
- Using the Elements of a Cell Phone resource, students will identify which chemical elements are in each of the components they label on their drawings in Section C of the Student Handout.

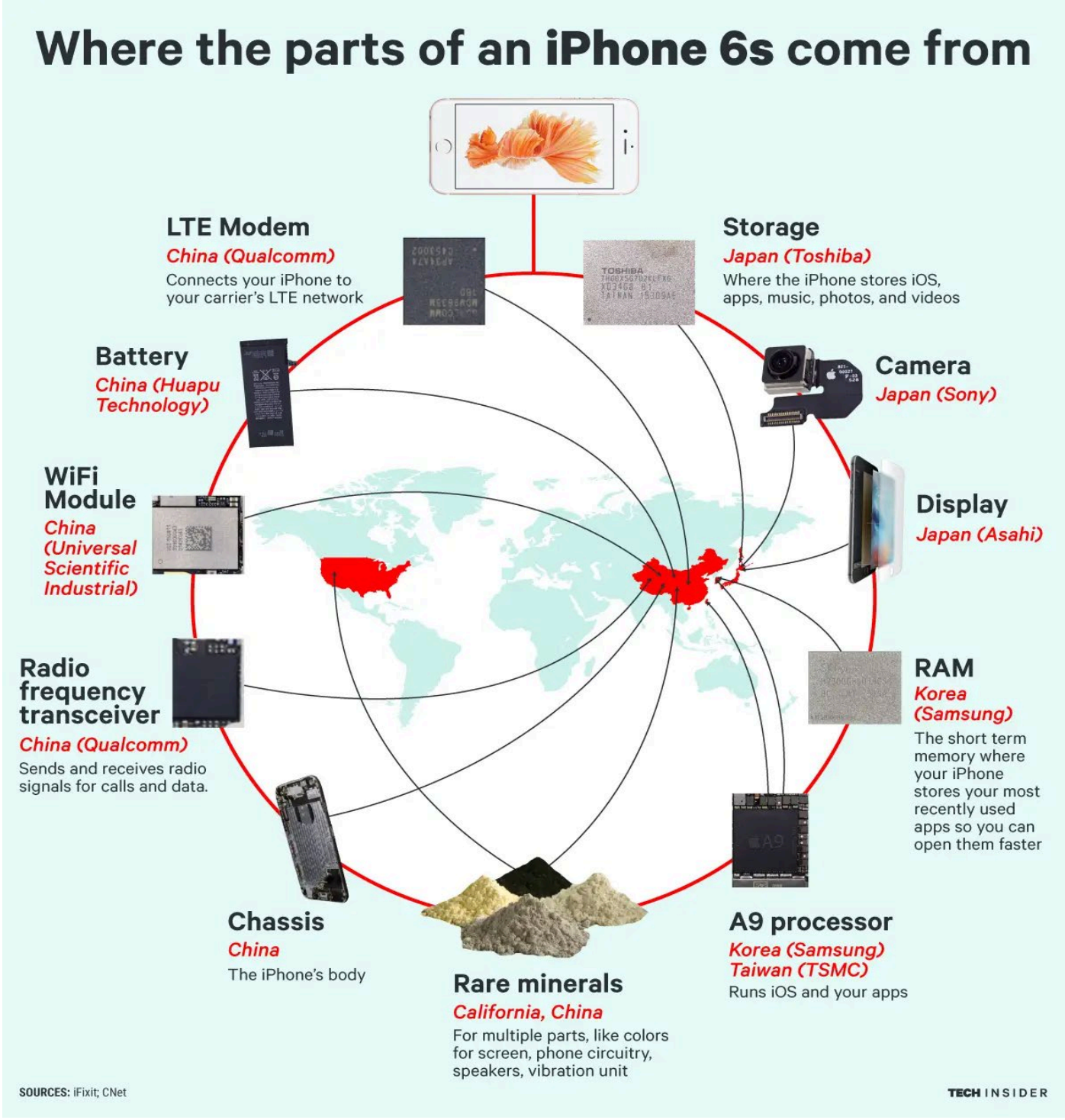
Explain

Academic Vocabulary Development (10 mins)

- In pairs, students will develop their academic vocabulary in Section D of the Student Handout.

Cell Phone Components (10 mins)

- Students will label the cell phone components and locations where they come from on the map in Section E of the Student Handout. They will be asked to draw a star next to every component that contains a semiconductor, which is every component except for the battery and the chassis.



- Students will answer the question: What would your cell phone look like if it did not have any semiconductors in it? What would its function be? *It would be a battery with no functionality.*

Rare Earth Metals (15 mins)

- Students will read the article, Rare Earth Metals: Will We Have Enough?
- In Section F of the Student Handout, students will answer the following questions:
    - What potential issues could arise from the majority of rare earth or other valuable minerals or materials being mined in primarily a single location or country? *That one nation could raise the prices for that material, or deny everyone else access to it.*
    - What are some ways that we, as consumers, can reduce our collective reliance on mining for resources? *We could improve our recycling processes for more of those precious resources when the devices they inhabit are no longer useful to us.*
- As a class, students will discuss the answers to the questions.

Elaborate

Blood Diamonds (5 mins)

- Students watch this trailer from the movie, Blood Diamond,
- On Section G of the Student Handout, students respond to the following questions:
    - Why might the presence of a valuable mineral or material cause armed conflict or subjugation of a local populace? *People seek to control the resource for themselves so that they can gain wealth from it, which might cause people to fight over control or force others to work for them.*
    - Are there any other instances throughout history that you know about that involved forced labor or power struggles centered around a valuable resource? *Answers will vary. Some examples include: Belgians in the Congo (rubber), Britons in India (spices), Japan in China (oil), and China with Chinese ethnic minorities (Gold, Tungsten).*

Elements Around the World (25 mins)

- *Teacher Note: Before class, print out the Elements Around the World Student Roles. Cut each role into a strip of paper and place it into an envelope.*
- Ask students to move their chairs to sit in a circle or find a space outside where students can stand in a circle.
- Hand out slips of paper to each student - depending on the number of students in the class, each student will have more than one slip of paper
- Teacher will read the Elements of the World Script. Each student will raise their hand when they hear their role read (the descriptor in the parentheses after each line in the script). The first student (blood diamond) will hold onto the end of the yarn roll. When the next line is read, the yarn roll will be unrolled and passed to the next student (carbon), while the first student remains holding onto the end of the yarn. This repeats with the next student (Sierra Leone) and so on, creating a giant yarn web connecting each student/role to the rest of the class.
- Before unraveling the web, reflect on the activity as a class:
    - Which roles are connected to many different people? *Answers will vary; most of the roles have many connections.*
    - Which roles in the web seem to be most important? *Answers will vary.*
    - What was most surprising from this activity? *Answers will vary.*

Evaluate

Mini Socratic Seminar Prep: Alternatives to Mining Conflict Minerals (35 min)

- Students will prepare themselves for a socratic seminar discussion by reading several articles with alternatives to mining conflict minerals. In Section H of the Student Handout, there are prompts for students to participate in the pre-reading exercises and write their own responses to the prompt: *What are the most viable alternatives for mining conflict minerals?*

    - NASA
    - NY Times Silicon
    - AZO Materials
    - The Verge
    - Reuters
    - NY Times Arctic
    - Harvard International Review

Mini Socratic Seminar: Alternatives to Mining Conflict Minerals (25 min)

- Students will participate in a socratic seminar to discuss multiple perspectives about alternatives for mining conflict minerals.
- Students begin with silent journaling in Section I of the Student Handout.
- Assign students to sit in groups of four or five with one student selected as the Facilitator for each group.
- Each Facilitator will have their own Mini Socratic Seminar Score Sheet. They will start by reminding the group of the norms for a socratic seminar discussion:
    - Step up, Step back
    - Share the Air
    - Invite others into the conversation by saying " what do you think about that..."
    - Reference the text- either by reading a quote or summarizing
    - Make connections to other artistic or life experiences as illustrations
    - Be bold- if you see something going wrong- do your best to fix it
- All students will take notes in Section I of the Student Handout during the discussion. The Facilitator will score the participation in the Mini Socratic Seminar Score Sheet which is submitted to the teacher at the end of the discussion. The teacher can circulate and check in on each group to see where discussions go.
- After the seminar, students answer the reflections in Section I of the Student Handout.

Reflection (10 mins)

- After the seminar, ask students to reflect on their writing prompt from the first day. In Section J of the Student Handout, students will answer the following questions:
    - How do you view your cell phone differently after this lesson?
    - What are some actions you can take to make a positive impact on the environment when a cell phone stops working?

Extend

With more time and interest, students can develop an eco-recycling campaign in their school or community. Students can design their campaign with virtual advertisements or physically go around their community to promote e-recycling.

CA NGSS Standards

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

HS-PS4-2. Evaluate questions about the advantages of using digital transmission and storage of information.

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

CTE Alignment

B3.0 Research and compare the properties of two metals using two different material specifications and a process specification.

B11.0 Understand and defend the purposes and processes of inspection and quality control in machining and forming processes.

Resources

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Name		Date	

Components of a Cell Phone Student Handout

Directions: Students read the prompts and answer in complete sentences in the box to the right.

Engage

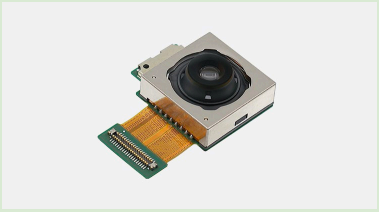
Section A: Cell Phone Reflection	
Write a reflection about your life without a cell phone: 1. How different would your life be in a world without cell phones? 2. What would your interactions with your friends be like? 3. How would it affect your access to information?	

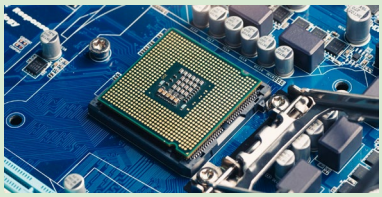
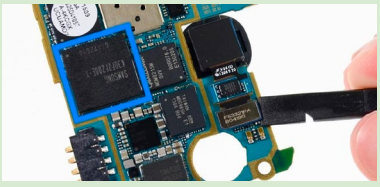
Explore

Section B: Cell Phone Tear Down	
Go to iFixit.com. How is iFixit working to eliminate eWaste?	
What is the Right to Repair?	

Section C: Cell Phone Tear Down	
Draw a diagram of the cell phone and label the external components.	
Draw a diagram of the cell phone and label the internal components.	

Explain

Section D: Academic Vocabulary Development			
Word	**Definition**	**Image**	**Description in Own Words**
Storage	A storage device is any hardware capable of holding information either temporarily or permanently.		
Modem	"Modulator-Demodulator." A device that can convert analog signals to a digital format, such as converting phone signals from antennas into the data we use. Used for cell phones, laptops, tablets, and even home internet (converting analog cable/fiber into internet data).		
Camera	A device for capturing a photographic image or recording a video, using film or digital memory.		
Display	a display or display device describes the device used to view video, images, or text.		

Chassis	Alternatively called the case, system unit, or base unit. The chassis is the housing that helps protect and organize all the components that make up a desktop computer.		
Processor	Alternately called a processor, central processor, or microprocessor, the CPU is the central processing unit of the computer. A computer's CPU handles all instructions it receives from hardware and software running on the computer.		
Battery	A combination of two or more cells electrically connected to work together to produce electric energy.		
Wireless Network Interface Card	These are NICs that use an antenna to provide wireless reception through radio frequency waves. Wireless NICs are designed for Wi-Fi connections.		
RAM	Alternatively called main memory, primary memory, or system memory, RAM (random-access memory) is a hardware device that allows information to be stored and retrieved on a computer.		

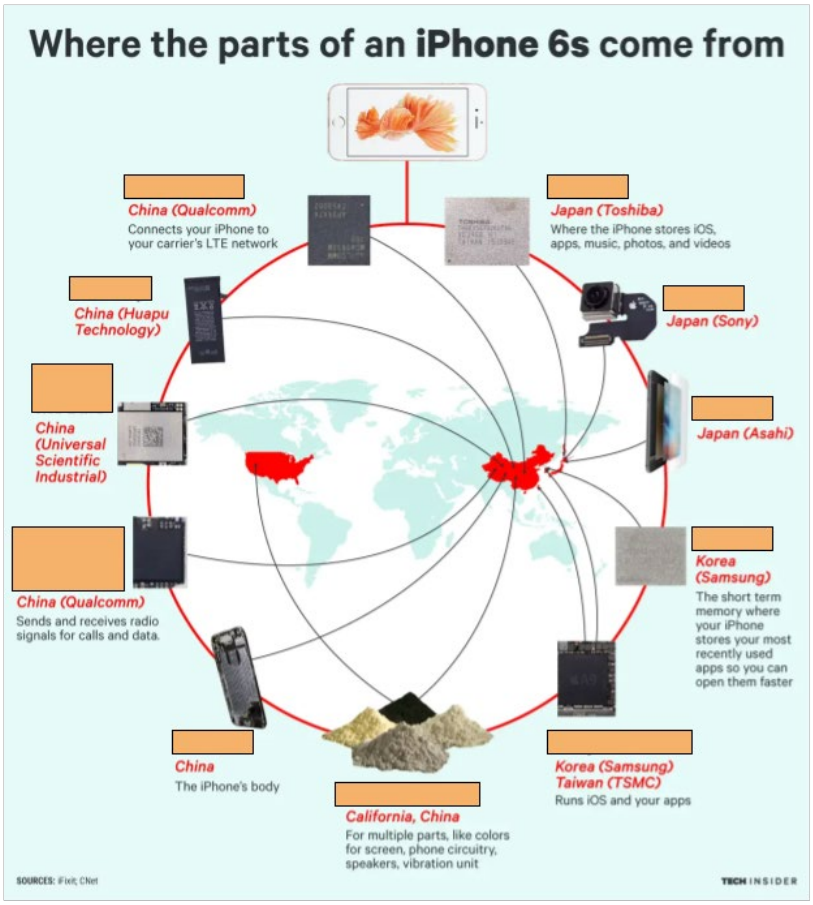
Radio frequency transceiver	Transceiver is the term used for a device which houses both transmitter and receiver in a single module. Such a device which transmits and receives Radio Frequency (RF) signal is called an RF Transceiver.		

Section E: Cell Phone Components

Label the following parts on the diagram to the right:

- Storage
- LTE Modem
- Camera
- Display
- Chassis
- A9 Processor
- Battery
- WiFi Module
- Ram
- Rare minerals
- Radio frequency transceiver

Draw a star next to each of the components that you think contains a semiconductor.



What would your cell phone look like if it did not have any semiconductors in it? What would its function be?

Section F: Rare Earth Metals	
Read the article "Rare Earth Metals: Will We Have Enough?" Then answer the following questions.	
What potential issues could arise from the majority of rare earth or other valuable minerals or materials being mined in primarily a single location or country?	
What are some ways that we, as consumers, can reduce our collective reliance on mining for resources?	

Elaborate

Section G: Blood Diamonds	
Watch the movie trailer, then answer the corresponding questions below.	
Why might the presence of a valuable mineral or material cause armed conflict or subjugation of a local populace?	
Are there any other instances throughout history that you know about that involved forced labor or power struggles centered around a valuable resource?	

Evaluate

Section H: Mini Socratic Seminar Prep	
In order to prepare for the mini socratic seminar, read the following articles and write down 3-5 points for each article. The prompt for the discussion will be: *What are the most viable alternatives for mining conflict minerals?*	
1. NASA	
2. NY Times Silicon	

3. AZO Materials	
4. The Verge	
5. Reuters	
6. NY Times Arctic	
7. Harvard International Review	
Section I: Mini Socratic Seminar	
1. Pre-seminar brainstorm: Summarize your prep notes and write down comments/questions you plan to ask during the socratic seminar.	

2. Take notes during the socratic seminar.	
3. How did your thinking change during this discussion? What facts and details were the most compelling? Why? Be sure to cite specific quotes/facts from the text/students.	
Reflect on the following questions and cite examples from the reading experience, journal, seminar and whole class share out to support your response.	
4. Did you read the prep articles? If so, how did you make it happen? When and where did you read? If you didn't read this week what prevented this from happening? What impact did that have?	
5. How participatory were you in this process? Did you follow the step up, step back norm? How much does reading the material impact your ability to contribute?	
6. How have you grown this week? What did you learn about yourself, your classmates or from this process?	
7. How did you feel about this structure?	
8. Other- what else do you want to communicate?	

Section J: Reflection	
1. How do you view your cell phone differently after this lesson?	
2. What are some actions you can take to make a positive impact on the environment when a cell phone stops working?	

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ELEMENTS OF A SMARTPHONE

ELEMENTS COLOUR KEY: ALKALI METAL | ALKALINE EARTH METAL | TRANSITION METAL | GROUP 13 | GROUP 14 | GROUP 15 | GROUP 16 | HALOGEN | LANTHANIDE

SCREEN

49 In Indium, 8 O Oxygen, 50 Sn Tin

Indium tin oxide is a mixture of indium oxide and tin oxide, used in a transparent film in the screen that conducts electricity. This allows the screen to function as a touch screen.

13 Al Aluminium, 14 Si Silicon, 8 O Oxygen, 19 K Potassium

The glass used on the majority of smartphones is an aluminosilicate glass, composed of a mix of alumina (Al_2O_3) and silica (SiO_2). This glass also contains potassium ions, which help to strengthen it.

39 Y Yttrium, 57 La Lanthanum, 65 Tb Terbium, 59 Pr Praseodymium, 63 Eu Europium, 66 Dy Dysprosium, 64 Gd Gadolinium

A variety of Rare Earth Element compounds are used in small quantities to produce the colours in the smartphone's screen. Some compounds are also used to reduce UV light penetration into the phone.

ELECTRONICS

Copper is used for wiring in the phone, whilst copper, gold and silver are the major metals from which microelectrical components are fashioned. Tantalum is the major component of micro-capacitors.

29 Cu Copper, 47 Ag Silver, 79 Au Gold, 73 Ta Tantalum

Nickel is used in the microphone as well as for other electrical connections. Alloys including the elements praseodymium, gadolinium and neodymium are used in the magnets in the speaker and microphone. Neodymium, terbium and dysprosium are used in the vibration unit.

28 Ni Nickel, 66 Dy Dysprosium, 59 Pr Praseodymium, 65 Tb Terbium, 60 Nd Neodymium, 64 Gd Gadolinium

Pure silicon is used to manufacture the chip in the phone. It is oxidised to produce non-conducting regions, then other elements are added in order to allow the chip to conduct electricity.

14 Si Silicon, 8 O Oxygen, 51 Sb Antimony, 33 As Arsenic, 15 P Phosphorus, 31 Ga Gallium

Tin & lead are used to solder electronics in the phone. Newer lead-free solders use a mix of tin, copper and silver.

50 Sn Tin, 82 Pb Lead

BATTERY

3 Li Lithium, 27 Co Cobalt, 8 O Oxygen, 6 C Carbon, 13 Al Aluminium

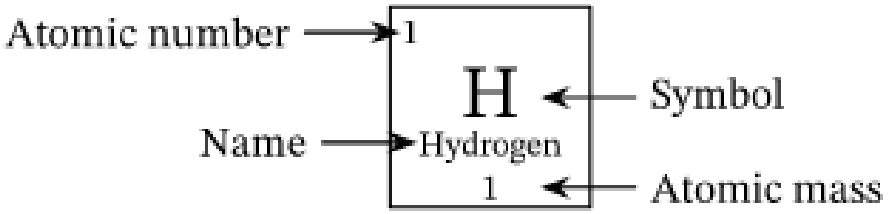
The majority of phones use lithium ion batteries, which are composed of lithium cobalt oxide as a positive electrode and graphite (carbon) as the negative electrode. Some batteries use other metals, such as manganese, in place of cobalt. The battery's casing is made of aluminium.

CASING

Magnesium compounds are alloyed to make some phone cases, whilst many are made of plastics. Plastics will also include flame retardant compounds, some of which contain bromine, whilst nickel can be included to reduce electromagnetic interference.

6 C Carbon, 12 Mg Magnesium, 35 Br Bromine, 28 Ni Nickel

Periodic Table of Elements



1 H Hydrogen 1																	2 He Helium 4
3 Li Lithium 7	4 Be Beryllium 9											5 B Boron 11	6 C Carbon 12	7 N Nitrogen 14	8 O Oxygen 16	9 F Fluorine 19	10 Ne Neon 20
11 Na Sodium 23	12 Mg Magnesium 24											13 Al Aluminium 27	14 Si Silicon 28	15 P Phosphorus 31	16 S Sulfur 32	17 Cl Chlorine 35.5	18 Ar Argon 40
19 K Potassium 39	20 Ca Calcium 40	21 Sc Scandium 45	22 Ti Titanium 48	23 V Vanadium 51	24 Cr Chromium 52	25 Mn Manganese 55	26 Fe Iron 56	27 Co Cobalt 59	28 Ni Nickel 59	29 Cu Copper 64	30 Zn Zinc 65	31 Ga Gallium 70	32 Ge Germanium 73	33 As Arsenic 75	34 Se Selenium 79	35 Br Bromine 80	36 Kr Krypton 84
37 Rb Rubidium 85.5	38 Sr Strontium 88	39 Y Yttrium 89	40 Zr Zirconium 91	41 Nb Niobium 93	42 Mo Molybdenum 96	43 Tc Technetium 98	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	49 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131
55 Cs Cesium 133	56 Ba Barium 137		72 Hf Hafnium 178.5	73 Ta Tantalum 181	74 W Tungsten 184	75 Re Rhenium 186	76 Os Osmium 190	77 Ir Iridium 192	78 Pt Platinum 195	79 Au Gold 197	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium		104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

57 La Lanthanum	58 Ce Cerium 140	59 Pr Praseodymium 141	60 Nd Neodymium 144	61 Pm Promethium	62 Sm Samarium 150	63 Eu Europium 152	64 Gd Gadolinium 157	65 Tb Terbium 159	66 Dy Dysprosium 162.5	67 Ho Holmium 165	68 Er Erbium 167	69 Tm Thulium 169	70 Yb Ytterbium 173	71 Lu Lutetium 175
89 Ac Actinium	90 Th Thorium 232	91 Pa Protactinium 231	92 U Uranium 238	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Elements (19)

Arsenic - a poison discovered by Roman Emperor Nero

Cadmium - used in the nickel-cadmium battery

Carbon (Diamonds) - the element that makes up diamonds

Cobalt - 27 protons

Copper - what the penny was made from in 1793 to 1837

Gallium - only metal, except for mercury, caesium, and rubidium, which can be liquid near room temperatures

Gold - CONFLICT MINERAL (Au)

Indium - named because of the indigo color used to trace this element

Lead - Latin word plumbum

Magnesium - second alkaline earth metal going down the periodic table

Mercury - first planet from the sun

Nickel - five cents

Palladium - located in the platinum group, but not the element platinum

Platinum - another word for blonde hair color

Rare earth elements (lanthanide series) - 97% of these are mined in China

Silver - a gift you receive on your 25th wedding anniversary

Tantalum - CONFLICT MINERAL (Ta)

Tin - CONFLICT MINERAL (Sn)

Tungsten - CONFLICT MINERAL (W)

Cell Phone Component (8)

Amplifier/receiver - it allows you to speak/listen

Electrical circuitry - allows electrical current to flow through a phone for operation

Liquid crystal display (LCD) - the screen of a phone

Phone casing - protects the internal hardware of a phone

Vibration mechanism - how you know your phone is ringing when it is on silent

Capacitor - responsible for rapid amounts of energy to be released when a flash from a camera goes off

Phone battery - when this dies, your phone is dead

“Blood Diamond” - starring Leonardo diCaprio

Country (25)

China- host of the 2008 Olympics

Chile- located between the Pacific Ocean and the Andes mountains

South Africa- home to the 2010 world cup

Peru- home to Machu Picchu, one of the new seven wonders of the world

Democratic Republic of Congo- colonized by Belgium, which resulted in the deaths of approximately 10 million people

Russia- the enemy of the United States during the Cold War from 1945 to 1990

Mexico- home to Chichen Itza, one of the new seven wonders of the world

Brazil- home to the 2014 world cup

India- home to the Taj Mahal, one of the new seven wonders of the world

Australia- known for kangaroos and koalas

Korea- United States allied with this country during a war from 1950-1953

Japan- known for sushi

Zambia- home to the famous Victoria Falls

Rwanda - borders Uganda, Tanzania, Burundi, and the Democratic Republic of the Congo

Uganda - bordered on the east by Kenya, on the north by South Sudan and on the west by the Democratic Republic of the Congo

Kenya - home of Nairobi national park

Liberia- located in West Africa, with Guinea to its north and Côte d'Ivoire to its east

Sierra Leone- the setting of the book A Long Way Gone, written by a former child soldier (a challenge book for humanities!)

Refiners/Smelters (East Asia)- a place that separates pure elements from a mixture

Factory/production (East Asia/Europe)- a place where things are made, often in an assembly line fashion

Consumer (US and Europe mostly)- a person who buys products

Elements of the World Script

1. In the movie “Blood Diamond”... (Blood Diamond)
2. Diamonds (which are made from the element carbon) are mined in Sierra Leone. (Carbon)
3. This caused a lot of violence in Sierra Leone among the rebels trying to gain valuable land. (Sierra Leone)
4. Diamonds were then smuggled across the border into Liberia. (Liberia)
5. These diamonds are then sold to buyers in Europe and the US who profit off of US consumers. (US/European consumers)
6. This situation can be compared to what is going on with conflict minerals in the Democratic Republic of Congo today. (DRC)
7. Coltan is mined in the Congo which makes up 80% of the world’s supply of the chemical element Tantalum. (Tantalum)
8. Coltan is smuggled across the border into Rwanda, Kenya, Uganda. (Rwanda)
9. It is then shipped to refiners and smelters of East Asia where it is processed into the element Tantalum. (Refiners and smelters)
10. From here, this is shipped to processing companies where it is made into cell phone components. (processing and factory)
11. Tantalum is used to make capacitors for cell phones which store charge for the flash on a camera. (capacitor)

12. Consumers purchase cell phones that have the newest camera so that they can take awesome pictures to upload to their Facebook. (consumer)
13. Going back to the Democratic Republic of Congo, wolfram, another conflict mineral, is mined. (DRC)
14. Wolfram is then smuggled across the border into Rwanda, Kenya, Uganda. (Uganda)
15. It is then shipped to refiners and smelters of East Asia. (Refiners and smelters)
16. Wolfram is then processed into the chemical element Tungsten. (Tungsten)
17. From here, it is shipped to processing companies where it is made into cell phone components. (processing and factory)
18. Tungsten is used to make the vibration mechanism for cell phones when your phone is on silent. (vibration mechanism)
19. Consumers purchase phones that have the ability to vibrate while on silent so they never miss an important text (even in class!). (consumer)
20. In the Democratic Republic of Congo, cassiterite is also mined. (DRC)
21. Cassiterite is then smuggled into Rwanda, Kenya, Uganda. (Kenya)
22. It is then shipped to refiners and smelters of East Asia. (refiners and smelters)
23. It is then processed into the chemical element tin. (tin)
24. From here, it is shipped to processing companies where it is made into cell phone components. (processing and factory)
25. Tin is used to make the liquid crystal display (LCD) that uses light modulating properties

to create the images on the screen of a cell phone. (LCD)

26. Consumers purchase phones that have higher graphics to look at clearer pictures or play games with a higher resolution. (consumer)

27. Going back to the Democratic Republic of Congo... (DRC)

28. Gold is another conflict mineral that is heavily mined. (gold)

29. The gold is then smuggled into Rwanda, Kenya, Uganda. (Rwanda)

30. From here, it is shipped directly to processing companies where it is made into cell phone components. (processing and factory)

31. As the third best electrical conductor, gold is used to make the electrical circuitry for cell phones so that your phone can function properly. (electrical circuit)

32. Consumers purchase phones that have rapid processing ability. (consumer)

33. In addition to the conflict minerals and transition elements, rare earth elements are also responsible for making up components in cell phones and other technology. 97% of these rare earth elements are mined in China. (China)

34. Rare earth elements of the lanthanide series on the periodic table are responsible for everything from magnets in the headphones to chemical and electrical circuitry of the internal components of the phone. (rare earth element)

35. So every time you purchase a new set of headphones since your dog chewed through your last pair, and every time you purchase a new cell phone because you dropped your last one in the toilet, there is an increase in demand for the rare earth elements from China which are responsible for hardware upgrades in the new phone. (Consumer)

36. China is also a leading mining and processing country for the many transition metals that are also used in your phone. (China)

37. China is the number one mining country of Cadmium. (Cadmium)

38. Cadmium is refined and produced in China to create the nickel-cadmium battery portion of the phone. (battery)

39. In countries like Korea... (Korea)

40. And even Japan... (Japan)

41. Nickel is mined... (Nickel)

42. And sent to China to be refined. (refiners and smelters)

43. From there it is sent to factories to combine with cadmium... (processing and factories)

44. And create the nickel-cadmium batteries that can be used in cellphones and other pieces of technology. (battery)

45. In Russia, the mining of certain minerals used in cell phone batteries can unearth other elements that may be harmful to humans and the environment. (Russia)

46. One of these metals is mercury. (mercury)

47. Mercury can be used in rechargeable batteries. (batteries)

48. This is then purchased by consumers who desire a phone with a longer lifetime. (consumer)

49. Another mineral that is used to create batteries can be found in Zambia. (Zambia)

50. It is also mined in the Democratic Republic of Congo. (DRC)

51. This element is known as cobalt. (cobalt)

52. Cobalt is also used to create lithium-ion batteries. (batteries)

53. Lithium-ion batteries are purchased by consumers who want high performing technology. (consumers)

54. China is also the leading mining country of elements such as lead and magnesium. (China)

55. Lead is an incredibly old metal that is very soft and malleable. (lead)

56. Magnesium is the eighth most abundant element in the earth. (magnesium)

57. Both of these elements are used to produce the phone casing. (phone casing)

58. Phone casings are very important to consumers in the United States and Europe because it protects the internal hardware and circuitry of the phone. (consumer)

59. In China and even Chile and Mexico, there are some other potentially harmful chemicals mined. (Mexico)

60. Arsenic is a common mineral that is usually combined with metals or sulfur. (Arsenic)

61. This metal can become hazardous during the smelting process when it is removed from other metals with which it is mined. (refiners and smelters)

62. Arsenic is used in the cell phone as a part of the amplifier and receiver. (amplifier/receiver)

63. US consumers demand phones that have the capability of allowing you to speak and listen on a cell phone. (consumer)

64. Gallium is another element responsible for the speaker function of the cell phone. (India)

65. Gallium can be found in countries such as Australia, Brazil, and India. (Brazil)

66. Australia is the number one mining country of Gallium, producing 50,000 kg/year. (Australia)

67. Gallium does not exist in its free form in nature. (gallium)

68. During the refining and smelting production, gallium can be removed from zinc ore and bauxite. (refiners and smelters)

69. The gallium can then be turned into a phone amplifier and speaker. (amplifier/speaker)

70. US consumers purchase phones that have speaker functions such as speakerphone and other hands-free devices for the ability to talk on our phones while doing other tasks. (consumer)

71. In countries like Chile, the transition metal copper is heavily mined. (Chile)

72. Copper is the second best conductor of electricity. (Copper)

73. This is why copper is used to produce electrical circuitry. (electrical circuitry)

74. Another South American country that mines metals to be used for electrical circuitry is Peru. (Peru)

75. In Peru, the greatest chemically mined mineral is silver. (silver)

76. Silver is the number one metal for conducting electricity and is therefore used as a part of the electrical circuitry of a phone. (electrical circuitry)

77. South Africa is the setting for our next two minerals. (South Africa)

78. Platinum is mined in the Bushveld Complex of South Africa. (Platinum)

79. Platinum, meaning “baby silver” in Latin, is mined for its ability to conduct electricity. (electrical circuitry)

80. Going back to South Africa… (South Africa)

81. Palladium is also mined in the Bushveld Complex of South Africa as a byproduct of Platinum. (Palladium)

82. Palladium is also used in cellphones as a part of the electrical circuitry. (electrical circuitry)

83. Consumers in Europe and the US purchase cellular electronics that have the most reliable electrical wiring to allow the fastest processing ability. (consumers)

84. We’ve already looked at elements responsible for the liquid crystal display in the Congo, but there is one more element that is mined in China… (China)

85. And Korea… (Korea)

86. And Japan. (Japan)

87. This element is known as Indium. (Indium)

88. Indium is very important in the production of LCD screens on computers, phones, and tablets. (LCD)

89. However, the demand for LCD technology is too great for the chemical supply of this substance. Companies such as Apple are struggling to find new ways to create this technology with different elements. (processing and factories #2)

90. The LCD screens on phones are valuable to consumers who buy the newest phones, hoping to have high resolution screens that will be strong enough to survive being dropped on the ground by careless users. (consumers)

91. This is just a small sampling of the number of chemical elements that can be found in your cell phone. (helper 1)

92. Hopefully this web gives you a better understanding of the interconnectedness that your cellphone has to the different chemical elements and where they are located in the world. (helper 2)

93. As we dive deeper into this project, we hope you will be able to take away some of these connections between chemistry, humanities, and your life. (helper 3)

94. Thank you for your participation in the Web of Connections for the Elements of Change Project. (helper 4)

Mini Socratic Seminar
Facilitator Scoresheet

Discussion Topic: *What are the most viable alternatives for mining conflict minerals?*

Facilitator:

Facilitator Role

- Remind students of socratic seminar norms:
  - Step up, Step back
  - Share the Air
  - Invite others into the conversation by saying " what do you think about that..."
  - Reference the text- either by reading a quote or summarizing
  - Make connections to other artistic or life experiences as illustrations
  - Be bold- if you see something going wrong- do your best to fix it
- Invite students to participate in discussion, posing questions to individuals
- Participate and self-evaluate during the discussion

Socratic Seminar Participation Grading Rubric

	0	1	2
Participation	0 - spoke less than 5 times during seminar	1 - spoke 5 to 10 times during seminar	2 - spoke 10 or more times during seminar
Quality of response	0 - just expressed agreement or disagreement	1 - provided some information to support an argument, asked questions	2 - analyzing ideas of others and making connections, asked thoughtful questions
Connection to others' ideas	0 - did not make an effort to connect to others	1 - referred to a comment made by someone	2 - analyzing ideas of others and making connections
Connection to text	0 - did not make an effort to connect to text	1 - referred to text in a comment	2 - pulled direct quotes from the text to support argument

Peer Evaluation Scores

Student Name					
Participation					
Quality of response					
Connection to others' ideas					
Connection to text					

Name:

Mini Socratic Seminar and Reflection

Step #1 Silent Journaling and Questions Generation (10 min)
Review the assigned reading and the notes you took in the Student Handout. Read over your annotations and generate questions for the seminar.

Step #2 Get into Groups and get Settled (5 Min)
Facilitator (in bold)

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6

Step # 3 Socratic Seminar and Debrief of the Discussion (35 min)

- Step up, Step back
- Share the Air
- Invite others into the conversation by saying " what do you think about that..."
- Reference the text- either by reading a quote or summarizing
- Make connections to other artistic or life experiences as illustrations
- Be bold- if you see something going wrong- do your best to fix it

Name:

Step # 4 Take notes on the discussion

How did your thinking change during this discussion? What facts and details were the most compelling? Why? Be sure to cite specific quotes/facts from the text/students.

Step # 5 Reflect

Complete a **one page** reflection that honestly addresses the following questions and cites examples from the reading experience, journal, seminar and whole class share out to support your response.

a. Did you read this week? If so how did you make it happen? When and where did you read? If you didn't read this week what prevented this from happening? What impact did that have?

b. How participatory were you in this process? Did you follow the step up, step back norm? How much does reading the material impact your ability to contribute?

c. How have you grown this week? What did you learn about yourself, your classmates or from this process?

d. How did you feel about this structure?

e. Other- what else do you want to communicate?