

Smartphones and the Environmental Cost of Their Materials

GRADE 8 & UP READING

Improve students' literacy skills

Sub Plan

Science Applicability



Reading Comment



★★★★★ Extremely satisfied - Great resource to work on student reading comprehension and it tied into the topic I was teaching. My students have been struggling with reading and I've been incorporating more reading into my lessons. Thank you for the resource.



SCROLL
to take a look inside!

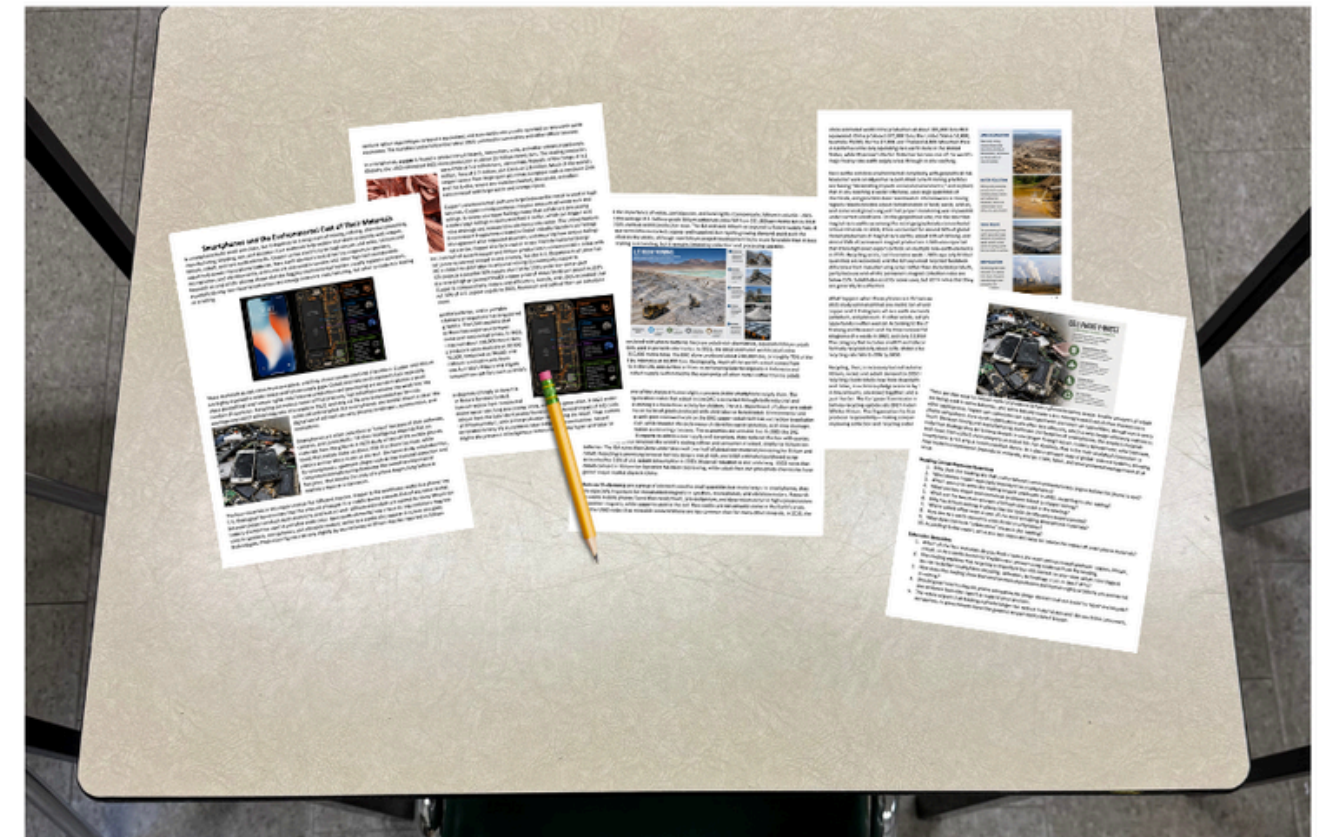


THE PROBLEMS YOU FACE

- **Limited time to teach scientific literacy and strengthen students' reading and analysis skills.**
- **Need meaningful extension activities to engage fast-moving learners.**
- **Difficulty creating effective last-minute sub plans that still support student learning.**

NO-PREP - PRINT/UPLOAD

- **CLASSROOM READY - No Prep, Ready-to-Use:** Print or assign digitally with Google Docs, Microsoft Word, and PDF formats for flexible classroom use
- **Questions and Answer Key**
- **Includes Varied Question Types:** Knowledge, thinking, connecting, application, and open-ended questions.



What Will Your Students Learn?

READING COMPREHENSION ARTICLE & QUESTION BUNDLE

Article with
Comprehension
Questions

Grade 8 and Up

Print & Digital

- Copper, lithium, cobalt, and rare earth elements
- Mining and refining of smartphone materials
- Water stress, tailings, and acid mine drainage
- Human-rights concerns in mining
- Battery materials and rare-earth magnets
- E-waste and low recycling rates
- Urban mining
- Repair, refurbishment, and reuse
- Producer responsibility and recycling policy
- How smartphones connect to global resource systems

Reading Comprehension Questions

1. Why does the reading say that a smartphone's environmental story begins before the phone is even made?
2. What makes copper especially important in smartphones?
3. Which countries were the leading copper producers in 2025, according to the reading?
4. What are two major environmental problems linked to copper mining?
5. What are the two main sources of lithium discussed in the reading?
6. Why is mining in places like the Salar de Atacama caused concern?
7. What are some of the most troubling smartphone materials?
- 8.
- 9.
- 10.

Extended Questions

1. How do you think the environmental impact of smartphones will change in the future?
2. What are some ways we can reduce the environmental impact of our smartphones?
3. How do you think the environmental impact of smartphones will change in the future?
- 4.
- 5.

Smartphones and the Environmental Cost of Their Materials

A smartphone looks small and clean, but it depends on a long chain of mining, refining, chemical processing, manufacturing, shipping, use, and disposal. Four materials help explain that chain especially well: copper, lithium, cobalt, and rare earth elements. Copper carries electricity through circuits and wires. Lithium and cobalt help power many phone batteries. Rare earth elements help drive tiny magnets in speakers, microphones, and vibration units, and some are also used in screens and other high-tech components. Research on end-of-life phones shows that the biggest environmental burden usually happens upstream, especially during raw-material extraction and energy-intensive manufacturing, not when a student is texting or scrolling.



These materials do not come from one place, and they do not create one kind of problem. Copper and lithium are highly exposed to water stress and future supply gaps. Cobalt and rare earth elements face especially sharp geopolitical and human-rights risks because production and processing are concentrated in a small number of countries. Recycling can reduce some of that pressure, but collection remains the weak link: the world generated 62 billion kilograms of e-waste in 2022, and only 22.3% was documented as formally collected and recycled. For smartphones, the central lesson is clear: the digital world still rests on very physical landscapes, communities, and ecosystems.

Smartphones are often described as "smart" because of their software, cameras, and connectivity. Yet their intelligence depends first on materials mined from the ground. A 2023 study of end-of-life smartphones found that more than 35% of a phone's weight is made up of raw materials. The same study found that the overall environmental impact of a smartphone begins long before the first text message is sent.

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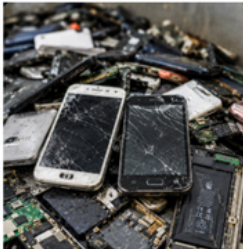
Your Reading

Smartphones and the Environmental Cost of Their Materials

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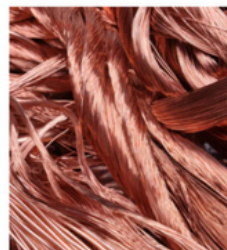


Smartphones are often described as “smart” because of their software, cameras, and connectivity. Yet their intelligence depends first on materials from the ground. A 2023 study of end-of-life mobile phones found that metals make up about 35% of a phone by mass, while plastics and ceramics make up the rest. The same study concluded that, for smartphones, upstream stages such as raw-material extraction and component manufacturing dominate the overall environmental footprint. That means the story of a phone begins long before it reaches a store or a classroom.

The four materials in this report matter for different reasons. Copper is the workhorse metal in a phone: the U.S. Geological Survey notes that the amount of copper in a mobile device exceeds that of any other metal, because copper conducts both electricity and heat so well. Lithium and cobalt are central to many lithium-ion battery chemistries used in portable electronics. Rare earth elements help create strong miniature magnets used in speakers, microphones, and vibration motors; some rare earths also appear in screen and glass technologies. Production figures can vary slightly by source because lithium may be reported as lithium

content rather than lithium carbonate equivalent, and rare earths are usually reported as rare-earth-oxide equivalent. The statistics below follow the latest USGS commodity summaries and other official sources.

In smartphones, **copper** is found in printed circuit boards, connectors, coils, and other electrical pathways. Globally, the USGS estimated 2025 mine production at about 23 million metric tons. The leading producers were Chile at 5.3 million tons, Democratic Republic of the Congo at 3.2 million, Peru at 2.7 million, and China at 1.8 million. Much of the world's copper comes from large open-pit mines in regions such as northern Chile and the Andes, where ore must be crushed, processed, and often concentrated with large water and energy inputs.



Copper's environmental costs are large because the metal is used in huge volumes. Copper mining produces massive amounts of waste rock and tailings. A review on copper tailings notes that sulfide-ore processing creates large tailings streams enriched in sulfur, which can trigger acid mine drainage and release toxic elements into water. The United Nations Environment Programme created a Global Industry Standard on Tailings Management after repeated disasters, underscoring how serious tailings risk can be. Copper also faces water stress: the International Energy

Agency has warned that more than half of current copper and lithium production is concentrated in areas with high water-stress levels. Social concerns are not limited to one country, but the U.S. Department of Labor has listed copper ore from the DRC as linked to child labor in artisanal mining. Economically, copper is indispensable but risky: the IEA projects a possible 30% supply shortfall by 2035 under current project pipelines, and USGS reported a record-high projected COMEX copper price of about \$4.80 per pound in 2025. Recycling is one bright spot. Copper is comparatively mature and efficient to recycle, and USGS estimated that recovered scrap supplied about 30% of U.S. copper supply in 2025. Aluminum and optical fiber can substitute in some uses, but not everywhere.

Lithium is essential to rechargeable batteries, and in portable electronics, the most common battery arrangement has long paired a lithium-based cathode with graphite. The USGS explains that lithium in mobile devices comes from two major source types: pegmatite ores such as spodumene and continental brines. In 2025, world lithium mine production reached about 290,000 metric tons of lithium content. The leading producers were Australia at 92,000 tons, China at 62,000, Chile at 56,000, Zimbabwe at 28,000, and Argentina at 23,000. Hard-rock lithium is mined mainly from spodumene, especially in Western Australia's Pilbara and Yilgarn regions, while brine lithium is pumped from salt flats such as Chile's Salar de Atacama.



Lithium's environmental damage depends strongly on how it is extracted. A major 2023 review in *Nature Reviews Earth & Environment* concluded that lithium extraction from continental brines has been criticized for intensive water use, long processing times, and waste generation. A 2025 water-footprint study of battery-grade lithium from the Salar de Atacama found a total potential impact of 442 cubic meters world equivalent per ton of lithium product, with brine production dominating the result. That matters because brine operations are often located in very dry ecosystems near Indigenous communities. Recent social life-cycle work on Chile highlights the presence of Indigenous communities in the hyper-arid Salar de

Atacama and the importance of water, participation, and local rights. Economically, lithium is volatile. USGS reported that the average U.S. battery-grade lithium carbonate price fell from \$11,800 per metric ton in 2024 to \$9,000 in 2025, even as world production rose. The IEA still sees lithium as essential to future supply risks. It reports that near-term lithium markets appear well supplied, but rapidly growing demand could push the market into deficit by the 2030s, although new lithium project development looks more favorable than it does for copper. Recycling is expanding, but it remains limited by collection and processing capacity.



cobalt is strongly associated with phone batteries because cobalt-rich chemistries, especially lithium cobalt oxide, have been widely used in portable electronics. In 2025, the USGS estimated world cobalt mine production at about 310,000 metric tons. The DRC alone produced about 230,000 tons, or roughly 73% of the global total, followed by Indonesia at 44,000 tons. Geologically, much of the world's cobalt comes from upper-cobalt deposits in the DRC and Zambia or from nickel-bearing laterite deposits in Indonesia and Australia. That means cobalt supply is often tied to the economics of other metals rather than to cobalt demand alone.

cobalt concentrates some of the sharpest human-rights concerns in the smartphone supply chain. The International Labour Organization states that cobalt in the DRC is extracted through both industrial and artisanal mining and that mining is a hazardous activity for children. The U.S. Department of Labor says cobalt ore from the DRC remains on its list of goods produced with child labor or forced labor. Environmental and health risks are serious as well: peer-reviewed work on the DRC copper-cobalt belt links extraction to pollution of water, food crops, and air, while broader life-cycle research identifies water pollution, acid mine drainage, and agricultural contamination as recurring concerns. The economics are unstable too. In 2025 the DRC temporarily banned cobalt exports to address oversupply and low prices, then replaced the ban with quotas. At the same time, China remained the world's leading refiner and consumer of cobalt, chiefly for lithium-ion batteries. The IEA notes that China undertakes well over half of global raw-material processing for lithium and cobalt. Recycling is promising because battery scrap is metal-rich, and USGS estimated purchased scrap accounted for 25% of U.S. cobalt consumption in 2025. Material reduction is also underway: USGS notes that cobalt content in lithium-ion batteries has been decreasing, while cobalt-free iron-phosphate chemistries have gained major market share in China.

are earth elements are a group of elements used in small quantities but crucial ways. In smartphones, they're especially important for miniaturized magnets in speakers, microphones, and vibration motors. Research in waste mobile phones found that neodymium, praseodymium, and dysprosium occur in high concentrations in speaker magnets, while copper is used in the coil. Rare earths are not actually scarce in the Earth's crust, but the USGS notes that mineable concentrations are less common than for many other minerals. In 2025, the

USGS estimated world mine production at about 390,000 tons REO equivalent. China produced 270,000 tons, the United States 51,000, Australia 29,000, Burma 22,000, and Thailand 4,800. Mountain Pass in California is the only operating rare-earth mine in the United States, while Myanmar's Kachin State has become one of the world's major heavy-rare-earth supply areas through in-situ leaching.

Rare earths combine environmental complexity with geopolitical risk. Academic work on Myanmar reports that current mining practices are having “devastating impacts on local environments,” and explains that in-situ leaching is water-intensive, uses large quantities of chemicals, and generates toxic wastewater. Interviewees in mining regions raised concerns about contamination of land, water, and air, and some local groups argued that proper monitoring was impossible under current conditions. On the geopolitical side, the IEA describes magnet rare earths as among the most geographically concentrated critical minerals. In 2024, China accounted for around 60% of global mined production of magnet rare earths, about 91% of refining, and almost 95% of permanent magnet production. USGS also reported that China tightened export controls on multiple rare-earth elements in 2025. Recycling exists, but it remains weak: USGS says only limited quantities are recovered, and the IEA says most recycled feedstock still comes from manufacturing scrap rather than discarded products, partly because end-of-life permanent-magnet collection rates are below 15%. Substitutes exist for some uses, but USGS notes that they are generally less effective.

What happens when these phones are thrown away? Here the idea of an "urban mine" becomes reality. A 2023 study estimated that one metric ton of end-of-life mobile phones can contain up to 53 kilograms of copper and 3.3 kilograms of rare earth elements, along with small but valuable amounts of gold, palladium, and platinum. In other words, old phones can be richer than some natural ores. But the opportunity is often wasted. According to the 2024 Global E-waste Monitor from United Nations Training and Research and the International Telecommunication Union, the world generated 64.6 million kilograms of e-waste in 2022, and only 13.8 billion kilograms, or 22.3%, was formally recycled. The category that includes small IT and telecommunication equipment generated 4.6 billion kilograms, with only 1.1 billion kilograms, or 23.9%, formally recycled. In other words, only about 22% of the e-waste generated is formally recycled, while the rest ends up in landfills or is incinerated. Under a business-as-usual scenario, the global formal recycling rate falls to 20% by 2030.

Recycling, then, is necessary but not automatic. The EU argues that battery recycling could lighten lithium, nickel, and cobalt demand by 2050. Extraction rates continue improving. The same recycling could reduce new mine development needs by 40% for copper and cobalt, and 10% for lithium and nickel, in a climate-pledge scenario by 2050. Rare-earth recycling is harder because there are so few in tiny amounts, are mixed together, and are difficult to separate economically. Still, policy push harder. The European Commission notes that the EU's WEEE rules cover smartphone battery-recycling. It sets 2027 material-recovery targets of 90% for cobalt, copper, and lithium. The Organisation for Economic Co-operation and Development also points to "producer responsibility" — making companies financially responsible for post-consumer waste — as improving collection and recycling systems.



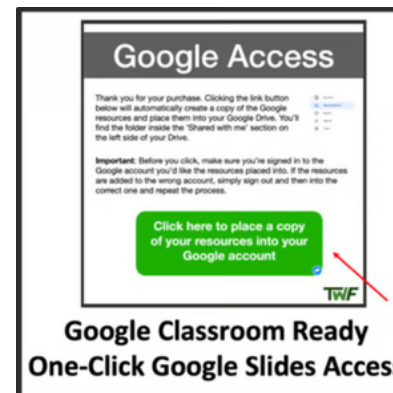
There are also ways to reduce material pressure before a phone becomes waste. Smaller amounts of cobalt are being used in some batteries, and some battery makers are moving toward cobalt-free chemistries in other applications. Copper can sometimes be substituted with aluminum or optical fiber, though not in every phone component. Rare-earth substitutions are often less effective, which is why design efficiency matters so much. Because mining and manufacturing dominate the footprint of smartphones, the simplest material-reduction strategy may be to keep devices in use longer through repair, battery replacement, refurbishment, and reuse, then collect them properly at end of life. For students, that is the main analytical conclusion: a smartphone is not only a communication device. It is also a compact map of global resource systems, showing how modern convenience depends on minerals, energy, trade, labor, and environmental management all at once.

Reading Comprehension Questions

1. Why does the reading say that a smartphone's environmental story begins before the phone is sold?
2. What makes copper especially important in smartphones?
3. Which countries were the leading copper producers in 2025, according to the reading?
4. What are two major environmental problems linked to copper mining?
5. What are two main sources of lithium discussed in the reading?
6. Why is lithium mining in places like the Salar de Atacama caused concern?
7. Why is cobalt often seen as one of the most troubling smartphone materials?
8. How are rare earth elements used inside smartphones?
9. What does the term "urban mine" mean in the reading?
10. According to the report, what are two important ways to reduce the impact of smartphone materials?

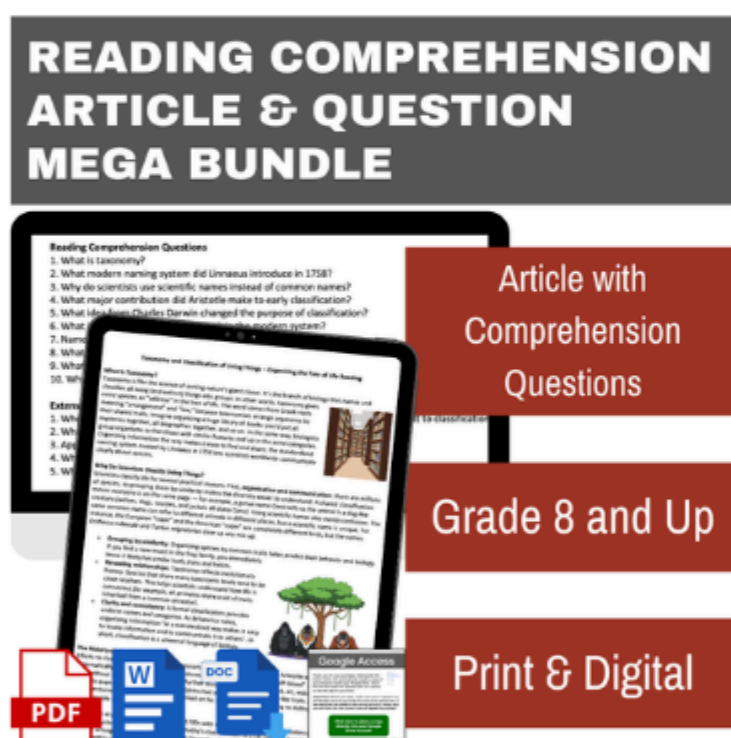
Full Answer Key

Comprehension and Extension Questions



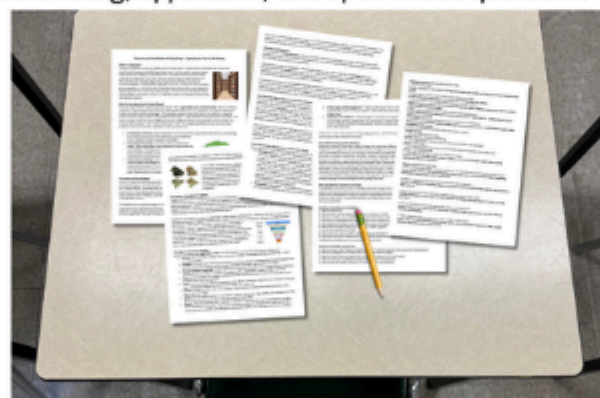
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- **Includes Varied Question Types:** Knowledge, thinking, connecting, application, and open-ended questions.



★★★★★ Extremely satisfied - It is a good supplemental activity either for review and at the same time introducing some concept. I also use this for sub plan. It is well presented, organized and interesting.

★★★★★ Extremely satisfied - This a great resource. I used this for a sub plan. It was fun and engaging for my students.

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