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National Security Commission on Emerging Biotechnology

Building the Future with Biotech

Biological Solutions to Secure Critical Materials

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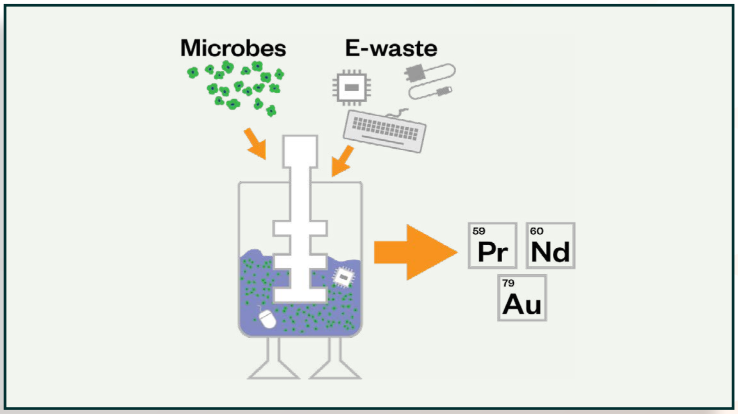
From cobalt in car batteries to niobium in nuclear reactors, critical materials are integral to modern life and national security.[1] Critical materials are materials necessary for military, industrial, and essential civilian needs; they span a wide range of elements, chemicals, and substances.[2] As technology has advanced, these materials have only grown more important. For example, one projection asserts that the global demand for lithium (used in car batteries) will grow 4000% by 2040.[3] **Biotechnology can play a key role in ensuring a robust and resilient critical materials supply chain.**

Geography and processing capacity present key supply chain challenges. China currently controls 55% of rare earth mining capacity and 85% of rare earth refining capacity. The Chinese Communist Party (CCP) has also shown a willingness to strategically restrict the supply of these minerals. In 2023, the CCP banned exports of technologies used for rare earth processing and introduced export controls for gallium and germanium, both of which are used in semiconductor chips.[4] U.S. companies are now getting back into rare earth refinement, after ceding ground to China for the past 30 years.[5]

Biotechnology can ensure a reliable supply of critical materials in several ways, from production (i.e. biomanufacturing) to recycling to opening new mining frontiers (such as on the seafloor)[6]. By leveraging biotechnological solutions, the United States can support domestic businesses and reduce reliance on imports and vulnerable supply chains. Phytomining and biomining are two approaches to collect and recycle critical materials.

Using Plants to Extract Minerals: Phytomining uses plants to extract minerals from soil. Most species of plants cannot survive in soil with high concentrations of metals, but some species thrive in such environments. These plants collect metals in the soil through their roots and store them in their bodies and leaves. The plants can then be harvested, and the metals collected. For example, one technique squeezes leaves through a peanut press which yields a "juice" that is 25% nickel.[7] Phytomining also yields some unique benefits over traditional mining: it can occur in areas that are not economically viable for a traditional mine and, once metals have been extracted from the soil, other plants can populate the area such as crops or vegetation.[8]



Using Biology to Mine Elements: Traditional processing methods for rare earth elements can be incredibly complex, energy intensive, and environmentally dangerous.[9] Mineral ore often needs treatment to remove radioactive substances after being mined from the earth, and separating the desired rare earth mineral from other minerals can require harsh chemicals such as hydrochloric acid which can produce carcinogenic waste.[10] Biomining provides a simpler, cleaner process, using engineered microbes to produce acids that can extract rare earth elements from ores. A similar process can be used on electronic waste (e-waste) such as computer chips and motherboards. Microbes can be combined with e-waste in bioreactors to extract left over elements as an alternative to traditional e-waste recycling.[11]

Sources

1 Congressional Research Service. "Critical Minerals"
2 Department of Energy. "What Are Critical Materials"
3 White House. "Building Resilient Supply Chains"
4 Reuters. "China's Rare Earths Dominance"
5 Reuters. "Western Start-ups Seek to Break China's Grip"
6 Munir, Misbahul. "Seabed Gold Biomining"
7 New York Times. "Down on the Farm that Harvests Metal"
8 ARPA-E. "Phytomining"
9 Boston Consulting Group. "Five Steps"
10 Reuters. "The Complexity of Transforming Rare Earths"
11 ARPA-E. "Ligand Facilitated Bioaccumulation"

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