

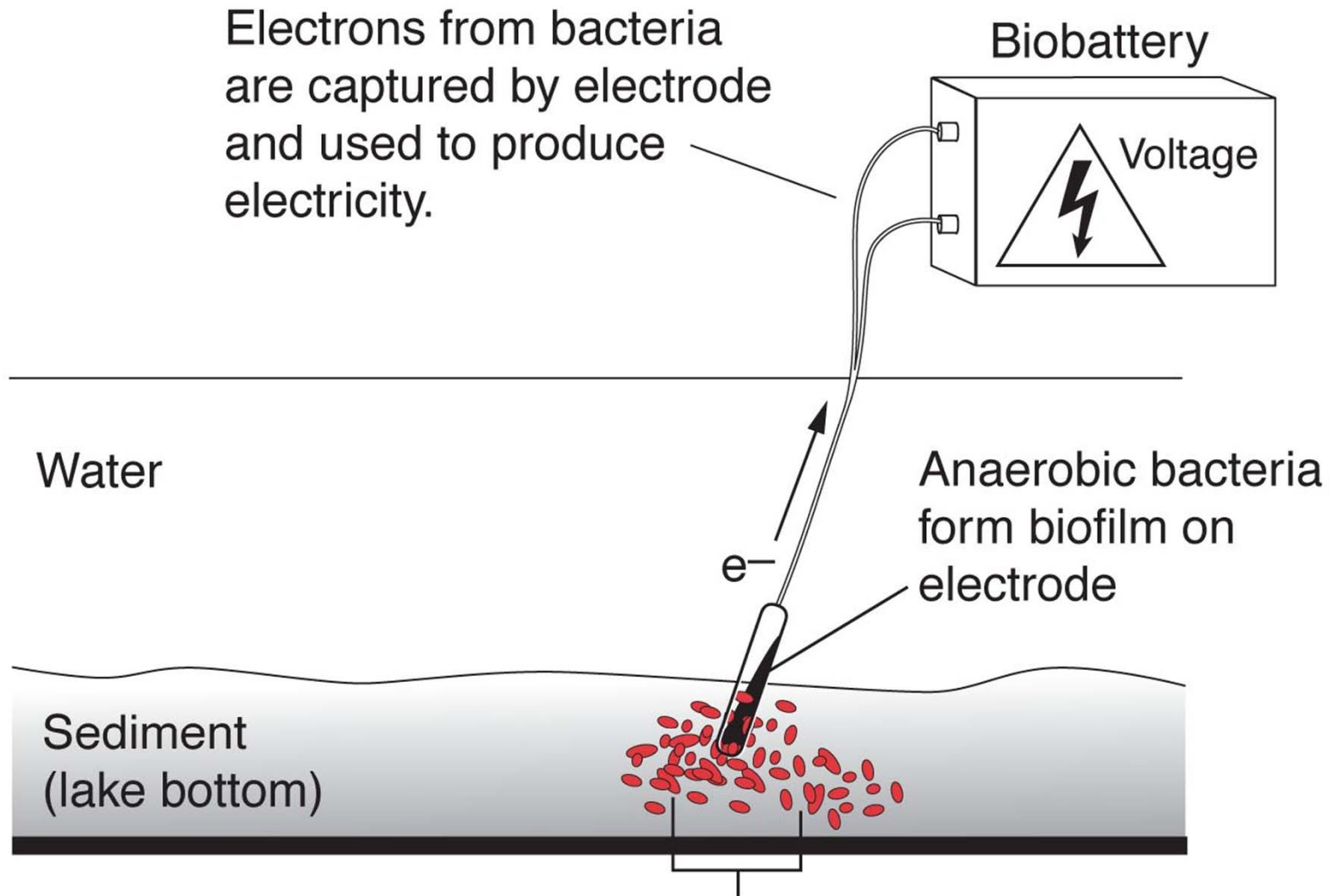
Previous class

- Soil cleanup
 - In situ bioremediation
 - Bioventing
 - Ex situ bioremediation
 - Slurry phase
 - Solid phase
 - Composting
 - Landfarming
 - Biopiles
- Water cleanup
 - Wastewater
 - Septic system
 - Sewage treatment
 - Groundwater
- Energy from wastes – microbial fuel cells
- GM strains for environmental cleanup, biosensors

Turning Wastes into Energy

- Anaerobic bacteria in bioreactors can convert food waste and other trash into
 - **Methane gas** – used to produce electricity
 - **Soil nutrients** – can be sold commercially as fertilizers
- Sediment is rich in organic matter
- Anaerobes in sediment use organic molecules to generate energy
 - **Electrigens** – electricity-generating microbes
 - Oxidize organic compounds to carbon dioxide and transfer electrons to electrodes
 - Electrigens can cluster and interconnect to form nanowires that conduct electrons.

Microbial Fuel Cell



Anaerobic bacteria oxidizing organic molecules in sediment transfer electrons to electron acceptor molecules such as iron and sulfur.

Applying Genetically Engineered Strains to Clean Up the Environment

- Many indigenous microbes can not degrade certain types of chemicals (very toxic compounds)
 - Manufacturing of plastic and resins
 - Radioactive compounds
- Petroleum-Eating Bacteria
 - Created in 1970s by Ananda Chakrabarty
 - Isolated strains of *pseudomonas* from contaminated soils
 - Contained plasmids that encoded genes for breaking down the pollutants

Applying Genetically Engineered Strains to Clean Up the Environment

- *E. coli* to clean up heavy metals
 - Copper, lead, cadmium, chromium, and mercury
 - Naturally occurring metal-binding proteins in plants and other organisms – metallothioneins and phytochelatins
 - For rapid uptake of metals *E. coli* is engineered to express transport proteins

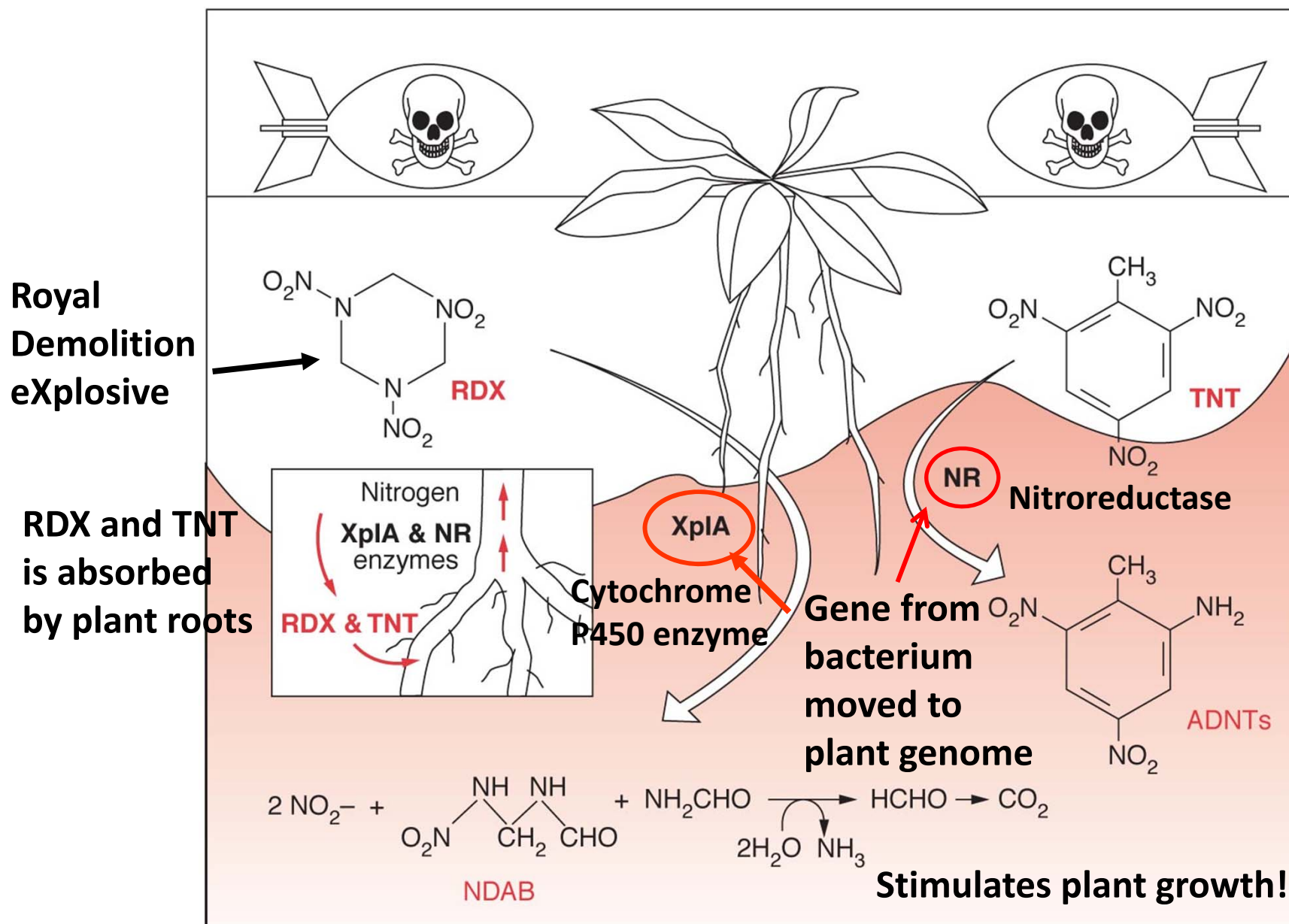
Applying Genetically Engineered Strains to Clean Up the Environment

- **Biosensors** – bacteria capable of detecting a variety of environmental pollutants
 - Genetically engineered *P. fluorescens* can degrade polycyclic aromatic hydrocarbons (PAHs)
 - Bacterial genes metabolizing these contaminants are spliced with *lux* genes for bioluminescence
 - As PAHs are degraded, bacteria release light and biodegradation rates can be monitored
 - Biosensors are used for assessment of heavy metals

Applying Genetically Engineered Strains to Clean Up the Environment

- Genetically Modified Plants and Phytoremediation
 - Mercury contamination of fish is a result of MeHg accumulation;
 - consumption of mercury-contaminated fish leads to many health problems
 - MeHg removal using plants engineered to contain mercury-detoxifying genes from bacteria

Transgenic Plants can Remove RDX and TNT



Future Strategies and Challenges for Bioremediation

- Recovering Valuable Metals
 - Microbes oxidize metals into metal oxides (ores) which are insoluble substances and accumulate in bacterial cells or attach to bacterial cell surface.
 - Microbes may be used to harvest valuable metals (gold and silver) from gold plating industries or mines waste
 - Plants may also be used

Future Strategies and Challenges for Bioremediation

- Bioremediation of Radioactive Wastes
 - Uranium and plutonium pollution near naturally occurring uranium processing mines
 - Nuclear power plants
 - Contaminants are mixture of cesium, uranium, plutonium, heavy metals, and organic pollutants (toluene)
 - Radioactive material kill most microbes

Future Strategies and Challenges for Bioremediation

- Bioremediation of Radioactive Wastes
 - *Geobacter* can reduce soluble uranium in groundwater to insoluble uranium – immobilizes radioactivity
 - *D. radiodurans* can tolerate radiation over 3000 times higher than other organisms
 - High doses of radiation create double-stranded breaks in DNA structure and causes mutations
 - *D. radiodurans* possesses system for folding its genome to minimize damage from radiation
 - It also uses novel DNA repair mechanisms to replace damaged copies of its genome
 - Scientists are attempting to create GM strains to be able to degrade organic and heavy metal wastes too

Environmental Disasters: Case Studies in Bioremediation

- Jet Fuel and Hanahan, South Carolina
- The Exxon Valdez Oil Spill
- Oil Fields of Kuwait