

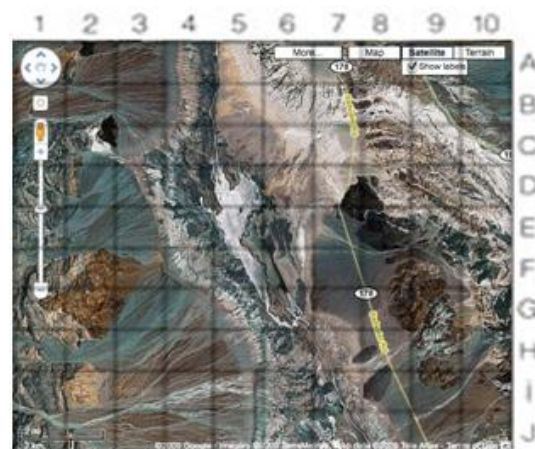
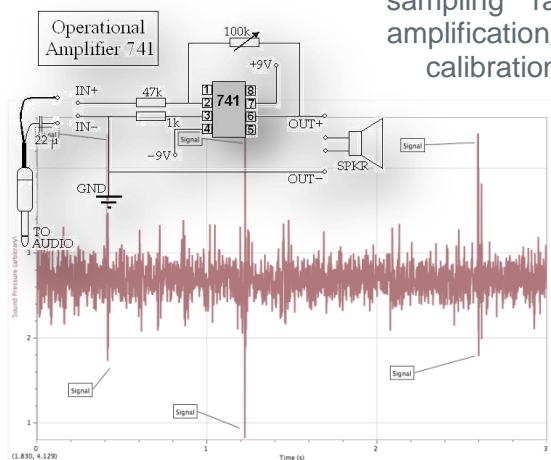
Curriculum Supplement Series

Observing Beyond our Senses: Inquiry Drives Technology

In this high school curriculum module, students in physics, integrated science, biotechnology, and STEM courses are confronted with the same challenges scientists and engineers are when the technology they need to answer questions is not available. Lessons may be taught separately or together as a 3 week module.

In this module, students focus on the role of physics and engineering in the increasingly interdisciplinary field of systems biology where investigations in biological networks are advanced through improving technologies. Centered on a case study requiring instrumentation for field research, the driving question is “**How do scientists measure what they cannot directly observe with their senses?**”

The complexities of proxy variables, the limitations of inferences, and the interpretation of quantitative data are examined. Tradeoffs in instrumentation design related to precision, accuracy, resolution, sampling rate, samples size, signal amplification, signal noise, and calibration are explored. This series of



inquiry based activities utilizes the graphing visualization capabilities of excel, real time data collection probeware such as Vernier or Pasco, student built proto-board circuits, and custom instruments provided in the kit. The culminating project is a case study involving a high saline environment impacted by mine tailings. Exploration of instrumentation design is driven by the need to count the indicator microbial populations invisible to the naked eye. Students develop an iterative sampling strategy based on limited resources to map the microbial population with the kit provided handheld spectrophotometer and infer point pollution and freshwater sources. Their findings and recommendations are presented as a water management plan.

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Name of Lesson	Main Question Explored	# of 50 min. Class Periods
1. Intro to Saline Environments and Halophiles	How can we count halophilic microbes?	1
2. Design Process: Measuring Wind Speed	How do scientists and engineers design and evaluate solutions to measuring problems?	2
3. Inferences from Proxy Variables: Mock Atomic Force Microscope	How do we count or measure things we cannot observe directly?	2-3
4. Resolution and Noise: Operational Amplifiers	What are the trade-offs and benefits to amplifying a signal?	2
5. Calibration and Inferring Properties from Light Behavior	How can we use light as a quantifiable proxy variable and how do we make our light measurements meaningful for population density?	2
6. Case Study: Mapping Death Valley	How can we make inferences from microbe populations to develop a water management plan?	2-4