Welcome to Xplorlabs:
The Science of Thermal Runaway
Engineering Solutions

The Xplorlabs Science of Thermal Runaway pathway provides opportunities for students to make sense of the science related to lithium-ion battery-powered devices, and then consider real battery failure testing data in order to engineer solutions associated with the phenomena of thermal runaway. This Xplorlabs pathway is framed most like a problem-based learning (PBL) with explicit teaching and learning of all three dimensions in science and engineering. An overview of the instructional flow follows.

Engineering Design Challenge

Through the suggested pathway, engineering a solution to a safe battery enclosure is at the core of student motivation to engage in sense making of the science.

Challenges associated with safe battery enclosures are defined early in the module, with subsequent learning cycles designed for students to make ongoing connections to the problem definition. As students make their thinking visible through models, discussion, and ideation of possible solutions they will consider the following:

- Materials for a battery enclosure
- Optimization of an enclosure design

See the teacher guide for the Engineering Process: Designing a Lithium-Ion Battery Enclosure for details.

Suggested Pathway

We have created a pathway that aligns closely with NGSS. It is important to note that the suggested instructional sequences are a vision for how instruction could occur, <u>not</u> a set of rules to follow. There is no singular way to approach phenomena driven, problem-based learning cycles. Thus, we encourage you to use whichever portions make the most sense for appropriately challenging your students.

The suggested pathway begins with a shared experience centered on safely observing the phenomenon of thermal runaway. Then, as students' progress through the learning cycle(s), they explore driving questions that they can later explain through engineered solutions (e.g. battery enclosures, safety labels) to a specific problem.

What is thermal runaway?

- Students record observations from lab tests conducted at the UL Fire Safety Research Institute and then share their wonderings about a lithium-ion battery powered device that is on fire. These wonderings become driving questions that serve as a guide to the remainder of the learning cycle.

Engage	Explore Questions	Connect to Engineering Design Challenge
A lithium-ion battery-powered device is on fire.	Students share related questions that guide learning.	Students identify the problem: to design battery enclosures that mitigate risk of thermal runaway.

How does a lithium-ion battery work?

- Students observe energy types and transformations in lithium-ion batteries, paying particular attention to the byproduct of thermal energy. Students use representations of lithium-ion battery interiors and circuits to support understandings of energy. Then, students explain why some energy transformations should be mitigated.

Explore	Explain	Connect to Engineering Design Challenge
Students observe models of battery and circuit structures that facilitate energy transfer and transformation.	Students explain energy transformations that occur in lithium-ion batteries and circuits.	Students identify risks related to transforming energy that their design will seek to mitigate.

Why are battery-powered devices designed to prevent physical damage?

- Students observe safety engineers in a lab testing batteries to the point of failure. Then, students carry out an online, simulated investigation to see how dropping a device impacts the likelihood of thermal runaway. Students will be able to explain how damage can lead to the internal short circuits that cause thermal runaway.

Engage	Explore	Explain	Connect to Engineering Design Challenge
Students observe the effects of physical damage on a battery via lab footage.	Students measure the effects of dropping a hoverboard in a virtual lab.	Students explain the cause and effect relationship between physical damage and thermal runaway.	Students identify risks related to physical damage that their design will seek to mitigate.

How does overcharge relate to thermal runaway?

- Students explore the effects of overcharge using a virtual simulation of mismatched chargers (a common misuse). Students will be able to explain how overcharge can create an uncontrolled chain reaction of heat, thermal runaway.

Explore	Explain	Connect to Engineering Design Challenge
Students observe the effects of overcharging by conducting an online simulation.	Students explain the cause and effect relationship between overcharge and thermal runaway.	Students identify overcharge risks that their design will seek to mitigate.

How does thermal runaway spread?

- Students view videos of UL lab tests that place batteries in extreme heat to observe the likelihood they will release high pressure gas and become airborne. Through this driving question, students will understand how excessive heat created in thermal runaway can spread between cells and batteries.

Explore	Explain	Connect to Engineering Design Challenge
Students observe the effects of excessive heat on a battery via lab footage.	Students explain modes of thermal energy transfer in battery and cell systems.	Students identify risks of thermal energy transfer and finalize their problem definitions.