

Learning objectives

- Synthetic biologists solve problems by applying engineering principles to living materials.
- Synthetic biology uses the engineering design process.
- Synthetic biology is interconnected with society.

Conversation questions

- How is designing a superhero similar to or different from building a microorganism to solve a problem?
- What could happen if an engineered organism were introduced into the wild? Could there be unexpected consequences?

Materials

- Activity and facilitator guides
- Activity sign and holder
- Superhero worksheets
- Super Organisms worksheets
- Background art and holders
- Scissors
- Tape
- Markers
- Reference sheet: Synthetic Biology

All written activity materials and graphics can be downloaded from buildingwithbiology.org.

Notes to the presenter

Safety: Scissors can be sharp.

Preparation: Before beginning this activity, become familiar with the materials. This activity uses the process of designing a superhero as an analogy for engineering with biology. You may want to become more familiar with common superheroes. (See background information below.)

Audiences: You can adjust this game to work for different audiences. Younger visitors might find it easier to draw new traits and attributes onto the person and organism rather than cutting pieces out.

Tailor the amount of information you initially share depending on the age and interest of the visitors. Remember that you can always share more information if visitors ask questions!

Conversation: This activity is designed to promote back-and-forth conversation about ways that technology is interconnected with society. You can help encourage visitors to develop and share their own ideas by referring to the **Tips for Conversations** guide.

You can use the “**Talk about it...**” questions in the activity guide to get visitors started. (These are also summarized in the list of “Conversation questions” above.) Be sure to listen to visitors’

thoughts and opinions, and feel free to share your own opinions as well. As visitors design their superheroes and organisms, discuss what abilities each trait adds, and what additional abilities might still be needed. Living organisms can evolve and change. What do you and the visitors think could happen if engineered microorganisms are introduced into the wild?

If visitors seem uneasy or have questions regarding the safety and security of synthetic biology systems, you might respond that these are serious factors that scientists—and we as a society—need to consider. As with many new technologies, there are important ethical and social questions surrounding research in synthetic biology. Government regulations, biosafety committees, scientific transparency, and informed citizens help to make sure that these technologies maximize benefits and minimize risks. Together, we all have a role in shaping how technologies are developed and used.

Additional Background: The selected traits listed on the activity worksheet are all examples of real interchangeable attributes that scientists are working on:

- **Solar power:** Photosystem I. This trait is the key component in photosynthesis in most plants. It uses light energy to mediate electron transfer, allowing organisms to use sunlight as a power source.
- **Self-destruct:** CRISPR-Cas9. This system can cut a cell's DNA in a desired location. If the correct location is selected, the cell may self-destruct.
- **Bioemulsifier:** Cell surface esterase. This trait is from *Acinetobacter venetianus* bacteria. It produces a bioemulsifier, which is used in bioremediation of alkanes (oil). That means that the bacteria produce a soap-like chemical to break apart clumps of oil.
- **Energy source:** Alkane hydroxylase. From *Acinetobacter calcoaceticus* bacteria, this attribute processes alkanes (oil) to use as an energy source. Bacteria with this trait can consume oil to power their own cells.
- **Oil processor:** Omega-hydroxylase. *Pseudomonas oleovorans* bacteria use this attribute to process alkanes (to eat and digest oil).
- **Oil receptor:** Phagocyte surface receptors. This attribute is found in macrophages, a type of white blood cell. Macrophages use this attribute to engulf foreign particles, such as oil.
- **Oil sensor:** Membrane proteins. These molecules, found on *Alcanivorax borkumensis* bacteria, bind to alkanes (oil).

It may also be helpful to be familiar with the origins of some superheroes from pop culture:

- **Superman** is an alien from a distant planet, and our sun gives his body powers of flight, strength, and invulnerability (among others).
- **Spiderman** was bitten by a radioactive spider and gained spiderlike characteristics of great proportional strength, ESP, and wall-climbing.
- **The Black Widow** is a world-class athlete and fighter, enhanced by biotechnology to give her rapid healing abilities and resistance to disease.
- **Mr. Fantastic and the Invisible Woman** (of the Fantastic Four) were exposed to extreme levels of cosmic radiation. He gained the ability to stretch and distort his own body, while she gained the powers of invisibility and telekinesis.
- **Storm and Iceman** (from the X-Men) were born with genetic mutations that allow them to control the weather and ice, respectively.
- **The Iron Man suit** was built and worn by Tony Stark, a billionaire and engineering genius.

- **Wonder Woman** is a warrior from a mythological land, born with superhuman strength and equipped with magical weapons.
- **Elsa** from *Frozen* was born with magical powers to make snow and ice.

Passports: In your activity box, you'll find a marker stamp. This stamp is for the Building with Biology event passports. Each facilitator will need to be prepared to stamp visitors' passports if guests ask them a question and/ or share what they think about synthetic biology. Facilitators who are scientists should wear "I'm a scientist" stickers at the event and should be ready to stamp passports if guests talk to them. Your event may choose not to use the passports, and that's fine, too.

Related educational resources

The NISE Network website (www.nisenet.org) contains additional training resources to help scientists and educators have conversations with museum visitors about the relationship between technology and society:

http://www.nisenet.org/catalog/tools_guides/nano_society_training_materials

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This activity is a modified version of the "Superheroes, Super Organisms" activity developed by the Museum of Science, Boston, MA, for the Building with Biology pilot project.

Hero and cell worksheet and background illustrations, Emily Maletz for the NISE Network.

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Image of Rena oil spill clean up, New Zealand Defence Force,

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