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Martian habitats in the classroom: testing *Artemia*

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Explore Mars in the classroom through accessible experiments with *Artemia*, linking astrobiology, aquatic ecology, light responses, and scientific inquiry.

Brine shrimp are small crustaceans of the genus *Artemia* that live in saline habitats such as salt pans, coastal lagoons, and salt lakes.[1,2] These environments often dry out completely during the hottest season,[3] but as true extremophiles, *Artemia* are remarkably well adapted to survive conditions that would be lethal to most organisms. This includes prolonged desiccation and exceptionally high salinity, making them valuable model organisms in scientific research across multiple disciplines.[1] Brine shrimp thrive in hypersaline conditions, with salinities ranging from around 3% to over 10%, which excludes most predators. As a result, only a limited range of algae and bacteria can survive alongside them. Among the several species of brine shrimp, the most studied and widely used are *Artemia salina* and *Artemia franciscana*,[4] which are widely available, inexpensive, and easy to culture. Learn more in the Artemia info sheet and find out how to grow them.

Nice to know

- Built to last: *Artemia* cysts can be stored for years at room temperature and still hatch successfully.[1]
- Upside-down swimmers: *Artemia* (adults) swim with their ventral side facing upwards, using rhythmic movements of their thoracic appendages.[5]
- A red secret: *Artemia* have haemoglobin in their blood, an adaptation that helps them survive in low-oxygen environments.[6]
- Tiny astronauts: *Artemia* cysts flew on the Apollo 16 and 17 missions, where they were used to investigate the effects of radiation on development.[7,8]

Using living organisms as biological models in science classrooms offers learning opportunities that virtual simulations cannot fully replicate. Although digital tools are valuable for visualising complex processes, hands-on work provides direct experience of biological responses, natural variation and the unpredictability of living systems. Evidence suggests that hands-on and virtual laboratories offer complementary benefits, with their combined use supporting conceptual understanding and inquiry skills more effectively than virtual environments alone.[9,10] Live models also help students to reconnect with natural environments by providing concrete encounters with living systems and their interactions within habitats. This promotes ecological literacy and an appreciation of biodiversity,[3,11] strengthening students' understanding of biology and fostering a more meaningful relationship with the natural world.

Mars at a glance

Atmosphere: 95% CO_2, 3% N_2 and 2% Ar; surface pressure is less than 1% of Earth's sea-level pressure[12]
Temperature: surface temperatures vary widely, from approximately –125°C to 20°C, depending on location and season[12]
Water: found mainly in the polar regions and buried beneath the surface[13]
Soil: mainly basaltic, containing a range of minerals and salts, including sulphates, chlorides and perchlorates[14]

Activity 1: Casting for the colonisation of Mars

Space agencies are increasingly interested in understanding how simple organisms cope with extreme environments, as this knowledge can inform future attempts to establish biological systems beyond our planet.[8] *Artemia* are particularly suitable for such investigations because their cysts can survive harsh conditions and hatch when placed in favourable environments,[15] meaning they would likely survive a journey to Mars and could potentially be stored safely under Mars-like environmental stresses. They are also essential in global aquaculture, where newly hatched *Artemia nauplii* are used as a high-quality live feed for fish larvae.[1,4] This suggests that, in future human colonies on Mars or other planets, *Artemia nauplii* could likewise support small-scale aquaculture systems, helping to establish reliable food production.

In this activity, students simulate the challenges of colonising Mars by examining how *Artemia* responds to environmental conditions that reflect those expected on the 'Red Planet'. By analysing hatching success across different salinities, students explore key ecological principles while carrying out an authentic scientific investigation. At the end of the activity, each group evaluates whether their assigned 'Martian habitat' could support the establishment of an initial *Artemia* population.

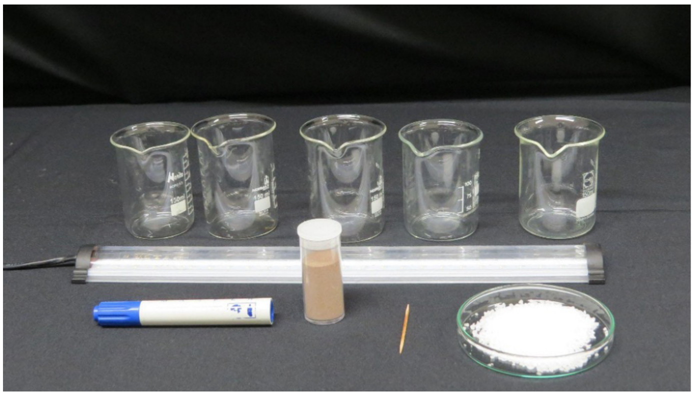
The activity is suitable for students aged 11–16 and will take two short lessons (+ 24–48 h incubation).

Safety notes

Artemia cysts may cause respiratory irritation or allergic reactions when inhaled, so avoid creating dust when handling them. Dispose cultures and biological material according to local environmental regulations. Do not release *Artemia*, cysts or culture water into natural aquatic environments, as they may affect local ecosystems.

Materials

- *Artemia salina* (50 cysts per beaker/250 cysts per group)
- Aged/dechlorinated tap water
- Sea salt or non-iodized coarse salt
- Marker
- 9 Beakers
- Lamp (optional, to simulate sunlight)
- Balance
- Toothpick
- Activity 1 worksheet



Materials of Acitivty 1: Beakers, lamp, marker, *artemia* cysts, toothpick, sea salt
Image courtesy of the authors

Procedure

Prepare the Martian habitats

1. Prepare four salt solutions using dechlorinated tap water and table salt. Dissolve the sea salt in separate beakers containing dechlorinated tap water to obtain salinities of 15, 30, 45 and 60 g/l (1.5, 3, 4.5 and 6%). The salt solutions may be prepared in advance and clearly labelled.

2. Prepare five small beakers and label each one in advance with the salinity to be tested and the student group. Add 50 ml of dechlorinated tap water to the control jar labelled 0 g/l, and 50 ml of the corresponding salt solution to each of the other jars.
3. Add 50 *Artemia* cysts to each container. For accurate cyst counting and transfer, use a moistened toothpick to gently pick up the cysts and place them into the labelled beakers.
4. Gently swirl the containers, then place them in a warm environment at 28°C. If only lower temperatures are available, the setup can still be used, but hatching will take longer. If available, provide continuous light to encourage hatching.
5. Record the number of hatched *Artemia nauplii* after 24 h and 48 h using a hand lens or stereomicroscope.
6. Compare the hatching success between the different salinity conditions.
7. Record and discuss the results.

Discussion

Once the hatching results have been recorded, students can use the following questions to interpret their data and connect the experiment to wider astrobiological ideas. The discussion encourages them to consider not only which salinity favoured hatching, but also what living organisms would need to survive, grow, reproduce and contribute to a future closed habitat beyond Earth.

Sample answers can be found on the [Activity 1 answer sheet] in the supporting material.

- How 'Martian' is this experiment?
- How do experimental variables affect the results?
- Which 'Martian habitat' worked best?
- Did *Artemia* hatch in freshwater?
- Compare the number of hatched *Artemia nauplii* after 24 h and 48 h. How can any difference between the two counts be explained?
- How could the experiment be improved to increase the reliability of the results?
- What would *Artemia* need, beyond hatching, to successfully colonise a habitat?
- Why use cysts rather than adult *Artemia*?
- Should we take life to other planets?

Ethical Notes

- Handle *Artemia* gently and responsibly throughout the experiment to avoid unnecessary stress or harm.
- Use only the minimum number of organisms needed to obtain meaningful results.
- Maintain appropriate culture conditions (salinity, temperature, oxygen and food) to avoid unnecessary stress.
- Limit exposure to extreme conditions to what is essential for the investigation.
- Where an aquarium is available, *Artemia* may be used to feed fish, helping students to understand how food chains operate in aquatic ecosystems.

Activity 2: From Earth to Mars: creating a self-sustaining ecosystem in a bottle

How might future astronauts produce oxygen, recycle waste and sustain food webs on Mars? One possible solution lies in bioregenerative life-support systems, which use living organisms to recycle essential resources. In this activity, students build a simple ecosystem in a bottle inspired by these systems. By following the movement of matter and energy through the system, students discover the principles that allow closed ecological systems to function. They also explore how small, self-sustaining biological communities might one day contribute to supporting human life on Mars. In doing so, the activity not only introduces ideas relevant to future space exploration but also deepens students' understanding of ecosystems and highlights the importance of protecting life-supporting systems here on Earth.

By simulating a salt lake, a 1.5 l bottle becomes a miniature model of the Earth's biosphere, containing algae as primary producers, *Artemia* as consumers, and bacteria and fungi as decomposers.[5] The bottle ecosystem lets students of all ages explore key ecological concepts, such as energy flow and nutrient cycling, through hands-on experimentation. Beyond teaching science, this project encourages students to understand, respect, and help protect animals and the ecosystems they inhabit.

This activity is designed for students aged 11–14 and requires about 30–45 minutes of class time to get started.

Materials

- Transparent plastic bottle (1–2 l)
- Clean sand (washed and dried)
- Crushed shells of marine animals
- Aged/dechlorinated tap water
- Sea salt or non-iodized coarse salt
- 6 Brine shrimps of different sizes (and ages)
- Liquid plant fertiliser
- Pipette
- Spoon

- Sieve
- Funnel
- Activity 2 worksheet

Materials of Activity 2: transparent plastic bottle, clean sand, shells of marine animals, funnel, sieve, sea salt or non-iodized coarse salt, liquid plant fertiliser, pipette, spoon

Image courtesy of the authors

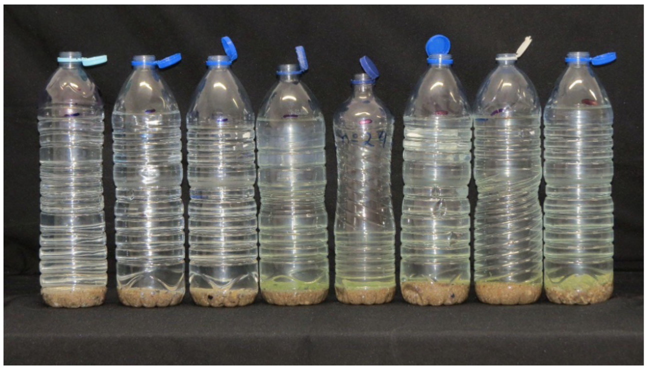
Procedure

Constructing a bottle ecosystem for Martian life-support studies

1. Wash the bottle (1.5 l) with tap water. Do not use detergent.
2. Add 1.2 l of tap water to the bottle and mark the water level. Empty the bottle afterwards. This mark will help maintain a stable water volume.
3. Add a thin layer (2 cm) of clean sand and crushed seashells (e.g., oyster shells) in a 3:1 ratio to the bottom of the bottle to simulate the sediment of a shallow aquatic habitat.
4. Prepare the seawater by dissolving 30 g of sea salt per litre (36 g for 1.2 l). Pour the solution into the bottle up to the marked level.
5. Add 2 drops of liquid plant fertiliser.
6. Place it in a sunny spot (20–25°C), such as a south-facing window or near a light source during the winter.
7. Observe the system weekly for 2–8 weeks. Check for algal growth by looking for green areas. Once green zones are present, the ecosystem is ready to receive the brine shrimp.

Maintaining a Martian life-support System

8. Add 6 brine shrimp of different sizes into the bottle.
9. During the first two weeks, add one drop of liquid fertiliser per week. After this period, reduce the dosage to one drop every two weeks.
10. Leave the bottle uncapped, or only lightly secure the cap.
11. Once a week, screw on the cap and roll the bottle gently.
12. Monitor the water level regularly. If evaporation occurs, add dechlorinated fresh water (without salt) to restore the original level.
13. Observe the *Artemia* regularly and record their behaviour, abundance and distribution within the bottle. Note where they swim, how they interact with the sediment, and whether the population changes over time.



'Mars in a Bottle' ecosystems ready to receive *Artemia*

Image courtesy of the authors

Results/discussion

Discuss the following questions. Sample answers can be found on the Activity 2 answer sheet in the supporting material.

- Why is the bottle washed before the experiment, and why is detergent avoided during cleaning?
- What is the purpose of adding sand and crushed shells?
- Why do we use sea salt?
- Why are algae essential in both the bottle ecosystem and a future 'Martian habitat'?
- Why must water levels and environmental conditions be carefully monitored in this model ecosystem, and how does this relate to future habitats on Mars?
- Why do we add liquid fertiliser at the beginning of the experiment, and why can the dose be reduced later?
- Why is the cap left loose or off?
- Why do we roll the bottle once a week?
- Why are different sizes of brine shrimp added?
- How do the geosphere, atmosphere, biosphere, and hydrosphere interact in the bottle ecosystem?
- Can a bottle ecosystem be considered a model of a Martian life-support system? Why or why not?

Activity 3: Navigating a new world – testing *Artemia* phototaxis for future Martian aquaculture

Marine environments are vast, dynamic and complex, posing significant challenges for the release and perception of sensory information that differ significantly from their terrestrial counterparts. Light is a critical factor in providing directionality within the water column, enabling diurnal migration and larval dispersal via currents. This principle is reflected in the phototactic behaviour of *Artemia nauplii*, which use light stimuli to orientate their ventral side and adjust their vertical distribution within their habitat.[16]

In Mars habitats, light would be a controlled design tool, not just an environmental factor. By studying phototaxis, students explore how light could help manage the distribution, feeding and stability of organisms in closed aquatic life-support systems beyond Earth.

Artemia nauplii

Image courtesy of the authors

Materials

- Aged/dechlorinated tap water
- Sea salt or non-iodized coarse salt
- Freshly hatched *Artemia nauplii*
- Transparent sealed tubes or clear plastic vials (without air bubbles)
- Light source (LED torch or desk lamp)
- Dark background or box to reduce ambient light
- Marker pen or adhesive labels
- Stopwatch or timer
- Activity 3 worksheet

Procedure

Testing Artemia response to light

1. Fill a transparent tube with salt water (3%).
2. Add 10 *Artemia nauplii* and seal it, ensuring no air bubbles are trapped inside.
3. Place the tube horizontally in a darkened area, ensuring that the experimental light source will be the main source of illumination.
4. Illuminate one end of the tube using a torch or LED light and observe the distribution of the *nauplii* after 1–2 minutes.
5. Indicate where *Artemia* density is highest.
6. Repeat the procedure with the tube positioned vertically, illuminating it either from above or below.
7. Compare the distribution of *Artemia nauplii* under different orientations and lighting conditions.
8. Allow the organisms to recover under normal light conditions between trials.

Results/discussion

Discuss the following questions. Example answers can be found on the Activity 3 answer sheet in the supporting material.

- How do *Artemia nauplii* move and distribute themselves in the horizontal and vertical tube setups?
- What can be inferred from *Artemia nauplii* distribution in horizontal and vertical tubes about their response to light?
- Why is it important to let the *Artemia nauplii* recover in normal light between trials?
- How could understanding *Artemia's* movement towards light help scientists design life-support systems for Martian aquaculture?
- How might the intensity or colour of the light influence the behaviour of *Artemia nauplii*?
- What limitations of this experiment should be considered when applying results to Mars?

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Resources

- Find out more about water on mars: de Pablo MA, Centeno JD (2014) Glaciers on Mars: looking for the ice. *Science in School* **28**: 12–17.
- Invite your students to think about what it takes to live on Mars: Tranfield E (2011) Building a space habitat in the classroom. *Science in School* **19**: 43–49.
- Learn about the connection between Mars and Antarctica: Usher O (2012) The white continent as a stepping stone to the red planet. *Science in School* **23**: 53–56.
- Gain insights into the biology of regeneration and the nervous system by using planaria as a model organism: Faria HM, Fonseca AP (2023) Hands-on experiments with planaria. *Science in School* **64**.
- Teaching biology and environmental sciences with pond snails: Faria HM, Fonseca AP (2025) Snail-powered science: hands-on biology for active classrooms. *Science in School* **75**.
- Observe how a spineless creature can adapt to changing environments: Poon H, Collins EMS (2026) Measuring is believing: quantifying adaptation behaviour of Hydra. *Science in School* **76**.

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