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Activity Guide Notes

Heatproof Balloon

A practical guide for teachers and educators

Primary Science and Geography
With Junior Cycle Extensions

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A practical teacher guide for primary science and geography, with Junior Cycle extensions

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A balloon, a candle and a little water. It looks like a recipe for a loud BANG! Yet add water to the balloon and something rather surprising happens. This is an opportunity to turn a moment of wonder into a question: where is the heat going?

This guide takes you through the candle demonstration, explains the science in everyday language and connects it with the water surrounding our island. Use it alongside the activity poster, choosing the depth of explanation that suits your class.



What children will discover

- Water absorbs energy and helps keep the heated part of a balloon cool enough to remain intact for a while.
- The water must touch the inside of the rubber where the flame heats it. Above the waterline, the rubber can heat up and burst almost instantly.
- Scientists make predictions, observe carefully and use new evidence to improve their explanations.
- The sea stores and releases energy, helping to moderate temperatures in Ireland.





The surprise to look out for

An air-filled balloon bursts almost as soon as it touches the candle flame—POP! Add some water, keep the flame beneath the water-filled part, and the balloon can remain intact for tens of seconds. Energy passes through the thin rubber into the water. Convection currents carry energy away from the heated area, while water's high specific heat capacity means it takes plenty of energy to warm it appreciably. That surprising contrast is the heart of this demonstration.

These are typical observations, not guaranteed timings. Balloon condition, flame position and heating intensity all matter. Use brief heating periods established when checking your apparatus, rather than seeing how long the balloon can survive.

A note from Scientific Sue

"I usually fill about a quarter of the inflated balloon with cool water. This gives me a useful depth of water above the heated area, so a slight wobble is less likely to bring the flame against rubber above the waterline. I attach the balloon to a stick—or my small fishing rod—to keep hands away from the balloon and flame."

Allow around 25–35 minutes for predictions, the demonstration and discussion. The adult handles the flame and apparatus. Children can be the predictors, observers, recorders and explainers.

Getting ready

What you need

- Two matching large opaque balloons, spares and a balloon pump. Choose balloons that conceal the water when inflated.
- A squeezable water bottle with a pop-up drinking spout, filled with cool water.
- A stick or small fishing rod, with a secure attachment for the balloon's tied neck and suitable support to limit swinging.
- A small candle in a stable candle holder or securely clamped to a stable retort stand.





- A long-handled lighter.
- A large heat-resistant catching tray on a stable, heat-resistant surface.
- Eye protection and materials for clearing spills and balloon fragments.

An experienced demonstrator may use a suitable litter-picker to grip the candle upright. Its grip, materials and stability must be assessed for that use. The classroom sequence below uses a fixed candle.

Prepare the mystery balloon

Prepare the balloon out of sight of the children. The trick is to inflate it first, then add the water using the squeezable bottle. This allows you to introduce a useful amount of water while keeping the balloon inflated.

1. Fill the squeezable bottle with cool water and open its pop-up drinking spout.
2. Inflate the opaque balloon using the pump. Pinch the neck to keep the air inside as you carefully remove the balloon from the pump.
3. Stretch the balloon's neck over the pop-up lid and bottle top, making a snug seal. Hold it securely in place.
4. Turn the bottle upside down so it is above the balloon. Gently squeeze water into the balloon until it occupies about a quarter of the inflated balloon's volume.
5. Push the pop-up spout down to close it. This stops the flow of water and makes removing the balloon much easier.
6. Pinch the balloon's neck to retain the air and water, carefully ease it off the closed bottle top and tie it.

Scientific Sue's tip: Keep a firm hold on the balloon's neck throughout filling, and take care not to catch the rubber on the bottle lid. Closing the pop-up spout before removal is the little trick that makes this method so manageable!

Leave the matching second balloon uninflated, ready to inflate in front of the class.

Set up the demonstration area

Secure the mystery balloon by its tied neck to the stick or rod. Check that the support can carry its weight and that you can position its water-filled base steadily over the candle. Remember that





opaque rubber conceals the waterline from you too. Establish the depth of water during preparation and keep the flame beneath the lowest part of the balloon. Place the candle holder or retort stand in the catching tray. Check that falling water would not topple the apparatus. Keep the arrangement well away from plugs, sockets and electrical equipment.

Keep the surprise in the science

Complete the school's risk assessment, follow its fire procedures and check the heated demonstration with the actual apparatus before presenting it. Set a viewing boundary that allows for splashes and flying fragments. Everyone stays out from beneath the balloon. The adult controls the apparatus; children should not hold the balloon directly or handle the candle. Wear eye protection in the demonstration area. Tie back hair, secure loose clothing and clear flammable materials. Check for latex allergies and sensitivity to sudden bangs. Warn children before either balloon approaches the flame, because even the water-filled balloon could burst unexpectedly. Children may cover their ears if they wish. For anyone distressed by sudden noises, arrange an appropriate alternative rather than relying on covering ears alone. Extinguish the candle while preparing or changing apparatus, revealing the water and showing the soot. Clear fragments promptly and deal with wet floors before anyone approaches. Have the school's appropriate fire-safety equipment ready. Do not rely on falling water to extinguish the candle. Cake flares and blowtorches require separate specialist arrangements and are not included in this classroom procedure.

Let the children do the thinking

1 Present the mystery

Show the prepared opaque balloon without revealing the water. "What do you think will happen when this balloon touches a candle flame? What makes you think that?" Give children time to think and talk. Keep the balloon steady so a sloshing sound does not reveal the secret just yet.

2 Create the surprise

Many children will predict a burst. Explain that there could be a loud bang and invite them to cover their ears if they wish. With everyone behind the viewing boundary, light the candle and bring the supported balloon's water-filled base into contact with the flame. Use a brief exposure established during your apparatus check—for example, around 3–5 seconds—then move the balloon clear



and extinguish the candle. “No pop! How could that be possible?” Pause. Let the surprise do its work before offering an explanation.

3 Gather their ideas

Invite the children’s suggestions first. If they need a prompt, ask: “Could it be a special balloon?” “Could there be something different about the flame?” “Could something be inside?” Record a few ideas to revisit. At this stage, the children are suggesting possible explanations, not being asked to guess the answer you want.

4 Test a matching balloon

Put the mystery balloon safely aside. Inflate the matching balloon with the pump in front of the children, tie it and attach it to the support. They have now watched you put air into this balloon. Warn them again about the expected bang. Relight the same candle and bring the supported air-filled balloon towards its flame. POP! It will usually burst almost immediately on contact. Extinguish the candle and collect the fragments. “The same candle burst this balloon. What might be different about our mystery balloon?” Let children reconsider their explanations. The comparison provides a useful clue, although they have not yet discovered what is inside the first balloon.

5 Listen for the secret

With the candle extinguished, gently shake the mystery balloon. “Listen carefully. What can you hear?” Allow children to identify the sloshing sound. Show the water bottle and confirm that you used it to add water to the balloon before the lesson. “Now we have another clue! Would you like to change your explanation?” Encourage them to connect the water with the balloon’s survival, rather than simply naming what they heard.





6 Follow the evidence

Check the support and position again, then relight the candle. Heat the water-filled base briefly once more. You can invite the children to count aloud. A slightly longer exposure, such as 5–10 seconds, should only be used if it has been established as suitable for your arrangement. Counting is a way to involve the children. Remember that repeated heating warms the water. Move the balloon clear and extinguish the candle before showing its underside. “Look at that black mark! It came from the candle flame—our balloon really was exposed to it. So, what is the water doing?” Explain that the mark is soot, a carbon-rich deposit produced when candle wax burns incompletely. It is a visible clue that the balloon was exposed to the flame. Bring the explanation together:

A simple explanation

“The water takes in heat from the candle, helping to stop the rubber getting too hot. Water needs lots of heat to warm up, so it protects the balloon for a while. But if we keep heating, the water gets warmer and the balloon may eventually pop!”

A more scientific explanation

“Energy passes through the thin rubber into the water. As the water near the flame warms, it expands, becomes less dense and rises. Cooler, denser water moves into its place. These convection currents carry energy away from the heated area. Water also has a high specific heat capacity, which means it takes a lot of energy to raise its temperature. Together, these effects help keep the heated rubber cooler for a while.”

7 Let them predict the ending

Point out where the water sits. “The water is down here. What would happen if the flame touched the rubber above the waterline?” “Which part of our demonstration helps you decide?” Give children time to explain. Above the waterline, water is no longer touching the inside of the heated rubber. That area can become hot enough to weaken and tear very quickly, just as the air-filled balloon did. For the standard classroom ending, finish with their prediction and explanation.

Optional finale with a splash

Ready for one last prediction? “What will happen if the flame touches the balloon above the water?” If including this ending, cover it in your risk assessment and use the supported balloon,





fixed candle and catching tray described earlier. Warn the children about the bang and splash, keeping everyone behind the viewing boundary. Relight the candle. The adult carefully repositions the balloon so the flame touches the rubber above the waterline. POP! Extinguish the candle if it is still alight and clear up before anyone approaches. “There was still water inside—so why did it pop?” The water could no longer take heat away from the rubber where the flame touched it. That small area quickly became hot enough to weaken and tear. The key discovery is that water must be in contact with the inside of the part being heated. Simply having water somewhere in the balloon is not enough.

If the mystery balloon bursts unexpectedly

Stop, extinguish the candle and clear up. Check whether the balloon moved, the flame reached above the waterline, the support slipped or the rubber was damaged. Only repeat with a fresh balloon after identifying and correcting any problem. If the cause is unclear, finish through discussion rather than repeating the same arrangement. “That was not what we predicted. What might have changed?” An unexpected result can still lead to useful scientific thinking.

The science without the jargon

Water is good at soaking up energy

The flame transfers energy to a small patch of rubber. The rubber is very thin, so energy can pass through it into water touching the inside. This keeps the heated patch cooler than it would be with only air behind it. As the water nearest the flame warms, it becomes less dense and rises. Cooler water moves down to replace it and is warmed in turn. This sets up convection currents, which carry energy away from the heated patch and spread it through the water.



The movement may be too subtle to see inside the balloon, so use arrows on a drawing to help children picture what is happening. Water also needs a lot of energy to produce a modest temperature rise. Scientists describe this as its high specific heat capacity. Together, energy transfer into the water and circulation within it help prevent the rubber from becoming hot enough to weaken and tear during brief heating.





Why air does not do the same job

The inflated balloon contains very little mass of air. Air also carries energy away from the heated patch much less effectively in this arrangement. The local rubber therefore gets hot quickly and tears. We do not need to heat all the air inside before the balloon bursts.

Three ideas behind the balloon

- **Conduction:** Energy passes through the thin rubber into the water touching it.
- **Convection:** Water warmed near the flame rises, while cooler water moves down to take its place. This movement carries energy away from the heated patch.
- **Specific heat capacity:** The energy needed to raise the temperature of 1 kg of a substance by 1 °C. Water has a high specific heat capacity, so it can absorb considerable energy with a relatively small temperature rise.

Is there a moment when the water stops working?

There is no single, fixed “heat limit” for this demonstration. The rubber’s temperature depends on how quickly energy arrives and how quickly it is transferred away. A stronger flame, warmer water, a shift above the waterline or damaged rubber can lead to failure. Water keeps warming; it does not offer permanent protection. For older learners: heat is energy being transferred because of a temperature difference. Temperature tells us how hot or cold something is. The demonstration illustrates these ideas; it does not measure specific heat capacity.

From a little balloon to a great big ocean

“If a little water can take up energy from our candle, imagine how much energy an ocean can store!” This gives children a starting point for thinking about the sea around Ireland. Oceans absorb energy and release it again over time. Their large mass and water’s high specific heat capacity help their temperatures change relatively slowly. Mixing and ocean circulation also spread energy through the water and move it between places. The Atlantic helps moderate Ireland’s temperatures. Air arriving from the ocean can soften winter cold and summer warmth. Latitude, prevailing winds, ocean currents and altitude also matter: the sea is an important part of the explanation, not the only part.





Make the connection with Monaghan

Ask: “Monaghan is inland, so can the Atlantic still influence its weather?” Yes. Air moves across Ireland, carrying the ocean’s influence inland. A place does not need to sit on a beach to be affected by the sea. Compare Monaghan with an inland place at a similar latitude using reliable temperature records. A very cold Canadian day beside a mild Irish day is a weather comparison. To compare climates, use long-term monthly averages from the same period, commonly 30 years. Check the places’ altitude and distance from the sea too. Weather is what is happening over a short period. Climate describes the longer-term pattern and its variation. For older children, compare the warmest and coldest monthly averages and calculate each place’s annual temperature range.

Investigations to build on the surprise

Let children suggest changes, then ask: “What would we measure, and how would we keep the comparison fair?” Any flame work remains an adult demonstration. Do not use time-to-burst as the primary classroom investigation. Water volume: children can predict whether more water would change the result. More water can absorb more energy for the same overall temperature rise, but it also changes the balloon’s shape, weight and depth of water. A survival-time comparison would therefore be difficult to interpret reliably. Starting temperature: cooler water has more scope to warm before reaching a given temperature. However, balloon survival is also affected by flame position and rubber condition. Use this as a prediction question; a flame-free warming or cooling investigation gives clearer measurements.

Curriculum links and useful next questions

Choose the depth that suits your class. These are teaching connections, not a claim that one demonstration completes a curriculum outcome.

Primary science and geography

In SESE Science, useful links include Energy and forces—Heat; Materials—Properties and characteristics of materials and Materials and change; and working scientifically. Children predict, observe, discuss evidence and communicate an explanation.

In SESE Geography, connect with Natural environments—Weather, climate and atmosphere, and geographical investigation skills. For planning with the redeveloped primary curriculum, connect





the activity with Science, Technology and Engineering and with Social and Environmental Education. Select the relevant learning outcomes from the specification and stage your school is using. Keep the scientific investigation and the weather or climate follow-up visible in the learning evidence.

- Infants to second class: talk about the two balloons, draw what happened and complete “The water helped because...” orally.
- Third and fourth class: draw arrows from flame to rubber to water; explain why water must touch the heated patch.
- Fifth and sixth class: plan a follow-up investigation, record measurements and use a graph to support a conclusion.

Junior Cycle extensions

Science: Physical world 6 supports discussion of energy transfers and dissipation. Nature of science supports prediction, investigation, interpretation and communication. Add independent measurement and evaluation through the follow-up rather than treating observation alone as a full investigation. Geography: outcome 1.6 links to factors influencing Ireland’s climate. Outcome 1.8 is supported when learners gather, record and interpret weather data. The balloon provides an introduction; weather records and climate evidence are needed for the geographical work. Optional enrichment: specific heat capacity is the energy needed to raise the temperature of 1 kg of a substance by 1 °C. Numerical calculations are not needed for the primary explanation. Avoid treating iron as representative of all land: rocks and soils differ, especially when wet.

What about adding salt?

Salt changes water’s properties, but an ordinary balloon comparison is unlikely to isolate a clear effect. Keep it as a question about designing a better test rather than promising a dramatic result.

Finish with an explanation

Ask children to complete: “‘I thought...’ ‘I observed...’ ‘Now I think...’”. Follow with: “Why must water touch the heated patch?” and “How might the sea affect temperatures in Ireland?” Listen for improved reasoning, not just the right vocabulary.

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Sparks of imagination are at the heart of creativity!



THE HEATPROOF BALLOON

WATER – FROM MOLECULE TO OCEAN

How does water keep its cool and protect the balloon?

1 The Mystery

You've already seen me put water into the balloon. Now the question is ...

How do we burst the balloon?



2 The Candle Test

Let's try a candle flame. I'll hold the water-filled part of the balloon just above the flame.



3 The Big Splash

Now I'll move the flame to the part of the balloon above the water line ...



4 The Cake Flare Challenge!

Now for a bigger test – a cake flare! This is a much hotter flame ... will the balloon burst this time?



The Science Behind It

Specific Heat Capacity

Specific heat capacity is the amount of energy needed to raise the temperature of 1 kg of a substance by 1 °C.

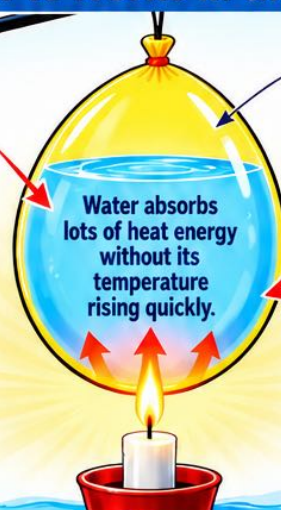
Material	Specific Heat Capacity (J/kg °C)	What does this mean?
Water	≈ 4,180	Needs lots of energy to heat up.
Iron	≈ 450	Needs much less energy to heat up.



Water needs more than nine times as much energy as iron to raise the same mass by 1 °C. That's why water is such an amazing heat store!

How It Works in the Balloon

Heat passes through the thin balloon material into the water.



The balloon material stays cool because the water inside absorbs the heat.

If the flame heats the part of the balloon above the water level, there is no water directly behind it to absorb the heat, so the balloon material heats quickly and pops.

Water – From Molecule to Ocean

This demonstration uses just a small amount of water. The same property of water that protects this balloon – its high specific heat capacity – allows our oceans to absorb and store vast amounts of heat energy.

**One small demonstration.
One very big idea.**

Links to the Irish Curriculum

Supports learning about:

- ✓ materials and their properties
- ✓ energy and heat transfer
- ✓ scientific investigation
- ✓ the natural world – weather and climate

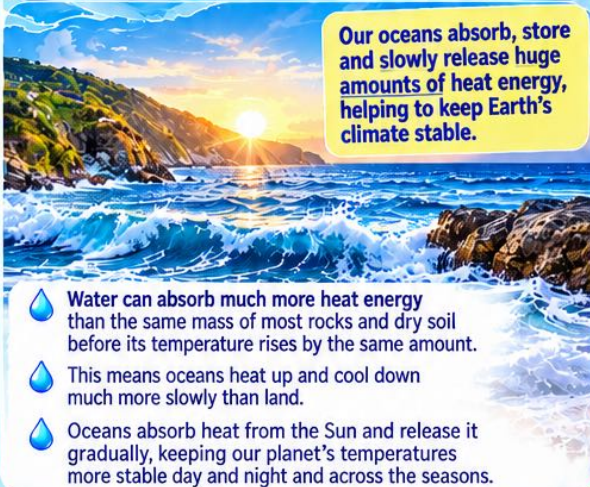


WATER – FROM MOLECULE TO OCEAN

How water's amazing properties shape our world

Same science ... bigger picture!

Oceans – Earth's Heat Reservoir



Our oceans absorb, store and slowly release huge amounts of heat energy, helping to keep Earth's climate stable.

- Water can absorb much more heat energy than the same mass of most rocks and dry soil before its temperature rises by the same amount.
- This means oceans heat up and cool down much more slowly than land.
- Oceans absorb heat from the Sun and release it gradually, keeping our planet's temperatures more stable day and night and across the seasons.

Same Latitude – Very Different Winters!

Monaghan in Ireland and The Pas in Canada are at almost the same latitude (about 54° N) – but their winters are very different! Why is Monaghan so much warmer?

 **Monaghan, Ireland**
Latitude: 54° N
January average: 4 °C

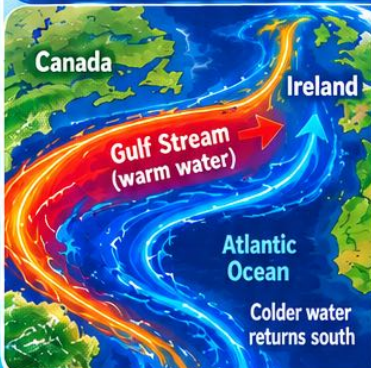


 **The Pas, Manitoba, Canada**
Latitude: 54° N
January average: –18.8 °C
Winter temperatures can fall below –30 °C



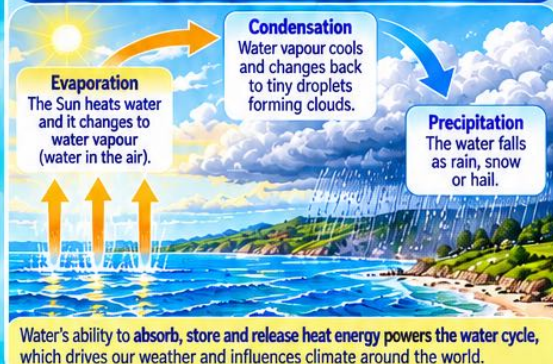
They're at the same latitude – so why is Monaghan so much warmer?

The Gulf Stream and Ocean Circulation



- The Gulf Stream carries warm water from the tropics towards Europe.
- This warm water helps to keep Ireland's climate milder than other places at the same latitude, such as parts of Canada.
- Warm ocean currents, together with prevailing winds, bring milder air to Ireland.
- Without this ocean heat transport, our winters would be much colder.

Water Drives Weather and Climate



Engineering with Water

Water's high specific heat capacity makes it useful in many real-world and industrial applications.

Cooling systems



Water absorbs heat in cooling systems (e.g. power plants and engines).

Energy storage



Water can store heat energy for later use (e.g. in solar thermal systems).

Heating and cooling buildings



Water is used in heating and cooling systems in homes and buildings.

Cooking



Water can absorb lots of heat energy, making it ideal for cooking.

The Big Picture – Our Amazing Planet



Water's unique properties make life on Earth possible.

- ✓ Regulates Earth's temperature.
- ✓ Drives our weather and climate.
- ✓ Supports ecosystems and the food we grow.
- ✓ Influences where people live.
- ✓ Plays a vital role in a safe, sustainable future.

SAME SCIENCE → BIGGER PICTURE → BRIGHTER, MORE SUSTAINABLE FUTURE

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Sparks of imagination are at the heart of creativity!