NPL
National Physical Laboratory

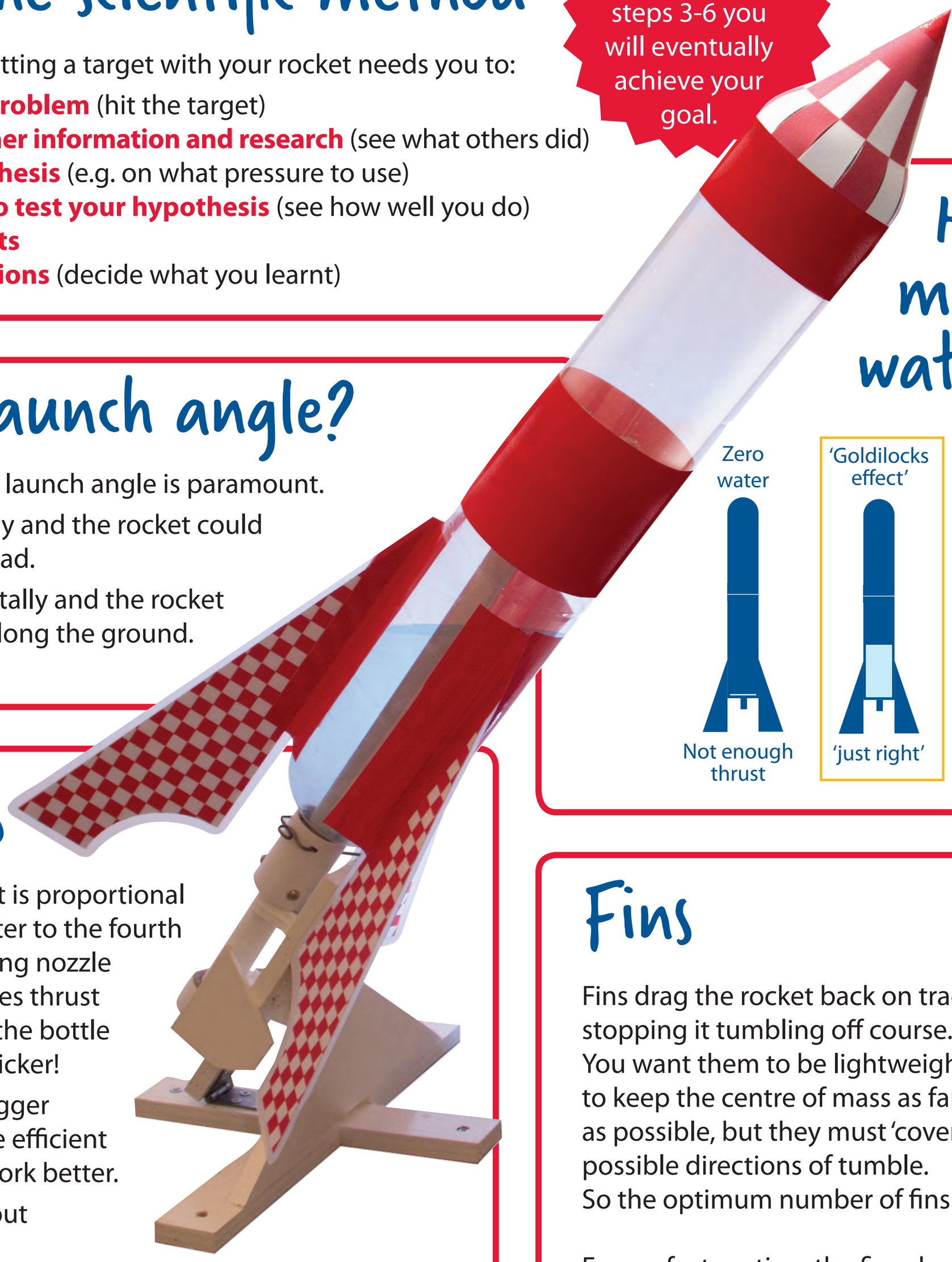
Designing water rockets

Using the scientific method

The challenge, hitting a target with your rocket needs you to:

1. **Define your problem** (hit the target)
2. **Observe: gather information and research** (see what others did)
3. **Form a hypothesis** (e.g. on what pressure to use)
4. **Experiment to test your hypothesis** (see how well you do)
5. **Analyse results**
6. **Draw conclusions** (decide what you learnt)

Hopefully, by repeating steps 3-6 you will eventually achieve your goal.



Which launch angle?

Getting the right launch angle is paramount.

- Launch vertically and the rocket could land on your head.
- Launch horizontally and the rocket will likely skid along the ground.

How much water?

Nozzles

Incredibly, thrust is proportional to nozzle diameter to the fourth power so doubling nozzle aperture increases thrust 16 fold, though the bottle empties a lot quicker!

Nevertheless, bigger nozzles are more efficient so do seem to work better.

It's time to drill out your nozzles!

Fins

Fins drag the rocket back on track, stopping it tumbling off course.
You want them to be lightweight – to keep the centre of mass as far forwards as possible, but they must 'cover' all possible directions of tumble.
So the optimum number of fins is 3.

For perfect motion, the fins should be identical in size and positioned evenly around the fuselage.

Amazing facts

On leaving the rocket, the air expands and its heat is shared over a larger volume so it cools down, typically to –75 °C. (Yes – we checked this!)

Typical rocket launch energy, just over 100 joules, creates a g-force of almost 30 g over a very short time (0.06 second). Mean launch power is about 2 kW. Check out **www.npl.co.uk/wrc**

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