Space Universities Network
Supporting the Space Higher Education Community

Making Comets Outreach Project

University of Nottingham

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Space Universities Network Case Study

Title

Making Comets Outreach Project – University of Nottingham

Summary

This is an activity on making comets, which engages students by linking rainbows, spectra, and flame tests to comets, emphasising the search for life-bearing minerals and the origin of water on Earth. It is designed to be carried out as an outreach activity for students in KS2-3 and can be carried out in most classrooms, provided there is good ventilation. The activity is also a good form of sensory engagement, especially for any student with visual impairments. The comets are made from a selection of household materials, with the only specialist/hazardous material being dry ice.

Mini-comet, mid-process

Finished mini-comet

Overview

This is an outreach project which offers a multi-sensory exploration of comets, including their feel and smell, and aims to inspire students to explore and discuss their findings, encouraging them to reflect on the broader implications of their studies. This has inspired and educated students about space, astronomy, and STEM subjects, as well as sparking curiosity in the wonder of space and our universe.

Aim

To help primary and secondary students learn about comets, make a model comet, and find out what light can tell us about the universe in a fun and accessible manner.

Objectives

1. To inspire students about space, astronomy, and STEM subjects, and to spark curiosity about the wonders of our universe.
2. To enable students to describe how comets have played a significant role in human (and dinosaur) history.
3. To highlight some ways engineers and scientists explore our universe (including smelling comets).
4. Some students may be able to explain how the properties of rainbows and rainbow science (spectroscopy) can help us understand our universe.

Context/Background

Outreach projects about space in primary schools are important because they help shape the future of science and technology while making learning fun and engaging for young minds. This can help bridge the knowledge gap at an early age, especially for schools without the infrastructure or resources to run projects like this, as well as helping to develop critical-thinking and problem-solving skills. Outreach is designed to help inspire the next generation of future space employees, and can also be a valuable tool in helping to encourage greater diversity in STEM subjects/careers further down the line.

This activity in particular, focusing on comets, was designed to work towards these above objectives and opportunities, and is especially useful for helping with DEI-elements as it is an inclusive activity that offers a multi-sensory experience, which is beneficial for all students. The obvious precautions taken around the dry ice used in the activity also highlights to students the importance of safety in science.

The activity was developed by Jez Turner at the University of Nottingham, who is a strong proponent of championing outreach projects such as this, and was inspired by a similar activity created at the National Space Centre in Leicester.

Key Learning Points

In aiming to enthuse a younger audience into STEM, the activity asks the key questions of ‘What is a rainbow scientist and what do they do?’ By providing some historical examples of comets in popular culture(s), it aims to demonstrate that this topic is something which has been a regular presence throughout human existence. Similarly, there are learning opportunities around the chemical make-up of comets, represented (mainly) by items that can be found in a household. There is also a key learning point around safety in science, by demonstrating the seriousness taken with the dry ice.

Required Resources

Well-ventilated classroom (or similar space)

Presentation delivery equipment (projector or TV, laptop, etc.)

Traditional (non-LED) light source

Prism

Plastic/paper cups

Paper

Wooden spoons

Sandwich bags

Sand

Soy sauce

Red wine vinegar

Malt vinegar

Salt

Solid CO_2 ('dry ice')

Water

Nitrile gloves for students making comets

Gloves with thermal insulation for staff handling dry ice

Lab coats

Eye protection

Health and Safety

This activity requires a well-ventilated area. Due to the use of dry ice, please make sure that safety spectacles, lab coats, and nitrile gloves that cover any exposed skin are used.

Before conducting the activity, a health and safety risk assessment will need to be carried out. Please check with the specific school about their requirements as this can vary, as well as any requirements from your institution; this is recommended whether you are hosting a visit to your facility, attending an event at the school, or meeting in a third location (who should also be consulted as part of the assessment). An overview of some key health and safety points that should be considered in your risk assessment can be found in Appendix A of this document.

Activity Description

Section One – Presentation

The presentation provides context to the activity, introducing the topic and motivating the students for the practical element. A copy of the example slides can be found in Appendix B as well as being available as a pdf on the Making Comets Outreach Page on the Space Universities Website, and a narrated version of this is available on this page as well. **Note**: This narrated presentation is to provide the details that accompany the slides to enable anyone conducting the activity to deliver this themselves, and has not been recorded to be played to the students.

The presentation asks students, ‘Who wants to be a rainbow scientist?’

Slide 1 - Illustrate what you expect them to kind of get out of the activity - mainly, that they should be able to state some properties of rainbows and comets, and describe the role of engineering and how it makes discoveries. Explain that astronomers spend about 90% of their time looking at spectra and spectrum to make discoveries about objects in the night sky.

Slide 2 - With the Northern Lights, explore why we see the colours in the sky, linking between the gasses and the atmosphere and gasses glowing. Make sure that people realise that Earth is a planet in space, and that it is not separate from the universe. This means that discovering things about Earth and what happens on Earth can help us understand what is out there in the wider solar system and beyond.

Slide 3 - This is where you provide the link to rainbows; an old fashioned light source and a prism allows you to create a rainbow. Demonstrate that a rainbow is not just 7 colours, but a spectrum with no clearly defined or delineated colours. Ask the students - What do you think a rainbow is? Allow them to discuss this, without giving any right or wrong answers, and encourage them to come up with some reasonable ideas to explore rainbows. This is also a good opportunity to ask if they would like to be a rainbow scientist.

Slide 4 - This slide helps to connect rainbows with the colour of the of the stars in Kemble's Cascade, which demonstrates both the chemicals that the star is made of as well as the temperature of the star itself. Get the students to think about a rainbow and think about atoms, how atoms can produce light, and how atoms can absorb light. Using a spectrometer, tiny dark lines can be seen where light has been absorbed, showing the presence of elements like calcium and iron and magnesium.

Slide 5 - This is a demonstration of another activity, called a ‘Whoosh Bottle’, which helps to demonstrate how different chemicals burn in different colours.

Slide 6 - This slide shows chondrite that has been put underneath a microscope for some chemical analysis based on the light and reflection of the light.

Slide 7 - This slide shows an excerpt of the Bayeux Tapestry, depicting the Battle of Hastings. In the Tapestry, there are people who can be seen pointing at a hairy star, which was a foreboding portend and seen as a 'harbinger of doom.'

Slide 8 - By working backwards, we have been able to work out that this ‘hairy star’ was actually Haley’s Comet, which appears every 76 years.

Slide 9 - These are images of Comet Halley in 1910 and 1986. This is an opportunity to ask the students to think about what a comet is, explaining that there isn't a definitive definition because some asteroids have comet-like properties and some comets have asteroid-like properties. Explain that these comets are coming from way out in the solar system and as they get close to the sun, they start to sublimate, and their dust gets blown away by the solar wind, creating tails. Looking at the light from this, we can analyse this light and find out what they're made of by using rainbow science.

Slide 10 - Ask the students to think about smelling a comet, because when Rosetta and Philae landed on the surface and did some chemical sniffing, they confirmed some of these observation from spectroscopy, about the chemical makeup of these comets.

Slide 11 - This accompanies that practical element of the activity, and is left visible throughout Section Two.

Section Two – Practical

Following the main section of the presentation, the practical element can then begin. A video demonstration of the activity can be found on the Making Comets Outreach Page on the Space Universities Website.

The activity can be carried out by individual students through to groups of up to 6, depending on the space/materials available. **All students must be wearing their PPE from this point**. Put paper down first before starting the comet making experiment.

Step 1 - Have the students line their plastic cups with a food bag.

Step 2 - The students can now add several spoons of sand to the cup; this does not have to be an exact amount or even between participants, reflecting the fact that comets come in different shapes and sizes.

Step 3 - They now begin to add further materials, giving a good stir between each one. These are the red wine vinegar (representing alcohol), the malt vinegar (representing acid), the soy sauce (representing organic matter), and the salt. These can be added in any order, and can again be added in varying amounts.

Step 4 - Students add water, approximately one third of the volume of the cup. Be sure they do not add too much water to ensure the dry ice has the desired effect in a good time. Stir the mixture again.

Step 5 - This step requires the staff member responsible for the dry ice to upgrade their PPE to include the thermal gloves. As you go around to add the dry ice, make sure to emphasise to the students that they should not touch their comets with the dry ice inside, and should not touch the dry ice directly.

Step 6 - Add 2-3 scoops of dry ice to each cup, and then give the cup a shake. Explain that the dry ice will be freezing the water in their cup.

Step 7 - At this stage, tell the students that the dry ice is freezing the comet, simulating the effects of deep space; the room is acting like the Sun as the heat source affecting the comet. As the room heats the dry ice, it is the same as the comet getting closer to the Sun, increasing in temperature, and the liquids and gasses are undergoing change, which is why their comets will be making hissing or popping noises.

Step 8 - Encourage the students to make observations about their comets – what does it look like, smell like, or sound like? Make sure they still do not touch the comets at this stage.

Step 9 - When the comet has sufficiently warmed up, the students will be able to draw the mixture together in the food bag and squeeze it in their gloved hands, allowing them to feel the comet binding into a solid mass.

Step 10 - Pour any liquid back into the cup and then carefully pull the edges of the bag back to expose the freshly made comets.

Step 11 - Ensure everything is tidied up thoroughly after the activity, checking for any dry ice that may have been spilled, and making sure that the dry ice container is secured.

Section Three – Presentation

Slide 12 - As a further activity/homework, encourage the students to watch ESA's video on Rosetta and Philae (this is approximately 25 minutes in length): https://www.youtube.com/watch?v=HD2zrF3I_II

Slide 13 - Return to and reinforce the objectives of the activity. Ask the students to reflect on what they have learnt and who they could discuss this with. Ask for one thing they are going to take away and share with someone who wasn't in the room for the activity, such as a friend or family member. Remind them that they could become a rainbow scientist.

Thematic Categories

Method		Topic	
Online Text and Notes	☐	Orbits and Trajectories	☐
Assessment Materials	☐	Rocket Propulsion	☐
Video and Audio Lectures	☐	AOCS/ADCS	☐
Lecture Slides	x	Payloads	☐
Curricula	☐	Power	☐
Video and Audio Clips	☐	Communications	☐
Recommended textbooks	☐	On Board Data Handling	☐
Useful software	☐	Systems	☐
Worksheets and Projects	☐	Mechanical	☐
Simulations	☐	Thermal	☐
Tutors' Guides	x	Astronomy	x
	☐	Earth Observation	☐
	☐	History of Spaceflight	☐
	☐	Other	x

Contact Details

Name of Organisation	University of Nottingham
Contact Name	Jez Turner
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Links	ESA Rosetta and Philae video: https://www.youtube.com/watch?v=HD2zrF3I_II

Thanks to the University of Nottingham for this case study.

University of Nottingham
UK | CHINA | MALAYSIA

The work to prepare this case study for SUN was funded by:

UK SPACE AGENCY
University of BRISTOL

Appendix A

Health and Safety

General Information

Chemicals Used:

Sand

Water

Soy sauce

Vinegars

Solid CO_2 (dry ice)

Special precautions for chemicals and experimental work:

Solid CO_2 needs a vent, for expansion.

Eyes must be protected; no exposed skin; thermal protection gloves must be used to limit the very low risk of solid CO_2 coming in contact with skin or eyes. This will also prevent sand or soy source getting in the eyes.

Adequate ventilation is needed to limit the very low risk of asphyxiation from CO_2 inhalation.

Physical conditions:

Temperature: −78.5°C

Pressure: Atmospheric

Environmental considerations:

Do not empty into drains.

Details of any biological effects:

No biohazards.

cont…

Risk Assessment

The following three hazards are applicable to all persons in the vicinity of the activity, including staff delivering the outreach, school staff, students, and any other persons involved or in the room in which the activity is taking place.

Hazard 1: Adequate ventilation is needed to limit the very low risk of asphyxiation from CO_2 inhalation.

Associated Risk: 10 kg of dry ice will produce 5 m^3 of gas, raising the level of CO_2 from 0.035% (natural) to safe-limit of 0.5% in a room 3m high by 19m on a side.

Risk Control Measures: Adequate ventilation is needed to limit the very low risk of asphyxiation from CO_2 inhalation. Windows should be open. Any room must be checked to ensure adequate ventilation before experiment is carried out (assuming that full opening of doors/windows will not in any other way cause a hazard to students).

Hazard 2: Cold 'burns' from solid CO_2.

Associated Risk: Dry ice sublimes at -78°C and will cause serious skin 'burns' on contact, but momentary contact is unlikely to be a problem.

Risk Control Measures: Only trained staff should use the solid CO_2, with all other people standing at least 1m away. Eyes must be protected with goggles/safety glasses, there must be no exposed skin, and thermal protection gloves must be used, to limit the low risk of solid CO_2 coming in contact with skin or eyes. This will also prevent sand or soy source getting in the eyes. Schools must be told in advance to make sure that students have long sleeves and covered legs. No open shoes, to prevent 'burns' to feet.

In the event of any cold 'burns', follow the processes listed below in the 'Emergency Procedures' section.

Hazard 3: Solid CO_2 needs a vent for expansion or it will pressurise any container.

Associated Risk: Explosion of container.

Risk Control Measures: Nitrogen-rated sealed container with a vent hole for expansion should be used for transport.

Please note – this risk assessment should not be considered exhaustive. Please ensure that you have conducted a full risk assessment before conducting this activity.

cont...

Emergency Procedures

Spillage/Accidental Release

Ventilate area by opening windows/doors and make sure people exit the room via a route away from the solid CO_2 (routes must be considered when planning the experiment) while a standard dustpan and brush are used to put it back in storage container.

Fire-Fighting Measures:

No specific recommendations; material will not burn. In case of fire in the surroundings, use appropriate extinguishing agent.

First Aid Measures:

Eye Contact

Apply copious amounts of tepid water to the affected area of skin to reduce freezing in the tissue, loosen any clothing that may restrict blood circulation, and move the injured person to a warm place but not a hot environment. Do not apply heat to any affected parts. In case of frostbite, spray with water for at least 15 minutes. To protect frozen areas, apply a loose, non-fluffy sterile dressing. Seek medical attention immediately.

Skin Contact

Apply copious amounts of tepid water to the affected area of skin to reduce freezing in the tissue, loosen any clothing that may restrict blood circulation, and move the injured person to a warm place but not a hot environment. Do not apply heat to any affected parts. In case of frostbite, spray with water for at least 15 minutes. To protect frozen areas, apply a loose, non-fluffy sterile dressing. Seek medical attention immediately.

Ingestion

Swallowing must be absolutely avoided, since coldness and developing pressure could be dangerous. Obtain immediate medical attention and take along these instructions.

Inhalation

Low concentrations of CO_2 cause increased respiration and headache. In high concentrations, this may cause asphyxiation. Symptoms may include loss of mobility/consciousness. Victim may not be aware of asphyxiation. Remove victim to uncontaminated area wearing self-contained breathing apparatus. Keep victim warm and rested. Call for emergency medical support. Apply artificial respiration if breathing stopped.

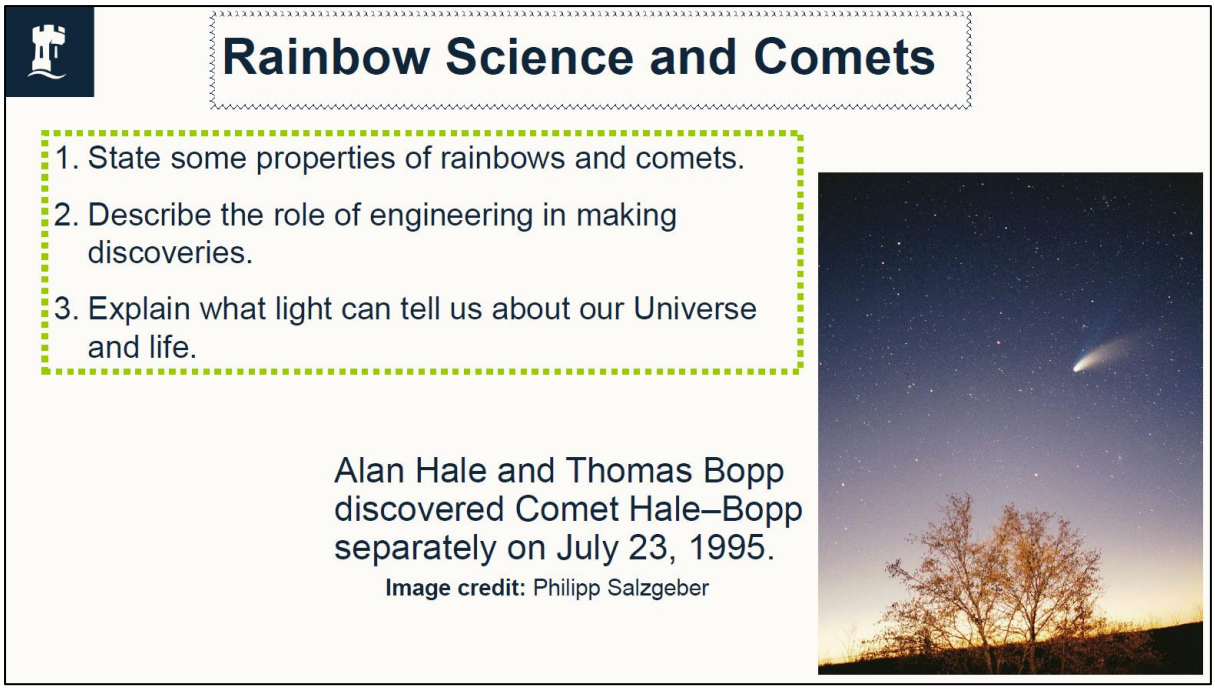
Ends.

Appendix B

Presentation Slides

These slides are available on the SUN website page for this activity; they are included here for ease of reference regarding the delivery of the activity.

Slide 1

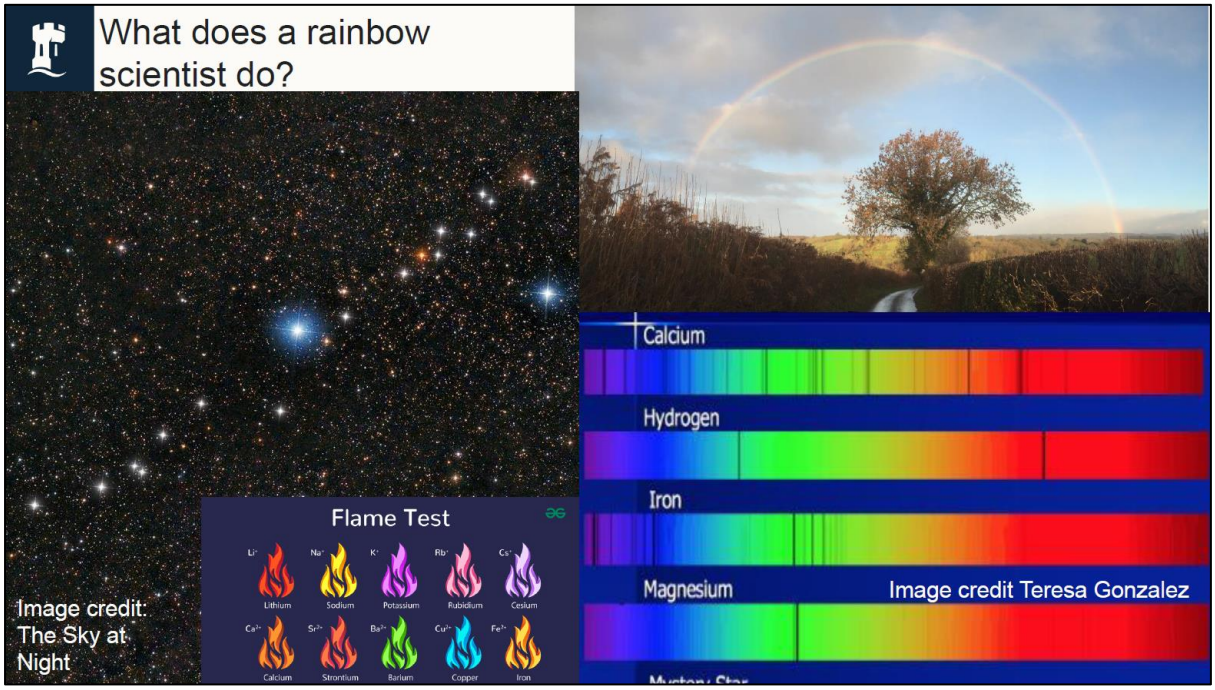


Slide 2

cont…

Slide 3

Slide 4



cont…

Slide 5

Slide 6

cont...

Slide 7

Slide 8

cont…

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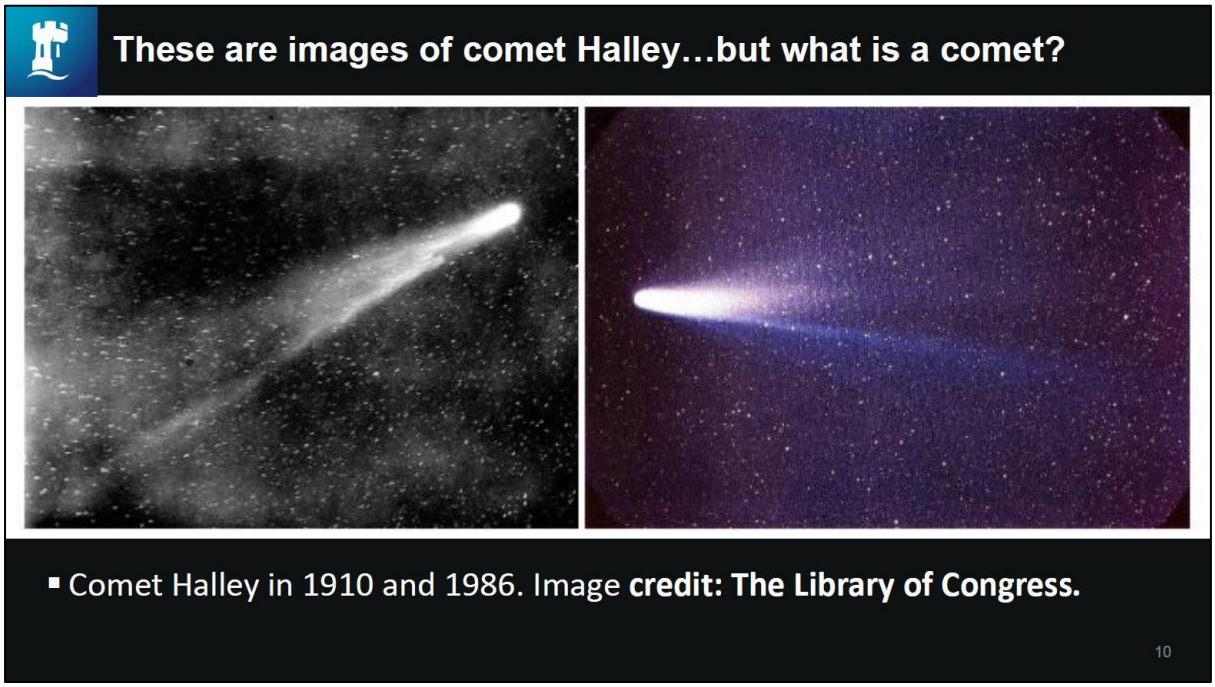
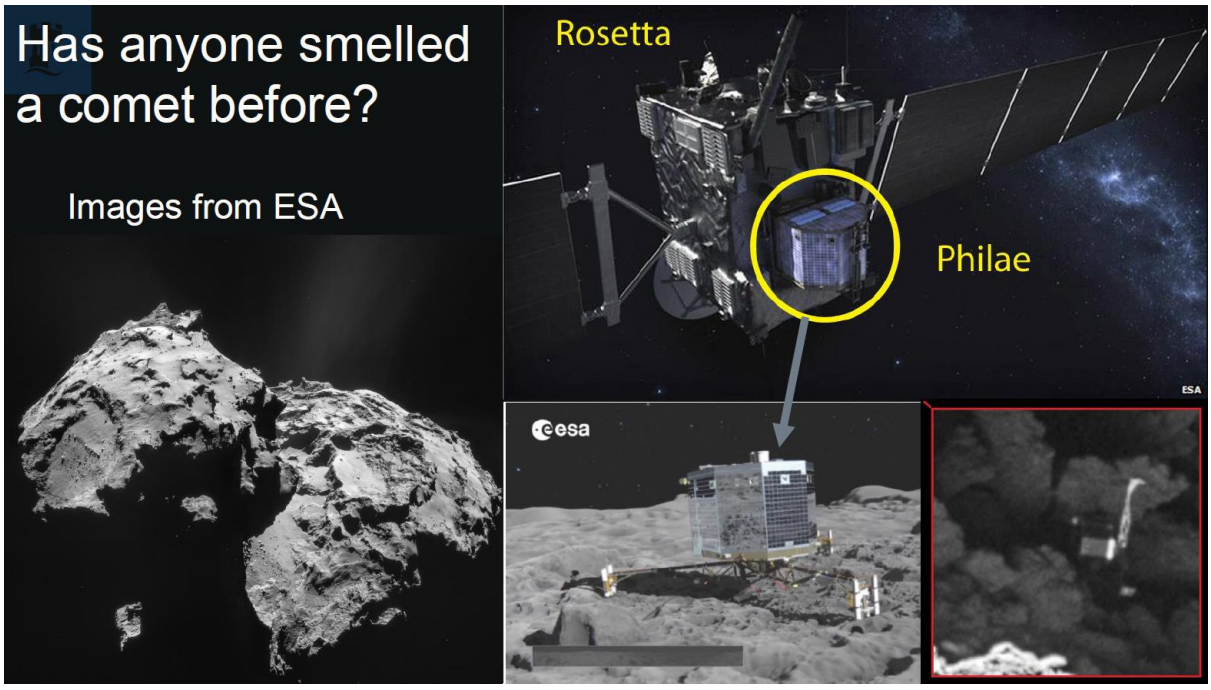
Slide 9



Slide 10



cont…

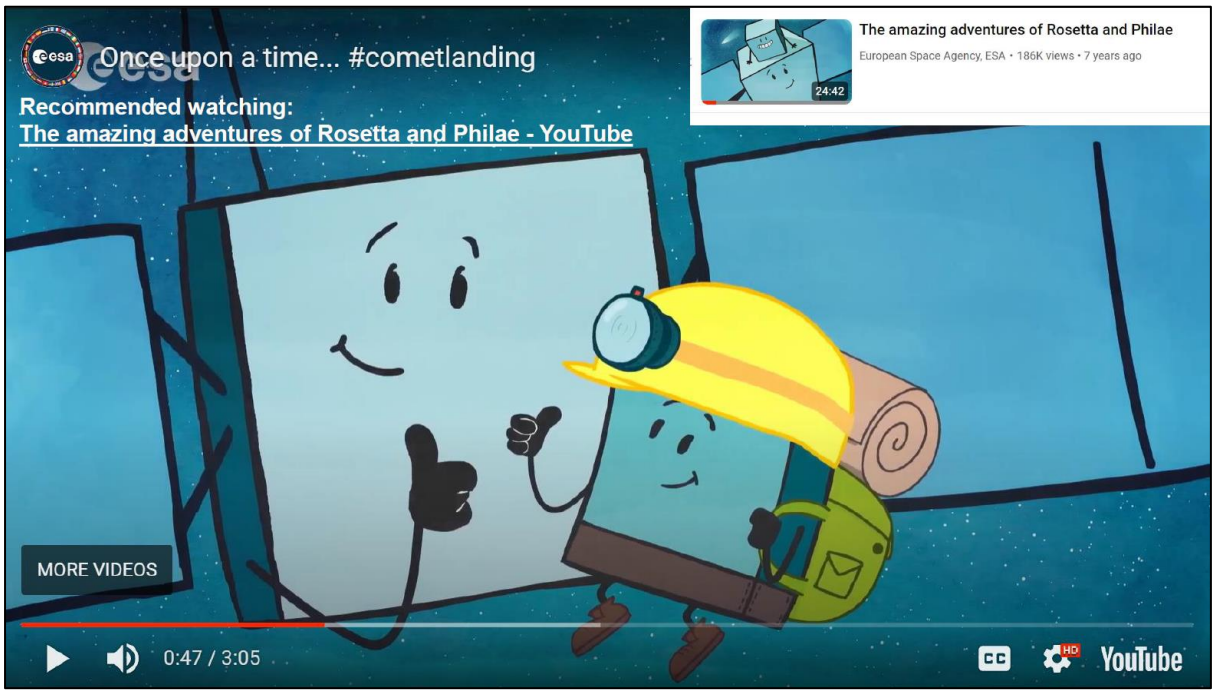
Slide 11

Make and smell a comet…wear gloves, long sleeves and goggles.

- Get a plastic cup and put a plastic bag inside it.
- **In any order you need to add:**
- Two or three spoons of sand (silicates)
- 1/3 cup of water
- A few **drops of** soy sauce (organic) and vinegar (acid)
- Some salt
- Mix them all up with the spoon
- Then Gloria or Jez will add dry ice (solid carbon dioxide) to freeze your comet.
- **Leave it for a few minutes then give the bag a gentle squeeze**
- Finally, pour off excess water into the waste bucket.

Warning!!!
Do not touch the frozen comet!!!

Slide 12



cont…

Slide 13

Rainbow Science and Comets

1. State some properties of rainbows and comets.
2. Describe the role of engineering in making discoveries.
3. Explain what light can tell us about our Universe and life.

Discuss the objects and ask questions please.

Image credit: Philipp Salzgeber

Ends.