This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 640190

EURO-CARES
A PLAN FOR EUROPEAN CURATION OF RETURNED EXTRATERRESTRIAL SAMPLES

Work Package 8

Deliverable 8.6: EDUCATIONAL MATERIALS (pre 16 years of age)

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Educational Materials (Schools)

Change to Deliverables content: Following analysis of the national curricula and education guidelines of several different EU nations, the Work Package 8 (WP8) team decided that it was more appropriate to include educational materials for students aged over 16 in the 'Universities' deliverable (D8.7) rather than the 'Schools' deliverable (D8.6). The change has been reflected in a change to the titles of the deliverables, from 'Schools' to 'Pre 16 years of Age' and 'Universities' to 'Post 16 years of Age'. This report covers material for the pre 16 years of age students.

Background: Prior to preparing any educational materials, the Work Package (WP) team had to decide on a strategy for producing materials that would be (a) relevant for a range of ages across the different curricula pertaining in the European nations and (b) useful for teachers. To tackle these criteria (relevance and usefulness), the team first examined the national schools' curricula of the UK, France, Germany and Italy, and then convened a focus group of teachers from different school levels to discuss what sort of materials would be most appropriate to produce.

National Curricula: the UK has a very detailed (some would say quite prescriptive) national curriculum for schools (https://www.gov.uk/national-curriculum/overview). France also has a national curriculum (http://www.education.gouv.fr/pid24/les-niveaux-et-les-etablissements-d-enseignement.html), but it is more general in terms of its content than in the UK. In contrast, Germany and Italy have teaching guidelines to ensure appropriate levels of literacy and numeracy, whilst leaving content to individual states/regions. **Conclusion**: The WP team preparing the materials decided, therefore, that the UK curriculum would be used as a basis for the resource, on the grounds that if the material spoke to the UK curriculum, it would also meet the more flexible requirements of the other consortium nations.

Focus Group: because of time constraints, the focus group convened was only of UK teachers; however, since we had already made the decision to base the materials on the requirements of the UK national curriculum, we felt that this was not a problem. Membership of the focus group (which met once, following exchanges of e-mails) included an Early Years (EY) teacher and a Special Needs specialist, as well as teachers at primary and secondary levels. **Conclusion**: the unanimous conclusion of the focus group was that there were abundant written materials already freely available, but that teachers did not have time to search them out. At all Key Stages (from Early Years to GCSE, ages 3 to 16) what was required were practical activities that would enrich lessons already designed to deliver the national curriculum. For ages over 16 (in the UK, sixth formers taking A-Levels in preparation for university entrance), enhancement activities were deemed to be more appropriate if they were in the form of material that was complementary to the syllabus, designed to stretch the capabilities of the more able students.

Outcome: Following the consultation exercise, the following decisions were taken regarding the materials to be delivered to schools:

(i) The subject of the materials would be 'Living and Working on the Moon';
(ii) There would, in the first instance, be a single practical project forming the core of an activity, around which information of increasing levels of complexity and depth would be

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built. At all stages, there would be adaptations of the material to enable children with special needs (physical and developmental) to take part;

(iii) There would be three levels, suitable for Early Years children (ages 3 to 4), primary school children at Key Stages 1 and 2 (ages 5 to 7 and 8 to 10, respectively) and secondary school students at Key Stages 3 and 4 (ages 11 to 13 and 14 to 16, respectively);

(iv) Sixth form students would have a separate set of materials, based around use of a Virtual Microscope and taking part in a virtual Field Expedition (vFE). These materials would now be included in deliverable D8.7.

Format of the Resource: It was stressed by the focus group that teachers were more likely to use the material if they had something that they could physically handle and work with, rather than a list of web-sites pointing to external resources. It was decided that the project would be presented as a series of cards in a wallet/envelope, with teaching notes that tied directly to specific sections of the national curriculum. This would be delivered to the schools using various networks. The resource will also be available through the EURO-CARES website (http://www.euro-cares.eu/).

Subject Area: analysis of the UK National Curriculum by the WP8 team was confirmed by the focus group: 'Space' does not appear as a stand-alone subject within EY and KS 1 and 2 of the curriculum, but rather is used as a basis in which to develop numeracy and literacy, as well as ideas of communication, collaboration and responsibility. Within KS 3 and 4, a more specialised study of 'Space' includes knowledge of the Sun and planets in the Solar System, orbits, satellites, etc. It was decided that the Moon will be the core of the resource, and that the main activity will be design of a lunar lander. Material included in the resource will be as follows:

A wallet containing the following cards (the wallet and cards would be laminated for durability):

1. A plan for an afternoon classroom practical session on 'Living and Working on the Moon'
2. Build a lander: Materials required
3. Build a lander: Practical notes, including link to video/podcast showing what to do
4. Five separate sets of teaching notes, covering specific sections of the National Curriculum for EY and the 4 Key Stages, for use in lessons both leading up to and following on from the practical session
5. Suggested enrichment and consolidation activities following on from the afternoon session (poems, stories, drama, etc.)

Next Steps:

(i) 'Road Test' the resource by deploying it in a primary school (EY and KS 1-2) and a secondary school (KS 3-4), gaining feedback from the teachers using the resource;

(ii) Upload the finalised project and associated teaching notes to a dedicated section of the EURO-CARES website;

(iii) Print the materials in English, and distribute to primary and secondary schools *via* the Association of Science Educators;

(iv) Translate the materials into French, German, Italian and Spanish;

(v) Determine the best national networks in the other European countries that can be used to distribute copies of the materials.

Visiting the Moon

Teachers' Notes and Suggested Activities

Key Stages 1 and 2

Foreword

These teaching notes have been prepared by Monica Grady, Professor of Planetary and Space Sciences at the Open University, on behalf of the EURO-CARES consortium. Monica was advised by a small team of teachers who work with a range of age groups from Early Years (EY) to KS4; the team also included a SEND specialist. The notes were 'road tested' on children of different age groups from schools in different Local Education Authorities in England.

The work was part of the EURO-CARES project, which received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 640190.

The teacher in the story is Mrs Grady, in memory of Professor Grady's mother, who was an EY teacher for over 50 years, still working in a local school up until she died in January 2017.

EURO-CARES:

European Curation of Astromaterials
Returned from the Exploration of Space

http://www.euro-cares.eu/

European Commission

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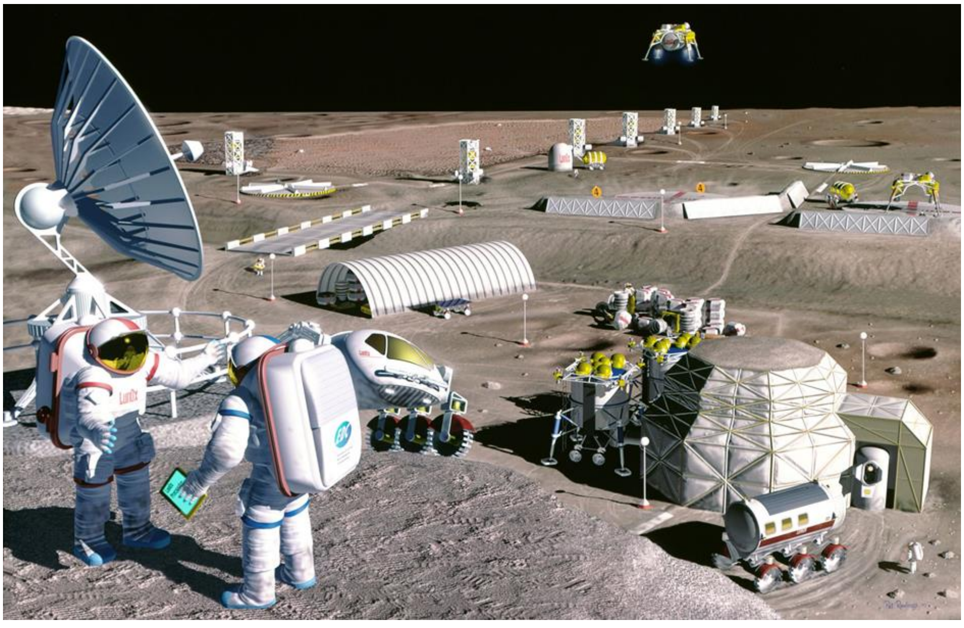
Introduction

The general principle of scientific observation and experimentation are introduced to students from the very earliest of stages in the national curricula of the different nations within the United Kingdom. The excitement of scientific discovery is demonstrated through experiments that the students can undertake themselves, either on their own or in groups. There is a careful attempt to link observations to everyday life, and a gradual progression in the complexity of the material taught.

This series of workplans for Keystages 1 and 2 (KS1, KS2) is based on the National Curriculum in England (NCE). We have extended application of scientific discovery beyond Earth, to explore our nearest neighbour, the Moon. We have taken the idea of ‘Visiting the Moon’ as a framework for activities that reinforce the learning objectives of the NCE. In doing this, we hope to strengthen the interest that younger students have in space and space exploration. After all, they are the generation that will be designing and building spacecraft for tourism, and it may be their children who are the first to live and work on the Moon.



How the Workbook Works

The premise behind this workbook is that we have produced a guided, self-consistent learning session that can be used by teachers without them having to search the library or the internet for additional material. The plan, which can be stretched over several sessions, should, we hope, stand alone, complementing the curriculum that is being taught.

The booklet comes in three parts: KS1 (ages 5 – 7), KS2 (ages 7 – 11) and Additional Resources. In preparing this material, which is an enhancement of the NCE, we have assumed that the statutory sections of the NCE have already been introduced. A precis of the relevant section is given at the start of each session, to act as a quick recap or revision.

The Additional Resources comprise images, games, puzzles, etc, which can be freely copied. The images can also be found in a downloadable powerpoint presentation, that can be found **here**:

There is no time length set for the sessions – there should be about 2 hours of classroom work in each part, and the material can be broken down into shorter chunks for ease of delivery. There is also a practical activity – building a lunar lander - which should be expected to take around two hours. This activity is intended as an exercise in communication and team-working, as much as being about the Moon. A list of materials required is given, along with some simple instructions.

The sessions are structured around a story set in 2030, about a class that has been told it is gong on a trip to the Moon to stay at the Lunar base. As the children in the story ask questions, it is intended that children in the 'live' classroom situation would also ask questions to explore the idea of a trip to the Moon. Clearly, the story framework can be adapted to the local situation, or dropped entirely; it is merely intended to serve as a mechanism for introducing concepts and enabling discussion.

We hope that this is a useful resource: we would value comments and suggestions – please send any feedback to monica.grady@open.ac.uk

Acorn Class goes to the Moon

Teaching Note: This is written assuming that the students have been introduced to the concepts of day and night, the length of day and the changing seasons on Earth. They will know that the Earth orbits the sun, giving us the year, and that the Earth turns on its axis, giving us the day. They will also know that the Earth is tilted on its axis, giving us the seasons. Some of these concepts are revised here, and the session explore these concepts from the standpoint of the Moon.

It is October in the year 2030, and at Park Primary School, Acorn class are waiting to hear what their school trip would be. Mrs Grady, Acorn's class teacher, came into the classroom looking excited.

"We are going to take the whole class to the Moon" she said "to visit the lunar base. There is a new spaceship that can get us there – but we have to do some training first"

The class started cheering. Emily put up her hand.

"When will we go?" she asked

"In 4 weeks' time" replied Mrs Grady "As long as everyone is ready"

Dan was next.

"What training will we do – does it mean we have to be super-fit?"

"No" said Mrs G "you don't have to be super-fit for this trip, just be in good health, and able to use your brain."

"What about me?" asked Ash. "Can I come too?"

Ash had to use a wheelchair because his legs and back didn't work properly.

"Of course you can come" said Mrs G. "There is space for wheelchairs on the rocket, no problem."

Ash looked really pleased, but was still a bit worried

"Will my wheelchair work on the Moon? Or will the motor get clogged with dust?"

"It will work inside the lunar base" replied his teacher "but not outside, on the surface. For that, you will have to travel on a lunar rover – and I think you would enjoy steering one of those."

Ash was now beaming with pleasure:

"I can't wait" he said.

"Any more questions before we get to work planning the trip?"

Mrs Grady knew that her class would have lots of things to ask

Ishan raised his hand:

"How many days will we go for?"

"Are there any animals there" questioned Ellie "I mean, I know we haven't ever seen any, but could they live in burrows, like the Clangers"

Ellie was talking about one of the programmes that children watched in the olden days, and which were being repeated on InterWebTV.

"Let's talk about that in a minute" smiled Mrs Grady.

Imani was next:

"Is it summer or winter on the Moon at the moment? Will we need a torch?"

"What about clothes" asked Jordan "Will we need pyjamas, and where do we get our spacesuits from?"

"Can we play football on the Moon" called out Cara "or will the ball float away"

Isabel looked worried:

“Will it be really cold? Should I bring my woolly socks” she said.

Sami had remembered seeing a programme on the TV about astronauts living in space. He rushed out several questions at once:

“What will we eat – and will we have to eat through a straw, like on the space station and will there be proper toilets?”

Mrs Grady clapped twice. The class knew what that meant – it meant that they had to be quiet and listen.

“They are all good questions – but I will only answer some of them. The ones I don’t answer, we will work out together. So let’s start with Jordan’s and Isabel’s questions about clothes. Yes, you will need a space suit for the journey, and for when we are outside, but the company running the trip will provide those. When you are inside the lunar base, you will just wear ordinary clothes – so, Jordan, you will need your pyjamas.”

Jordan looked pleased – he had got some Star Wars Next Generation pyjamas for his birthday, and he wanted to show them off.

“Isabel – in a minute, we will talk about the temperature on the moon, so you can decide after that if you need your woolly socks”

Mrs Grady noticed that Kartik was looking a bit upset.

“What’s wrong Kartik,” she asked.

“I don’t think I can go” said Kartik

“Why not?”

“Because I wear specs, and you can’t put a space helmet over glasses” replied Kartik

“Who told you that?” said Mrs Grady. “Because it isn’t true – the new design of space helmet fits over spectacles – I wear glasses too, and I’m definitely going!”

Kartik beamed and wriggled with excitement and his specs bounced up and down on his nose!

Mrs Grady continued

“What would you like to eat Sami,” she asked.

“Pizza” was his reply.

“I’m sure they have pizza on the Moon, and a whole lot of other foods as well”

“Great” said Sami. “I was worried that we might just get to eat food pills, like on TV”.

“Remember we’ll be inside the Moon Base for most of the time” replied Mrs Grady “So we’ll get proper food, but there won’t be a lot of choice. And there won’t be much fresh fruit or vegetables – just dried fruit, like raisins and banana chips. Can you think why?”

The class was silent for a bit, then Matt put up his hand.

“Is it because the fresh fruit weighs more, so the supply ship can’t carry so much?”

“Exactly right” said Mrs Grady “And there are two other reasons as well. Any idea what they might be?”

“I think I might know” said Jess. “Is it because you get banana peel and apple cores and stuff, and then you have to throw that away?

“Good” said Mrs Grady “That’s correct. Anyone got an other ideas why dried fruit might be better than fresh? I’ve given you a clue in what I just said”

“Dried fruit lasts longer than fresh fruit, and it doesn’t go bad” said Matt

“Well done. Now Sami, if we have stopped you worrying about whether you’ll get enough to eat, shall we think about how you will go to the toilet? “

The class all laughed. Sami thought for a moment.

“On the space station, you have to go in a tube and it gets sucked away.”

“That’s right” Mrs Grady replied “but it won’t be quite that bad—there are proper toilets on the Moon Base, with a seat to sit on, but with a smaller opening. The girls will be OK—but you boys are going to have to learn how to go for a wee like girls do. Start practising at home”

The boys all looked embarrassed and shifted about on their seats awkwardly whilst the girls laughed at them. Mrs Grady started speaking again.

“Now, that’s all the questions I’m going to answer for the moment. It is time for you to do some thinking. We’ll work together to find out the answers to the questions that Ishan , Isabel and Imani asked: How many days are we going to go for? Is it summer or winter on the Moon? Is it very cold? First of all, though, what does the Moon look like in the sky? Is it always the same shape?”

Mrs Grady was pleased to see that almost everyone had their hand up.

“What’s the answer Zac?”

“Sometimes it’s round, and sometimes it looks like a banana going this way and sometimes it looks like a banana going that way” replied Zac

“Good – do you know what the banana shape is called?”

“I can’t remember”, Zac shook his head sadly.

“Anyone else know what a banana-shaped Moon is called? No? It’s called a crescent Moon”.

Teaching Note: There is a picture in the Resource section of phases of the Moon to explain why we see the Moon as different shapes. Also why we can often see it during the day, and not just at night.

Next, let’s remind ourselves of how long a day is on Earth. Hands up who can tell me?”

Almost everyone stuck their hand up.

“Go-on then Ishan, you tell us – and also say what the day is measuring”

A day is 24 hours” answered Ishan. “it is the time taken for the Earth to go through one complete turn”

“Very good” said Mrs G. “Now though, how long is a day on the Moon? How long does it take for the Moon to turn once on its axis?”

This time, no-one put up their hand.

“Well” said Mrs Grady “maybe you will be surprised to find that the Moon takes about 28 days to turn once on its axis. So a day on the Moon would last 28 days on Earth. So, Ishan, it is a good job that we are going to the Moon for 5 Earth days and not 5 Moon days – else we would be away from Earth for 5 Earth months – and that means that you would miss Christmas and all the other winter celebrations”

Teaching Note: there is a short animation that could be shown to explain this, but probably a bit too complicated for KS1 **here**

“Here’s something else to think about. How long does it take the Earth to go round the Sun, and what is that length of time called?

Everyone’s hand shot up

“All right Jess, what is the answer?”

“It takes 365 days, and that’s a year”

“Correct. What is unusual about the Moon, though, is that the length of its year is almost the same as its day, because it takes about 28 days to go round Earth, and about the same length of time to turn on its axis. That is why we always see the same side of the Moon.

“Now let’s see if we can answer Imani’s question – will it be summer or winter on the Moon? Imani – why do we have seasons on Earth?”

“Erm” said Imani “is it because the Earth goes round the Sun?”

“Partly, but it’s not just that is it? What can you tell me about the Earth’s axis?”

“Oh, right, it’s tilted isn’t it? And its summer for the half that’s tilted towards the Sun and winter for the half that’s tilted away”

“Well done Imani” said Mrs Grady “That’s correct. The half of the Earth that is in summer receives more light from the Sun than the half that is in winter.

Teaching Note**:** There is a graphic illustrating this in the Resource section

“Now, let’s think about the Moon. Does the Moon orbit the Sun? Hands up if you know”

Again, everybody could answer that question

“All right Shelley, what is the answer”

“The Moon orbits the Earth, not the Sun” replied Shelley.

“Correct. Now, Imani has just told us that we have seasons on Earth because it is tilted on its axis. The Moon is only tilted a tiny bit, not enough to make much difference to the amount of light the northern and southern halves of the Moon receive. So the Moon doesn’t really have any seasons.”

Mrs Grady looked at Isabel.

“We haven’t answered your question about whether or not you should take woolly socks. Now we have to think about what temperature it is on the Moon. Would anybody like to guess? Is it hot or cold? Hands up those who think it’s hot? Hands up who thinks it’s cold? Hands up if anyone thinks it’s both?”

Nobody seemed keen to answer, so Mrs Grady explained:

“It is both hot and cold – the part in the Sun gets very hot, and the part in the dark gets very cold, so there is a massive difference in temperature between the sunlit and dark areas. This is very different from the Earth. What do we have that keeps us from getting too hot in the daytime and too cold at night? I’ll give you a clue – it’s why we don’t need a spacesuit on Earth.

This time, plenty of hands shot up.

“Go for it Ned, what’s the answer?” encouraged Mrs Grady

“Is it air?” answered Ned.

“That’s right – our atmosphere acts like a blanket, keeping the heat in at night, but also preventing too much sunlight hitting the Earth during the day. Without the atmosphere, parts of the Moon that are in direct sunlight get hotter than boiling water, and those in the dark are nearly 200 degrees below freezing”

“So I’d better take my woolly socks then” said Isabel

"I don't think we'll be camping out overnight on the Moon" laughed Mrs Grady, "and the lunar base is heated inside, so you should be OK without them. And, Imani, that helps to answer your question about a torch – we won't be going anywhere in the dark. In fact, it will be the opposite – we'll be arriving in the early morning of a lunar day, so that we aren't completely boiled, but there will still be sufficient sunlight to make us very hot in our spacesuits. The spacesuits are much lighter than the ones the early astronauts wore – but they are still white, to reflect as much sunlight as possible, and the face plates are like mirrors, again to reflect the light. You should probably take sunglasses rather than a torch Imani!

"Now then Year 1, it is time for morning break. We've done a lot of work about the school trip to the Moon. We'll have another session next week, and find a bit more out about gravity. Off you go"

Mrs Grady dismissed her class , watching them run out into the playground. She was pleased to see that Ash had two of his friends helping with his wheelchair. As they went past, she heard them talking about what speed Ash would be able to get up to in a lunar buggy, and whether it had indicator lights for turning.

She smiled to herself. This was going to be a fun trip!

<u>Teaching Note</u>:
Possible activities: Discussion about whether the children would like to go to the Moon? What questions would they ask Mrs Grady?
Additional activities: word-games, puzzles, etc at the start of the Resource section

Mrs Grady came into the classroom, bouncing a football.

"Cara" she said "What was the question you asked about our trip?"

"Will we be able to play football on the Moon?"

"Well, the Moon's gravity is only about 1/6th of Earth's, and there is no atmosphere, so what effect do you think that would have on a game?"

Cara thought a bit before answering:

"Well, with low gravity, the ball would be much lighter, so when you kicked it, it would go further, and higher."

"Good, said Mrs Grady "anything else? How would the players get on?"

"They'd have to wear space suits, so even though they should be able to move faster, the spacesuits will probably slow them down."

Mrs Grady could see Rachel, Cara's twin, with her hand up.

"Go-on Rachel, what would you like to say?"

"There isn't any sound in space, so you wouldn't be able to hear the crowd cheering"

"or the referee's whistle," added Cara "and there's no wind, so the linesman's flag wouldn't flutter"

"Why isn't there any sound in space?" asked Mrs Grady.

"Because there's nothing for the sound waves to travel through" replied Rachel.

"That's very good. Shall we take a football with us to see if we can have a game?"

“Yes” shouted the twins together “yes please”.

“There’s one thing you haven’t mentioned”, said Mrs G. “and that’s the pitch. What do you think that will be like?”

“A bit stony, maybe” replied Rachel. “Or dusty” added Cara.

“That’s right” agreed Mrs Grady “probably very dusty – and every time the ball bounced, or you were bounding across the pitch, you would raise clouds of dust – which might stop you seeing where you were going and clog up your spacesuit”

“Hmm, that’s a bit of a problem” said Cara.

Becky now had her hand up.

“Go-on Becky” said Mrs Grady

“I’ve had a better idea – we could play rugby. Throwing the ball, not kicking it”.

Mrs Grady nodded.

“But there is a snag with rugby as well” she said “would you be able to score a try? I’m not sure a spacesuit would survive if you threw yourself on the ground.”

Tim was waving his hand in the air

“I’ve got an idea” he burst out

“Well done” said Mrs Grady “tell us about it”

Mrs Grady was really pleased that Tim had put his hand up – he often did not join in with the lesson, but fidgeted and wandered around the classroom.

“I could take my jacket and put the ball in that and it wouldn’t float away”

“Wow” said Mrs G “That is a good idea – make the ball heavier. I like it – but I think we might have to use something other than your jacket. Your parents won’t be very pleased if it comes back all torn from the rocks on the lunar surface”

Tim had to wear a special jacket in school that was quite heavy. It helped him to sit still so he could concentrate on what was going on in the lesson.

“Will Tim’s jacket be as heavy on the Moon anyway?” asked Ana “If the football is lighter, then won’t his jacket be as well?”

“That is very true – Tim’s jacket will feel lighter, but it will still be heavier than other jackets. But we don’t need to worry about that as he will be wearing a spacesuit like everyone else, won’t you Tim?

Tim nodded, and seemed pleased that his idea was a good one.

“Miss, Miss” Ellie called out.

She was frantically trying to catch Mrs Grady’s attention. The teacher looked up

“All right Ellie, it’s your turn. What would you like to ask?”

“I asked this last time. Are there any animals or plants on the Moon?” You know, underground, not on the surface?”

“Let’s think about that” said Mrs Grady “What does a plant need to live?”

“Water” answered Ellie

“Correct. What else? Let someone else answer”

Mrs Grady looked at the class. Ash had his hand up.

“Ash—what do you think?”

“Air to breathe, and food”

“Exactly. Now, first of all, there is water on the Moon—it is there as ice at the poles—but in places where it is so cold that it would be very unlikely there was anything alive - do you remember how cold I said it was?

Ellie was looking unhappy.

“You said it was 200 degrees below freezing, and I suppose because it’s do cold and there’s no air, nothing can live”

“Never say never” said Mrs Grady “people are discovering new things all the time. Who can say what might be found deep below the surface where it is warmer? But I don’t think there will be anything living on the Moon that is more complicated than bacteria”

“Apart from us, Mrs Grady” said Jordan with a grin.

All the class laughed, and Mrs Grady was smiling as she answered

“Very clever Jordan. But we must get on. Before we learn anything else about the Moon, we need to think about our trip – we have to give it a name. There have been some famous mission names: the Apollo series of missions went to the Moon, and the one that landed Neil Armstrong and Buzz Aldrin was called “Eagle”. Tim Peake’s mission to the Space Station was called “Principia”, which is the name of the book that Isaac Newton wrote where he described gravity. We also need to design a mission patch – that is the badge sewn onto your spacesuit with a symbol of the mission on it. So Neil Armstrong’s mission patch had an eagle on it – which is the symbol of America. Tim Peake had an apple, to symbolize gravity. So we need a mission name and a symbol, to go on the mission patch. Then once we have done that, we will have a go at designing a lunar lander”.

Teaching Note: Have the groups of children discuss potential mission names and symbols. The rest of the session is taken up with working in groups to design the mission patch. Plus other games, puzzles, etc. There are examples of mission patches in the Resource section of the book

For KS2 students, the framework story of a trip to the Moon is probably not required – although that does not preclude it being used!

What is the effect of low gravity on the human body?

The first part of the session is a recap of what the students know about the function of bones and blood in the human body.

What do we have bones for?
- To support our body
- To protect internal organs
- To help us move

What does our blood do?
- Transports oxygen and carbon dioxide and nutrients around the body

We would still need these functions if we were on the Moon. But what happens to bones and blood when you are in space for a long time?

Our bones are dense, because they have to be strong to support us against Earth's gravity – without bones, we would collapse, like a jellyfish. That's why the biggest creatures without bones live in the sea – the water helps to support them.

Activity: A short diversion into the difference between mass and weight, which can be demonstrated using a spring balance.

Using a spring balance, weigh a familiar item, say a litre carton of milk or fruit juice. It weighs about 1 kilogram. You can see how far the spring of the balance had to stretch to weight the carton. This is because the force of gravity is pulling the spring down. Imagine if the gravitational force were lower – the pull would not be as strong, so the spring would not stretch as far, so the carton would not appear to weigh as much. But the carton hasn't changed – it has still got the same amount of juice in it. So it has the same mass, but a different weight.

Why should things be any different on the Moon? Because the gravity on the Moon is 1/6th that of Earth's gravity, so the pull on bones would not be as great as it is on Earth. This means that bones would not have to be as strong to support the same mass.

This sounds as if it might be a good thing – if we weigh less, we are not putting so much load on our legs and knees, so they would not wear out so quickly.

But what astronauts living for 6 months on the International Space Station have found is that being in space makes your bones weaker. They start to get more spongy inside – which is really bad for when the astronaut returns to Earth, because their bones can no longer support their weight.

Being in space affects other parts of the body: your heart does not have to work so hard to pump blood around the body, so it starts to get smaller. Your eyesight can change because the fluid inside your eyeball is at a different pressure, so you might need to wear different glasses.

Activity: A short (2 min) video interview with NASA astronaut Leland Melvin explains some of the things that happen to the human body: https://ed.ted.com/featured/QS6sEKzz
There is also a series of multiple choice questions with the video.

These effects have been noticed on astronauts living for 6 months in the zero gravity environment of the space station. Things might not be quite as extreme on the Moon, because there is some gravity. But even so, it will be essential to take plenty of exercise to make sure that muscles and bone don't waste away.

Activity: Imagine that you were born and have grown up on the Moon, living in the Moon Base, so that your body is used to the low gravity. You are also used to having to be careful with water – so that means only having 1 shower a week. What do you think you would look like? Would you be tall, because gravity doesn't pull you down? Or would you be short because your bones don't need to be so big to support your weight? (We don't know the answer to this). Would you like to have long hair that floats round you? Or short hair so that it doesn't get in a mess because you can't wash it so often? Draw yourself as a Moon child!

What type of rock is the Moon made from?

Recap of rocks on Earth: some have come from volcanoes, and crystallised from molten lava, whilst others were built up from layers of mud and sand and might have fossils inside them. Soil is made from rocks and organic matter – leaves, roots, bits of twig, insects and so on.

When Neil Armstrong became the first person on the Moon, he said as he stepped onto the lunar surface:

> "One small step for a man, one giant leap for mankind"

NASA engineers were very relieved when he got down from the ladder safely, because they had been worried about the Moon's surface – no-one knew how deep the dust was. They had wondered if it might be so deep that the astronauts and the lunar lander got stuck. Fortunately, that wasn't the case. The astronauts brought some of the lunar soil back with them.

Teacher note: There is an image of lunar regolith in the Resources section – you can see that it is a lot of particles of broken crystals. No twigs or bits of leaf!

Activity:

Q. On Earth, soil is defined as having organic matter in it, from plants and animals. Why is it wrong to talk about "lunar soil"?

A. Because there are no plants and animals on the Moon, so there is no organic matter in the surface layer.

Q. Do you think there are rocks like clays that were laid down in water on the Moon? Do you think there are any rocks with fossils in on the Moon?

A. No – there are no clays, or any other rocks, like limestone, that were produced in water – because there is no water on the Moon. Also, because there is no life there, there are no fossils in any of the rocks.

We call the surface layer of the Moon its Regolith.

Moon rocks are igneous rocks – the ones that have come from volcanoes.

There are two different types of Moon rock, and you can see them when you look at the Moon: there are dark patches and lighter patches.

The dark patches are called 'Mare', plural Maria (pronounced Mah-Ray and Mah-reeya) from the Latin word for sea. This is because people who first described the Moon thought the dark patches were lunar oceans. We now know that the regions are dark because of the type of rocks they are made from.

The light parts are the highlands and are made of a different rock type from the maria. Here, the rocks contain a lot of a very bright crystal, which reflects a lot of light.

Teacher note: There are pictures of both rock types in the Resources section.

We can look at pieces of the Moon using a microscope: a slice is cut from a rock, and then polished until it is very thin, so that light can be shone through it. Thin sections of lunar samples can be accessed through the internet: https://www.virtualmicroscope.org/.

The Virtual Microscope

Activity: Access the virtual microscope, and select the Apollo rock collection:

https://www.virtualmicroscope.org/collections/apollo

You can look at any sample, but these three are the ones illustrated in the Resources section:

Regolith: https://www.virtualmicroscope.org/content/70181-85-mature-mare-regolith

Mare: https://www.virtualmicroscope.org/content/15476-36-porphyritic-pigeonite-basalt

Highlands: https://www.virtualmicroscope.org/content/67559-9-highland-basalt

In each case, follow the link, and then click on the “View Microscope” icon:

There are three options to view the sections:

PPL – this is Plane Polarised Light – light has been shone through a polariser (like a pair of sunglasses), which produces a parallel beam of light;

XPL – crossed polarised light – after the light goes through the sample, it passes through another polariser before being detected. The colours are an indication of how much the beam of light has been bent as it travels through the mineral crystals (as light is bent in a water droplet in a rainbow), and is an indication of the composition of the grains.

REF - reflected light, where light is bounced off the surface of the section. It shows where metal grains are – but there is not much metal in lunar samples.

The images have one or two numbered red circles:

If you click on them, it takes you to a page where you can see how the appearance of the rock changes as it is rotated {It can take about 30 s for the page to load).

Building a Lunar Lander

Materials:

1 Egg box	Paper clips
Bubble wrap	String
Balloons	Kitchen Towel
Sellotape	Plastic carrier bag
Scissors	Aluminium foil

Something heavy – not necessarily a magnet, but that would do. Maybe a teaspoon? Or 3 or 4 pencils bundled together.

Something delicate to be the astronauts. Something that would squish if dropped hard. Grapes? over-ripe cherry tomatoes?

Before starting , the children should be divided into groups of not more than about 6. Introduce the subject of landing on the Moon – if you have used the School Trip story, then you will probably need to stress that they are going to build a very simple version of a lander, and not one that would carry 25 students and teachers.

There should be discussion before starting, including giving the mission a name, the lander a name, the astronauts names – here you can draw on the images in the Resources section . It is also a good opportunity to stress that there are many women astronauts as well as men.

The egg box is the landing craft. The grapes/tomatoes are the astronauts. Balloons are for landing bags. Bubble wrap is insulation. Aluminium foil for reflecting sunlight. The plastic bag is a red herring

The children have to make various decisions:

Can they put the astronauts directly in the egg box?

- It is better to wrap them in a bit of kitchen towel and Sellotape them in for safety during take-off and landing.

Do you need a parachute to slow down the capsule as it approaches the surface?

- No – there is no atmosphere, so a parachute would not be any use

Do the balloons go all round the landing capsule, or just on the bottom?

- They should just go on the bottom – but in space, how do you decide which is the bottom? This is where they need to be imaginative. Use the magnet/teaspoon/bundle of pencils as a weight to pull the capsule down

How will you stop the lander bouncing off the surface?

- An anchor made from string and paperclips on the underside of the capsule

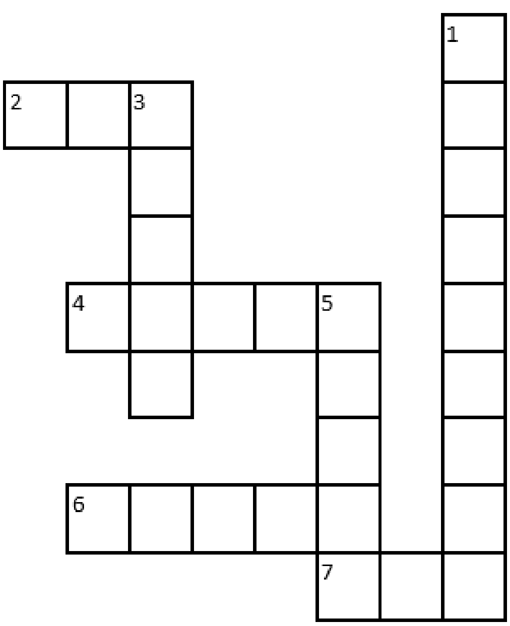
After the craft is built, then the groups should throw them across the playground, or out of a top floor window, to see whose astronauts survive……

Games and Puzzles

Q	U	O	C	N	Y	I	O	Z	N
D	A	Y	T	J	E	S	L	K	I
B	I	R	A	D	A	B	O	A	G
Y	U	V	S	E	R	H	R	E	H
E	M	A	U	G	S	T	B	L	T
M	O	O	N	L	Y	S	I	W	T
K	N	D	F	E	A	R	T	H	U
F	T	H	P	M	O	B	R	I	D
S	H	I	N	E	Z	Q	U	A	F
G	R	J	T	W	F	A	C	E	X

Find the hidden words:

DAY	MOON	MONTH
SUN	YEAR	NIGHT
FACE	EARTH	SHINE

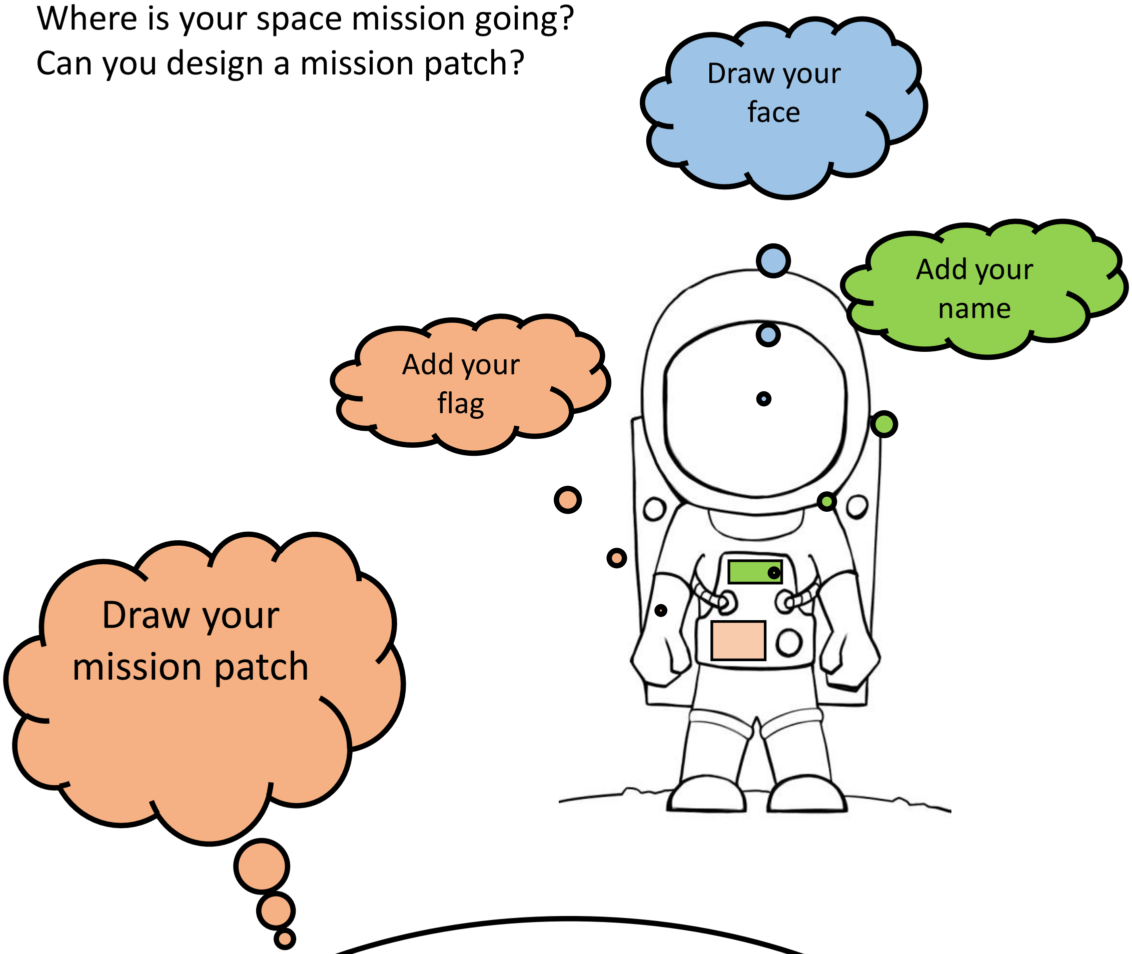


CLUES

1. A space traveller
2. Our star
3. Bedtime?
4. What we like the Sun to do
5. Our home
6. What we call the path the Earth takes round the Sun
7. What the temperature is when the sun shines in summer

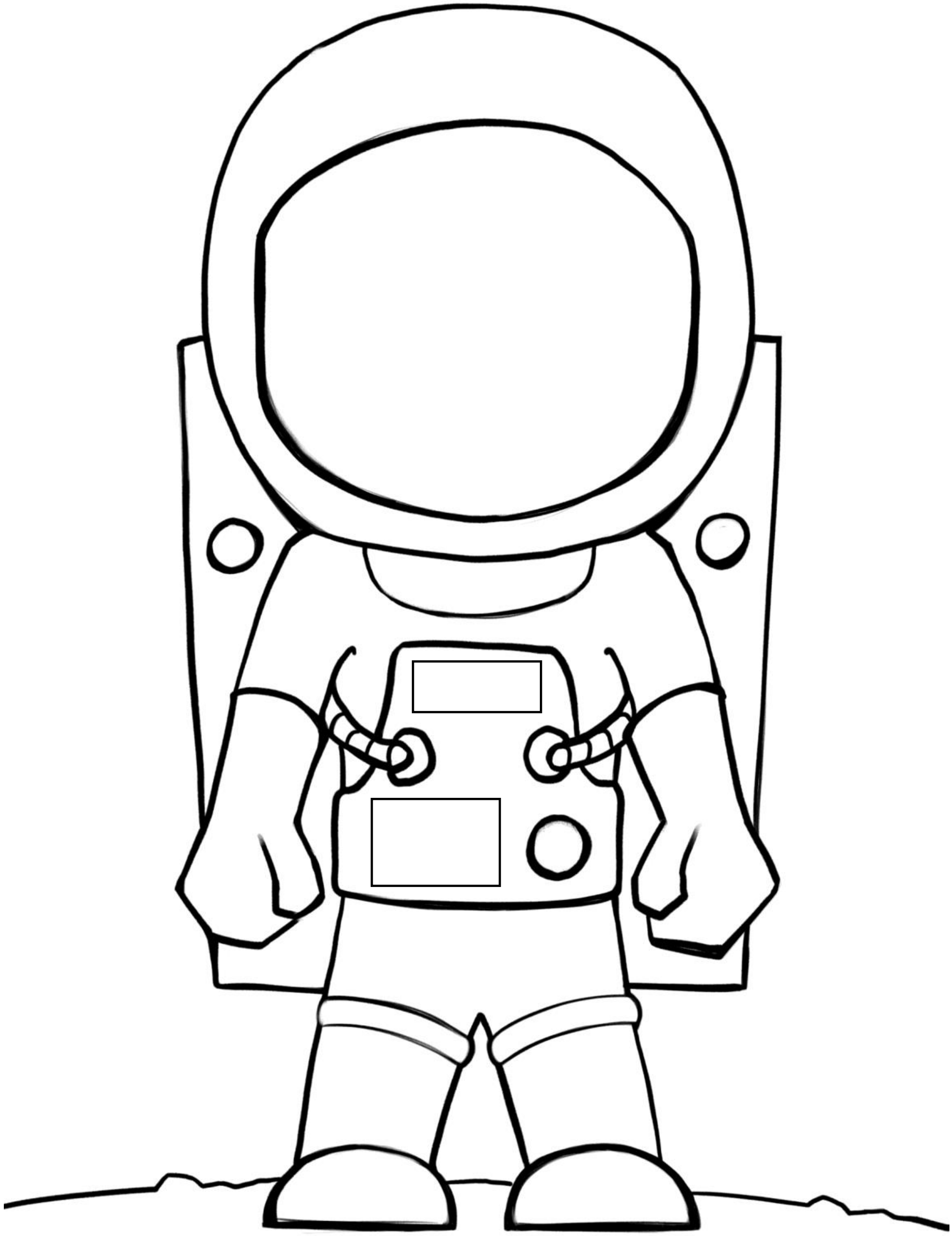
I am an Astronaut

Draw yourself as an Astronaut
Where is your space mission going?
Can you design a mission patch?

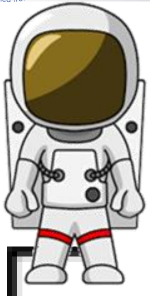


Draw yourself as an astronaut:

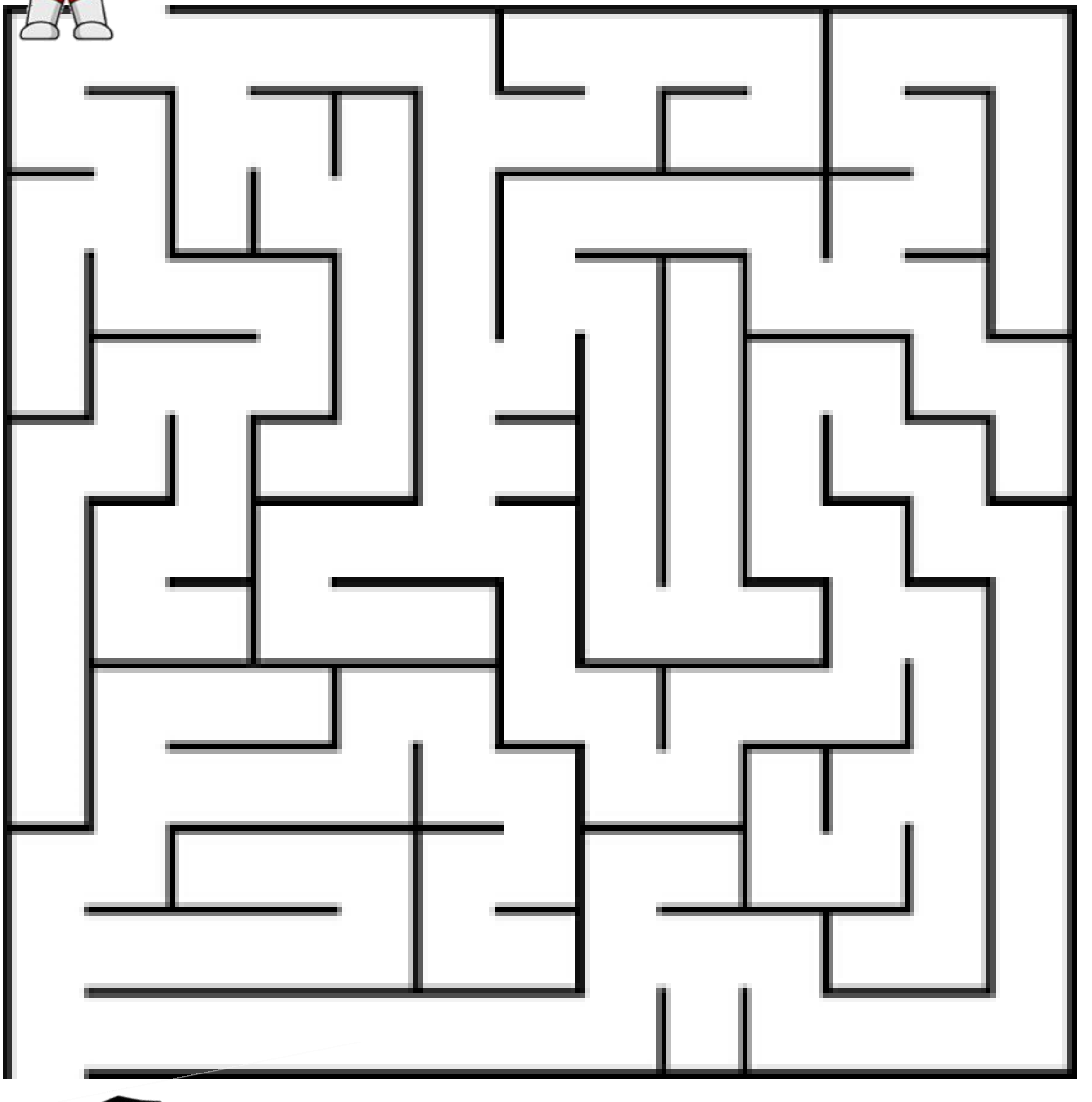
I am going on a space mission to _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _



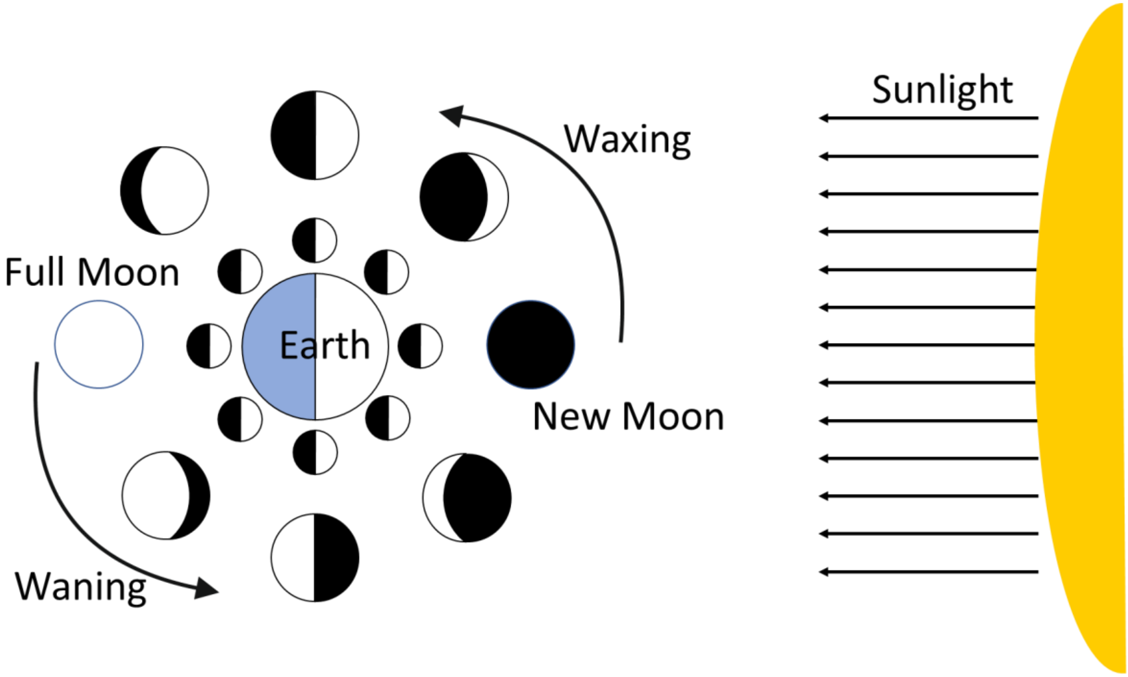
Moon Buggy Maze



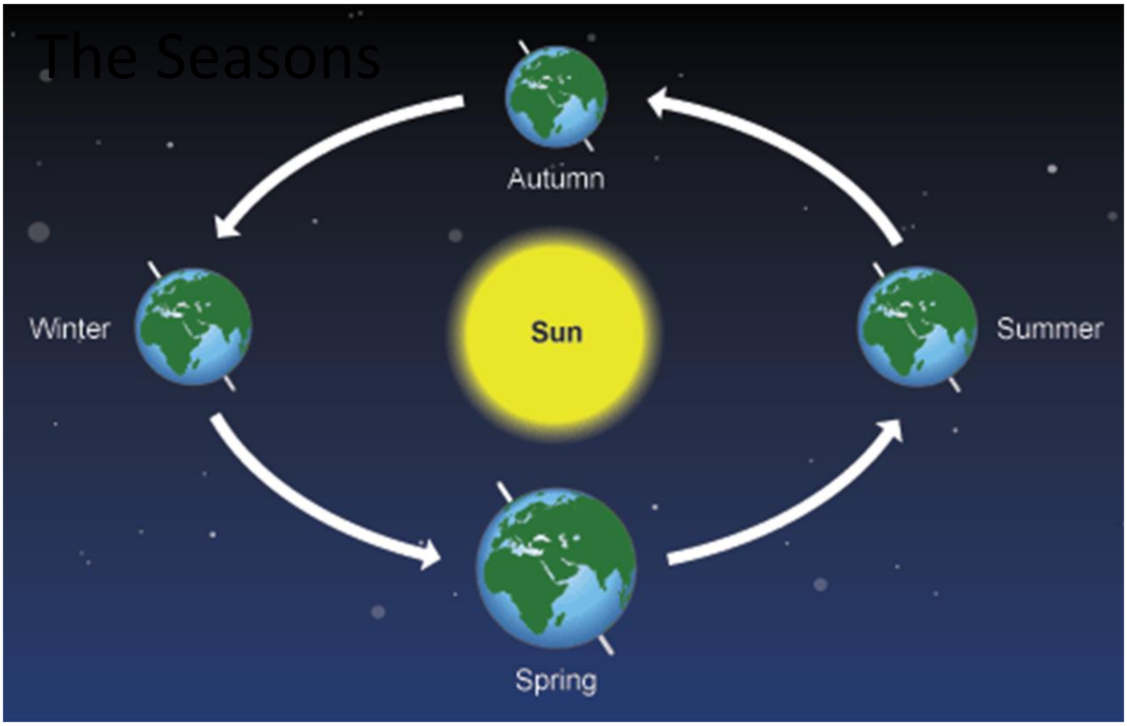
Can you help the astronaut get back to her moon buggy?



Phases of the Moon



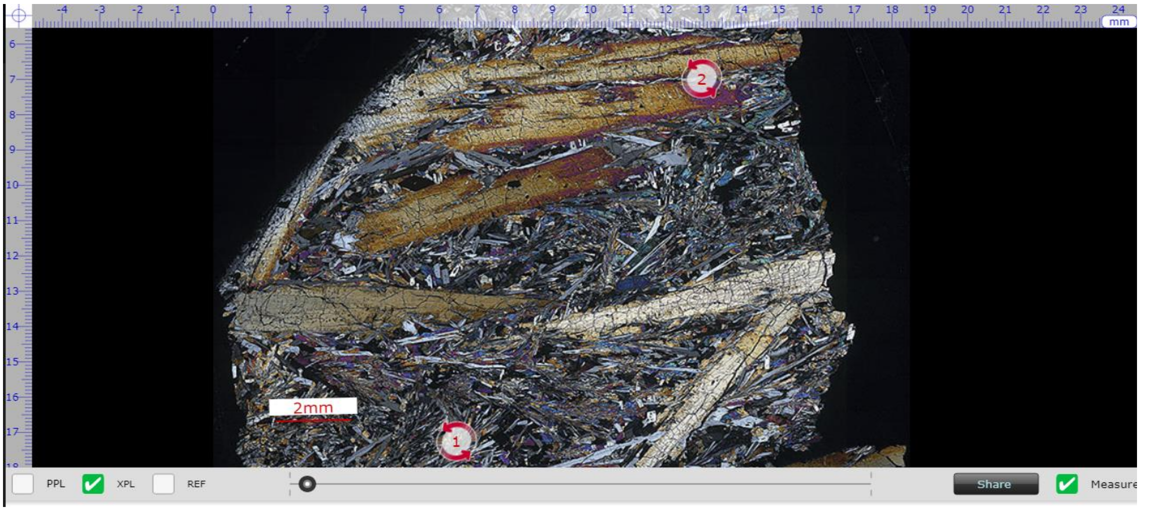
The diagram shows how the Moon's appearance changes as we see it in the sky. The Sun's rays illuminate the sun-facing hemisphere of the Earth, casting half the Earth in shadow. It does the same to the Moon, as shown by the inner circle of moons, which are half in sunlight, half in shadow. The shape of the Moon that you see looking into the sky from the Earth's surface is shown by the outer circle of Moons.



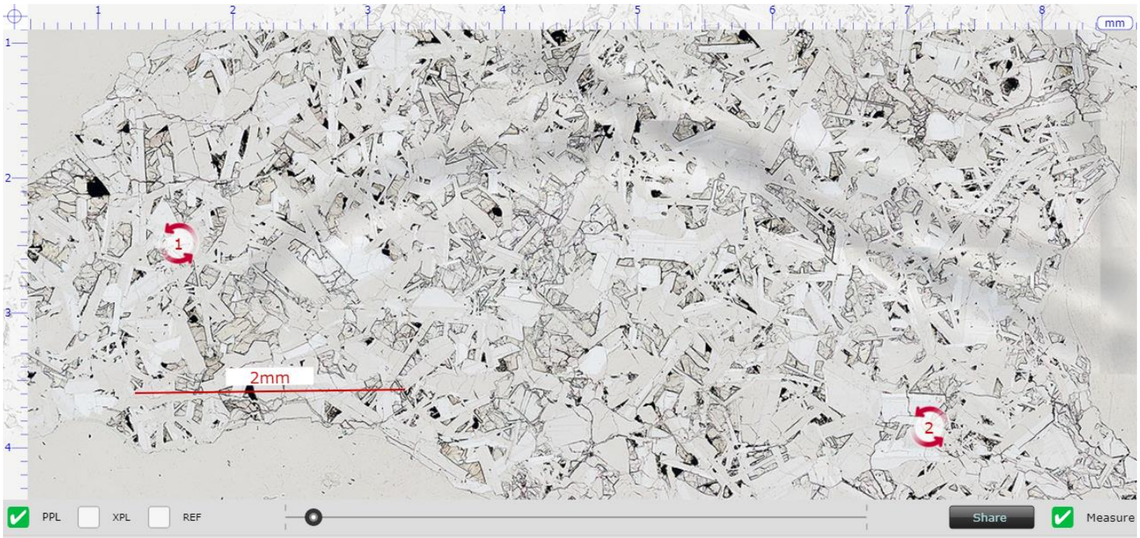
Plane Polarized light

The image shows large crystals of pyroxene set in a finer-grained groundmass. The large crystals are known as phenocrysts. The groundmass has a distinct foliation or lineation, giving an impression of the rock flowing. Many of the black speckles are vugs or cavities in the rock, presumably where gas bubbles in the magma burst as the lava solidified.

Crossed Polarized light

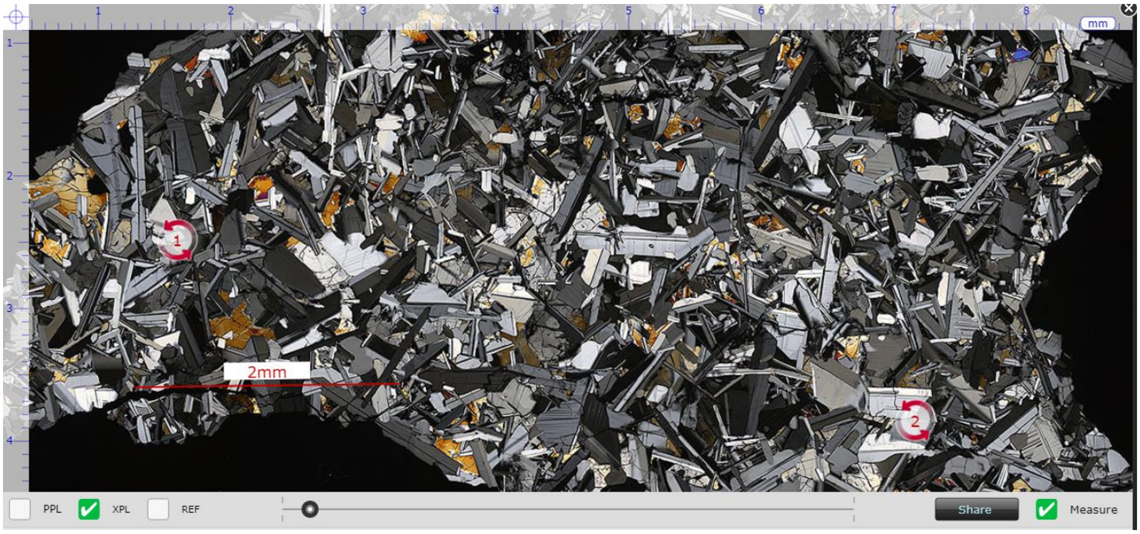


Plane Polarized light

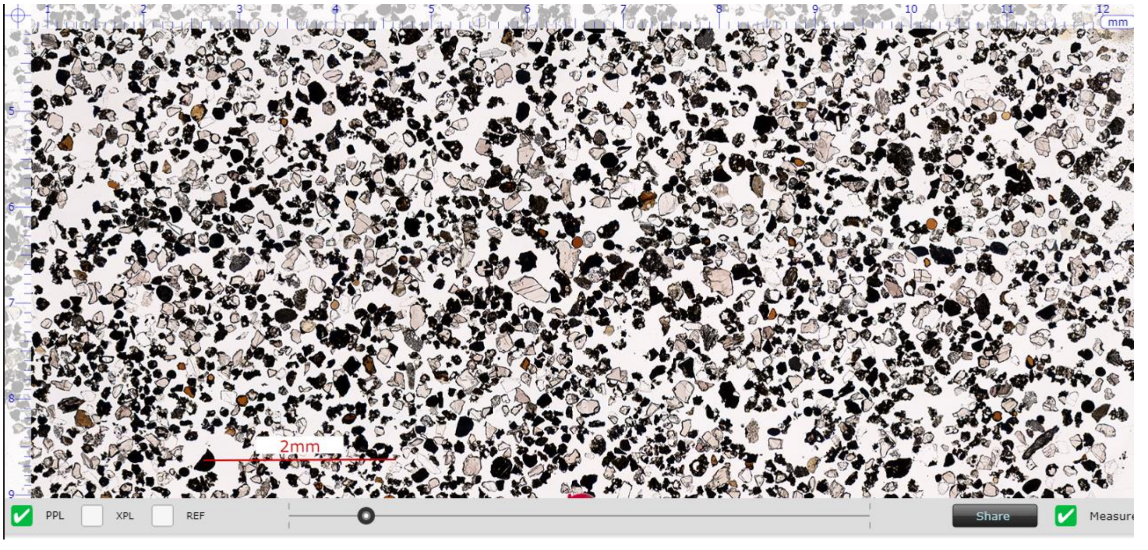


The image shows a basalt with a texture of interlocking crystals of plagioclase and pyroxene. This is a fairly typical igneous texture indicating that the rock cooled from a liquid. In the image taken under crossed polars, the plagioclase is readily seen as the black-grey-white striped grains, whilst the pyroxene *and some olivine) occurs as the brownish-coloured crystals.

Crossed Polarized light

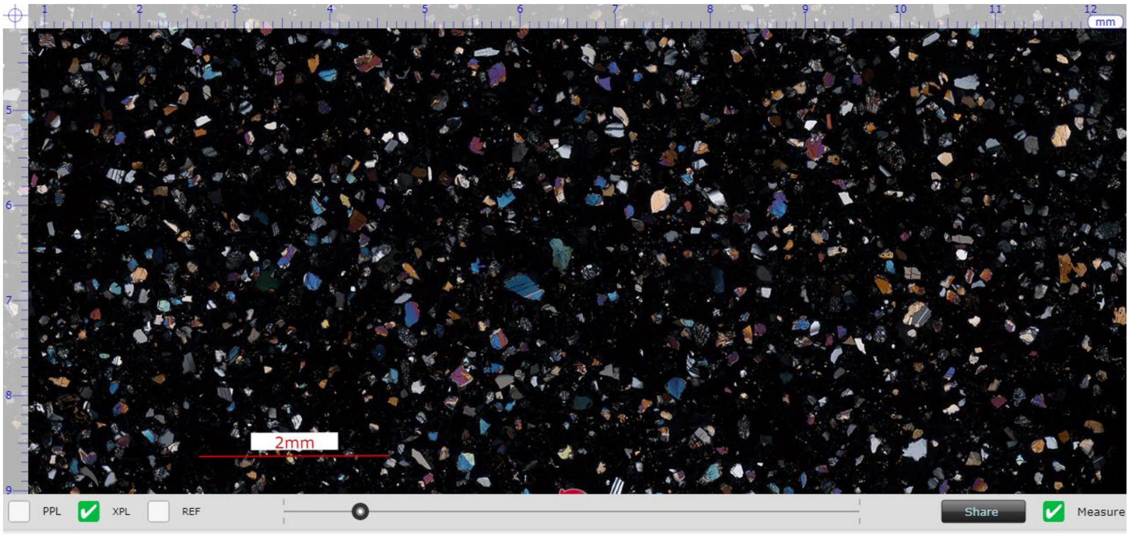


Plane Polarized light



The image shows fine-grained shards of broken mineral grains, fragments of rock clasts and small orange spherules. The spherules are from splashes of molten volcanic rock. There are agglutinates: clusters of grains welded together by micrometeorite and cosmic ray bombardment at the lunar surface.

Crossed Polarized light



Earth from the Moon

The first picture of the Earth from space :

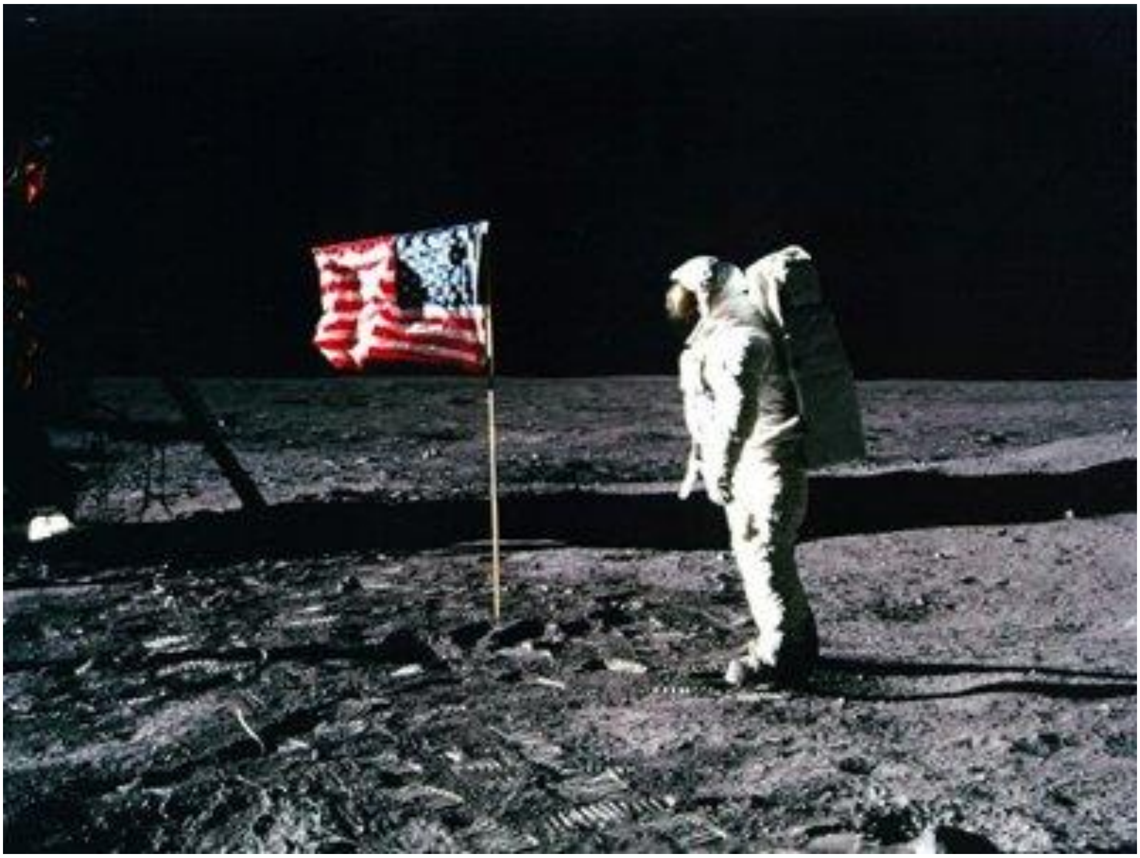
Apollo 8, the first manned mission to the moon, entered lunar orbit on Christmas Eve, Dec. 24, 1968. That evening, the astronauts-Commander Frank Borman, Command Module Pilot Jim Lovell, and Lunar Module Pilot William Anders-held a live broadcast from lunar orbit, in which they showed pictures of the Earth and moon as seen from their spacecraft. Said Lovell, "The vast loneliness is awe-inspiring and it makes you realize just what you have back there on Earth." Image and Caption credit: NASA

First Men on the Moon

PRIME CREW OF FIFTH MANNED APOLLO MISSION

NEIL A. ARMSTRONG MICHAEL COLLINS EDWIN E. ALDRIN, JR.

Flag and Footsteps



European Astronauts

Tim Peake (UK)

Claudie Haignere (France)

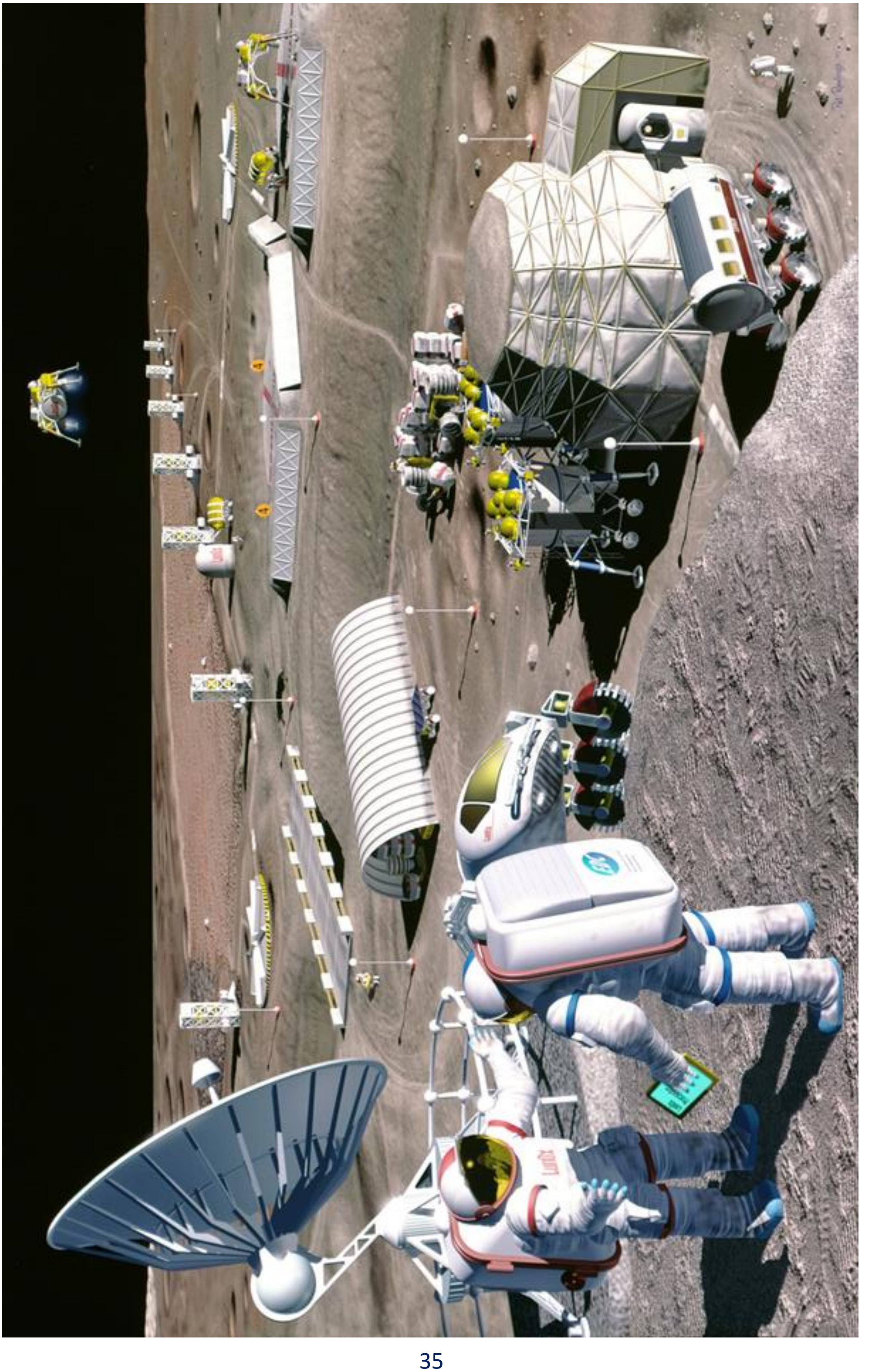
Sam Cristoforetti (Italy)

Thomas Pesquet (France) André Kuipers (Netherlands)

Mission Patch

Tim Peake was an astronaut on the International Space Station from December 2015 – June 2016. His mission was called ‘Principia’, after the famous book by Isaac Newton, in which he first described the effects of gravity

A future lunar base ?



The EURO-CARES project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 640190

Images courtesy of NASA, ESA and members of the EURO-CARES consortium

Investigating the Moon

Suggested Activities
Key Stages 3 and 4

Foreword

These teaching notes have been prepared by Monica Grady, Professor of Planetary and Space Sciences at the Open University, on behalf of the EURO-CARES consortium. Monica was advised by a small team of teachers who work with a range of age groups from KS1 to KS4; the team also included a SEND specialist. The notes were 'road tested' on children of different age groups from schools in different Local Education Authorities in England.

The work was part of the EURO-CARES project, which received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 64019

EURO-CARES:
European Curation of Astromaterials
Returned from the Exploration of Space

http://www.euro-cares.eu/

European Commission

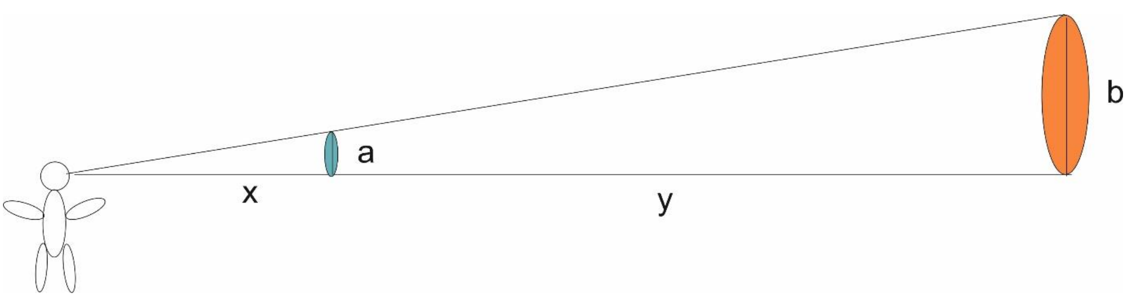
Contents

The purpose behind this set of notes is to provide two sets of practical activities that students can undertake on their own, in their own time, or as enrichment exercises in groups at school. The concepts encountered in the activities complement the requirements of the National Curriculum in England GCSE in Combined Science.

How big is the Moon?

On a day of hazy cloud, we can see the Sun. And on a clear night, we can often see the Moon. Have you ever noticed that the full Moon appears to be about the same size as the Sun? This correspondence is fortuitous, and a reflection of the fact that the Sun is about 400 times greater in diameter than the Moon and is also about 400 times as far away.

The coincidence in apparent size is what enables a total eclipse to occur. The Sun and Moon have the same angular size. In the diagram below, the blue and orange disks have the same angular size – they subtend the same angle at the observer's eye.



If the distance from the observer to the blue circle is ***x*** and the diameter of the circle is ***a***, and the distance from the orange circle is ***(x +y)*** and the diameter of the orange circle is ***b***, then the angular size of the objects is given by:

$$\text{angular size} = \frac{a}{x} = \frac{b}{(x+y)}$$

For this relationship to work, the angular size is in radians, where 1 radian = 57°

So angular size depends on an object's actual size and its distance from the observer's eye. We can use this relationship to determine the size of the Moon and its distance from us.

How big is the Moon ?

The following activity needs to be carried out when the Moon is clearly visible – either day or night.

DO NOT ATTEMPT THIS ACTIVITY ON THE SUN

Materials:

- selection of round coins (e.g., 1p, 5p, 10p or 1€, etc)
- a straight rod at least 2 m long (e.g. garden cane)
- tape measure at least 2 m long
- ruler marked in mm and cm
- blu-tack or plasticine
- Calculator

The aim is to set up an arrangement with a coin fixed to the rod so that the coin just blocks out (eclipses) the Moon see the diagram below.

Observing from one end of the rod, try different coins until you find one that is the right size to eclipse the Moon when fixed somewhere on the rod. Then adjust the position of the coin until it just blocks your view of the Moon.

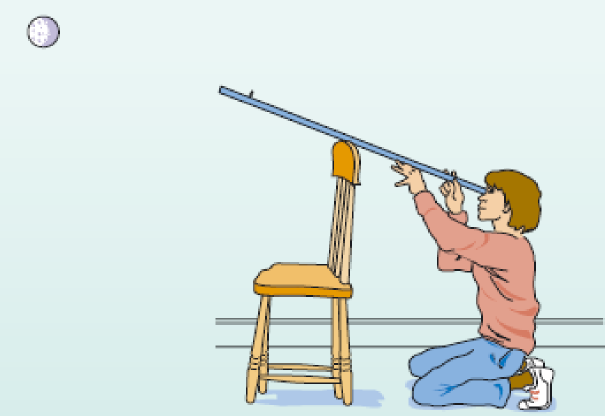


Image Credit: Open Univ.

Measure the distance from the coin to the end of the rod where you have placed your eye and measure the coin's diameter.

You now have the measurements that will enable you to calculate the angular size of a coin that has the same angular size as the Moon.

Use your two measurements on the coin to calculate its angular size in degrees, using the formula introduced earlier, adapted to the current case:

i.e. in the equation on the previous page, a = diameter of coin; b= diameter of Moon (=3476 km), x = distance from the end of the rod to your eye and y is the unknown to find.

Remember to be consistent with units – either convert a to km or b to cm

You might like to compare your result with the accurately measured value of the Moon's distance: 384 500 km. It is unlikely that you obtained exactly this value, but you probably got something in the range 300 000 to 500 000 km, which is pretty good for a quick and fairly rough measurement.

This activity has been adapted from one of the learning resources of the Open University. If you are interested in investigation any of the OU's free learning resources, they are available **here**.

What is the Moon made from?

The history of the Moon is hotly debated by scientists, but most are agreed that the Moon formed in a giant impact on the newly-forming Earth by a body about the size of Mars. The surface of the Moon remained molten for many millions of years, and parts of it were re-melted during continued bombardment by asteroids and comets. Moon rocks are igneous rocks, i.e., they have been produced from a melt.

There are two different types of Moon rock, and you can see them when you look at the Moon: there are dark patches and lighter patches.

The dark patches are called ‘Mare’, plural Maria (pronounced Mah-Ray and Mah-reeya) from the Latin word for sea. This is because people who first described the Moon thought the dark patches were lunar oceans. We now know that the regions are dark because of the type of rocks they are made from.

The light parts are the highlands and are made of a different rock type from the maria. Here, the rocks contain a lot of a very bright crystal, which reflects a lot of light.

The Moon rocks that we study today are almost all brecciated – that means that they have been broken up, then re-assembled, possibly several times.

We call the surface layer of the Moon its regolith – it differs from a soil on Earth because it does not contain organic matter (leaves, bits of animal, etc). It is produced by impact bombardment of the surface of the Moon. Occasionally by asteroids, but daily by micrometeorites and cosmic radiation. Constant cycling of temperature (a range of almost 400 °C between night and day) also contribute to breakdown of the rocks. Regolith samples are mainly fragments of minerals, some of which have become glued together by material melted by more recent impacts by micrometeorites.

We can look at pieces of the Moon using a microscope: a slice is cut from a rock, and then polished until it is very thin, so that light can be shone through it. Thin sections of lunar samples can be accessed through the internet:
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Activity: Access the virtual microscope, and select the Apollo rock collection:

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XPL – crossed polarised light – after the light goes through the sample, it passes through another polariser before being detected. The colours are an indication of how much the beam of light has been bent as it travels through the mineral crystals (as light is bent in a water droplet in a rainbow), and is an indication of the composition of the grains.

REF - reflected light, where light is bounced off the surface of the section. It shows where metal grains are – but there is not much metal in lunar samples.

The images have one or two numbered red circles: If you click on one of them, it takes you to a page where you can see how the appearance of the rock changes as it is rotated {It can take about 30 s for the page to load).

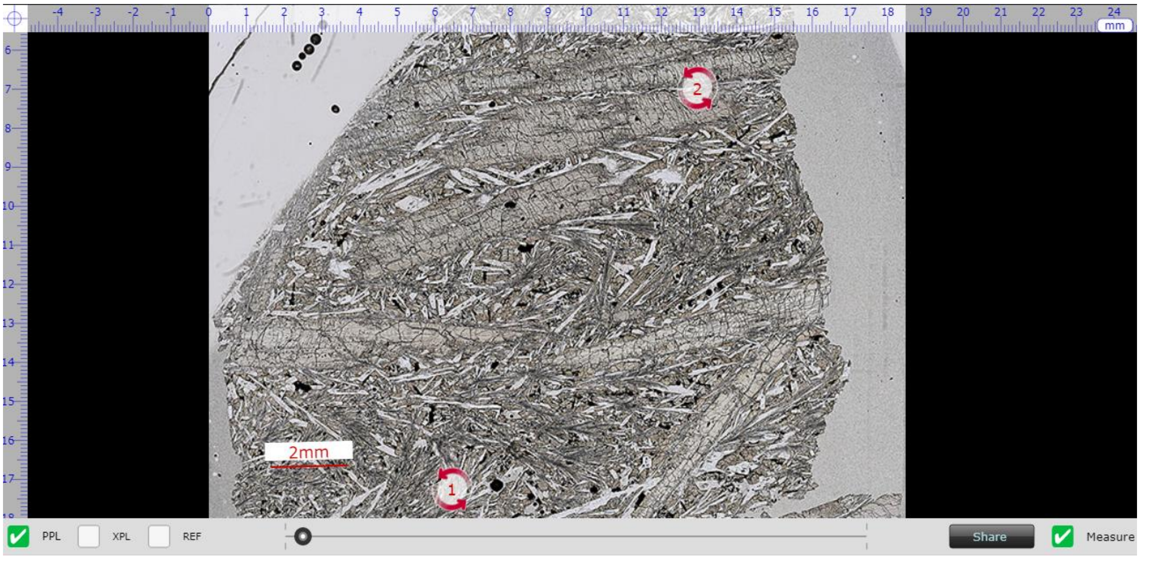
Each of the Apollo sections is accompanied by an abbreviated description, and a link to a much more detailed and technical report

There are two minerals that are very common in lunar rocks. The first is plagioclase, which is pale in colour in plane polarised light, and usually black, white, grey and blue under crossed polars. Plagioclase is a calcium and aluminium silicate, and is a major constituent of the highland basalts.

The second mineral is pyroxene. This tends to be pale pinky-brownish in colour in plane polarised light, and a darker yellowy-brown under crossed polars. It is less abundant in the highland basalts than in mare basalts, and is an iron and magnesium silicate.

Apollo 15 mare basalt 15476

Plane Polarized light



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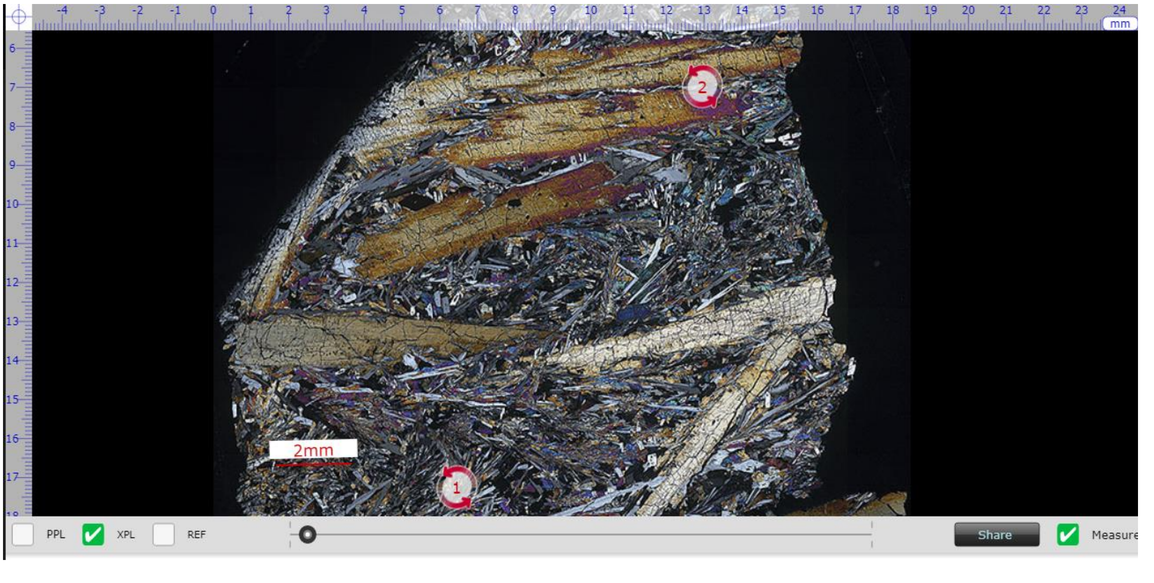
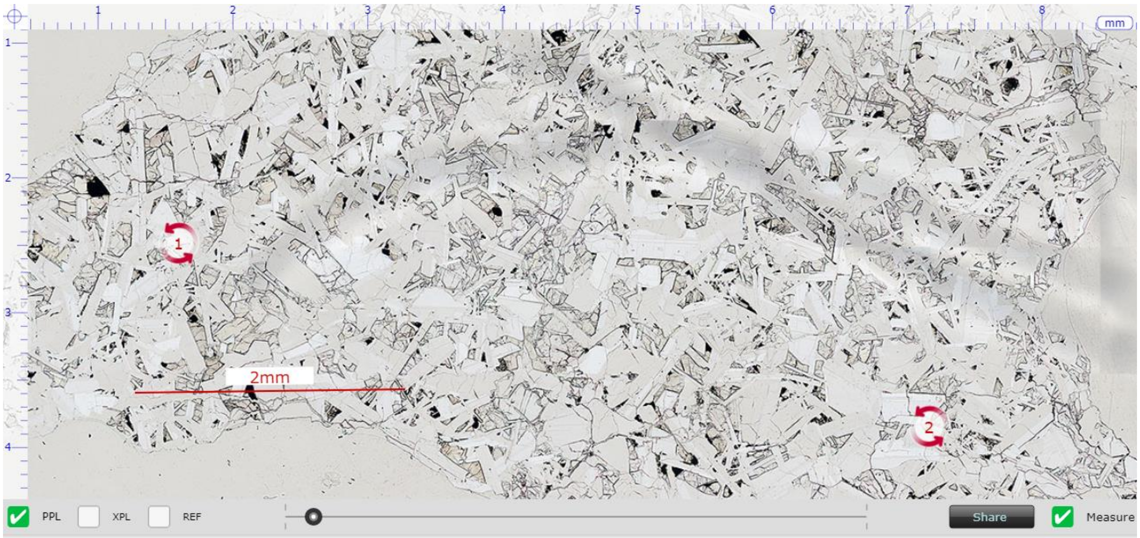


Plane Polarized light



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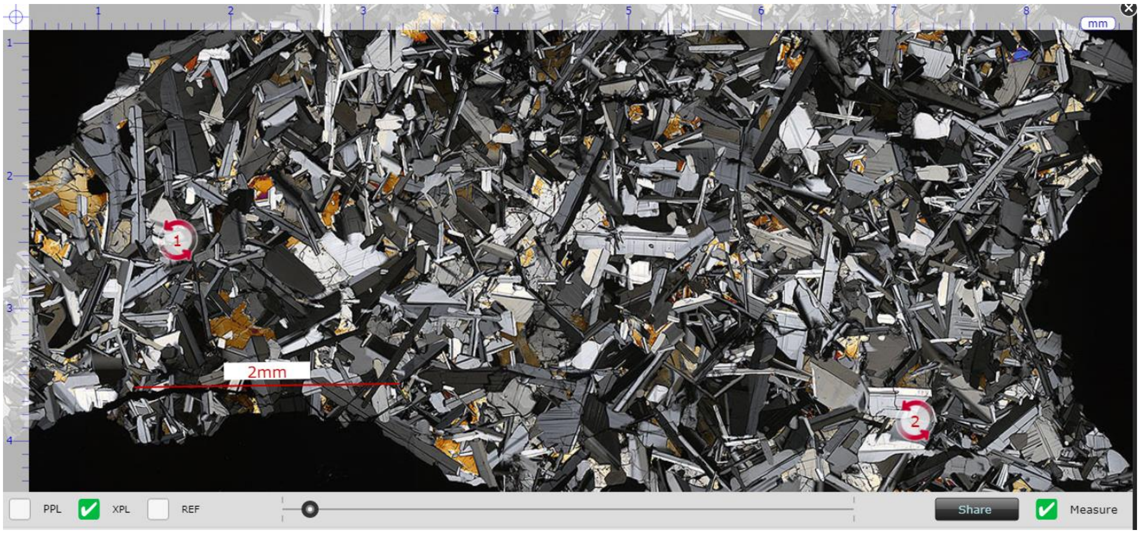

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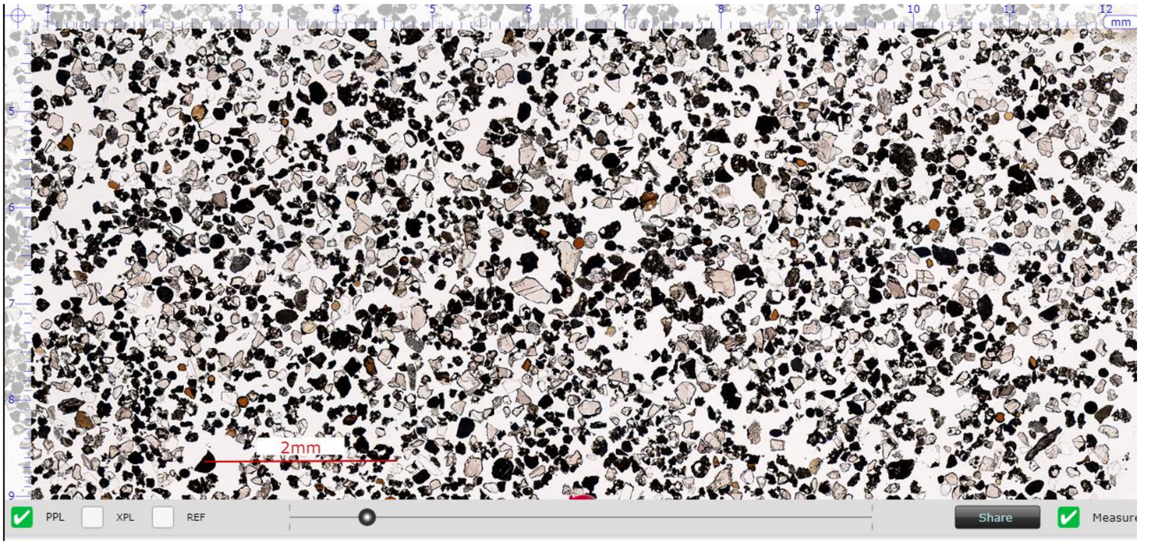

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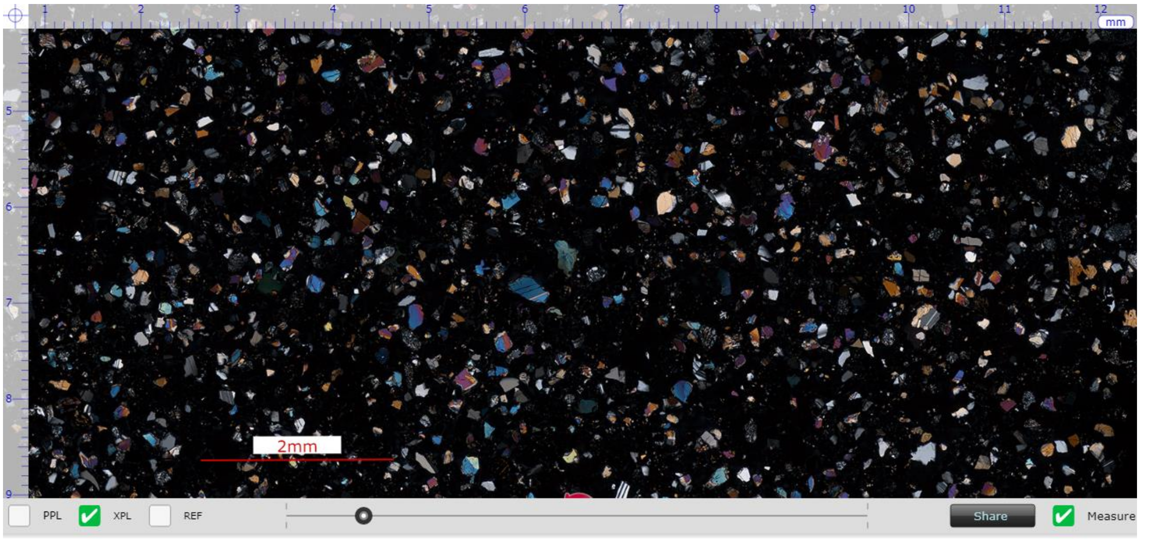

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Images courtesy of NASA, ESA and members of the EURO-CARES consortium