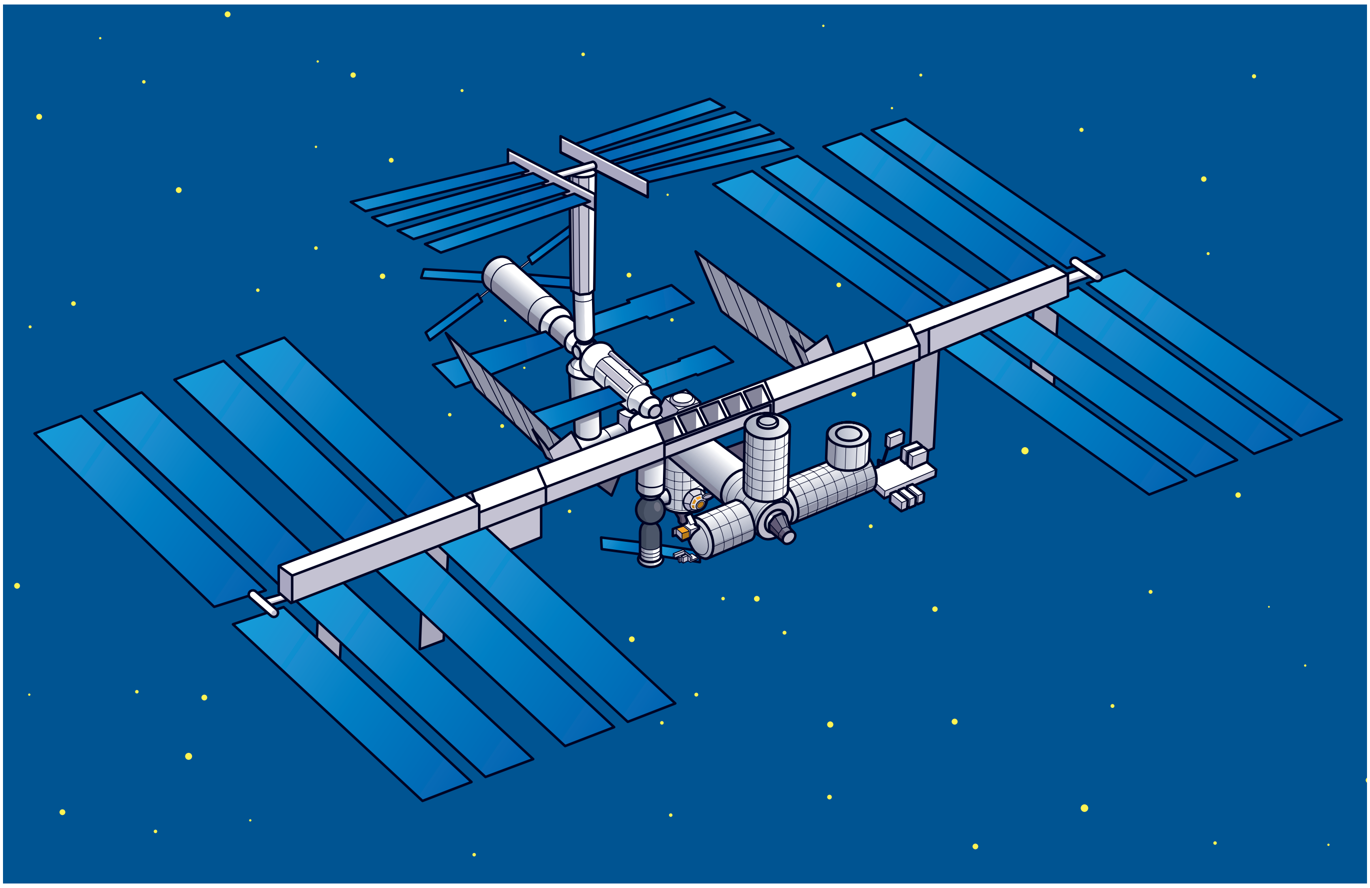
The International Space Station is a floating laboratory where astronauts can live for months at a time. It is full of equipment for doing science experiments. The experiments that astronauts do on the Station teach us many things we need to know before humans can travel further out in space, and a lot of the new knowledge will be useful on Earth, too.



The Station is the biggest object humans have ever built in space. It travels around the Earth at a speed of 28 000 kilometres an hour, about 400 kilometres above our heads. It is not so far away, actually. On a clear night, it is possible to see it from the Earth. It looks almost like a wandering star as it passes in the sky above you.

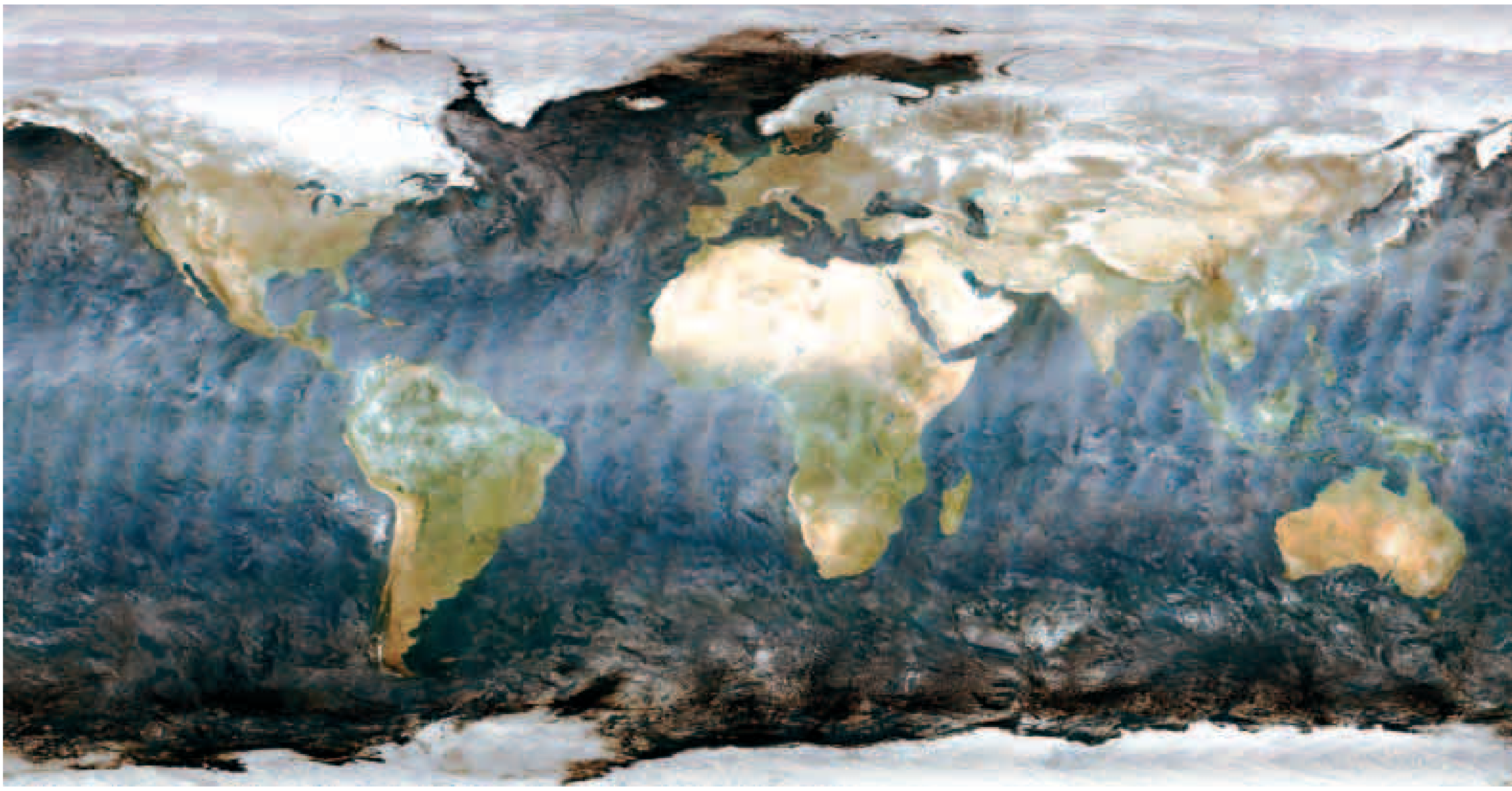
# 3.1 What is a Space Station?

## Worksheet A: International cooperation

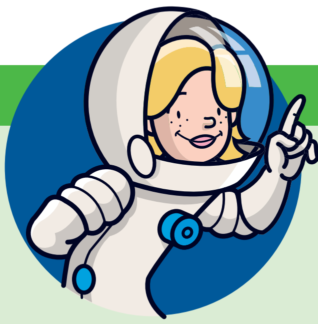
Many countries are working together to build the Space Station. Some of their brightest engineers and scientists are doing their best to make it a success. **USA**, **Russia** and 10 countries in **Europe** are sharing the effort with **Canada** and **Japan**.

Look at the satellite image below and use an atlas to:

1. Mark Europe and the names of the other countries that are cooperating in building the International Space Station.
2. Mark the names of the continents of the world.
3. Mark the names of the biggest oceans in the world



A satellite image of the Earth



### Think about it!

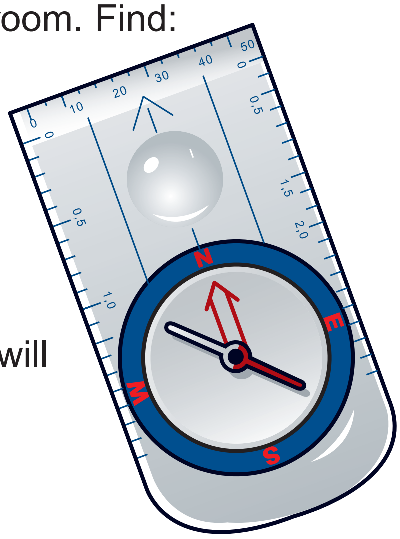
- Why is it important to cooperate?
- What situations have you experienced where it was better to cooperate with your friends and family?
- What examples can you think of where people did not cooperate? How did that end?

## Worksheet B: See the International Space Station

The International Space Station can sometimes be seen on a clear night. Ask your teacher to help you to find out when and where to see it!

**Preparations**

1. Practise using a compass in the classroom. Find:
   a. North
   b. South
   c. East
   d. West



2. Use the compass and practise finding the direction where the Space Station will appear in the sky on the night you are planning to see it.

The International Space Station.

**Watch the Space Station**

Take the compass and a torch and meet to watch the Space Station. Once again, practise finding North, South, East, West and where the Space Station will appear in the sky by using the compass.

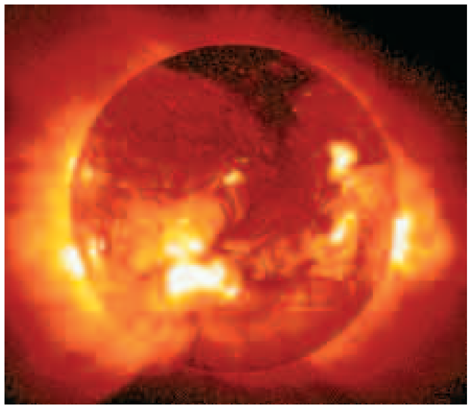
Remember, the Space Station travels fast – it will pass in a few minutes, so be ready when it is time to see it!

### Think about it!

The Sun rises in the East and sets in the West. The Sun is in the South at midday. About what time of day would it be when the Sun is in the North?

## Worksheet C: Discover what is in the sky

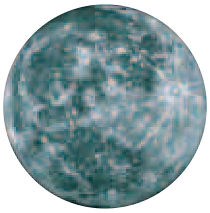
### Preparations


The Sun.

Discuss and find out (use books or other resources – if you need more space, write on a separate sheet):

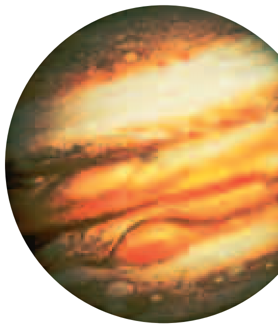
- What is a **star**?

- What is the **Sun**?


The Moon.

- What is a **moon**?

- What is a **planet**?


Jupiter, a planet.

- What is a **satellite**?


Stars.

Which ones can you see in the night sky?

## Worksheet D: Watch the night sky (1)

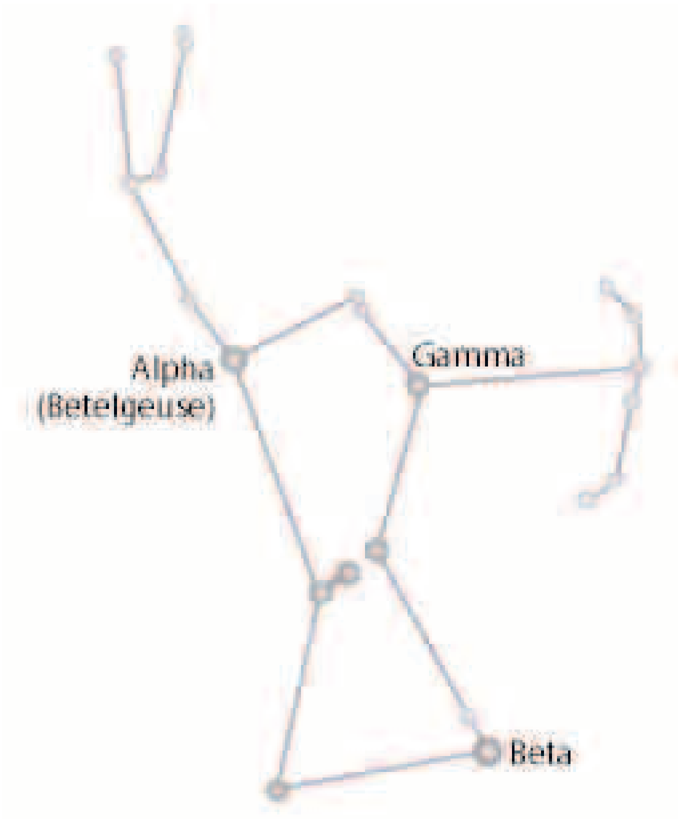
●●○

**Introduction**

A group of stars that makes a pattern in the sky is called a constellation. Through our imagination, we can see a line from one star to another one, and in the end, we imagine that a group of stars forms a picture. There is often a story or a myth connected to a constellation.

**Preparations**

Look at pictures of constellations. Find out which ones you can recognise in the night sky.




The constellation "Orion".

## Worksheet: Watch the night sky (2)

**Watch the night sky**

- Look up at the sky and describe what you see.
- Look for some of the constellations you have seen pictures of in the classroom.

**The day after**

Choose:

1. Write a story about what is out there, in the Universe.
2. Use musical instruments to create a sound picture that describes the mood you experienced when watching the night sky.
3. Make a cartoon about life on a different planet.
4. Find out more about man-made satellites and whether you can see some of them with your naked eyes.

Stars.

### Think about it!

Astronomers estimate that there are at least 70 sextillion stars in the Universe, that is 70 000 000 000 000 000 000 000 stars.

## Worksheet E: Make a model of our Solar System (1)

The Universe is huge! It is so big that it is difficult to imagine. If the whole class works together, you can make a model of our Solar System to get an idea about the distances in the Universe.

You will need an open field, a tape measure and the table below. Go outside and place yourselves at the correct distances.

| | Distance from the Sun (in Million km) | Distance from the Sun Scale: 1:100 000 000 000 |
|---|---|---|
| Sun | 0 | 0 |
| Mercury | 58 | 0.58 m |
| Venus | 108 | 1.08 m |
| Earth | 149 | 1.49 m |
| Mars | 228 | 2.28 m |
| Jupiter | 778 | 7.78 m |
| Saturn | 1430 | 14.3 m |
| Uranus | 2900 | 29.0 m |
| Neptune | 4500 | 45.0 m |
| Pluto | 5900 | 59.0 m |

### Think about it!

The closest star is about 40 000 000 000 000 km away. This would be about 400 kilometres away in your model.

Challenge: Find the name of a place that is 400 kilometres away from where you are right now.

# 3.1 What is a Space Station?

## Worksheet E: Make a model of our Solar System (2)

You can also make models of the Sun and the planets. Use the table on this page to find out how big the models should be (use balls, marbles, nuts or sand, for example).

| | Approximately diameter (by equator) | Diameter for model |
|---|---:|---:|
| Sun | 1 392 000 km | 14 cm |
| Mercury | 4880 km | 0.5 mm |
| Venus | 12 100 km | 1.2 mm |
| Earth | 12 756 km | 1.3 mm |
| Mars | 6 790 km | 0.7 mm |
| Jupiter | 143 000 km | 1.4 cm |
| Saturn | 120 500 km | 1.2 cm |
| Uranus | 51 100 km | 0.5 cm |
| Neptune | 49 500 km | 0.5 cm |
| Pluto | 2 320 km | 0.2 mm |

**Further exploration:**

- Discuss what you think about the distances and the size of the planets. (Imagine how much time it would take to walk these distances!)
- Guess where the Earth's Moon would be in your model.
- Guess where the International Space Station would be in your model.

### Think about it!

It might be difficult to remember the order of the planets. To make it easier, try this or come up with your own one:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **M**y | **V**ery | **E**ducated | **M**other | **J**ust | **S**howed | **U**s | **N**ine | **P**lanets. |
| Mercury | Venus | Earth | Mars | Jupiter | Saturn | Uranus | Neptune | Pluto. |

## Worksheet F: Make a star or planet mobile

**Make four figures:**

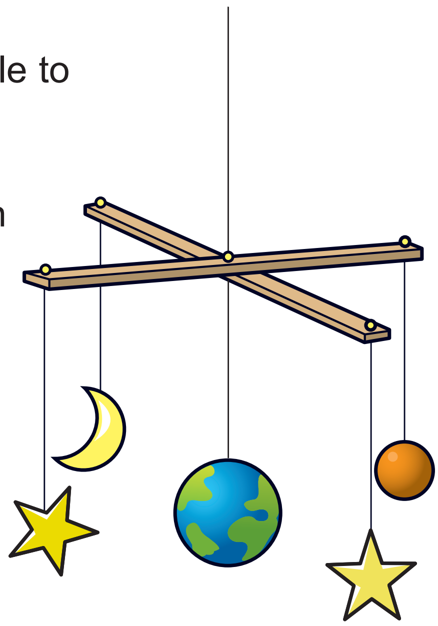
1. Decide which shapes you want for your mobile figures – stars, Moon, Sun or planets.
2. Decide which tools (ruler, pair of compasses etc.) you can use to draw the lines of your figures. Use these tools to draw the shapes for your figures on the cardboard.
3. Cut out the figures.

**You need:**

- Ruler, pair of compasses or other tools to draw the shapes
- Coloured pencils
- Coloured cardboard
- Glue
- Scissors
- 2 Sticks
- Thread
- Needle

**Put the mobile together:**

1. Put two sticks together in the middle to form a cross and tie them together with thread.
2. Make a hole at the top end of each of your figures. Use a needle to pull the thread through.
3. Hang your figures from the sticks with thread.
4. Tie another thread in the middle of the cross so that you can hang it up in the classroom or at home.



### Did you know?

A galaxy is a collection of stars, gas and dust. In our own galaxy, the “Milky Way”, there are around 300 billion stars. Galaxies are held together by gravitational attraction.

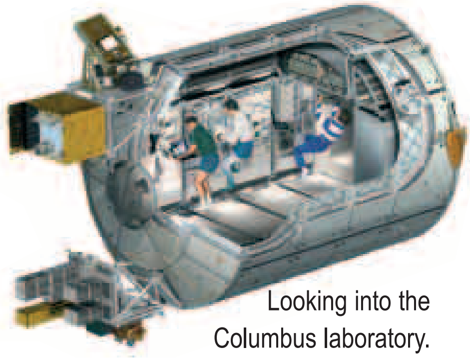
The International Space Station will be as long as a football field once it is completed and thus far too big to be sent up in a single rocket. Instead, the Space Station is being built in parts on Earth. Each part is launched on a rocket, and put together by **robotic** arms and astronauts up in the sky.

It is a little like working with building blocks. But these are very big and complicated building blocks. All the pieces of the Space Station are made to fit exactly. Computers help to guide them into place so they join up gently without crashing into each other.

Even though everything up there is weightless, it is still very hard work. Astronauts have to push and pull in all sorts of awkward positions. And there is no solid ground for them to push against.

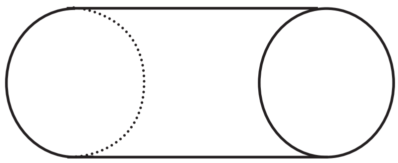
## Worksheet A: The shapes of the modules (1)

One of the Space Station modules is called ‘Columbus’. It has been built in Europe and is a laboratory where the astronauts can perform scientific experiments. From the outside it almost looks like a big can.

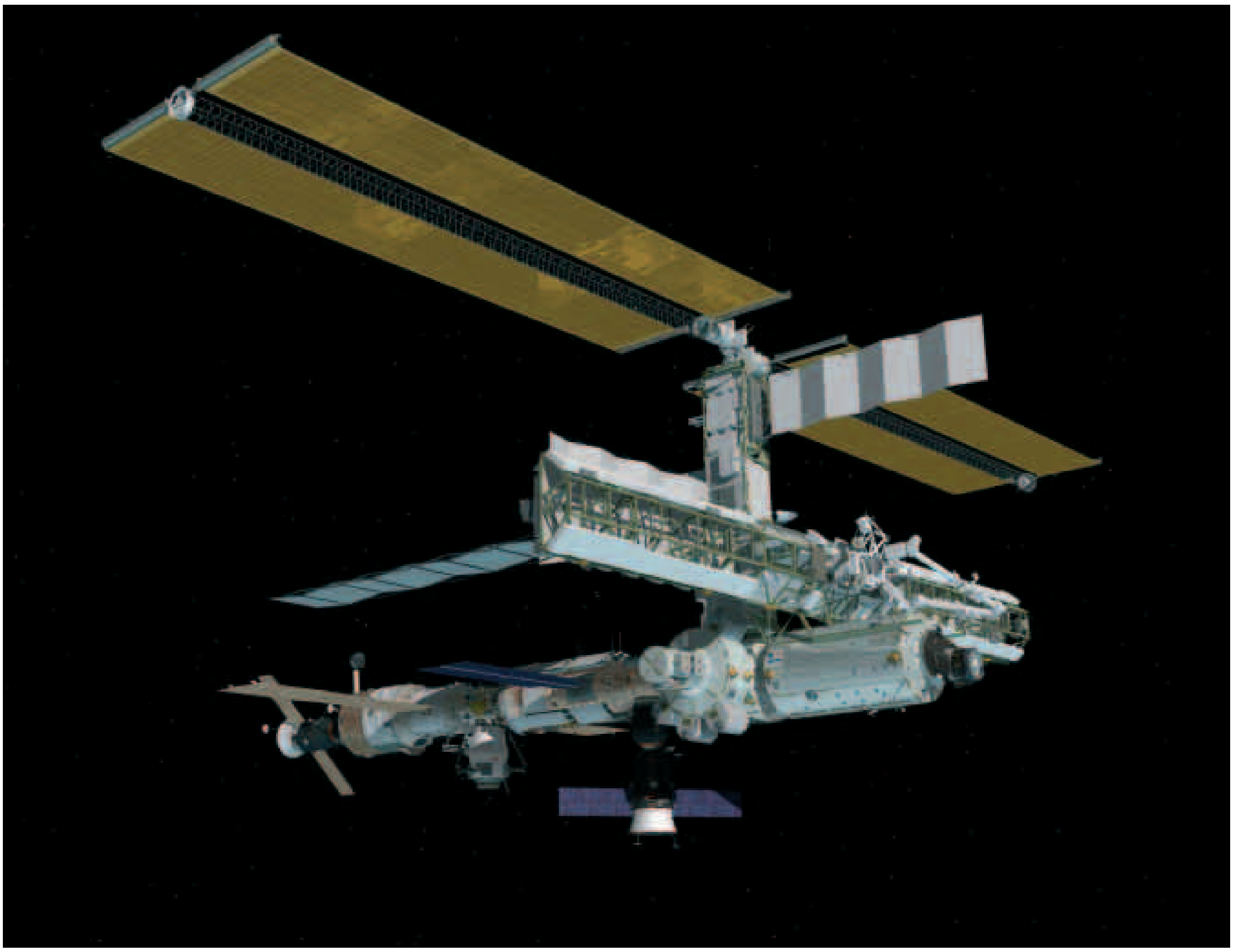


Looking into the Columbus laboratory.

We call this shape a cylinder.



Look at a picture of the International Space Station and describe the shapes of the different parts. Find out what we call these shapes.

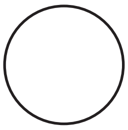


The International Space Station.

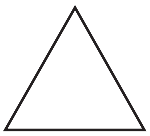
## Worksheet A: The shapes of the modules (2)

**What are the names of these shapes?**

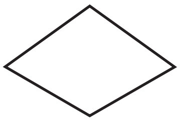
A ____________________



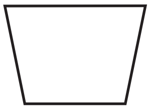
B ____________________



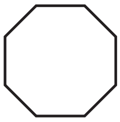
C ____________________



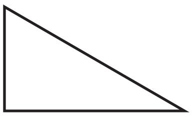
D ____________________



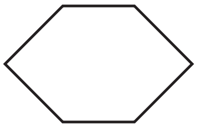
E ____________________



F ____________________



G ____________________



H ____________________

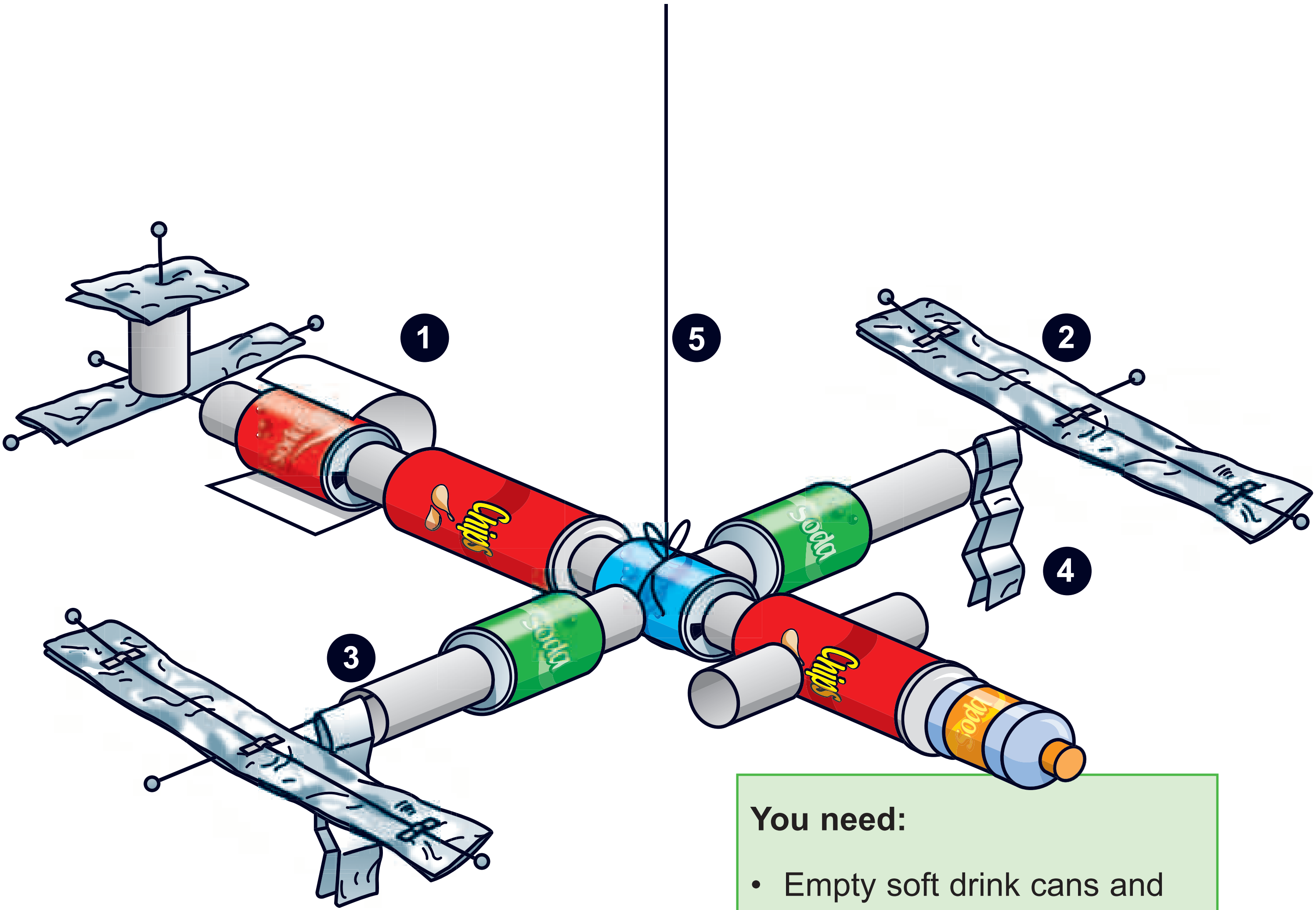
**Discuss and draw:**

- Give examples of where you can find these shapes in the classroom, at home or outside.
- Which tools would you use to draw the different shapes? Use the tools and draw the shapes in your notebook.

## WorksheetB: Build your own space station (1)

Work in groups and build your own space station.

Use cans and aluminium foil or other material that looks similar to the Space Station's modules and solar panels.




**You need:**

- Empty soft drink cans and crisp tubes
- Toilet roll tubes
- Wooden skewers (sticks)
- Aluminium foil
- String
- A4 white paper
- Felt-tip pens
- Glue
- Scissors

## Worksheet B: Build your own space station (2)

**1 Modules**
For the modules, like the European Columbus laboratory, you can use empty cans or crisp tubes. Use paper and coloured felt-tip pens to decorate each of your modules and give them a name.

**2 Solar panels**
The solar panels are long and flat. Use aluminium foil and cut it into strips that should be 12 cm wide and as long as the sticks (for the bigger solar panels). Put two sticks of 5 cm lenght in between and fold the aluminium round them. To attach the solar panels, put a stick through the panel and the toilet roll.

**3 Nodes**
To connect two modules together, glue half a toilet roll in between. This makes it look like the corridor units (called nodes) that fix the different modules together.

**4 Radiators**
Cut two strips of white paper that should be 3 cm wide and 20 cm long. Fold the strips in half and make an “accordion”. Fold the “accordion” over a stick (you can secure it by putting tape around it). Let the radiators hang over the sticks and point downwards.

**5 Let the station float in space**
When you have fixed all the modules together, tie a string around the module in the middle so both ends are in balance. Hang it up in the classroom.

## Worksheet C: Robotics

Astronauts have to steer robotic arms on the outside of the Space Station. When the astronauts control the arm from the inside of the Space Station, they have to be very careful not to bump into something and break it.

If you have got remote-controlled toys (a car or a robot), set up a steeplechase and try to move the toy through the steeplechase without touching anything.

Astronaut using a robotic arm outsie the Space Station.

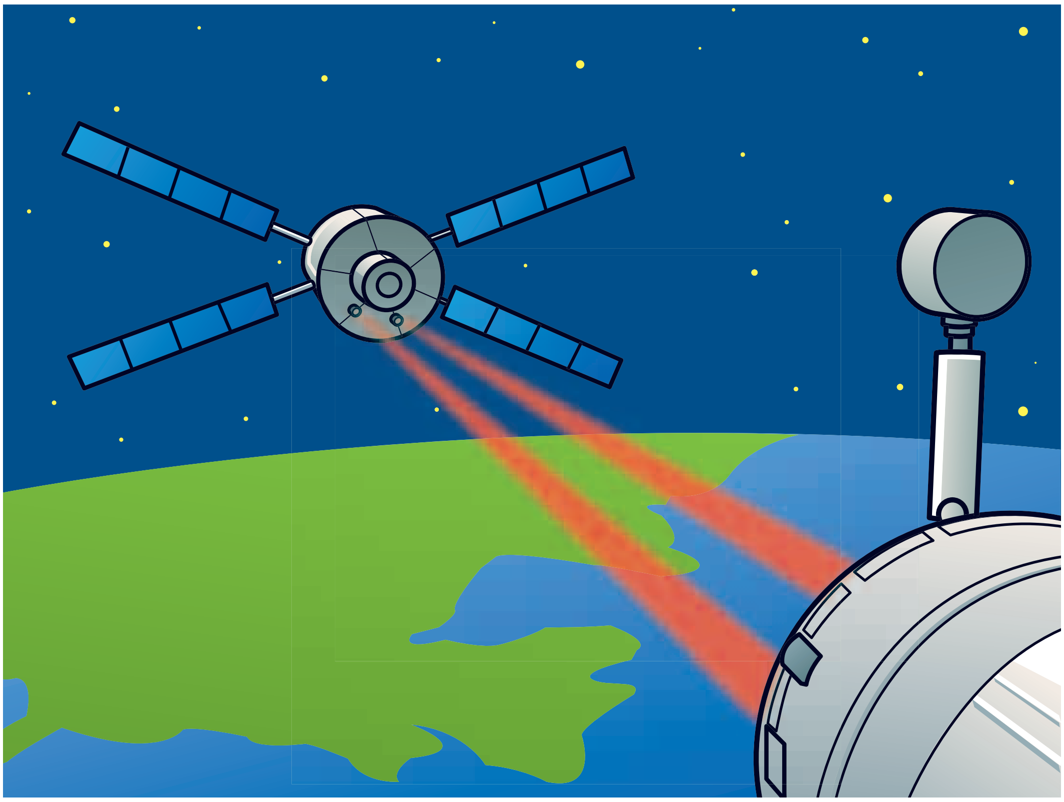
### Think about it!

We use robots in our daily life and in factories. Robots are often used when it is too dangerous for people to do a specific task. They are also used for tasks that are repetitive or boring. They help people to be more efficient. What kind of robots do you know of?

Challenge: What task could you think of that is boring or dangerous to do? How would you make a robot help you with this task?

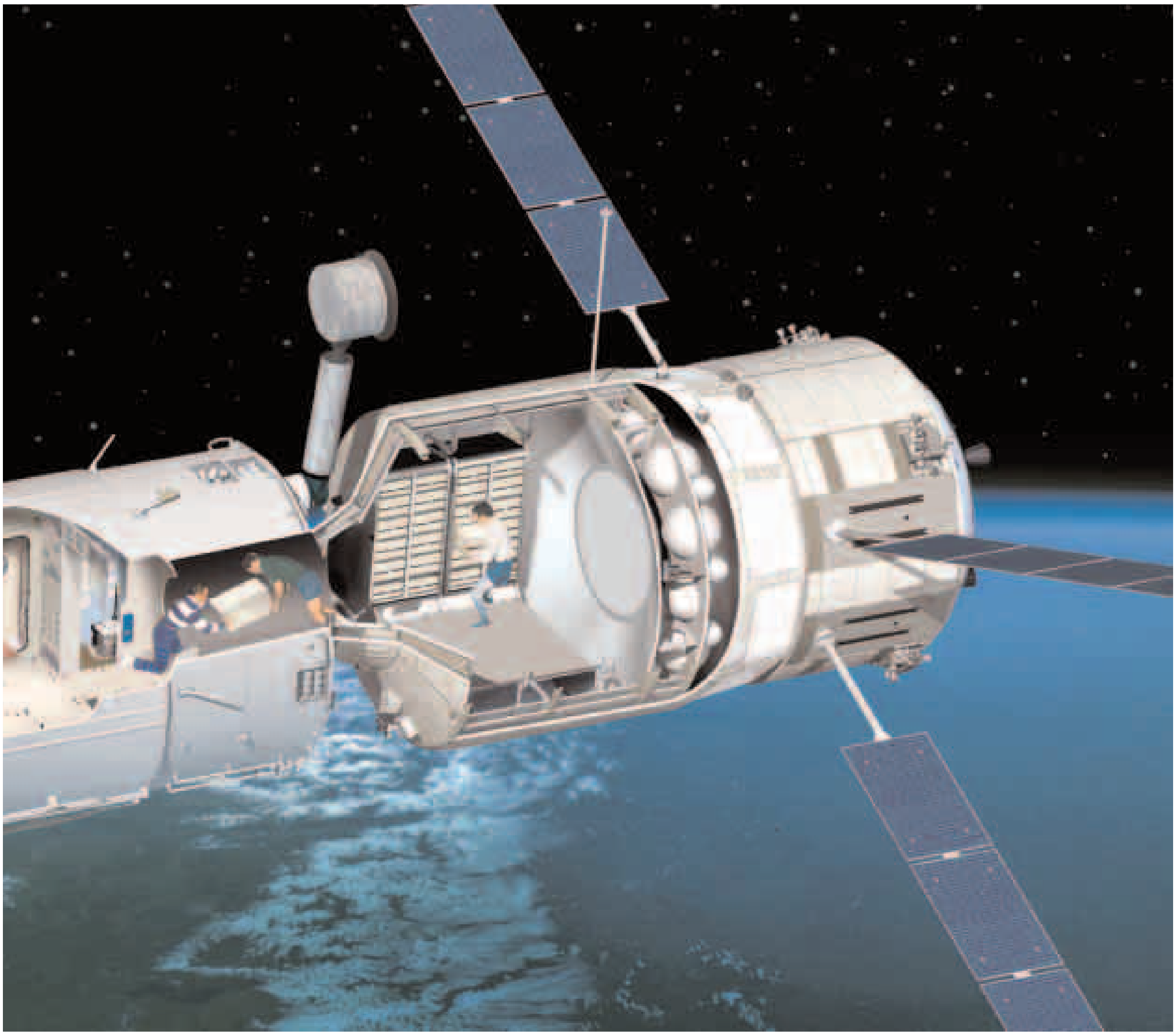
Like everyone else, the astronauts on board the Space Station need to eat and drink. They need to breathe, too – but unlike everyone else, they cannot just open a window if they feel like having some fresh air!

The astronauts also need materials for their scientific experiments, and sometimes they need spare parts to fix worn-out or broken parts of the Space Station.



All these supplies are sent up from Earth in rockets or in an **automatic** “space truck” called the **Automated Transfer Vehicle (ATV)**. It has automatic systems, which makes it possible to dock to the Space Station without astronauts on board steering it.

When the astronauts have unloaded the space truck (the supplies usually include gifts from their families), they fill it with the Station's rubbish. Then it undocks and heads back towards the Earth. It burns up high above the Pacific Ocean. Nothing is left to cause pollution.



An artist's impression of the "space truck" ATV docked to the Space Station. Astronauts are unloading the new supplies.

# 3.3 Getting things there and back

## Worksheet A: Plan a mission (1)

**How much water do you need for your mission?**
A short mission to the Space Station normally lasts around 10 days, while longer missions last 4 to 6 months. Plan how much water you need to take for a 10-day mission.

- An astronaut needs about 3 litres of water per day for drinking and preparing food.
- An astronaut needs about 4 litres of water per day for personal hygiene.

| Calculate: | Calculate: |
|---|---|
| | |

When you have found out how much water you need, find out how much room this amount of water will take. (You can, for example, place empty milk cartons in the corner of the classroom).

Discuss:
- What do you use water for here on Earth?
- How can you reduce the amount of water you use?

### Think about it!

On average, a European citizen uses up to 230 litres of water per day! Flushing the toilet takes 6 litres every time!

Astronauts use washcloths instead of having a shower. They wash their hair with a special shampoo that they wipe off with a towel and they recycle as much water as possible.

## Worksheet A: Plan a mission (2)

●●○

There is limited space on board the Space Station, and every kilogramme (kg) of supplies brought to the Space Station is quite expensive because it costs a lot of money to send a rocket to space. Deliveries to the Space Station are therefore kept to a minimum.

In addition to water, what other things do you need to survive for ten days in space? Plan what would you take. Fill in the table and calculate the amount of kiligrammes:

| Amount | | kg |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| Total amount in kg | | |

### Think about it!

- What do you need to survive?
- What do you need for comfort?
- What can you manage without?

## Worksheet B: Create an astronaut menu (1)

●●○

Astronauts on board the Space Station eat a lot of the same food we eat on Earth: meat, cereal, cheese, vegetables, biscuits, yoghurt, cakes, crackers, nuts, fruit, pasta, rice and fish. And they drink coffee, tea, fizzy drinks, fruit juices and milk.

But it is important that an astronaut eats healthily. They need to make sure that they get all the **nutrition** the body needs during the day. Before they leave for space they put together the menu for their space mission.

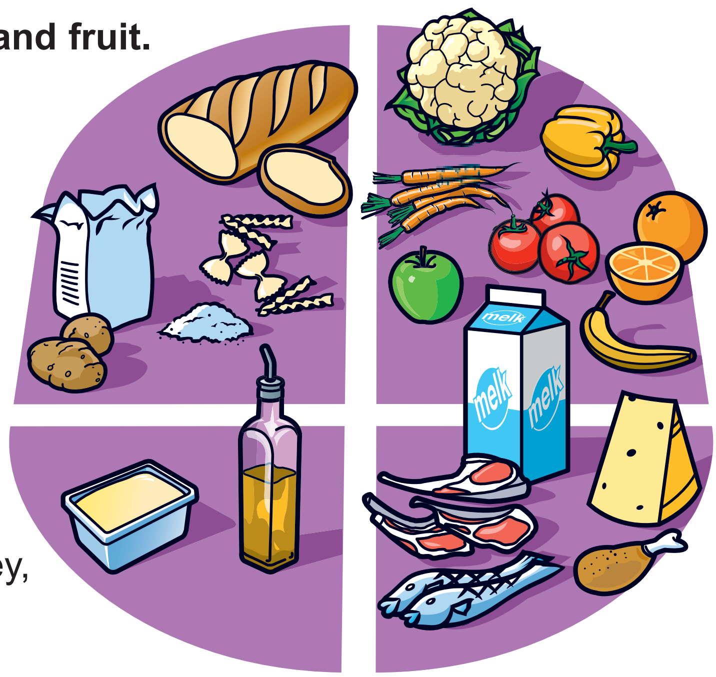
**Put together your astronaut menu**
Make sure your menu is varied and contains different kinds of nutrition. Choose food from the four food groups: You need the most food from group 1 and 2, less from group 3 and the least from group 4.

**Group 1: Carbohydrates**
Examples: Bread, potatoes, rice, pasta, cereals.

**Group 2: Vegetables and fruit.**
Examples: Apples, tomatoes, bananas.

**Group 3: Proteins**
Examples: Dairy products, nuts, meat, fish, chicken, egg.

**Group 4: Fats and Sugars**
Examples: Sugar, honey, margarine, butter, oil.



## Worksheet: Create an astronaut menu (2)

|  | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Breakfast |  |  |  |  |
| Lunch |  |  |  |  |
| Dinner |  |  |  |  |

“Dinner” in space.

### Think about it!

It is difficult to bring fresh food up to the Space Station because it takes several days to deliver it. A lot of the food has been dried or dehydrated (the water has been taken out) and packed in sealed bags. What dried food can you buy from the grocery shop?

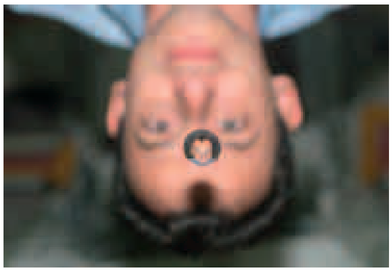
## Worksheet C: Test and taste the astronaut diet – food (1)

●●○

**Preparations**

Work in pairs. Make a collection of food from the astronaut menu and slice them or make small test portions. For instance:

- Salt cracker
- Orange
- Yoghurt
- Apple
- Biscuit
- Honey
- Grapefruit
- Ham



Water floats around in spheres.

**Test**

In turn, one of you wears a blindfold, while the other serves the food.

The one with the blindfold has to:

1. Taste the food the other pupil serves.
2. Guess what it is.
3. Tell whether you think the test sample tastes sweet, sour, salty or bitter.

Cheese for breakfast.

The one serving the food has to:

1. Serve the other pupil with test samples in a random order. Write down in the table what you serve.
2. Write down what the one with the blindfold thinks the test sample is.
3. Write down what the one with blindfold think it tastes like (mark it with an 'x' under sweet, sour, salty or bitter).

When you have both tested the various samples, compare your answers. Discuss in the class what each tastes like.

## Worksheet C: Test and taste the astronaut diet – food (2)

**Name:** ______________________________

| | Test sample served: | The one with the blindfold thinks it is: | Sweet | Sour | Salty | Bitter |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

### Think about it!

An astronaut's taste changes in space. Some astronauts find that the taste is stronger. Have you ever felt that the taste of food has changed (for example, becoming weaker or stronger)?

## Worksheet C: Test and taste the astronaut diet – drink

●●○

**Preparations**

Work in pairs. Make a collection of drinks from the astronaut menu. For instance:

- Fizzy drinks
- Orange juice
- Grapefruit juice
- A mix of water and salt.

**Test**

Dip a cotton tip in the various fluids. Try to find out on which part of your tongue you can taste:

- Sweet?
- Sour?
- Bitter?
- Salty?

Draw on the illustration where you tasted sweet, sour, bitter and salty the most.

## 3.1 What is a Space Station?

**Lesson – core elements:**

| | |
|---|---|
| Pupil's text: | The International Space Station (ISS) is a floating laboratory in space:<br>• It is the biggest man-made construction in space<br>• Visible from Earth, orbits 400 km above the Earth<br>• Travels at 28 000 km/h<br>On board, scientific experiments are performed<br>The experiments which will be useful for further human exploration of the Universe and for further developments on Earth |
| Worksheets: | International cooperation (continents, oceans, countries, satellite image of the world – shown as a map)<br>**Watch**:<br>• The ISS<br>• Objects in the sky (star, sun, planet, satellite, moon)<br>• Constellations<br>**Orientation**:<br>• Compass<br>• North-South-East-West<br>Model of our Solar System (distances, scale)<br>Make a star or planet mobile |

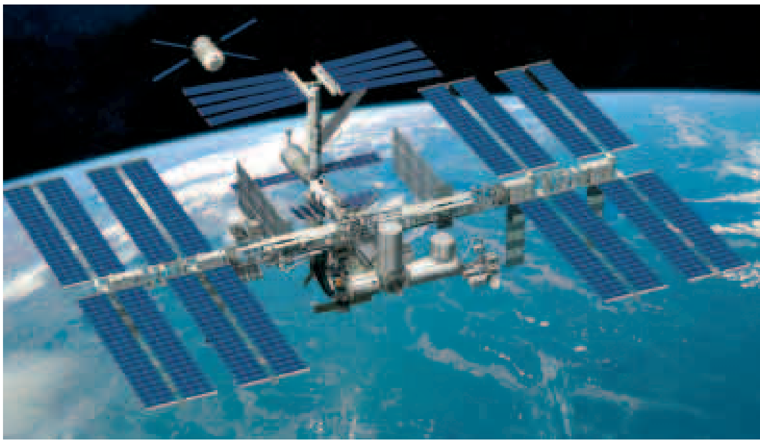
**Subjects represented:**
Arts
Language
Science
Geography
Maths


The ISS in its current configuration.

**Background information:**
The International Space Station is exactly what it says it is: a station in space, and one that is truly international. America and Russia are the two biggest contributors, and, working through the European Space Agency, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden and Switzerland are all taking part. Canada and Japan are also partners in the cooperation.

The ISS orbits the Earth at an altitude of about 400 km, and it provides a permanent – well, at least for the next 15 years – human presence in space. The station's prime purpose is to be a platform where scientific experiments can be performed in weightlessness. (We could say "in the absence of gravity's effects"; it is gravity that keeps the ISS circling in its orbit.)

Most of these experiments take place inside one of the station's "science modules". There are two of these – one Russian, one American – in operation at the moment, but they will eventually be joined by a Japanese module and Europe's own Columbus module. Other experiments can be performed outside the station's pressurised, shirt-sleeve environment: equipment destined to work in the vacuum of space can be bolted on to the station's exterior and tested for days, weeks or months before it is used on a mission that might take it very far from human sight.


Artist's impression of the ISS in its final configuration.

The station's orbit is tilted at just over 51 degrees with respect to the equator. As it whirls around the Earth, the Earth in turn rotates beneath it. That means that the ISS passes over 85% of the planet's surface – only the extreme north and the extreme south are never beneath its orbital track. So the ISS is also a good Earth observation platform, from which a host of terrestrial phenomena, from pollution to ocean currents, can be tracked. The superb views the crew members have from the station are a bonus.

The orbital track also means that at one time or another, the station passes over the heads of 95% of the Earth's population. It crosses over them at a height of 400 km, and if the sky is clear at night, it is visible as a bright wandering star.

When it is complete, the Station will have a mass of 455 tonnes. Much of that mass is taken up by structural components and the huge array of solar panels that supply the station's power. But there is plenty of room for the crew even now, and when the ISS is complete its pressurised volume will be about the same as two Boeing 747 jumbo jets.

**Ideas and hints for the worksheet activities:**

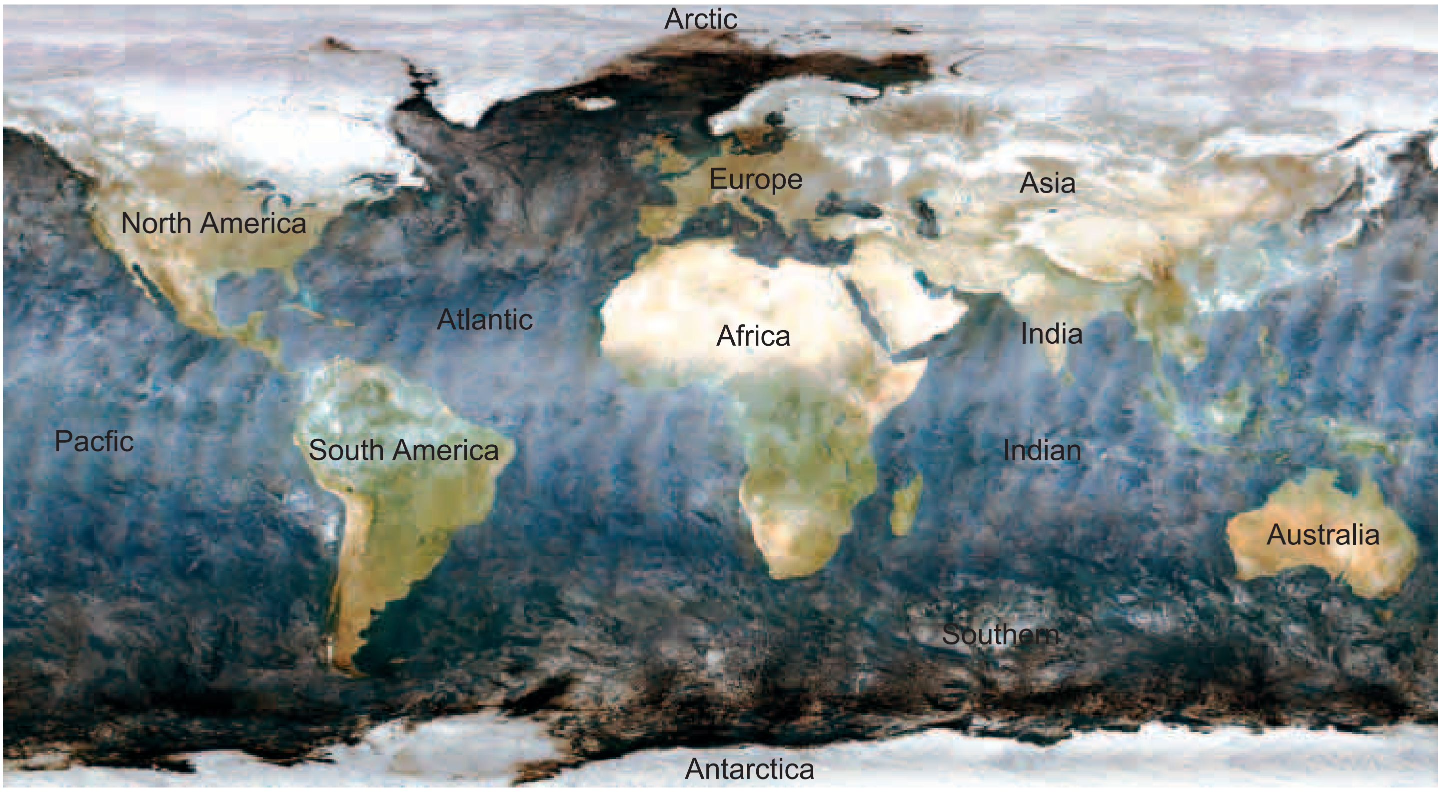
*Worksheet A: International cooperation, page 81*

Question2: Africa, Antarctica, Asia, Australia, Europe, North America, South America

Question 3: Pacific Ocean, Atlantic Ocean, Indian Ocean, Arctic Ocean

*Worksheet B: See the International Space Station, page 82*

Help the pupils find out whether the ISS is visible from where you live. Visit www.esa.int/seeiss and enter the name of your town. If it is visible, the site will give you a star map showing where the ISS is and its path. The site will also show a table giving you the exact coordinates of the pass.



Satellite image of the Earth with the names of the continents and oceans.

When you have found out when and where to see the ISS, maybe it is possible to organise an event for the class and their families to meet at night and watch “the wandering star” together.

Let the pupils practise beforehand to use a compass – let them find North, South, East, West, and the direction in the sky where the ISS will appear on the chosen night. On the night itself, remember to bring a torch so that you can see the indicators on the compass.

***Worksheet C: Discover what is in the sky, page 83***

Definitions of the words “Sun”, “star”, “moon”, “planet” and “satellite” can be found in the glossary.

The Sun is visible during daytime (remember never to look directly into the Sun!) and the stars are visible at night. The Moon is illuminated by the Sun. Some of the planets and man-made satellites cannot be seen, while others can be seen in the night sky as they get illuminated by the Sun. Of the planets in our Solar System, the ones visible to the naked eye are:

- Venus (just before sunrise and just after sunset),
- Mars (red in colour),
- Jupiter and
- Saturn.

Find out what is visible from where you live at www.heavens-above.com

### Worksheet D: Watch the night sky, pages 84-85

The majority of planets is named after Greek and Roman gods and mythical figures:

| | |
|---|---|
| Mercury | Roman god of trade, profit and commerce (Greek: Hermes) |
| Venus | Roman goddess of love (Greek: Aphrodite) |
| Mars | Roman god of war (Greek: Ares) |
| Jupiter | main Roman god (Greek: Zeus) |
| Saturn | Roman god of agriculture (Greek: Cronus) |
| Uranus | Greek mythology only, a personification of the sky and the earliest main god |
| Neptune | Roman god of water (Greek: Poseidon) |
| Pluto | Roman god of death and the underworld (Greek: Hades) |

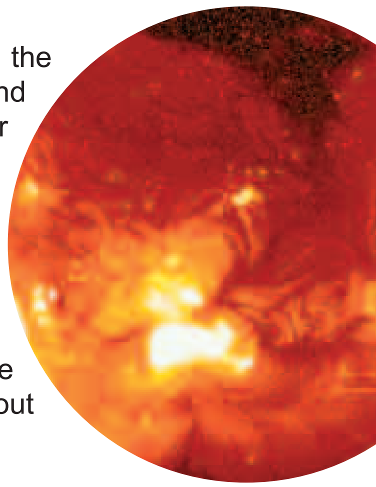
The Sun was also believed to be a god – Helios in Greek mythology – driving his chariot pulled by fiery horses every day across the sky from East to West.

The constellations we see in the night sky are of course just projections of our imagination and do not really belong together – stars that appear close together viewed from Earth in the sky can be light years away from each other. Most are named after ancient mythology, some after animals (Leo, Cancer, Serpens etc, which also have mythological meanings) and some after objects (Lyra (lyre), Telescopium (telescope)). A constellation that is easy to find is Orion, named after a giant hunter from Greek mythology.

### Worksheet E: Make a model of our Solar System, pages 86-87

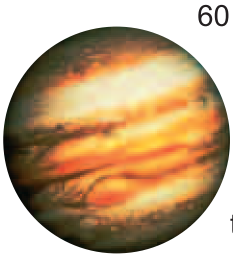

The Moon.

This activity gives an idea of how enormous distances are in space. Graphical illustrations of the Solar System often give a wrong impression of dimensions as it is impossible to get the right dimensions into a small picture…


The Sun.

In the Pupils' Worksheet, you'll find a table indicating the distances between the Sun and the planets in million km and in a scale 1: 10 000 000 000. The latter one is intended for you to use with your pupils to get an idea of the distances.

You will need an open field, but you might have to use your imagination or improvise to illustrate where the far-away planets would be (unless you've got a field of about 600 metres available). In the table below, we also provide you with the numbers for an even smaller model (scale 1:100 000 000 000) – in this model you need an area of about 60 metres length.

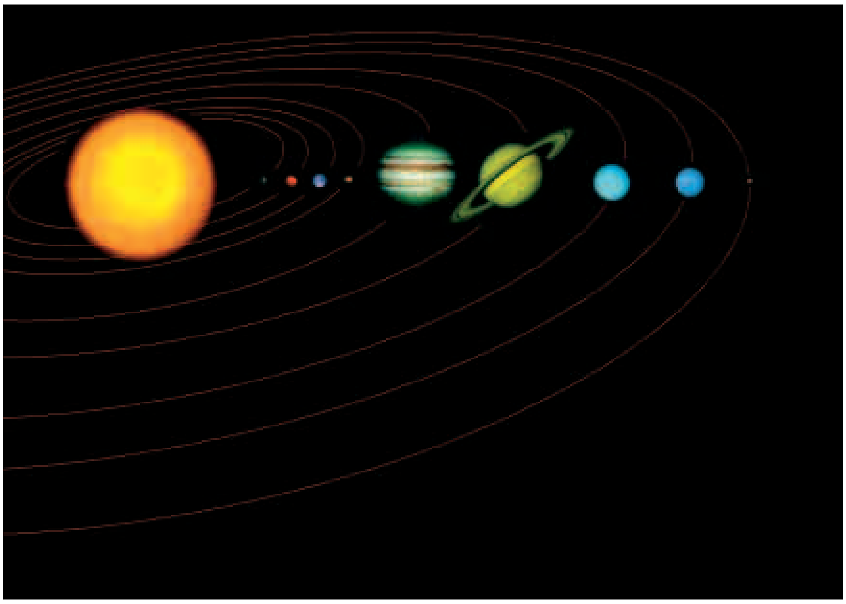

Jupiter.

When making a model of our Solar System to scale, the planets become tiny, especially in the model below (most of the planets have to be as small as grains of sand…). We propose to use balls, marbles, nuts or sand to represent the various planets – let the pupils be creative and come up with their own ideas.

| | Distance from the Sun (in Million km) | Distance from the Sun Scale: 1:10 000 000 000 | Distance from the Sun Scale: 1:100 000 000 000 |
|---|---|---|---|
| Sun | 0 | 0 | 0 |
| Mercury | 58 | 5.8 m | 0.58 m |
| Venus | 108 | 10.8 m | 1.08 m |
| Earth | 149 | 14.9 m | 1.49 m |
| Mars | 228 | 22.8 m | 2.28 m |
| Jupiter | 778 | 77.8 m | 7.78 m |
| Saturn | 1430 | 143 m | 14.3 m |
| Uranus | 2900 | 290 m | 29.0 m |
| Neptune | 4500 | 450 m | 45.0 m |
| Pluto | 5900 | 590 m | 59.0 m |

The mean distance from the Earth to the Moon is about 384 400 km. The Moon would be about 3.84 cm away from Earth in the scale 1:10 000 000 000 model and 3.84 mm away from Earth in the scale 1:100 000 000 000 model.

The ISS is in orbit 400 km above the Earth's surface. It would be difficult to place the ISS in the models with the above scales. In the scale 1:10 000 000 000 model the ISS would be 0.04 mm away from the Earth and 0.004 mm away in the scale 1:100 000 000 000 model.



The Solar System.

| | Approximately diameter (by equator) | Diameter for model Scale: 1:10 000 000 000 | Diameter for model Scale: 1:100 000 000 000 |
|---|---|---|---|
| Sun | 1 392 000 km | 14 cm | 14 mm |
| Mercury | 4880 km | 0.5 mm | 0.05 mm |
| Venus | 12 100 km | 1.2 mm | 0.12 mm |
| Earth | 12 756 km | 1.3 mm | 0.13 mm |
| Mars | 6 790 km | 0.7 mm | 0.07 mm |
| Jupiter | 143 000 km | 1.4 cm | 14 mm |
| Saturn | 120 500 km | 1.2 cm | 12 mm |
| Uranus | 51 100 km | 0.5 cm | 5 mm |
| Neptune | 49 500 km | 0.5 cm | 5 mm |
| Pluto | 2 320 km | 0.2 mm | 0.02 mm |

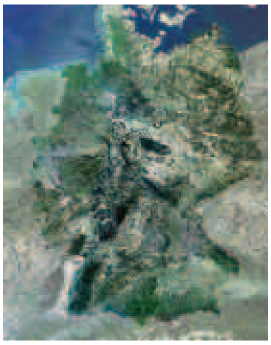
(The Moon has a diameter of about 3480 km. The size of the Moon in the two models would be 0.35 mm and 0.03 mm, respectively.)

***Worksheet F: Make a star or planet mobile, page 88***

This Worksheet suggests how to make a simple star or planet mobile. There are no limits of creativity – the pupils can add more stars, moons or planets. They can vary the sizes, the shapes and where to hang them. Depending on what kinds of materials are available, pupils can decorate their shapes with glitter, aluminium foil or fluorescent paint, etc.


Satellite image of Belgium.


Satellite image of Denmark.


Satellite image of Germany.


Satellite image of Italy.


Satellite image of Sweden.

**Further ideas and explorations:**

### *International cooperation*

This worksheet can lead to more extensive work on how to use maps, mark major rivers, cities, lakes and mountains on the map provided in the worksheet.

It can also be used to find out more about the countries involved in the International Space Station. One country alone would not have the resources to build the ISS. Several countries have joint forces to be able to build the ISS, these are: America, Canada, Japan, Russia and 10 countries in Europe: Belgium, Denmark, France, Germany, Italy, The Netherlands, Norway, Spain, Sweden and Switzerland.

- Find out more about the countries.
- Find out more about the space race and the cold war.
- Find out more about international cooperation and international agreements.
- Find out more about large construction projects.

### *See the International Space Station*

If you haven't worked with a compass in class before, this is a good opportunity to let the pupils learn how they work. Possibly link this with magnetism.

Let the pupils use a magnet and explore how it works. Gather various types of materials: pens, pins, paper clips, cutlery, coins etc. and let the pupils place the samples on the table in front of them. The pupils should:

- Guess what materials they think will be attracted by the magnet.
- Test and find out what materials are attracted by the magnet.

### *Watch the night sky*

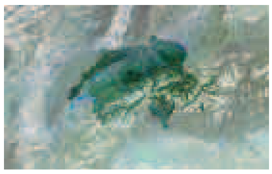
1. Let the pupils find out which planets have moons and what the names of the moons are.
2. Let them find out more about constellations and the myths behind them. It could be connected to learning about e.g. the Roman and Greek Gods and Goddesses that many constellations are named after.
3. Talk about astrology and the difference between astronomy and astrology. Name the astrological signs and let the pupils find out what sign corresponds to their date of birth.

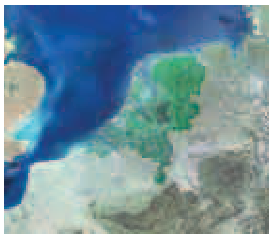
**Websites:**
www.heavens-above.com


Satellite image of Norway.


Satellite image of Spain.


Satellite image of France.


Satellite image of Switzerland.


Satellite image of The Netherlands.

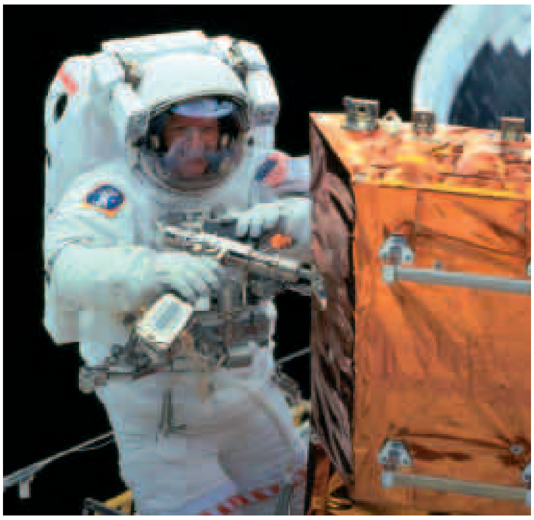
## 3.2 Building the International Space Station

**Lesson – core elements:**

| | |
|---|---|
| Pupil's text: | The ISS is too big to be sent up in one go<br>The ISS is assembled piece by piece by rockets, astronauts, robotic arms and computers |
| Worksheets: | Build a model of the ISS<br>The shapes of the modules (and other shapes)<br>Robotics |

**Subjects represented:**
Arts
Maths
Language
Science

**Background information:**
The International Space Station is probably the most ambitious construction project ever, and by far the most complex structure ever assembled in space. It is still under construction, although it has been partly functional since 2000 and is already doing useful work. The finished station will have a mass of 455 tonnes; since the most powerful rockets available can loft no more than 20 tonnes to its orbit, it has to be built from self-contained "modules", all of which fit together like Lego bricks.



Claude Nicollier during his 8-hour spacewalk.

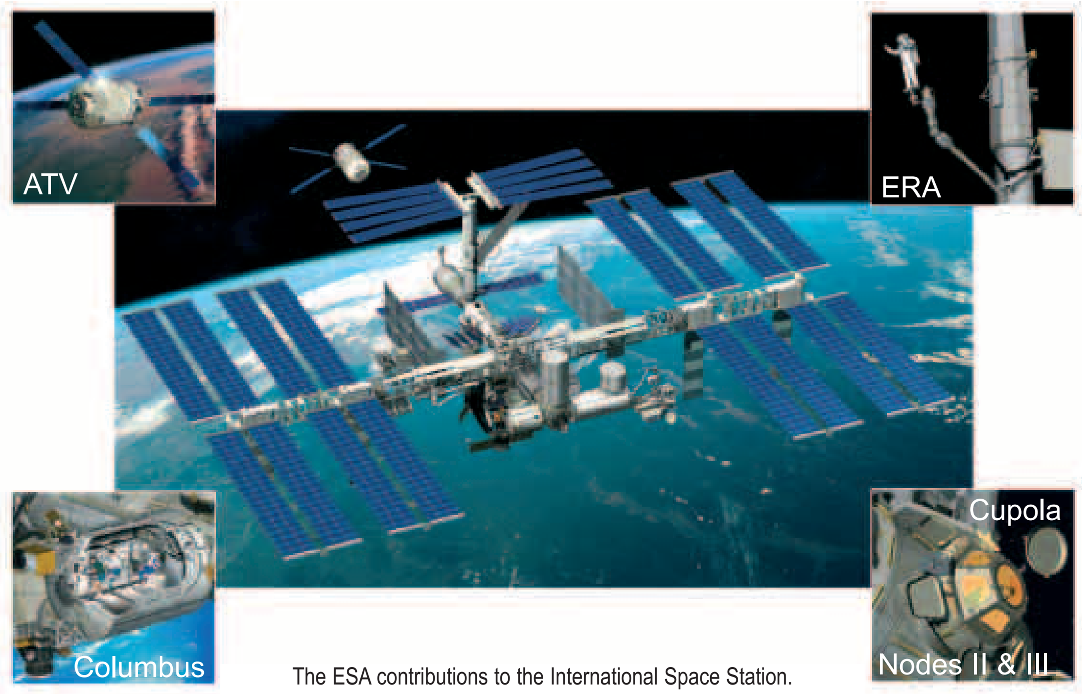
The main sub-units are the science and habitation modules, and the "nodes" that link them together. These are all built with docking adaptors that allow them to mate together in space under the guidance of the station's crew and visiting construction teams, usually with the help of a robotic arm – a complex sort of space crane.

In fact, one of the first important pieces of equipment was the Station's own robotic arm – the Canadarm2 – which can move quite massive components to almost anywhere within the Station's area with astonishing precision. But not everything is automated: much construction work requires considerable physical effort from astronauts, who must work for up to six hours at a time in spacesuits to bolt equipment into place.

Despite the weightlessness of orbit, building work in space is at least as strenuous as similar jobs on Earth, and much more complicated. Astronauts use power tools whenever possible, but they have to be very special power tools. Take a screwdriver, for example, or a powered wrench or spanner: in weightlessness, it will turn the astronaut who holds it just as much as the screw or bolt it is supposed to tighten. Such tools must be built with counter-rotating flywheels to cancel out the unwanted rotary motion. This makes the things cumbersome – but it also makes them effective.

**Ideas and hints for the worksheet activities:**

*Worksheet A: The shapes of the modules, pages 90-91*
It takes years before one part of the station is ready to be launched and attached to the Space Station. Currently, the ISS consists of several cylindrical modules called Zarya, Zvezda, Unity and Destiny.

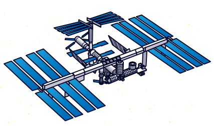



The ESA contributions to the International Space Station.

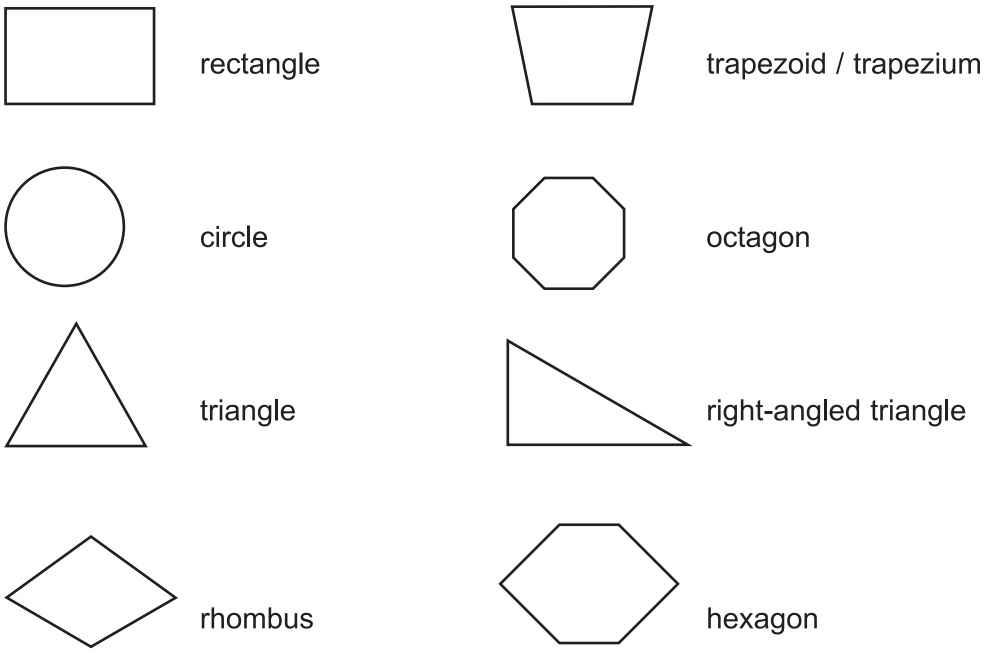
The Space Station has big solar panels for energy supply. The rectangular surfaces of the solar panels are blue , the radiators are grey and look almost like an accordion. The radiators make sure that excess heat is radiated away from the Space Station to cool it down when facing the Sun. There are also docking compartments for spacecraft, and a Soyuz craft is always attached to the Space Station to be used as a rescue vehicle.

On the Space Station's outside there are several robotic arms (the European Robotic Arm, ERA, and the Canadian robotic arm called the "Canadarm2") that can move from one end of the Space Station to the other and carry and attach bulky equipment.

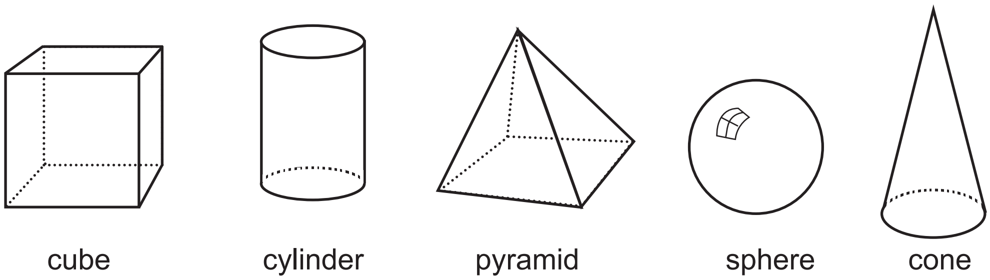
Use this activity to talk about different sorts of shapes in real life. Let the pupils list the shapes they already know and introduce the names they don't know. Talk about the differences between the shapes and what is special about each one of them.



**2D shapes:**




**3D shapes:**




### *Worksheet B: Build your own Space Station, pages 92-93*

The instructions are included in the worksheets for the pupils. You may decide not to copy it and hand it out, but rather explain and show the pupils how they can do it by demonstrating it in the classroom. Build a model yourself to show in class to give pupils ideas.

As the pupils are supposed to bring material from home (cans and toilet roll tubes) , they need some time to prepare in advance.

### *Worksheet C: Robotics, page 94*

Let the pupils bring their remotely controlled toys to school (as described in the worksheet). Challenge your pupils to come up with an idea for a robot design, let them draw it, bring in a device or design and build a mechanism that can solve the task the robot is set to do (has to be defined beforehand – for example picking something up, putting something together, fetching a glass of water etc).

**Further ideas and explorations:**

A do-it-yourself robotic arm.

*The shapes of the modules*
When working with the shapes of the modules, create models of the shapes in plasticine, for example, bring in examples of objects that have the shapes you have looked at (e.g. a milk or juice carton, a can, dice etc.).

Depending on the level of your pupils, this work can be related to calculating the surface area of various shapes or to introduce concepts like volume.

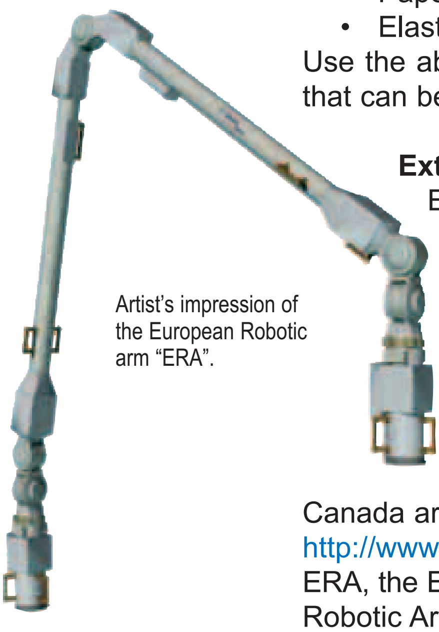
*Build your own Space Station*
In addition to building the Space Station, the pupils can build a spacecraft – for instance an Automated Transfer Vehicle (ATV). For instructions on how to build an ATV see next chapter: "Further ideas and explorations".

*Robotics*:
*Experiment: Design your own robotic arm*
A robot is a machine or device that operates automatically or by remote control. It can be used to perform human tasks or imitate some of the things a person can do. Especially in industry, robots are used to perform repetitious and boring tasks. But they are also used for tasks that are difficult or too dangerous for humans. In popular literature and science fiction movies robots have often been described as machines with human-like features. The first modern robots were invented in the 1940s.

**Equipment needed:**
- Lolly sticks
- A small hand drill
- Paper pins and
- Elastics

Use the above-mentioned materials to design and construct a robotic arm that can be used as a small lifting device.

**Extra:**
Extend your robotic arm – for instance add material on the ends to increase the grip (e.g. rubber finger grips used for counting sheets of paper).
Give examples of different types of robots and how they are used – think also about robots used in daily life.



Artist's impression of the European Robotic arm "ERA".

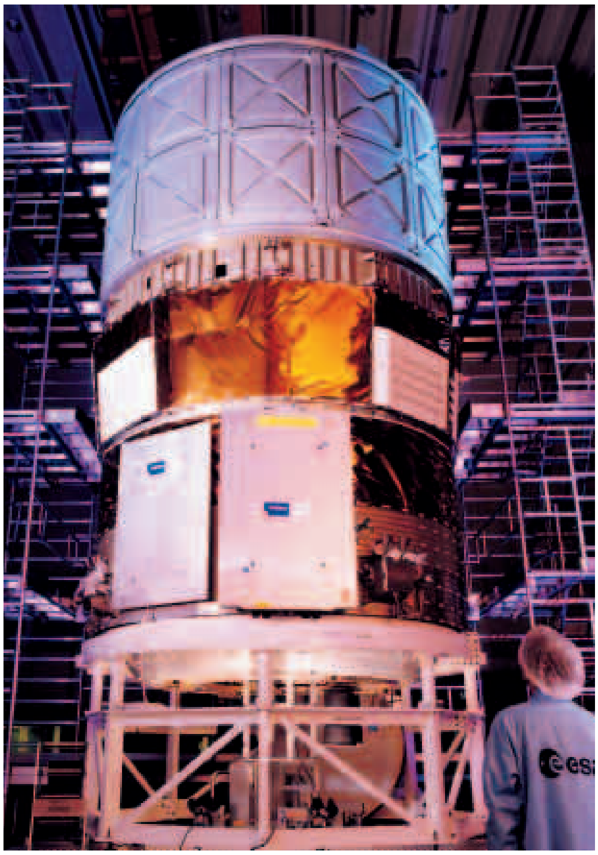
**Websites:**
Building the ISS www.esa.int/buildISS
Canada arm, http://www.space.gc.ca/asc/eng/missions/sts-097/kid_canadarm.asp
http://www.space.gc.ca/asc/eng/exploration/canadarm/introduction.asp
ERA, the European robotic arm http://www.esa.int/esaHS/ESAQEI0VMOC_iss_0.hml
Robotic Arms, http://spaceflight.nasa.gov/station/eva/robotics.html

**Lesson – core elements:**

| | |
|---|---|
| Pupil's text: | Need of supply of food, drink, scientific materials etc.<br>Supplies are sent by rockets or the Automated Space Vehicle (ATV)<br>The ATV is unmanned and docks automatically to the Space Station<br>Astronauts unload the ATV and fill it with waste<br>The ATV burns up on re-entry |
| Worksheets: | Water: what do you use water for, how much do you need, how do you reduce consumption? – Plan a mission to the ISS<br>What do you need to survive?<br>An astronaut menu – food groups (nutrition)<br>Test and taste food – sweet, sour, salty, bitter<br>Build the ATV |

**Subjects represented:**
Language
Science
Maths
House economics
Arts

**Background information:**
The International Space Station needs regular deliveries of supplies. The station's life-support system is designed to recycle air and water as much as possible, but in any case the crew must have fresh food and drinking water. Scientific experiments must be updated or replaced when their work is done, and, occasionally, damaged or worn equipment might require spare parts. The station needs rocket propellant, too, for even 400 km above the Earth, the vacuum of space is not quite perfect. There are still faint traces of air – less than a millionth of what we need to breathe, but enough, over a period of months or years, to slow the station down. Without occasional re-boosts, the ISS would slow sufficiently to fall from its orbit.



The ATV during testing at ESA's testcentre ESTEC in Noordwijk in the Netherlands.

Some supplies are brought up on the Space Shuttle and Soyuz flights and carry humans to and from the Station. The Space Shuttle's cargo bay can loft one of the European Space Agency's Multi-Purpose Logistics Modules, packed with everything from oxygen cylinders to fully-prepared and ready-to-run experiments. But these spacecraft are often crammed full of gear for their own missions, and have very little room to spare for the ISS's household needs – especially the tiny Soyuz.

At present, the bulk of Station supplies are launched from Earth on board the unmanned Russian Progress-M spacecraft, which automatically dock with the ISS – if necessary, with a little help from the Station crew. A Progress can hold almost three tonnes of equipment and consumables, and it is designed to arrive at the Station with a reserve of rocket fuel. Once it has docked with the ISS and been unloaded – a busy few days for the Station crew, who will generally find a few small personal items packed among the supply containers – it will fire its motors again, to nudge the Station's orbit a little higher and make up for atmospheric drag. Those motors still have enough fuel left for one final burn. The empty Progress is filled with the Station's waste and undocks itself. A last flare of its boosters knocks it out of orbit and sends it hurtling down into the atmosphere above the Pacific Ocean. Long before it reaches the ground, friction with the air has burned it up.

Soon, ESA's Automated Transfer Vehicle (ATV) – one of Europe's main contributions to the International Space Station – will replace the Progress. It is designed specifically as a kind of "space truck" to service the ISS. Like Progress, the ATV is unmanned. But with a maximum cargo capacity of 7.7 tonnes, it is much larger, and its automated docking system is more sophisticated. An ATV will remain docked to the Station for six months at a time, serving as a storage bunker and, as it empties, a waste dump. Then, just like Progress, it will de-orbit and plunge to a fiery but harmless end in the atmosphere. (For more information about returning spacecraft, see chapter "Coming home").

The Space Shuttle.

**Ideas and hints for the worksheet activities:**
***Worksheet A: Plan a mission, pages 97-98***

Food & drink: 3 litres per day / mission lasts 10 days:
3 x 10 = 30 litres
Personal hygiene: 4 litres per day / 10 days:
4 x 10 = 40 litres


Astronaut with waterbags.

This activity helps pupils reflect on basic things they need in order to survive. It can also be a bit like planning a trip or going on holiday. Let the pupils find out how much water they need for food, drinks and personal hygiene for a space mission. Discuss what we use water for and define when we use water as a necessary source for life and when water is used more for decoration and recreation. Discuss also the access to and supplies of water in different parts of the world and how we can reduce water consumption. Other things that need to be taken on a 10-day space mission include food, clothes, experiments etc.

Water behaves differently in weightlessness than on Earth where gravity pulls it down. Under weightless conditions, liquids float around in globes and have a tendency to stick to surfaces. For this reason, the astronauts don't think it is as relaxing to have a shower in space as on Earth. They can't fill a sink to wash or shave, either. Instead, they take sponge baths. A positive side effect of this is that the water consumption is drastically reduced.


The Space Shuttle on its way to space and the Space Station.

Does this look appetising to you?

***Worksheet B: Create an astronaut menu, pages 99-100***

This activity could be used to discuss what healthy food is and what nutrition the body needs to stay fit. Let the pupils reflect on what they eat, the different meals they eat during the day and what different types of food they should eat to stay healthy.

If you can find dehydrated or dried (e.g. fruit, fish, meat) food in grocery stores (similar to what the astronauts bring to the Space Station). Let the pupils experiment with this – maybe they can even prepare astronaut food for the event proposed in chapter 3.1 "What is a Space Station?"

These are examples of daily menu plans for the International Space Station: (source: NASA)

Day 1

Meal 1
Scrambled Eggs with bacon, hash browns, sausages
Toast
Margarine
Jelly
Apple Juice
Coffee / Tea / Cocoa

Meal 2
Chicken
Macaroni and Cheese
Corn
Peaches
Almonds
Pineapple-Grapefruit Juice

Meal 3
Beef Fajita
Spanish Rice
Tortilla Chips
Sauce
Chili con Queso
Tortilla
Lemon Bar
Apple Cider

Day 2

Meal 1
Cereal
Yoghurt
Biscuit
Margarine
Jelly
Milk
Cranberry Juice
Coffee / Tea / Cocoa

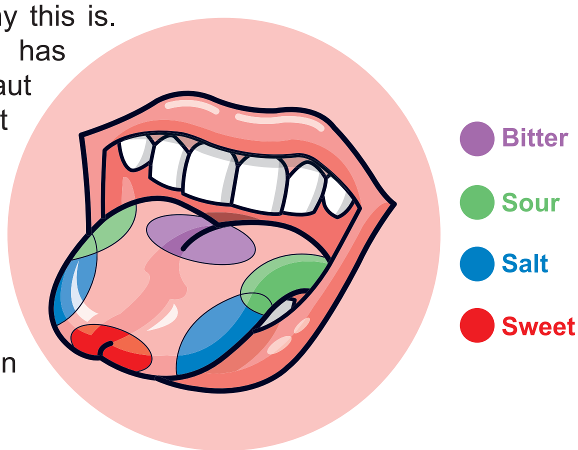
Meal 2
Soup
Cheese
Sandwich Bun
Pretzels
Apples
Vanilla Pudding

Meal 3
Fish
Tartar sauce
Lemon Juice
Pasta Salad
Green Beans
Bread
Margarine
Cake
Strawberries
Orange-Pineapple Drink

***Worksheet C: Test and taste the astronaut's diet, pages 101-103***

Astronauts say that food doesn't taste the same in space. Some say it tastes bland – they might not even like their favourite dish.

There are several explanations to why this is. One reason might be that the food has been stored for a long time. An astronaut thinks that food might taste different because they have to eat the same type of food over and over again.




We have 4 different kinds of taste buds; each kind specialised in its own taste: sweet, salty, sour and bitter. All tastes we can define are a combination of these four.

Smell is also very important to how we taste things. If something smells good, we want to eat it. Also texture is important (if something is slimy or thready we might not like it) and colour and sound play a role.

**Further ideas and explorations:**

*Plan a mission*

This worksheet could lead to more extensive work on volume and mass. Look at different types of measurements:

- Tonnes – kg – g (1 tonne = 1000 kg, 1 kg = 1000 g)
- 1 litre = 1 dm$^2$ (and: 1 dm$^3$ = 1 dm x 1 dm x 1 dm)

This activity is linked to chapter 3.2 “Building the International Space Station”, and chapter 2.1 “The training of an astronaut”, “Further ideas and explorations” .

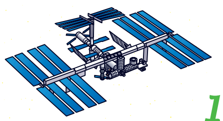
*Additional activity: Make a model of the ATV*

For the body of the ATV you need:
o an empty can
o glue
o scissors
o A4 white paper
o felt-tip pens

For the ATV’s solar panels:
o 2 skewers
o tape
o aluminium foil

The body of the ATV

1. Use an empty soda can for the body of the ATV.
2. Measure how much paper you need to cover the body of the ATV. The paper has to fit the can exactly. Cut out the paper.
3. Decorate the paper with the felt-tip pens.
4. Glue the paper onto the can.



Solar panels

Use two skewers and make a cross. Tape or tie them together. On each of the four ends, fold strips of aluminium foil around the sticks. Attach the solar panels with tape to the end of the Automated Transfer Vehicle's body.

***Additional activity:***
***Make a paper model of the Automated Transfer Vehicle***
http://esamultimedia.esa.int/docs/atv_model/ATV_2002_Intro.htm

**Related topics:**
Chapter 2.1 “The training of an astronaut”.
Chapter 3.2 “Building the International Space Station”.

**Websites:**
Astronauts and food:
http://www.nasa.gov/audience/foreducators/k4/features/F_A_Matter_of_Taste.html