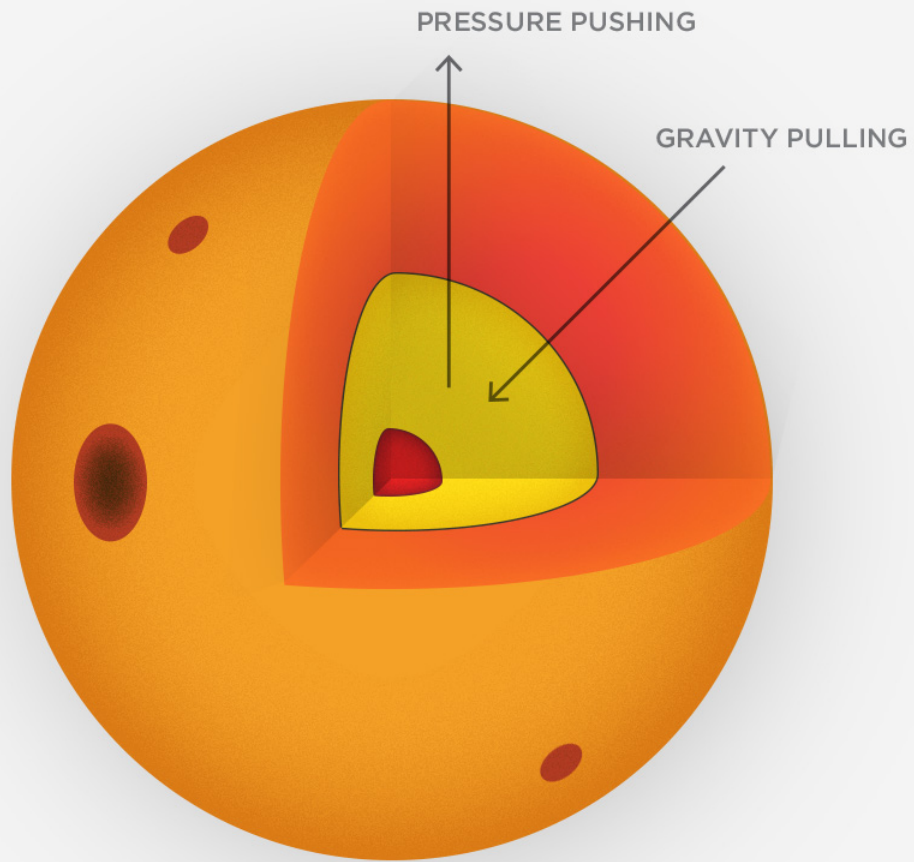











# Sun's Shadow

**Learn about Sun's shadow through observation.**

Tasneem Rossenkhan, UNAWE



 <b>AGE</b> 6 - 16	 <b>LEVEL</b> Primary, Middle School, Secondary, Informal
 <b>TIME</b> 1 day	 <b>GROUP</b> Group
 <b>SUPERVISED</b> Yes	 <b>COST PER STUDENT</b> Medium Cost
 <b>LOCATION</b> Outdoors	

### CORE SKILLS

Asking questions, Constructing explanations, Engaging in argument from evidence, Communicating information

### TYPE(S) OF LEARNING ACTIVITY

Structured-inquiry learning, Observation based

### KEYWORDS

Sun, Light Rays, Shadows, Seasons, Time



## SUMMARY



## GOALS

- To understand how shadows vary in length at different times of the day and how they change over the seasons.
- To understand how the amount of sunlight varies by season and how seasons can indicate the time of year
- To understand how the Sun is used to tell the time and the importance of shadows in determining the time of day/year.
- To gain hands on experience with scientific practices through observation, recording and concluding based on data in order to understand the process of scientific inquiry.



## LEARNING OBJECTIVES

- Discover the influence of the Sun's position on the length of shadows
  - Understand the diurnal movement of the Sun and its relation to Earth's rotation, i.e. how the apparent motion of the Earth through the ecliptic changes over the year and the seasonal differences in the northern and southern hemispheres.
  - Understand how seasonal changes affect life on Earth.
  - Learn how to tell the time without a clock.
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## EVALUATION

- Ask the students to explain their findings to the instructor/class.
  - Were the students able to make the connection of the sun's position and the resulting shadow?
  - What are the practical applications of this experiment? (Example: Timekeeping with Sundials)
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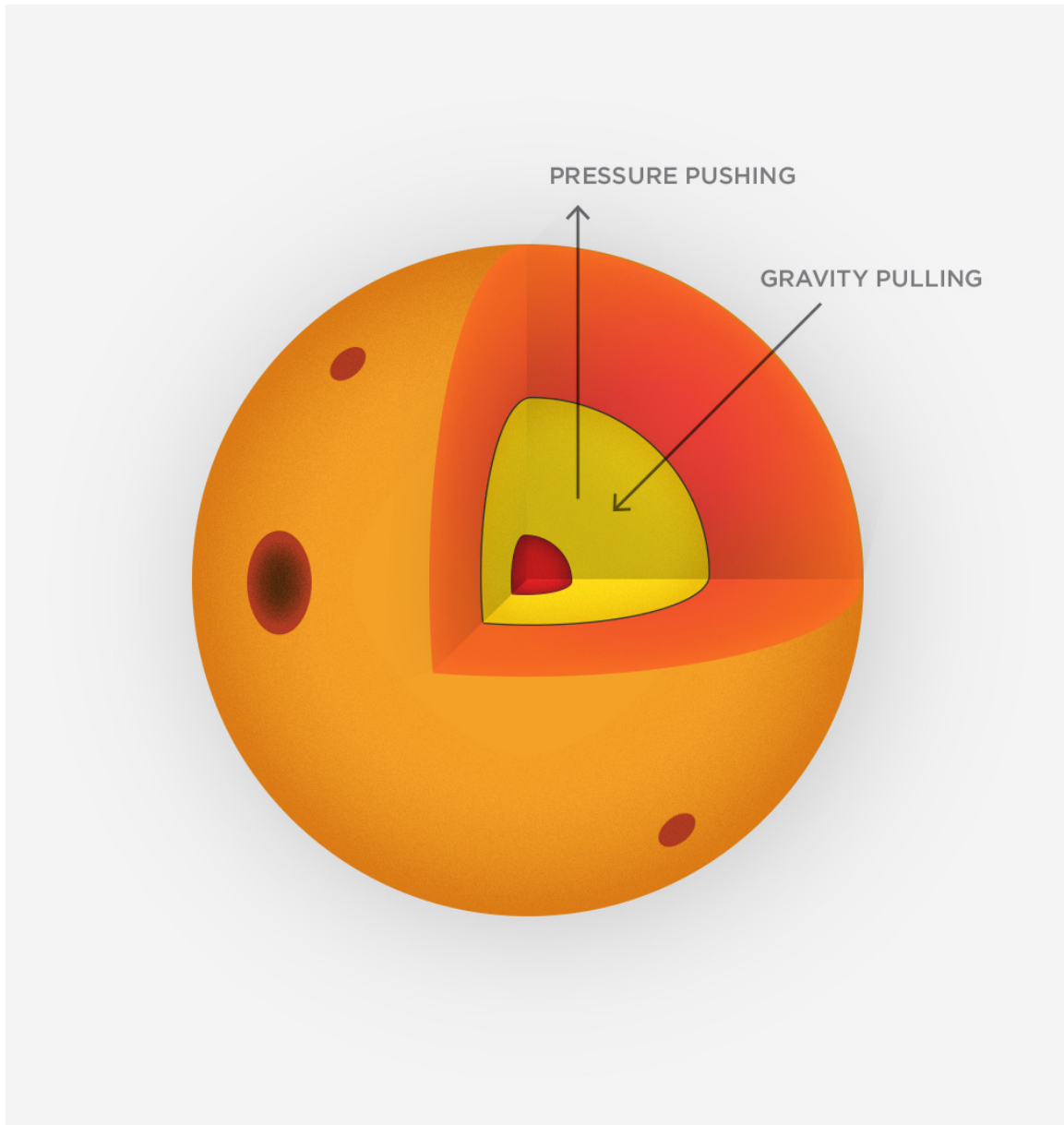
## MATERIALS

- Weather conditions that allow shadows to be cast with the Sun, i.e. sunny weather
  - Opaque objects (e.g. building, tree, person, stick, etc.)
  - Paper (standard size, A1 or A0)
  - Marker
  - Measuring tape (teacher)
  - Rulers (students)
  - Earth globe (or ball to represent the Earth)
  - Flashlight
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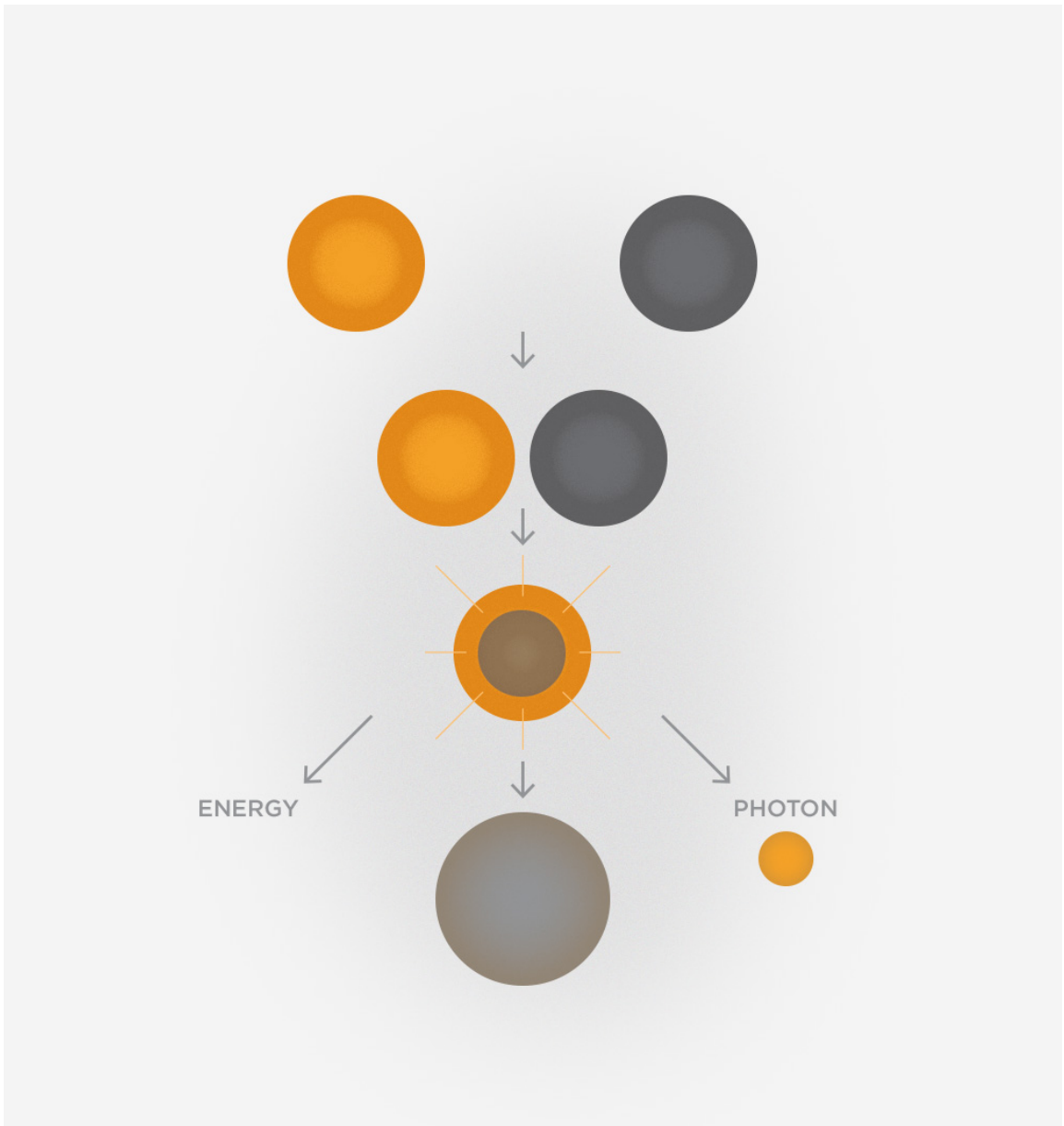


## BACKGROUND INFORMATION

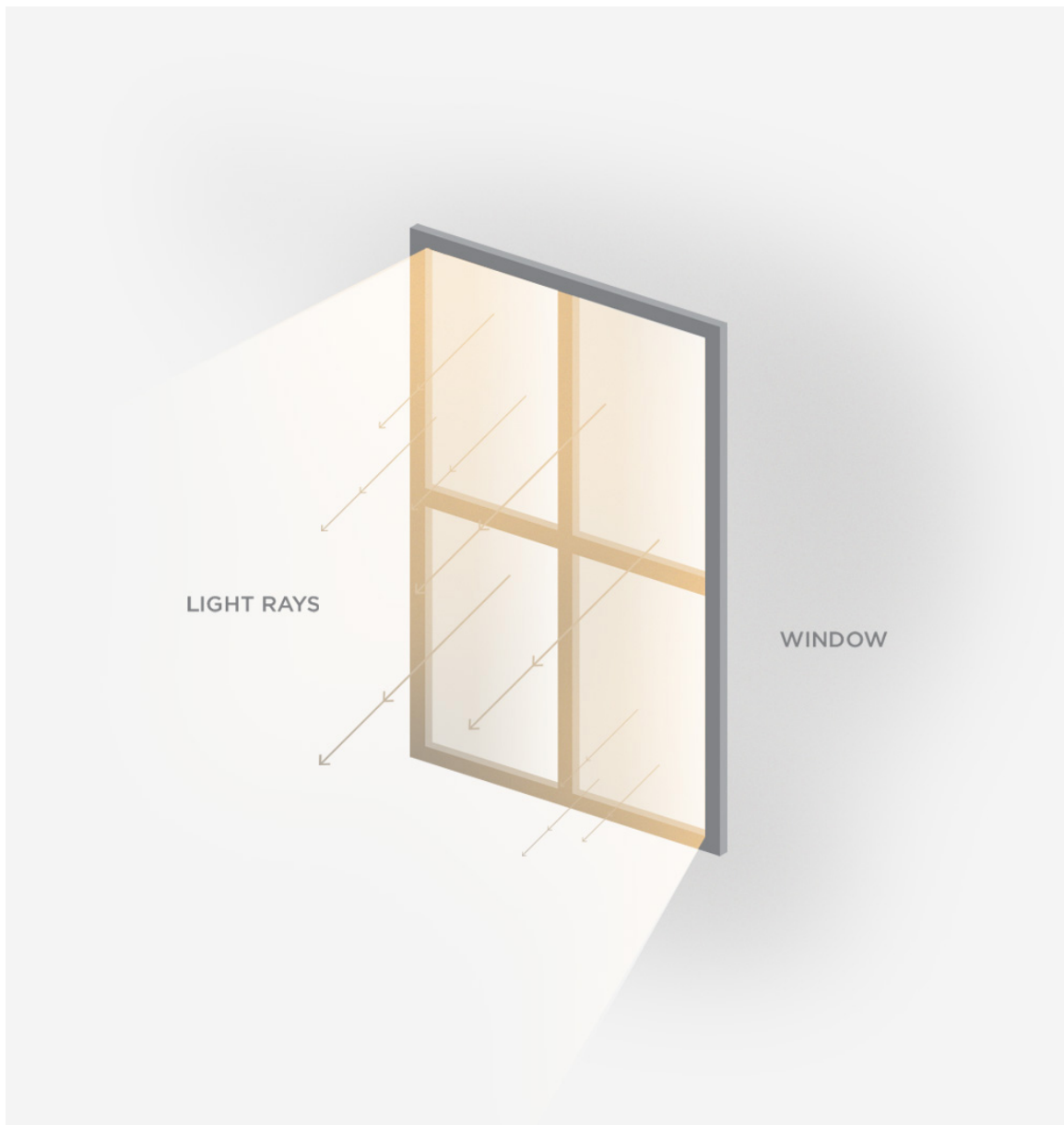
The Sun (our nearest star) is a bright source of light that also generates a huge amount of energy. There is a violent process going on inside our Sun. The elements within the Sun, mostly hydrogen, are burning through a process of uncontrolled nuclear fusion. During the fusion reaction, a large amount of energy is released in the form of heat and light. The surface temperature of the Sun is around 5500 degrees Celsius (~5700 Kelvin), whereas the temperature of the core is roughly 15 million degrees Celsius (~15 million Kelvin).



Light leaves the Sun at very high speeds, travelling at a distance of 300 000 000 metres in 1 second (i.e. 299 792.458 kilometres or 186 282.397 miles in 1 second). This is the fastest speed known to humans on Earth. Despite the fact that light travels so fast, it still takes around 8 minutes to reach us. This is because the Sun is very far away from us. The distance to the Sun from the Earth is around 149 600 000 km (149 million kilometres) or 92 960 000 miles (92 million miles).



*Image: Fusion of two atoms: a visual of the physics behind nuclear reactions and the energy behind light rays.*



One interesting phenomenon that takes place with the Sun is the Analemma. An Analemma is the changing angular offset of a celestial body when observed from another body (e.g. observing the Sun from the Earth or observing the Earth from the Moon). Usually the movement of the observed body is seen to change at regular intervals, such as daily or yearly. In most cases, the Analemma diagram is used for the Sun but can also be used for other bodies.

If a person were to record the position of the Sun everyday at exactly the same time (for example 12 noon) for a period of 30 to 50 days, a very interesting pattern emerges. The Sun forms a figure 8 in the sky because of the slight elliptical orbit of the Earth around the Sun and the axial tilt of the Earth (23.5 degrees). The highest point of the Analemma is observed in summer and the lowest point is observed in winter. It should be noted that the shape made by the Analemma changes depending on the observed body (e.g. if we observed the Sun from Mars, we would see a tear drop/egg shaped Analemma.)

The Analemma phenomenon helps us to understand why shadows change over the course of the year despite observations made at the same time each day. This highlights the fact that our Earth has an axial tilt and has an elliptic orbit. It also shows that the variations change in different hemispheres, e.g. when the Northern Hemisphere has the lowest point observed (indicating winter), it corresponds to the highest point observed in the Southern Hemisphere (indicating summer).



As we have seen earlier, light rays from the Sun reach us and when they hit an object (e.g. trees, buildings, people and animals.) they cast a shadow. The object blocks some of the sunlight and causes the shadow. However, when the object is transparent (such as a glass window), the sunlight goes through it. If the Sun's rays are incident on an object, the shadow is oriented away from the Sun. The shadow length changes through the course of a day as well as through the year, for example, a noon shadow is much shorter in summer than in winter.

Throughout history, human kind has relied on the Sun and Moon as astronomical time keeping devices. The first known records were from the ancient Egyptians, although it is believed that time keeping existed well beyond 6000 years, but most records were lost. Various civilizations had accurate time keeping devices and utilized a calendar system that is much like the one we use today (a 365 day cycle, with 12 months of 29 to 30 days). They used the Sun, Moon and stars, or a combination thereof, to depict the time of year. They also used various types of sundials to keep track of the time of day, and the stars to calculate the time at night when sundials could not be used.

Examples of time keeping devices from the past include sundials, astronomical clocks, obelisks, water and sand clocks (like the hour glass), candle and incense clocks, mechanical clocks, and more recently quartz and atomic clocks. It is worth mentioning that even today astronomy has played a key role in time keeping. In today's age, the discovery of the millisecond pulsar, a type of neutron star, is more



accurate than the atomic clock. (Note: Pulsars are rapidly spinning neutron stars formed as a result of a supernova explosion).

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## FULL ACTIVITY DESCRIPTION

### **Before the Activity:**

Ask the students what would happen if this activity were carried out on a cloudy or rainy day.

Ask the students why they think it is important to measure the shadow length in relation to the Sun.

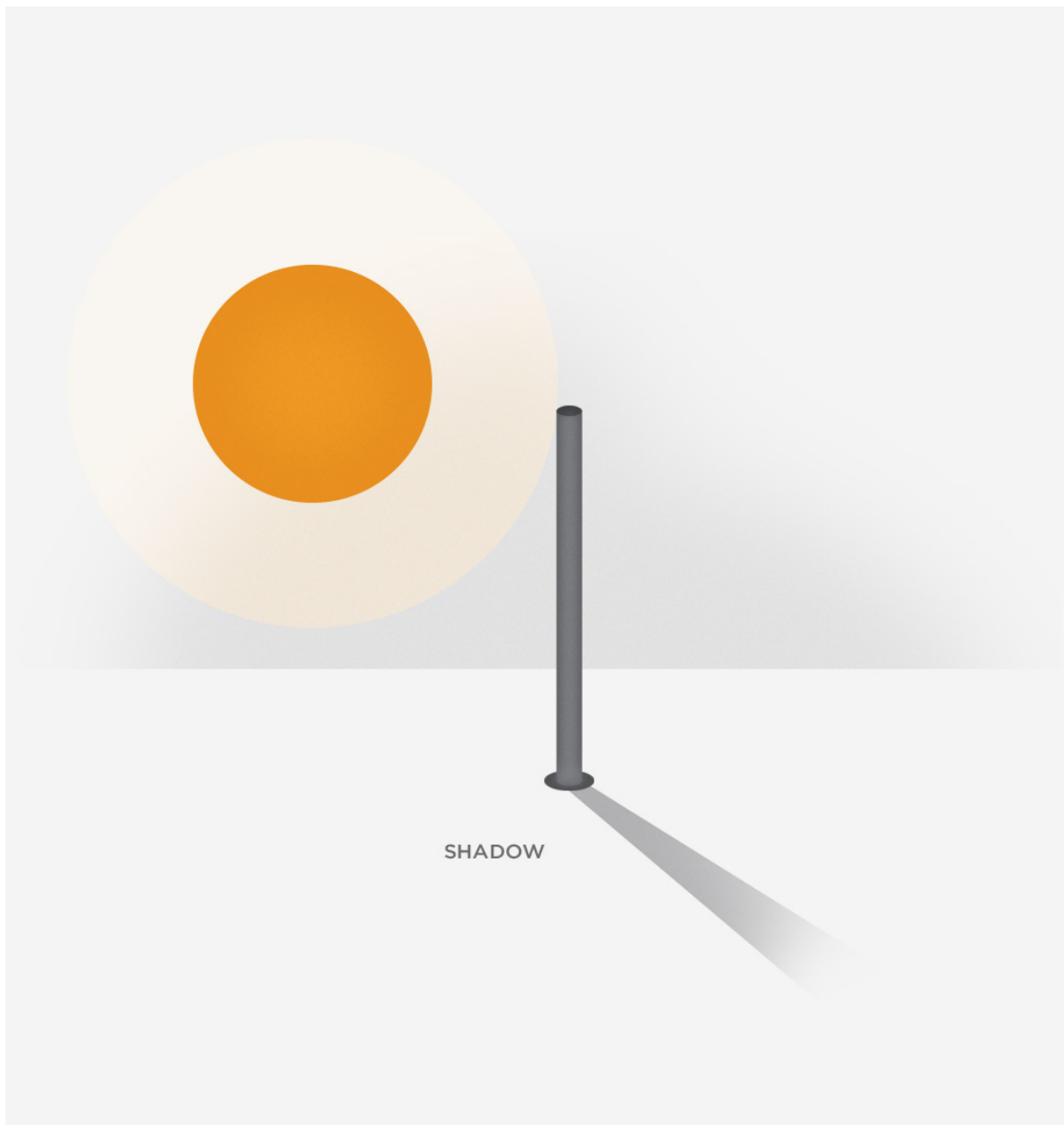
## **Main Activity:**

### **Step 1:**

Begin the activity in the morning and ask the children to look at various objects that cast a shadow. For control purposes fix a stick to the ground with paper beneath it.

### **Step 2:**

Observe the solar shadow with the children and ask them to note the direction of the shadow. Ask the children to take note of the position of the sun in the sky (ensure that the children do not look directly at the sun).



### Step 3:

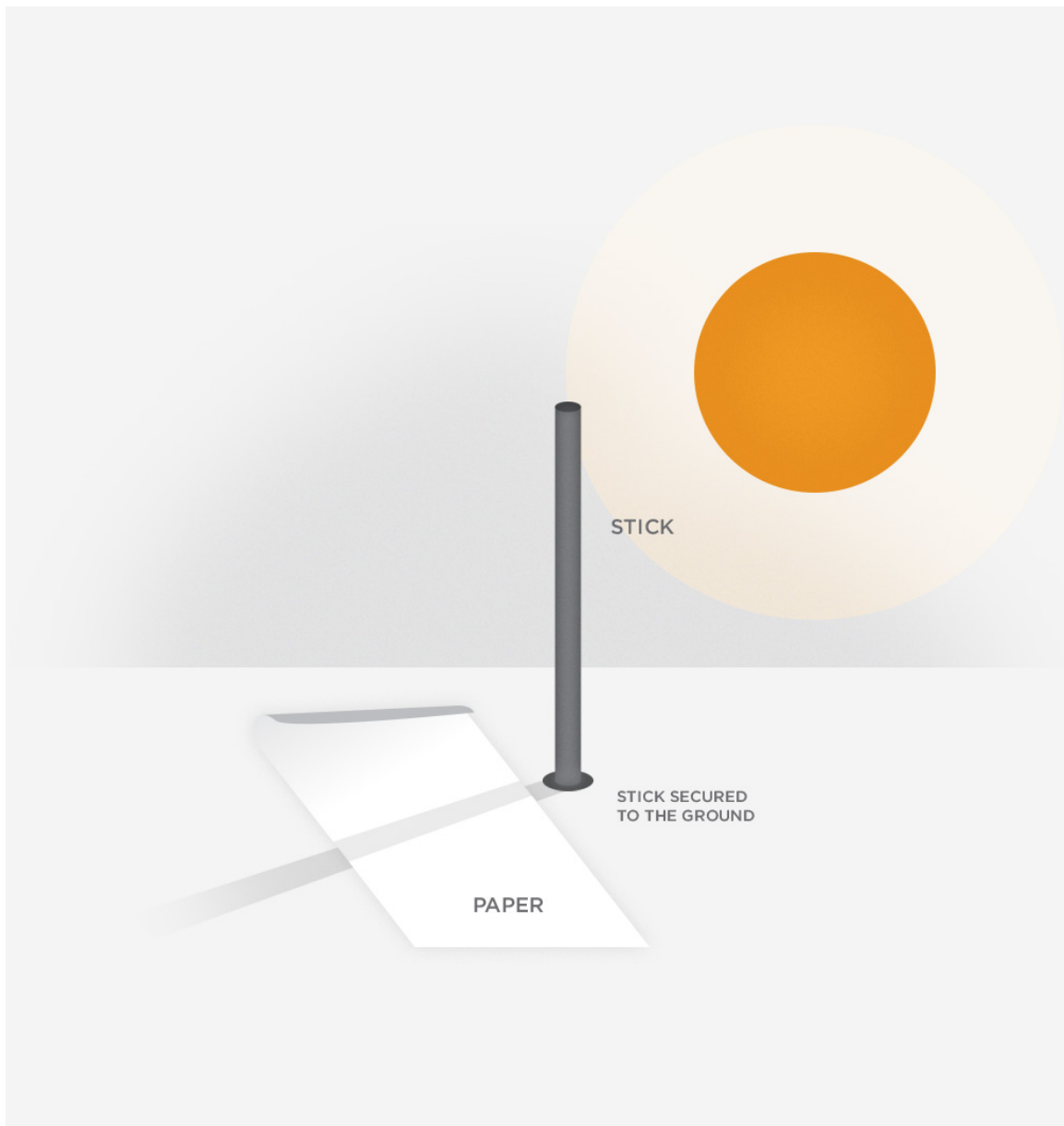
Ask the children to note the length of the shadow cast and the position of the sun. Go to the control setup and mark out the position of the shadow and time of day.

Have the students record the following in groups:

- Measure and record the length of the shadow
- Record the time and observe the relation of the time to the position of the Sun.
- Record the date and link it to the current season
- Record the weather conditions

During this step, it would be worthwhile to ask the children if they understand how the rotation of the Earth influences the time and seasons, i.e., is it daytime all around the world? Or is it the same season all around the world?

(For example, if it is Summer, ask the children if they think it is summer all around the world? If they say no, ask them why. If the students do not know, then refer to the post activity experiment section).



#### **Step 4:**

Repeat step 3 over different periods of the day (e.g. twice before noon, at noon, twice before sunset). Also ask the children to note how the sun is moving across the sky each time the experiment is carried out.

### **Post Activity:**

#### **Step 1:**

Ask the children to write out and draw their findings at the end of the day and discuss their observations in groups. Have the students compare the measurements from the day and make a conclusion from their findings.

#### **Step 2:**

Have the groups present their findings to the class and engage in a discussion with the instructor/teacher. Have the students compare their findings with the different groups and discuss with the instructor/teacher.

### Step 3:

Repeat the exercise in the next season over the period of one year. Did the shadows at noon get bigger? This will be the case if the season got colder (e.g., from autumn to winter). Did the shadows at noon get smaller? This will be the case if the season got warmer (e.g., from winter to spring).

## Post Activity Experiment:

- Use the Earth model (or ball to represent the Earth) and flashlight to demonstrate how the Earth revolves around the Sun.
- Tilt the ball/globe on an axis to demonstrate how the Earth receives different amounts of sunlight as the Earth makes one revolution around the Sun.

This should enable the students to visualise why each hemisphere has opposite seasons. It should also help students visualise what causes the seasons and its changes. Lastly, the experiment will enable the students to understand day and night and will link to the main activity.



### CURRICULUM

Country | Level | Subject | Exam Board | Section

— | — | — | —

UK | KS1: Year 1 | Science | - | Seasonal Changes: observe changes across the four seasons.

UK | KS2: Year 3 | Science | - | Light: find patterns in the way that the size of shadows change.

UK | KS2: Year 5 | Science | - | Earth and Space: Pupils might work scientifically by: constructing simple shadow clocks and sundials, calibrated to show midday and the start and end of the school day.

UK | KS3 | Science | - | Space Physics: the seasons and the Earth's tilt, day length at different times of year, in different hemispheres.

UK | GCSE | Astronomy | Edexcel | 1.4 Earth-Moon-Sun Interactions: k, l, m. Link to Observation A6.



### ADDITIONAL INFORMATION



### CONCLUSION

The activity demonstrates the concept of how the sun's position in the sky influences the shadows that are cast. The students should make the relation between shadow length and the time of day and year.

Our experience shows that the shadow always moves clockwise around the object casting it. Its length continuously diminishes between sunrise and noon and, afterwards, prolongs again correspondingly.

The Sun's shadow has enabled generation after generation to observe changes in the time of day and changes in seasons. Measuring the shadow length is necessary to learn the principle behind time and seasons.

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**CITATION**

Rossenkhan, T., 2016, *Sun's Shadow*, [astroEDU](https://astroEDU.org/doi/10.11588/astroedu.2015.3.81607), doi:10.11588/astroedu.2015.3.81607

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**ACKNOWLEDGEMENT**

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