Teachers' Guidelines

Title of the package: Northern lights

Information about the package:

Brief Description: An aurora is the emission of light caused by collisions of highly energetic, charged particles originating from the plasma emitted by the sun (solar wind) with the gases in the part of the Earth's atmosphere called the thermosphere. Students will learn about the epic battle between the Sun and the Earth and will be encouraged to chase auroras on Earth, but also on other planets.

How does the package relate to STEAM education: The package mainly focuses on science with some inquiry-based activities. It is interdisciplinary as it uses physical, geographical and some chemical concepts and may be used during Science, Geography or Physics classes.

Keywords: Northern lights, aurora, solar wind, solar flare, coronal mass ejection, Earth's magnetic field, magnetic poles, aurora oval, Carrington event.

Age Range: 14-18

Didactical Hours: 2 hours.

Learning objectives:

The student will:

- know what the Northern Lights are and how they formulate;
- understand how Sun's activity is affecting the Earth's magnetic field;
- know how the Earth is protected from the solar flares;
- learn how auroras fascinated people in ancient times and who explained this phenomenon;
- know, what colors may aurora have and why;
- know how scientist may forecast auroras;
- know, if auroras appear on other planets of the Solar System.

Content of the package and guidelines for teachers:

Link to the package: https://graasp.eu/s/yhb9jd

We encourage teachers to copy the graasp package to their own graasp space in order to become "owner" and be able to modify the content, hide or unhide some materials, add quizzes etc. Moreover, teachers may share the package with their students and check the progress of each student.

A short video tutorial on how to do it is available at:
https://view.genial.ly/5f7ef81f1b2b330d2efa3411/video-presentation-tutorial-graasp

If you don't have access to the graasp package, contact us: edukacja@igf.edu.pl

EDU-ARCTIC 2: from polar research to scientific passion – innovative nature education in Poland and Norway receives a grant of ca. 240 000 EUR received from Iceland, Liechtenstein and Norway under EEA funds. The purpose of the EDU-ARCTIC 2 project is to: enhance the knowledge about nature, geography, natural resources, political specificities concerning polar regions and increase awareness of environmental issues and climate change, increase of interest in pursuing STEM education and careers due to enhancement of knowledge about scientific research, and their place in the modern world, familiarizing young people with scientific career opportunities; introduce innovative tools by way of an e-learning portal and effective methods of teaching science in schools.

The package consists of 6 sections described in detail below:

1. **Introduction to Northern Lights**

First, students watch a short video taken next to the Polish Polar Station Hornsund on Svalbard - the archipelago in the north, in the European part of the Arctic. Ask your students to observe the colours and type of movement of the northern lights. Then, they watch NASA's video with a timelapse of the Northern lights as seen from space. Next, they learn a few facts about aurora (Northern and Southern Lights, auroral oval and auroras on other planets of the Solar System).

Next, let them learn much more from the lesson by Michael Molina, who explains every step of this phenomenon. Finally, ask your students to answer 3 open questions. They should base on what they saw and heard in the 3 videos.

Suggested resources:

- Northern Lights ppt presentation (slides 1-7)
- Video on YouTube: https://youtu.be/9BDbEZdB7PU
- NASA video on YouTube: https://youtu.be/YlFvpdewY10
- Michael Molina's lesson on auroras: https://youtu.be/czMh3BnHFHQ
- Worksheet for students – task 1.
- Section "Introduction to Northern Lights" on graasp.eu platform

Estimated time: 15 minutes

2. **Up, up, to the Sun!**

The Auroras are the effects of 'battles between the Sun and the Earth'. The Sun storms could have catastrophic impact on the Earth, if we were not protected by the Earth's magnetic field. Our magnetosphere (the upper part of the atmosphere) protects us from the enormous energy emitted in the form of solar flares. This energy produces fantastic spectacles on the sky near the magnetic poles.

In this section, students will learn how the Sun activity affects the Earth's magnetic field. They will learn what are the types of solar activity (**Solar flares**, **coronal mass ejections**, **solar wind**) and find out, how strong are aurora's currents. Ask your students to check, how long the solar activity circle lasts.

Next, students watch a short animation on the Carrington Event - the largest recorded coronal mass ejection, which hit the Earth's magnetosphere - the solar storm of 1859. To summarize this section, ask your students to write a short paragraph on what surprised them most.

Suggested resources:

- Northern Lights ppt presentation (slides 8-13)
- NASA video on YouTube: https://youtu.be/eQQkXsTUakQ
- Worksheet for students – task 2.
- Section "Up, up, to the Sun!" on graasp.eu platform

Estimated time: 15 minutes

3. Find more!

In this section students will learn, how auroras fascinated people in ancient times and who explained this phenomenon. They will also learn, what colors may aurora have and why.

Start with a short animation on what people thought about the northern lights before scientists could give explanation of this phenomenon. Next, inform students about Birkeland's discovery. They may read more on it, by clicking on the "show more" in the grasp section.

Next, students learn, why auroras are formed mainly near the magnetic poles and what are auroras' colors.

In order to better remember the learnt concepts, students may create a mind map. In the graasp package the connections are pre-defined as: common region of appearance, part of the atmosphere, colors, excited atoms, height above ground, source of energy), but the students may also add their own connections. The concepts should be typed by them.

Suggested resources:

- Northern Lights ppt presentation (slides 14-19)
- video on YouTube: https://youtu.be/HWwchLtARwo
- Worksheet for students – task 3.
- Section "Find more!" on graasp.eu platform

Estimated time: 15 minutes

4. Let's chase auroras

Students will learn that auroras occur mainly along the "auroral ovals," which center on the magnetic poles (not the geographic poles) and roughly correspond with the Arctic and Antarctic circles. Scientists may forecast auroras by measuring the magnetic effects of incoming solar storms. The magnitude of geomagnetic storms is called the Kp index. Then, students will try to find the region, where the probability of visible aurora is high. If the solar activity is low during the lesson, they may search for high Kp index (5 or more) in historical database of NOAA. They will compare K indices for middle and high latitudes. Finally, they may search for Aurora from the camera in Lapland.

Suggested resources:

- Northern Lights ppt presentation (slides 20-22)
- Website NOAA Space weather prediction: https://www.swpc.noaa.gov/products/aurora-30-minute-forecast
- website NOAA planetary K-index: https://www.swpc.noaa.gov/products/planetary-k-index
- video on YouTube: https://youtu.be/LdeavC75n6Y
- Worksheet for students – task 4.
- Section "Let's chase auroras" on graasp.eu platform

Estimated time: 20 minutes

5. Auroras on other planets

In this section students will learn, if the Earth is unique with auroras. Could they be observed at other planets of our Solar System? Each of the **gas giants (Jupiter, Saturn, Uranus, and Neptune)** has a strong magnetic field, a dense atmosphere and, as a result, its own aurora. Mercury also has a magnetosphere and so we might expect aurora there too. But, there are no auroras. Ask your students to find out why.

Venus has an atmosphere, but does not have a large-scale magnetic field. There are some light spectacles, but the origin of this phenomenon is different than on the Earth. For long time scientists thought that there are no auroras on Mars. A discovery from 2016 showed that Mars has much larger auroras spread across the northern hemisphere, and probably the whole planet too. Ask students to find information about this discovery and write down, how Martian auroras differ from ours.

Suggested resources:

- Northern Lights ppt presentation (slides 23-26)
- Worksheet for students – task 5 and 6.
- Section “Auroras on other planets” on graasp.eu platform

Estimated time: 10 minutes

6. Wrap-up

First, students wrap-up their knowledge by watching a short video on 5 facts about the Northern Lights. Next, they check themselves in a 4-question quiz. Next, your students may create their own mini-auroras with the use of a professional walkie-talkie and a fluorescent lamp. Holding the fluorescent lamp by the screw does not cause electric shock in this activity. If you do not have the proper equipment to create this artificial aurora, students may watch a short video instead.

Finally, students evaluate, how they liked the activity.

Suggested resources:

- Northern Lights ppt presentation (slides 27-34)
- video on YouTube: https://youtu.be/Erbw6G2aCxQ
- video on how to create mini-aurora: https://youtu.be/AL8AdiuDCj8
- Worksheet for students – task 7.
- Section “Wrap-up” on graasp.eu platform

Estimated time: 10-25 minutes (Time differs depending, if you decide to create artificial auroras. Then, many students may want to have a try.)

Answer keys:

1. Introduction to Northern lights

Quiz:

What colours may aurora have? It is usually green, but may be also violet, blue and rarely red.
What words or phrases would you use to describe the movement of aurora in the sky? Students may describe this movement on many ways: dancing over the night sky, flickering curtains of light, glowing, constantly changing, etc.
What atoms are getting excited and glow? Oxygen and Nitrogen.

2. Up, up, to the Sun!

Solar activity cycle: The sun's activity runs on a roughly 11-year cycle, moving regularly from its most quiet period – solar minimum – to its most active – solar maximum – and back to quiet.

3. Find more!

Concept Mapper: concepts to be added to connections:
common region of appearance – i.e. Auroral oval, near the magnetic poles, around North and South magnetic poles, polar circles;
part of the atmosphere – ionosphere (thermosphere);
colors – green, blue, violet, red
excited atoms – oxygen and nitrogen (they could be also with the combination of colors: oxygen – green and rarely red, nitrogen – blue and violet);
height above ground – usually 100-200 km, up to 1000 km;
source of energy – Solar wind, solar flares, Coronal mass ejections

4. Let's chase auroras

If the Kp index for last 30 days was high, the task is relatively easy. However, if students need to check the historical data, make sure that they choose the proper file (the one with _DGD.txt). The files contain K indices for middle and high latitudes. The last part in dedicated to planetary index (Kp). Students should take them into account. Comparing K index for high and middle latitudes they should find that the high latitudes have usually higher K index than middle latitudes and this index is also higher than the planetary one.

5. Auroras on other planets

Mercury: Mercury is too small and too close to the sun for it to retain an atmosphere, meaning the planet doesn't have any molecules for the solar wind to excite and that means no auroras.
Martian auroras: A discovery from 2016 showed that **Mars** also has much larger auroras spread across the northern hemisphere, and probably the whole planet too. This "diffuse" aurora is the result of solar energetic particles raining into the Martian atmosphere, rather than particles from the solar wind interacting with a magnetic field. If an astronaut were to stand on the surface of Mars, they might still see an aurora but it would likely be rather faint and blue, and, unlike on Earth, not be necessarily near the planet's poles.

6. Wrap-up

Quiz:

Auroras may appear

- [x] near the north magnetic pole
- [x] near the south magnetic pole
- [ ] on Mercury
- [x] on Jupiter

The aurora occurs when highly charged particles from the solar wind interact with gases in the Earth's atmosphere.

Yes

The most popular color of aurora is green. It is connected with excited atoms of

- Nitrogen - No. Excited nitrogen gives purple or blue colour.
- Oxygen - It is true. Oxygen may also give red lights.
- Argon – No. Argon is not glowing.

Auroras are mainly formed at altitudes

- 1-2 km
- 20-40 km
- 100-200 km
- 500-1000 km

Additional resources and links, references:

1. NOAA database with 30-day-data on Kp index: https://services.swpc.noaa.gov/text/daily-geomagnetic-indices.txt
2. NOAA database with historic data on Kp index: ftp://ftp.swpc.noaa.gov/pub/indices/old_indices/
3. Online lessons on auroras “Northern lights – a magic spectacle in the sky: https://youtu.be/WpZHAFpYcns
4. Online lesson “All the colours of the aurora”: https://youtu.be/N6Zo0nAy5rM
5. Polarpedia - Aurora: https://polarpedia.eu/en/aurora-northernsouthern-lights-polar-lights/
6. Polarpedia - Auroral oval: https://polarpedia.eu/en/auroral-oval/
7. Carrington event: https://polarpedia.eu/en/carrington-event/
8. Space weather: https://polarpedia.eu/en/space-weather/
9. Online lesson on space weather: https://youtu.be/r6wNiHXesNU
10. Geomagnetic storm: https://polarpedia.eu/en/geomagnetic-storm/
11. Martian aurora: https://www.nasa.gov/press-release/goddard/2019/mars-proton-aurora-common
12. Article: *The aurora, or what lights up the polar night*: https://edu-arctic.pl/en/articles/theaurora