National Aeronautics and
Space Administration

JOURNEY THROUGH THE HELIOSPHERE

The Sun-Earth System in Color

About this book

The Sun is our closest star, and it plays a powerful role in shaping life on Earth. For thousands of years, people have looked to the sky to understand their place in the universe. Today, scientists called heliophysicists study the Sun's light, heat, and the constant stream of energy and particles it sends into space. This science, called **heliophysics**, helps us understand everything from Earth's climate and seasons to auroras, space weather, and how to keep astronauts and spacecraft safe. Learning about the Sun and its connection to the planets helps us better understand our home in the solar system and how we can explore beyond it.

Artists and scientists alike are inspired by the Sun. In art, light defines form, creates mood, and reveals texture to help bring ideas to life. In heliophysics, light helps scientists study the Sun, understand solar activity, and explore how our star shapes the space around Earth. By combining art and science, we can make the invisible visible, transform data into stories, and inspire deeper connection and curiosity about our place in the solar system.

In Alaska, the Sun shapes daily life, traditions, and ways of knowing. The state stretches from 51° to 71° North latitude, and this dramatically affects how sunlight is experienced there. In summer months, some Alaskans live with 24 hours of daylight, while in the heart of winter, the Sun does not rise at all for weeks. In the long winter nights, the aurora borealis often lights up the sky with a dazzling display created when energy from the Sun interacts with Earth's atmosphere. This natural wonder is a living example of heliophysics in action.

Alaska is home to diverse Indigenous peoples and cultures, each with a unique language, perspective, and relationship to the Sun and sky, and each of which holds its own knowledge systems and names for the world. In this project, we showcase these cultures by including a small sampling of Alaska Native languages to honor the heritage of Alaska, the only Arctic state in the Nation. A map is provided to help explore where these languages are spoken and to recognize the deep, place-based knowledge that connects land, sky, and people. Many other heritage languages represent the citizens of this country. What corresponding words are used in your community or culture? You may wish to use those in place of the translations used here.

Educators can use this book to spark curiosity and creativity while exploring the science of the Sun and its connection to life on Earth. Each page blends artistic expression with key heliophysics concepts, encouraging students to learn through both science and storytelling. This resource is aligned with the Framework for Heliophysics Education (FHE) and supported by the NASA Heliophysics Education Activation Team (HEAT), which helps educators bring Sun-Earth science into classrooms and communities. Whether used to introduce a new topic, support hands-on learning, or inspire conversations about space and culture, this coloring book invites learners to see heliophysics through both scientific and artistic lenses.

You can access digital, printable versions of the coloring pages and additional teaching resources at science.nasa.gov/learn/heat.

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The Heliosphere in the Voices of Alaska

English	Alutiiq/Sugpiaq	Central Yup'ik	Iñupiaq	Lower Koyukon Athabascan	Ten Kenaga' / Lower Tanana Athabascan	Ts'msyen / Sm'algya̲x	X̲aad Kíl / Haida
atmosphere		ellarrlainaq	siḷa	yo	yok'et	ha	sangáay
Earth		nunarpak	nuna	nen'	nen'	ha’lidzog	hlan-gwáay tlagáay
heat	maqaq	kiiq *(environmental heat)*	uunnaq	hʉnaalk'ʉh *(environmental heat)*	khwnadheł	gyemk	k̲áwsda
light	tanqik	tanqik	qaumaniq	yekkoyh	negholdrayh	goy’pa/laawks	g̲adgáay
Northern Lights	qiuryat	qiuryat	kiuġuyat	yo yekkoyh	yoyekoyh	gisigwilgwelk	hlats'ux̂
particles	pelut *(lit. dust or ashes)*			k'eleye'	khwchałts'en'	k’aba ts’a’atiks	
shadow	talineq	tarenraq	taġġaq	yeege'	yik	gano’ots’n *(lit. instrument for soul/spirit)*	x̲ánj
star	mit'aq *(northern)* agyaq *(southern)*	agyaq	uvluġiaq	tloon'	sen'	bikbiyaals	k'aayhlt'áa
Sun	macaq	akerta	siqiñiq	no'oy	sro	gyemk	juuyáay
year	uksuq	allrakuq	ukiuq	oghe		kóoł	tadáa

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This work was conducted at the University of Alaska Fairbanks Geophysical Institute through a Cooperative Agreement with the NASA Goddard Space Flight Center. We acknowledge the Indigenous nations upon whose ancestral lands UAF and NASA GSFC campuses reside. In Fairbanks, our Troth Yeddha' Campus is located on the ancestral lands of the Dena people of the lower Tanana River, and NASA GSFC is located on the ancestral lands of the Piscataway people. **Special thanks to the following Alaska Native language speakers for sharing their cultural knowledge for this book:**

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Ten Kenaga'/Lower Tanana Athabascan: David Engles, Siri Tuttle
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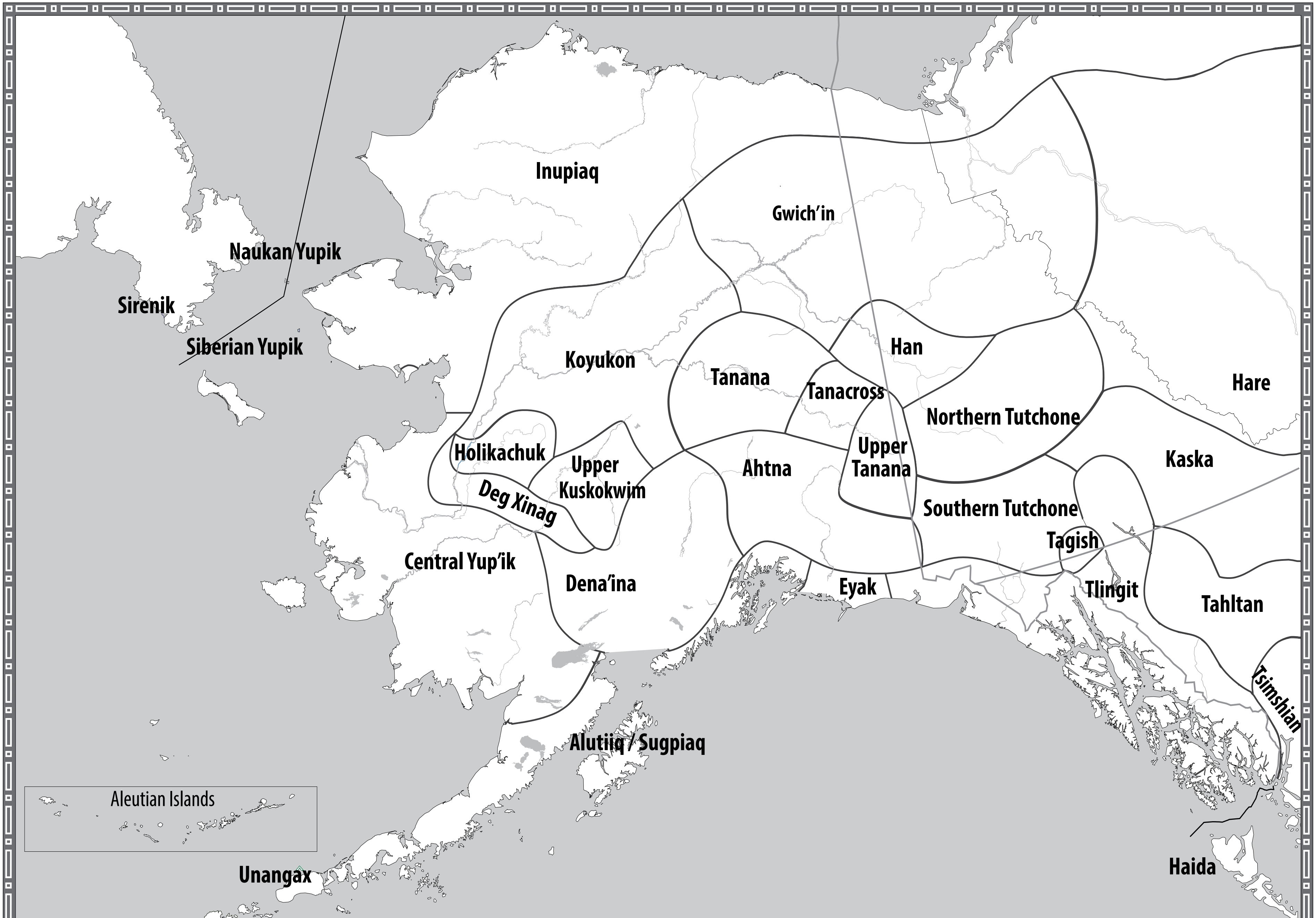
X̲aad Kíl/Haida: Kihl Gúul Jáad Emily Edenshaw-Chafin, 'Waats'asdiyei Joe Yates



Indigenous Peoples and Languages of Alaska

map courtesy of the Alaska Native Language Center, University of Alaska Fairbanks

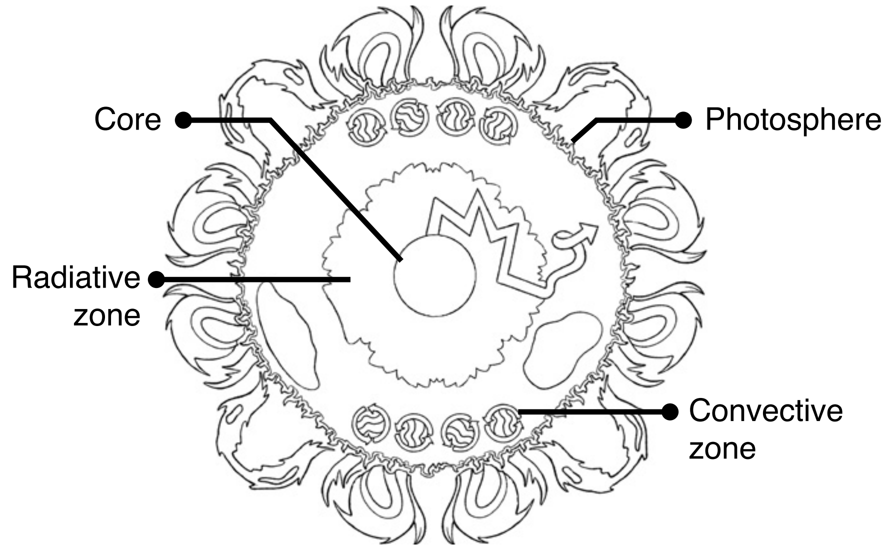
The Sun

The Sun is a giant ball of hot, glowing gas consisting of electrically charged particles called plasma that gives Earth light and energy. At its center is the **core**, where extreme pressure and temperature cause hydrogen atoms to fuse and release energy through a process called nuclear fusion. This energy moves outward through the **radiative zone**, where it slowly travels as radiation, bouncing around for thousands of years.

Next, it reaches the **convective zone**, where hot gases rise and cooler gases sink in a churning motion that helps move energy toward the surface.

The part of the Sun we can actually see is the **photosphere**, a glowing surface that sends sunlight to Earth. Beyond that is the outermost layer of the Sun's atmosphere, called the corona. It is usually hidden by the brightness of the photosphere, but is visible during a total solar eclipse.

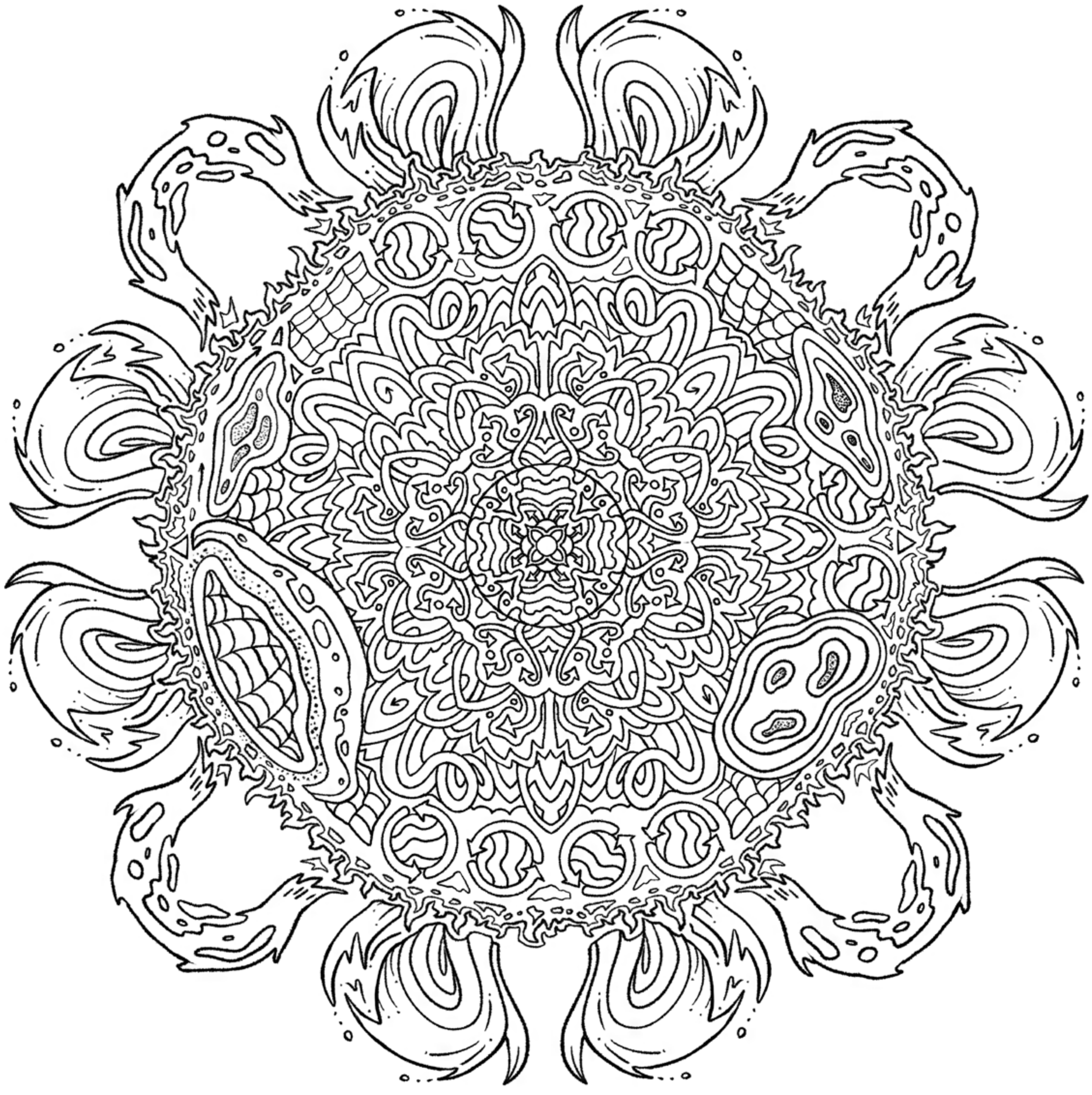
The Sun becomes more and then less active over a repeating, roughly 11-year period called the solar cycle. When the Sun reaches solar maximum, there are many sunspots caused by its agitated magnetic field. This time is also when space weather is most common, with events like solar flares and Coronal Mass Ejections (CMEs) leading to the auroras here on Earth.



Speaking of the Heliosphere...

People have observed the Sun for millennia. The Sun influences all other objects in our solar system, and is the primary source of energy on Earth. The Sun is also integral to how Arctic peoples live their lives. What activities are dependent on the Sun where you live?

In the Alaska Upper Kobuk dialect of Iñupiaq, the word for *Sun* is **siqiñiq**. Scan the QR code to learn how to say siqiñiq in Iñupiaq.



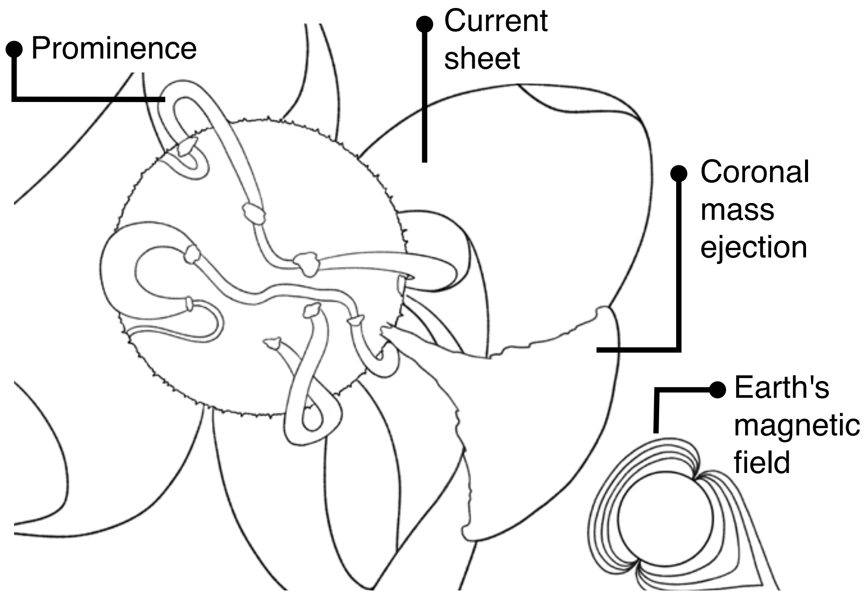
Solar Magnetic Fields

The Sun is filled with invisible magnetic fields, just like the force around a magnet. These magnetic fields shape many exciting features on the Sun.

Sometimes, magnetic fields trap cool, dense clouds of solar gas above the surface, creating dark ribbons called **prominences**. When these are seen with the Sun behind them, they are called filaments. When these magnetic fields stretch and twist, they can form thin layers known as **current sheets**, where magnetic energy is stored and can suddenly be released.

Occasionally, a big explosion called a **coronal mass ejection (CME)** occurs, launching huge clouds of magnetic field and hot gas out into space. If these clouds interact with **Earth's magnetic field,** they can sometimes disrupt technology like satellites and power grids!

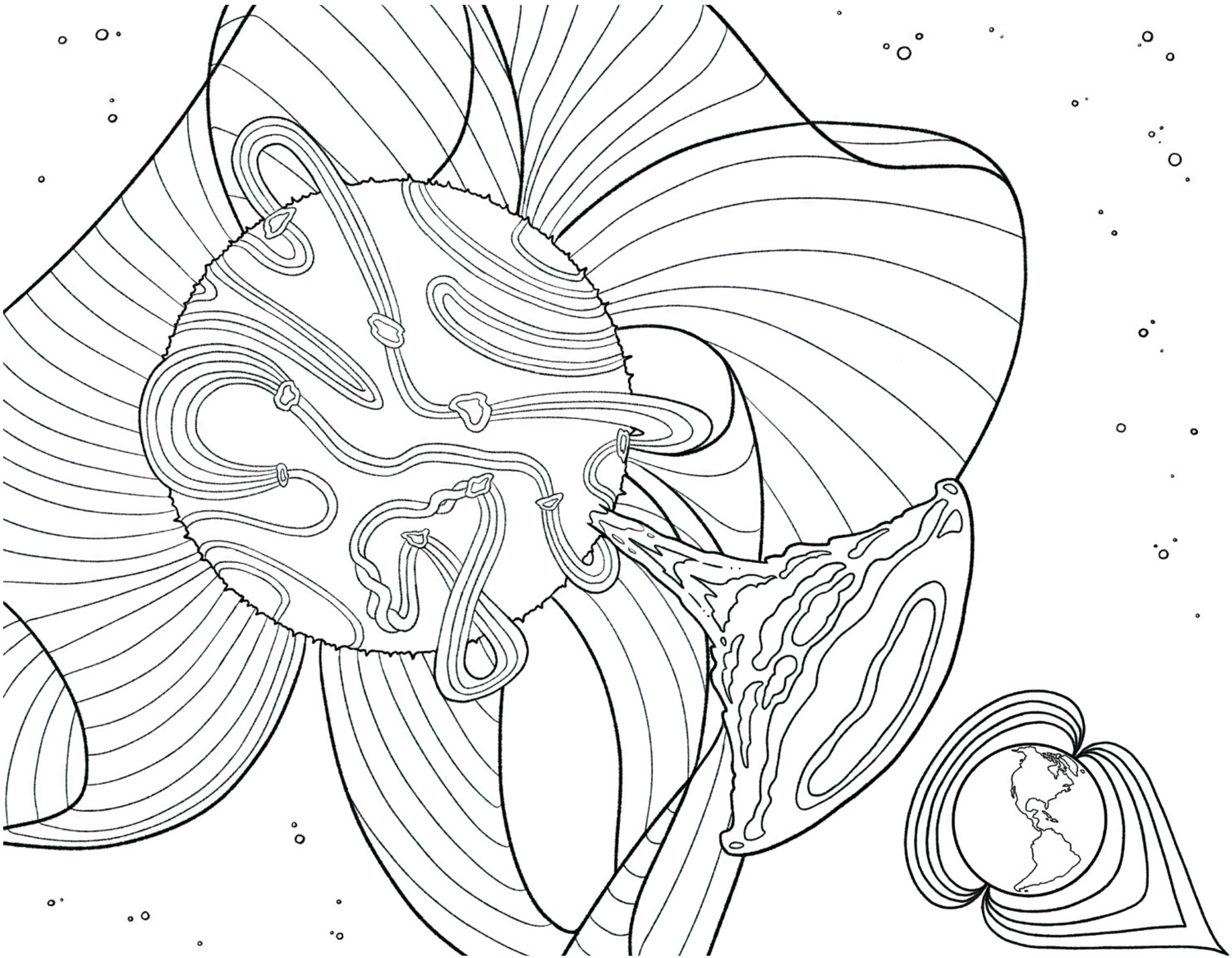
The Sun's magnetic influence extends all the way out to the outer edge of our solar system, too. The part of space that falls under this influence is called the heliosphere.



Speaking of the Heliosphere...

Without Earth's magnetosphere, the solar wind will strip away air molecules and erode our atmosphere. NASA scientists study Earth's atmosphere to better understand how the interaction between the solar wind and Earth's atmosphere affects the atmosphere's ability to protect us from the Sun.

The Haida people use the word **sangáay** for *atmosphere*. Use the QR code to learn how to say this and other Sun-related words in X̱aad Kíl, the language of the Haida.

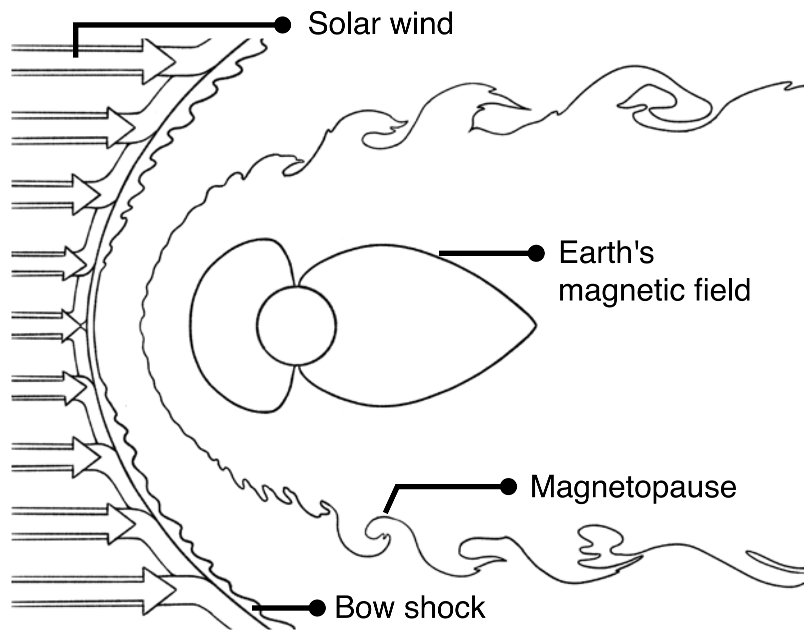


Solar Wind

The Sun does more than just give out light. It also sends out a stream of charged particles called the **solar wind**. The solar wind travels from the Sun all the way to Earth and throughout the rest of the solar system. Fortunately, our planet is protected by the magnetosphere, an invisible shield created by **Earth's magnetic field**. When the solar wind reaches Earth, it crashes into this shield and is forced to flow around it.

The point where the solar wind first meets Earth's magnetic field is called the **bow shock**, kind of like the wave that forms in front of a moving boat. Just beyond that is the **magnetopause**, the boundary where the pressure from the solar wind and Earth's magnetic field balance out. This protective system keeps most of the solar wind from reaching Earth's surface.

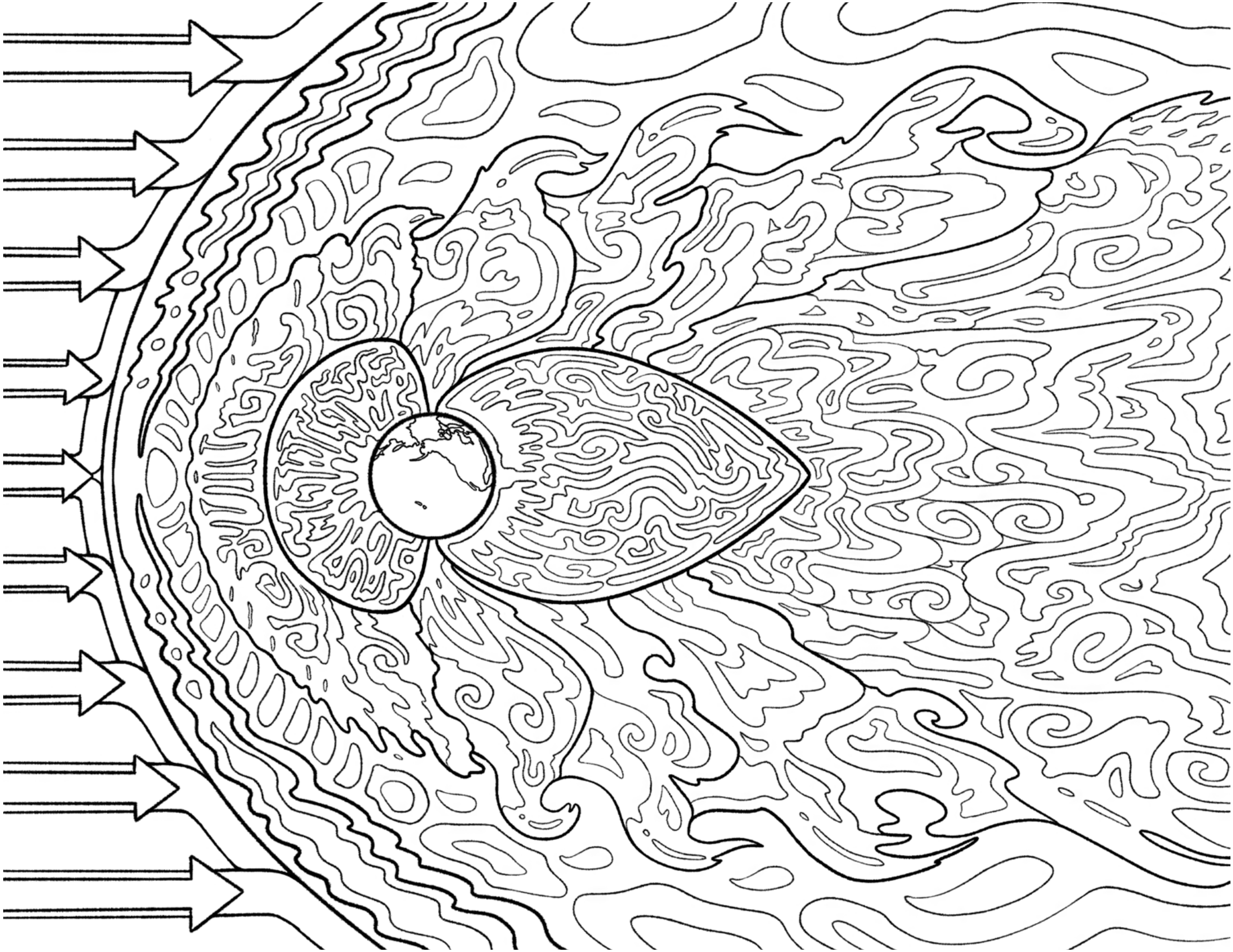
The solar wind also runs up against the interstellar medium, which permeates the space between stars. This creates a bow shock similar to the one created by Earth's magnetosphere, only much, much bigger. Everything inside this bubble or "shock" is called the heliosphere.



Speaking of the Heliosphere...

We cannot see the solar wind with our eyes, but people living in high latitudes can often see the effects of its presence. Charged particles in the solar wind cause beautiful auroras to occur in the night sky. Have you ever witnessed these phenomena that are caused by solar wind?

In Alaska's Alutiiq / Sugpiaq language, the word for particles is **pelut** (literally *dust* or *ashes*). To hear the word pelut and other Alutiiq / Sugpiaq words spoken, scan the QR code.



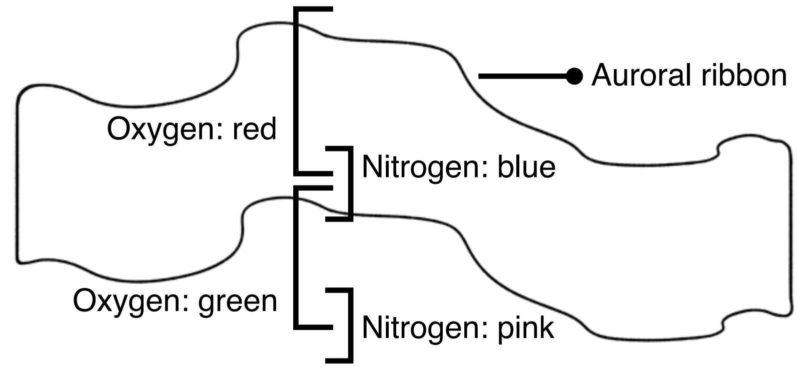
Aurora

Auroras are beautiful lights that dance across the sky near the North and South Poles. They happen when energy and particles from the Sun run into and dance with Earth's magnetic field, and are pushed toward the North and South Poles. This interplay creates the auroras.

The colors we see (like green, red, or purple) come from different gases: **oxygen** makes green and red light, while **nitrogen** creates blue and pink. The basic colors can also mix and create other shades. Sometimes, the glowing light forms long, wavy shapes called **auroral ribbons** that stretch across the sky like curtains. Seeing an aurora is like watching Earth's atmosphere light up all the way out on the edge of space.

The mechanics of how auroras work are pretty exciting, too. When solar particles run into electrons of oxygen and nitrogen high in the atmosphere, these electrons are excited by the interaction with Earth's magnetosphere, which causes them to give off light as they "calm down." This is what causes the dazzling display of lights that we know and love.

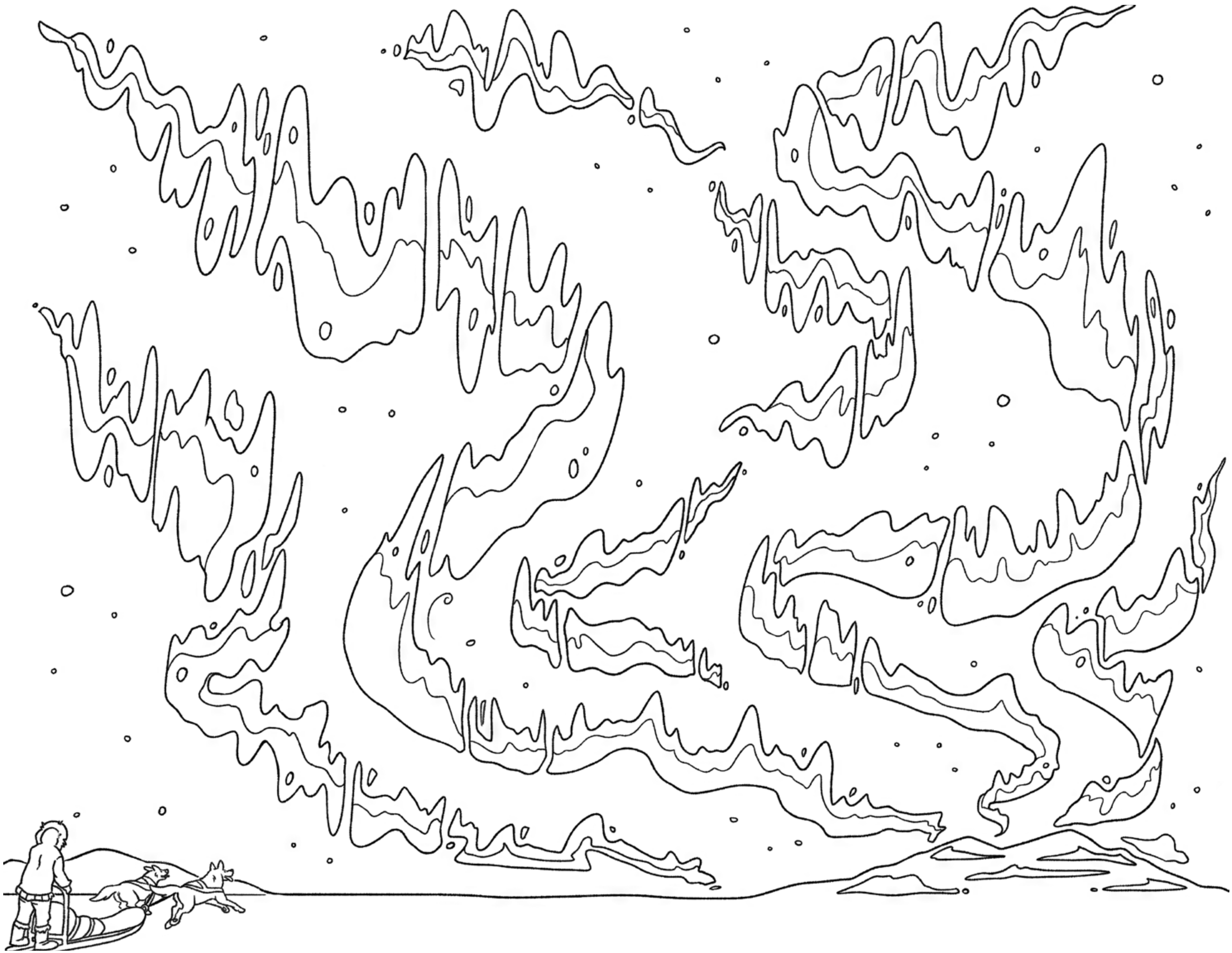
It's also worth noting that stronger solar storms bring auroras that extend far beyond their normal northern and southern boundaries, and reach much closer to the equator. For one powerful solar storm in 1859, the auroras were visible as far south as Hawaii!



Speaking of the Heliosphere...

Alaska's geographic location in the Northern Hemisphere offers overhead views of the aurora during long, dark, clear nights. The Iñupiaq and other Alaska Native groups have cultural stories that are handed down from one generation to the next through oral history, storytelling and songs. Have you heard any of these stories?

The Iñupiaq people use the word **kiuġuyat** for *aurora*, or *Northern Lights*. Scan the QR code to listen to this and other Iñupiaq words spoken by a Native speaker.



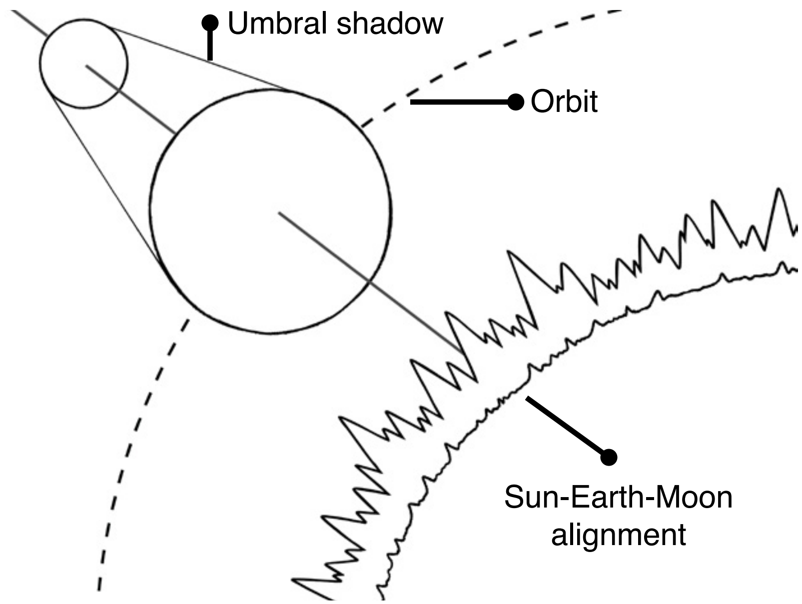
Eclipse

Eclipses happen when the Sun, Earth, and Moon align in just the right way. This **Sun-Earth-Moon alignment**, also known as a syzygy, is what leads to the Moon blocking the Sun or the Earth to come between the Sun and the Moon.

A solar eclipse happens when the Moon moves between the Earth and the Sun, casting a shadow on Earth. If you're in the darkest part of that shadow, called the **umbral shadow**, the Sun can be completely blocked out for a short time.

A lunar eclipse happens when Earth moves between the Sun and the Moon, and Earth's shadow falls on the Moon. These alignments don't happen every month because the Moon's **orbit** is tilted compared to Earth's path around the Sun, so the shadows usually miss. But when everything lines up just right, we get an amazing eclipse!

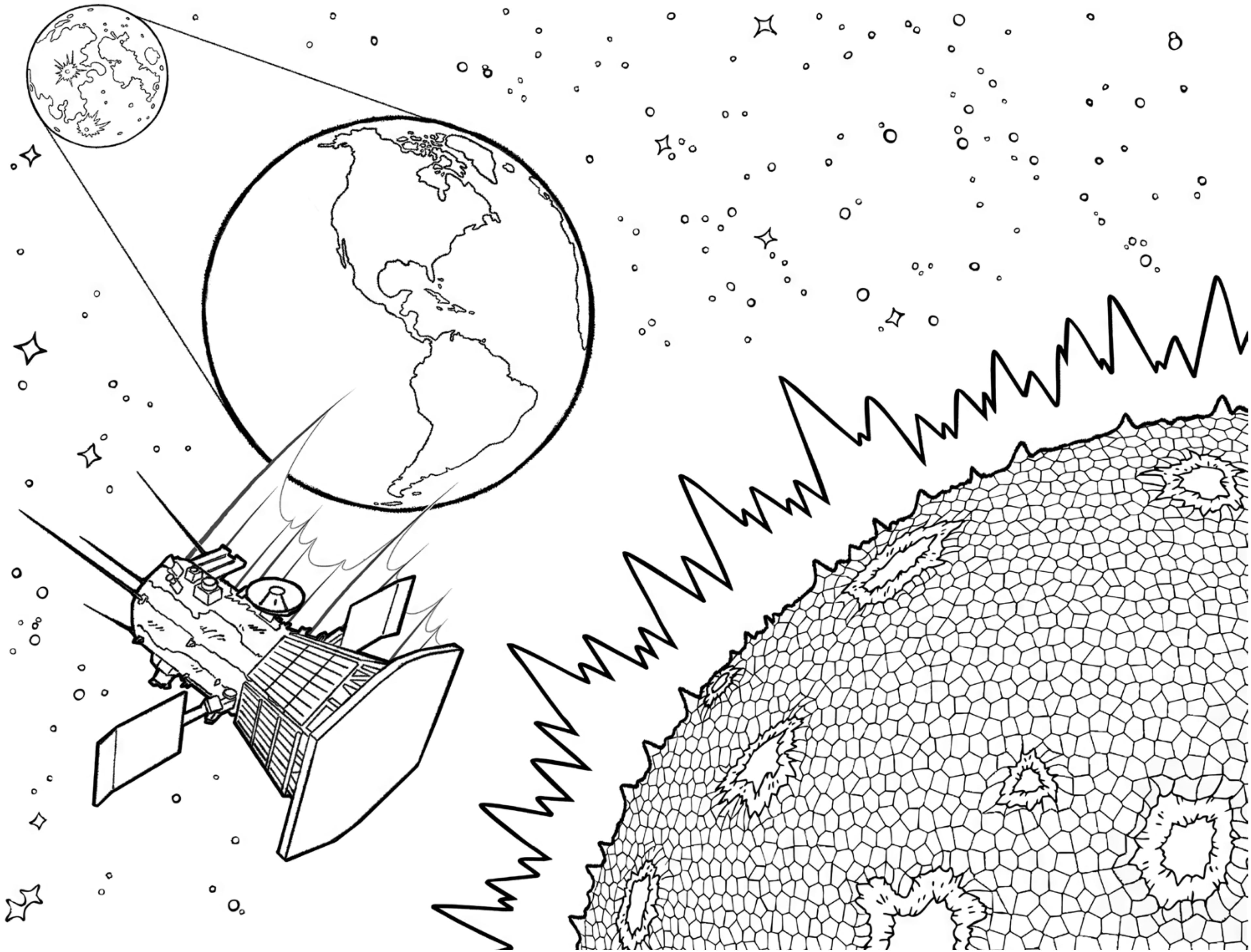
Eclipses seem rare, but they actually happen somewhere on the Earth about once every eighteen months. But thanks to the dynamics of the Earth-Moon orbital system and Earth's rotation, any given spot on Earth's surface only sees a total solar eclipse about once every 375 years. You usually only notice solar eclipses when you're near or in the path of totality, which cuts a narrow path across Earth's surface. This is what makes being in that path so exciting.



Speaking of the Heliosphere...

Solar eclipses are experienced less frequently in Alaska than at lower latitudes. This is because the Moon's **umbral shadow** rarely crosses the polar latitudes on Earth. Have you ever seen a solar eclipse? Where were you when you had that experience?

In the Interior Alaska village of Nulato, people use the Lower Koyukon Athabascan word **yeege'** for *shadow*. To hear the word yeege' and other Lower Koyukon Athabascan words spoken, scan the QR code.



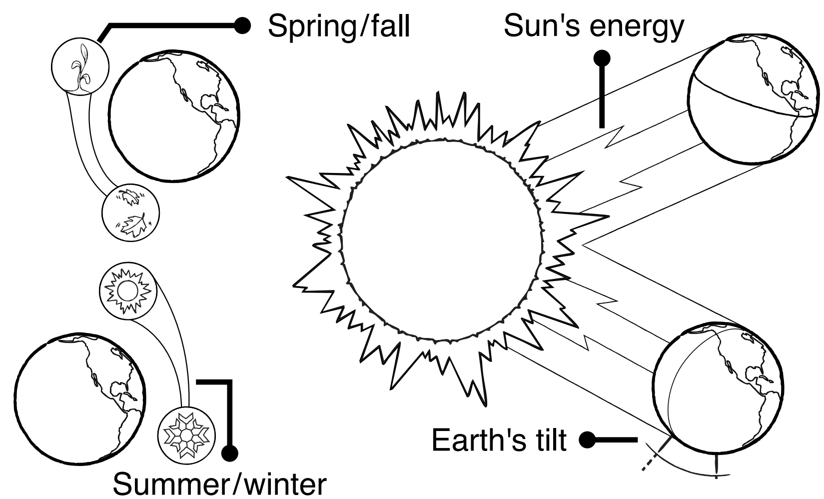
Seasons

The **Earth's tilt** affects how much of the **Sun's energy** different parts of the planet receive throughout the year. This difference leads to the changing seasons we experience.

Earth is tilted on its axis, so as it orbits the Sun, one hemisphere (either the northern or southern) leans toward the Sun while the other leans away. When your hemisphere is tilted toward the Sun, you get more sunlight and warmer temperatures. That's **summer**. When it's tilted away, the Sun's energy is weaker, and you experience **winter**.

Spring and **fall** happen in between, when both hemispheres get about the same amount of sunlight. So the seasons are all about sunlight and tilt — not how close Earth is to the Sun. In fact, for people in the northern hemisphere, summer actually happens when Earth is farthest away from the Sun in its orbit, and winter happens when Earth is closest to the Sun.

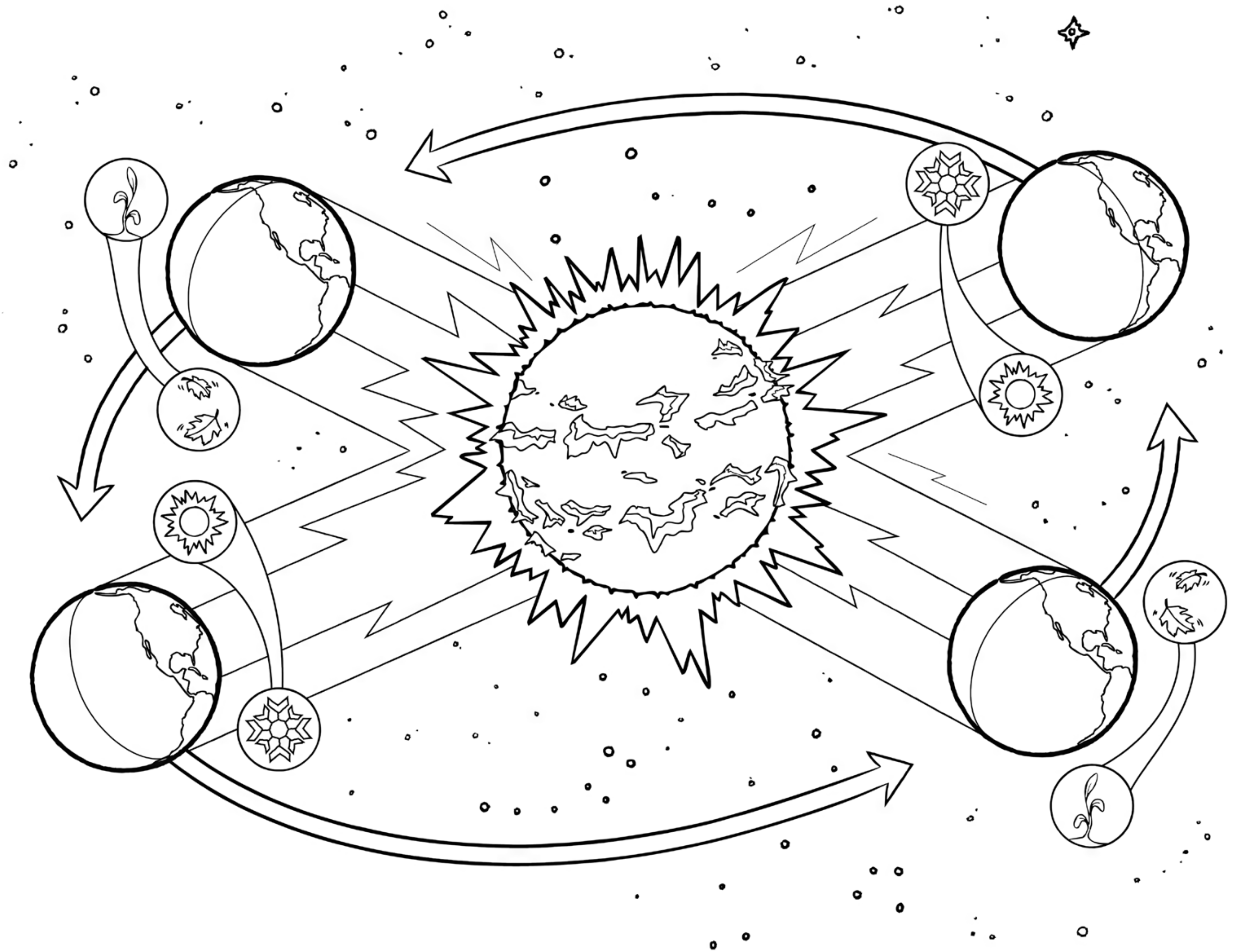
Earth's tilt also causes places farther away from the equator to get more or less sunlight as the seasons change. In winter in Northern Alaska, the Sun hardly rises at all. In summer, it almost never sets. This is due to these regions being tilted toward or away from the Sun.



Speaking of the Heliosphere...

A year on Earth encompasses all four seasons. Each season has distinctive weather patterns. Depending upon where you are located on the Earth, seasonal weather patterns differ, and some seasons may last longer than others. Which is your favorite season of the year? What kind of weather do you experience during that season?

Lower Tanana Athabascans inhabit a region of Alaska that enjoys heat from the summer sun, allowing many natural foods to be harvested. In their language, Ten Kenaga', the word **khwnadheł** means, *"it is hot."* Scan the QR code to hear its pronunciation.

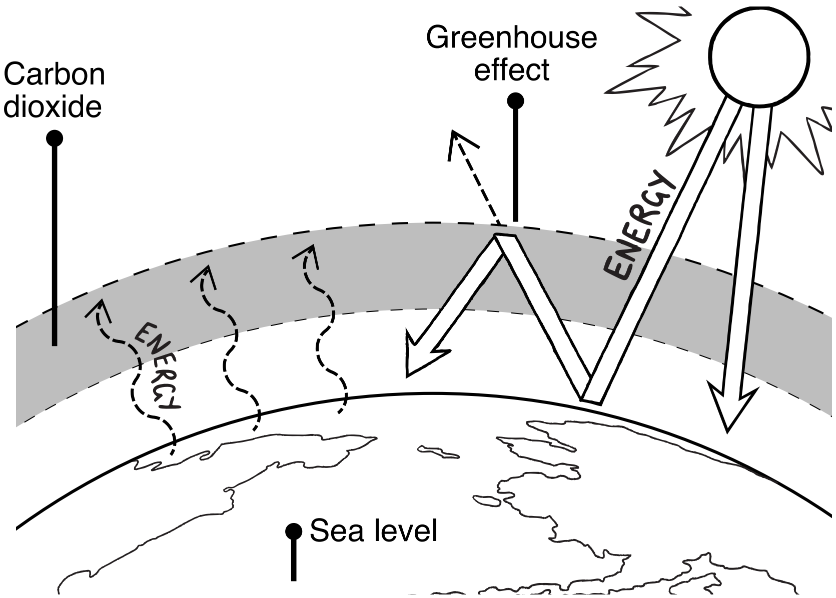


Earth's Climate

The Sun gives Earth the energy it needs to stay warm and support life. Some of that energy is absorbed by Earth, and some bounces back into space — this constantly changing balance is called Earth's **energy** budget.

Gases in our atmosphere, like **carbon dioxide**, trap some of the escaping heat in a process called the **greenhouse effect**. This is natural and keeps Earth warm enough for life, but when too much carbon dioxide is added, it traps too much heat. This causes Earth's climate to shift over time, which can lead to rising sea levels as glacier ice melts and oceans get warmer.

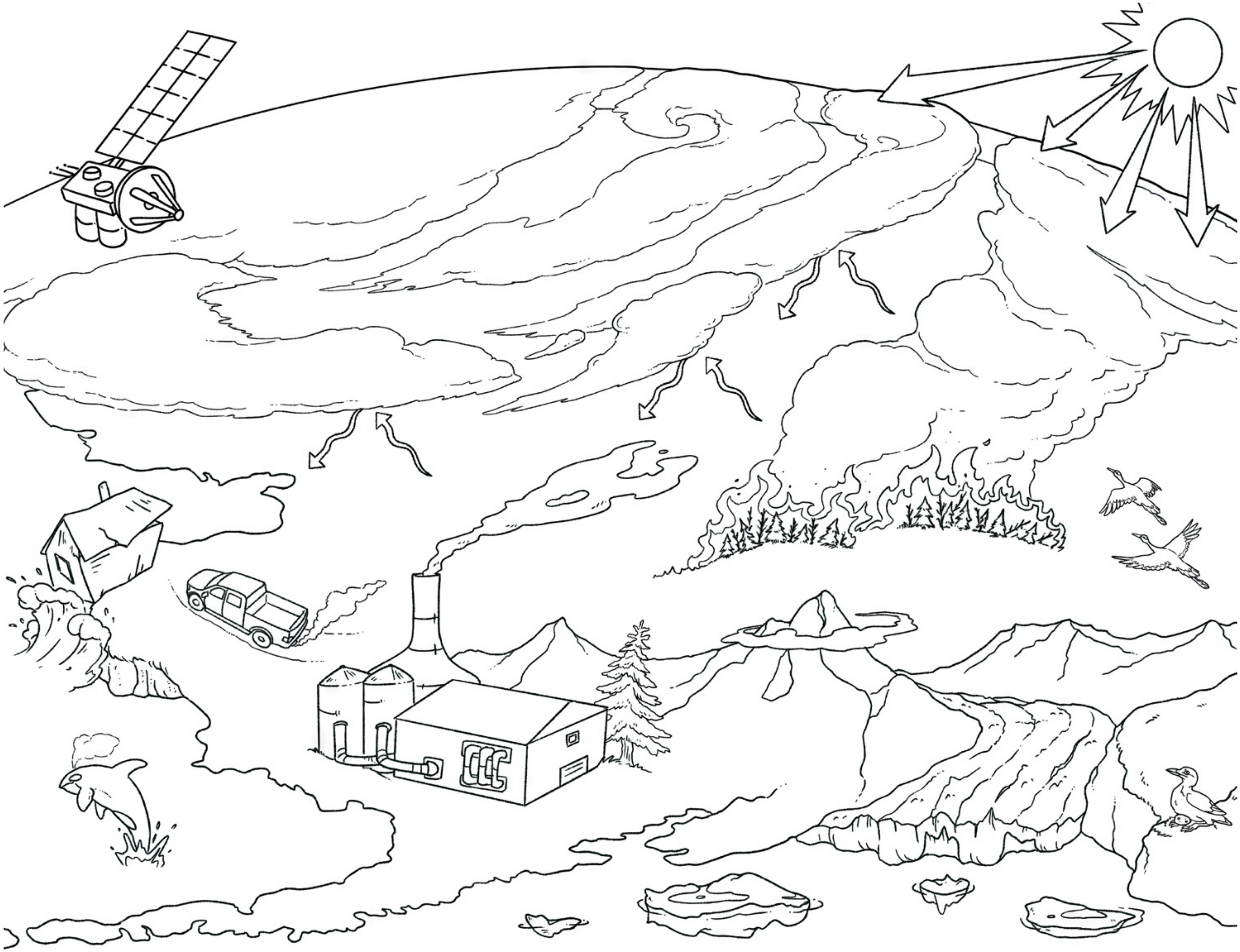
Warmer oceans have less sea ice and more dark water, which absorbs more heat than reflective ice. Sea ice loss means less protection from storms and more erosion for coastal Arctic communities, and greater challenges for polar bears and walrus that depend on sea ice to survive. It could also affect the jet stream, a band of high winds driven by different temperature layers in the atmosphere that typically guides weather systems in the northern hemisphere. This in turn could cause more intense storms and flooding far away from the Arctic.



Speaking of the Heliosphere...

The Sun drives Earth's complex climate system, which is characterized by long-term weather patterns. These weather patterns, such as temperature and precipitation, are often grouped into categories described as tropical, dry, temperate, continental, and polar.

The Iñupiaq live in a polar climate where the year is dominated by a long winter season. Their word for *year* is **ukiuq**. Scan the QR code to hear its pronunciation.



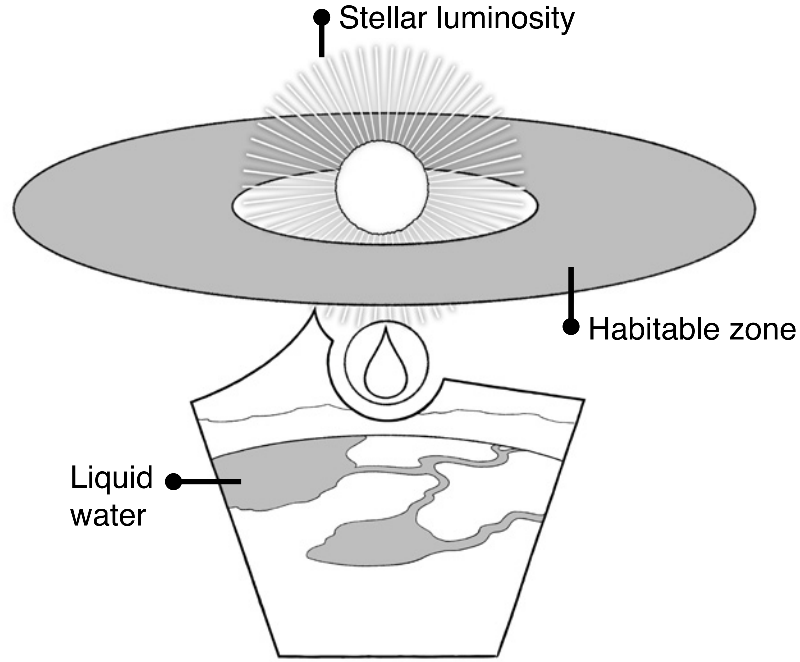
Habitable Zone

When scientists look for planets that might support life, they focus on something called the **habitable zone** — a region around a star where it's not too hot and not too cold for **liquid water** to exist. Liquid water is important because it's essential for life as we know it.

The size and distance of the habitable zone depend on the star's **stellar luminosity**, which means how bright and powerful the star is. A brighter star has a habitable zone that's farther out, while a dimmer star's habitable zone is much closer in.

This is a major factor in our search for other worlds like Earth. Knowing which orbits could support liquid water helps scientists decide which planets to examine more closely. The variety of the other stars we see and of the planets orbiting them also helps us fill in the gaps in our understanding of the habitable zone as a concept.

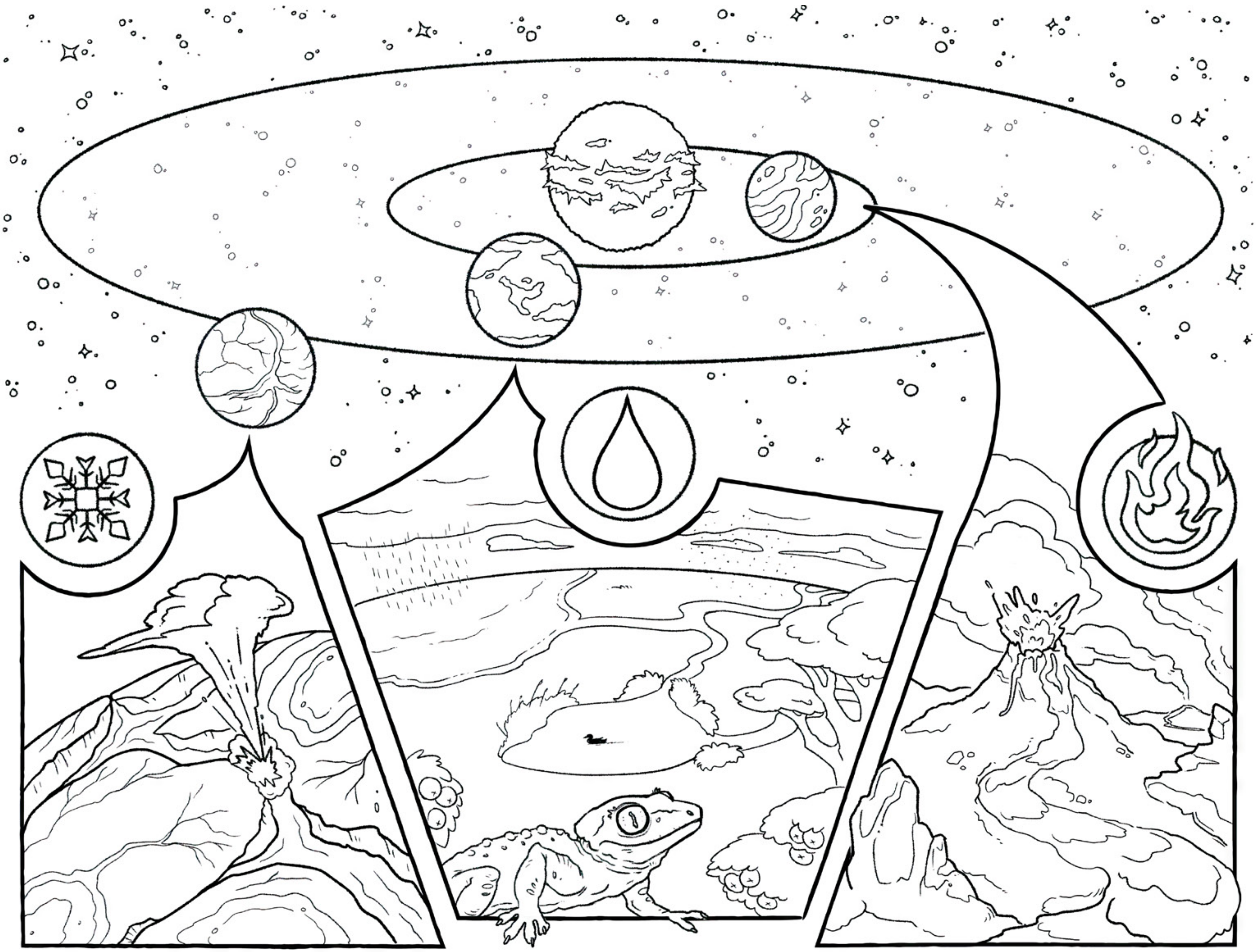
It's worth noting that as our Sun gets older and moves into the red giant phase, its increasing size and brightness means that the habitable zone will move outward. This means that Earth will likely become uninhabitable, like Mercury and Venus are today, while planets like Mars and the moons of the gas giants could be the habitable worlds of the distant future.



Speaking of the Heliosphere...

Earth sits comfortably in the habitable zone of our Sun. As a result, it is the only planet in the solar system with a temperature range that allows liquid water to exist in large quantities. This liquid water allows life to exist and flourish.

The Ts'msyen / Sm'algyax of the Alexander Archipelago rely on the Earth's water for life. In their language, Ts'msyen / Sm'algyax, *Earth* is called **ha'lidzog**. Scan the QR code to hear it spoken.



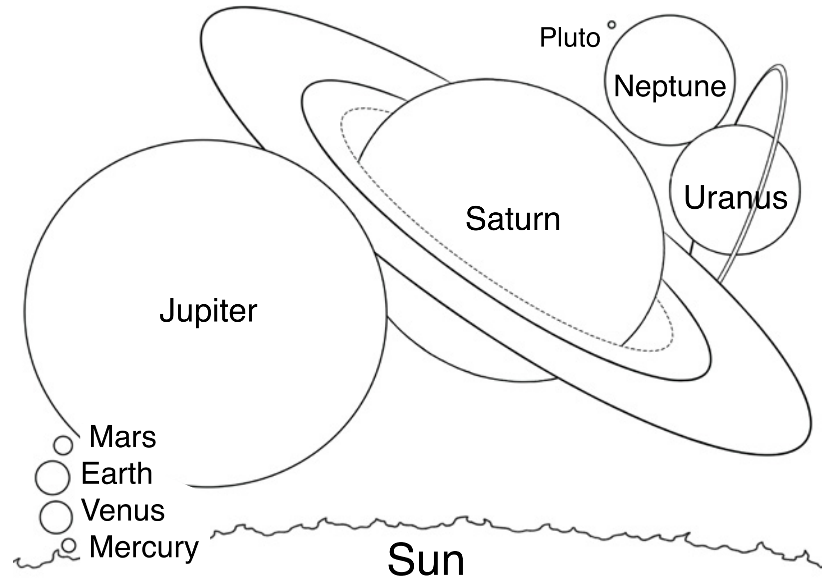
Solar System

Our solar system is made up of the Sun and everything orbiting it. The Sun itself is a huge ball of hot, glowing gas called plasma. It gives light and energy to everything in the solar system.

There are eight planets that travel around the Sun: Mercury, Venus, Earth, and Mars are the rocky inner planets. Then come the giant outer planets: Jupiter and Saturn, which are made mostly of gas, and Uranus and Neptune, which are icy and cold. These four outer planets all have many moons orbiting them, as well. Saturn alone has more than 270.

Beyond Neptune is Pluto, which is known as a dwarf planet. Scientists have found more dwarf planets out there too! Even though Pluto isn't considered one of the main planets anymore, it's still an exciting part of our solar system.

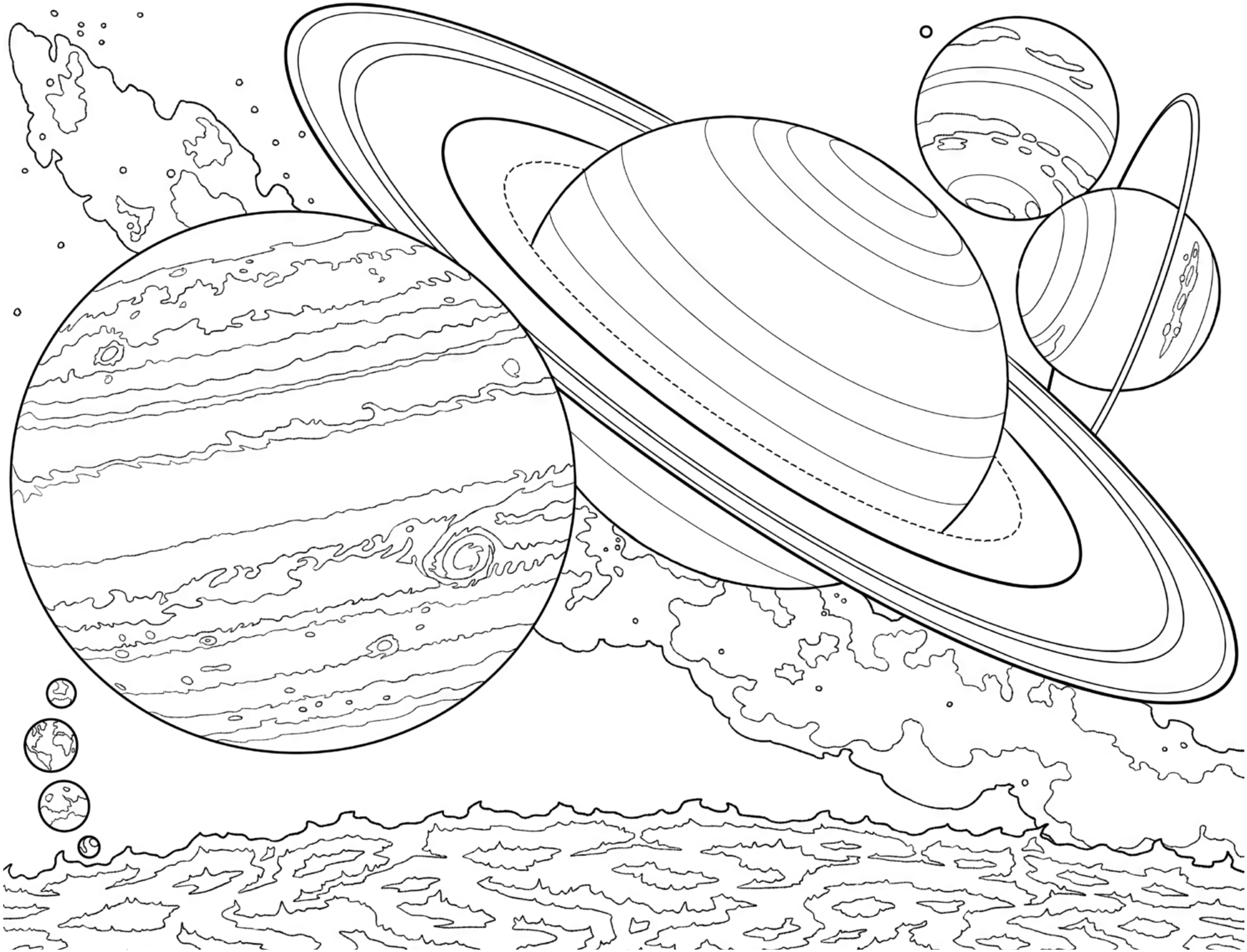
And here's something else amazing: two spacecraft called *Voyager 1* and *2* are the only human-made objects to have ever left the solar system. They're out there flying through interstellar space, still sending back data almost fifty years after they were launched!



Speaking of the Heliosphere...

Long before GPS was available, nomadic people in Alaska used light from the stars for navigation. These earliest observers of the stars noticed patterns and organized groups of stars as they seemed to travel consistently across the sky. What would you like to know about the Sun or other stars beyond the solar system?

The Ten Kenaga'/Lower Tanana Athabascan people use the word **sen'** for *star*. Scan the QR code to hear a Native Ten Kenaga'/Lower Tanana Athabascan language speaker say this word.



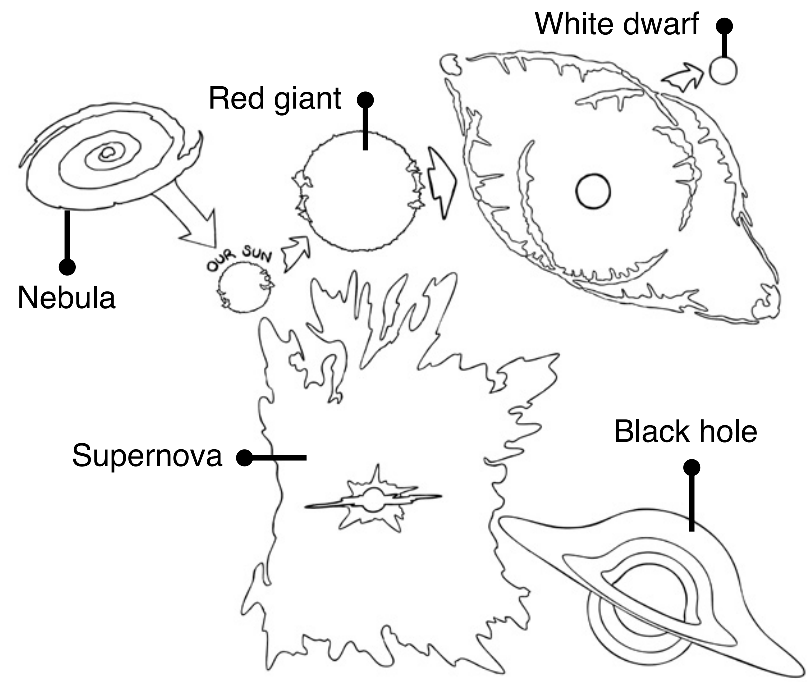
Life Cycle of a Star

Stars have a life cycle, just like you! They are born, live for millions or even billions of years, and then die in a number of quite amazing ways. All stars begin their lives in a **nebula**, which is a huge cloud of gas and dust floating in space. Gravity pulls the gas in a nebula together until it gets hot and dense enough to start shining.

Our Sun is a medium-sized star and middle-aged at about 4.5 billion years old. One day, as it runs out of fuel to power its internal fusion engines, it will swell into a **red giant**. Stars much more massive than the Sun burn through their fuel in only a few million years, and then go out with a bang in a gigantic explosion called a **supernova**.

Red dwarfs, which are smaller than the Sun, burn their fuel much more slowly than their larger brethren. Because of this, they can live for trillions of years — that's hundreds of times longer than the current age of the universe!

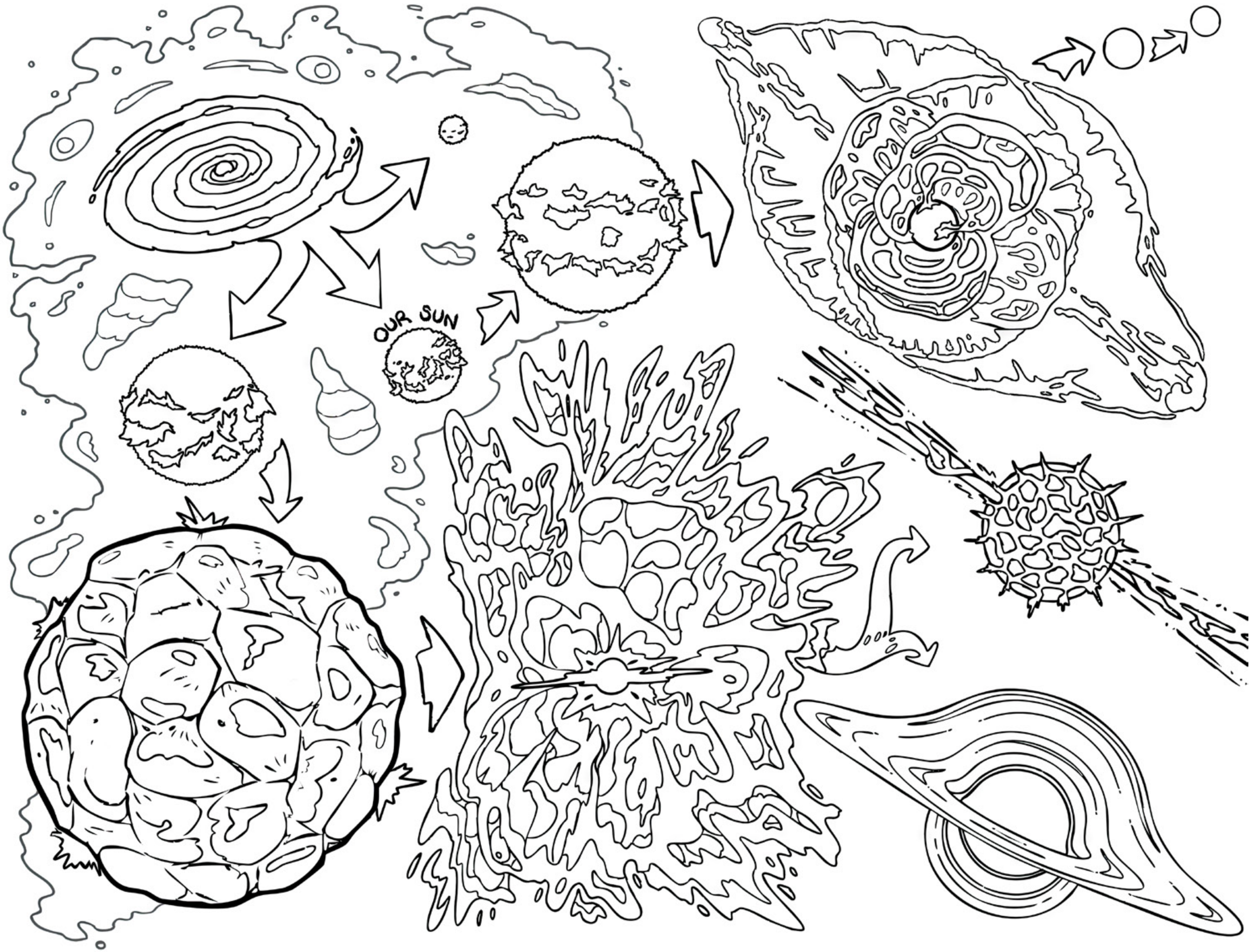
After becoming a red giant, the Sun will shrink into a small, dense object called a **white dwarf**. The cores of slightly larger stars become extremely compact objects (usually about 12 miles in diameter) called neutron stars after they go through a supernova. The largest stars of all collapse into something so dense that not even light can escape: a **black hole**.



Speaking of the Heliosphere...

For millennia, people on Earth, including the first people to inhabit its northern regions, have observed the stars. Light emitted by stars provides all kinds of information to observers. The color of light that a star emits helps astronomers understand where each star is in its life cycle. What colors are the stars you can see?

In the Central Yup'ik language, **tanqik** is the word used to mean *light*. Scan the QR code to listen to a Central Yup'ik language speaker say this word.


OUR SUN

Glossary

aurora: Northern/Southern Lights near the poles caused by charged solar particles that strike oxygen and nitrogen in the atmosphere.

auroral ribbon: A wispy strand of energy which makes up the glowing appearance of an aurora as it shines in the northern or southern sky.

black hole: A region of space-time which is so densely packed with matter that not even light can escape its huge gravity.

bow shock: A three-dimensional shockwave in space caused by an object or energy moving through space at high speed. In the case of the Sun, this comes from solar energy slamming into the interstellar medium at the edge of the heliosphere.

convective zone: A region in a star where convection, rather than radiation, is the main method of heat transfer. Convection requires a large difference of temperature between the top and bottom of the layer in order to work.

core: The central region of a star. In the core of a main sequence star, such as the Sun, this is where hydrogen atoms are fused into helium.

corona: The outermost part of the Sun's atmosphere, which is usually hidden by the bright light of the Sun's surface.

coronal mass ejection (CME): An eruption of charged particles from the Sun's corona that travels through space at a very high speed. When directed at Earth, it can take one to three days to reach us and then creates a geomagnetic storm and auroras.

current sheet: A narrow electric current layer that is spread through a three-dimensional volume of space. Our Sun's current sheet is about 10,000 km thick and extends beyond the orbit of Pluto.

dwarf planet: An object that orbits the Sun and has enough mass to assume a roughly round shape, but which shares its orbit with many other objects.

Earth's magnetic field: Earth's magnetosphere, which extends from the interior out into space and, generated by electric currents caused by the convective motion of a mixture of molten iron and nickel in Earth's outer core.

Earth's tilt: Axial tilt is the angle between an object's rotational axis and its orbital axis, which is the line perpendicular to its orbital plane. In Earth's case, this tilt is approximately 23°, which leads to the changing of the seasons as different parts of Earth receive more or less sunlight during different times of the year.

eclipse: A solar eclipse happens when the Moon moves in between Earth and the Sun, blocking the Sun from our view. A lunar eclipse occurs when the Moon moves into Earth's shadow.

energy: Energy stored within a resource can be released as work through physical or chemical processes. Solar energy reaches Earth in the form of both light and heat, contributing to Earth's overall energy budget or balance. This energy in our atmosphere must either be absorbed or reflected to space.

energy budget: The balance between the radiant energy that reaches Earth from the Sun and the energy that flows from Earth back out to space.

filament: Dark, thread-like features seen in the red light of hydrogen (H-alpha). These are dense, cooler clouds of material that are suspended above the solar surface by loops of its magnetic field.

greenhouse effect: The quality of trapping heat energy from the Sun and allowing it to heat up an atmosphere, as in a greenhouse used for gardening.

habitable zone: The range of distances relative to a parent star within which planets orbiting that star can have liquid water on their surfaces.

heliophysics: The study of the Sun and how it influences the entire solar system.

heliosphere: A giant bubble around the solar system formed by particles the Sun emits as part of the solar wind.

interstellar medium: The matter and radiation that exists in the space between stars. This includes gas in ionic, atomic, and molecular form, as well as dust and cosmic rays.

jet stream: A relatively thin band of strong wind in the upper levels of the atmosphere, typically around 30,000 feet (9,100 meters) in elevation.

magnetopause: The boundary between a planet's magnetosphere and the solar wind.

magnetosphere: A magnetic bubble that shields a planet from harmful solar wind and cosmic radiation. The solar wind compresses the field's shape on Earth's Sun-facing side, and stretches it into a long tail on the night-facing side.

nebula: A tenuous cloud of gas and dust that occurs in the space between stars.

neutron star: An extremely dense, compact star (typically about 12 miles in diameter) which is left over after a supernova and is thought to be made primarily of neutrons.

orbit: The elliptical path one body follows as it travels around another (e.g., the path Earth takes around the Sun). A year is the time it takes for the Earth to make one orbit.

photosphere: The surface layer of the Sun that radiates the visible light we can see.

plasma: A gas in which atoms have been broken up into free-floating negative electrons and positive ions, which are atoms that have lost electrons and become positive.

prominence: A large, bright feature created by the Sun's magnetic field and extending outward from its surface, often in a loop-like structure. When seen with the Sun's disc behind it, it is called a filament and appears dark.

radiative zone: A region in the Sun where energy from the core slowly travels outward.

red dwarf: A type of star with about 8-60% of the Sun's mass. This lower mass means they burn colder and slower, giving them lifespans in the trillions of years.

red giant: A bright, giant star in a late phase of stellar evolution. The outer atmosphere becomes loose, which inflates the star to a massive size and cools the surface temperature to around 8,500 °F (4,700 °C) or lower.

solar cycle: A predictable, 11-year (on average) cycle during which the Sun becomes more active and then less active.

solar flare: A great burst of light and radiation on the Sun that reaches Earth in eight minutes. These can cause changes to the Earth's upper atmosphere and can be dangerous for unprotected astronauts in space.

solar system: A planetary system made up of the Sun and the eight planets, more than 400 known moons, many thousands of asteroids, comets, and other icy bodies, and gas and dust known as the interplanetary medium.

solar wind: A constant stream of charged particles that flows off the Sun and then moves throughout the solar system, including toward Earth.

stellar luminosity: The total amount of electromagnetic energy (i.e., light) emitted per unit of time by a star, galaxy, or other astronomical object.

sunspot: An area on the Sun that is highly magnetic and may give rise to flares and coronal mass ejections. Often bigger than Earth, sunspots appear darker and are relatively cool. The number and intensity of sunspots increase and decrease over approximately an 11-year cycle *(see also solar cycle).*

supernova: When there is no longer enough fuel for fusion in the core of a star to create an outward pressure, the star first expands on the outside, then shrinks inside, and finally explodes. See more at https://spaceplace.nasa.gov/supernova/en/

umbral shadow: The innermost part of a shadow, where the light source (e.g., the Sun) is completely blocked by the occulting body (e.g., the Moon).

white dwarf: A Sun-like star that has run out of fuel and expelled most of its outer material, so that only the hot core remains.

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