Module 3 – Nautical Science

Unit 4 – Astronomy

Chapter 14 - The Sun

Section 1 – The Sun

What You Will Learn to Do

Demonstrate an understanding of astronomy and how it pertains to our solar system and its related bodies: Moon, Sun, stars and planets

Objectives

1. Explain the basic facts about the Sun, and its relationship to Earth
2. Describe the composition of the Sun
3. Explain sunspots and the effects they have on the Earth's atmosphere
4. Explain the effects the Sun has on the Earth's magnetic field

Objectives

5. Describe the effects the Sun's energy has on the Earth
6. Explain the importance of developing solar energy systems
7. Explain the missions for further observations of the sun that has been launched in recent years

Key Terms

CPS Key Term
Questions 1 - 14

Key Terms

Thermonuclear fusion -	A thermonuclear reaction in which nuclei of light atoms join to form nuclei of heavier atoms, as the combination of deuterium (an Isotope of hydrogen) atoms to form helium atoms
Astronomical unit -	Abbreviated au; a unit of length, roughly the distance from the Earth to the Sun

Key Terms

Photosphere - The luminous visible surface of the Sun, being a shallow layer of strongly ionized gases

Corona - A white or colored circle or set of concentric circles of light seen around a luminous body, especially around the Sun or Moon

Key Terms

Heliosphere - A vast region of space surrounding the Sun; a sort of bubble filled by the interplanetary medium and extending well beyond the orbit of Pluto

Heliopause - The theoretical boundary where the Suns solar wind is stopped by the interstellar medium

Key Terms

Sunspots -	Relatively dark patches that appear periodically on the Sun that affect terrestrial magnetism and certain other terrestrial phenomena
Solar flares -	A sudden flash of brightness observed over the Sun's surface or the solar limb

Key Terms

Solar wind -	Hot plasma (ionized gas) continuously ejected from the Sun's surface into and through planetary space
White dwarf -	A stellar remnant composed mostly of electron-degenerate matter
Red giant -	A luminous giant star of low or intermediate mass in a late phase of stellar evolution

Key Terms

Aurora - The radiant emission from the upper atmosphere sporadically over the middle and high latitudes of both hemispheres in the form of luminous bands, streamers or the like; caused by the bombardment of the atmosphere with charged solar particles that are being guided along the Earth's magnetic lines of force

Key Terms

Aurora borealis -	"Northern Lights," a natural light display in the sky caused by the collision of solar wind and magnetosphere charged particles with the high altitude atmosphere
Aurora Australis -	"Southern Lights," dynamic displays of light similar to what is seen in the northern hemisphere, appearing in the Antarctic skies in winter

Opening Question

Describe some safe ways to observe the Sun.

1.

2.

3.

(Use CPS "Pick a Student" for this question.)

Warm Up Questions

CPS Lesson
Questions 1 - 2

Introduction

For 4.6 billion years, the Earth has been warmed by the light of the Sun.

Introduction

Most life is maintained by solar energy that is converted into chemical energy by plants.

Introduction

The power from fossil fuels, water, and winds can be traced back to the Sun.

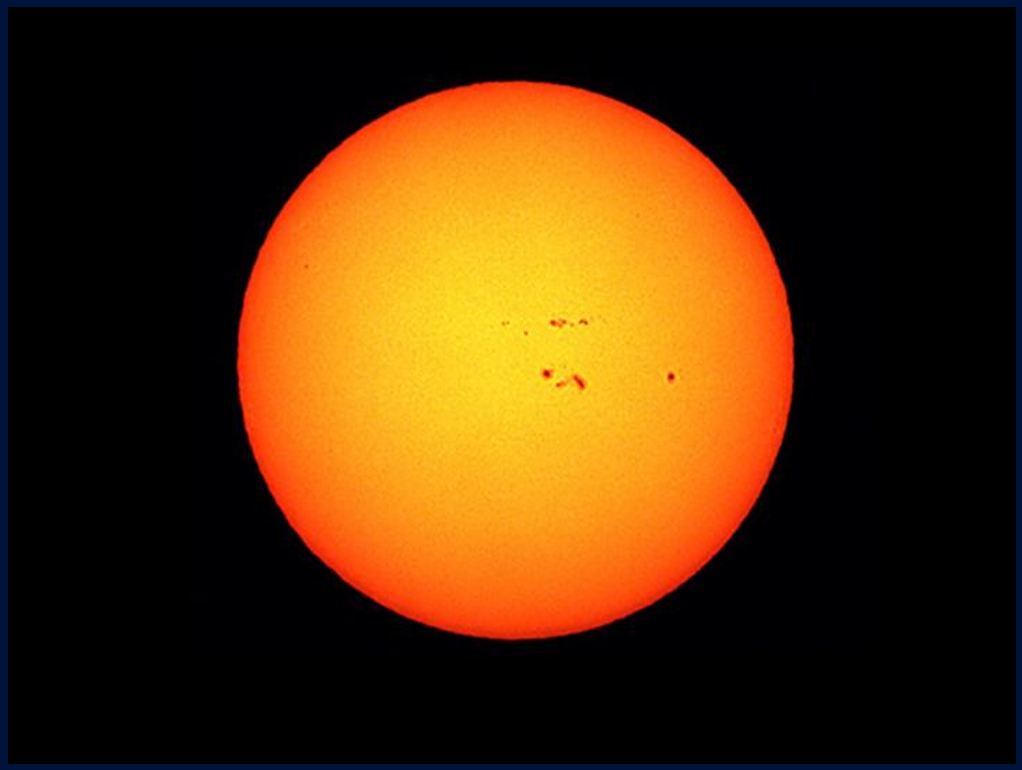
Introduction

Exceptions are: nuclear, tidal, and heat produced in the interior of the Earth.

Introduction

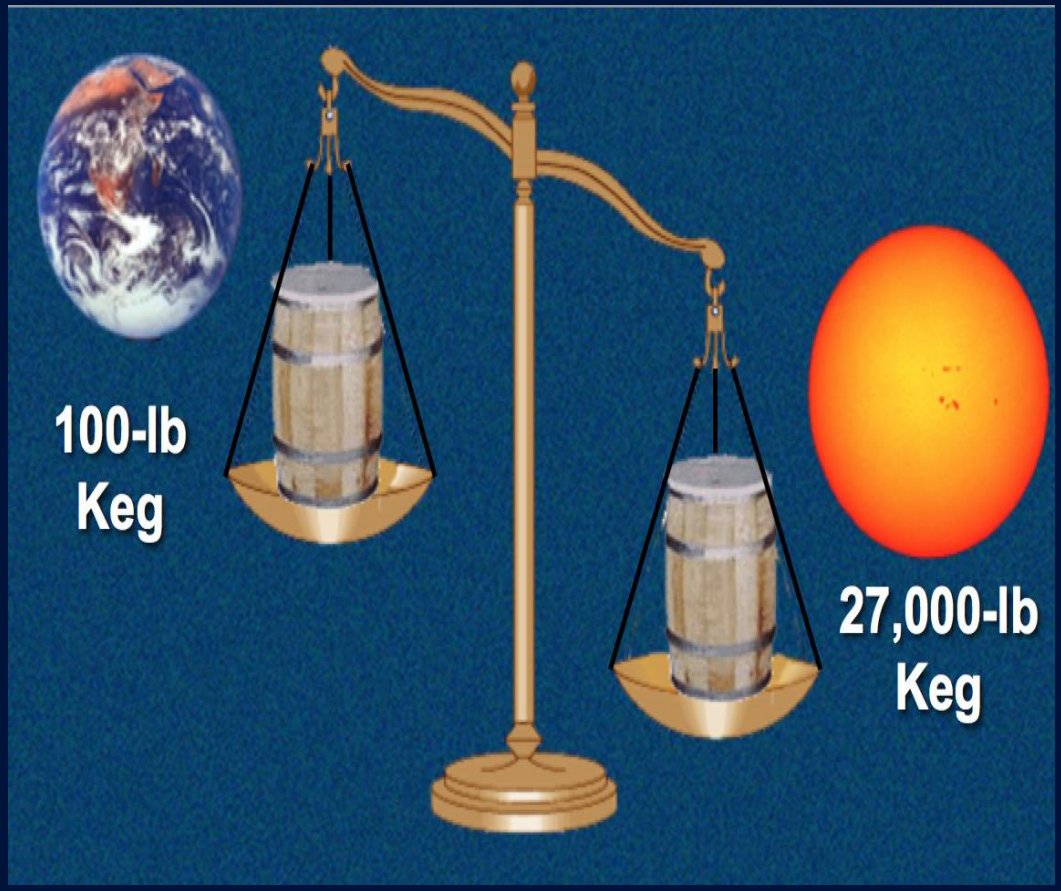
The Sun:

- Contains 99% of all the matter in our solar system
- Weighs about 1 million times more than the Earth



Introduction

A 100-pound keg of nails on the Earth would weigh 27,000 pounds on the Sun.

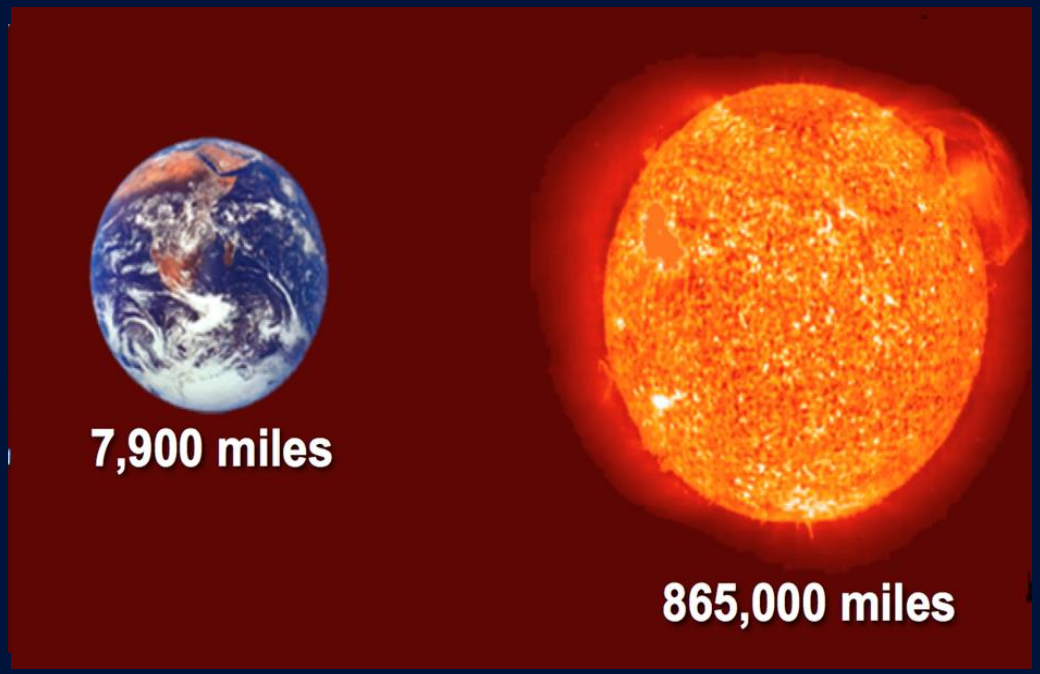


Introduction

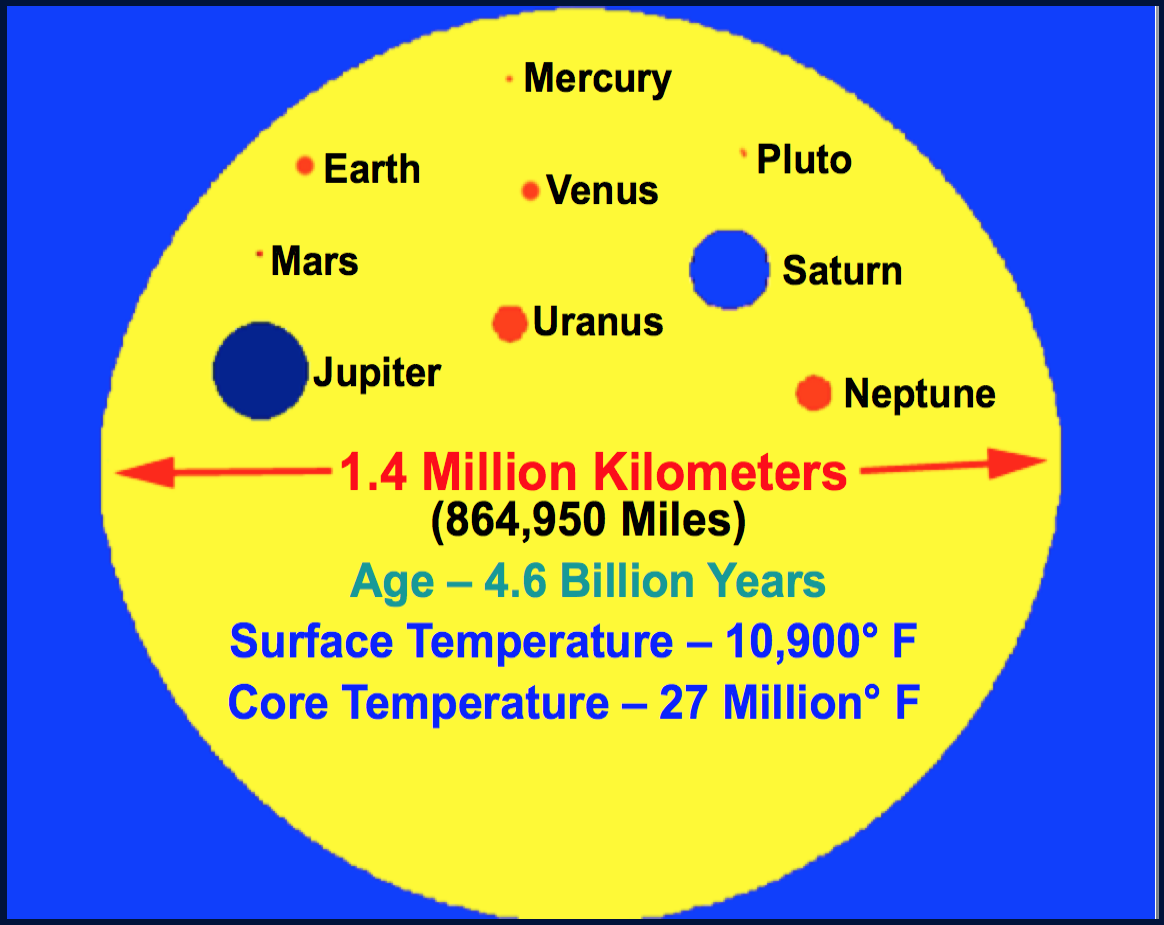
The average distance between the Sun and Earth is approximately 93 million miles.

This distance is known as an astronomical unit.

The Sun's diameter is 109 times that of Earth

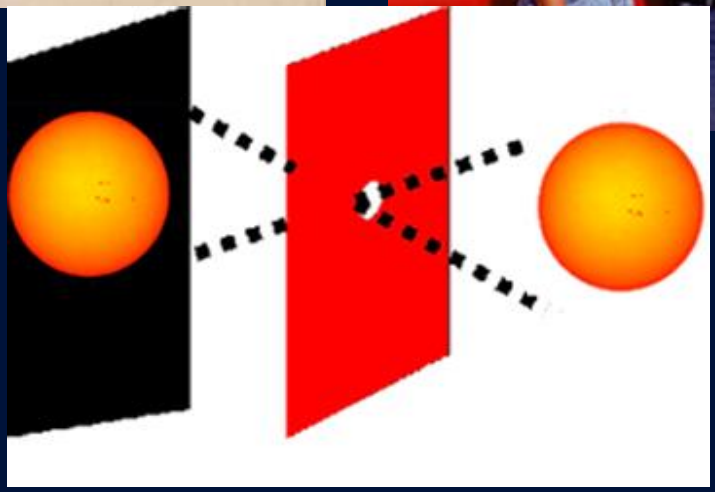


Introduction



Introduction

Never look directly at the Sun. You can easily make a device to let you view it safely.



Introduction

Only use these devices if they have a filter or special fogged lens.

Introduction

The Sun will burn the retina, causing impaired vision or blindness.

Check On Learning Questions

CPS Lesson

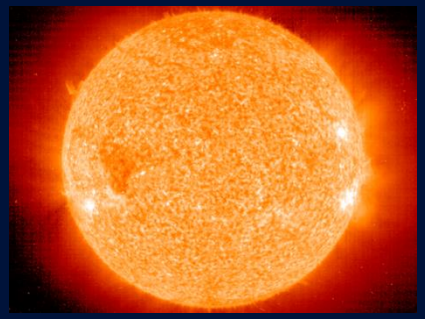
Question

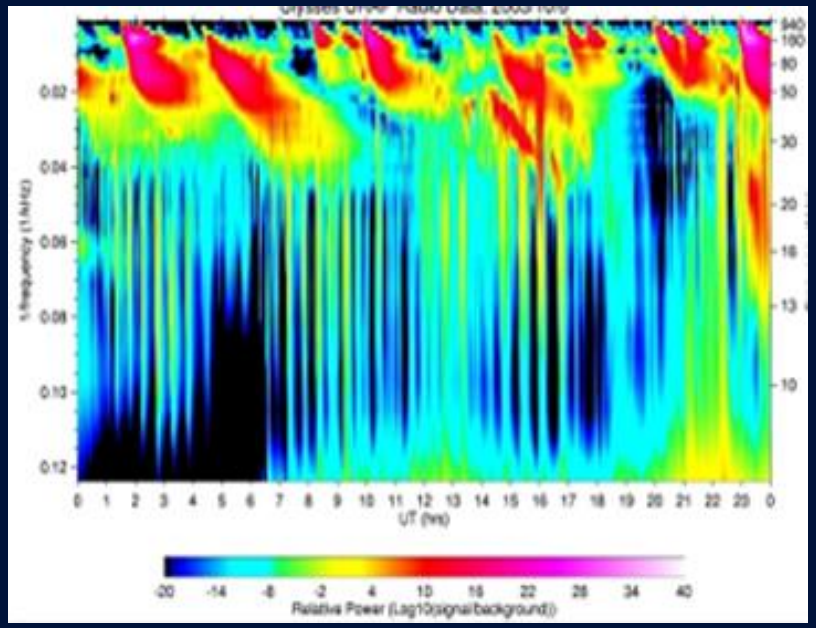
3 - 4

Composition of the Sun

Spectrographic evidence shows that the Sun consists of gases at very high temperatures...

92.0% = Hydrogen
7.8% = Helium
.2% = Other elements

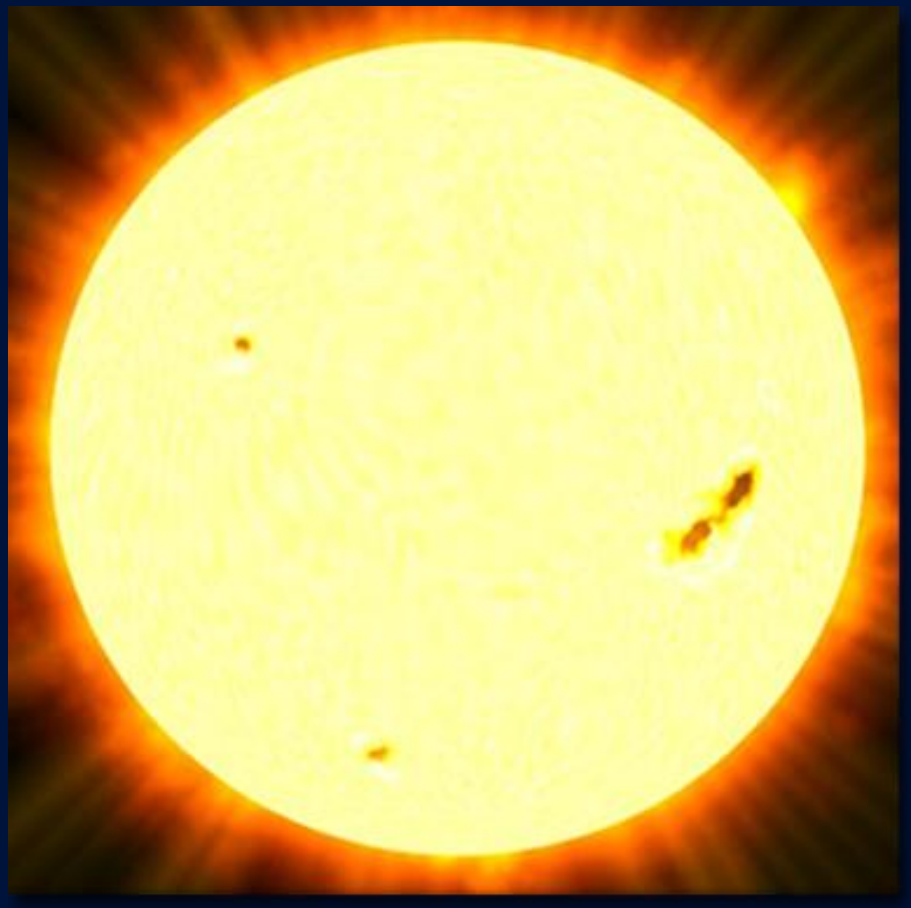




Composition of the Sun

Each second, about 600 million tons of hydrogen is converted into about 596 million tons of helium by nuclear fusion.

About 40 percent of this energy escapes in the form of visible light.

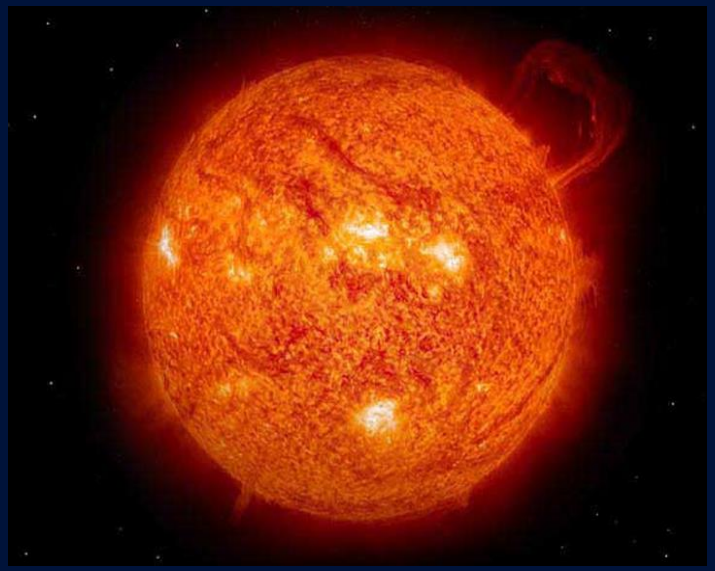


Composition of the Sun

Even with this fantastic rate of fuel consumption, it will take over 5 billion more years before its supply of hydrogen is exhausted.

Energy created in the core of the Sun travels outward until it reaches the three layers of the Sun's atmosphere:

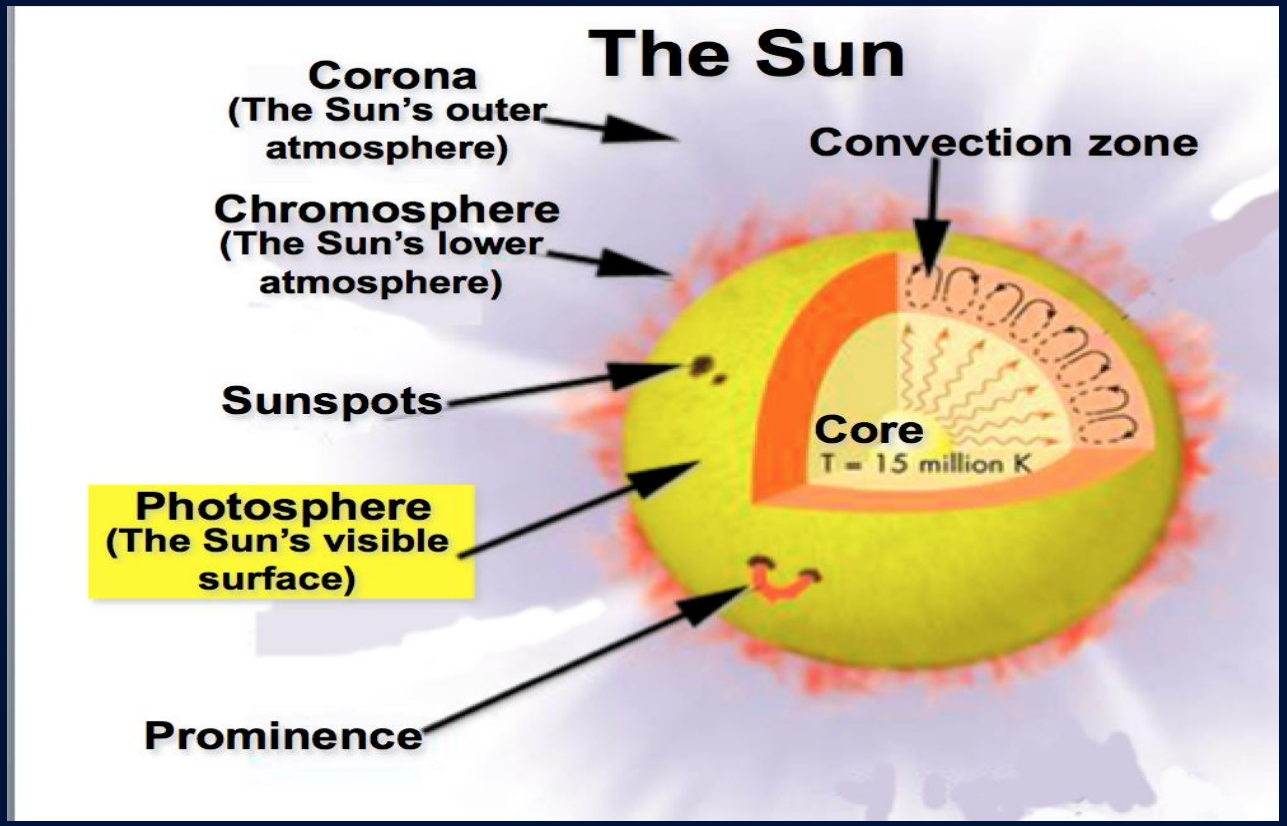
1. the photosphere
2. the chromosphere
3. the corona



Composition of the Sun

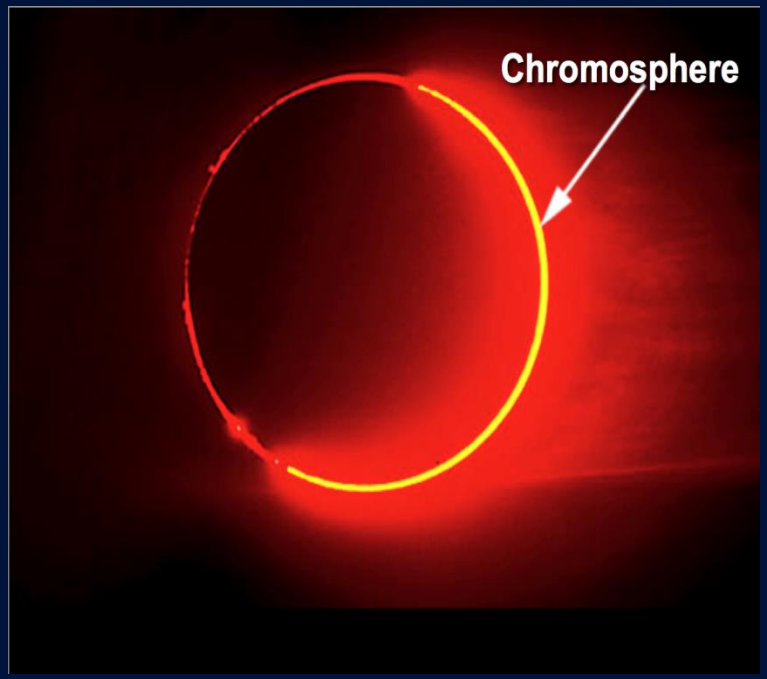
The Sun's photosphere is about 800 km (500 mi) thick.

This is the layer of visible light.



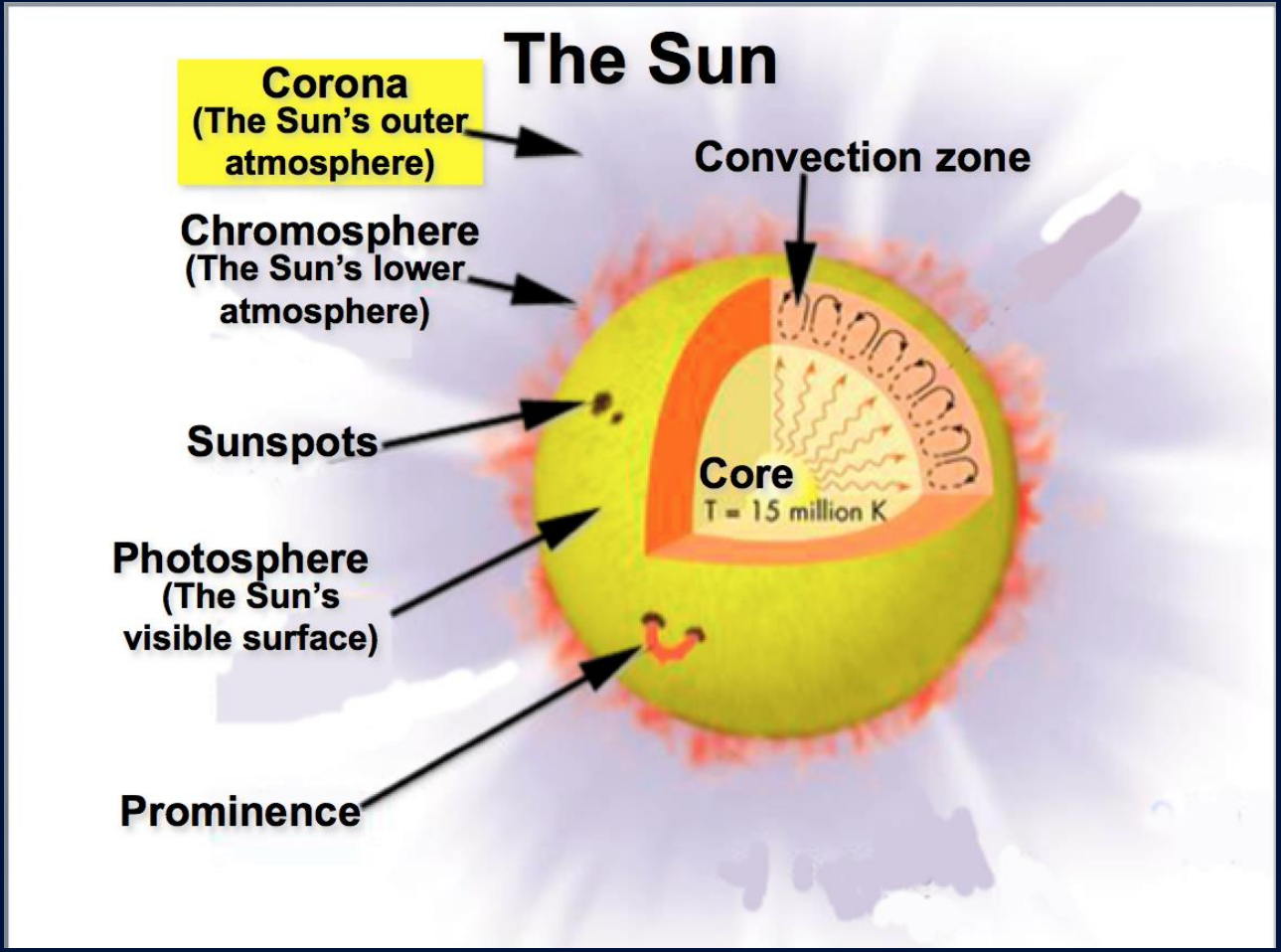
Composition of the Sun

The chromosphere is a 10,000-km (6,000 miles) thick layer in which temperatures range from 6,000 °C to 10,000 °C.



It is only visible during eclipses of the Sun, or by using a coronagraph.

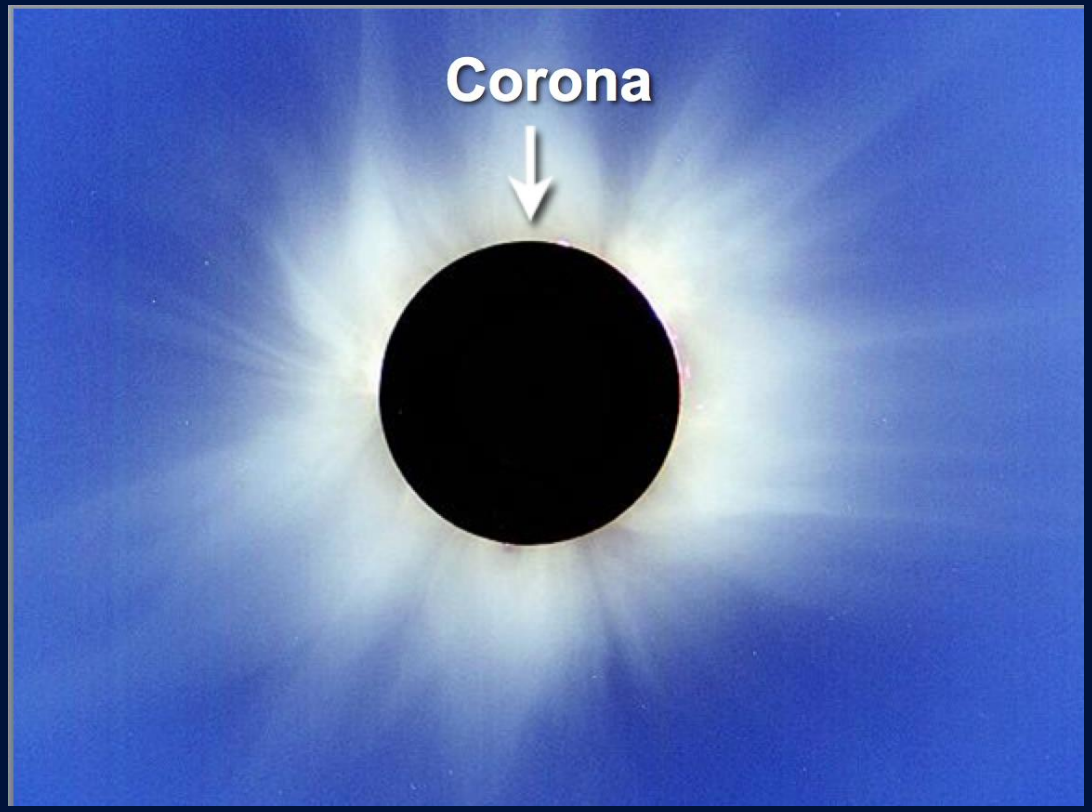
Composition of the Sun



Composition of the Sun

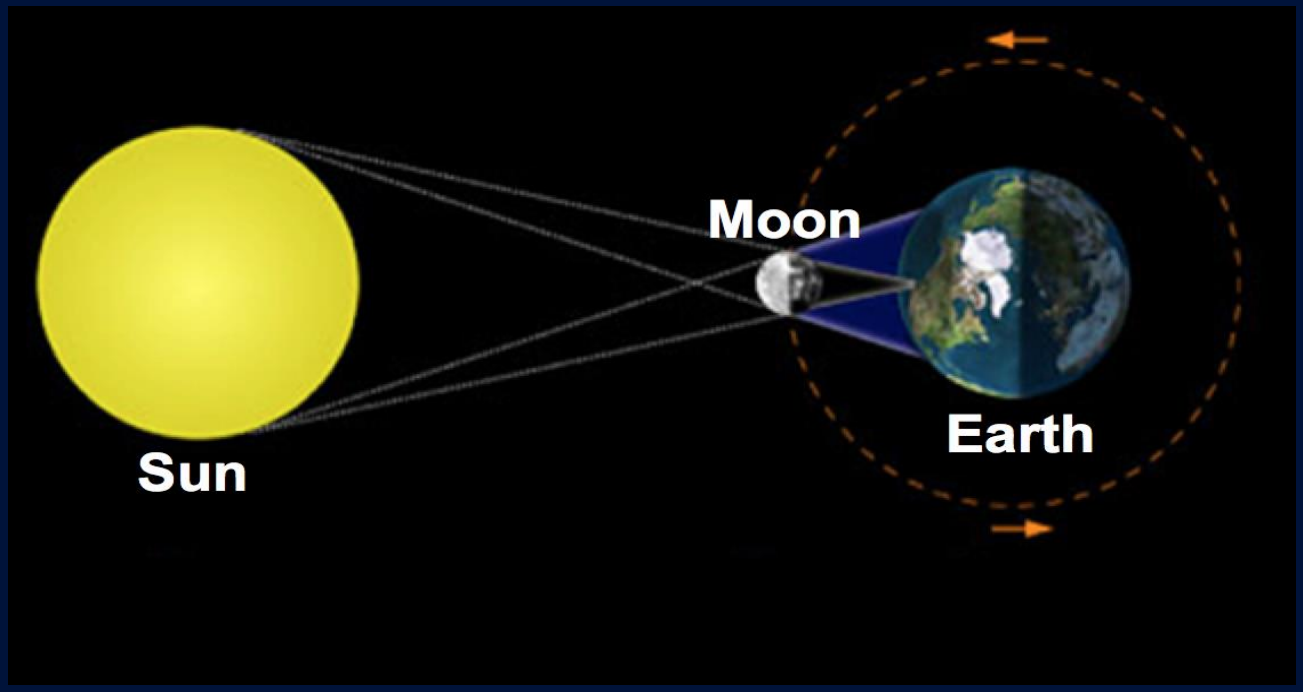
The Corona is the outermost layer, extending millions of miles into space.

Temperatures reach more than a million degrees Celsius.



Composition of the Sun

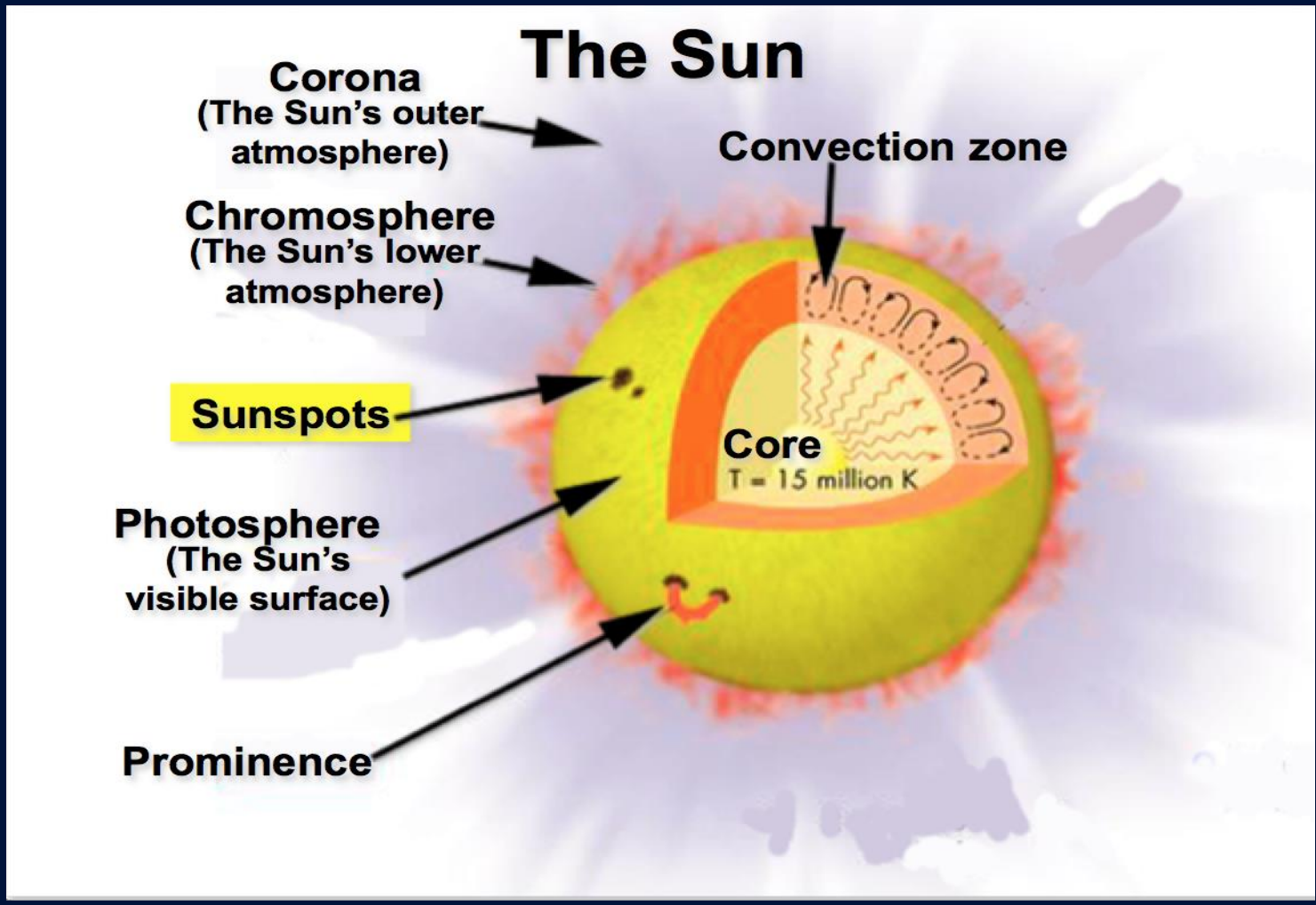
When the Moon passes between the Earth and the Sun, it can partially or totally block most sunlight from reaching Earth, a phenomenon called a solar eclipse.



Composition of the Sun

During a total eclipse of the Sun, its chromosphere– and, to a lesser extent, its corona– becomes visible to observers on Earth.

Composition of the Sun



Check On Learning Questions

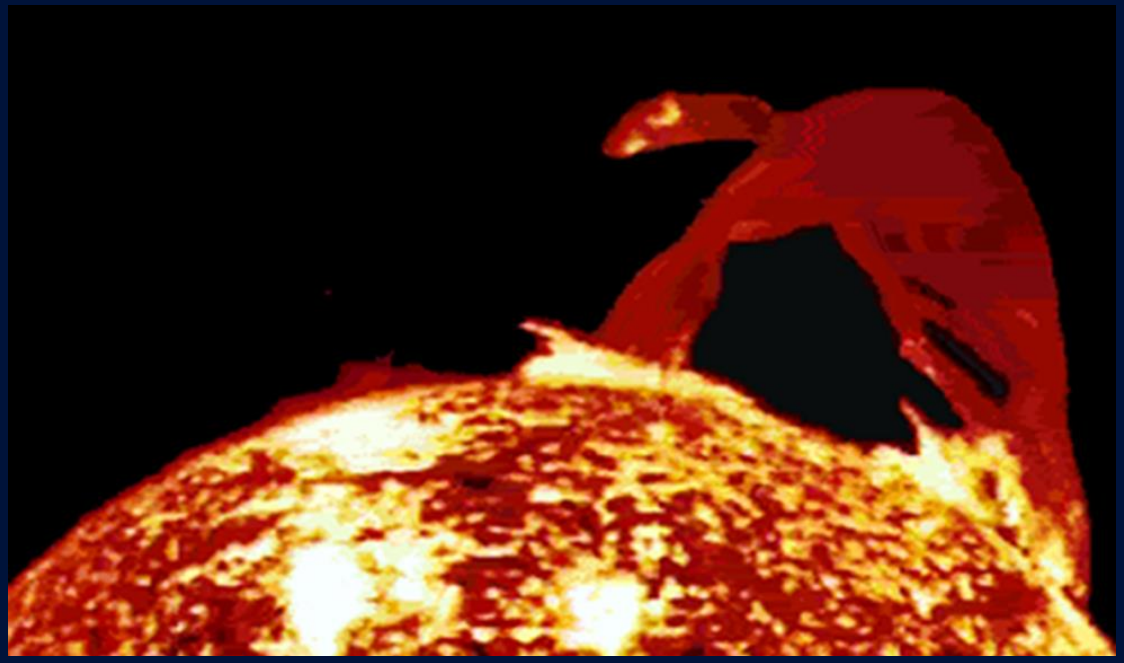
CPS Lesson

Question

5 - 6

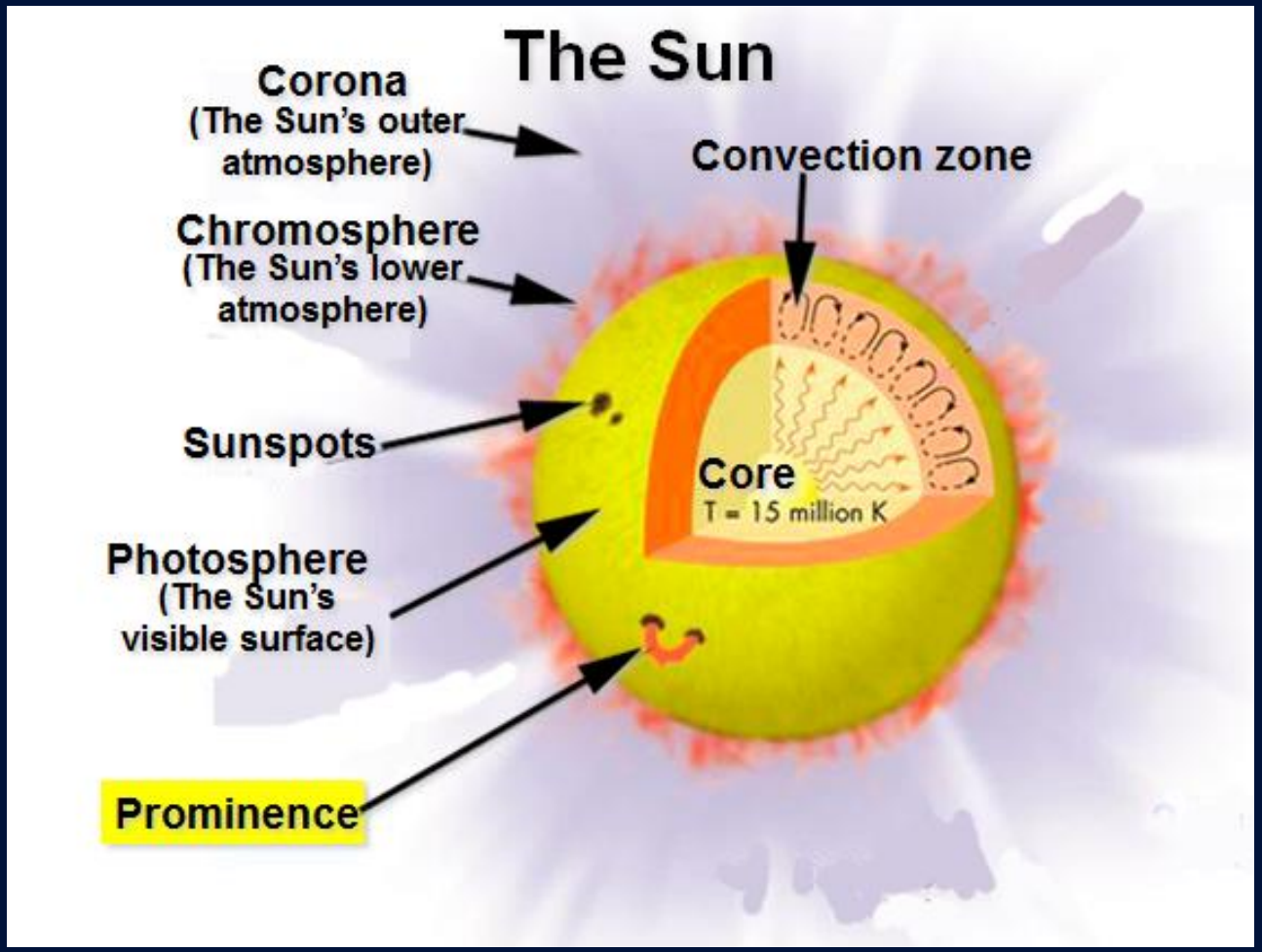
Sunspots and Solar Flares

Sunspots are fountains of hot gas rising through the chromosphere, expanding then cooling.



They may be seen projecting well beyond the chromosphere as a prominence.

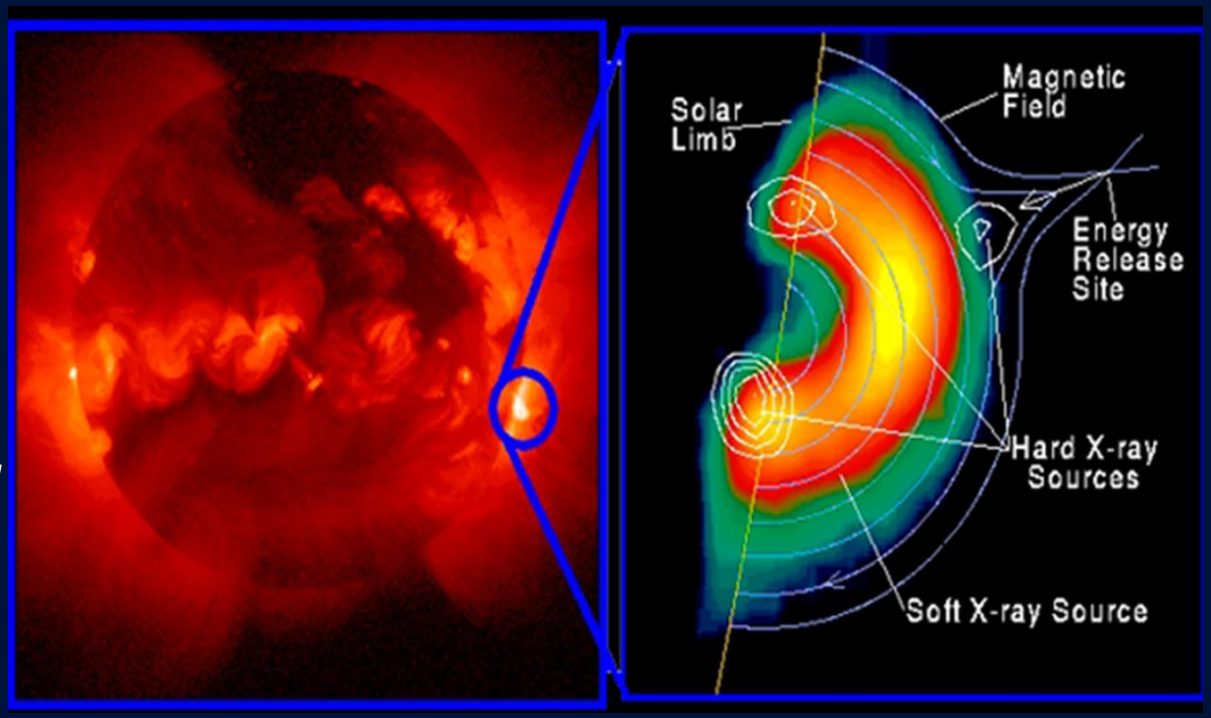
Sunspots and Solar Flares



Sunspots and Solar Flares

Flares erupting from sunspots send x-rays and atomic particles called solar winds across our solar system.

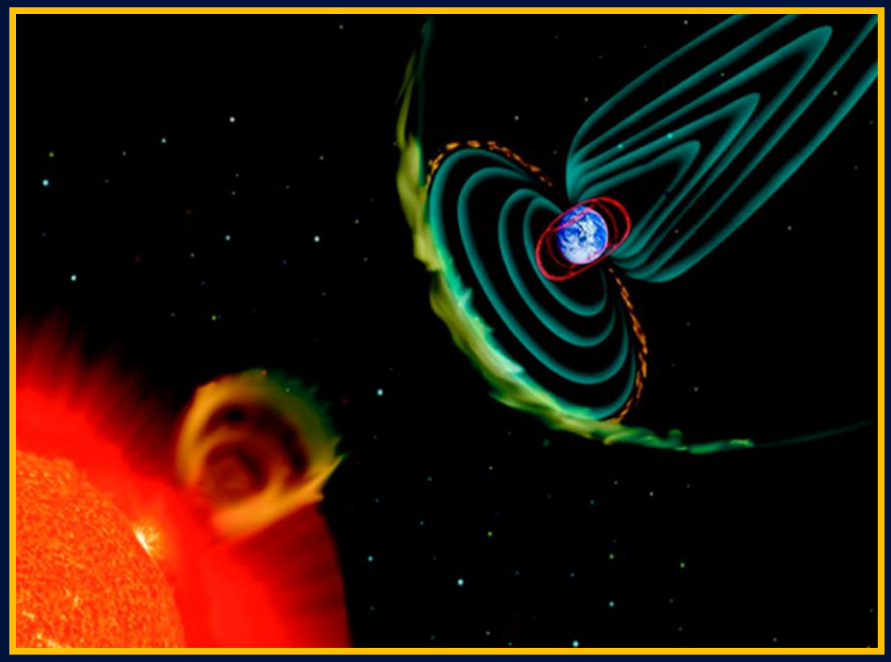
These can represent serious health hazards to humans aboard the *International Space Station(ISS)*.



Sunspots and Solar Flares

Solar winds:

- Erode the lunar surface
- Create comet tails
- Cause erratic changes in compass readings and the weather



- Affect the height of the ionosphere and degrade radio transmissions

The Polar Auroras

The interaction of the solar wind with the Earth's magnetic field in the upper atmosphere are responsible for the Aurora Borealis in the Arctic.

Similar lights occur in Australia in the southern hemisphere and are called Aurora Australis.

The Polar Auroras

The energy released by collisions between nitrogen and oxygen atoms and molecules in the thermosphere, ionizes some nitrogen atoms and causes other nitrogen atoms and oxygen atoms to be excited to a higher energy level.

Release of photons of light occurs; tinted green or brownish-red in the case of oxygen, blue or red in the case of nitrogen.

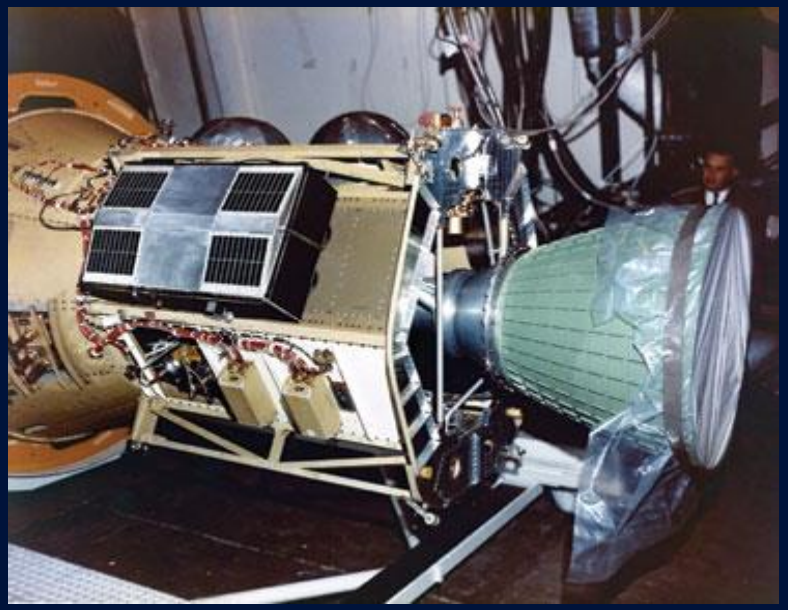
This light creates the auroras we see.

Solar Exploration

The first satellites designed to observe the Sun were *Pioneers 5 -9*.

Launched by NASA between 1959 and 1968. They…

- Orbited the Sun about the same distance as Earth
- Made the first detailed measurements of the solar wind and solar magnetic field



Solar Exploration

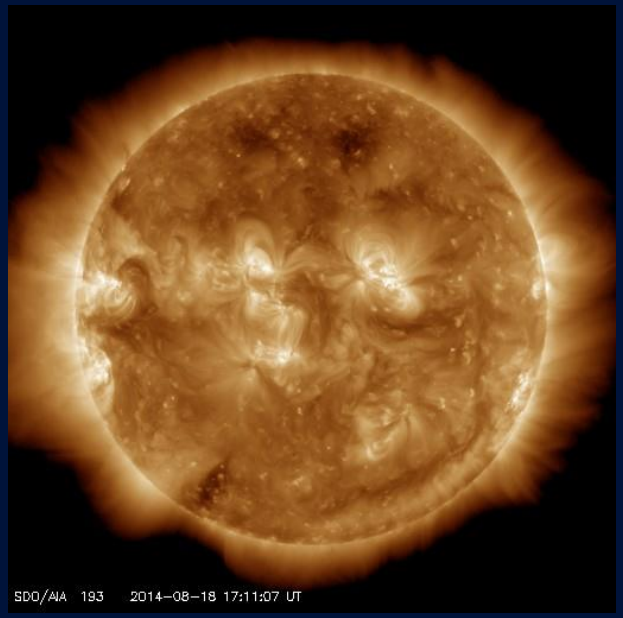
Other solar exploration projects:

- *Solar and Helio Observatory (SOHO)* – joint project of European Space Agency and NASA – December 1995
  - Extended through 2014
  - In a heliospheric solar orbit of gravitational pull similar to Earth's
  - Discovered a large number of small comets

Solar Exploration

Other solar exploration projects:

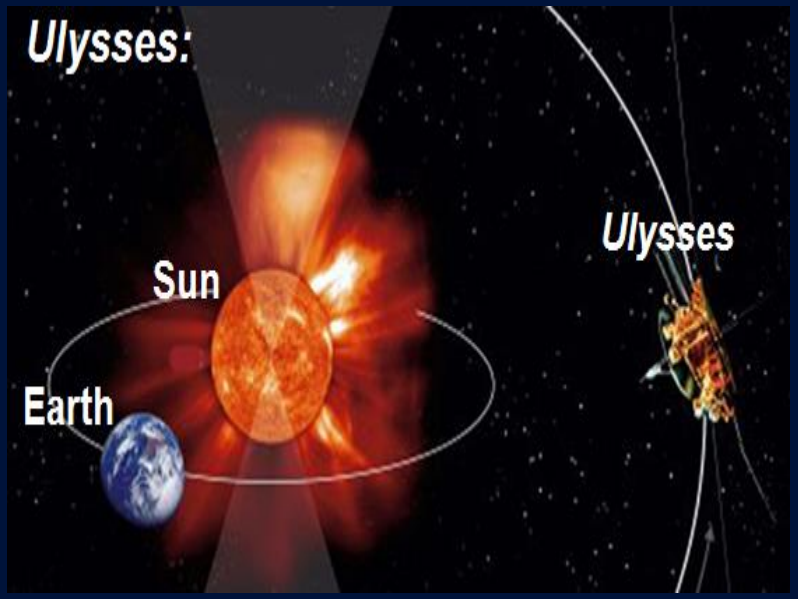
- *Solar and Dynamics Observatory (SDO)*
  - Launched February 2010 into geosynchronous Earth orbit
  - Using the Atmospheric Imaging Assembly (AIA) to study the Sun's magnetic field
  - Picture here taken recently the SDO



Solar Exploration

All previous spacecraft had been placed in equatorial orbits, only able to observe only that part of the Sun.

The *Ulysses* probe was launched by the space shuttle Discovery in 1990, to observe polar orbit around the sun.



Its position was achieved through a slingshot gravity boost from Jupiter.

Ulysses was deactivated in 2009 when it ran out of power.

Solar Exploration

A *Solar Terrestrial Relations Observatory (STEREO)* was launched in 2006, including two identical spacecraft launched to the same orbit as Earth around the Sun (one ahead and one behind).

This provides stereoscopic imaging of the Sun and various solar phenomena such as comets and coronal –mass ejections.

Solar Exploration

A *Solar Terrestrial Relations Observatory (STEREO)* was launched in 2006, including two identical spacecraft launched to the same orbit as Earth around the Sun (one ahead and one behind).

This provides stereoscopic imaging of the Sun and various solar phenomena such as comets and coronal –mass ejections.

Solar Exploration

An *Interface Region Imaging Spectrograph(IRIS)* space telescope was launched in 2006 to investigate:

- Nature of the interface between the chromosphere and the transition region in the Sun's atmosphere
- Mysteries about the Sun's temperature with relation to the photosphere

Final Stages of Life

Scientists have deduced from observations of the life cycles of other stars that our Sun is about halfway through its life as an average main sequence star.

In about five or six billion years, it will become a red giant, increasing in size, luminosity and temperature.

Earth will be become hotter than Venus is now, and the habitable zone around the Sun will extend past Mars.

Final Stages of Life

Since it is unable to end its life in a supernova explosion, the Sun will spend another billion years as a red giant.

After another 120 million years or so, it will continue to expand and contract until it's only half its current mass with its core exposed.

Finally it will contract, cool and become a dense Earth-sized white dwarf before eventually fading to black.

Review Question

Why is an understanding of the nature and charac-teristics of the Sun so important to astronomers and meteorologists?

1.

2.

3.

(Use CPS "Pick a Student" for this question.)

Closing Questions

CPS Lesson
Questions 7 - 8

Questions?