https://stellarium-web.org/en/

Andres, Boston University

Constellations and Asterisms, modern definition

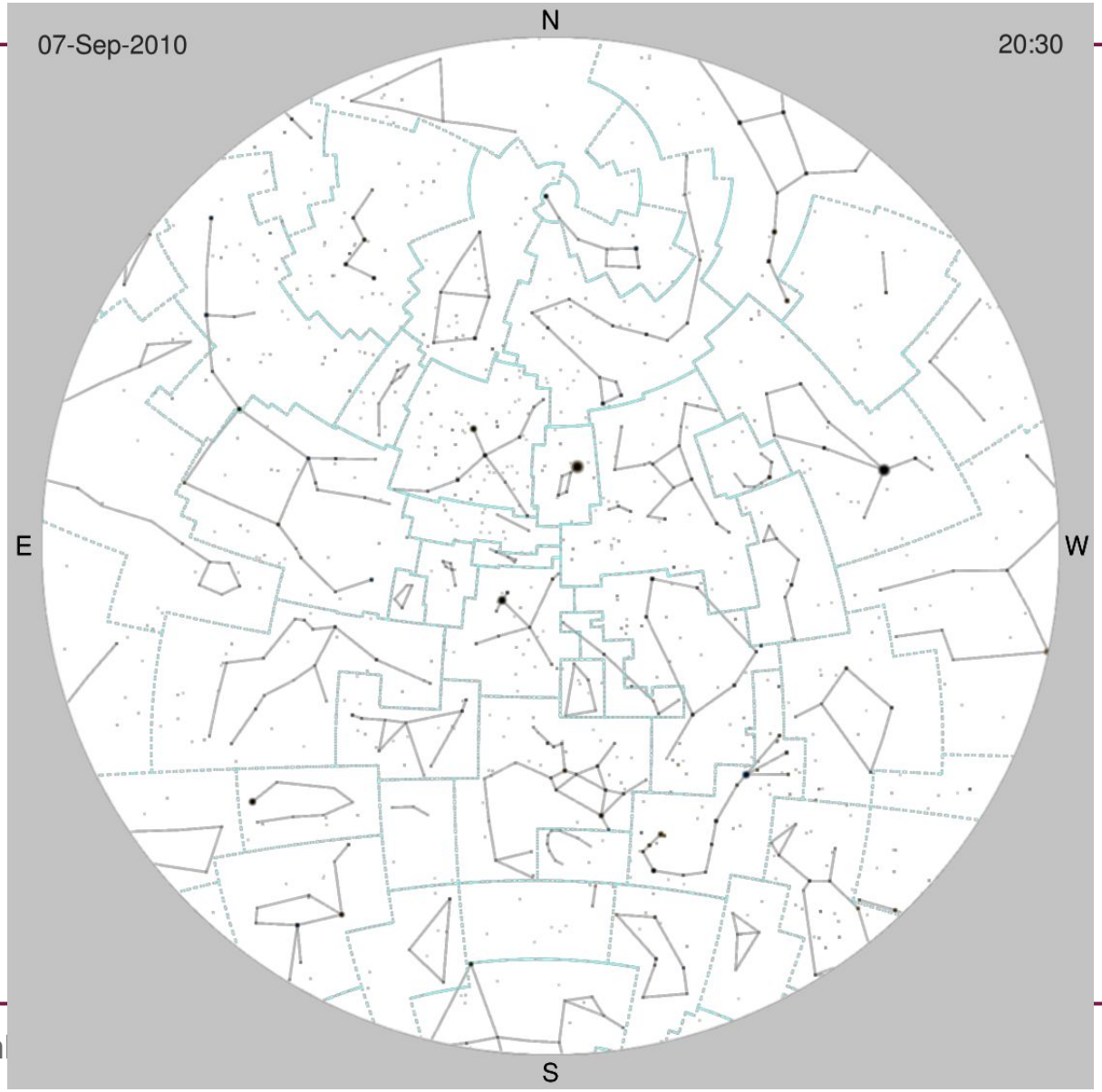
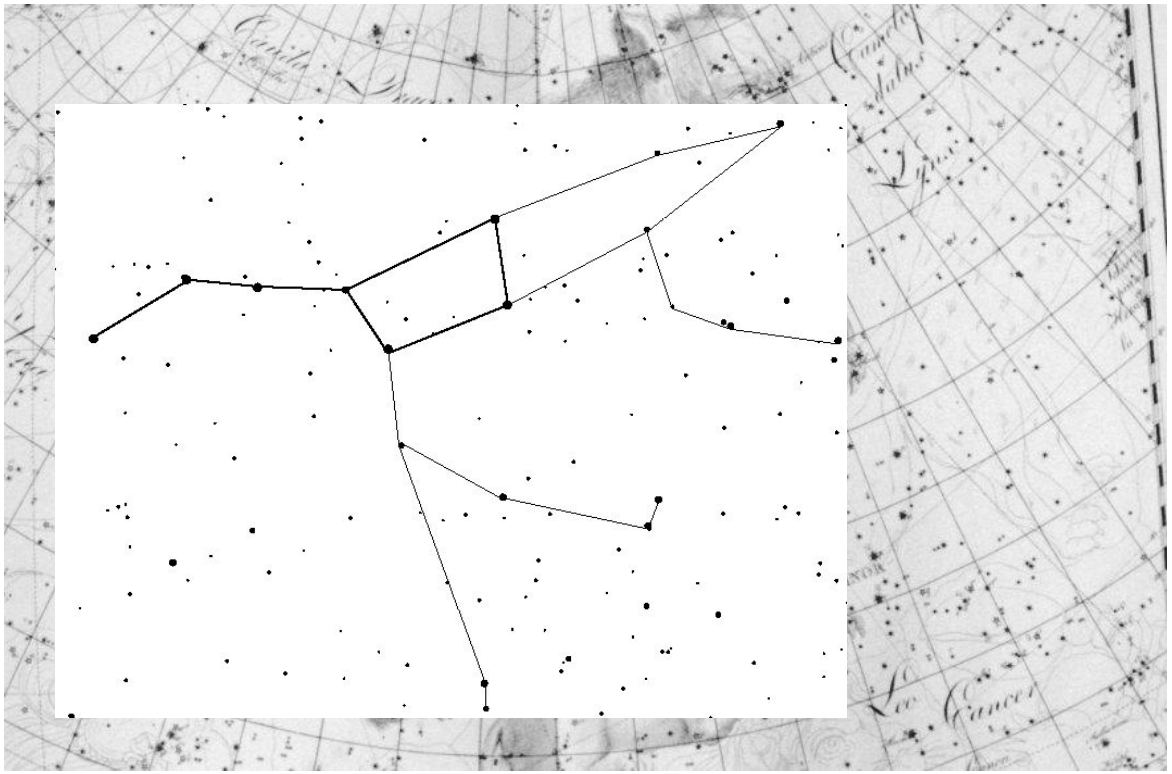


Image Credit Lin

Constellations and Asterisms

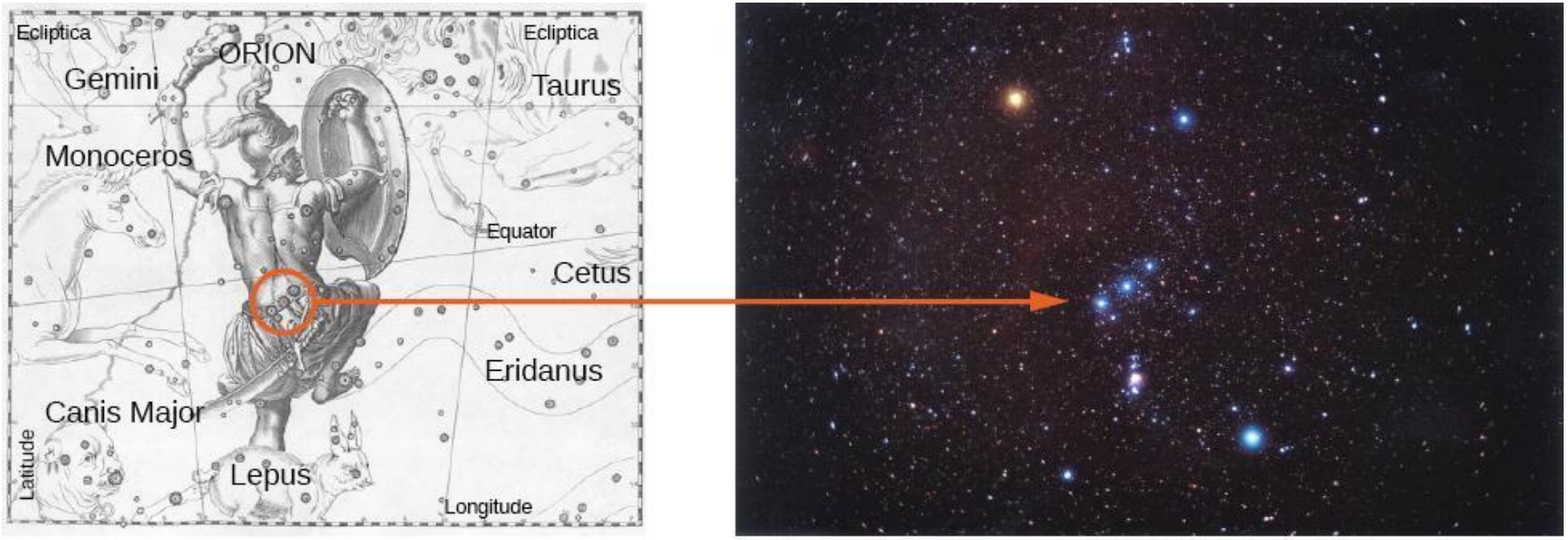


This simplified star chart might help.

An **asterism** is a *subset* of stars that form a widely recognized shape. The ***Big Dipper*** is a great example.

Image Credit Link: http://www.physics.csbsju.edu/astro/constellations/ursa_major_nl.html

Constellations and Asterisms



(a) (b)

Orion's Belt is an **asterism** within the **constellation** of *Orion*.

Chapter 4: Earth, Moon, and Sky

Thinking Ahead
4.1 Earth and Sky
4.2 The Seasons
4.3 Keeping Time
4.4 The Calendar
4.5 Phases and Motions of the Moon
4.6 Ocean Tides and the Moon
4.7 Eclipses of the Sun and Moon
Key Terms
Summary
For Further Exploration

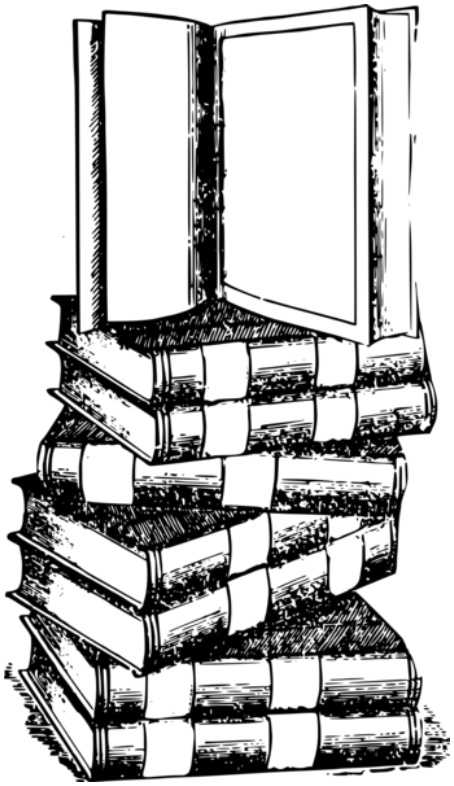
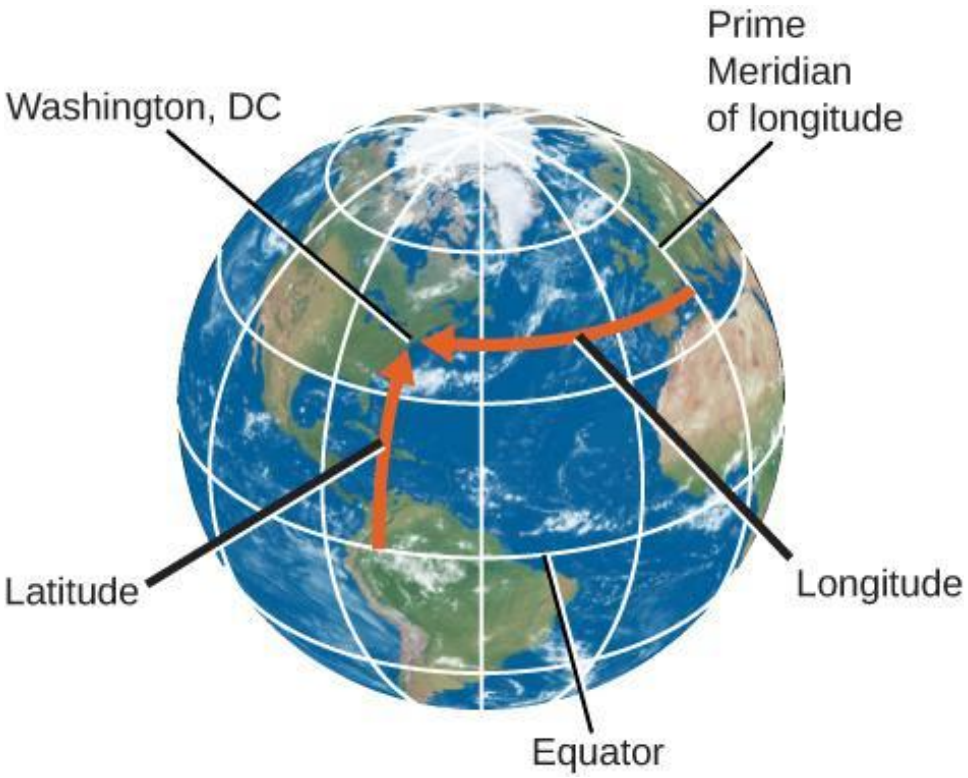


Image: "school" is licensed under CC0 1.0

Coordinates on Earth

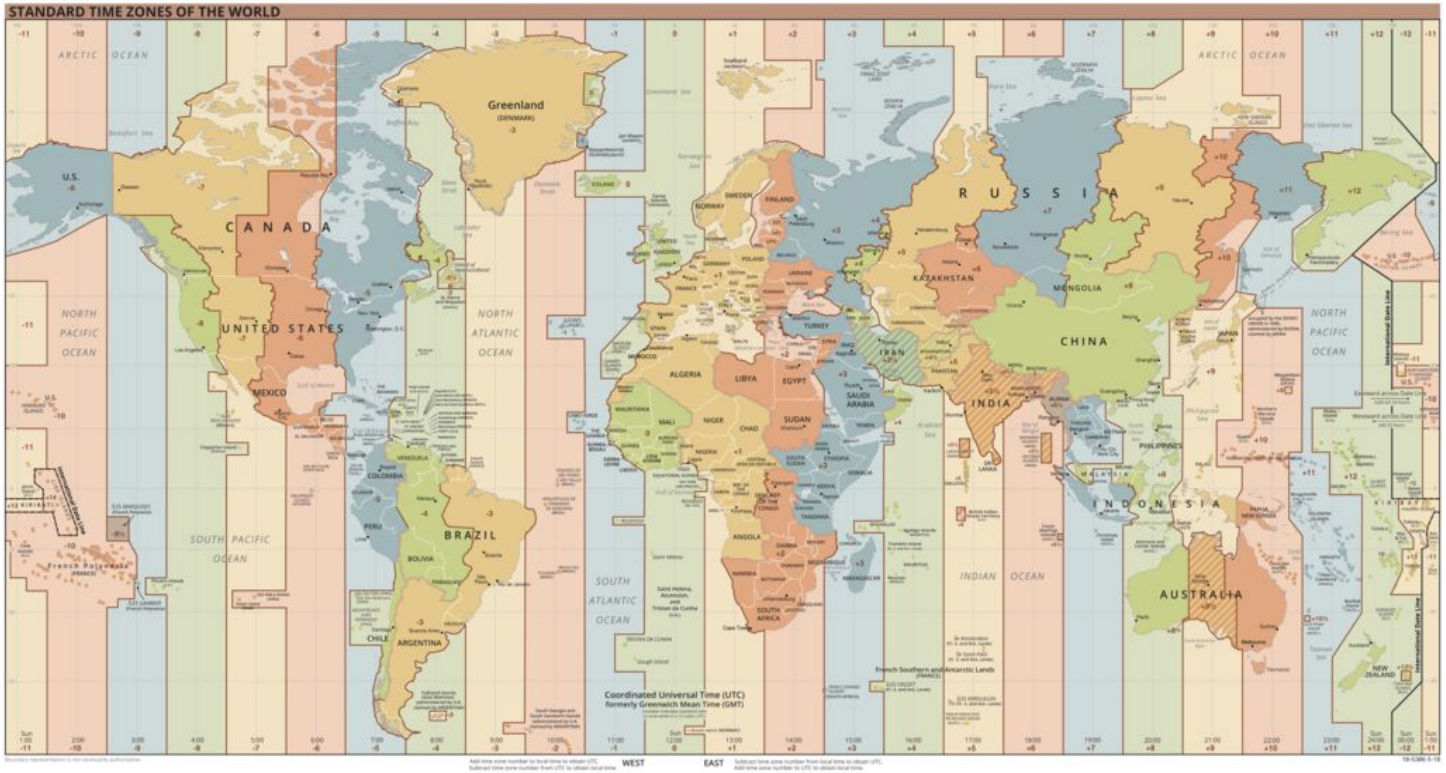


On Earth, we can give a precise location by using **latitude** and **longitude**.

Latitude has a physically meaningful **zero point**: the Earth's **equator**.

Latitude is measured in **degrees**.

Coordinates on Earth



Time zones across the Earth are a bit like lines of longitude.

They are based on average sunrise and sunset times.

Image Link, Credit: TimeZonesBoy - US Central Intelligence Agency, Public Domain

Coordinates on the Sky

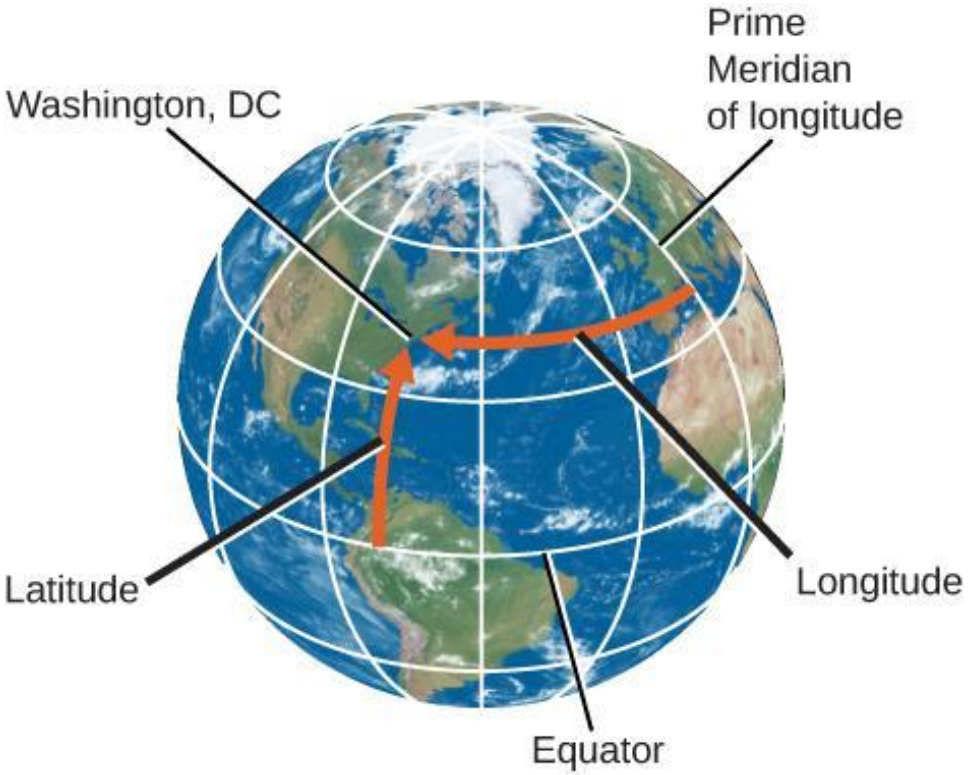
"Up-Down" Direction:

- Earth's **Latitude**: in degrees, relative to Earth's *Equator*
- Sky's **Declination** (Dec): in **degrees**, relative to the *Celestial Equator*.

"Left-Right" Direction:

- Earth's **Longitude**: in degrees (and time zones), relative to an arbitrary starting point called the *Prime Meridian*.
- Sky's **Right Ascension** (R.A.): in **hours**, relative to an arbitrary starting point called the *Vernal Equinox*.

Coordinates on the Sky



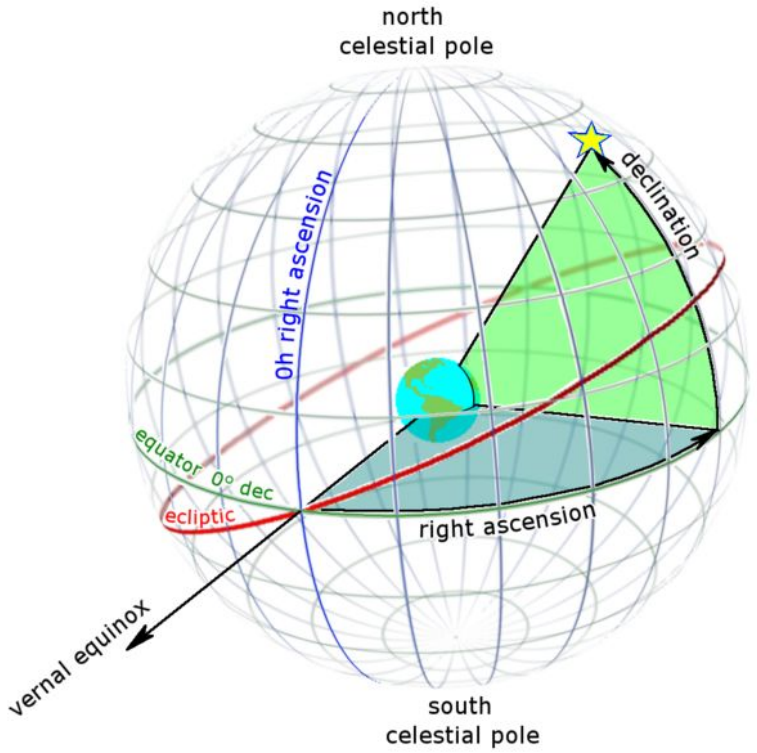
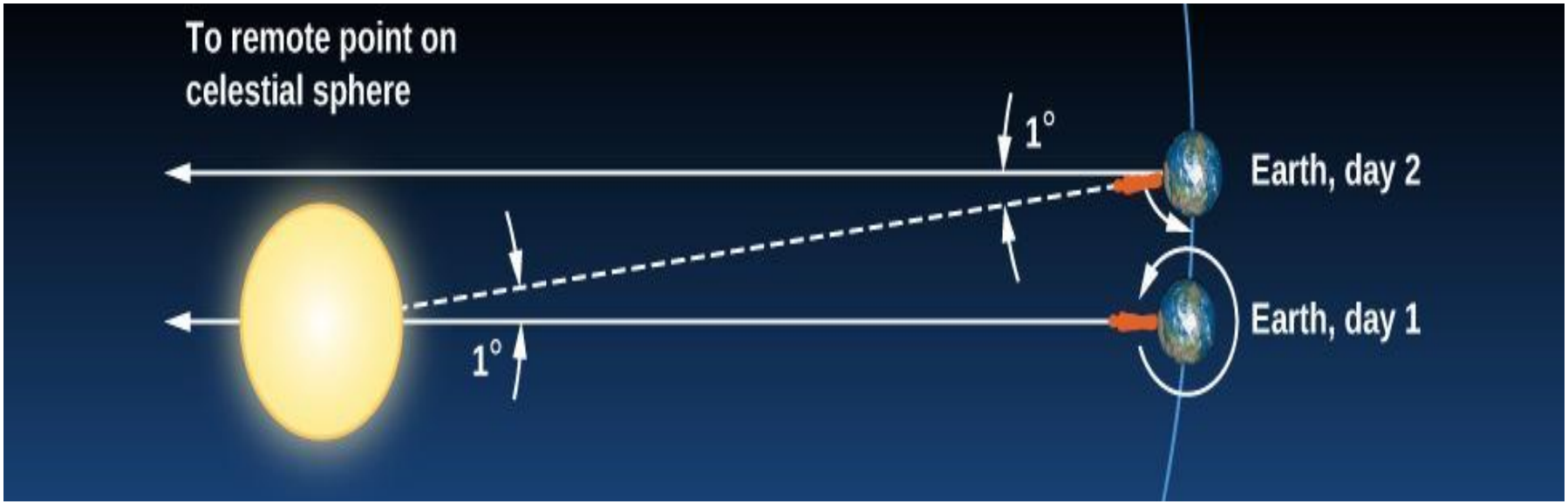


Image Link, Credit: Tfr000 (talk) 15:34, 15 June 2012 (UTC) - Own work, CC BY-SA 3.0

Keeping Time: Solar vs Sidereal Day

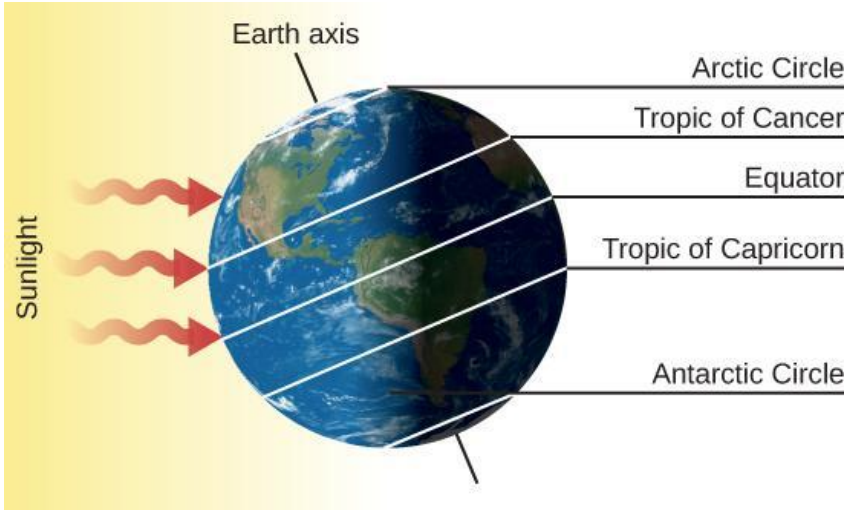
The Sun and stars both appear to move nearly the same way over the course of a day, but there is a 4-minute difference.

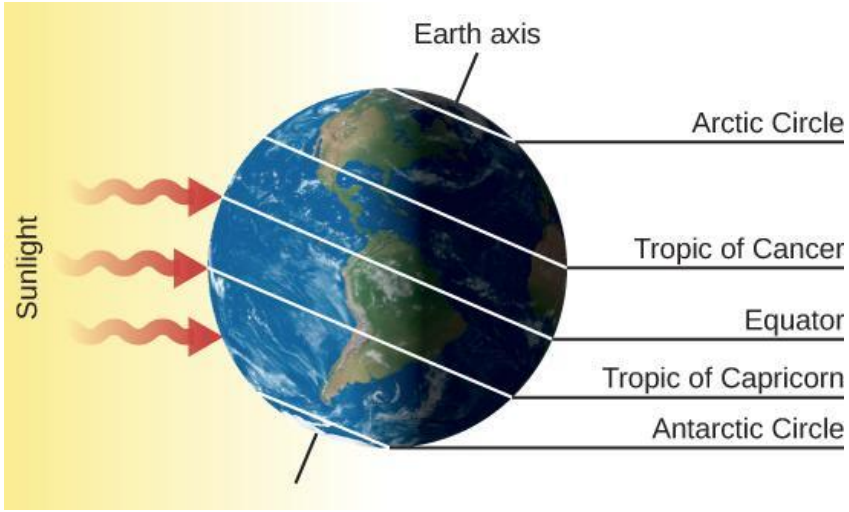
Solar day: one rotation, facing the Sun to facing the Sun. 24 hr
Sidereal day: one rotation with respect to distant stars. 23 hr 56 min



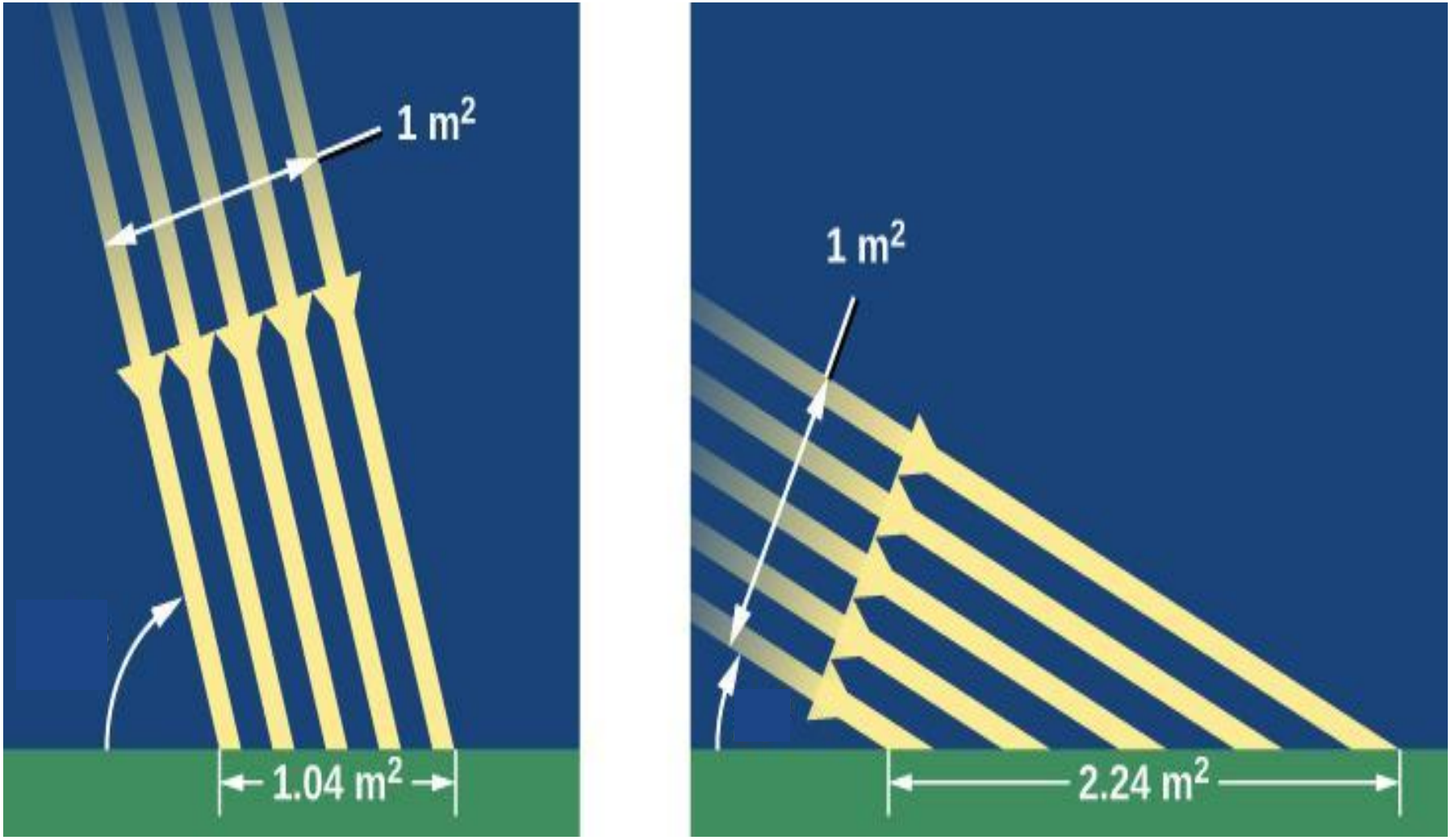
Seasons: Direct and Indirect Sunlight

The first main reason is based on how direct or indirect the sunlight is. One image shows the **summer solstice**, the other shows the **winter solstice**. See also next slide.





Seasons: Direct and Indirect Sunlight



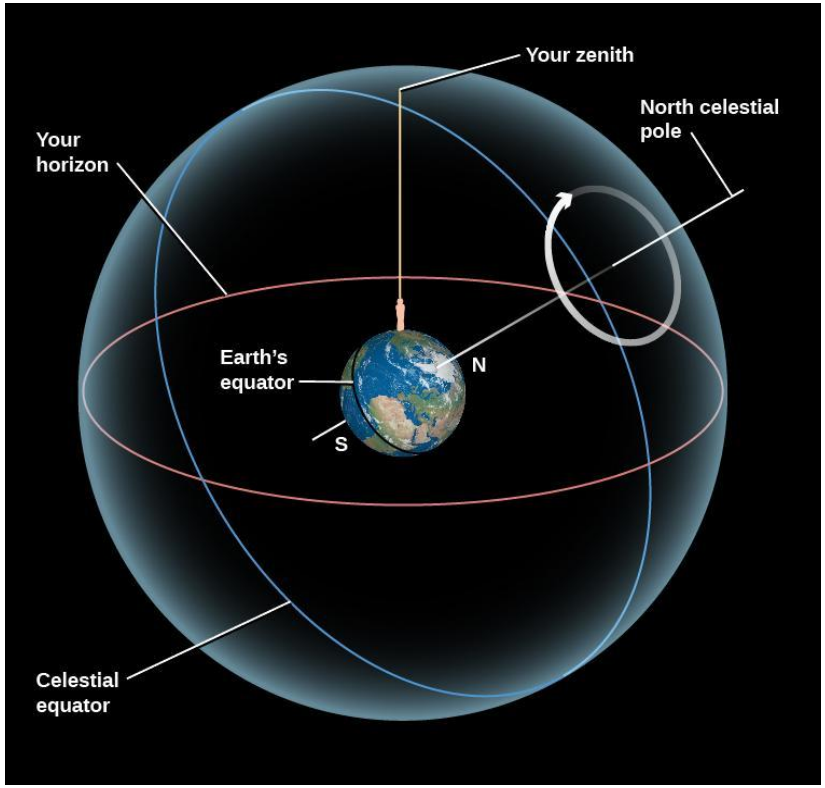
Seasons: Length of the Day

The second main reason for seasonal variation is that we have different numbers of hours of daylight throughout year. This is because the location of sunrise and sunset changes during the year; it is not always perfectly East and West.

If you struggle to visualize the changes of the Sun's path throughout the year after this topic, I recommend this site: ccnmtl.github.io/astro-simulations/sun-motion-simulator/

The Celestial Sphere

To help us understand how stars move through our skies, we make a simplified scientific model of the sky. We'll call this the **Celestial Sphere**. This assumes all stars, no matter how far they are, are projected onto a sphere around the Earth.



The Celestial Sphere: Star Motions

This is an example of star trails, taken in Hawaii. Look at how the stars appear to make big circles.

What object is at the "center" of those circle motions?

Image Credit Link: http://apod.nasa.gov/apod/ap051220.html

The Celestial Sphere: Star Motions

Pause-and-Think MC Question:

You see a star rising due East. When this star reaches its highest position above the horizon, where will it be?

1) high in the Northern sky
2) high in the Eastern sky
3) high in the Southern sky
4) high in the Western sky
5) directly overhead

The Celestial Sphere: Star Motions

Pause-and-Think MC Question:

Imagine you are camping in a field outside Grand Rapids. Looking directly north, you see a star just barely above the horizon. About fifteen minutes later, you notice that it has shifted position slightly. Which way did it move?

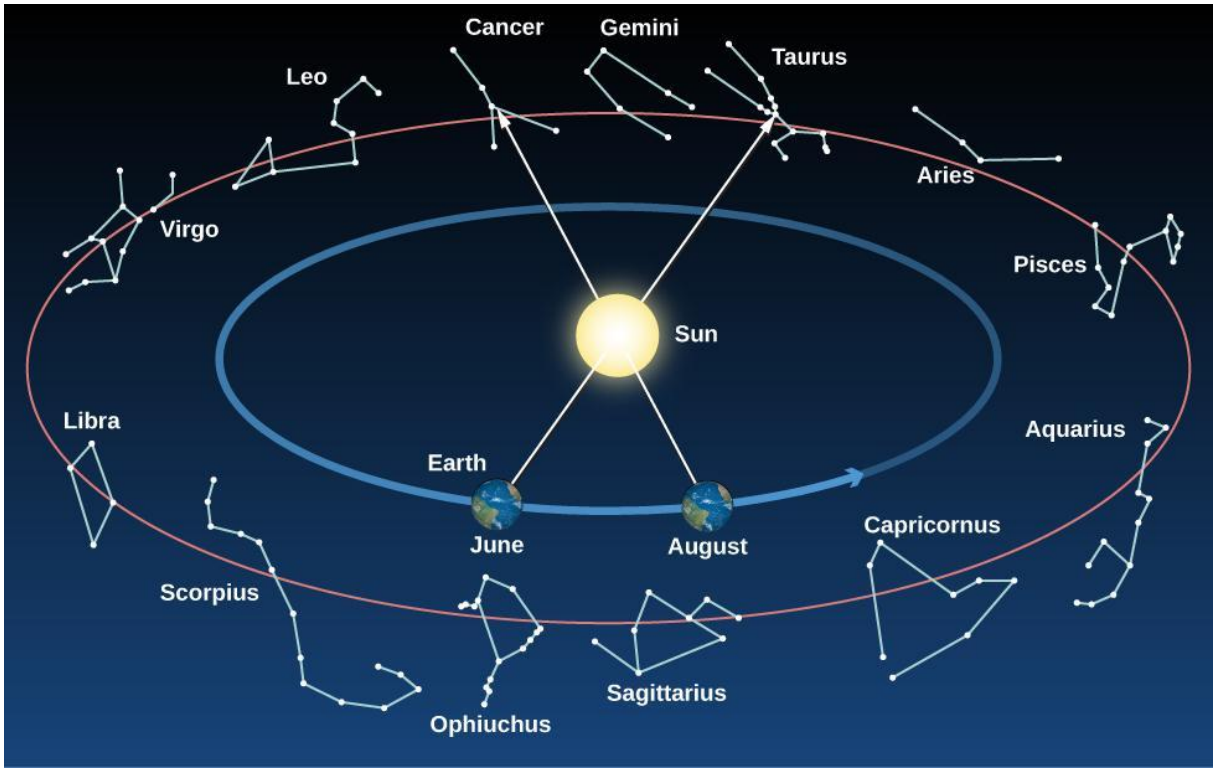
1) to the right, (east)
2) to the left, (west)
3) up, (rising)
4) down, (setting)

The Ecliptic

Do you know your astrological sign? (a.k.a. sign of the zodiac)

Astrology is a ***pseudoscience*** (see Section 2.3) but it has roots in astronomical observation.

The Ecliptic



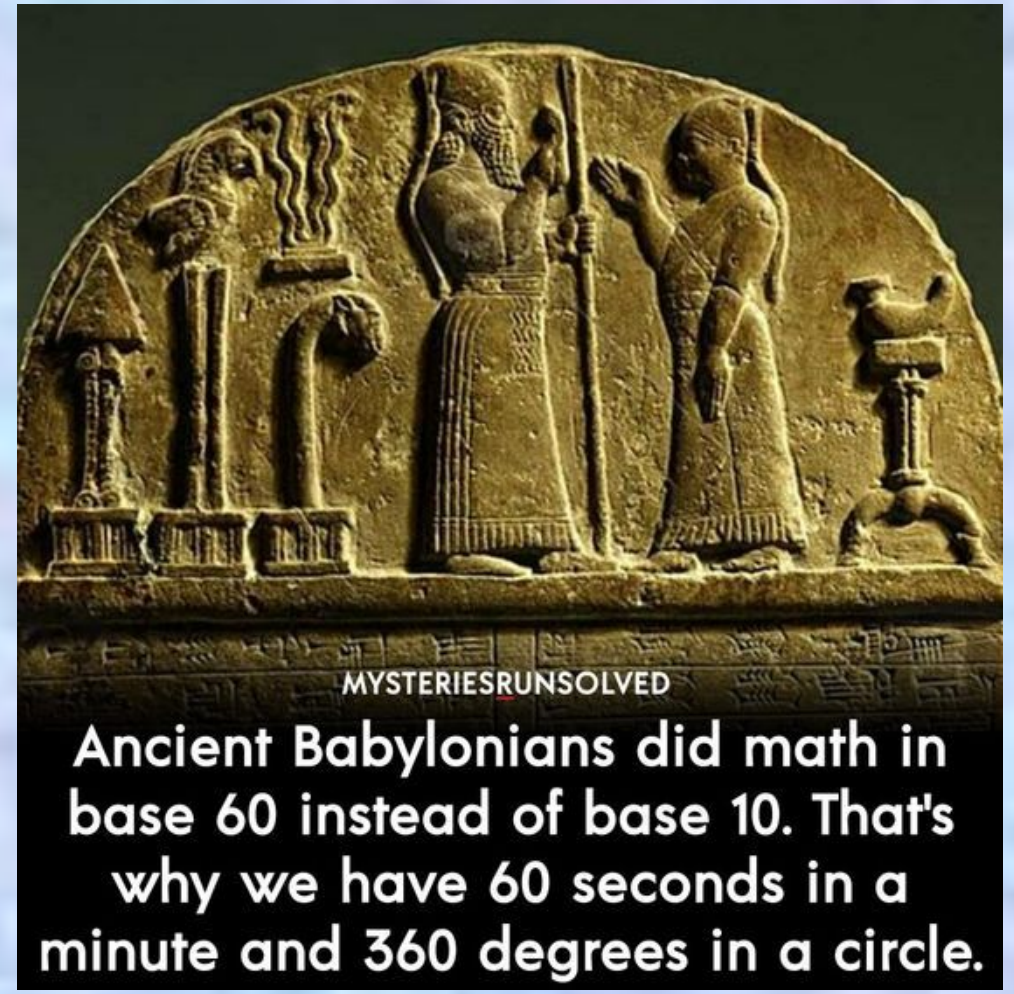
The astrological signs represent the constellations that the Sun “appears” in throughout the year.

But that also means that our night time constellations change during year.

Ancient Calendars

- Every culture on Earth had some form of early calendar in its history

- Most of these calendars used a 360 day year, plus five extra days tacked on to the end
  - South and Central American cultures used 18 months of 20 days each, with the five extra days considered very unlucky and dangerous
  - Egyptians used a calendar with 12 months of 30 days, and the five extra days were used for celebration



Ancient Calendars

- Many of these calendars relied on direct observation of the Moon to signal a new month
  - Whenever an official observer would see a full moon, the start of the next month would be announced

Numbers and the Calendar

- Sexagesimal numbering system - Base 60
  - Used for time and angle measurements
- Babylonian Calendar
  - Lunisolar calendar
  - Day begins at sunset
  - 12 months - new month begins when crescent moon first visible after sunset
  - 12 lunar months = 354 days - extra month added every few years
  - Year began in spring - 3 seasons of 4 months
  - Early calendar - observational - around 500 BC, 19 year cycle = 235 months

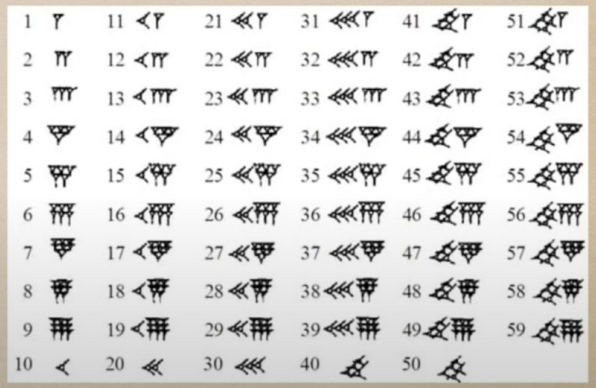


Image Credit: Sugarfish, Public Domain, via Wikimedia Commons

Where Did Our Calendar Originate? The Julian Calendar

- Like many things in our culture, our calendar originates from the Roman Empire
  - Julius Caesar introduced the 'Julian' calendar ***in 45 BC***, and its design was heavily influenced by Cleopatra
    - Remember, the Egyptian calendar had 12 months of 30 days each

JULIAN CALENDAR

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	DAY
JAN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	JAN
FEB	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59				FEB
MAR	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	MAR
APR	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120		APR
MAY	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	MAY
JUN	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181		JUN
JUL	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	JUL
AUG	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	AUG
SEP	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273		SEP
OCT	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	OCT
NOV	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334		NOV
DEC	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	DEC

  - The Julian calendar was very similar to our modern calendar, except for leap years
    - The Julian calendar assumes the year is exactly 365.25 days and inserts a leap day every 4 years
      - Remember, the mean year is actually more like 365.2422 days
    - This is a very small difference, but will lead to an extra day of time every 128 years

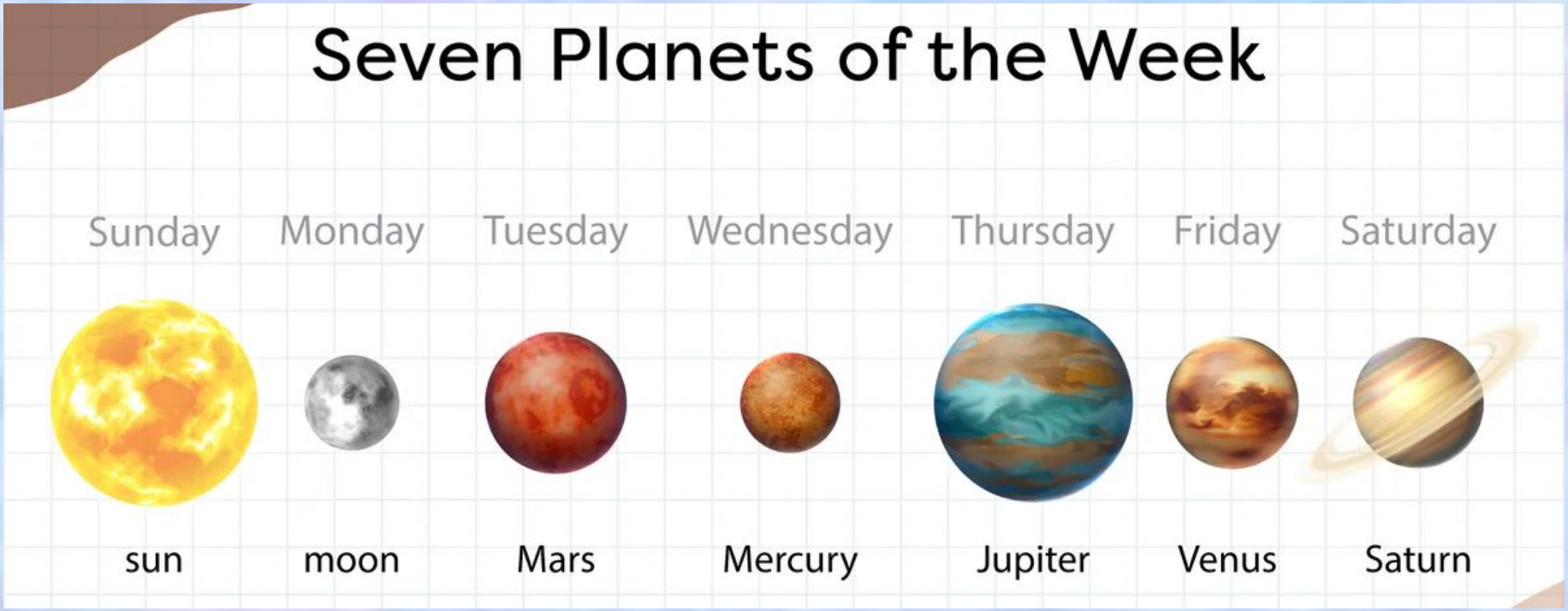
Revisions to the Calendar

- It took quite some time for people to realize that the calendar was drifting
- In 1582, Pope Gregory finally took action, and adjusted the calendar accordingly
  - By this time, the calendar had drifted by about 10 whole days
    - In order to correct this, Pope Gregory eliminated October 5 - 14, 1582 from the calendar
  - He also revised the rules for leaps years to ensure this wouldn't happen again
    - The new leap year rules (and still in used today) are:
      - Years divisible by 4 are leap years
      - Years that are divisible by 100 years are NOT leap years
      - Years that are divisible by 400 years are leaps
- The calendar was not accepted by the British and American colonies until 1752!
  - The Catholics and the Protestants didn't play well together
- This calendar, known as the Gregorian calendar, is the one we still use today
  - Note: Even with the confusing leap year rules, the Gregorian average year is 365.2425, different from the mean tropical year of 365.2422
  - Over a long period of time, our current calendar will drift also!

Months are Named After These:

- **January**: Named after the Roman god Janus.
- **February**: Named after the Roman festival of purification, Februa.
- **March**: Named after Mars, the Roman god of war.
- **April**: From the Latin word aperire, meaning "to open".
- **May**: Named after Maia, a Roman goddess associated with growth.
- **June**: Named after Juno, the Roman goddess of marriage & childbirth
- **July**: Named after Julius Caesar.
- **August**: Named after Augustus Caesar.
- **September**: Comes from the Latin word septem, meaning "seven".
- **October**: Comes from the Latin word octo, meaning "eight".
- **November**: Comes from the Latin word novem, meaning "nine".
- **December**: Comes from the Latin word decem, meaning "ten".

Days of the Week:



Pause-and-Think Open Question:

Of the following lengths of time in the list below, which are based primarily on astronomical cycles and motions?

- **Day**
- **Week**
- **Month**
- **Year**
- **Century**

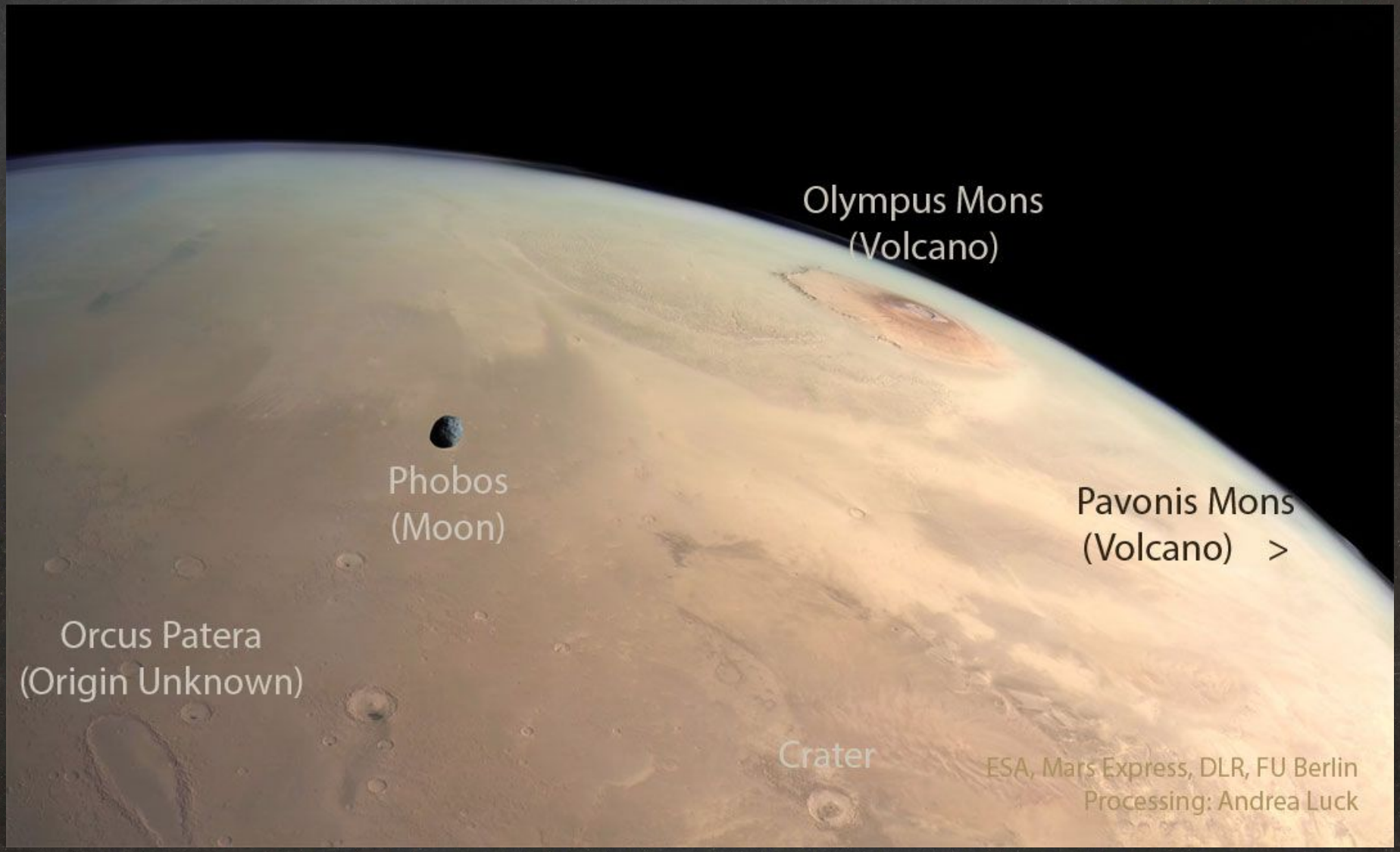
The Calendar

One day: based the rotation of the **Earth** (i.e. the solar day, not the sidereal day) Astronomical value: 1.0000 days

One month: based on the orbit of the **Moon** around the Earth. Astronomical value: 29.5306 days

One year: based on the orbit of the Earth around the **Sun**. Astronomical value: 365.2422 days

Our calendar is right to ~1 day in 3300 years with leap years.


Olympus Mons
(Volcano)
Phobos
(Moon)
Pavonis Mons
(Volcano) >
Orcus Patera
(Origin Unknown)
Crater
ESA, Mars Express, DLR, FU Berlin
Processing: Andrea Luck

In-Class Small Group Assignment

1. Form groups of 3-4 students
2. Create a shared "Google Doc" and share it with your professors too (LAndres@BU.edu and Henebry@BU.edu)
3. Include the names of all students on your small team in the body of the document.
4. Create a Mars Calendar. Be creative!!
   a. A day on Mars (called a "sol") is 24 hours and 40 minutes
   b. Mars goes around the sun in 668.6 days
   c. The moons (Phobos and Deimos) take eight hours and 30 hours to travel around Mars. Our moon takes 27.3 days to Travel around the Earth.

Create Your Own Martian Calendar

- This is a situation we could run into if we ever colonize another world (Mars, for example)

- From the previous slides and your knowledge of our own calendar, you should realize there are multiple possible solutions to each situation, you choose which is best

Attempt to Satisfy These Criteria

It would be convenient if the calendar met some criteria to match human comforts as well as possible. Your calendar will probably not satisfy all these conditions (neither does our own!).

1. **Each day of the year has a place in your calendar. There are no extra or bonus days tacked onto the end of the year (like in the Egyptian example)**
2. **The week has 7 days (like we are used to here on Earth)**
3. **The months match your lunar cycle (this doesn't happen with our calendar)**
4. **A whole number of weeks per month**
5. **A whole number of weeks per year**
6. **Number of months divides evenly into quarters (to mark the seasons)**