

Where is everyone?

Mario Ivanov

Astrophysics Honors BSc 2018



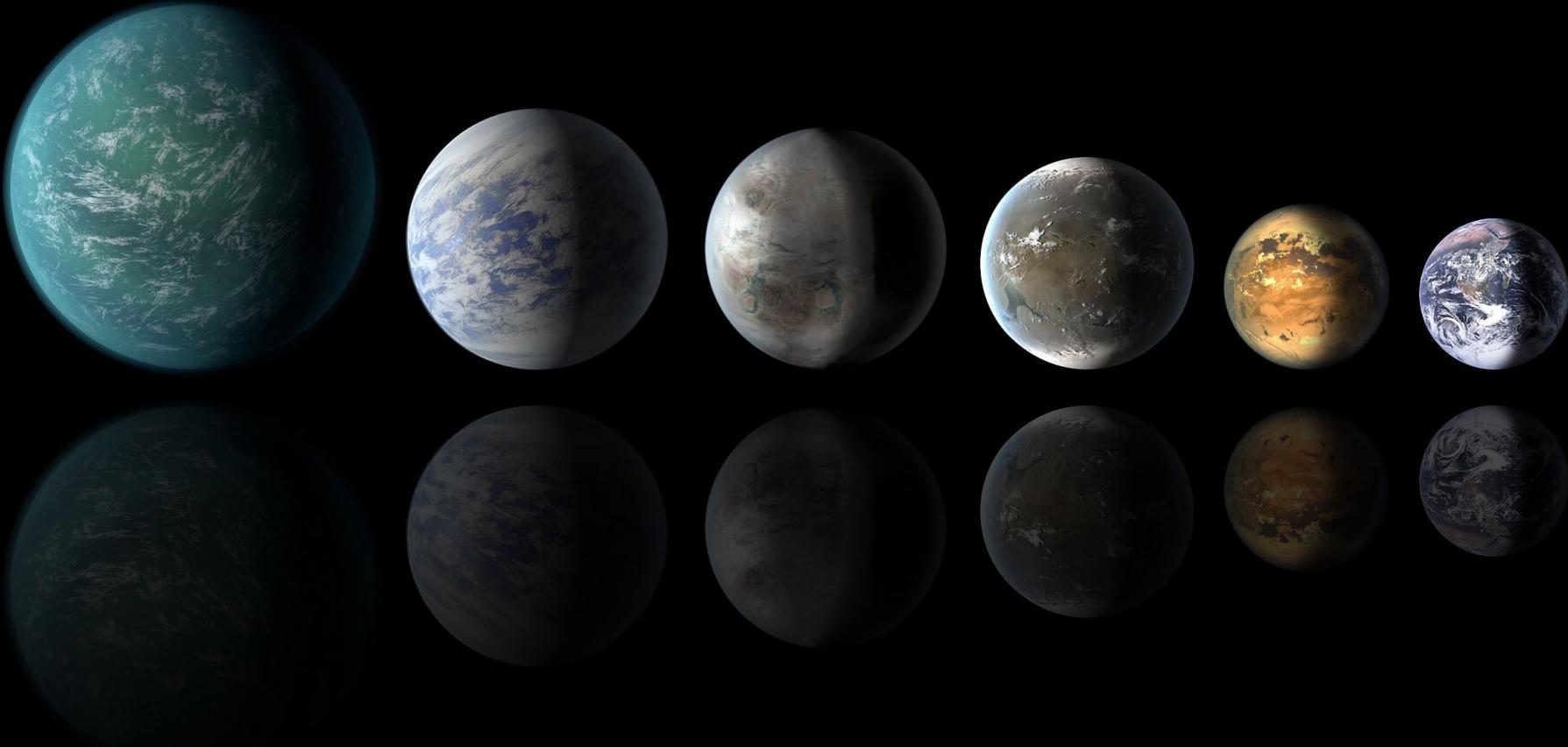
The Observable Universe

100,000,000,000 galaxies

100,000,000,000 to

93,000,000,000 light-years

1,000,000,000,000 stars





The Fermi Paradox



Andromeda's Distance From Us (to Scale)

100,000
light years



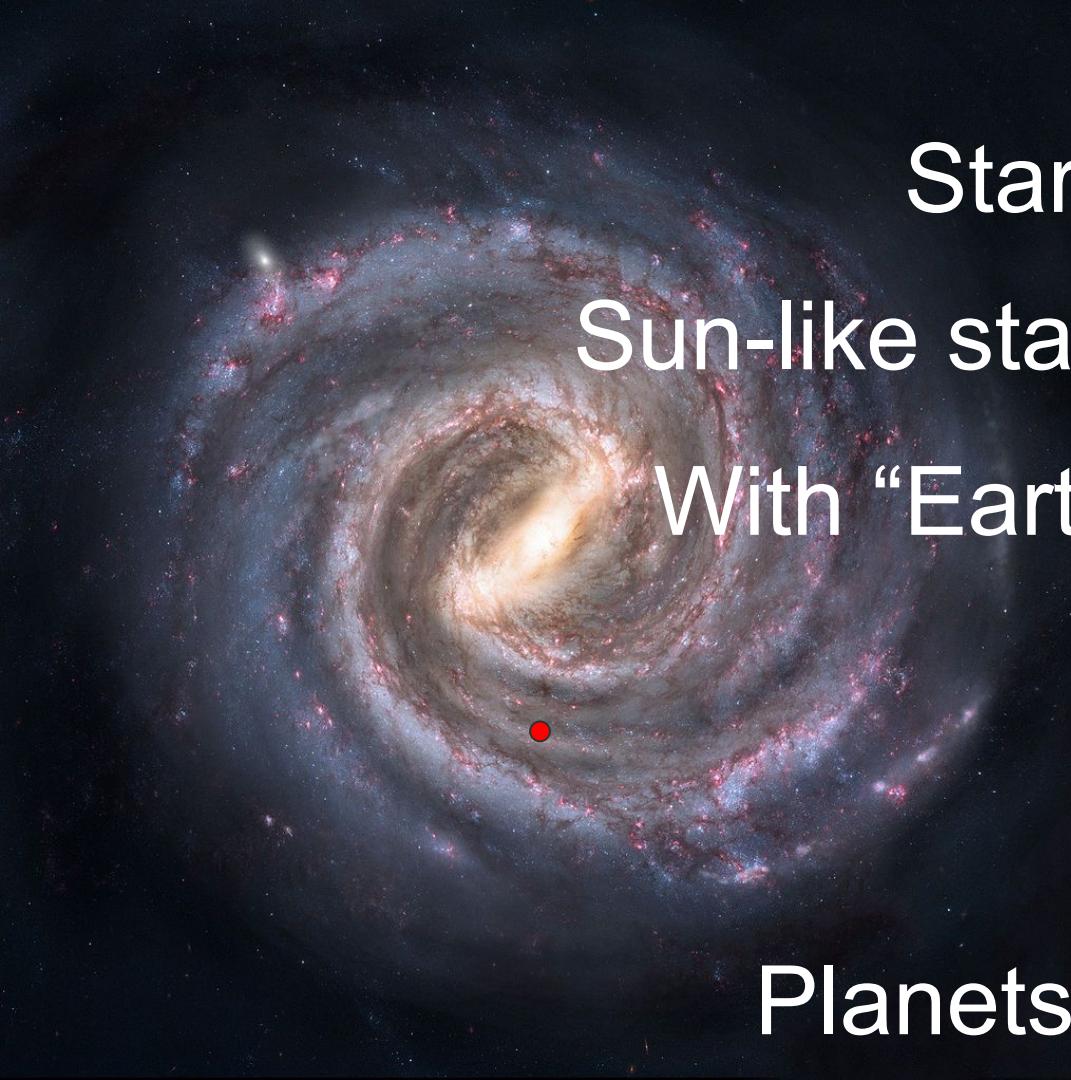
Milky Way

2.5 million
light years

140,000
light years



Andromeda

A photograph of a spiral galaxy, likely the Milky Way, showing its central bulge and winding arms of stars and interstellar gas. A small red dot is placed on one of the inner spiral arms, representing the location of Earth.

Stars: 400,000,000,000

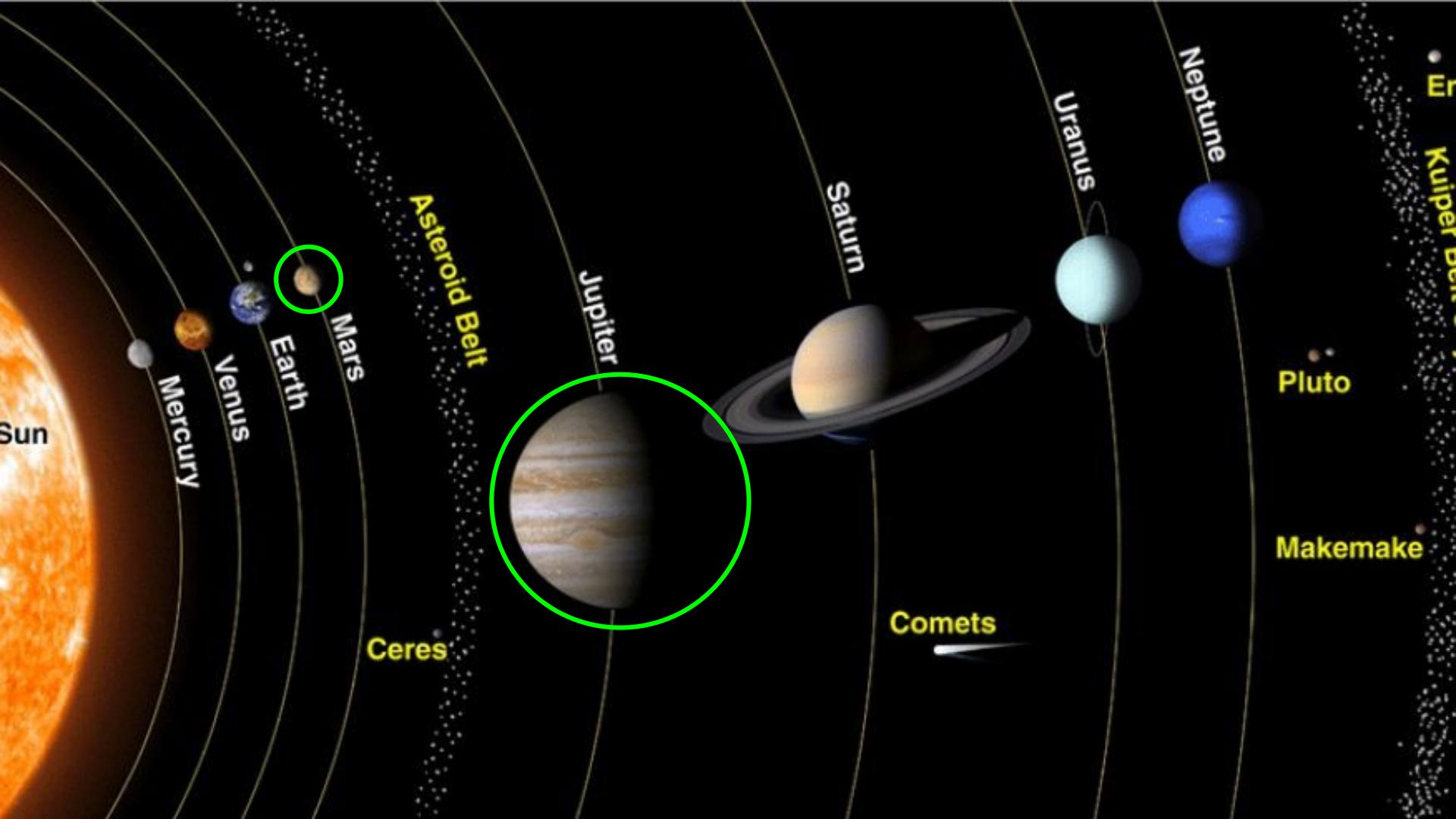
Sun-like stars: 20,000,000,000

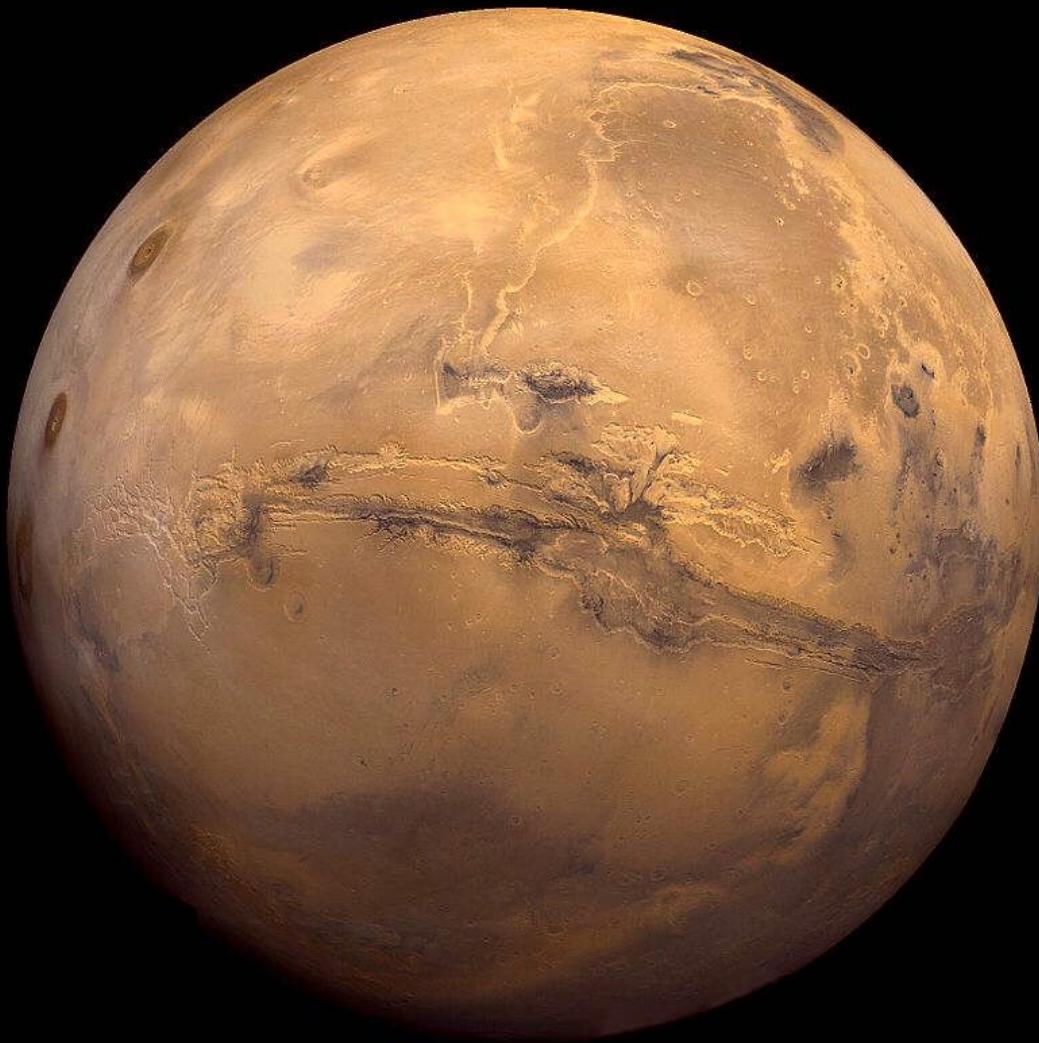
With “Earth’s”: 4,000,000,000

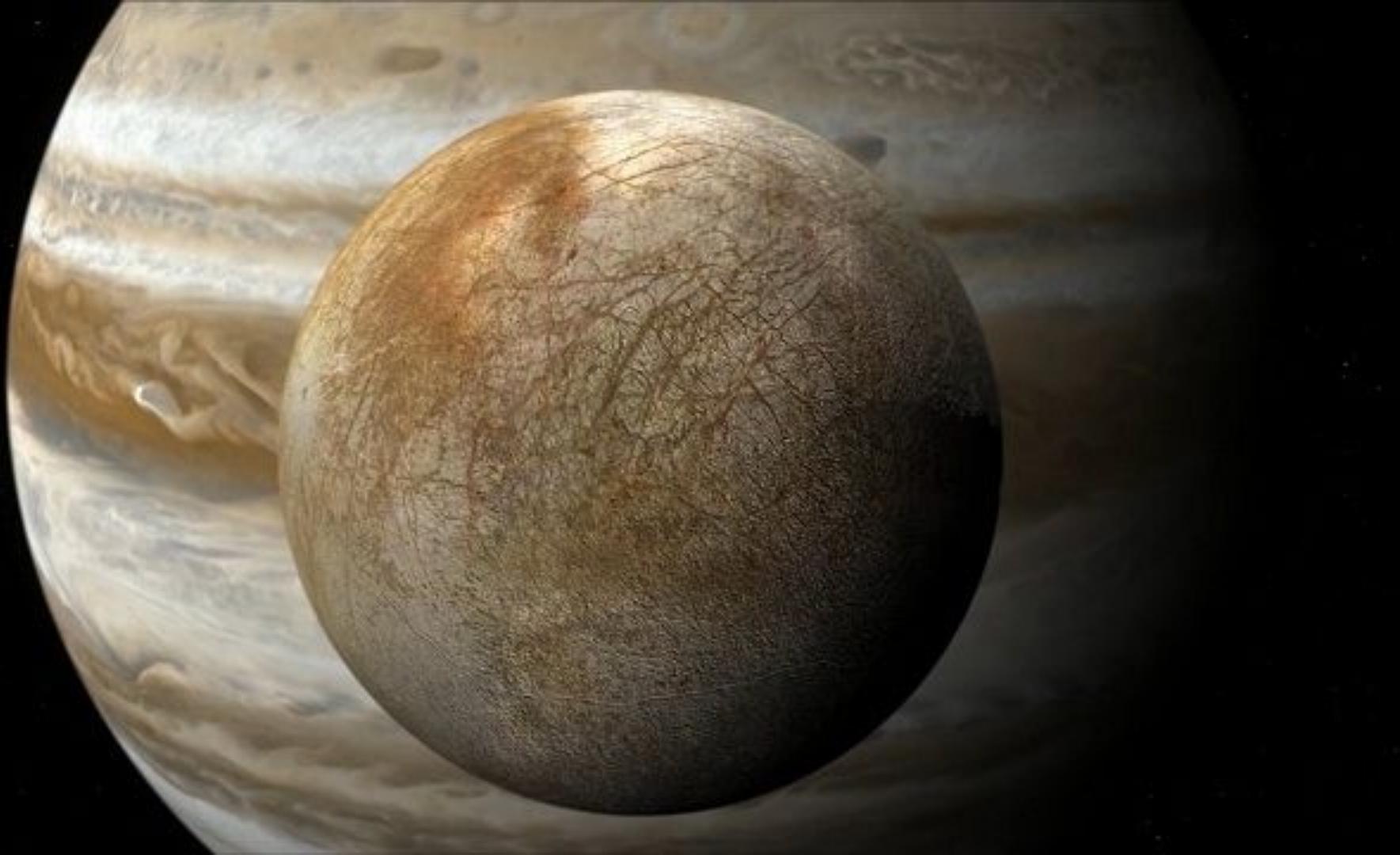
What if only 0.025% harbored life?

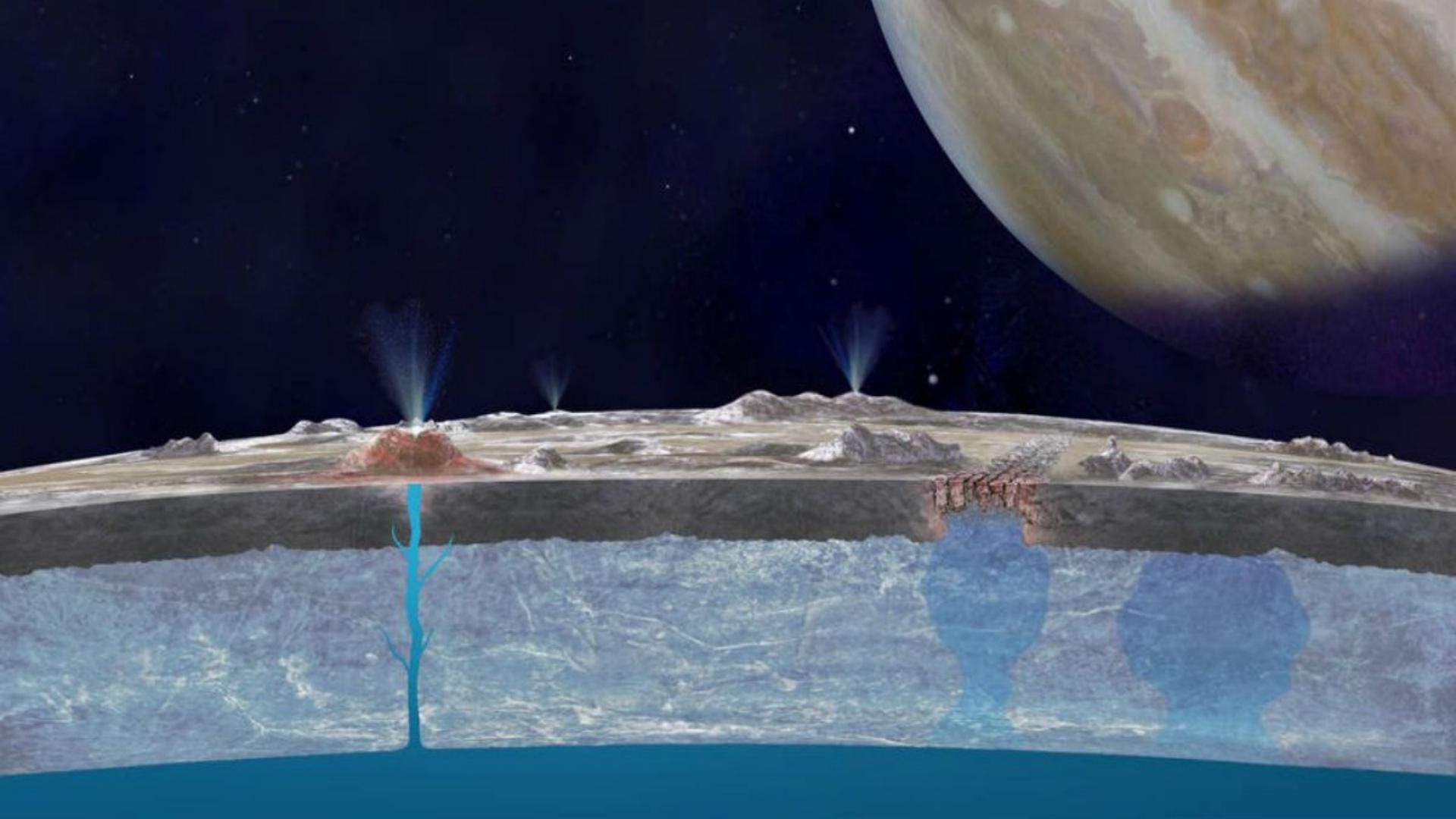
Planets with life: 1,000,000











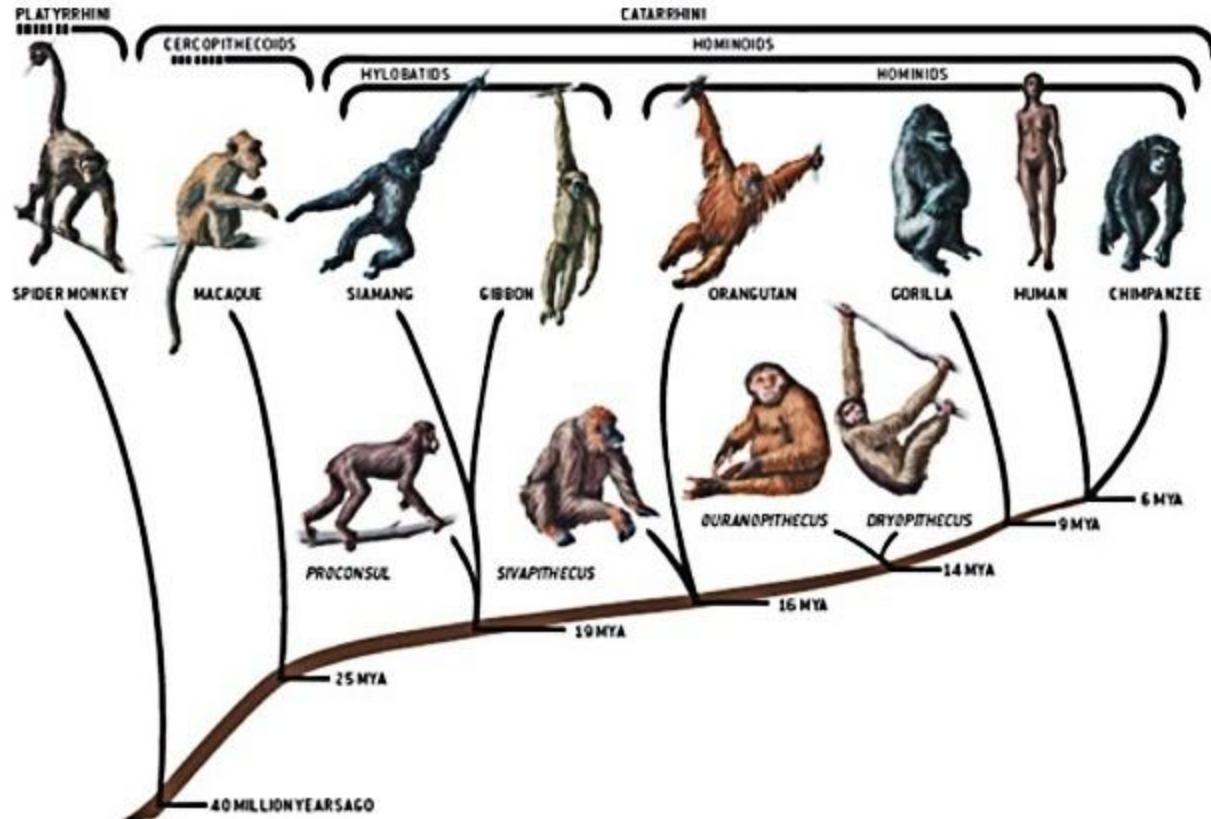


Six properties of life on Earth

- **Order:** patterns that form cell structures
- **Reproduction:** capable of having offspring
- **Growth and Development:** heredity plays its part
- **Energy Utilization:** use energy to fuel activities
- **Response to Environment:** organisms may alter their chemistry
- **Evolutionary adaptation:** natural selection to become better adapted

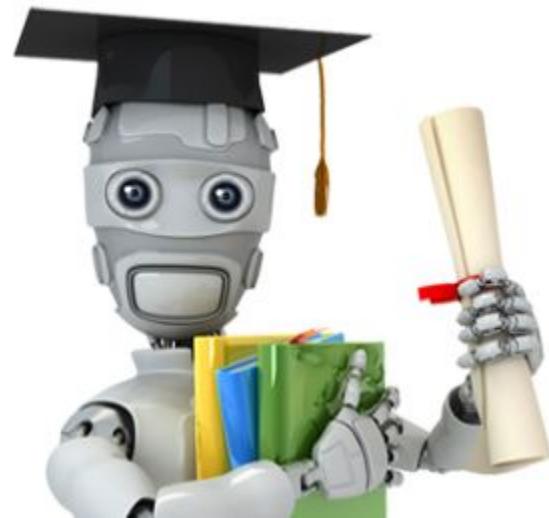
Definition of life

Something that can reproduce and evolve through natural selection



```
252
253     }
254
255     ■■■ function updatePhotoDescription(){
256         ■■■ if (descriptions.length > (page * 5) + (currentImage - subImg) - 1){
257             |   document.getElementById('bigImageDesc').innerHTML = descriptions[page * 5 + currentImage - subImg];
258         }
259     }
260
261     ■■■ function updateAllImages() {
262         var i = 1;
263         ■■■ while (i < 10) {
264             |   var elementId = 'foto' + i;
265             |   var elementIdBig = 'bigImage' + i;
266             |   if (i < descriptions.length) {
```

“Artificial life” that evolves and learns by itself





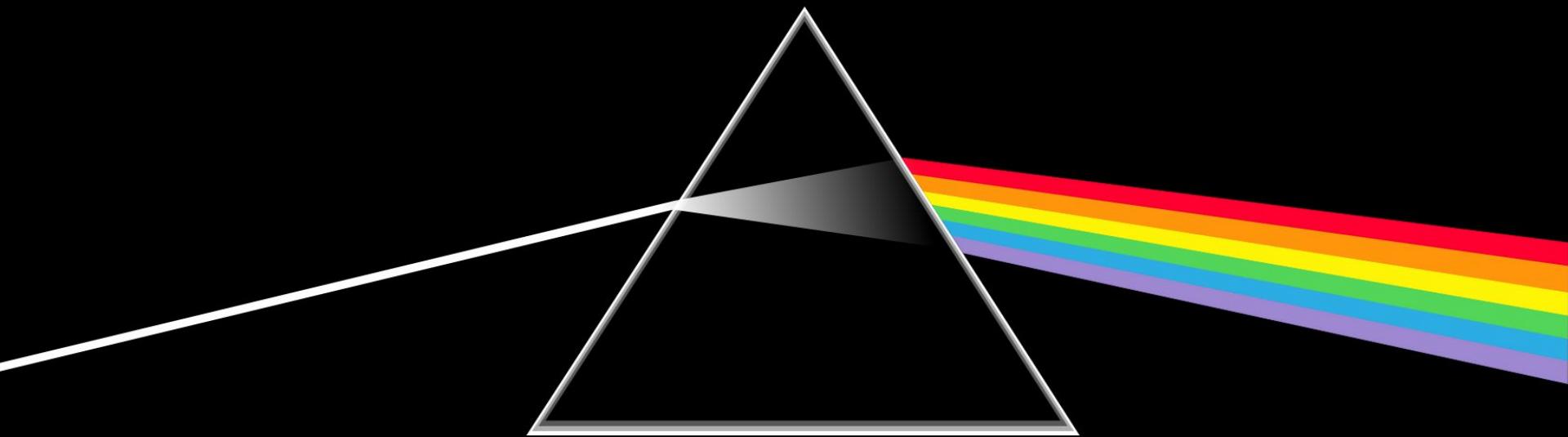
HABITABLE ZONE

Too Hot

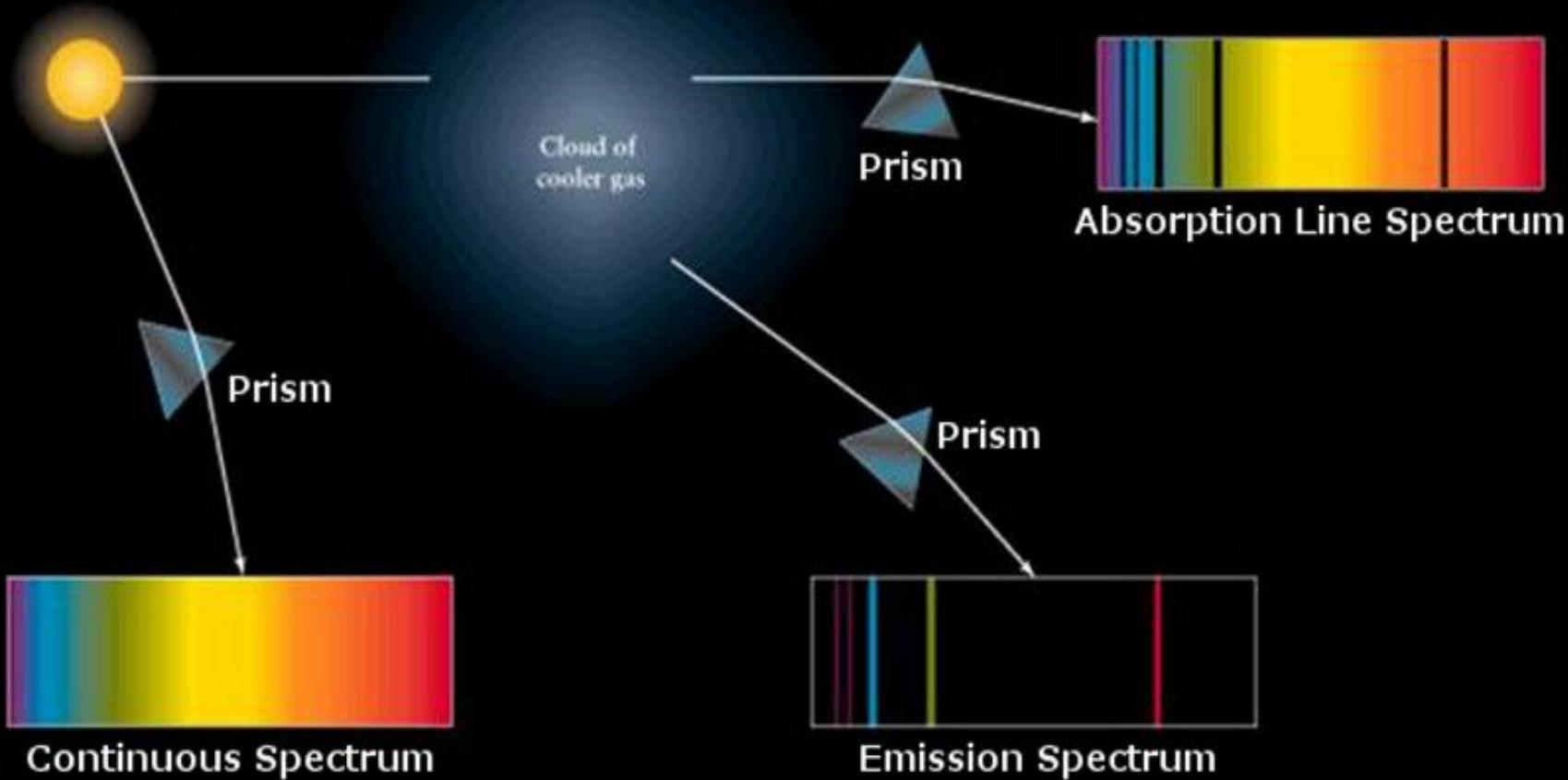
Just Right

Too Cold

Planet size: 1-2x Earth

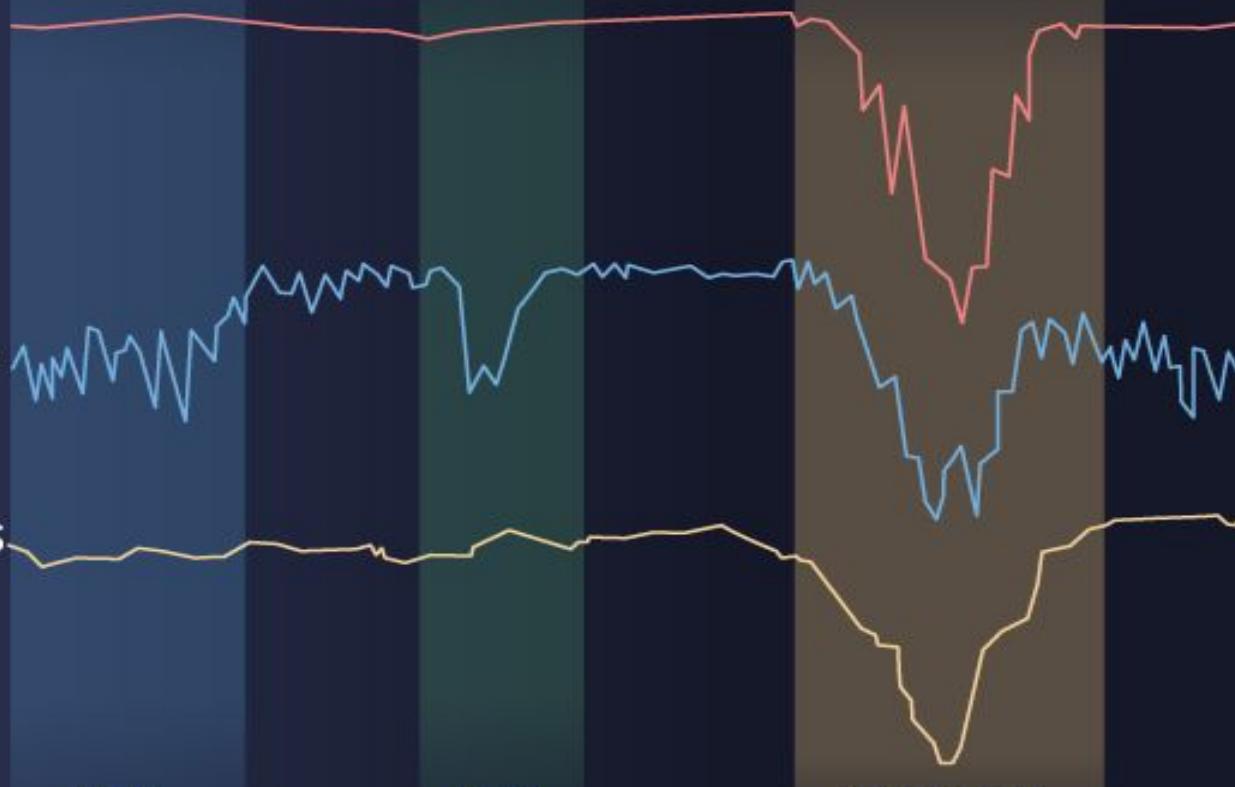


Heated Element
Gives Off Light



Spectroscopic Analysis of Three Planets

MARS



EARTH



VENUS

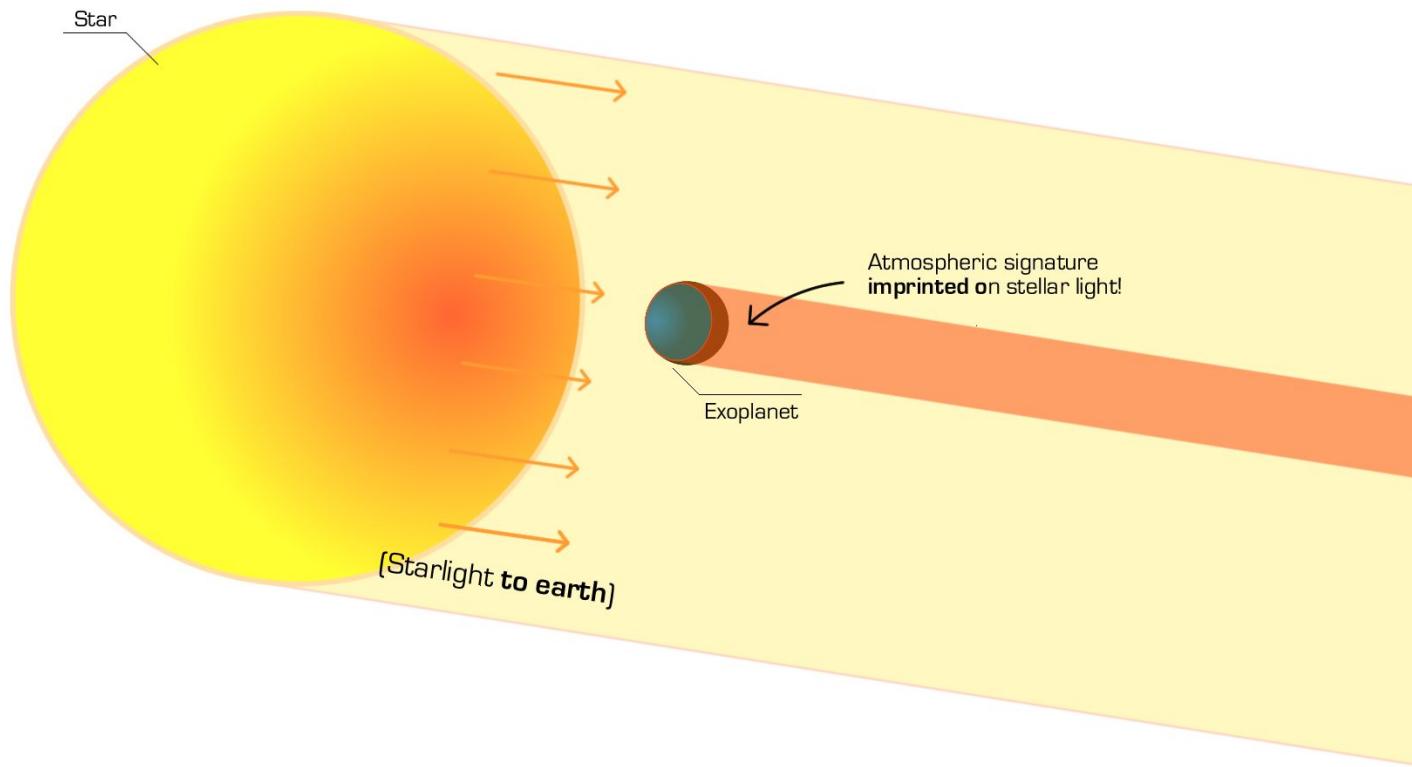


Water

Ozone

Carbon Dioxide

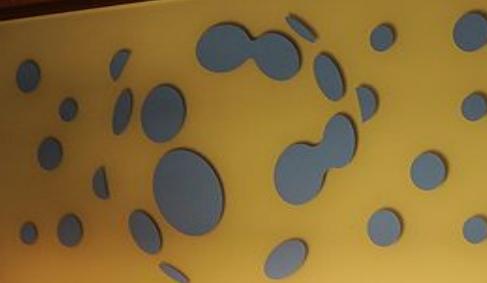
Abundant oxygen
in the atmosphere
of a distant world
might indicate the
presence of life





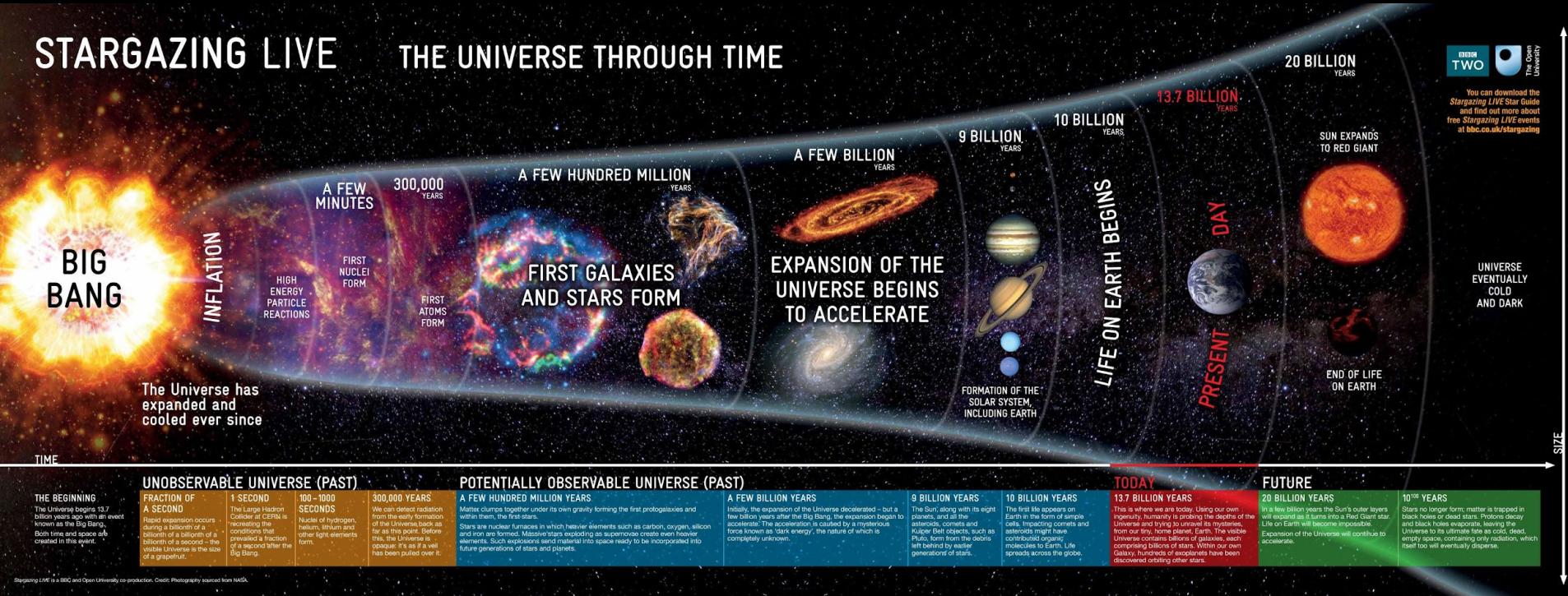
189

SETI INSTITUTE



STARGAZING LIVE

THE UNIVERSE THROUGH TIME





“Intelligent” civilizations

- Species must evolve with sufficient intelligence to develop interstellar communication
- Species must develop a civilization with technology at least as advanced as ours

DAD, LOOK, THAT STAR THERE, DO YOU THINK THERE'S A PLANET
NEAR THAT STAR WITH A BOY AND HIS DAD, WONDERING IF
THERE'S LIFE OUT THERE?



MAYBE
SON...
MAYBE

1. ፳፻፲፭ ዓ.ም. በ፳፻፲፭ ዓ.ም. ከ፳፻፲፭ ዓ.ም.

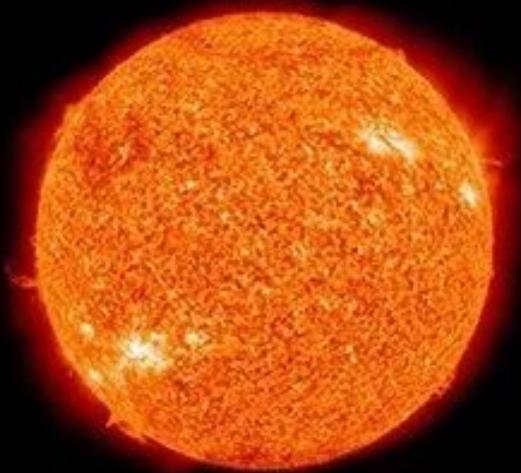




The Kardashev Scale



TYPE 1



TYPE 2



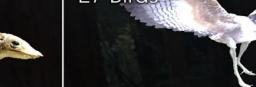
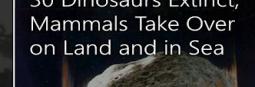
TYPE 3

The Cosmic Calendar

The 13.8 billion year history of the universe scaled down to a single year, where the Big Bang is January 1st at midnight, and right now is midnight 1 year later

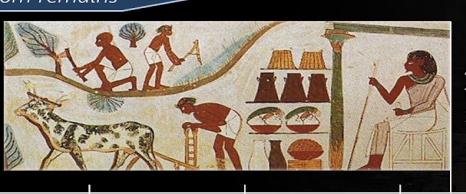
| January | February | March | April | May | June | July | August | September | October | November | December | | |
|--|---|---|---|---|------|------|--------|---|---|---|---|---|--|
| Known from telescopes looking back in time, physical models | | | | | | | | Known from geologic record, fossils, genetic drift | | | | | |
|  |  |  |  |  | | | |  |  |  |  |  | |
| The Big Bang, Stars First Appear | | | | Thin Disk of the Milky Way | | | | The Solar System, Life | Oxygen from Photosynthesis | Eukaryotic Cells | Multicellular Life | | |

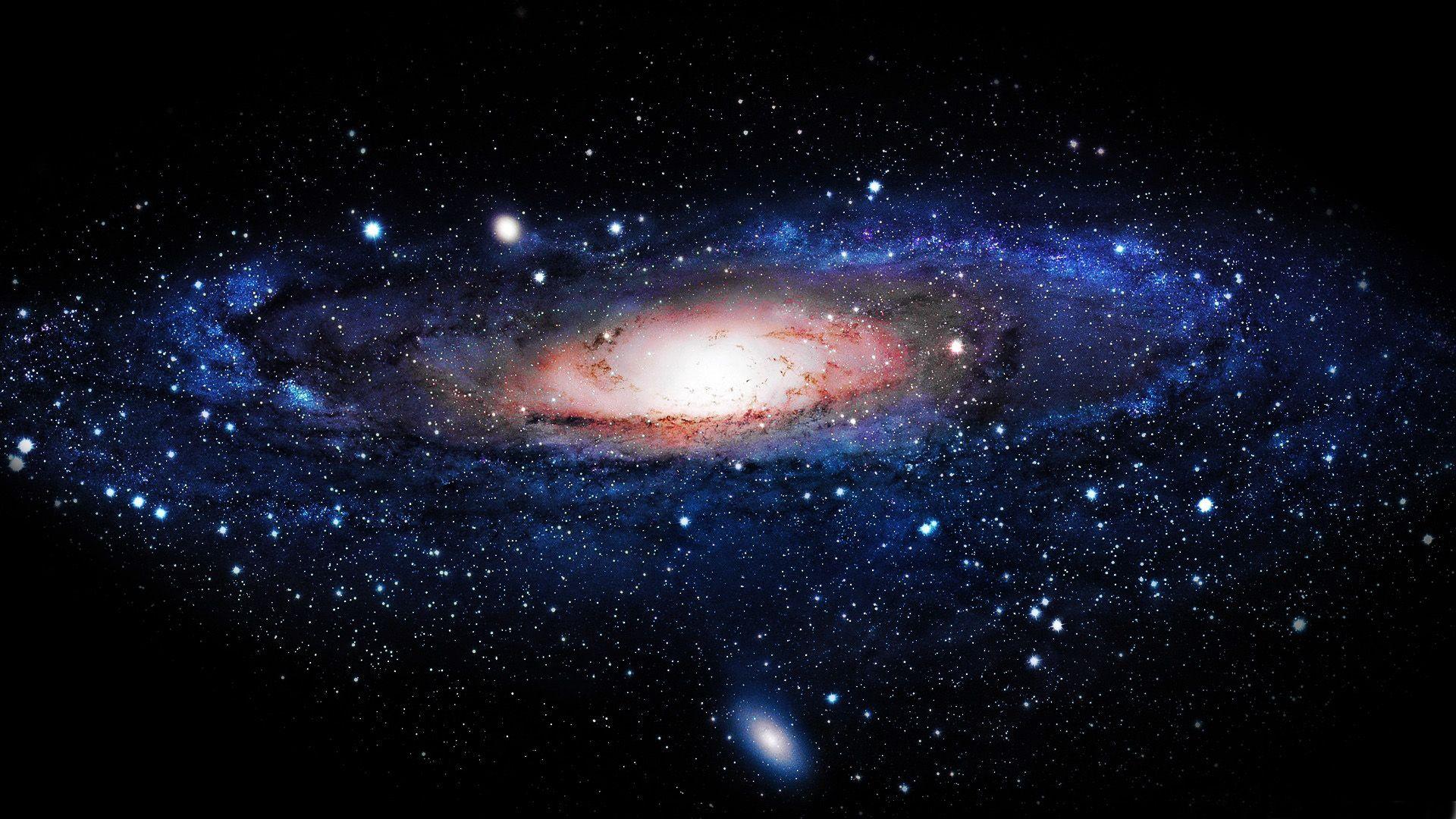
The Month of December...

| | | | | | | | | | | | | | | |
|--|---|---|--|---|---|---|---|---------------------------------|----|----|----|----|----|--|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | |
| 15 Trace Fossils Only | 16 | 17 Bones and Shells | 18 Vertebrates | 19 Land Plants | 20 Fish with Jaws | 21 Insects | | | | | | | | |
| 22 Amphibians | 23 Reptiles | 24 Pangaea Forms | 25 Dinosaurs | 26 Mammals | 27 Birds | 28 Flowers | | | | | | | | |
|  |  |  |  |  |  |  | | | | | | | | |
|  | 30 Dinosaurs Extinct, Mammals Take Over on Land and in Sea | 31 The Final Day... | Dawn: Apes and Monkeys Split | 8 PM: Humans and Chimpanzees Split | 9:25: Humans First Walk Upright | 10:30: Human Brain Size Begins Tripling | 11:52: Modern Humans Evolve | 11:56 to 11:59: Human Migration | | | | | | |
| |  | |  |  |  |  |  | | | | | | | |

The Final Minute...

A human life only lasts for the blink of an eye on the Cosmic Calendar: $100 \text{ years} * 365 * 24 * 60 * 60 / 13,800,000,000 = 0.23 \text{ Cosmic Seconds}$

| | | | | | | | | | | | | |
|---|--|--|---|--|---|----|----|----|----|----|---|---|
|  |  | End of Last Ice Age, Sea Level 400 Feet Lower Than Now |  | Agriculture Leads to Permanent Settlements | Columbus Arrives in America (1.2 Seconds Ago) | | | | | | | |
| | | | | | Christ Born | | | | | | | |
| | | | | | Mohammed Born | | | | | | | |
| | | | | | Old Testament, Buddha | | | | | | | |
| | | | | | Dynastic China Begins | | | | | | | |
| 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 |







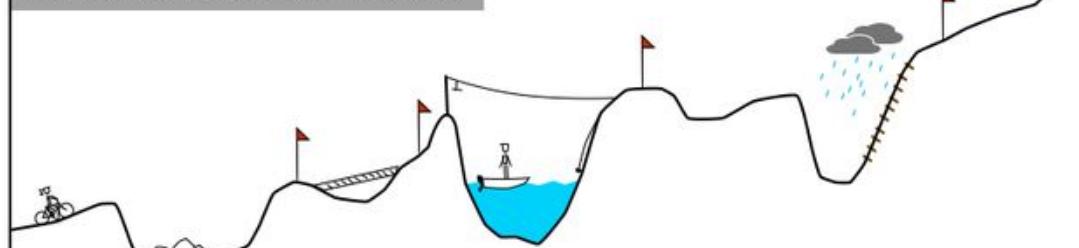
FILTER

A barrier that is
really hard for life
to overcome

YOUR "PLANS"



THE UNIVERSE'S PLANS FOR YOU



DOGHOUSEDIARIES

There are Great Filters,
and we have passed them.



There are Great Filters,
and they are ahead of us.



The background of the image is a deep, dark blue space filled with numerous small white stars of varying sizes. In the upper right quadrant, there is a prominent, glowing nebula with a mix of purple, blue, and white colors, suggesting a star-forming region. The overall texture is slightly grainy, typical of a high-resolution photograph of deep space.

Thank you!

Have a good rest of the night!