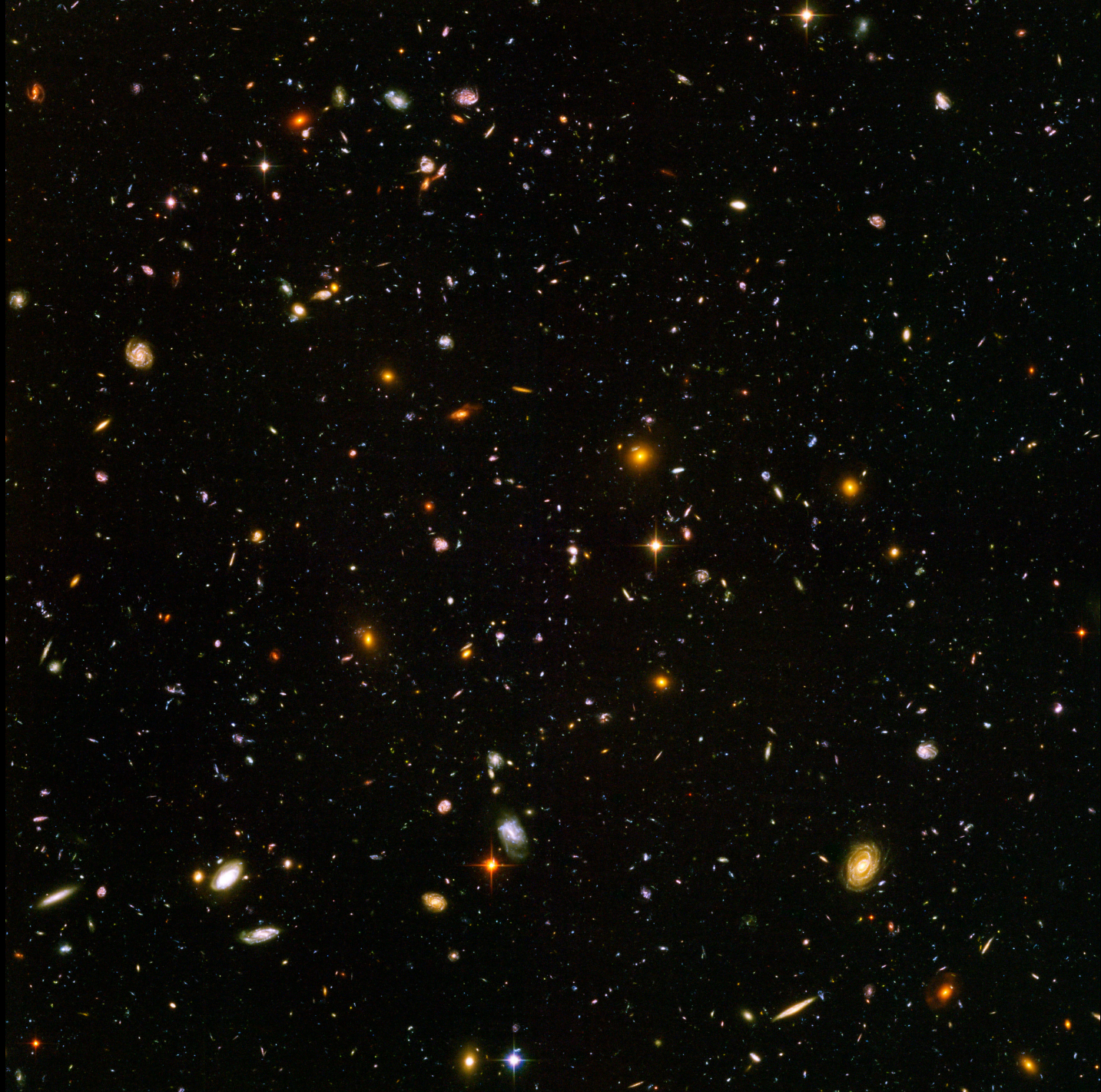








Wally Pacholka / AstroPlace

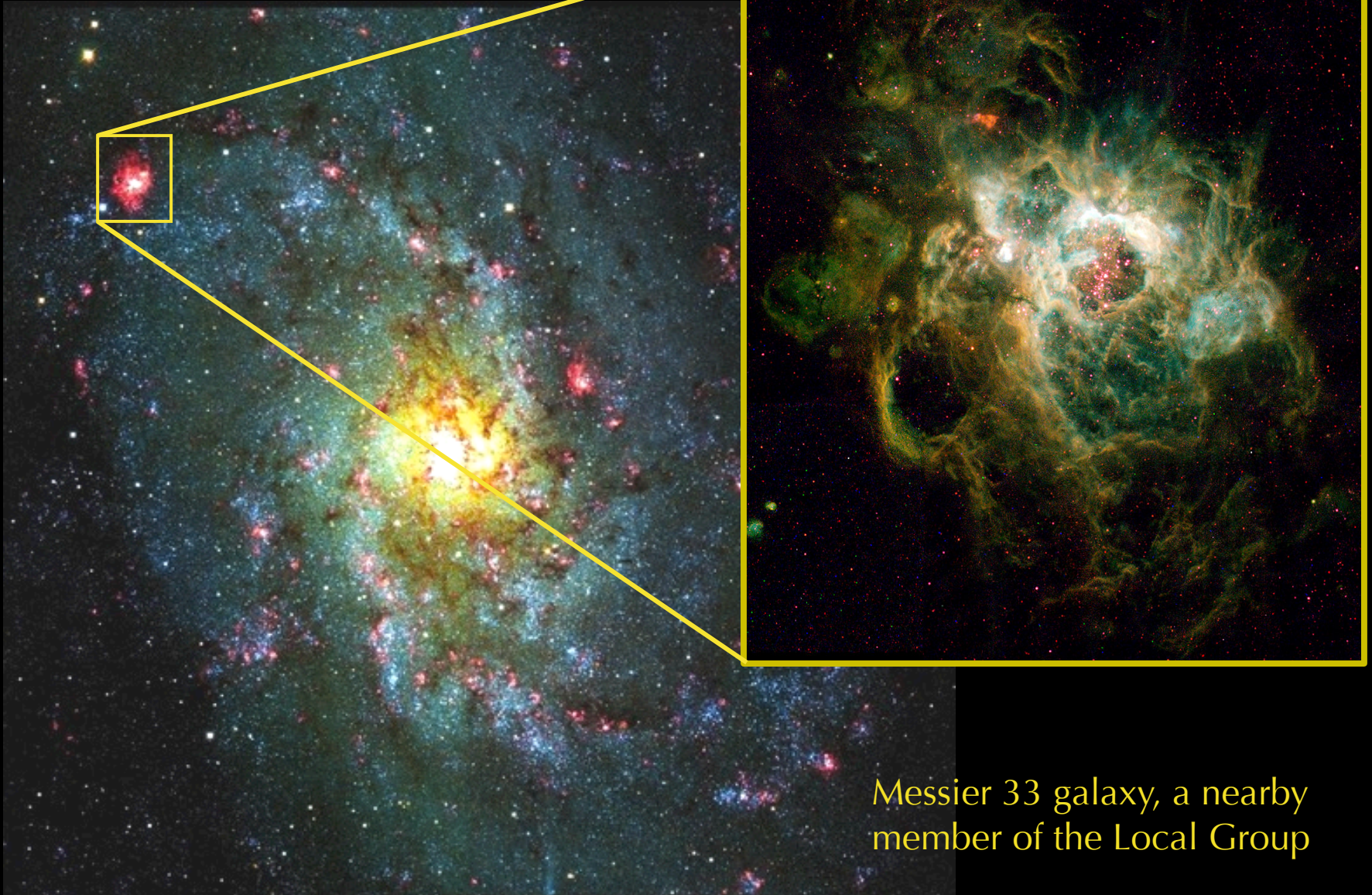




# ASTRONOMY

FINDING OUT YOU REALLY JUST DON'T MATTER

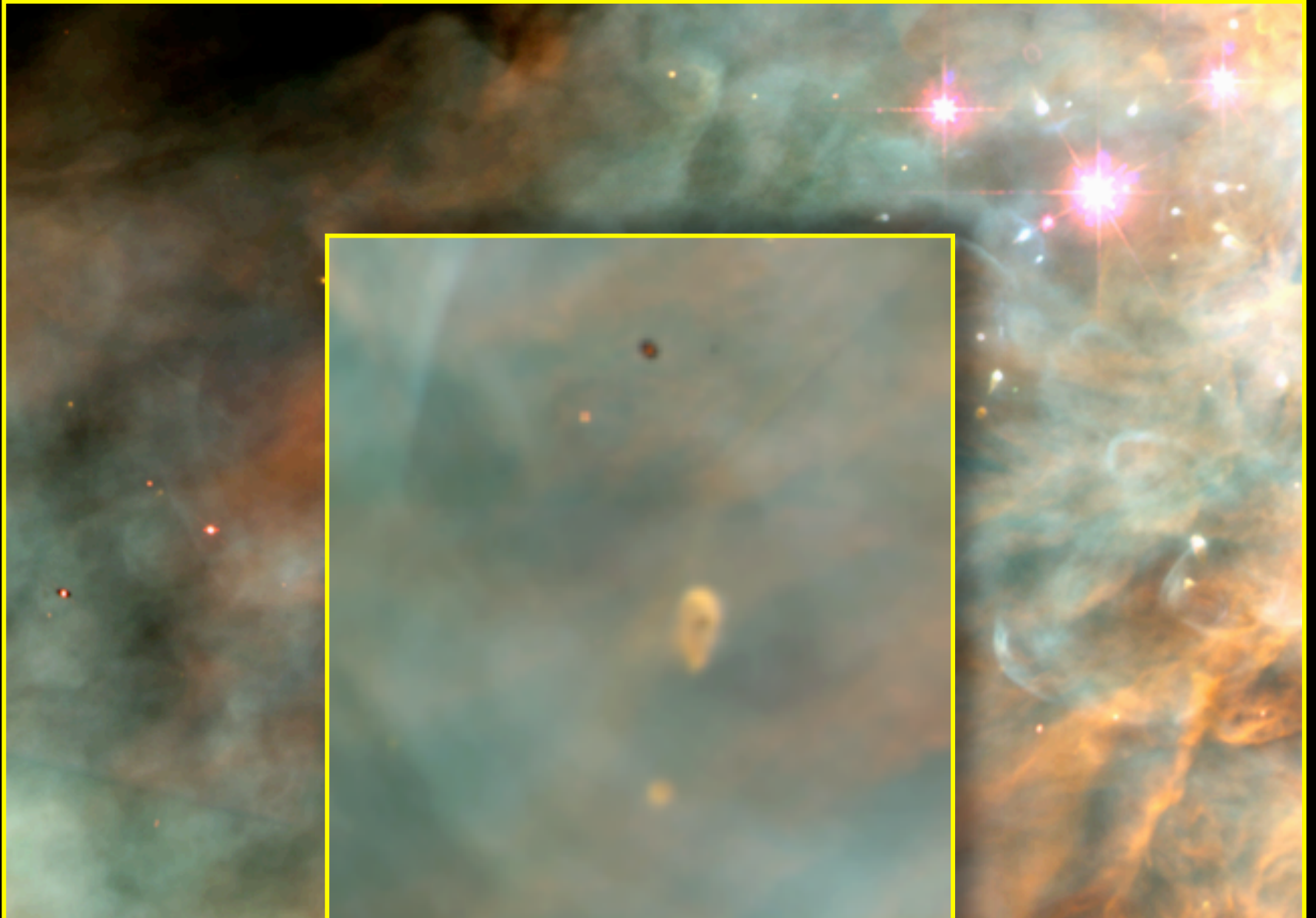
*Stars form from dense clouds of gas*

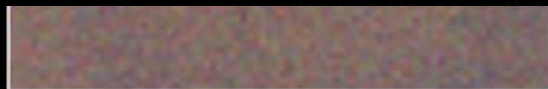
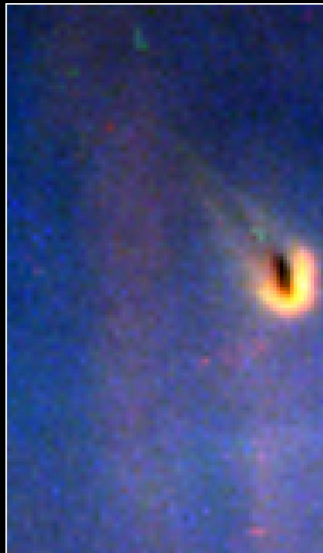
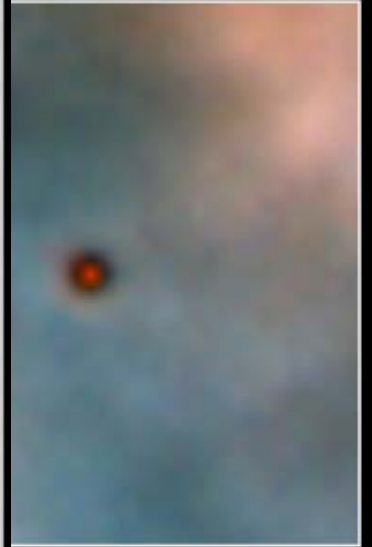
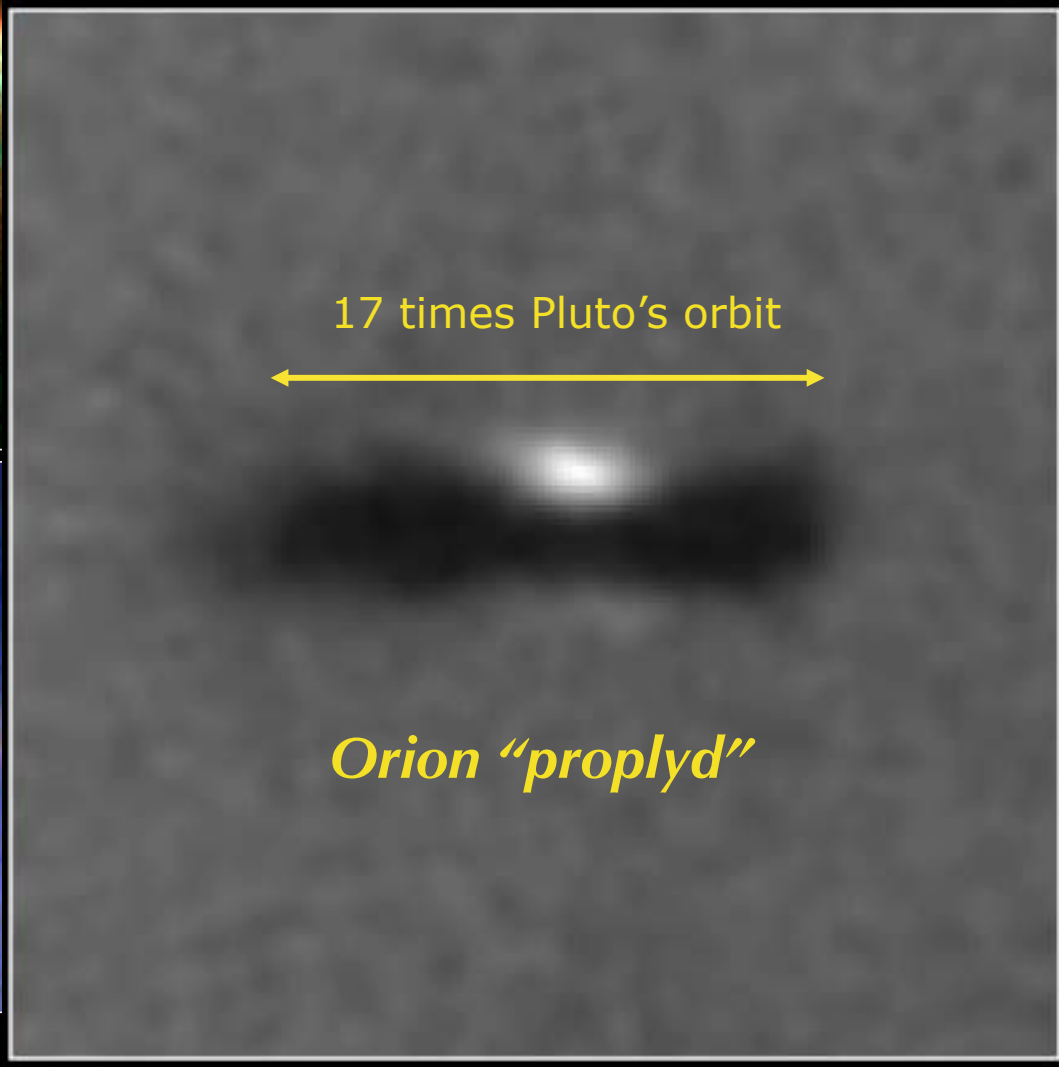
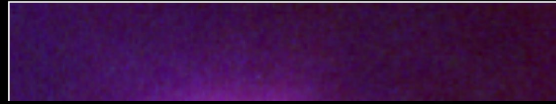
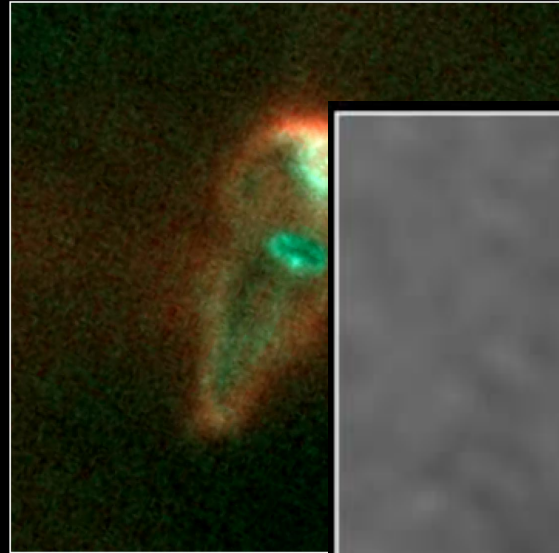


*Messier 33 galaxy, a nearby member of the Local Group*

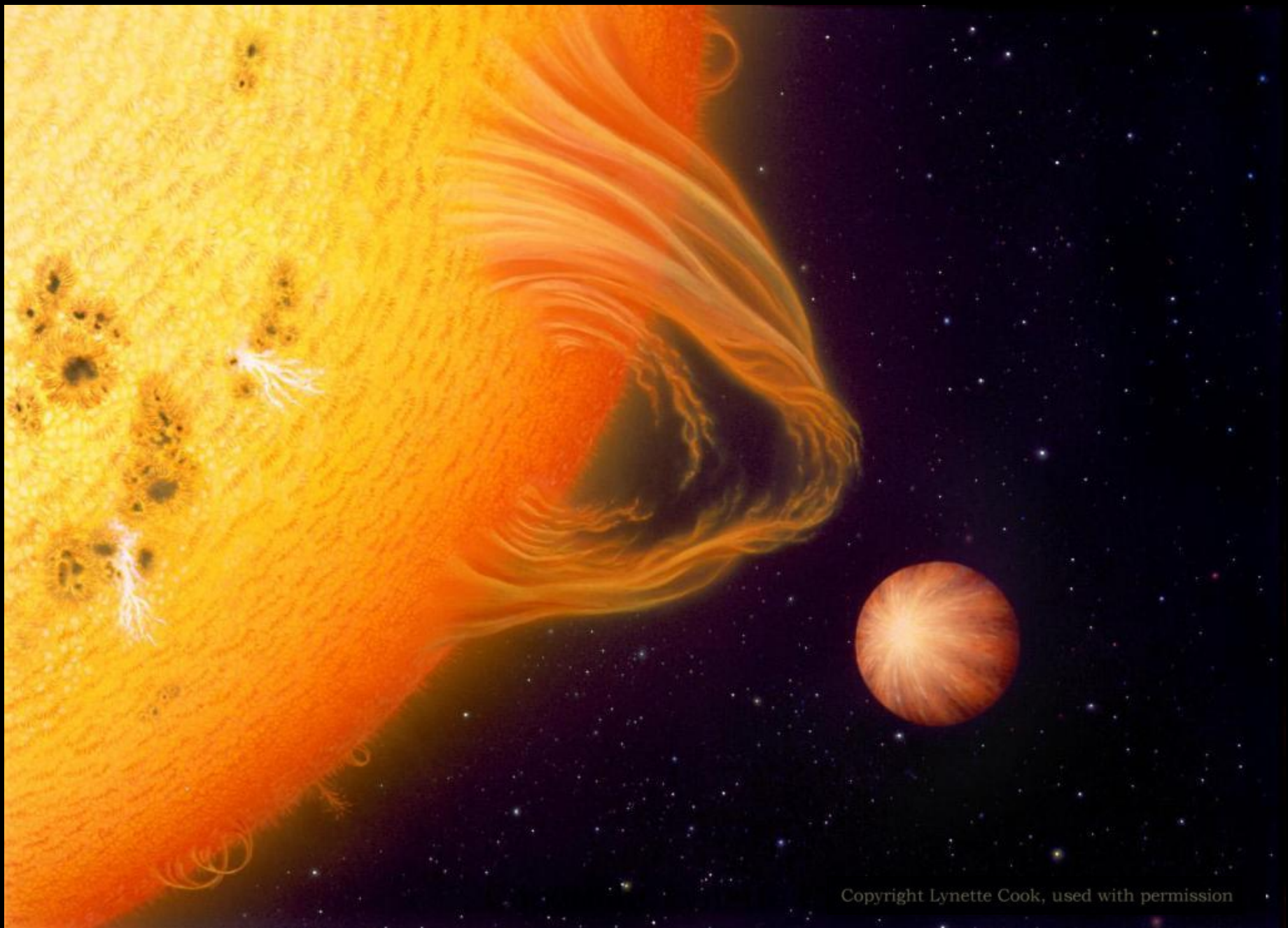












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# LESSONS FROM COSMOLOGY

# LESSON #1

- We got here according to the laws of physics.

We are subject to those laws and must live within them.

## LESSON #2

- Our Solar System is *rare* in having planets that are well separated and on circular orbits.

It is exceptionally stable with a future lifetime of >1 billion years.

## LESSON #3

- The Sun has a billion years of useful life remaining.

We have the precious **gift of cosmic time.**

*We are the first human beings to know these things.*

**What is “steady” growth?**

Assume 3.5% growth each year....

$$(1.035) \times (1.035) \times (1.035) \times \dots$$

Doubling time = *Twenty years!*

Twenty years: 2

Forty years: 2 x 2

Eighty years: 2 x 2 x 2 x 2

$$= 2$$

$$= 4$$

$$= 16$$

# The “miracle” of compound interest... on cosmic time

3.5% growth every year for 1 billion years...

**WHAT HAPPENS?**



$$10^{13,000,000}$$

That's "10" with **13 million zeros** after it.

What is sustainable growth  
on cosmic time?

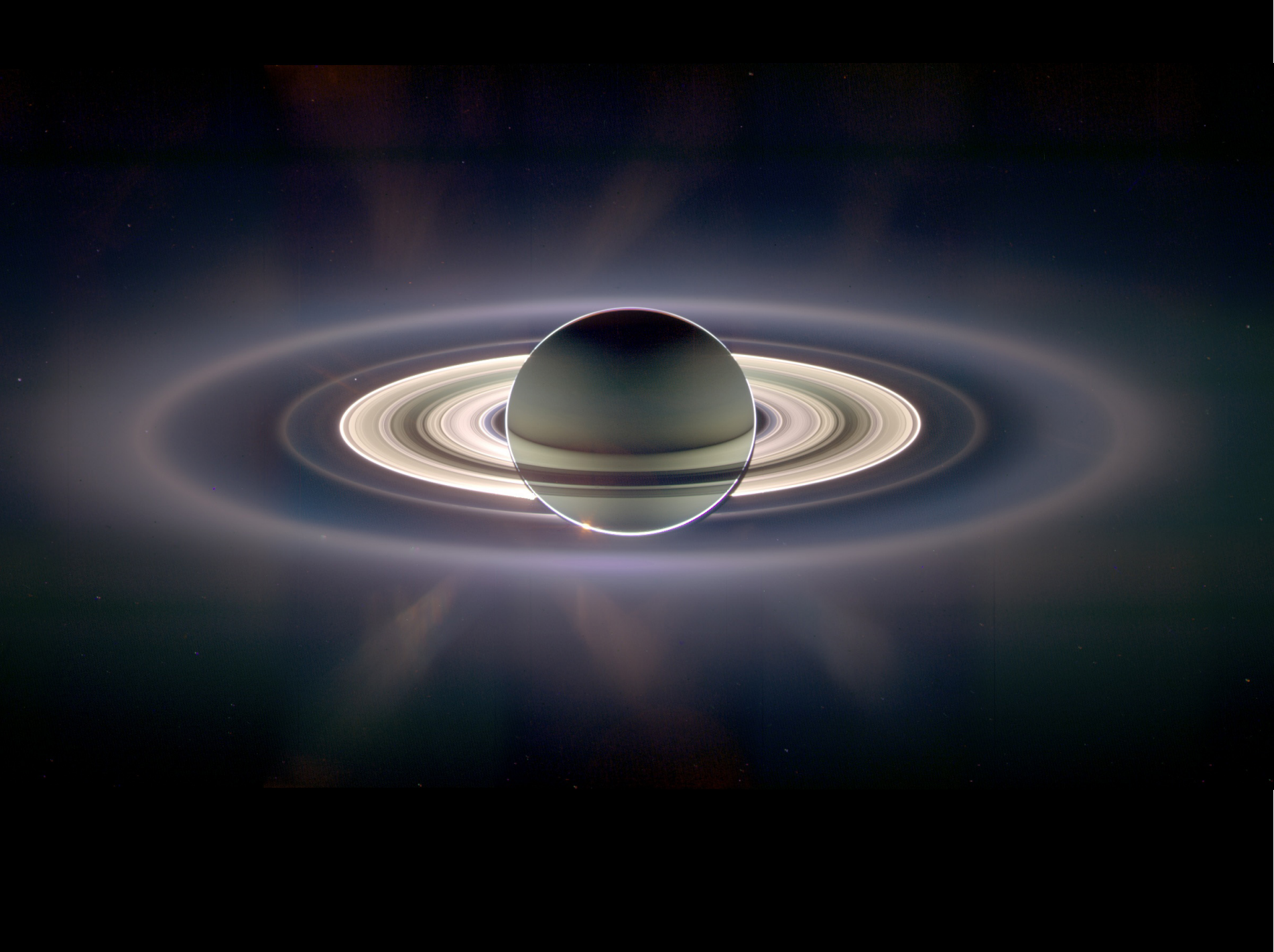
Allow x2 growth over 1 billion years....

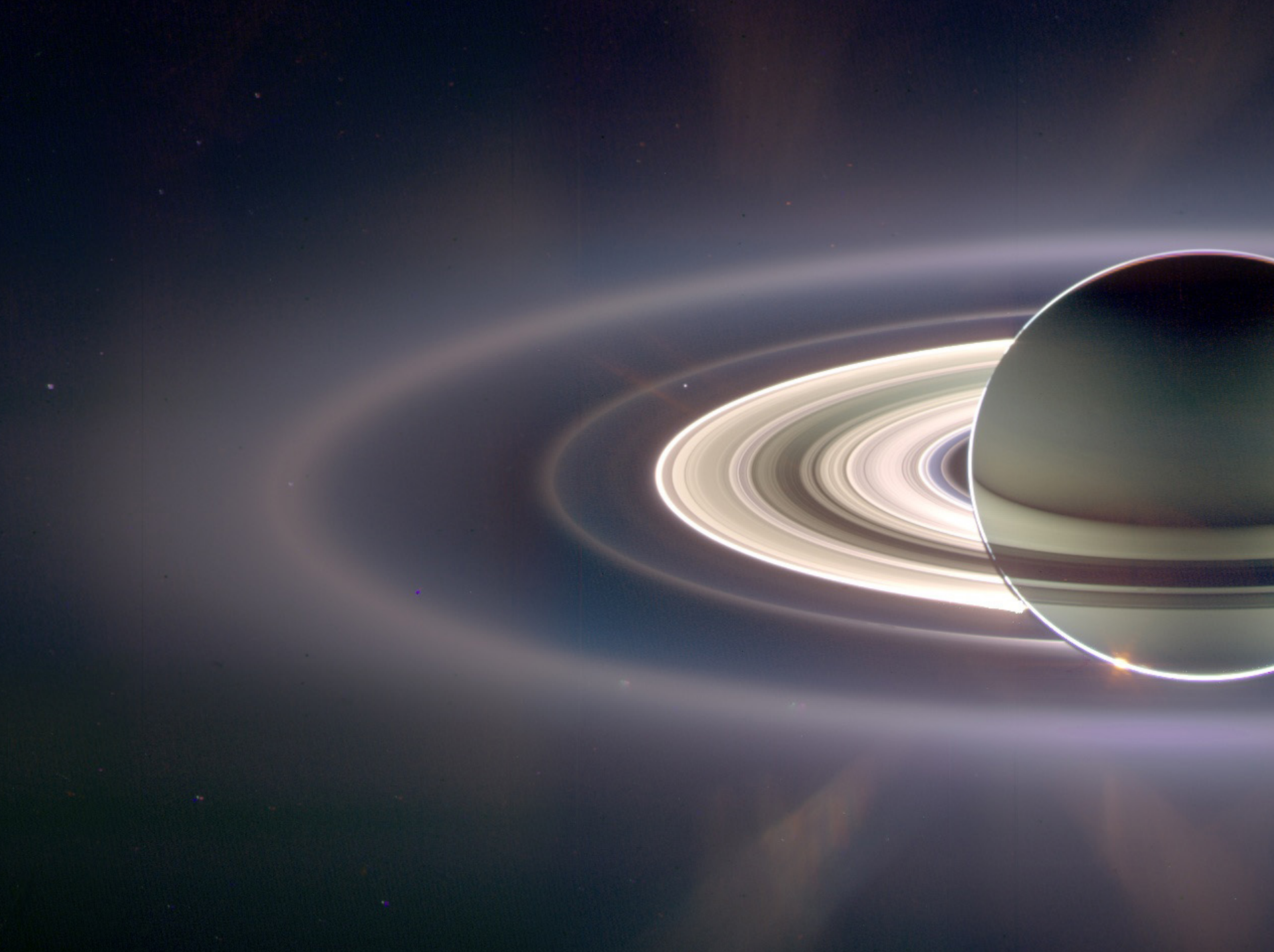
**0.000000003% per year**

***NO*** net increase in resource use. Waste reduced to levels that can be completely naturally recycled.













# A fly-through toward Orion, through the Galaxy, and into intergalactic space



Courtesy Brent Tully, Institute for Astronomy, University of Hawaii