

ASTR 4800 - Space Science: Practice & Policy
 Today: *Life on Mars* – guest lecture by Prof. Bruce Jakosky


- **Next Class:** Student presentation on *Robotic Exploration of Mars*. Read article linked to class website for Oct. 17
- *Interview with a Space Scientist* paper: deadlines Oct. 19 & 28.



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Life On Mars: Past, Present, And Future

Bruce Jakosky
 Laboratory for Atmospheric and Space Physics
 University of Colorado
 bruce.jakosky@lasp.colorado.edu
 ASTR 4800 guest lecture, 14 October 2022



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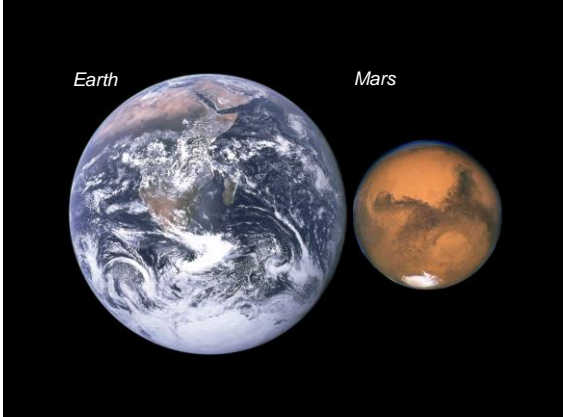
"Life" As The Overarching Question About Mars



- Has Mars ever been habitable?
- Has Mars ever had life? How are we searching for it?
- When will humans go to Mars? Can we "terraform" Mars to give it a more-clement climate?
 - Why are we exploring Mars (and elsewhere) and looking for life?

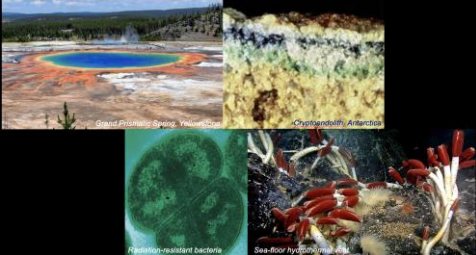
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Earth *Mars*



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Life On Earth Guides Our Thinking About Life Elsewhere
The Environmental Limits Of Life



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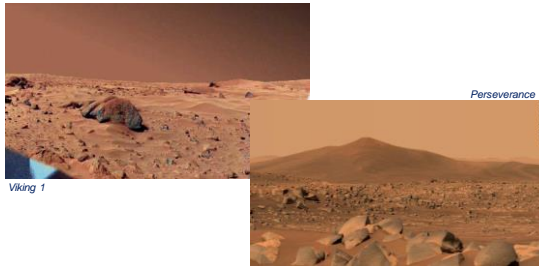
The Environmental Requirements For Life Are Thought To Be Very Simple

- Access to the biogenic elements
- A source of energy to drive metabolism
- Liquid water



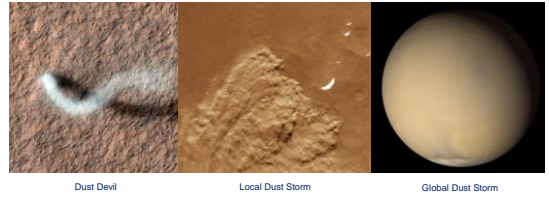
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Mars Is A Cold And Dry Planet Today



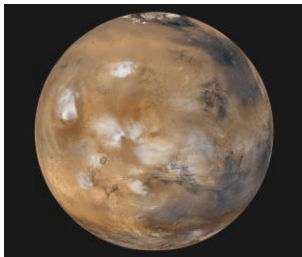
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The Weather Is Dominated By Airborne Dust



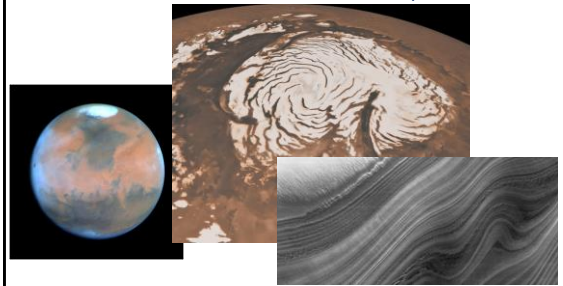
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Only Trace Amounts Of Water Are Present In The Atmosphere



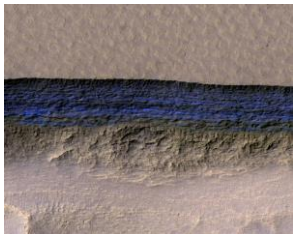
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Water Ice Is Frozen In The Polar Caps...



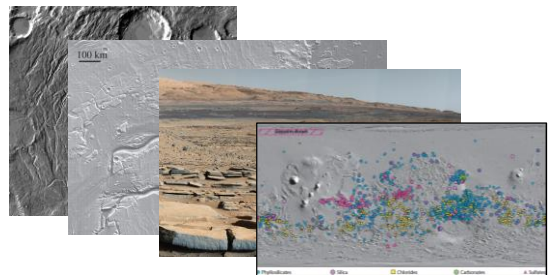
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...And In "Massive" Buried Mid-Latitude Deposits



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Liquid Water Was Present On Mars In Earlier Times



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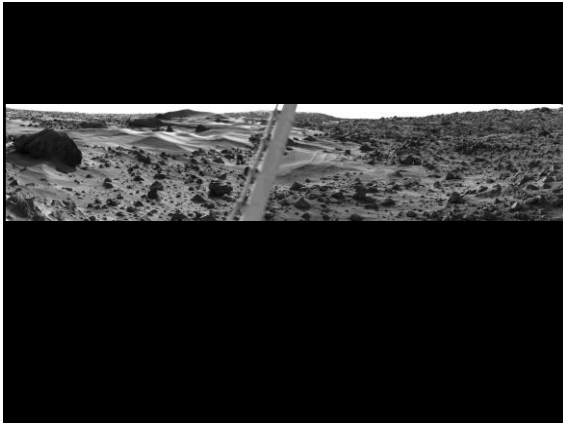
The Environmental Requirements For Life Are Thought To Be Very Simple

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Searching For Life On Mars: (i) Viking Landers

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Viking Biology Experiments

Three different approaches to looking for evidence of ongoing metabolism:

- Is C taken up from CO₂? (Carbon Assimilation)
- Is C taken up from nutrients? (Labeled Release)
- Are gases given off when nutrients are added? (Gas Exchange)

Fig. 9. Viking 1 L.R. data
Viking Labeled Release Experiment

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Are There Organics In The Soil?

- If life were present, organic molecules should be present in the soil
- None were detected using the Viking mass spectrometer

	molecular formula	condensed structural formula	expanded structural formula
ethane	C ₂ H ₆	CH ₃ CH ₃	
butane	C ₄ H ₁₀	CH ₃ CH ₂ CH ₂ CH ₃	
cyclohexane	C ₆ H ₁₂		
ethene	C ₂ H ₄	CH ₂ =CH ₂	
ethyne	C ₂ H ₂	HC≡CH	

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So what's the bottom line?

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Searching For Life On Mars: (ii) Mars Meteorite ALH84001

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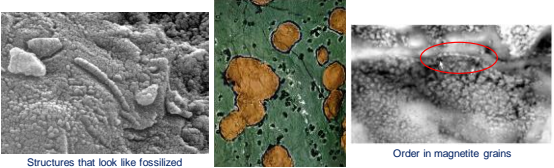
The Mars Meteorite Zagami




Note: This sample is ~10 carat = 2 g

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Possible Fossil Life In ALH84001?



Structures that look like fossilized terrestrial microbes


Chemical disequilibrium (seen in layering of minerals)

Order in magnetite grains

So what's the bottom line?


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Searching For Life On Mars: (iii) Mars Sample Return



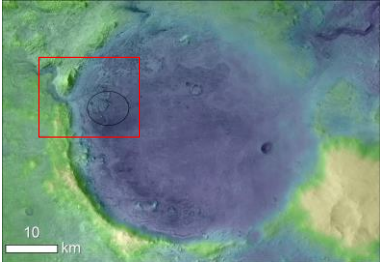
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Perseverance Rover – Successful Landing In Jezero Crater On 18 February 2021



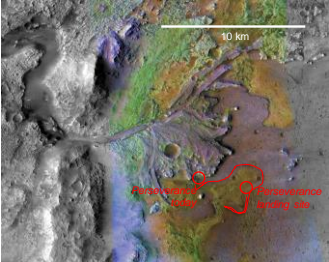
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Perseverance Landed In Jezero Crater, Site Of An Ancient Lake

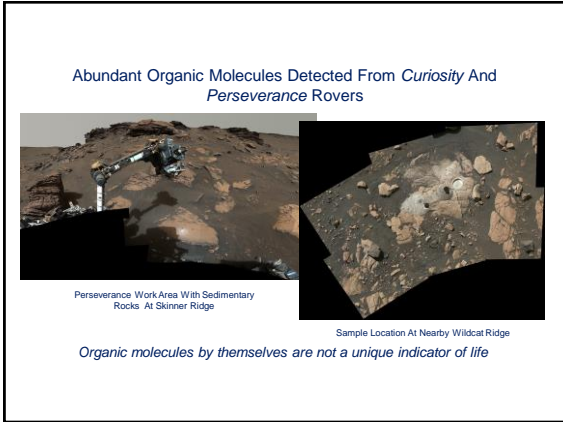


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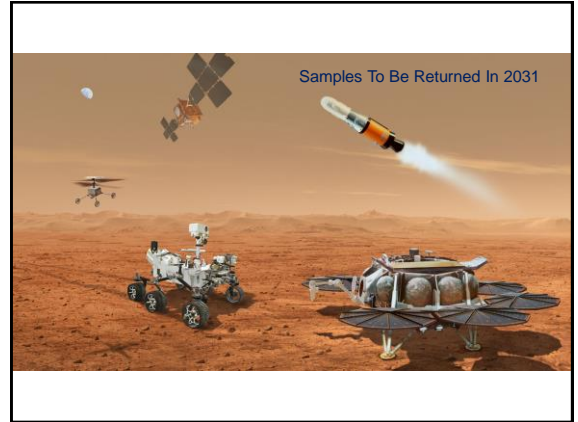
Delta Deposits Show Where Water Entered Jezero Crater



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Outpost On Mars?



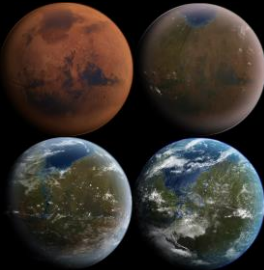
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City On Mars?

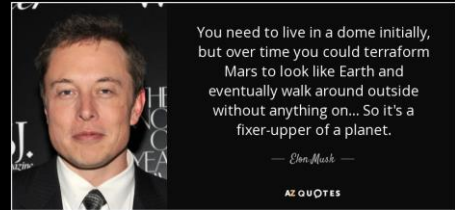


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Farther Into The Future: Can Mars Be Terraformed?



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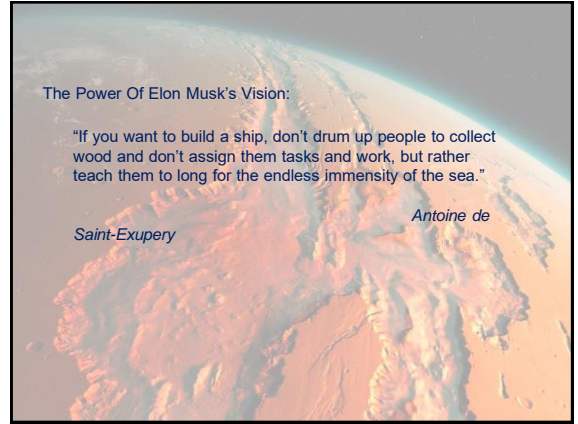
Can We Find And Mobilize Enough CO₂ To Terraform Mars?



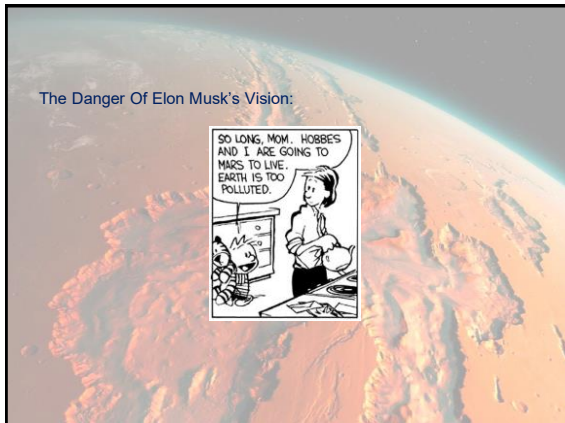
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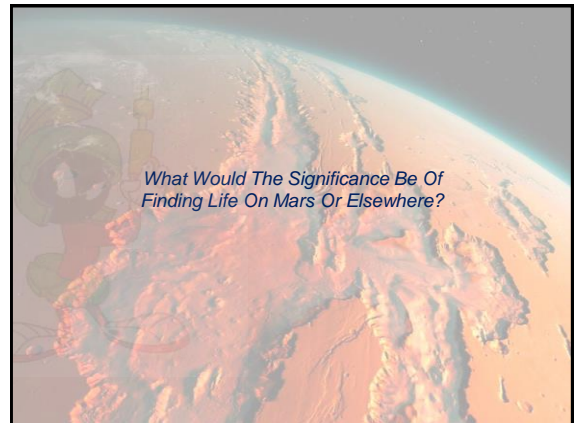
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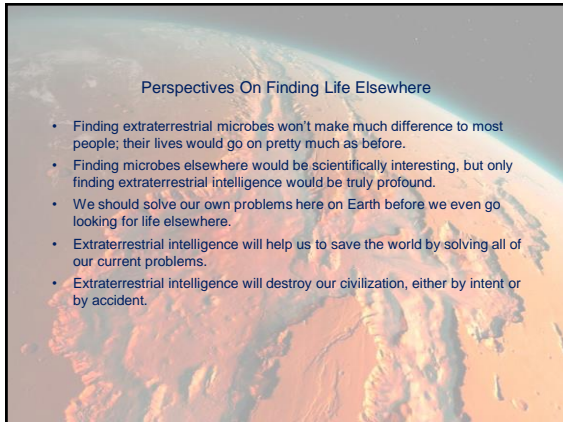
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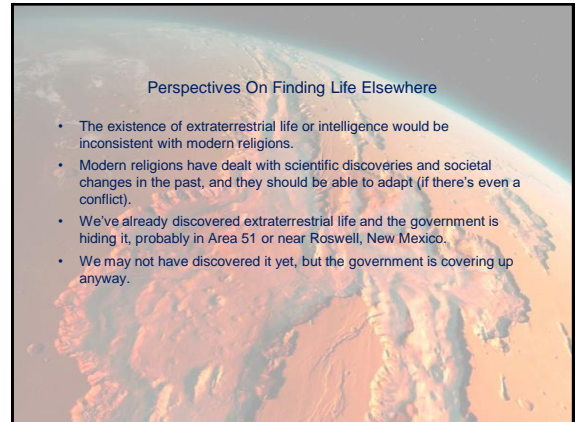
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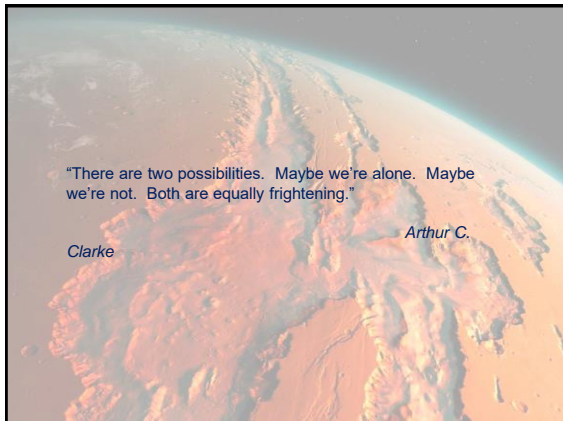
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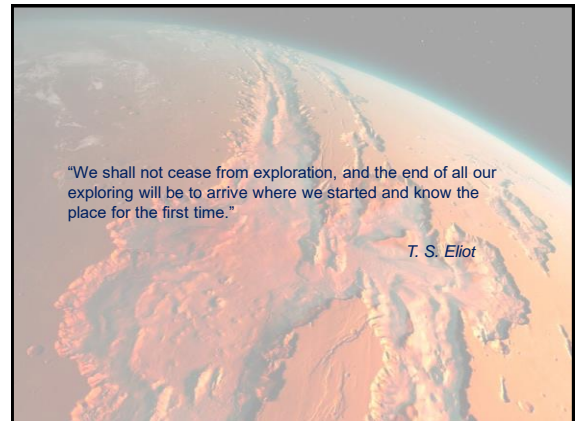
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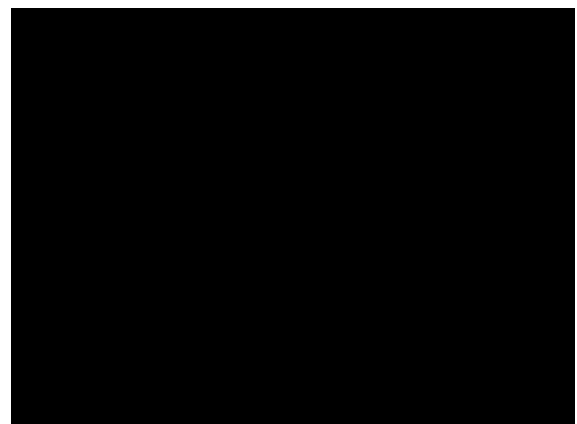
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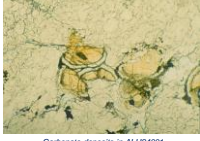
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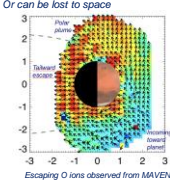
Early Mars Environment Was Warmer And Wetter Than Today: Where Did The CO₂ Go? Where Did The H₂O Go?

Atmospheric gas can go into the crust



Carbonate deposits in ALH84001

Or can be lost to space



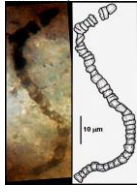
Escaping O ions observed from MAVEN

Spacecraft results suggest that both processes have been important in the evolution of the atmosphere and climate.

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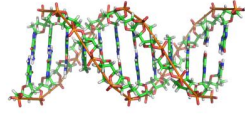
Life On Earth Guides Our Thinking About Life Elsewhere

Fossilized 3.5 b y.-old microbe




10 µm

DNA molecule



All life on Earth represents only a single independent example of life

Life can thrive in what we consider to be extreme environments



Grand Prismatic Spring, Yellowstone


Life began on Earth very quickly after it became possible

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Perseverance Rover Carried With It The *Ingenuity* Helicopter To Test Out Aerial Operations



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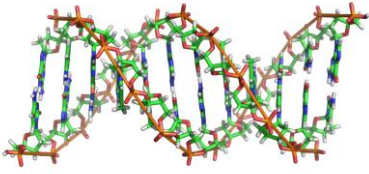
Saturn V	SLS Block 2	Starship	Space Shuttle
USA	USA	USA	USA
116.6 m	111.3 m	120 m	136 t
140 t	130 t	120 t	136 t



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Life On Earth Guides Our Thinking About Life Elsewhere


DNA molecule



All life on Earth represents only a single independent example of life

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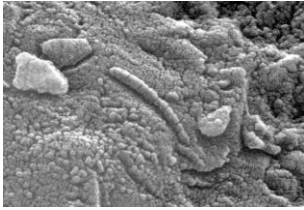
These Are Familiar Here On Earth



Dust Devil Local/regional dust storm (Phoenix) Large-scale dust storm (Dubai)

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Possible Life In ALH84001?



Structures that look like fossilized terrestrial microbes
So what's the bottom line?

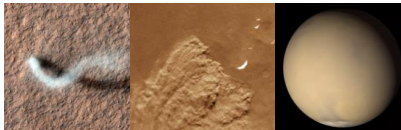
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The New York Times.



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The Weather Is Dominated By Airborne Dust



Dust Devil Local Dust Storm Global Dust Storm

These things are familiar to us:



Dust Devil Local/regional dust storm (Phoenix) Large-scale dust storm (Dubai)

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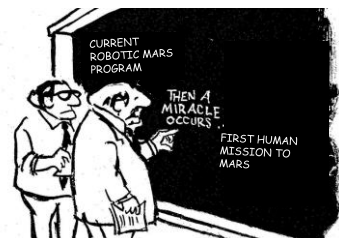
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Mars Meteorites



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Getting To The First Human Mission To Mars



"I think you need to be more explicit here in step 2"

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