# A1.1
# Water

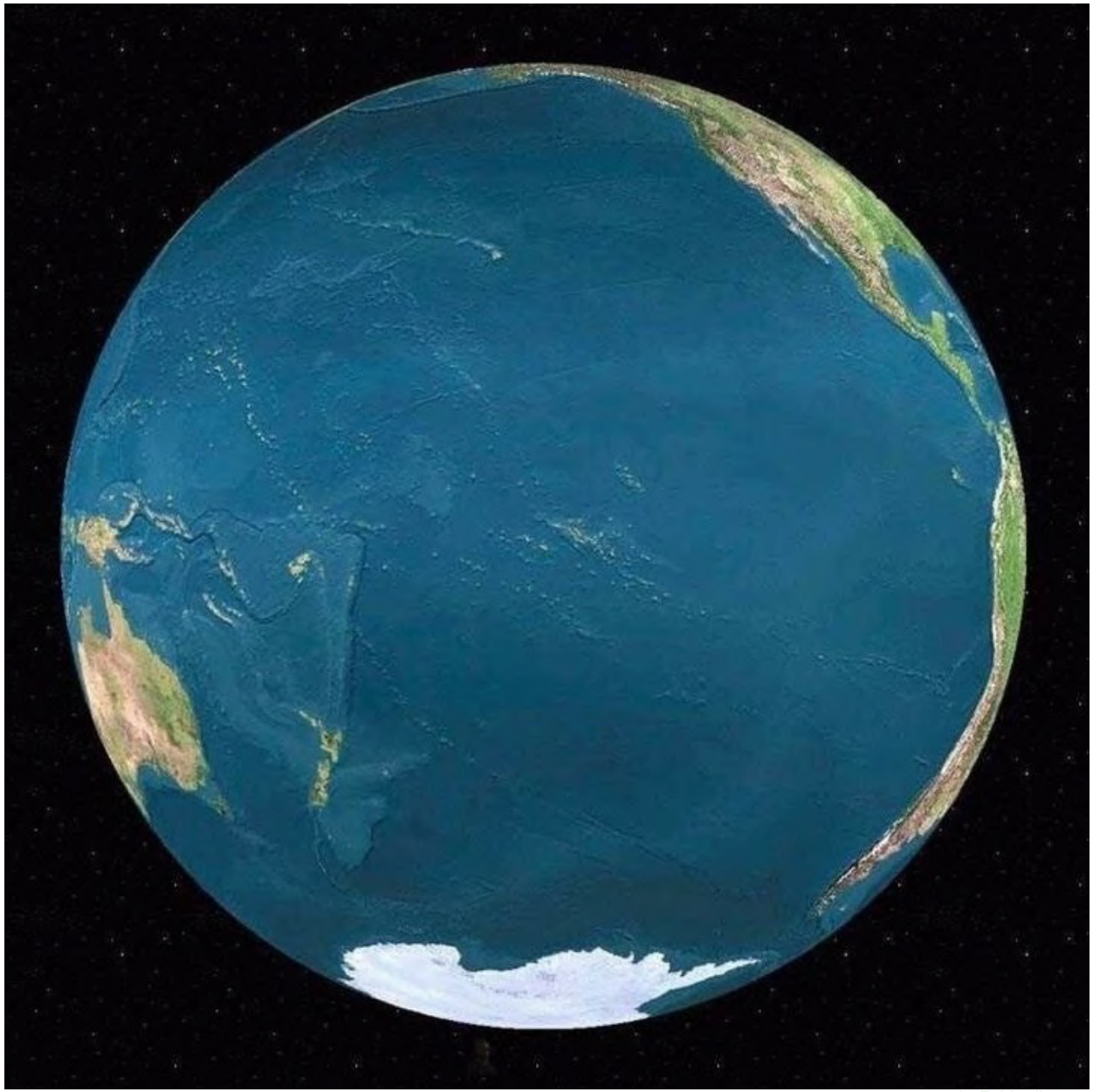
What physical and chemical properties of water make it essential for life?
What are the challenges and opportunities of water as a habitat?

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# Water as a medium of life

Just over 70% of the Earth's surface is covered by water.

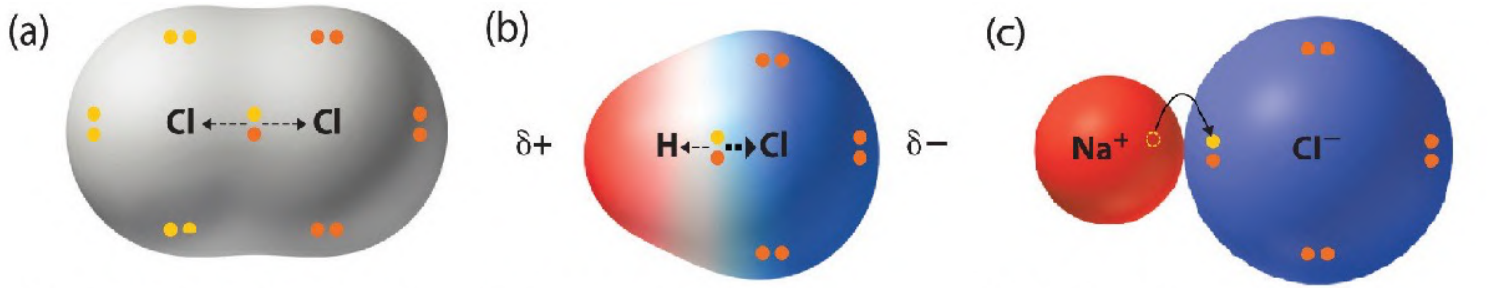
If the Earth had a smooth surface topography, then it would be completely covered in water and to a depth of more than 2.5km.



via R Nasibov

View of Earth over the Pacific Ocean, with white reflective clouds removed.

# Hydrogen bonds




**Nonpolar covalent bond**

Bonding electrons shared equally between two atoms. No charges on atoms.

**Polar covalent bond**

Bonding electrons shared unequally between two atoms. Partial charges on atoms.

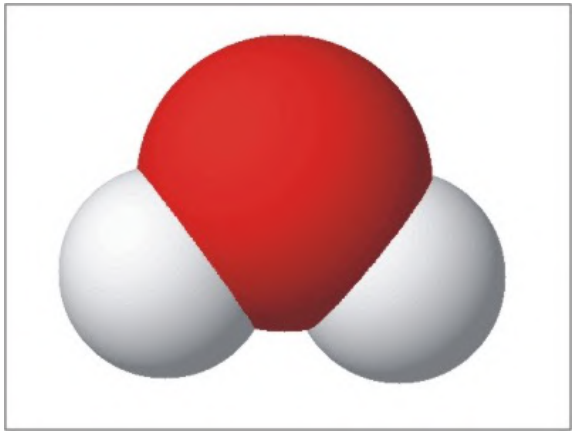
**Ionic bond**

Complete transfer of one or more valence electrons. Full charges on resulting ions.

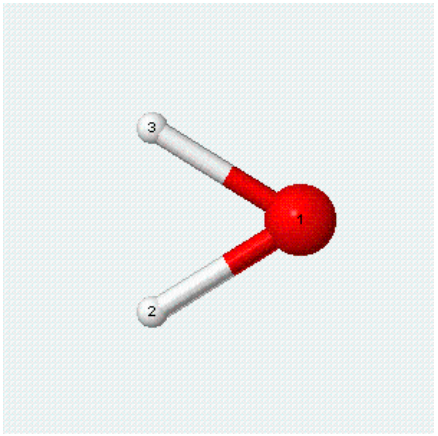
Cambridge Structural Database

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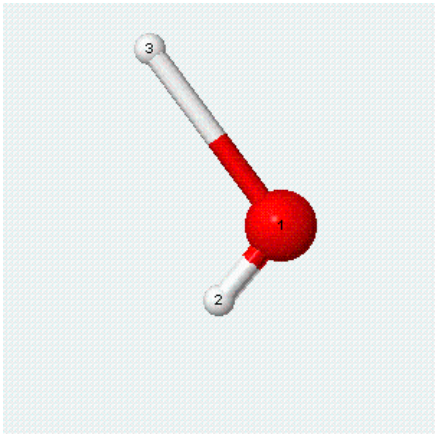
# Hydrogen bonds



Юрок гладкий

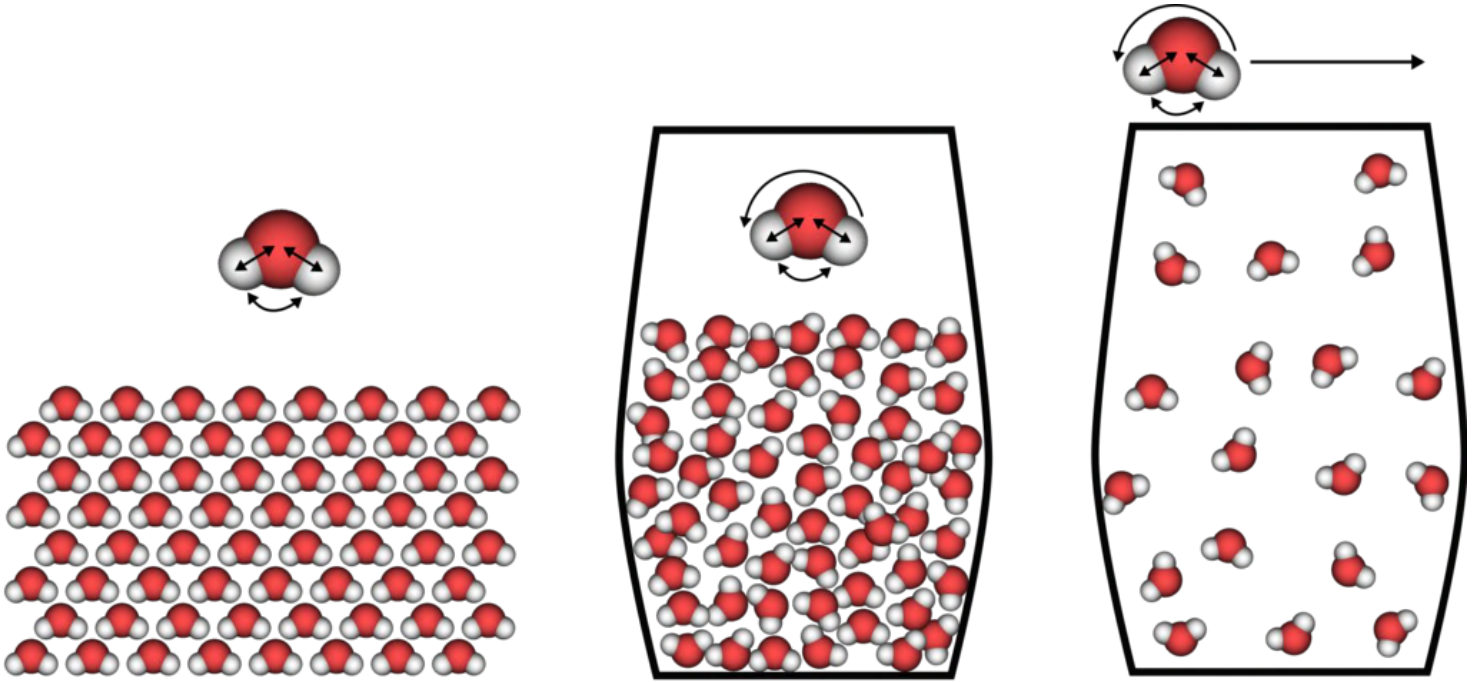



Evan585619




Evan585619

click on each hyperlink above to view animations



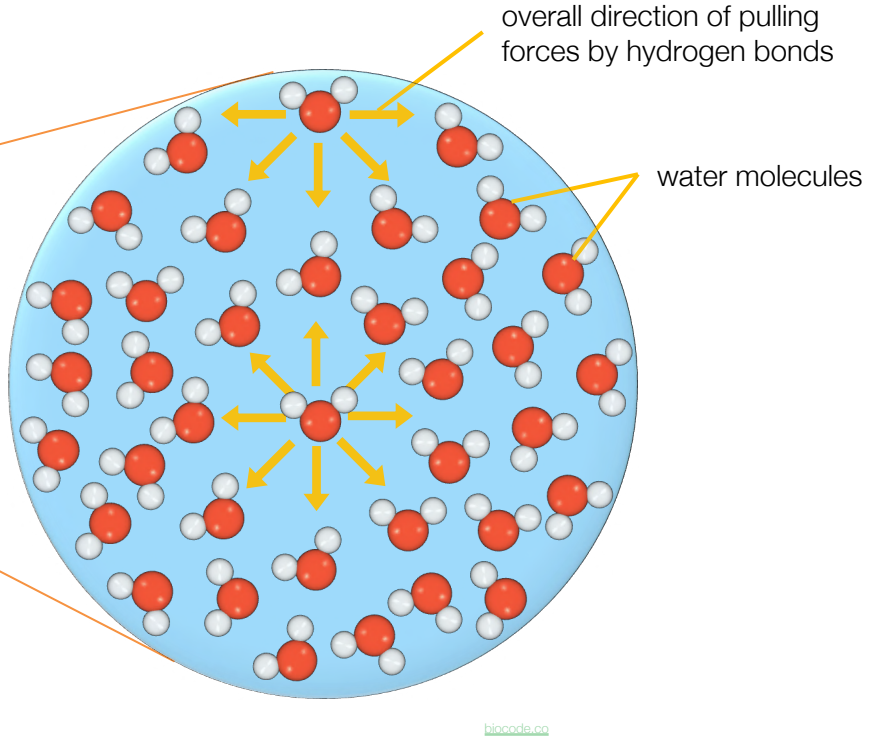
AGeremia

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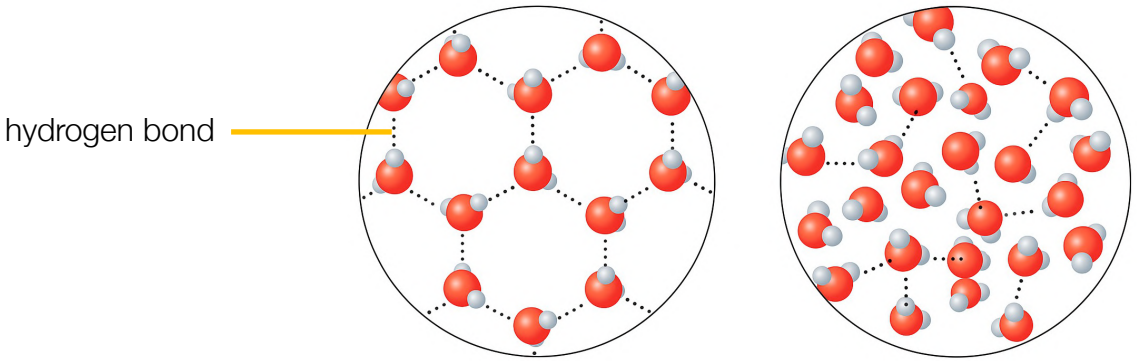
# Cohesion



Anees Ur Rehman Unsplash

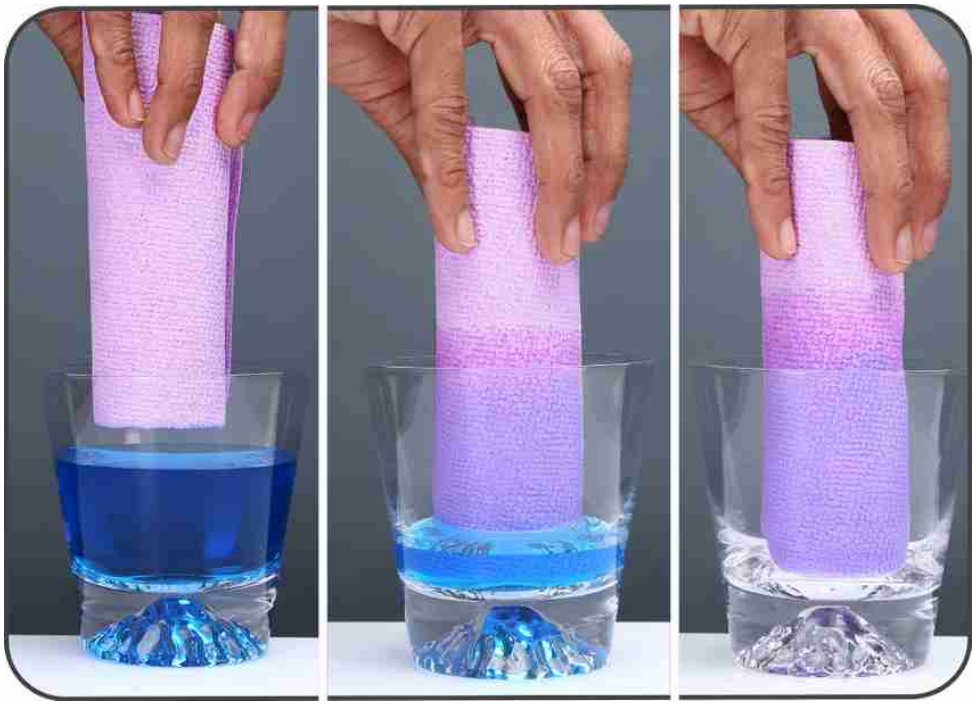



Water is sticky due to cohesion between water molecules.




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# Adhesion – capillary action

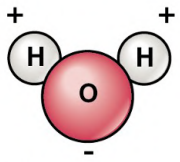



Capillary action between the fibers of a cloth.

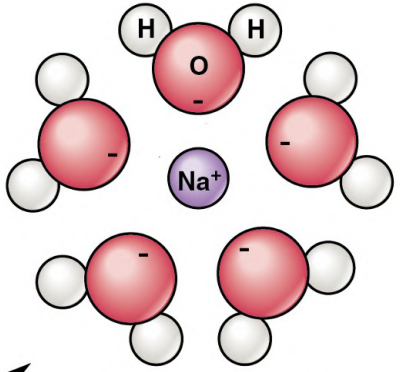
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# Solvent properties of water

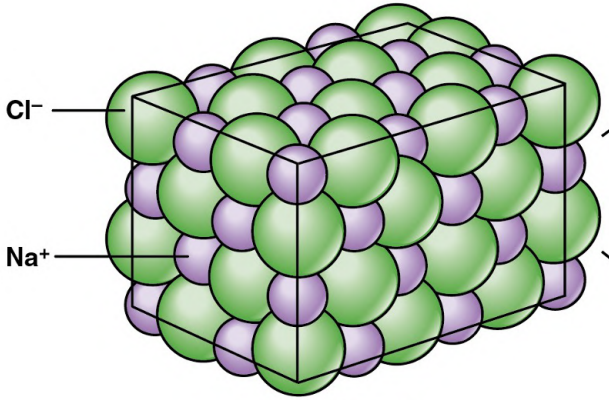


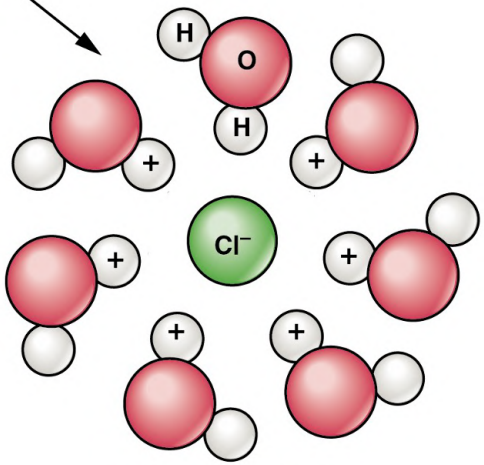

Water molecule



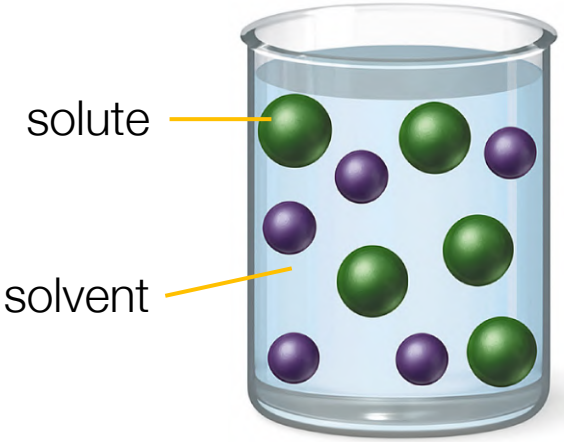

Hydrated sodium ion




Crystal of NaCl




Hydrated chloride ion

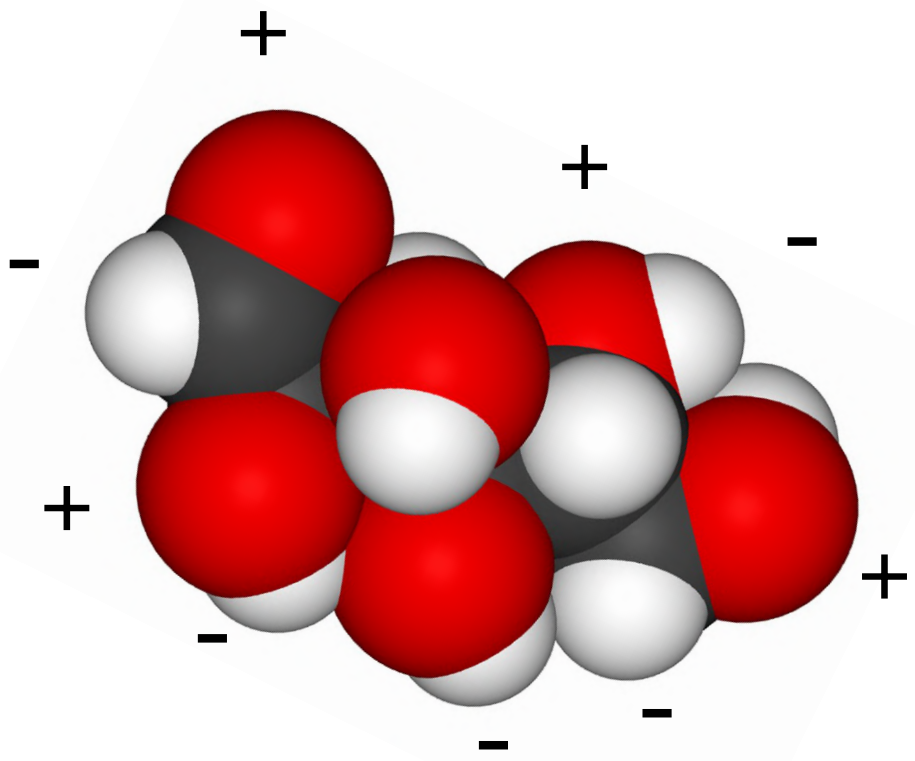



solution

adapted from OpenStax

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# Solvent properties of water



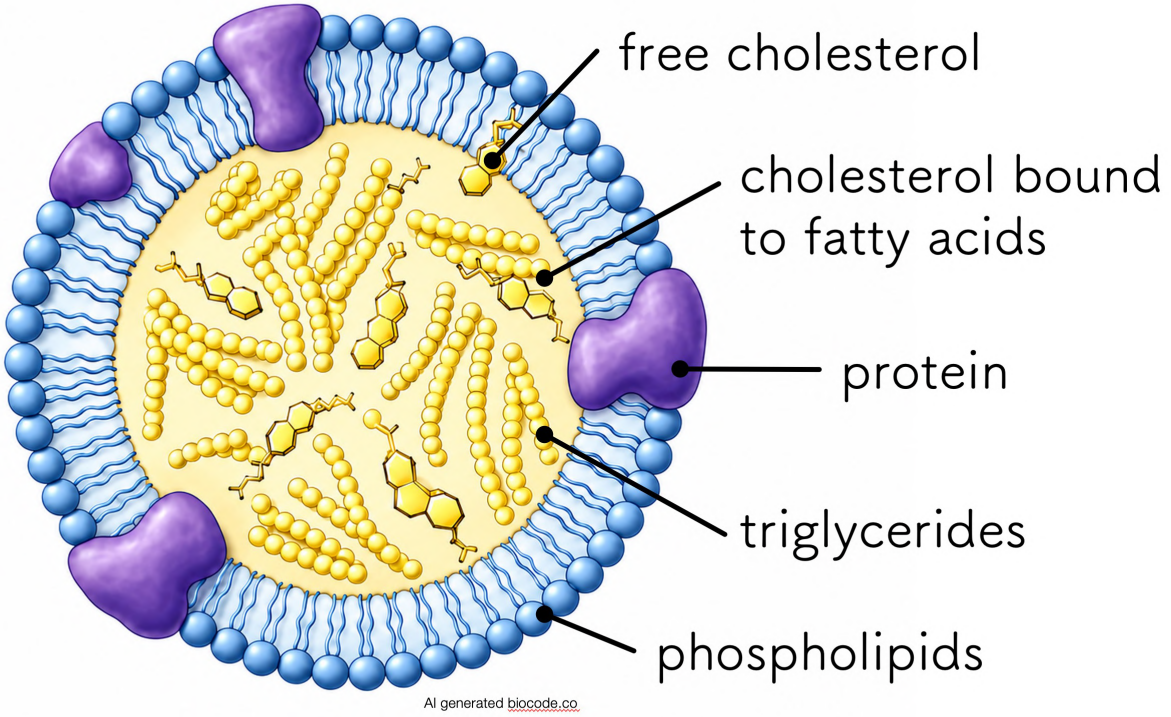

glucose molecules are hydrophilic



oil is hydrophobic

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# Solvent properties of water




lipoprotein structure

# Physical properties of water



David Brown

Water forms reflective white clouds and snow.
Ice floats on the surface of liquid water – maintaining habitat for fish beneath.

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# Physical properties of water

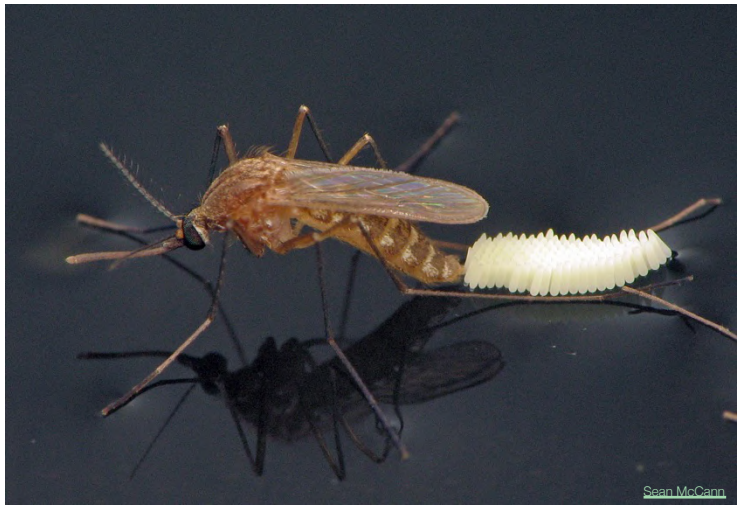


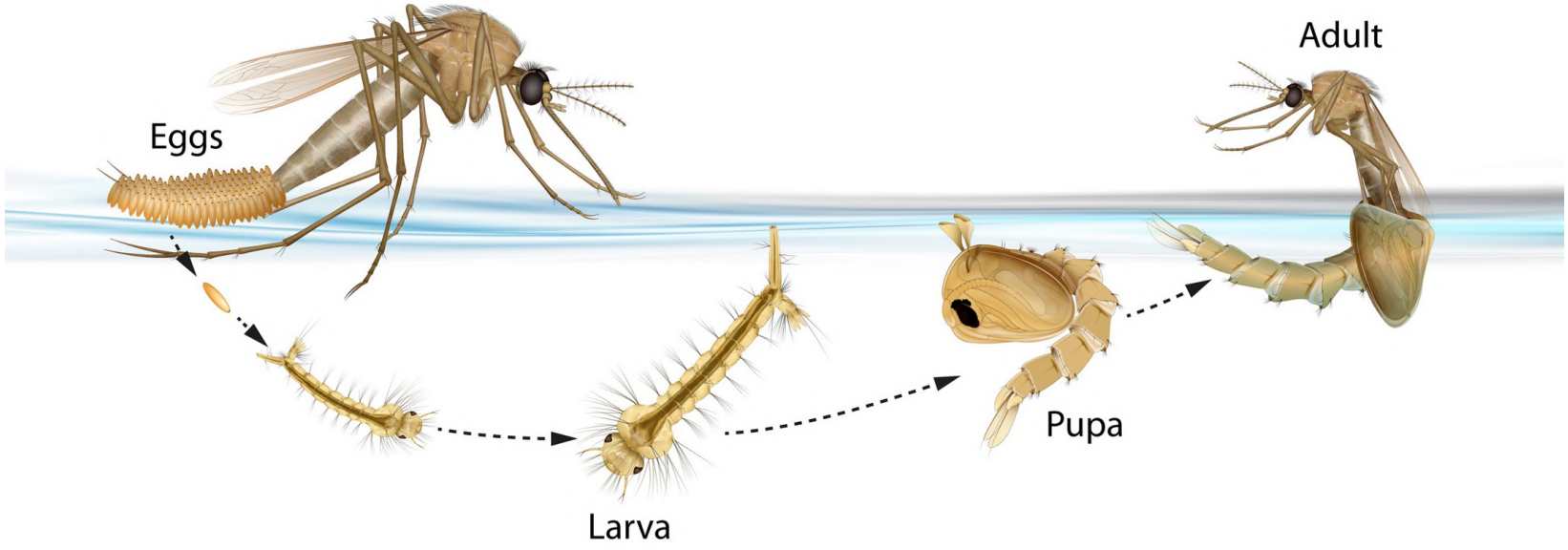
Ocrdu Wikimedia

raft spider *dolomedes fimbriatus*

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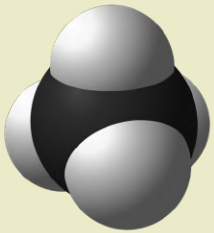
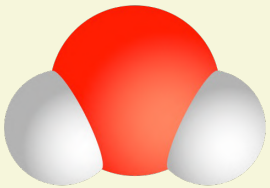
# Physical properties of water




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# Physical properties of water

| | methane | water |
|---|---|---|
| |  |  |
| formula | $CH_4$ | $H_2O$ |
| molecular mass | 16 | 18 |
| bonding | single covalent | |
| polarity | nonpolar | polar |
| density (g $cm^{-3}$) | 0.46 | 1 |
| specific heat capacity (J $g^{-1}$ $^oC^{-1}$) | 2.2 | 4.2 |
| latent heat of vaporization (J $g^{-1}$) | 760 | 2257 |
| melting point ($^oC$) | -182 | 0 |
| boiling point ($^oC$) | -160 | 100 |

methane

- waste product of anaerobic respiration in certain prokaryotes living in anaerobic conditions
- can be used as a fuel
- if present in the atmosphere it contributes to the greenhouse effect

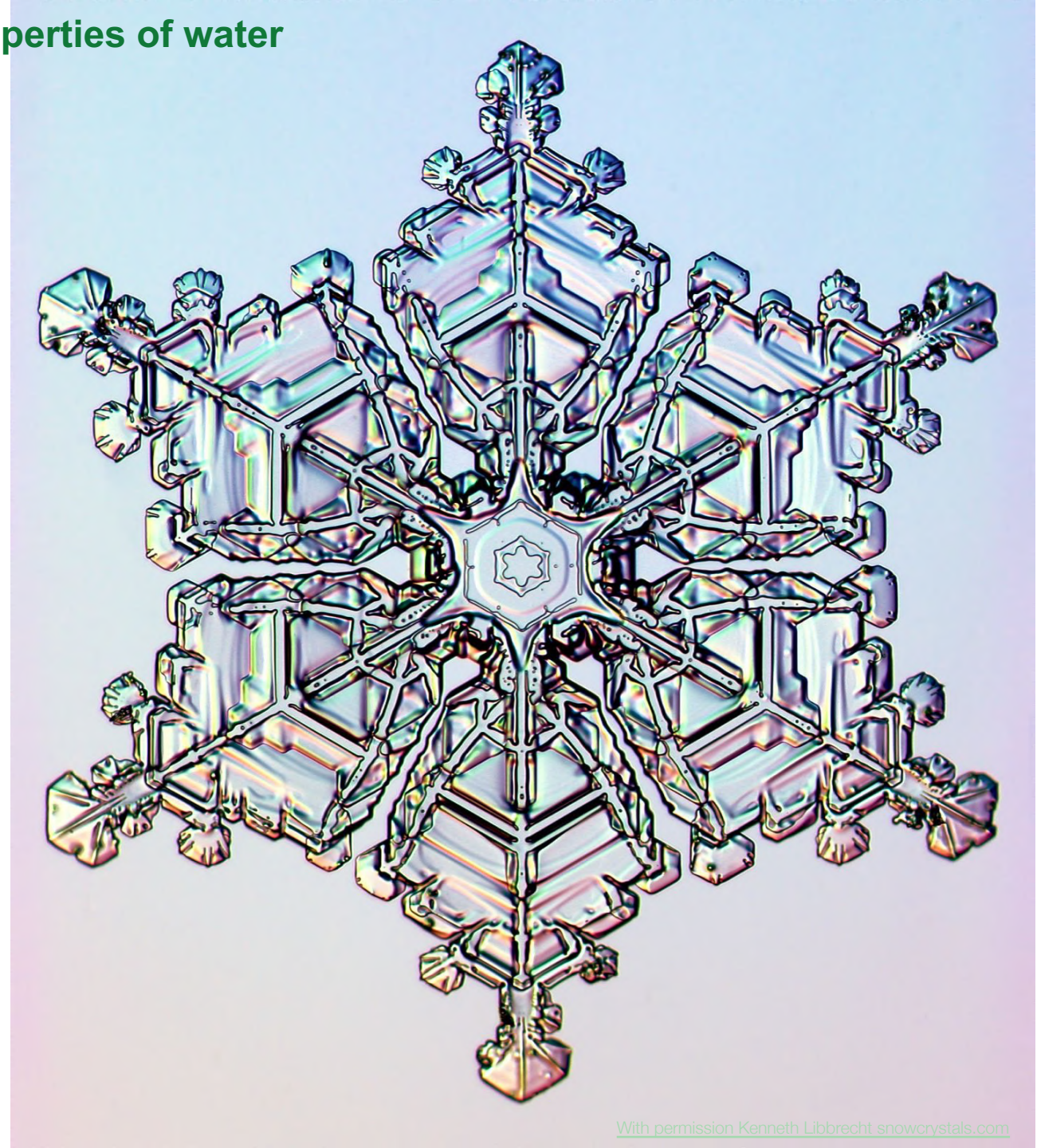
key reason for different properties

methanogenic prokaryotes are found in anaerobic:

- mud of wetlands
- stomachs of ruminants such as cattle
- decomposing waste

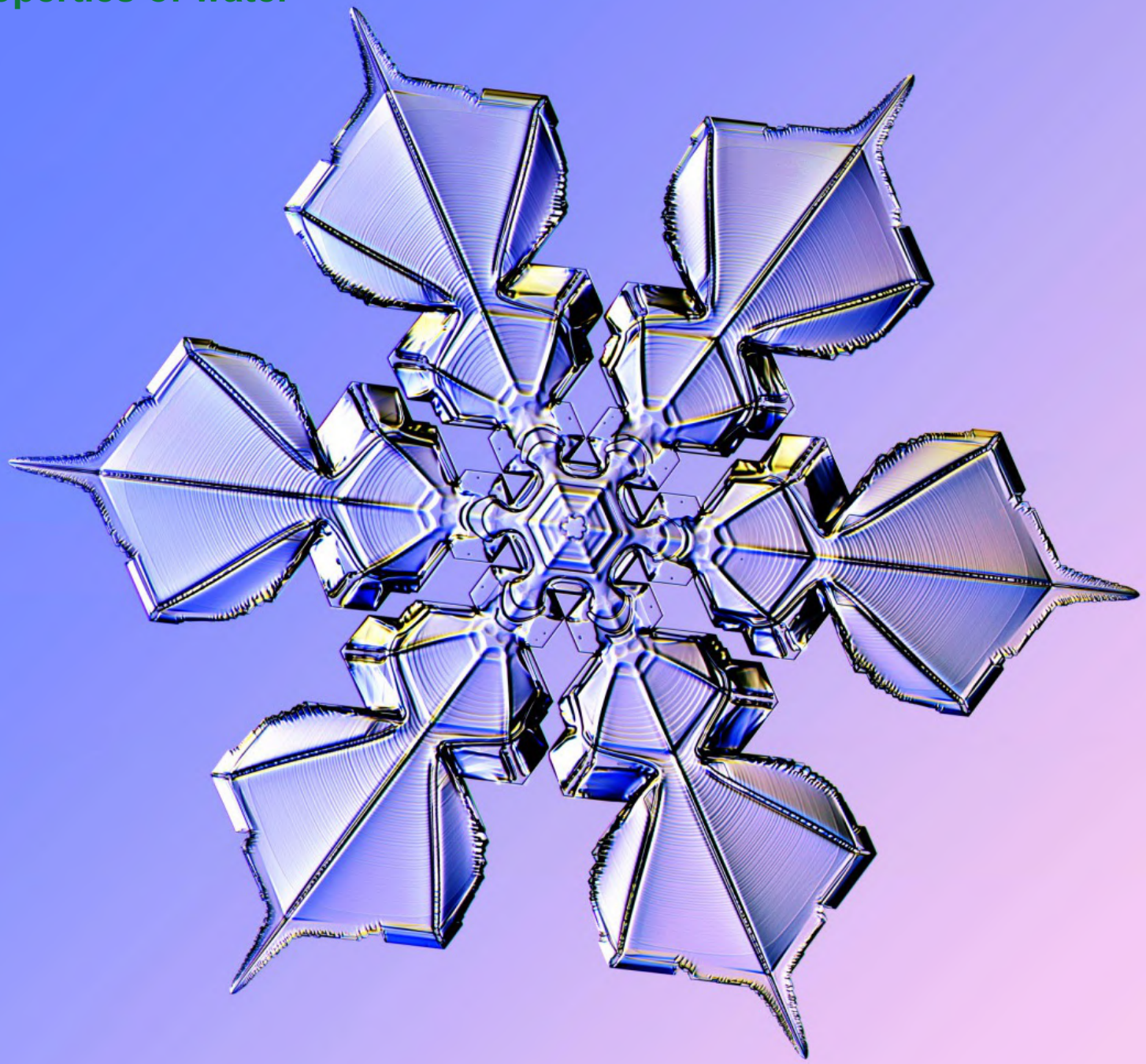
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# Physical properties of water



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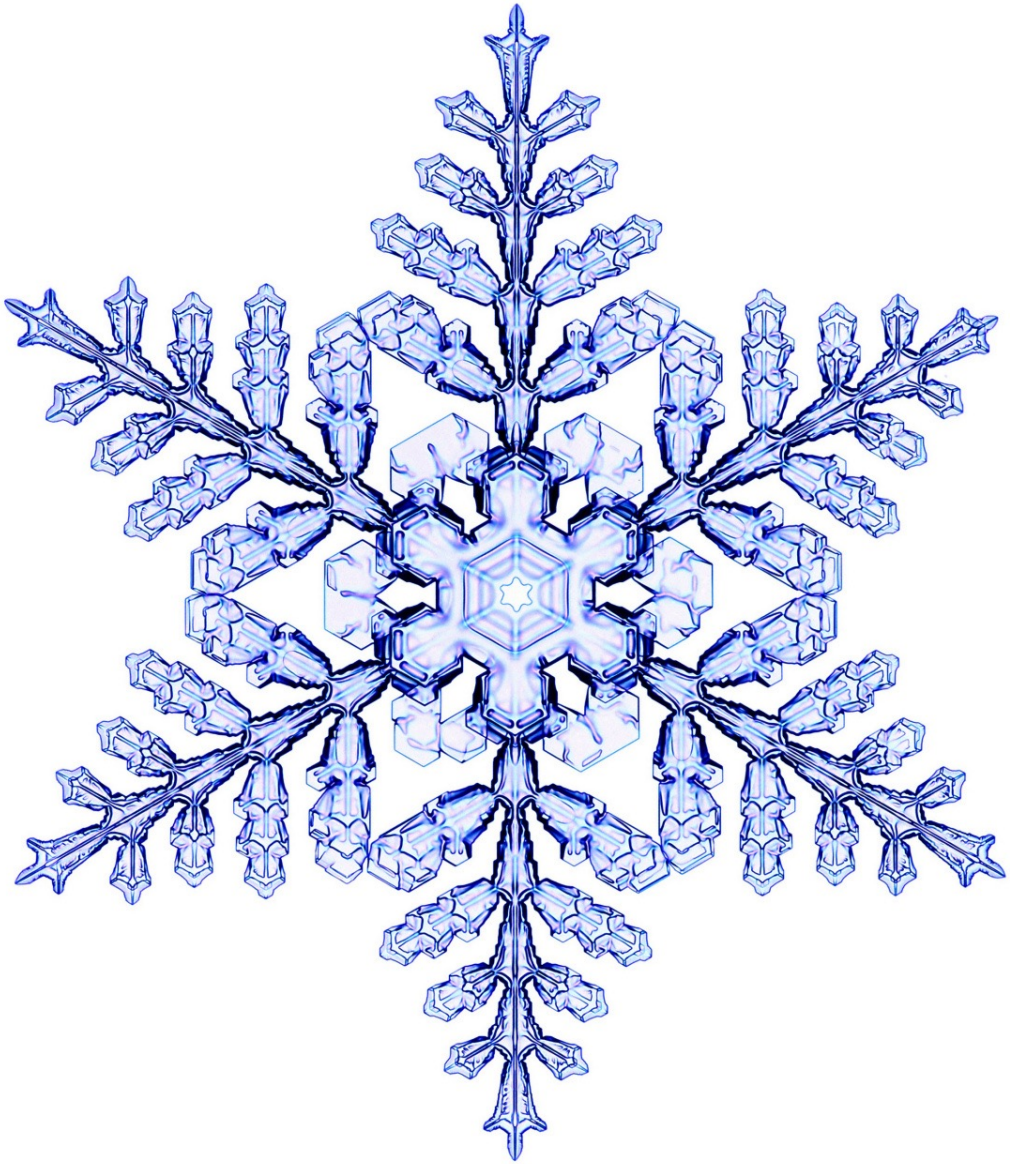
# Physical properties of water



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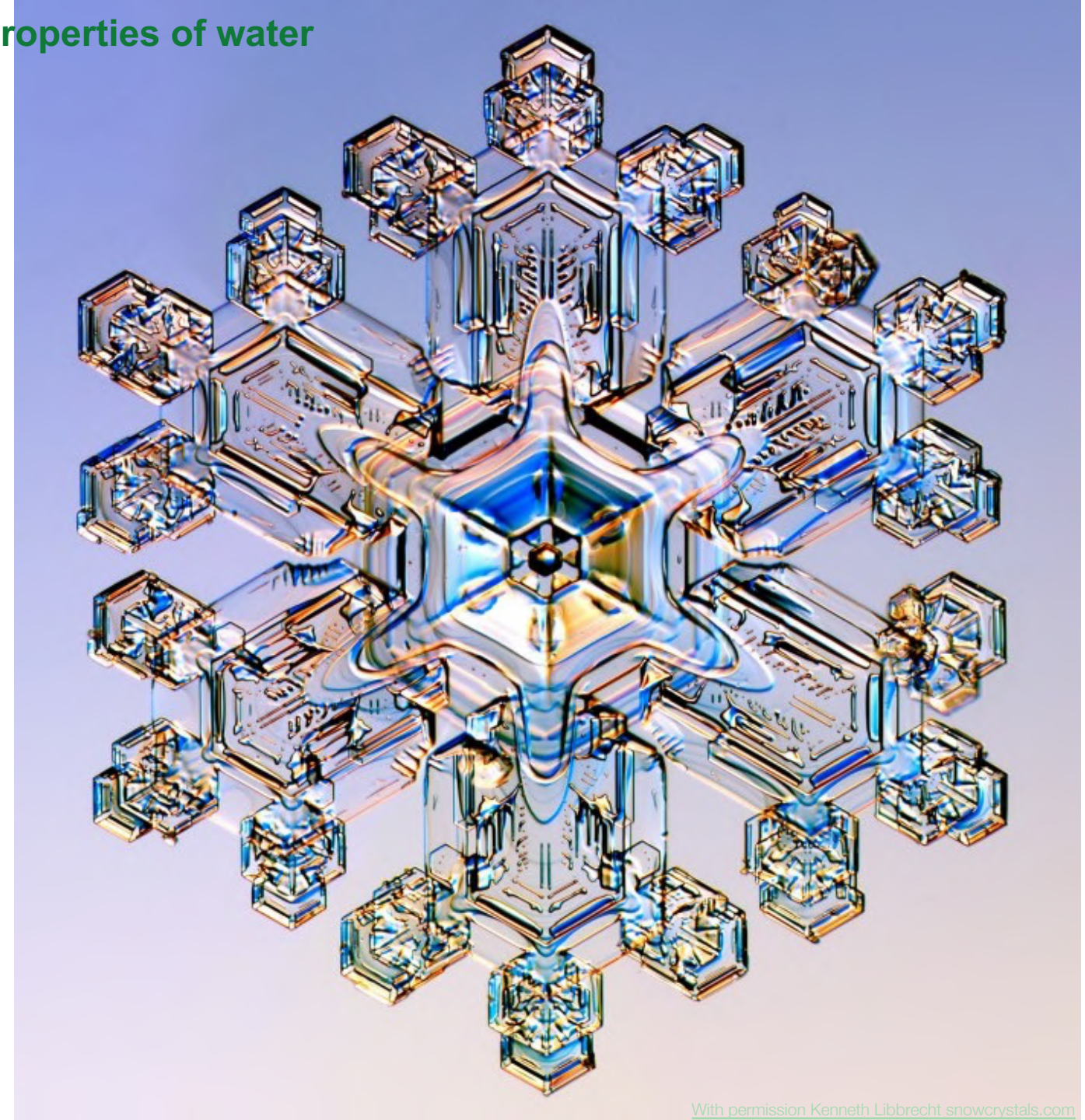


*Have you entered into the store houses of snow?*
*Job 38*



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# Physical properties of water



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## Optional Extension

(not required for the IB exam)



*"Under the microscope, I found that snowflakes were miracles of beauty;*
*and it seemed a shame that this beauty should not be seen and appreciated by others.*
*Every crystal was a masterpiece of design and no one design was ever repeated.*
*When a snowflake melted, that design was forever lost.*
*Just that much beauty was gone, without leaving any record behind."*
*— Wilson A. Bentley The Snowflake Man America's First Cloud Physicist*

# Physical properties of water



Bengt Nyman

black throated loon



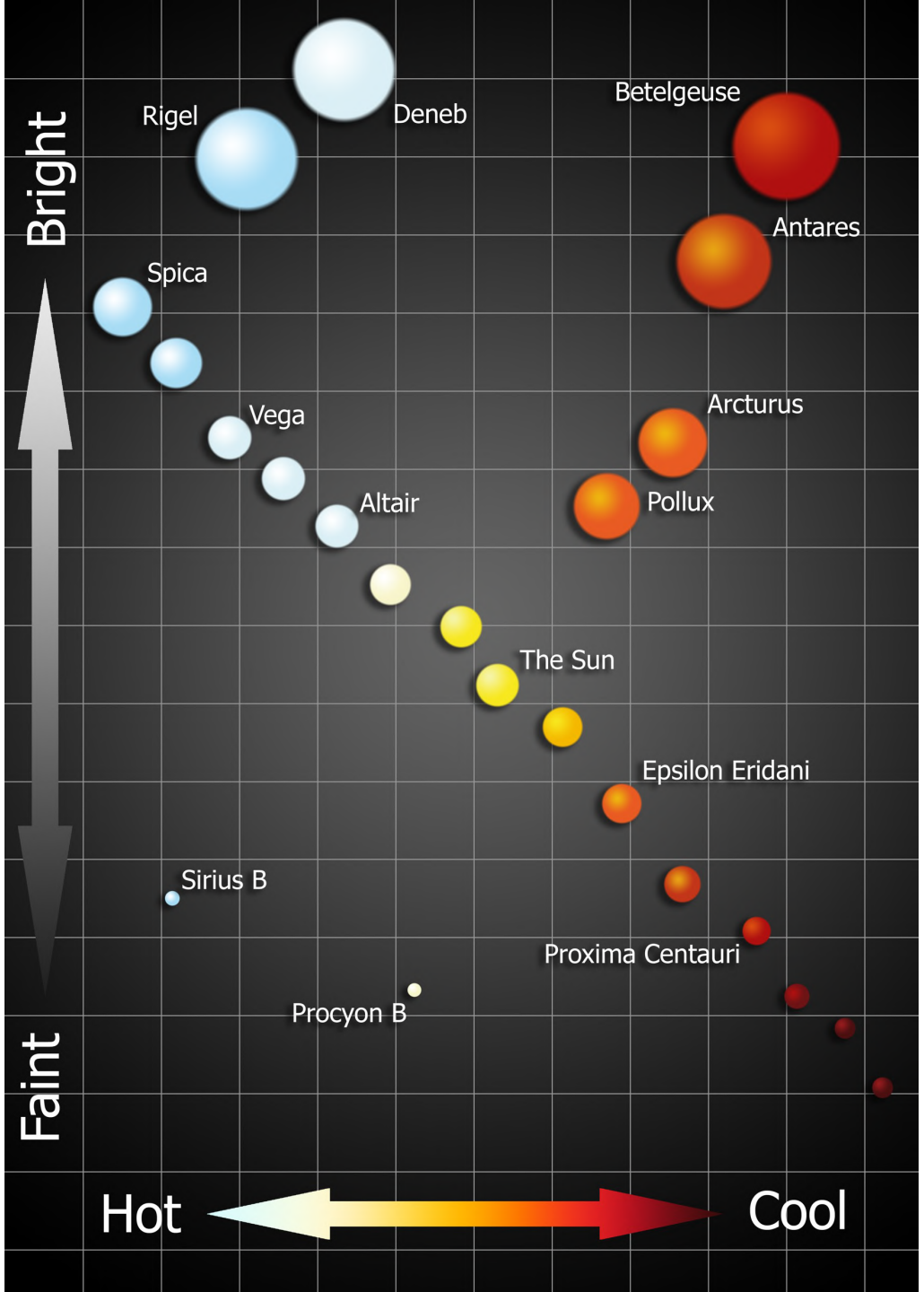
alaska sealife center

Arctic ringed seal

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# Origin of water

Star size and mass usually determines brightness and temperature.




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North CC-BY-NC-SA

# Origin of water



Cambridge University

left - an iron meteorite from the core of a melted planetesimal – contains little water
right - chondrite unmelted meteorite, from a ‘primitive’, unmelted planetesimal – contains some water
Credit: Rayssa Martins/Ross Findlay

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# Origin of water

Barrington Crater or Meteor Crater in Arizona USA



Emma Buchanan

# Origin of water

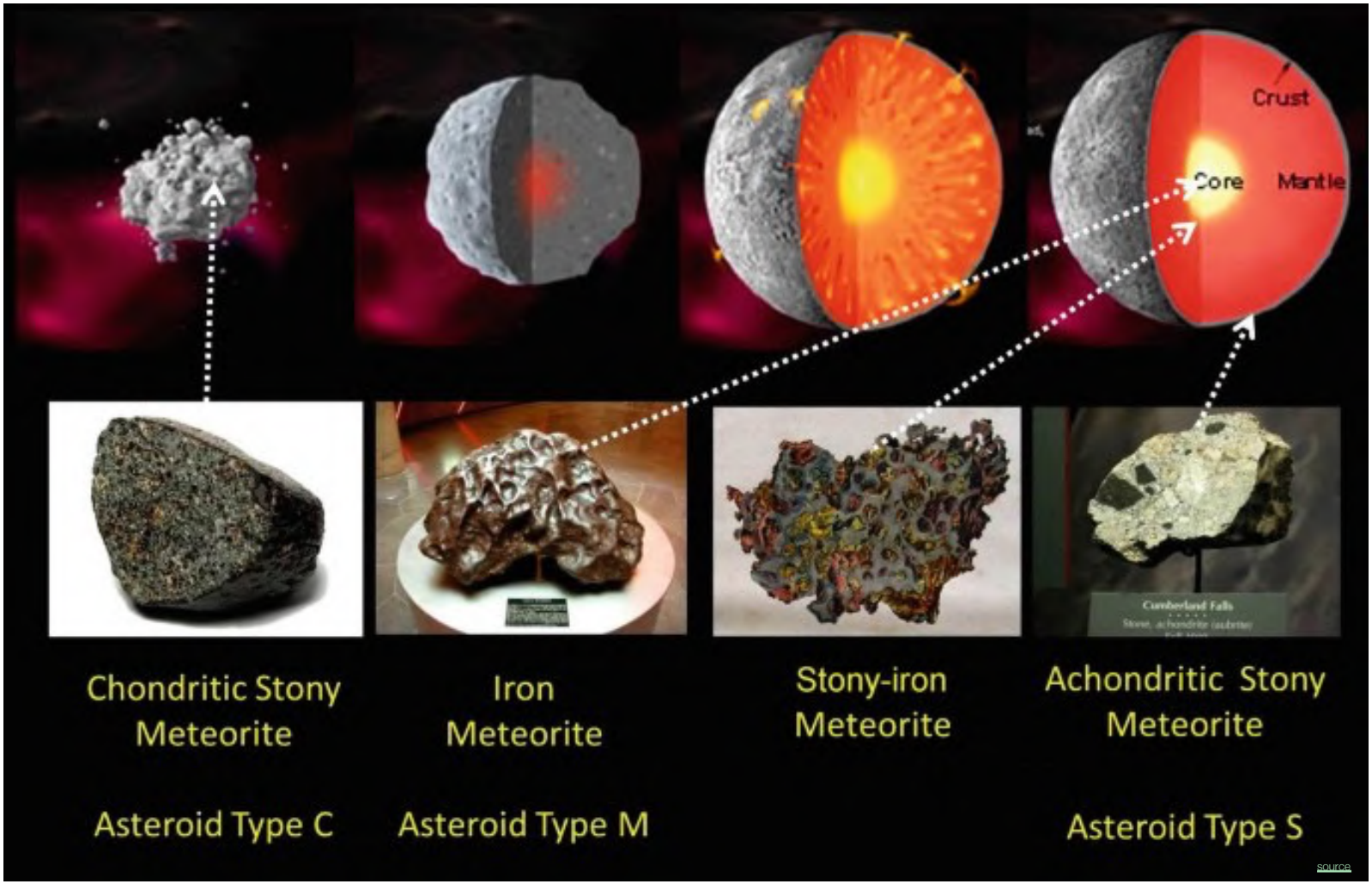
**Q:** How many asteroids would be needed every year to supply 1 386 000 000 $km^3$ of water if each asteroid contained

a) 25% water and was 40$km^3$ in volume over 200 000 000 years?

b) 10% water and was 0.1$km^3$ in volume over 4 billion years?

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# Origin of water




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# Origin of water

*Water makes up 71% of Earth's surface, but no one knows how or when such massive quantities of water arrived on Earth.*
*University of Maryland* CMNS News

*"One of the most fundamental questions on the origin of life is where the materials we need for life to evolve came from"*
*Dr Rayssa Martins*
*Cambridge's Department of Earth Sciences*

# Origin of water: answers

**Q:** How many asteroids would be needed every year to supply 1 386 000 000 $km^3$ of water if each asteroid contained

a) 25% water and was 40$km^3$ in volume over 200 000 000 years?

b) 10% water and was 0.1$km^3$ in volume over 4 billion years?

**A:**

a) Step 1 — Water per asteroid:
40 $km^3$ × 0.25 = 10 $km^3$ of water per asteroid
Step 2 — Total asteroids needed:
1,386,000,000 ÷ 10 = 138,600,000 asteroids
Step 3 — Asteroids per year:
138,600,000 ÷ 200,000,000 = 0.693 asteroids/year
Roughly ~1 asteroid every 1.44 years
(a 40$km^3$ asteroid is bigger than the one that was thought to have selectively wiped out the dinosaurs)

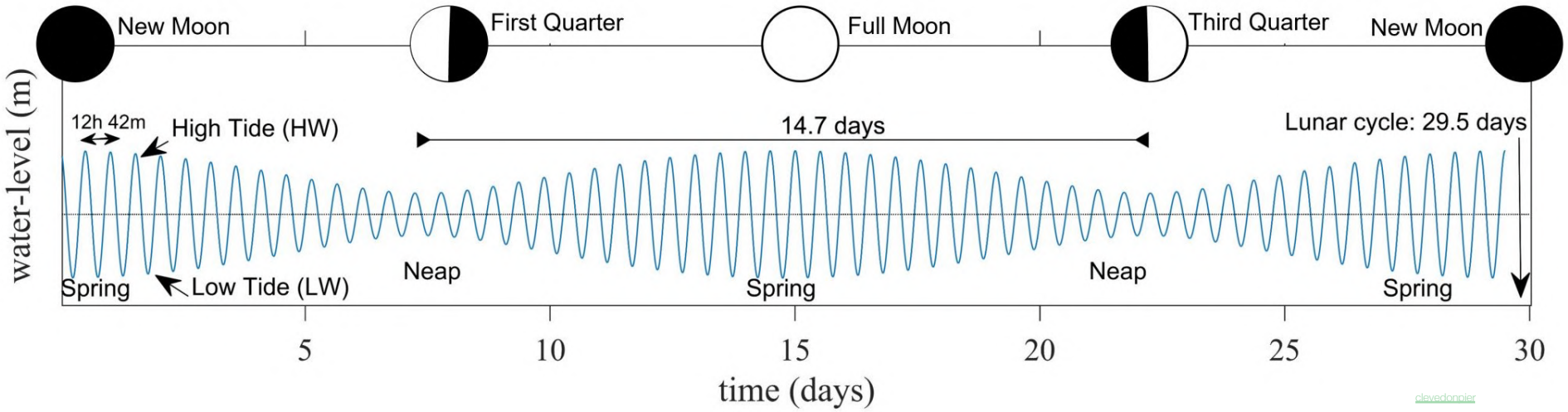
b) 10% water, 0.1 $km^3$ volume, over 4,000,000,000 years
Step 1 — Water per asteroid:
0.1 $km^3$ × 0.10 = 0.01 $km^3$ of water per asteroid
Step 2 — Total asteroids needed:
1,386,000,000 ÷ 0.01 = 138,600,000,000 asteroids
Step 3 — Asteroids per year:
138,600,000,000 ÷ 4,000,000,000 = 34.65 asteroids/year
Roughly ~35 asteroids every year or 1.5 a week

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## Optional Extension

(not required for the IB exam)




Without daily tides and their decreasing then increasing size over a 15 day cycle there would not be productive and diverse coastal wetlands.

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## Optional Extension
(not required for the IB exam)



The solar corona with streamer and prominences (in red).
Moon is illuminated by earth shine. Aug 21 2017

M Adler

## Optional Extension
(not required for the IB exam)

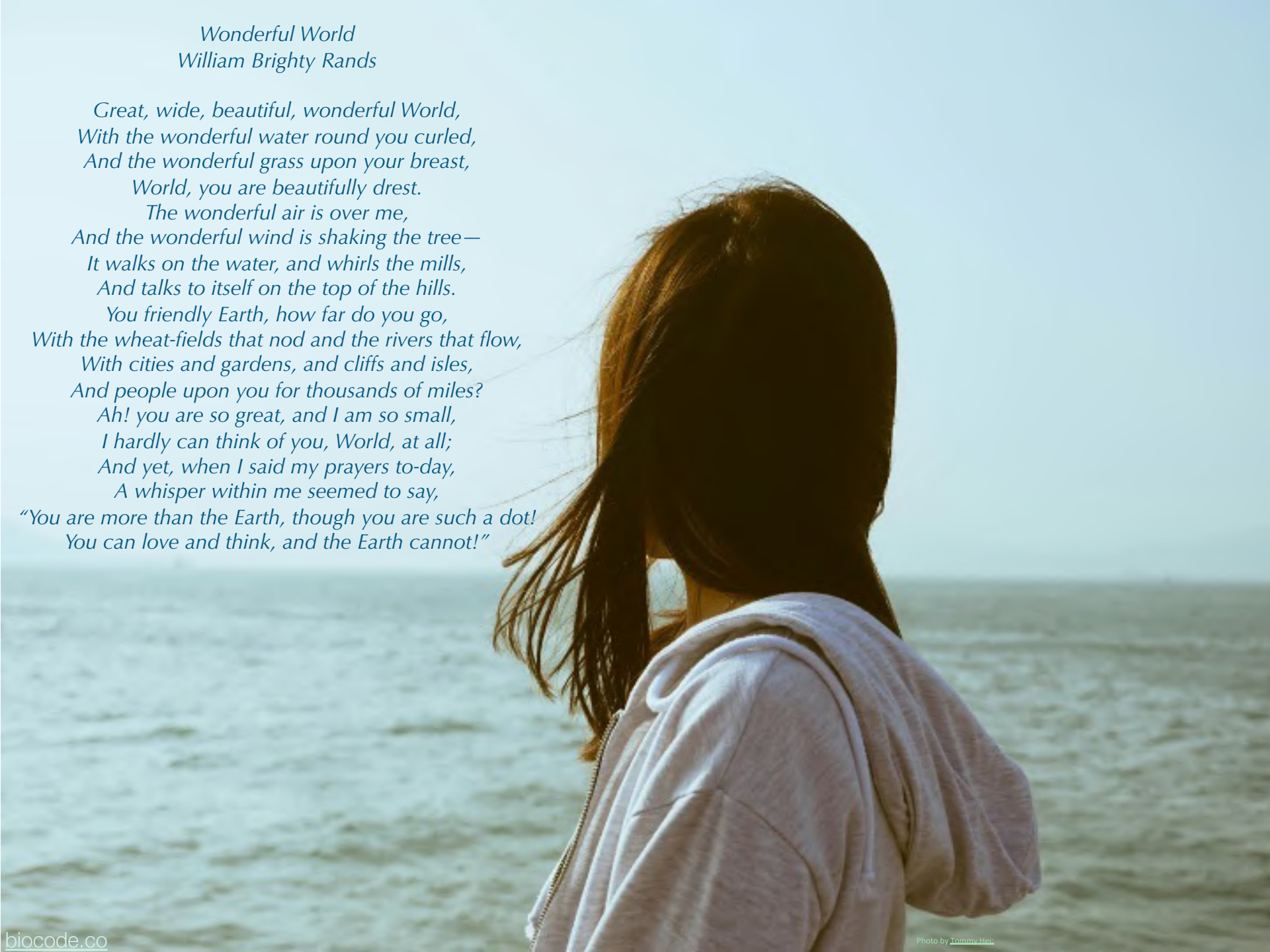
Was the Universe Designed? with Dr Faulkener




Annular solar eclipse with diamond ring effect.

*Wonderful World*
*William Brighty Rands*

*Great, wide, beautiful, wonderful World,*
*With the wonderful water round you curled,*
*And the wonderful grass upon your breast,*
*World, you are beautifully drest.*
*The wonderful air is over me,*
*And the wonderful wind is shaking the tree—*
*It walks on the water, and whirls the mills,*
*And talks to itself on the top of the hills.*
*You friendly Earth, how far do you go,*
*With the wheat-fields that nod and the rivers that flow,*
*With cities and gardens, and cliffs and isles,*
*And people upon you for thousands of miles?*
*Ah! you are so great, and I am so small,*
*I hardly can think of you, World, at all;*
*And yet, when I said my prayers to-day,*
*A whisper within me seemed to say,*
*"You are more than the Earth, though you are such a dot!*
*You can love and think, and the Earth cannot!"*



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Photo by Tommy Hei



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