Surface Tension and Wetting

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Let’s start with some chemistry

What is?

$$H_2$$

Let's start with some chemistry

What is?

$$N_2$$

Let's start with some chemistry

What is?

$$O_2$$

Let's start with some chemistry

What is?

S

Let's try some more chemistry

What is?

$$H_2O$$

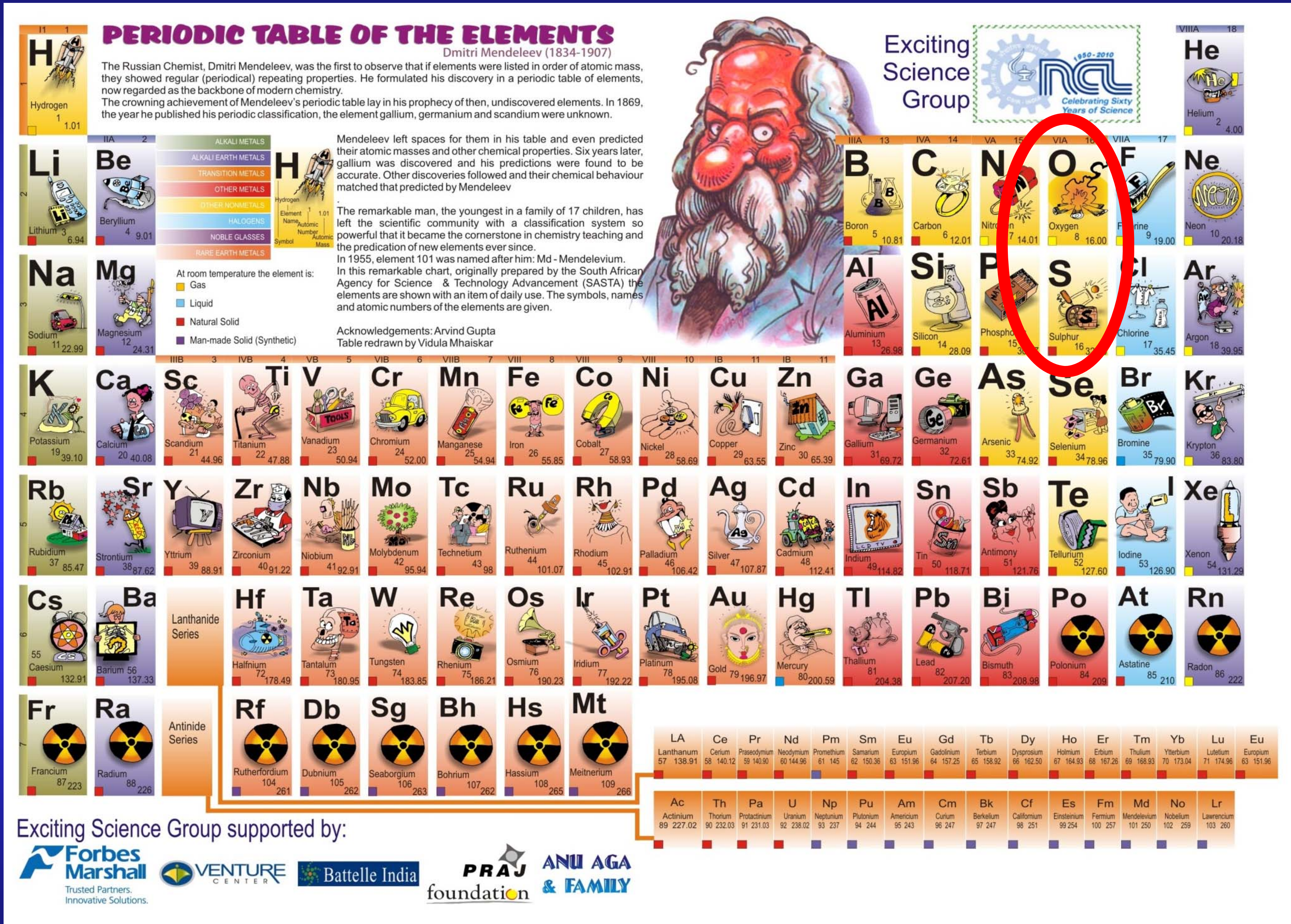
What are the properties of H_2O?

Let's try some more chemistry

What is?

H_2S

What are the properties of H_2S?


PERIODIC TABLE OF THE ELEMENTS
Dmitri Mendeleev (1834-1907)
The Russian Chemist, Dmitri Mendeleev, was the first to observe that if elements were listed in order of atomic mass, they showed regular (periodical) repeating properties. He formulated his discovery in a periodic table of elements, now regarded as the backbone of modern chemistry.
The crowning achievement of Mendeleev's periodic table lay in his prophecy of then, undiscovered elements. In 1869, the year he published his periodic classification, the element gallium, germanium and scandium were unknown.
Mendeleev left spaces for them in his table and even predicted their atomic masses and other chemical properties. Six years later, gallium was discovered and his predictions were found to be accurate. Other discoveries followed and their chemical behaviour matched that predicted by Mendeleev
The remarkable man, the youngest in a family of 17 children, has left the scientific community with a classification system so powerful that it became the cornerstone in chemistry teaching and the predication of new elements ever since.
In 1955, element 101 was named after him: Md - Mendelevium.
In this remarkable chart, originally prepared by the South African Agency for Science & Technology Advancement (SASTA) the elements are shown with an item of daily use. The symbols, names and atomic numbers of the elements are given.
Acknowledgements: Arvind Gupta
Table redrawn by Vidula Mhaiskar
ALKALI METALS
ALKALI EARTH METALS
TRANSITION METALS
OTHER METALS
OTHER NONMETALS
HALOGENS
NOBLE GLASSES
RARE EARTH METALS
At room temperature the element is:
Gas
Liquid
Natural Solid
Man-made Solid (Synthetic)
Exciting Science Group
Celebrating Sixty Years of Science
Lanthanide Series
Antinide Series
Exciting Science Group supported by:
Forbes Marshall
Trusted Partners. Innovative Solutions.
VENTURE CENTER
Battelle India
PRAJ foundation
ANU AGA & FAMILY

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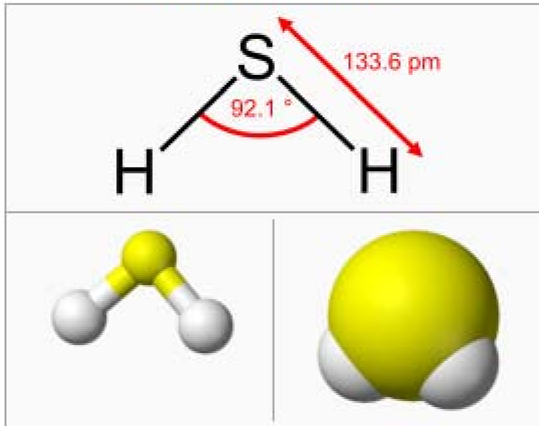
Hydrogen sulfide

From Wikipedia, the free encyclopedia

Hydrogen sulfide is the chemical compound with the formula H_2S. It is a colorless gas with the characteristic foul odor of rotten eggs; it is heavier than air, very poisonous, corrosive, flammable, and explosive; properties shared with the denser hydrogen chalcogenides.

Hydrogen sulfide often results from the prokaryotic breakdown of organic matter in the absence of oxygen gas, such as in swamps and sewers; this process is commonly known as anaerobic digestion. H_2S also occurs in volcanic gases, natural gas, and in some sources of well water. It is also present in natural halite type rock salts, most notably in Himalayan Black Salt, which is mostly harvested from the mineral-rich Salt Range mountains of Pakistan. The human body produces small amounts of H_2S and uses it as

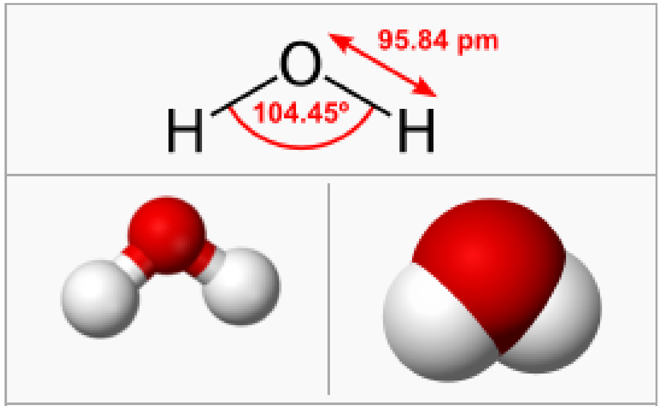
Hydrogen sulfide



Water (H_2O) is a polar inorganic compound that is at room temperature a tasteless and odorless liquid, nearly colorless with a hint of blue. The simplest hydrogen chalcogenide, it is by far the most studied chemical compound and is described as the "universal solvent" for its ability to dissolve many substances.[13][14] This allows it to be the "solvent of life".[15] It is the only common substance to exist as a solid, liquid, and gas in nature.[16]

Water molecules form hydrogen bonds with each other and are strongly polar. This polarity allows it to separate ions in salts and strongly bond to

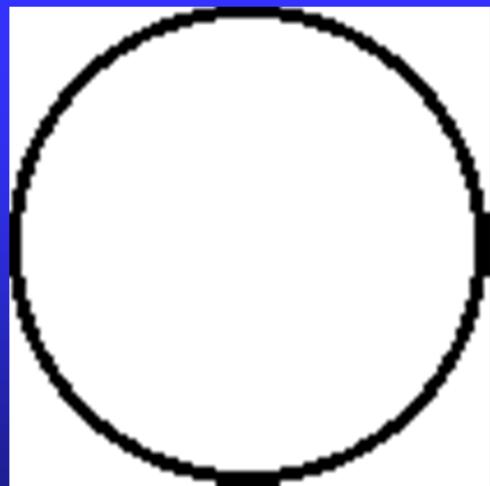
Water (H_2O)



We expect S and O to have similar properties...

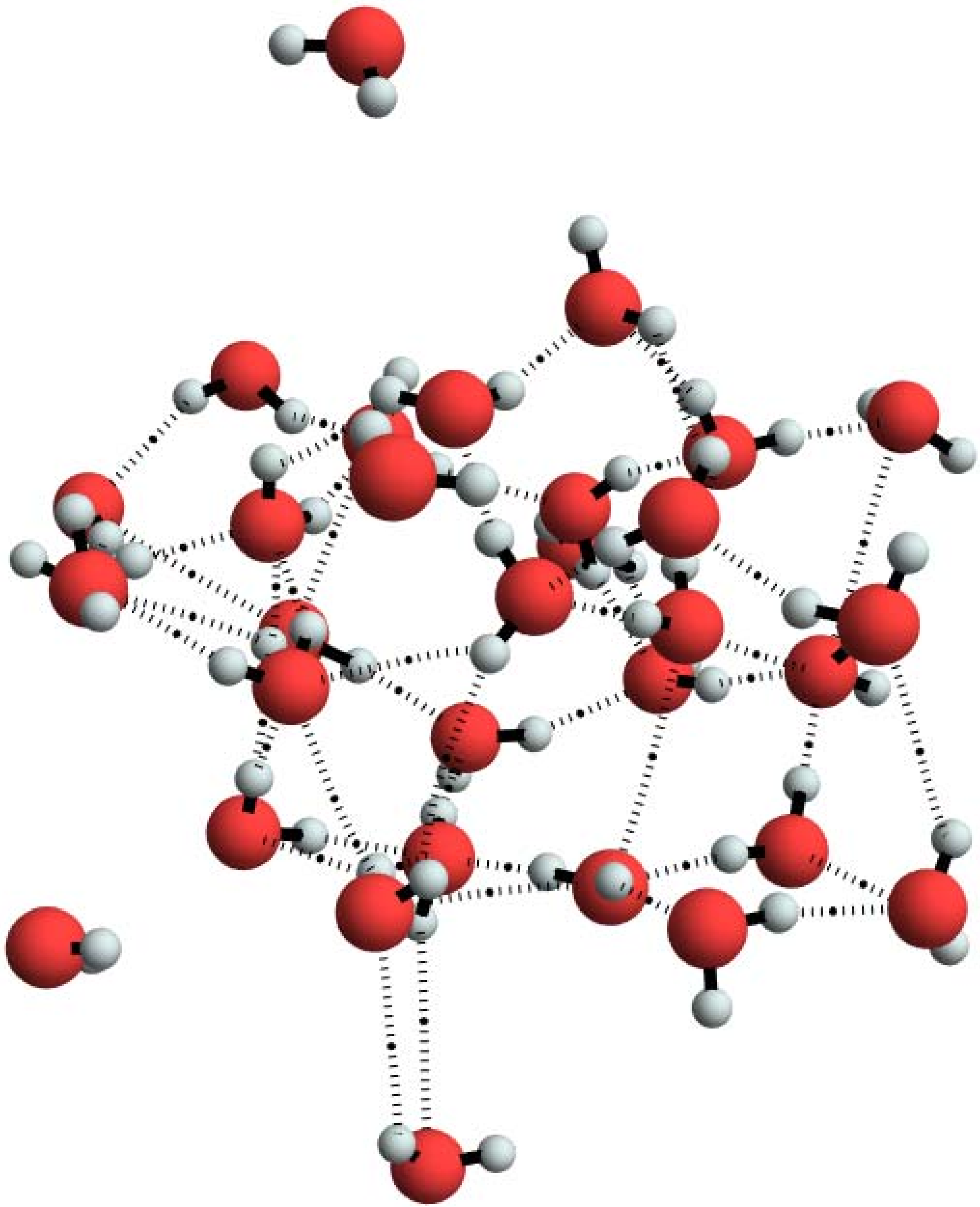
H_2S a gas while H_2O is a liquid .
WHY?

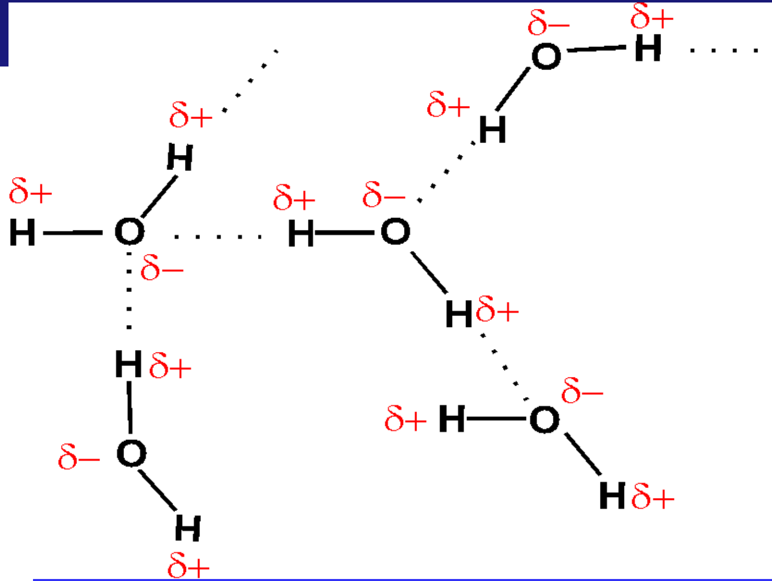
The difference between a gas and a liquid?



http://www.chem.purdue.edu/gchelp/atoms/states.html

Molecules in a liquid are STUCK to each other





Water forms hydrogen bonds

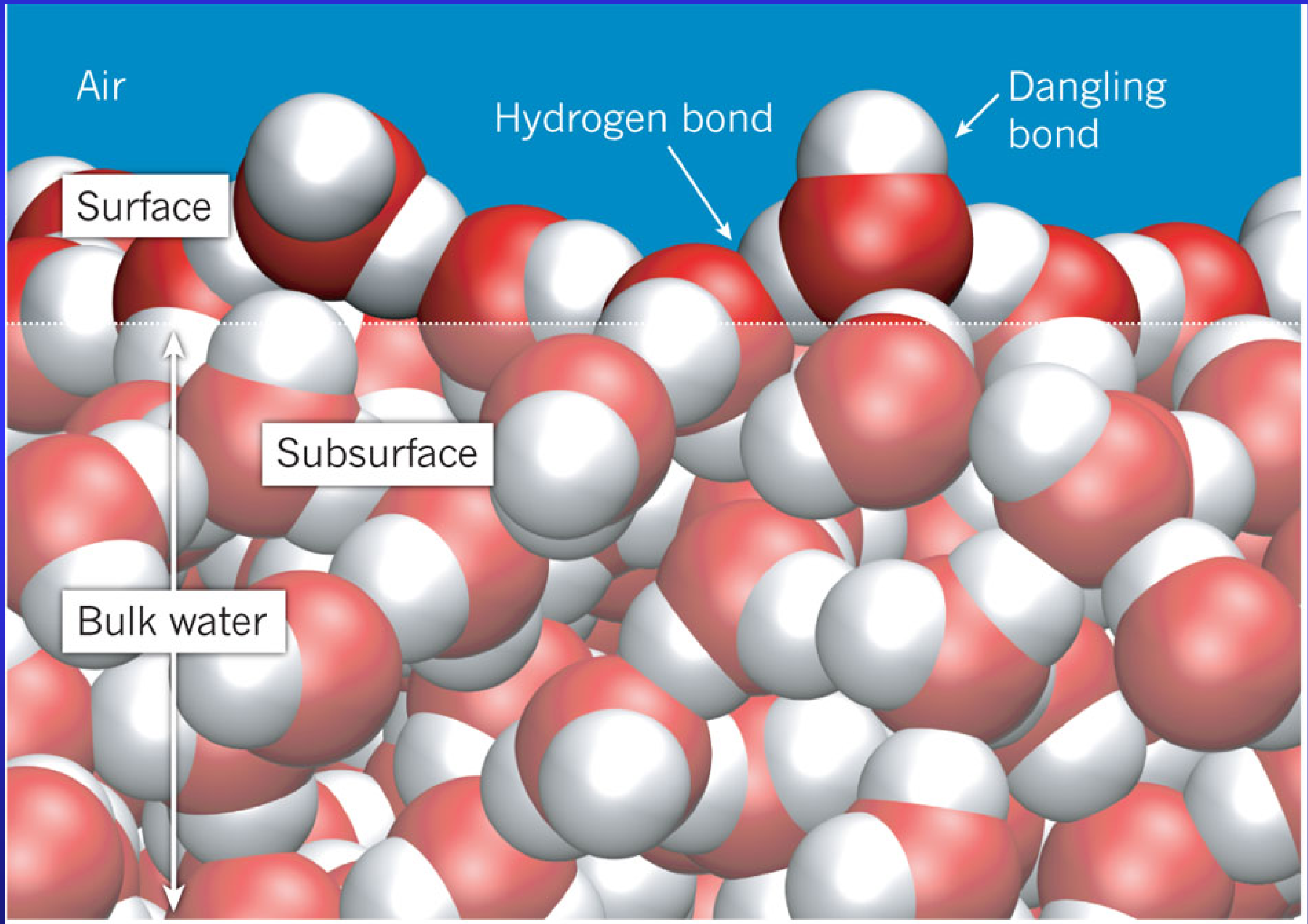
attractive force that holds water molecules tightly together in liquid phase

http://chemistry.stackexchange.com/questions/4315/covalent-bond-hydrogen-bond

http://www.columbia.edu/cu/biology/courses/c2005/lectures/lec2_10.html

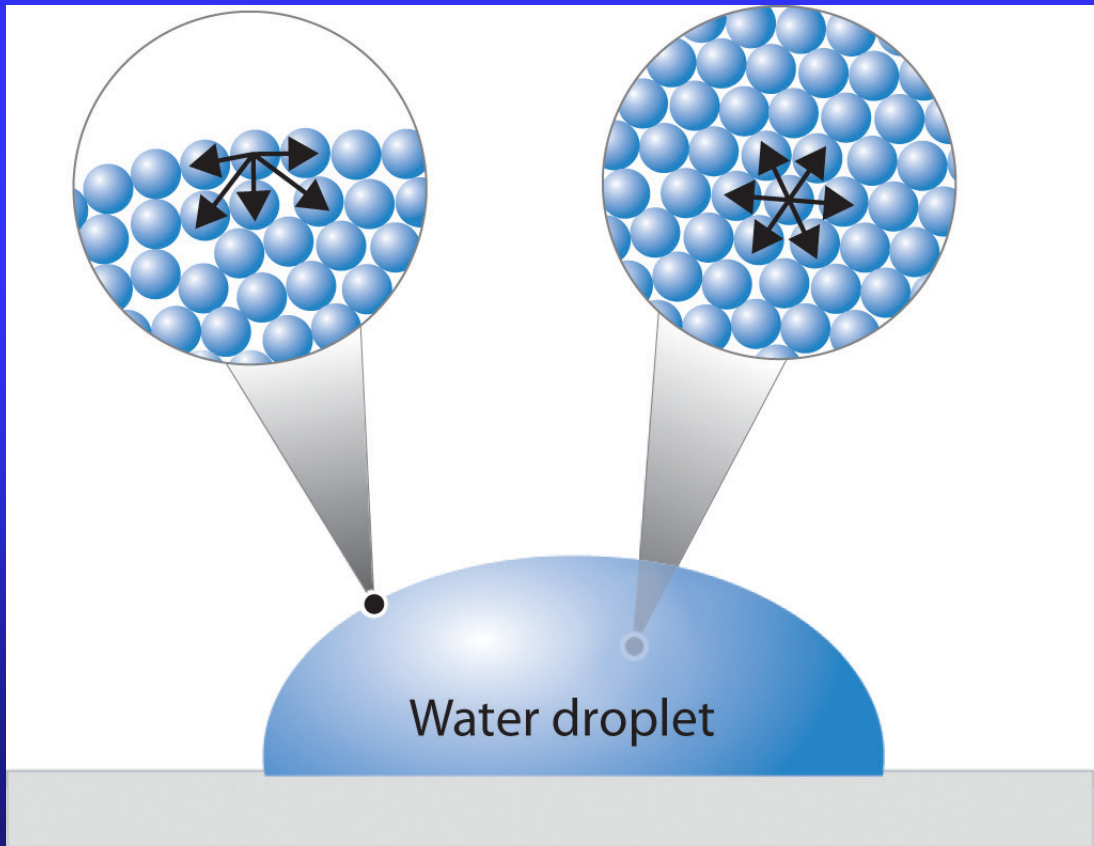
This happens in the bulk

What happens at the surface of water?



http://www.nature.com/nature/journal/v474/n7350/full/474168a.html

ONE molecule thick layer of water
where bonds are very different from the bulk
Interface water molecules can’t H-bond with air
DANGLING BONDS



http://chem.libretexts.org/LibreTexts/University_of_California_Davis/UCD_Chem_002BH/Unit_II%3A_States_of_Matter/10%3A_Solids,_Liquids,_and_Phase_Transitions/10.1%3A_Bulk_Properties_of_Gases,_Liquids,_and_Solids%3A_Molecular_Interpretation

Can think of this as a *SKIN* for water

The force that holds the skin together is the surface tension

Due to strong H-bonding, water has a really high surface tension (72 mN/m at RT)

http://hyperphysics.phy-astr.gsu.edu/hbase/surten.html

Surface tension – how much is 72 mN/m?

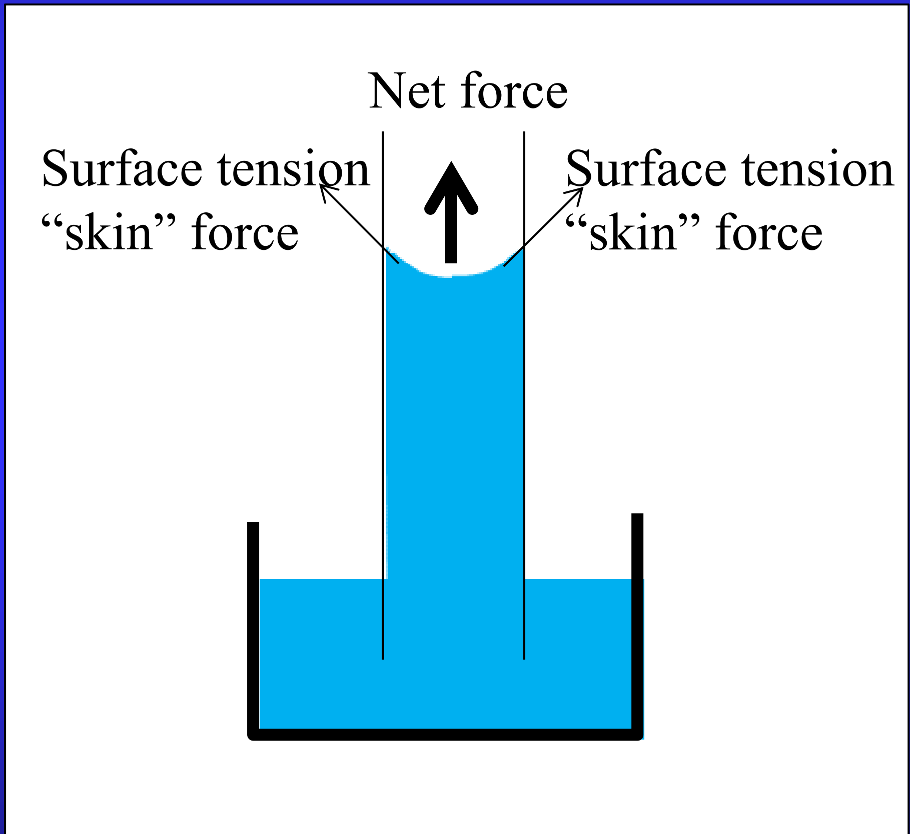
- Water "skin" can hold up insects…
- Can water "skin" support the weight of dense metal objects? Can metal objects float?

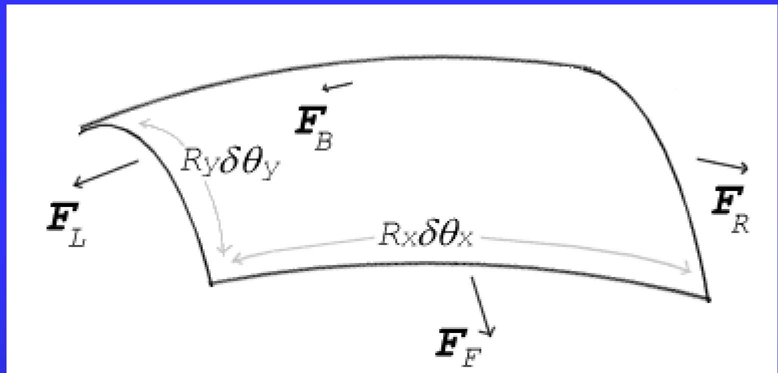
But, this has nothing to do with surface tension

Remember Archimedes?

Is 72 mN/m sufficient to hold up a paper clip?

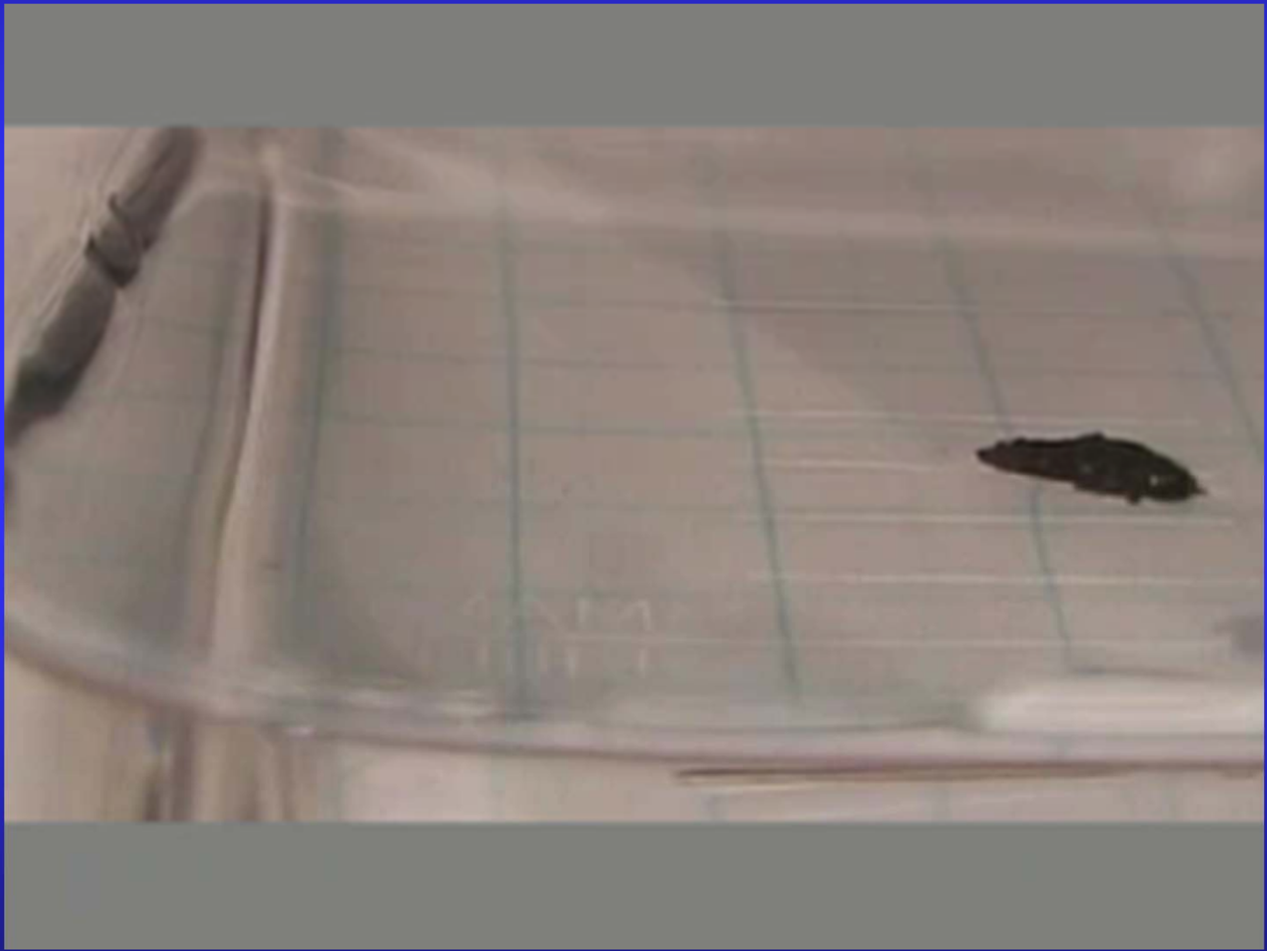
Can the skin of water pull itself up, into a tube?





https://upload.wikimedia.org/wikipedia/commons/6/66/CurvedSurfaceTension.png

Some creepy crawlies have learnt some really cool ways of using surface tension effects



Where do we encounter capillarity?

Chromatography

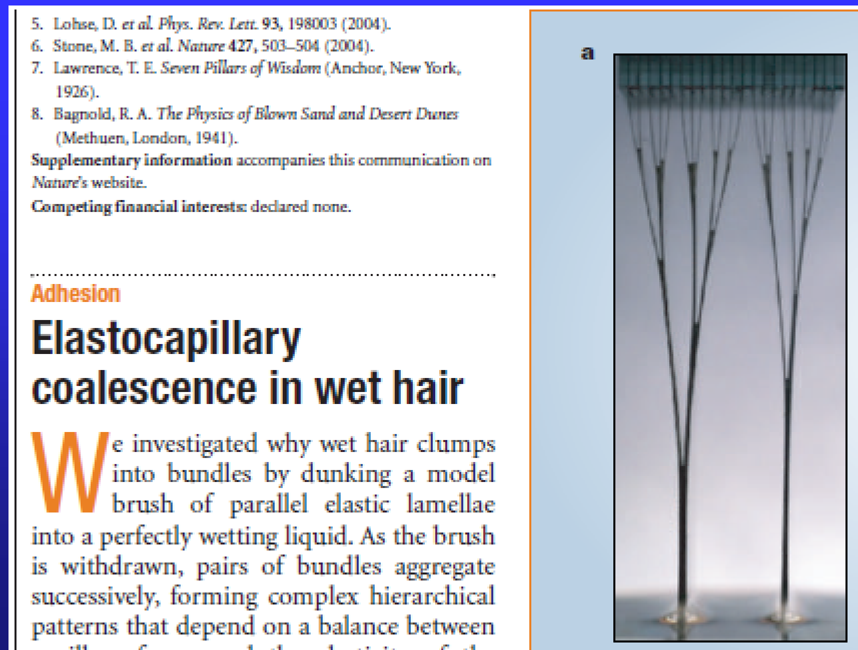
chromatography

/ˌkrəʊməˈtɒɡrəfi/

noun CHEMISTRY

a technique for the separation of a mixture by passing it in solution or suspension through a medium in which the components move at different rates.

Wet hair, fibers stick together



5. Lohse, D. *et al. Phys. Rev. Lett.* **93**, 198003 (2004).
6. Stone, M. B. *et al. Nature* **427**, 503–504 (2004).
7. Lawrence, T. E. *Seven Pillars of Wisdom* (Anchor, New York, 1926).
8. Bagnold, R. A. *The Physics of Blown Sand and Desert Dunes* (Methuen, London, 1941).

Supplementary information accompanies this communication on *Nature*'s website.

Competing financial interests: declared none.

Adhesion

Elastocapillary coalescence in wet hair

We investigated why wet hair clumps into bundles by dunking a model brush of parallel elastic lamellae into a perfectly wetting liquid. As the brush is withdrawn, pairs of bundles aggregate successively, forming complex hierarchical patterns that depend on a balance between

Wet sand sticks together

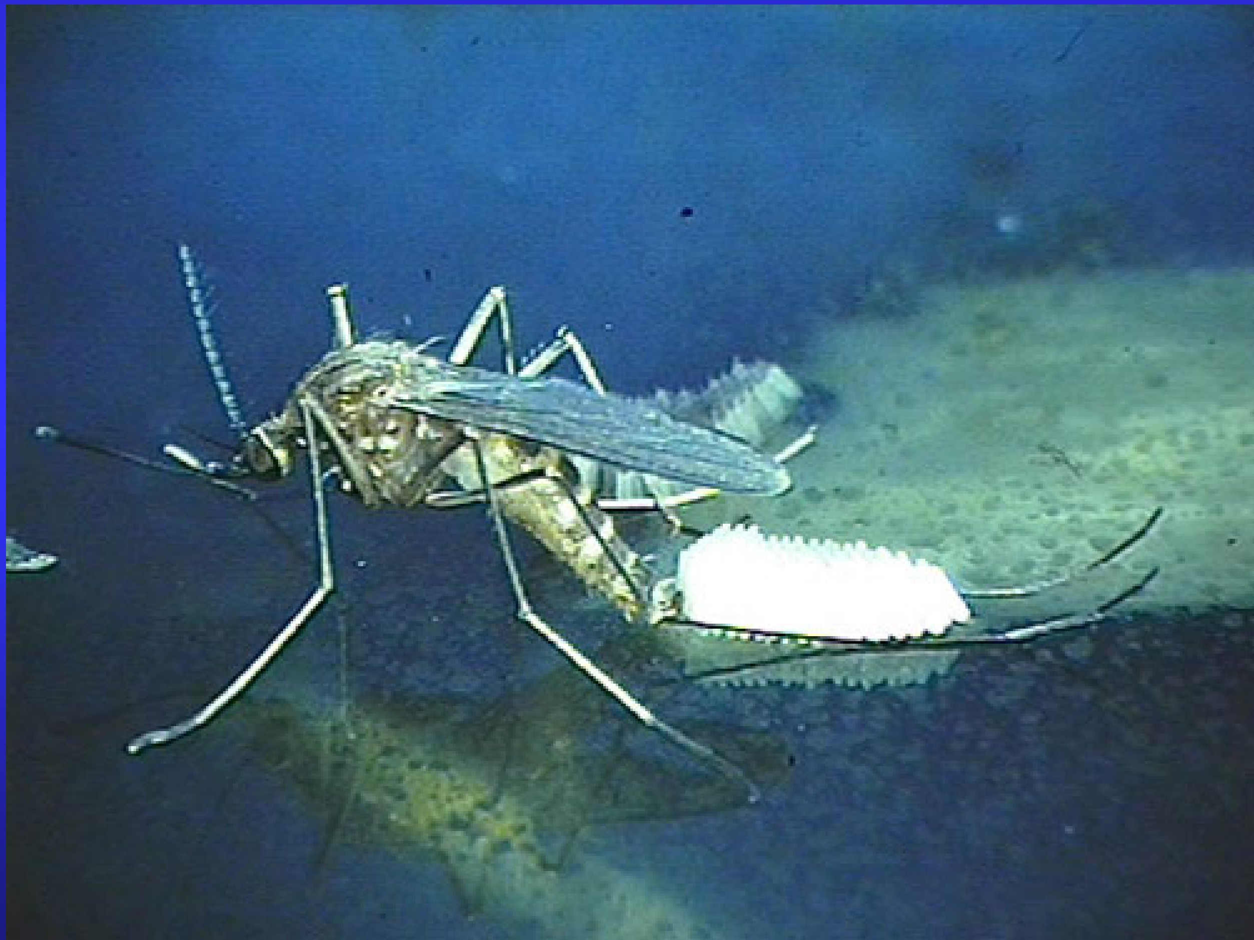
Plant uptake

Is this the only mechanism for water uptake?

Does this set a limit on how high plants can grow?

http://water.usgs.gov/edu/pictures/full-size/plant-uptake-large.jpg

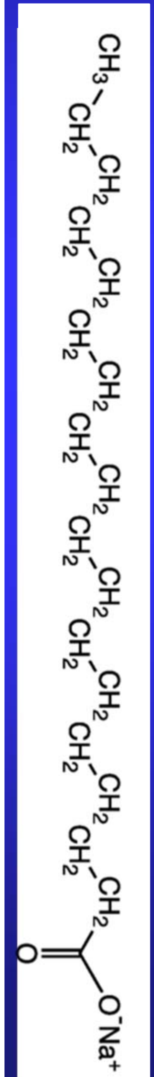
Question:
Why does adding soap to stagnant water help control dengue?

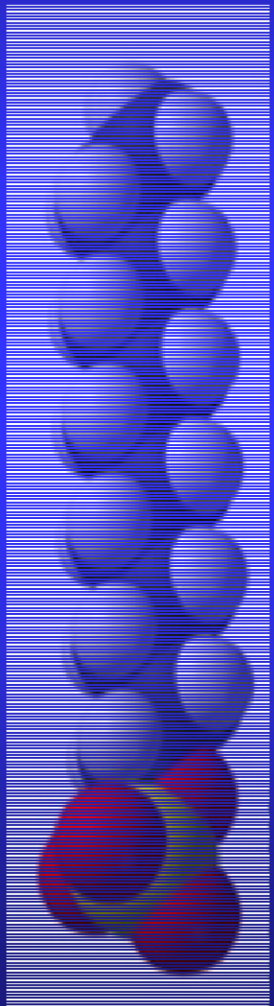


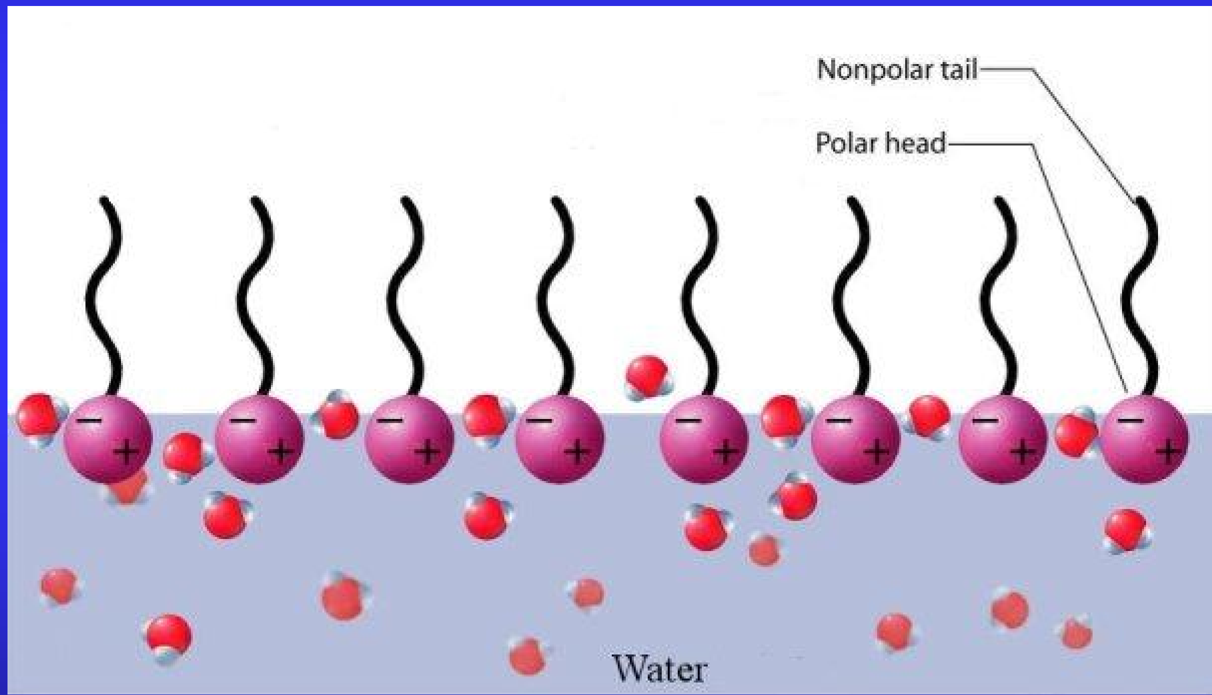
http://www.pharmaceutical-technology.com/projects/chengdu-vaccine/chengdu-vaccine3.html

Covering the skin – Changing surface tension

What happens when we add soap to water?







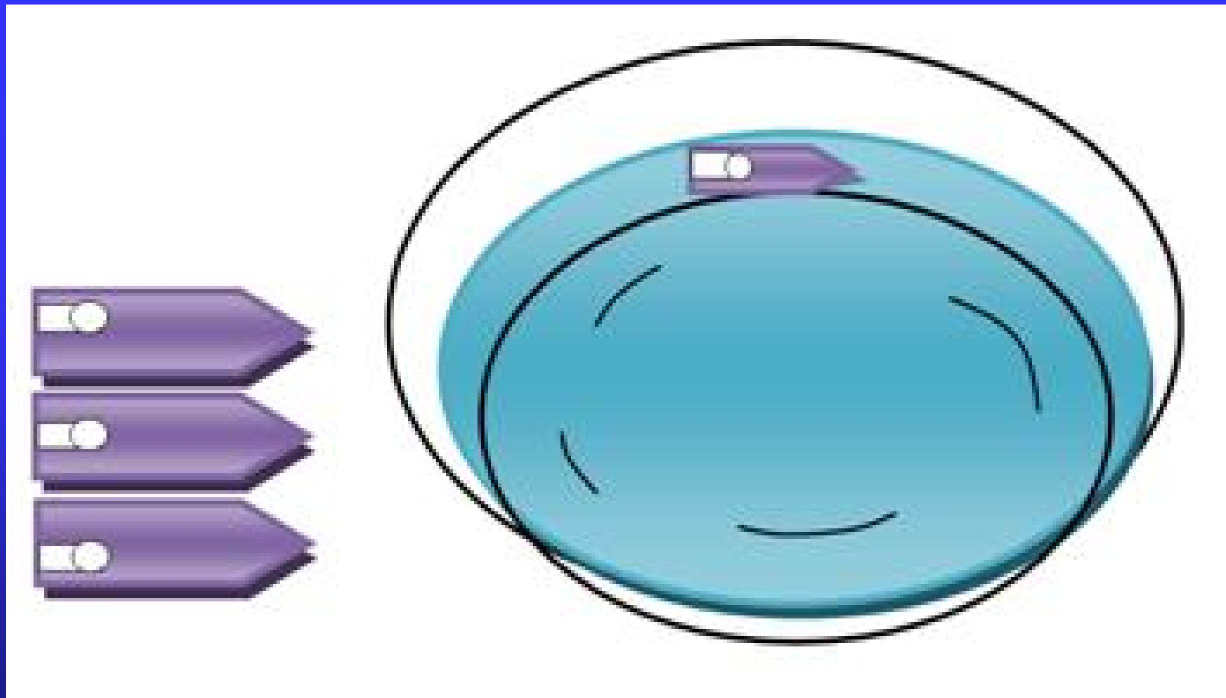
Tails don't stick so strongly
Skin force decreases a lot

https://skullsinthestars.files.wordpress.com/2012/05/soapmolecule.png
http://soapbubble.dk/wp-content/uploads/2013/10/Dias41.jpg
https://upload.wikimedia.org/wikipedia/commons/0/03/Surfactant.jpg

Making surface tension anisotropic

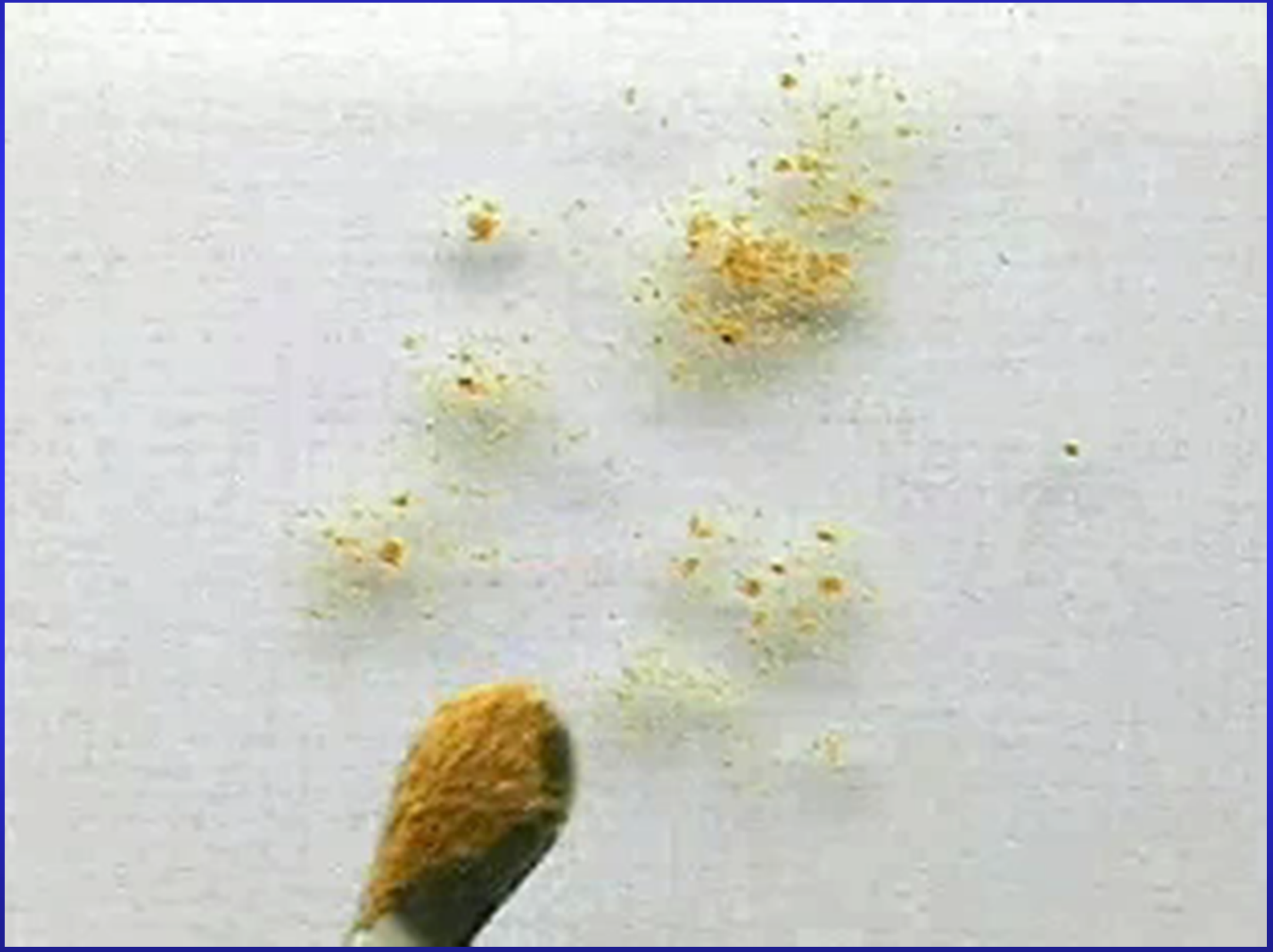
Marangoni effect

Camphor boat experiment

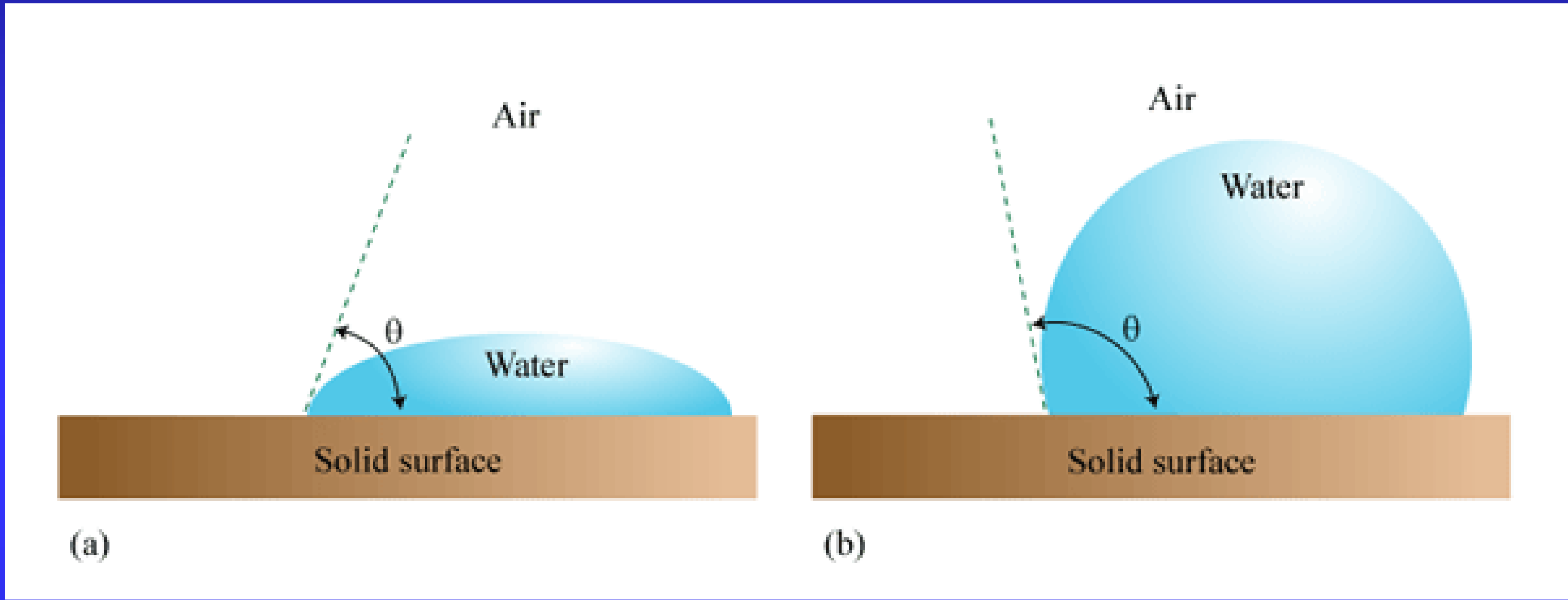


https://upload.wikimedia.org/wikipedia/en/1/1f/Figure2a-Camphor_Boat.jpg

Temperature also changes surface tension



Now, let's talk about **WETTING**



The contact angle tells us about wetting

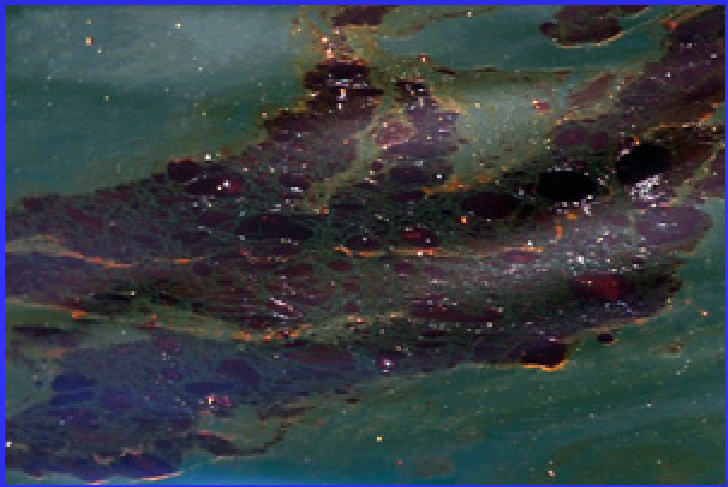
Hydrophobic: $\theta > 110^o$

SUPER-hydrophobic: $\theta > 160^o$

http://www.hk-phy.org/atomic_world/lotus/lotus02_e.html

WETTING depends on whether the solid likes the liquid

Oil and water hate to mix



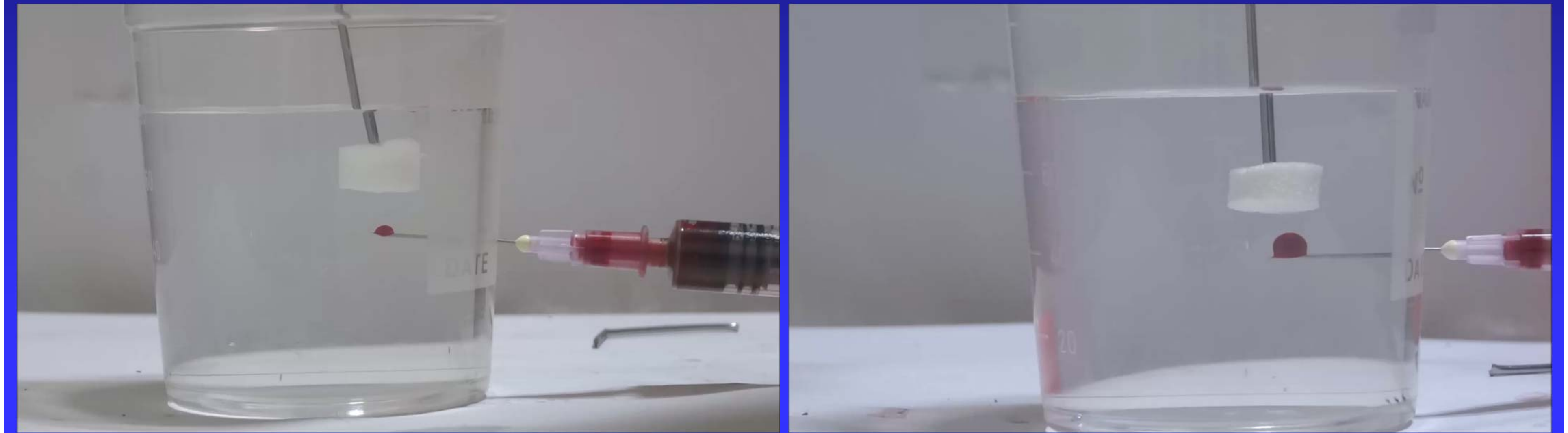
Solids that like water, don't like oil
and
Solids that like oil, don't like water
Can we use this to separate oil and water?

https://www.propublica.org/images/articles/flickr_dwh_oilslick_300x200_100615.jpg

http://i2.cdn.cnn.com/cnnnext/dam/assets/150519135626-01-oil-spill-0520-exlarge-169.jpg

Sponges that love oil but hate water

We've made



- **HYDROPHOBIC** sponges that are capable of absorbing hexane (dyed red) underwater

- **OMNIPHILIC** sponges: absorb > 10X their weight of water OR oil

Problem: How do we *efficiently* get hydrophobic pesticides onto leaves?

Green shore is still far away

THE TIMES OF INDIA

Viju B | TNN | Feb 16, 2016, 10.54 AM IST

The central survey found that 21.3% of the vegetable samples contained measurable pesticide residue; in 2.9% of samples, residue concentrations exceeded the limit.

BBC NEWS

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News Front Page

Last Updated: Wednesday, 4 February, 2004, 13:34 GMT

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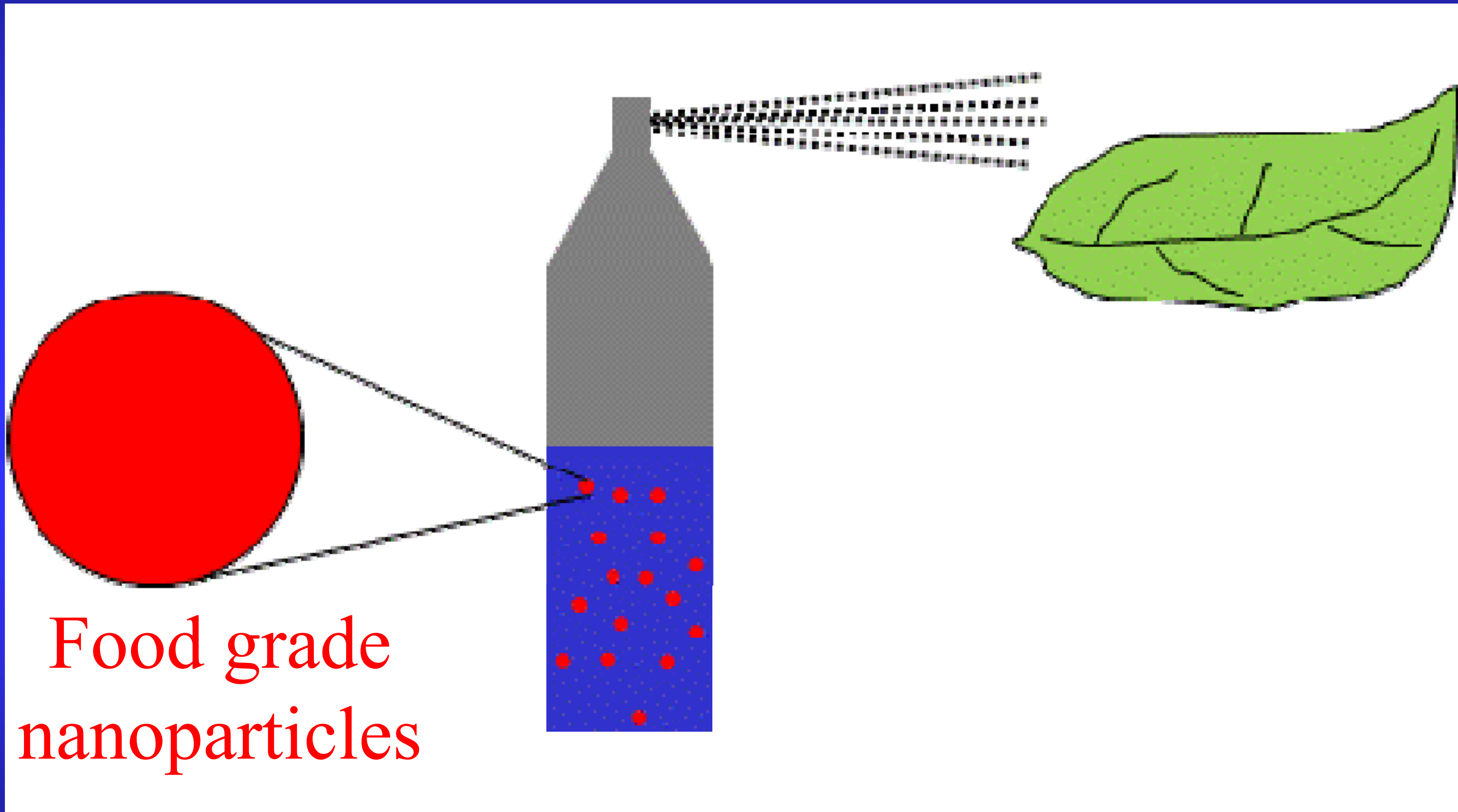
India finds pesticides in colas

Pesticide use can contaminate food, soil, water

In general, leaf surfaces are HYDROPHOBIC

Leaf surfaces have a waxy coating. Therefore, they hate water.

We've done some work on this problem



We've done some work on this problem

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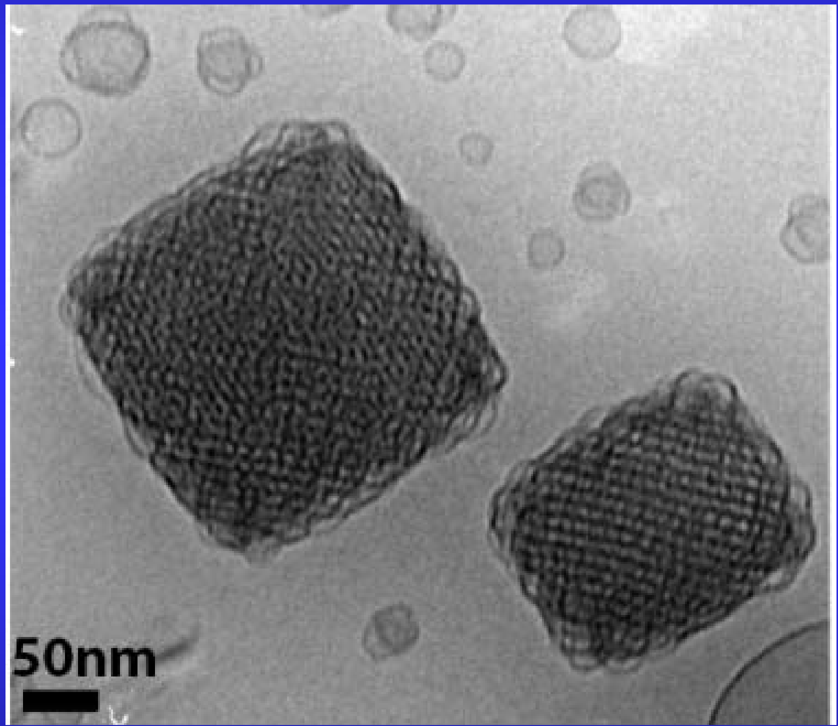
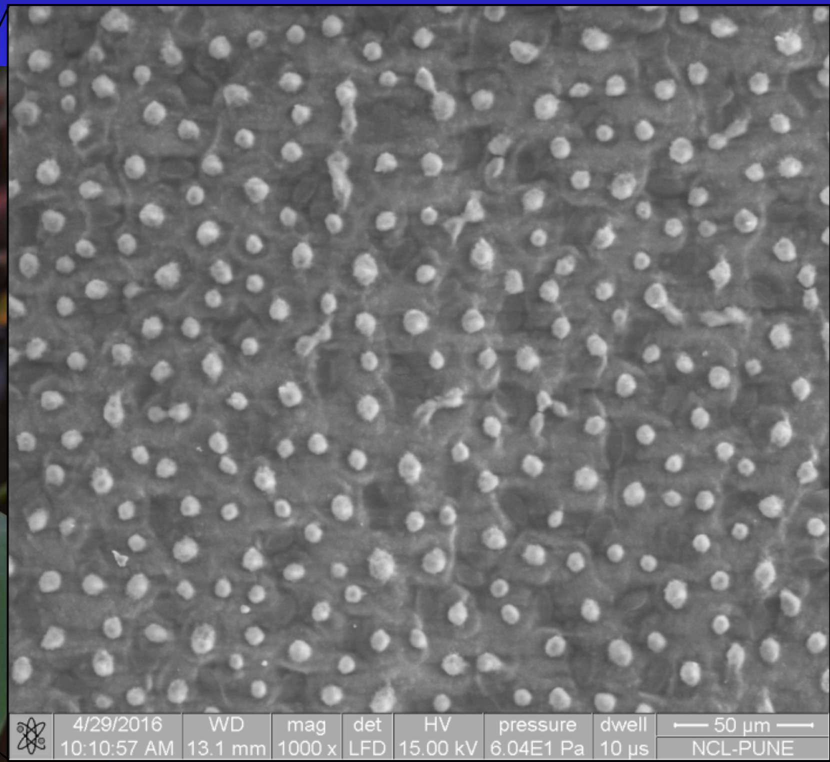


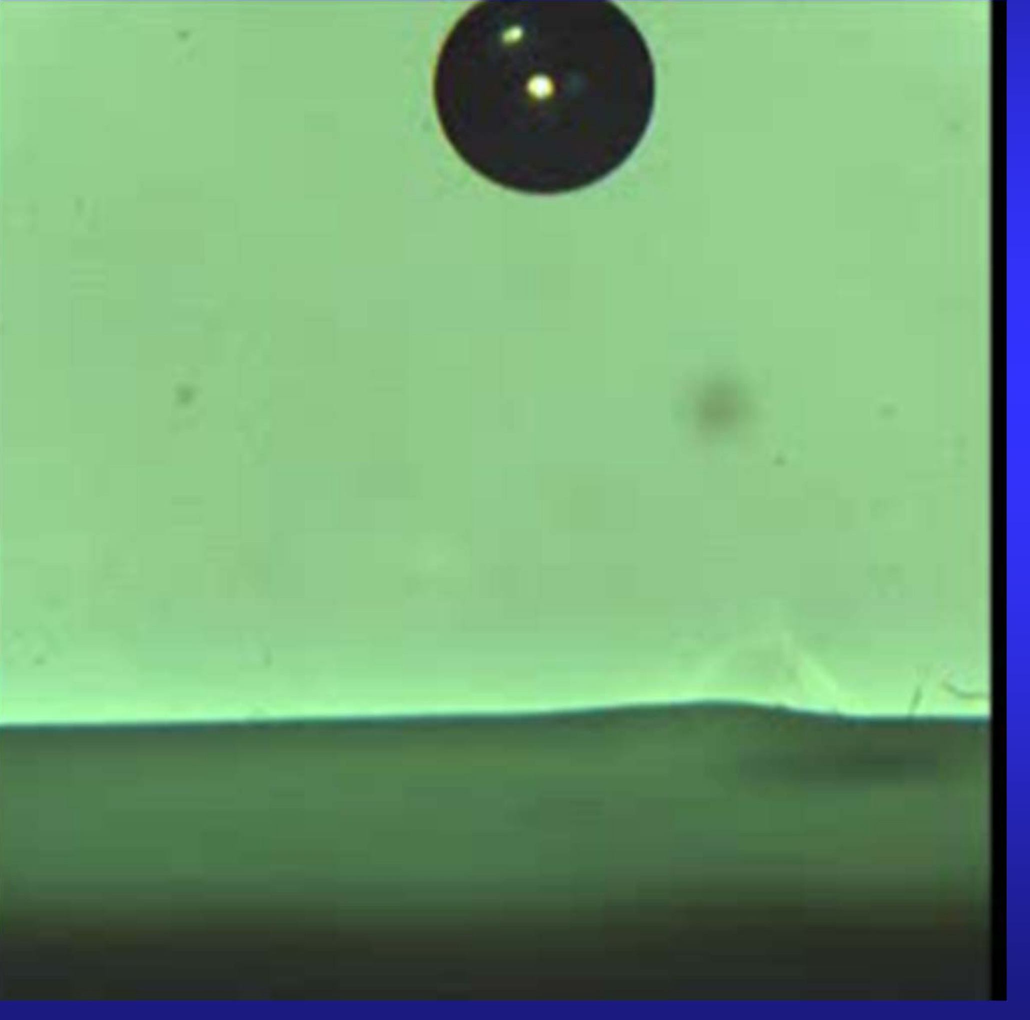
We have discovered that nanoparticles (prepared from sunflower oil) can solve this problem

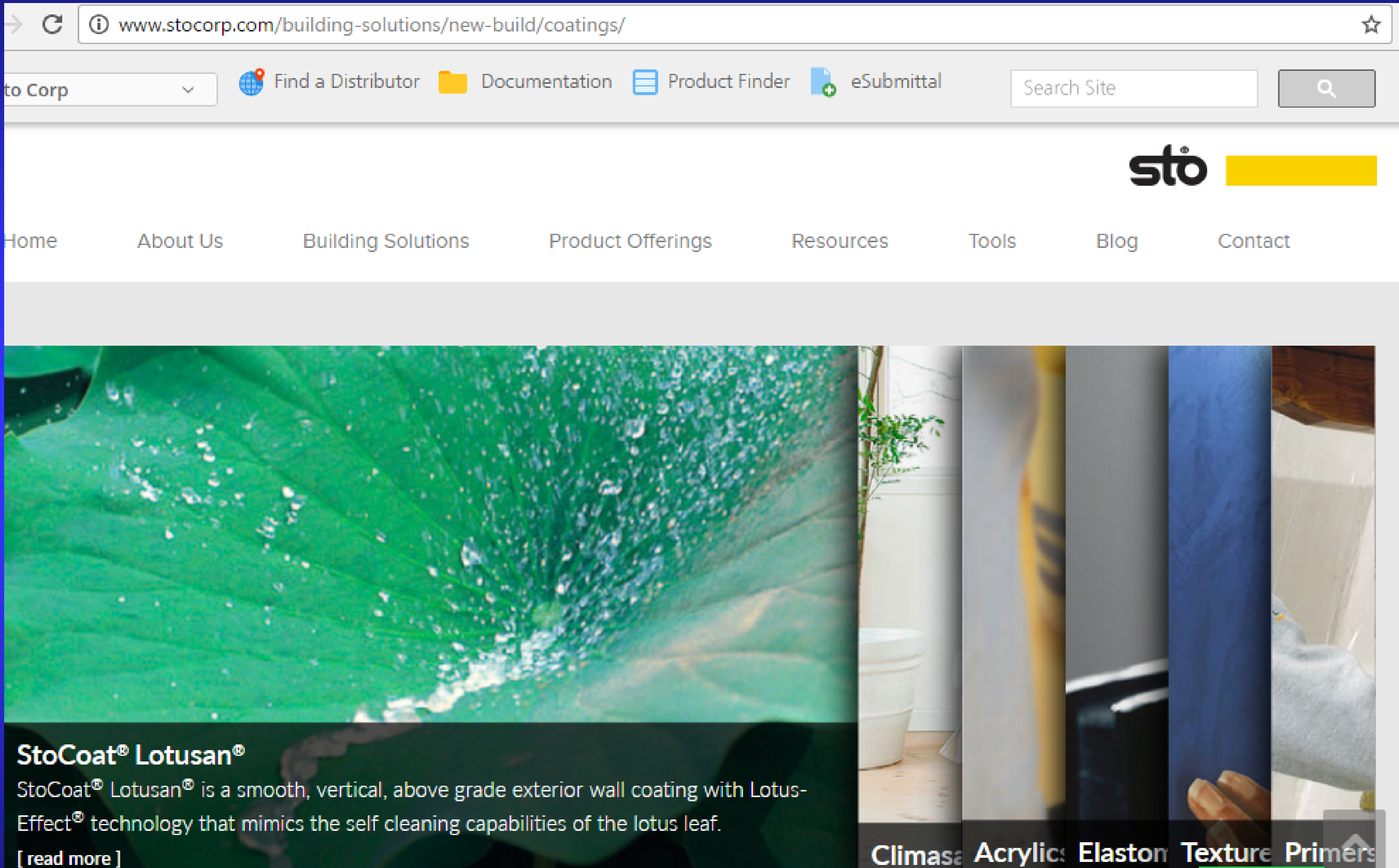
These nanoparticles are non-toxic. In fact, they are food-grade (viz. you can eat them)

SUPERHYDROPHOBICITY
Natural superhydrophobic surface: Lotus leaf



High speed imaging of water drop falling on lotus leaf





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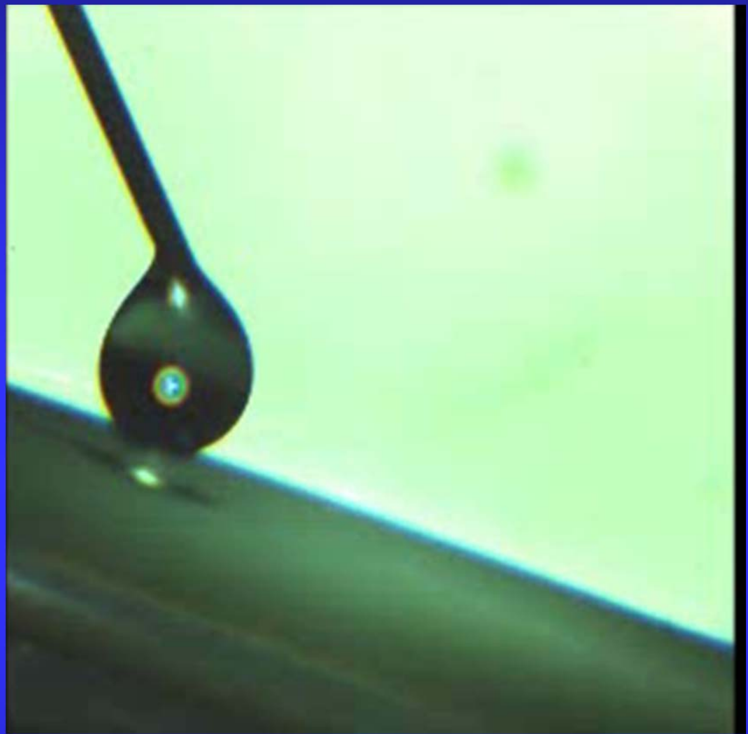
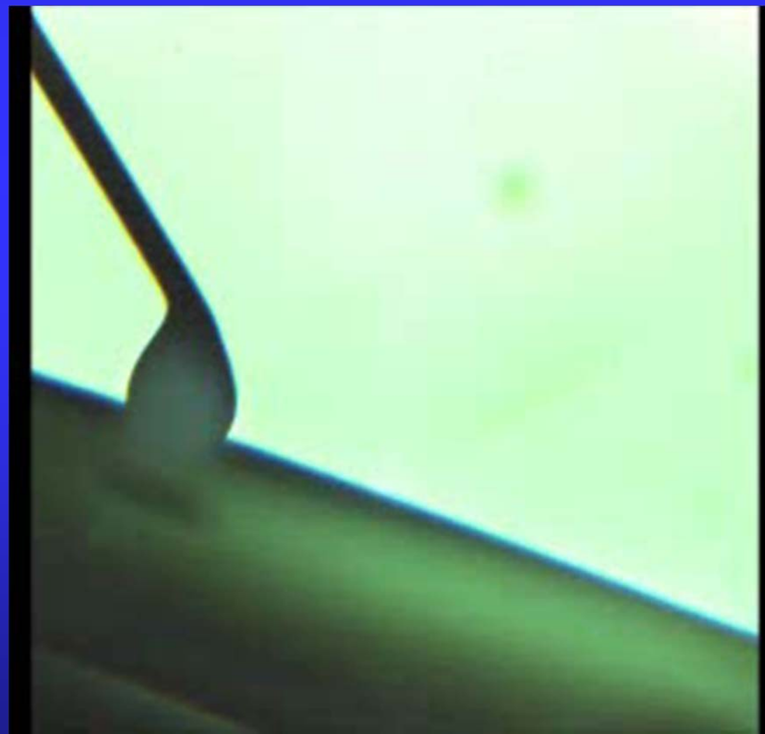
StoCoat® Lotusan® is a smooth, vertical, above grade exterior wall coating with Lotus-Effect® technology that mimics the self cleaning capabilities of the lotus leaf.
[read more]
Acrylic
Elaston
Texture
Primers

Drops of water/our nanoparticle dispersions on Lotus leaves





Spray Experiments on

Colocasia and Nelumbo (Lotus) leaves


THANK YOU
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