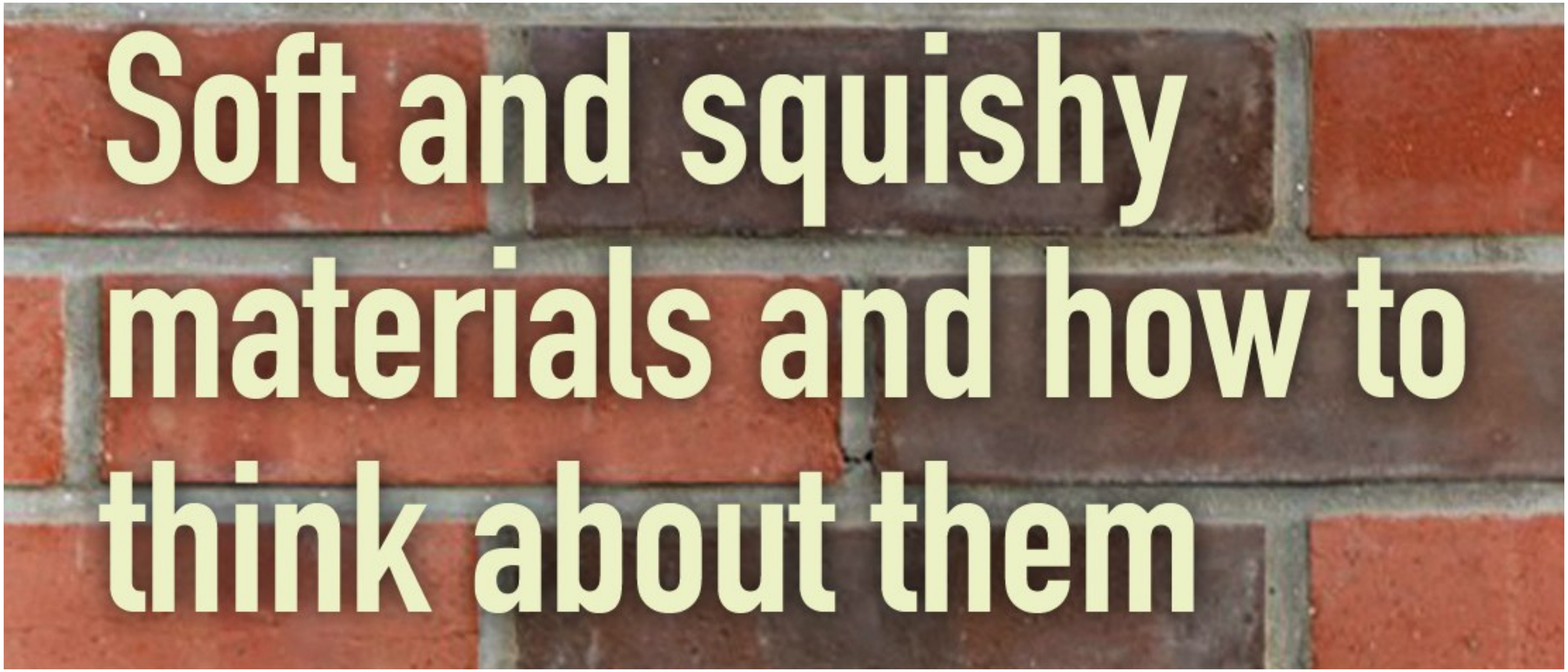


Gautam Menon
Ashoka University, Sonepat
The Institute of Mathematical Sciences, Chennai

https://upload.wikimedia.org/wikipedia/commons

https://s-i.huffpost.com/

http://media3.s-nbcnews.com/

Materials

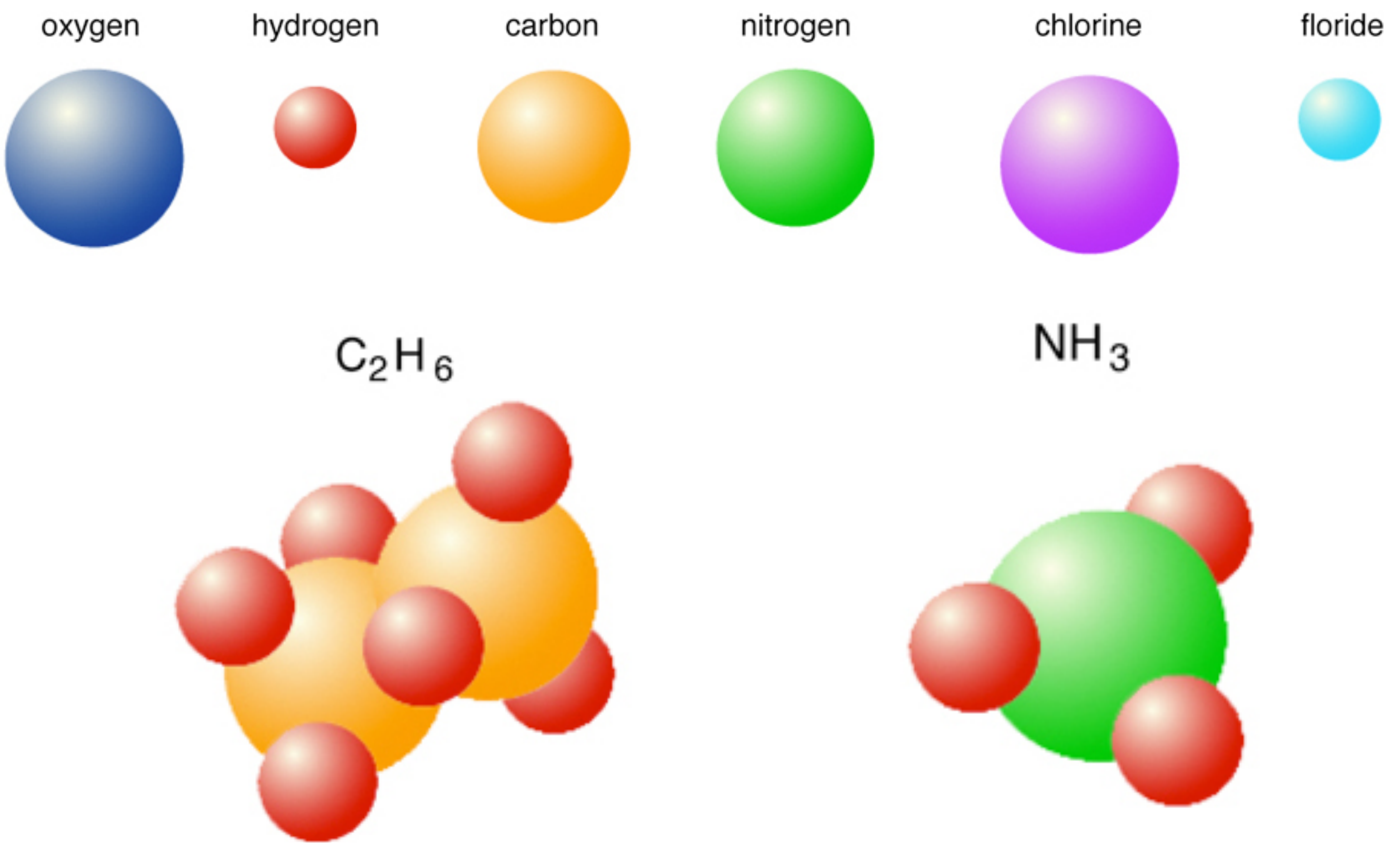
https://unsplash.com/photos/xzPMUMDDsfk

Wikipedia

All matter is made of atoms

1 H Hydrogen																	2 He Helium
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magnesium											13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
55 Cs Cesium	56 Ba Barium		72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium		104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson
			57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
			89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

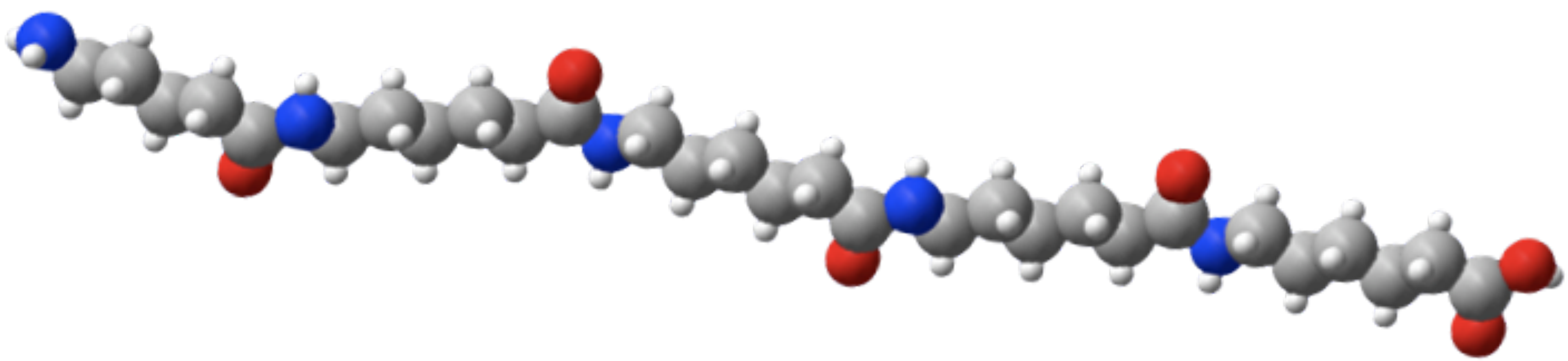
Atoms make molecules



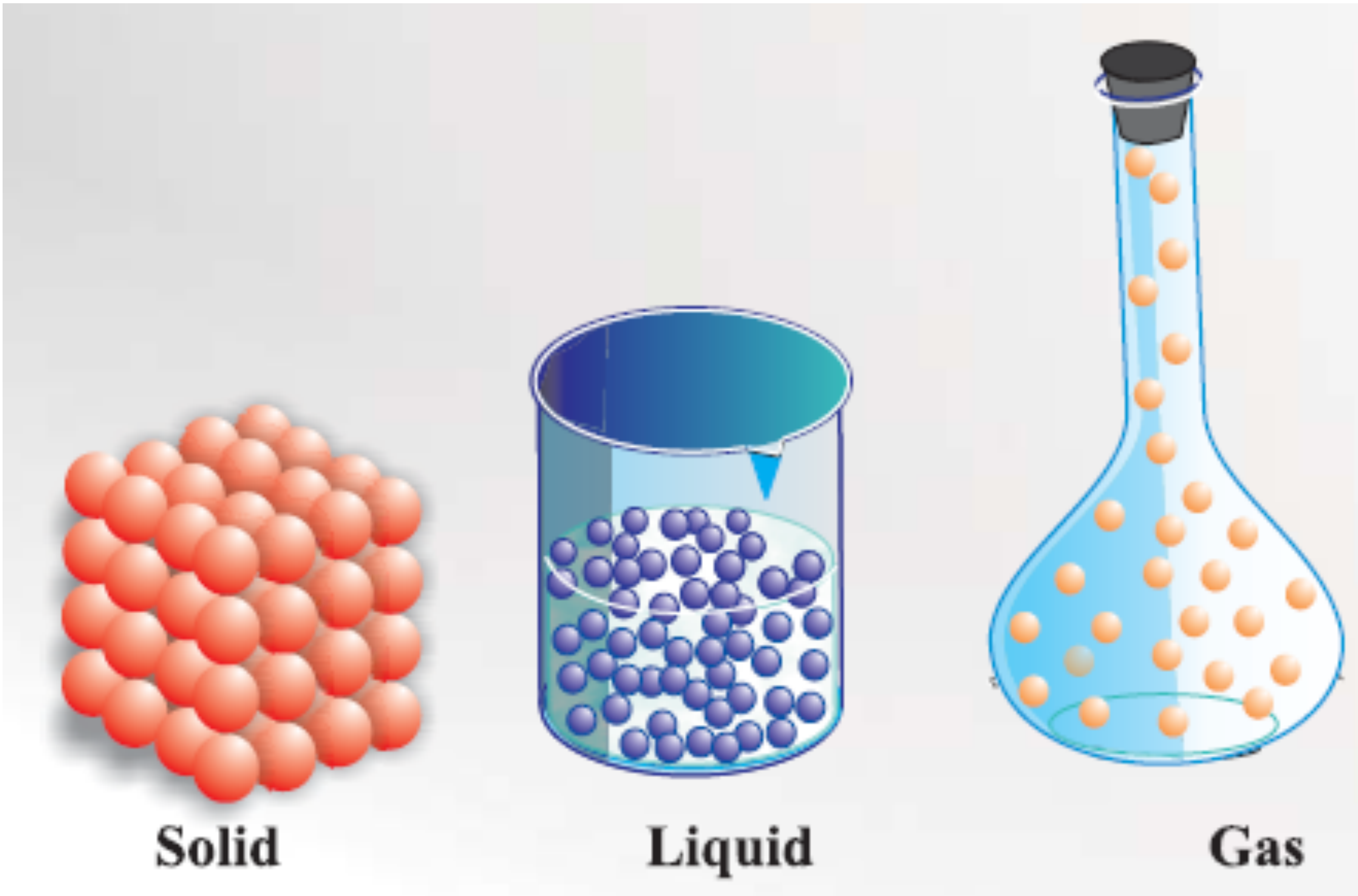
https://empoweryourknowledgeandhappytrivia.files.wordpress.com/2014/09/molecules.jpg

Molecules can be complex

Polymer



Atoms and molecules can be in different physical states IF there are lots of them



http://ncerthelp.com/scienceimg/11-C-CH1-Concept/image001.png

Ask questions about any material

How are atoms linked? Simple molecules?

Long molecules (polymers)?

Is the material a mixture of different molecules?

Is the substance overall solid, liquid or a bit of both?

https://upload.wikimedia.org/wikipedia/commons

https://s-i.huffpost.com/

http://media3.s-nbcnews.com/

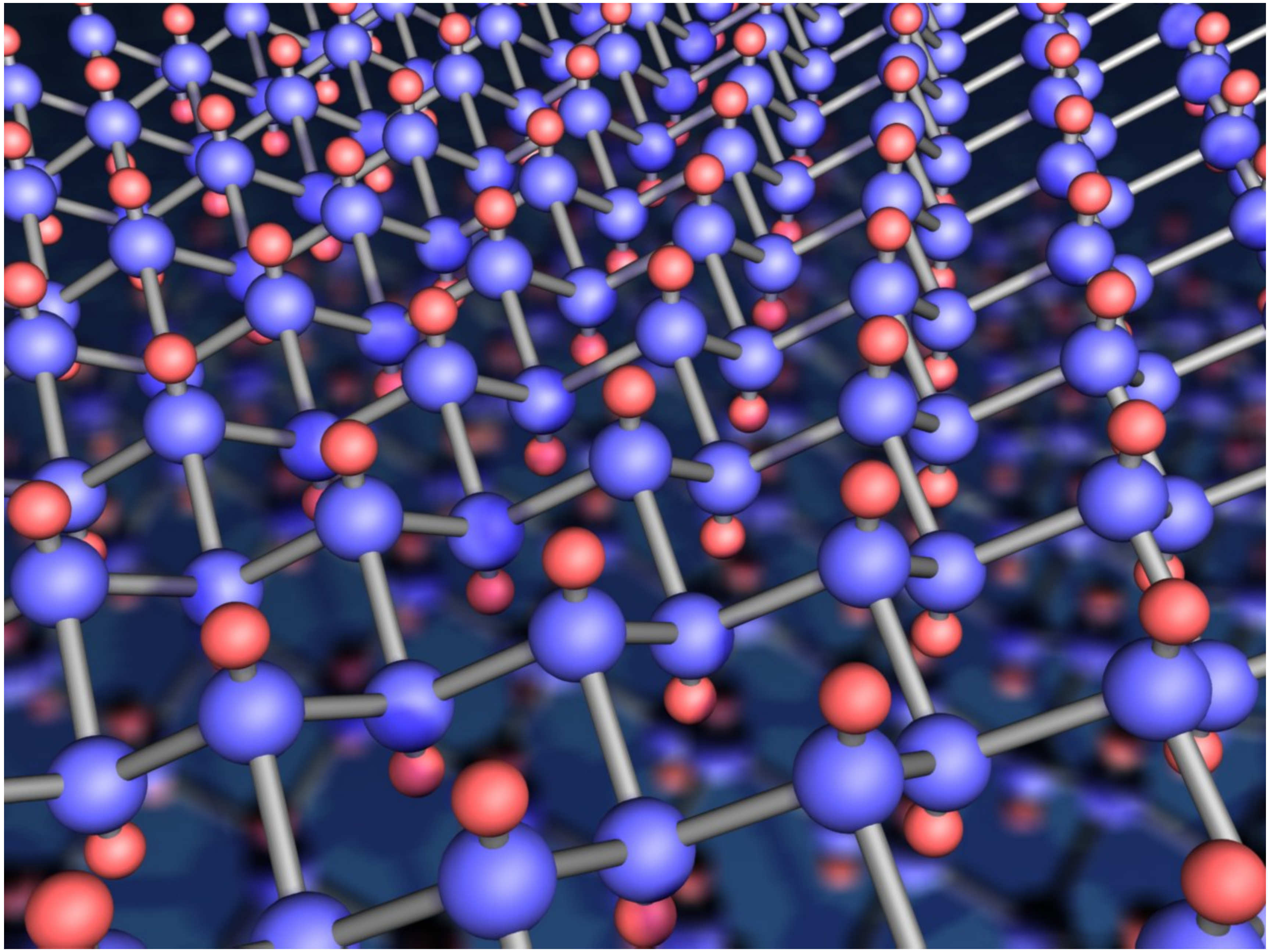
Soft and squishy materials

- Are usually mixtures of different types of atoms and molecules
- Often include long polymers
- Have properties between those of solids and liquids

Solid, inflexible (crystalline) materials

https://www.flickr.com/photos/schwigor/423356856/

Crystal: Hard to change relative positions of atoms



http://www.condmat.physics.manchester.ac.uk/images/pictures/graphane3.jpg

Solid, inflexible non-crystalline materials

https://chivewholesale.com/collections/coming-soon-glass/products/loft-2

Solid, non-crystalline, flexible materials

https://guardian.ng/wp-content/uploads/2016/09/Plastic-Bottles-Trash.jpg

Solid, but flexible biological materials

https://cdn1.medicalnewstoday.com/content/images/articles/321/321154/close-up-image-of-the-ear.jpg

Fluids

https://www.demilked.com/ocean-photography-waves-water-light-warren-keelan/

Suspensions

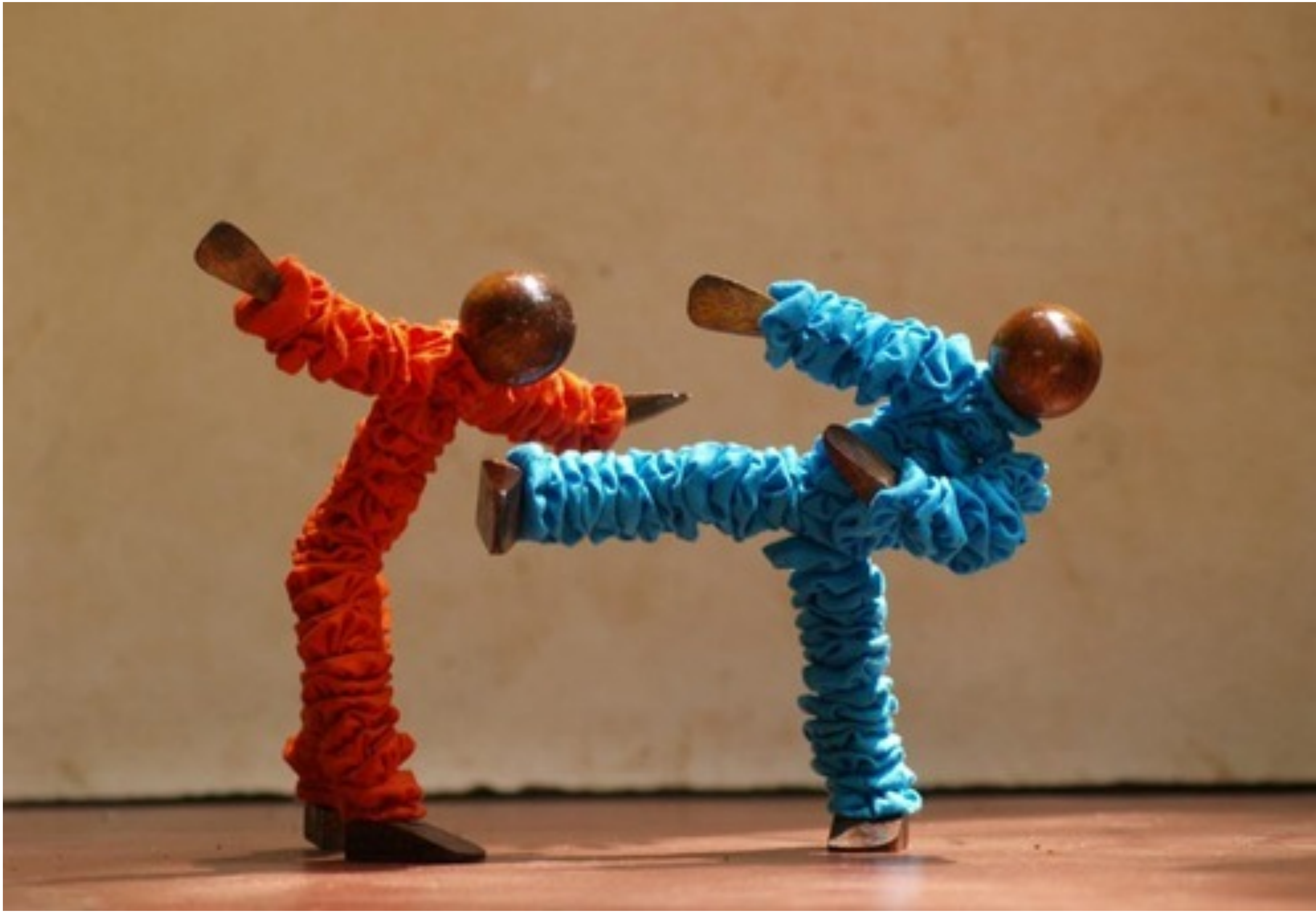
https://www.holidify.com/images/compressed/attractions/attr_1411.jpg

Man-made materials

Get their properties right

https://www.childishthings.com.au/product/ice-cream-money-bank-union-products/
https://periclean.com/wp-content/uploads/2014/09/toothpaste.jpg

https://lh6.ggpht.com/wsThjvVrP_tDO-WTJutOn4LZ6lv1_a57k0FJUOzAd4k4HHVP4UVXuM7Ur4Rg48XpwIsL_vwvaBxB-a0A24cATquyHA=s0



A “bendi” toy

But flexible living materials can also "grow"

Not just materials, information encoded in them

https://www.gettyimages.co.nz/
https://i1.wp.com/www.yogabasics.com/

Deformation - a change of shape

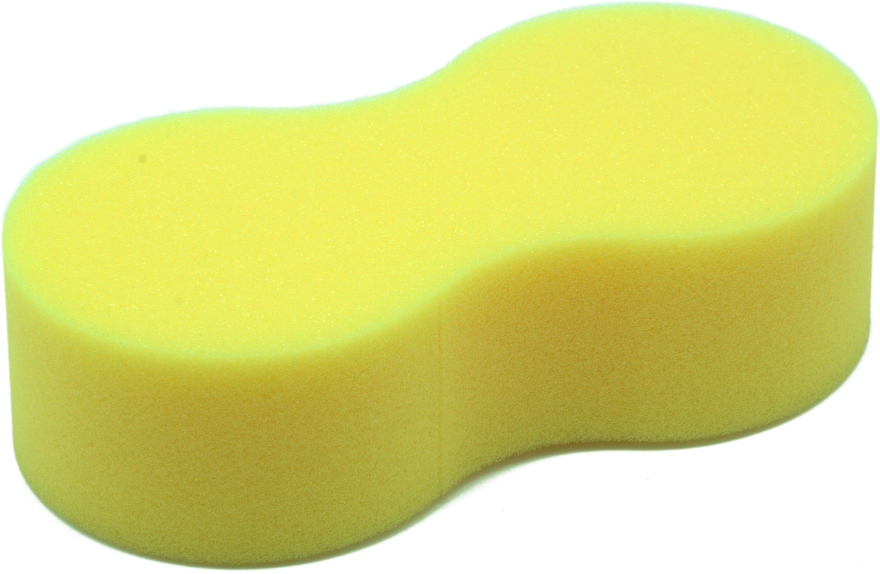
Materials that resist being deformed

Materials that are easy to deform

Materials that resist having their shape changed

https://www.educationquizzes.com/ks1/science/materials-rough-and-smooth/
https://www.metalsupermarkets.co.uk/wp-content/uploads/2019/06/What-is-a-ferrous-metal.jpg

Materials whose shape can be easily changed



https://www.teknistore.com/2905671-large_default/100ml-paper-clay-soft-ultralight-diy-non-toxic-magical-space-mud-plasticine-gift.jpg
https://i.pinimg.com/736x/cb/72/04/cb72049e208953aaae7e14cad21064e7.jpg

It takes the "Incredible Hulk" to deform this

https://i.pinimg.com/474x/be/98/c6/be98c64cdd1ddce9c48191addfc0ea16.jpg

Soft (and squishy) materials don’t need “Hulk-level” forces to deform them

How big should the force be?

The “softer” the material, the less the force

Slime

https://www.pinterest.com/pin/365924342585l621/

https://i.pinimg.com/736x/1e/06/50/1e0650f63ebd22be9eb7d0ed80f21fdb.jpg

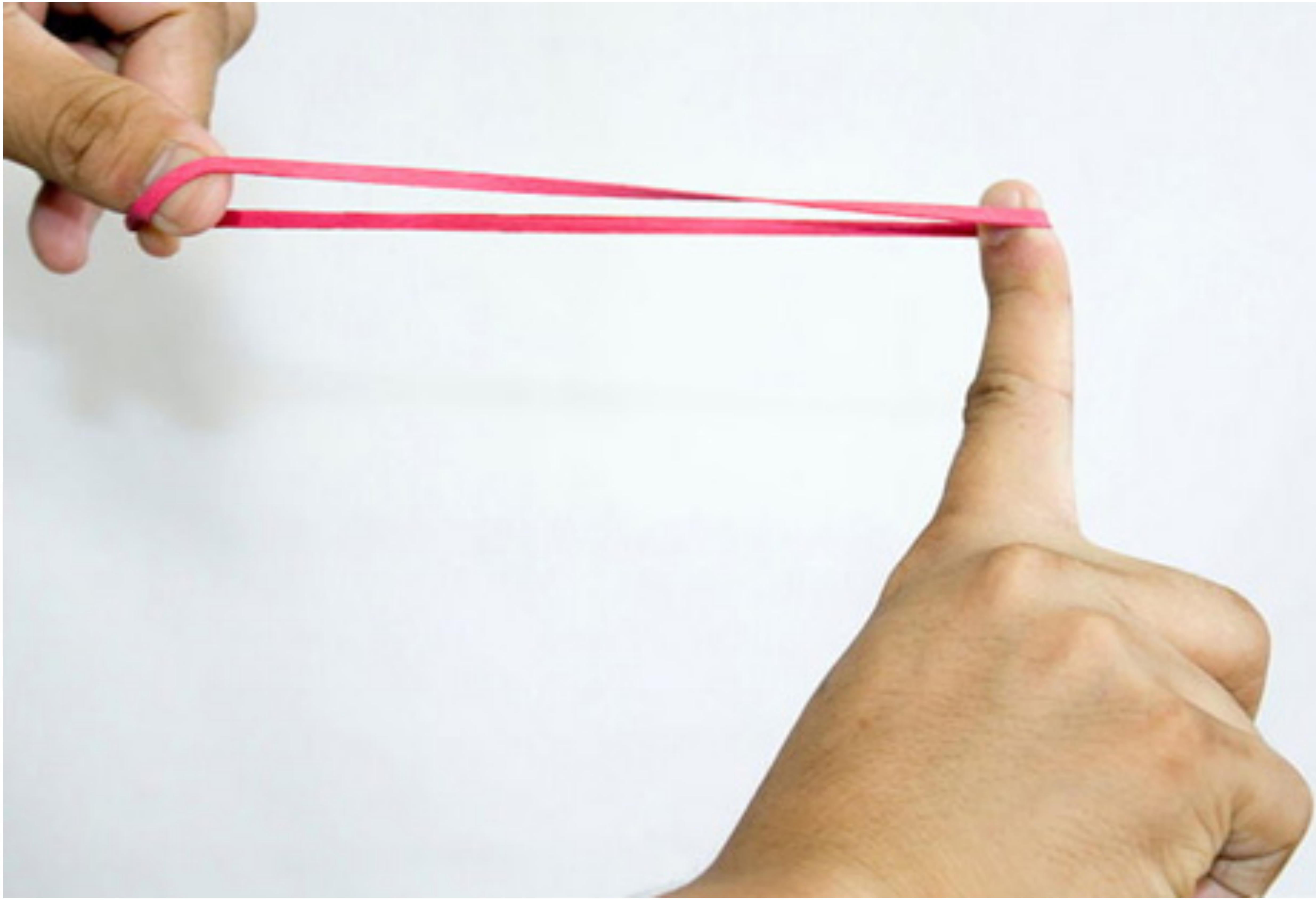
Elasticity

Materials that have a “natural” shape

Want to return to that shape, if deformed

Goes back to its old shape after you deform it

https://chembam.files.wordpress.com/2016/07/sponge.jpg
https://unlikelyhomemaker.files.wordpress.com/2011/04/sponges.jpg



https://arts2science.wordpress.com/matter/propertiesmaterials/

Plasticity

Materials that have a "natural" shape

If you deform them too much, change shape

Doesn't go back to its old shape after you deform it

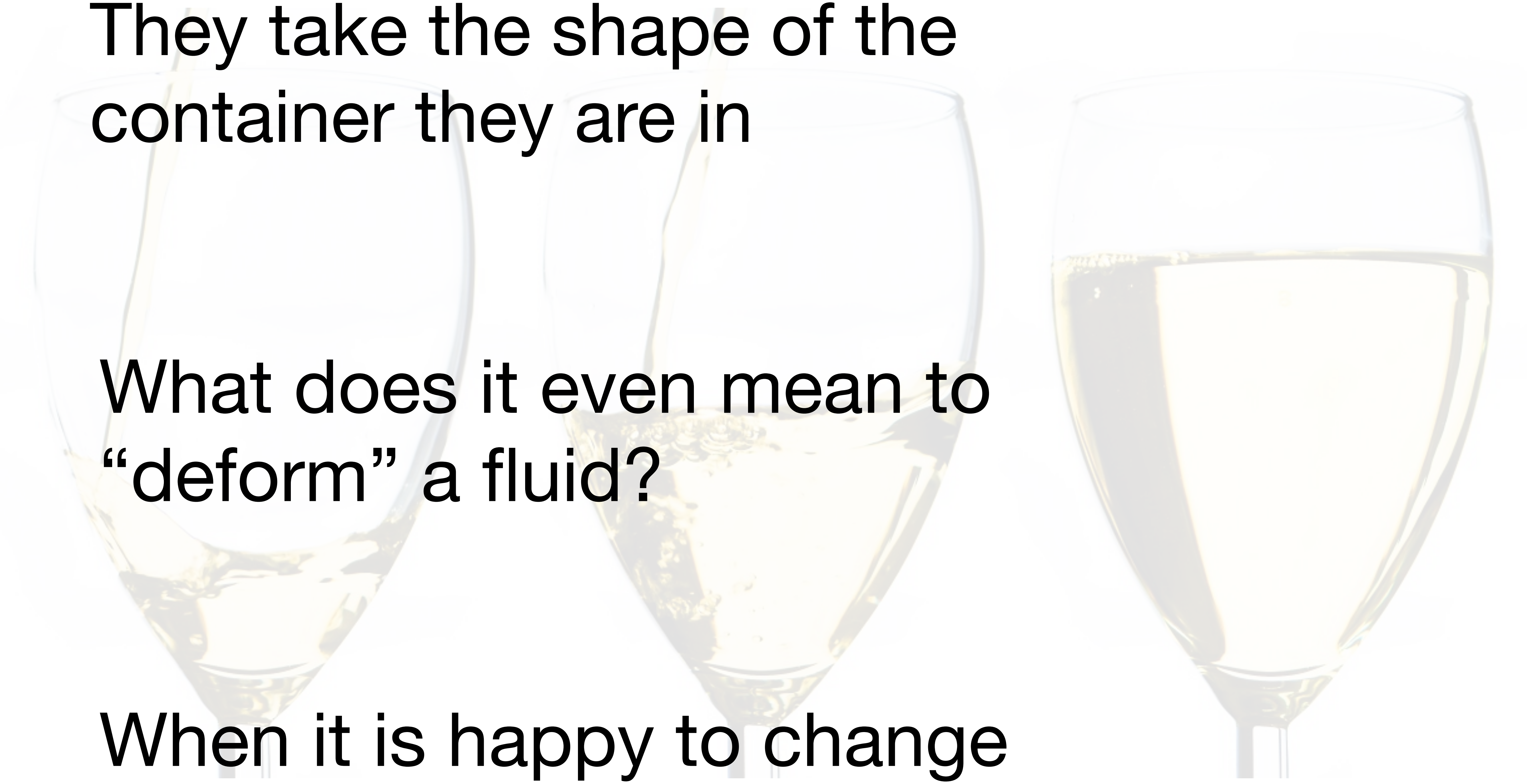
http://www.dieselcrew.com/wp-content/uploads/2009/12/090613rb0118-1_2.jpg

Fluids: materials that flow

Materials that have no
“natural” shape

https://www.heinonwine.com/wp-content/uploads/2019/01/Glass-half-full-wine.jpg

Fluids have no “natural” shape. They take the shape of the container they are in



What does it even mean to “deform” a fluid?

When it is happy to change its shape anyway?

Fluids are happy to adapt to any shape you impose on them, so deforming them is fine

But how fast you impose that change matters!

The faster you do this, the more the resistance

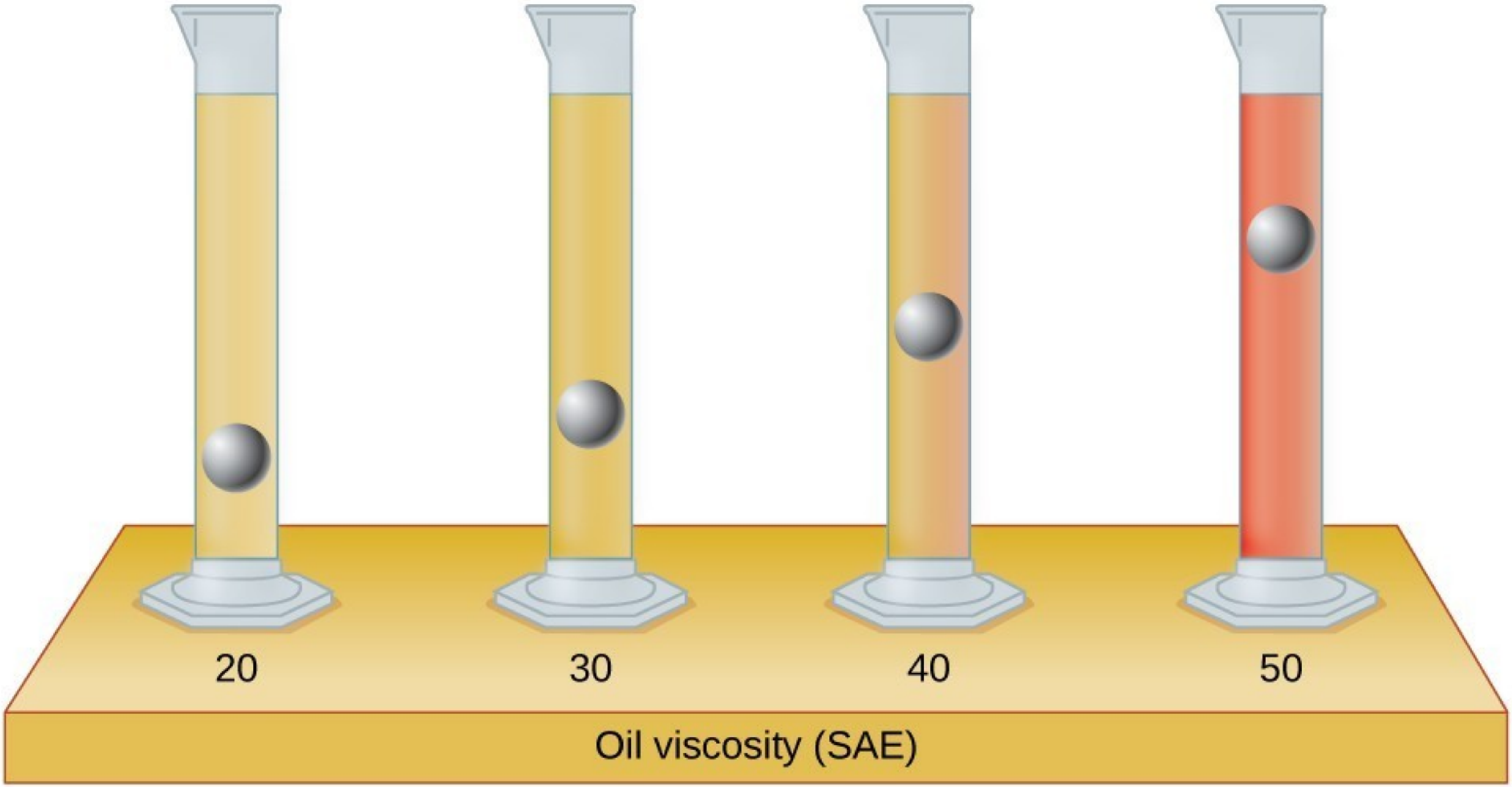
All changes of shape involve molecules moving relative to others

Different parts of the liquid don’t like to move at different speeds

Viscosity: Quantifies this

Water and honey, liquids of very different viscosity

The more the viscosity, the slower the ball falls

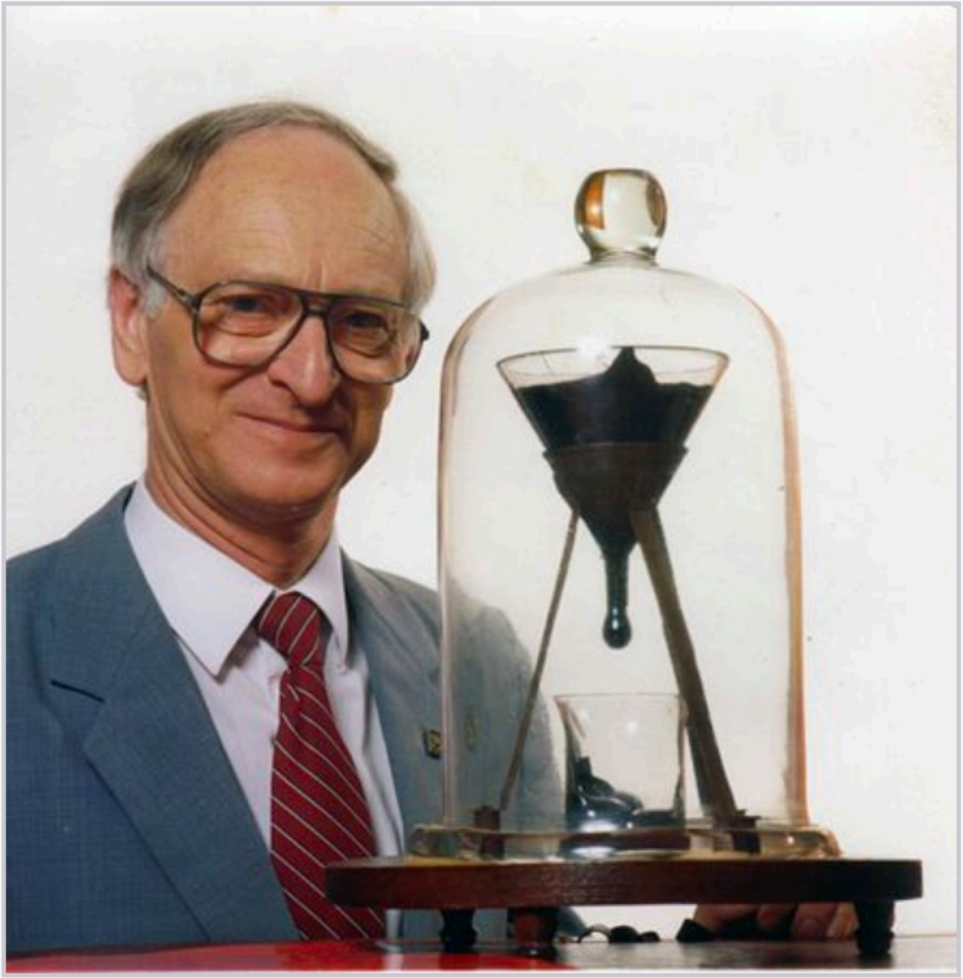


https://s3-us-west-2.amazonaws.com/courses-images-archive-read-only/wp-content/uploads/sites/887/2015/05/23213548/CNX_Chem_10_02_Testtubeoi_img.jpg

Longest experiment sees pitch drop after 84-year wait

PHYSICS 17 April 2014

By Lisa Grossman and Celeste Biever



The University of Queensland pitch drop experiment, featuring its then-current custodian, Professor John Mainstone (taken in 1990, two years after the seventh drop and 10 years before the eighth drop fell).

Materials in-between

Materials that can behave like liquids or like solids, depending on how fast you make them change their shape, and by how much

Shapes change because atoms and molecules move out of their earlier positions to adopt newer ones

If you change the shape too fast, the atoms and molecules can't keep up, resist the change (a solid property)

But if you do so slowly, then can flow smoothly (if they are liquids)

But the molecules can also change their shapes and how they are connected to move more freely

https://statics.sportskeeda.com/wp-content/uploads/2015/01/bhakti-sharma-1421243885.jpg

https://imagesvc.meredithcorp.io/

https://nypost.com/wp-content/uploads/sites/2/2014/07/skydivemain.jpg?quality=90&strip=all&w=915

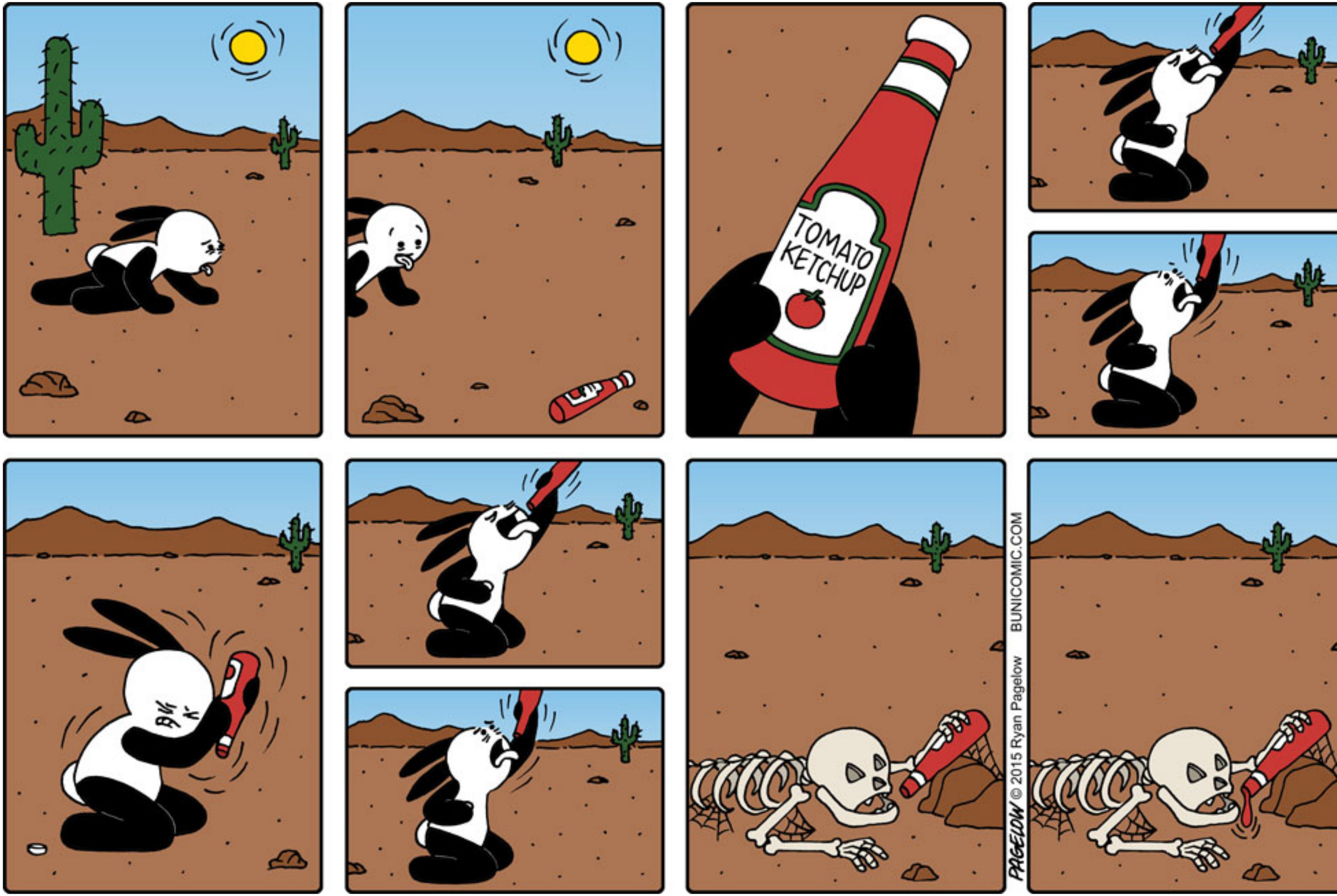
Without a parachute to slow you down, what would the experience of jumping into the ocean from an airplane be like?

Answer: If you try to change the shape of fluids very fast (the water must move around your body as it hits it with high velocity), it resists much more - solid-like

So .. not good

https://i.redd.it/oiun6xx07ke21.jpg

https://www.mouthshut.com/

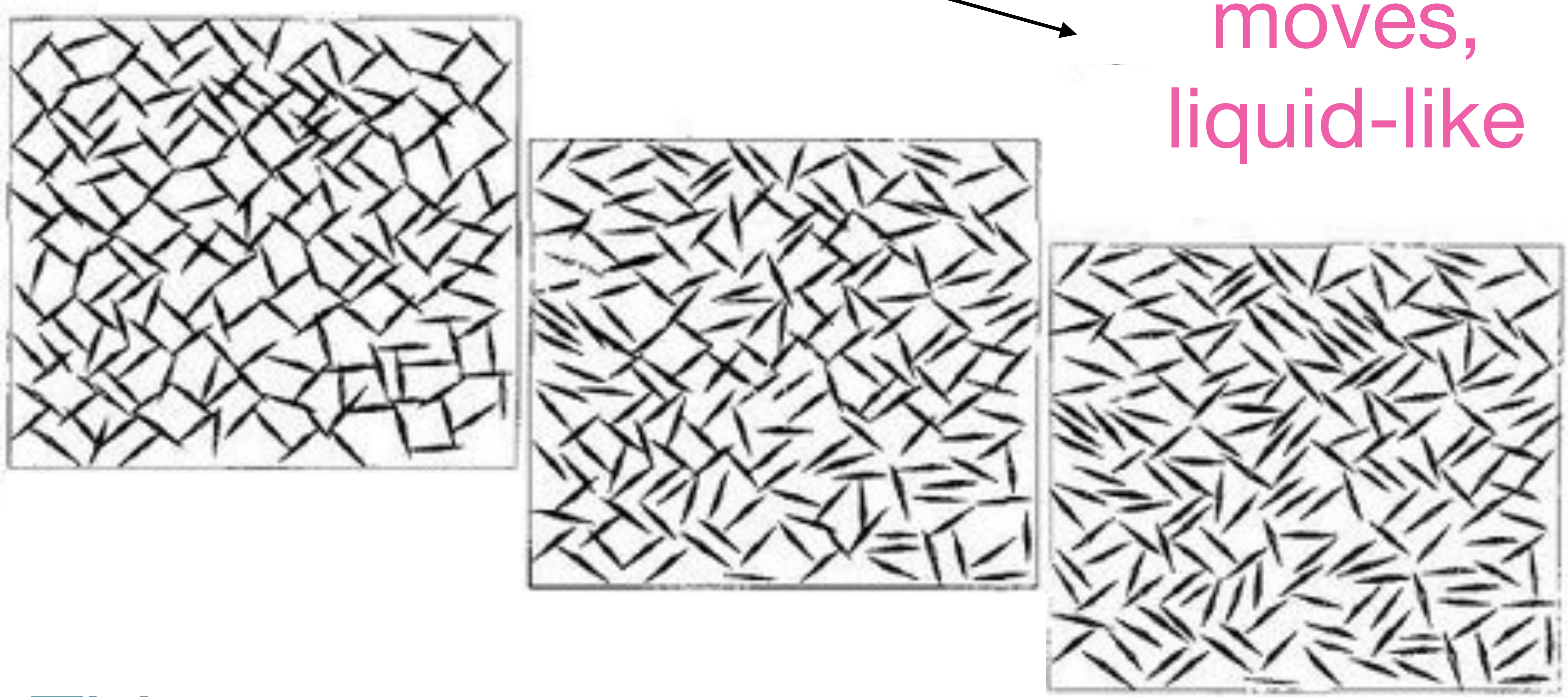


http://www.bunicomic.com/wp-content/uploads/2015/07/2015-07-24-Buni.jpg

Sauce holds together, doesn't move, solid-like (gel)

Shake bottle

Sauce moves, liquid-like



Thixotropy

https://periclean.com/wp-content/uploads/2014/09/toothpaste.jpg

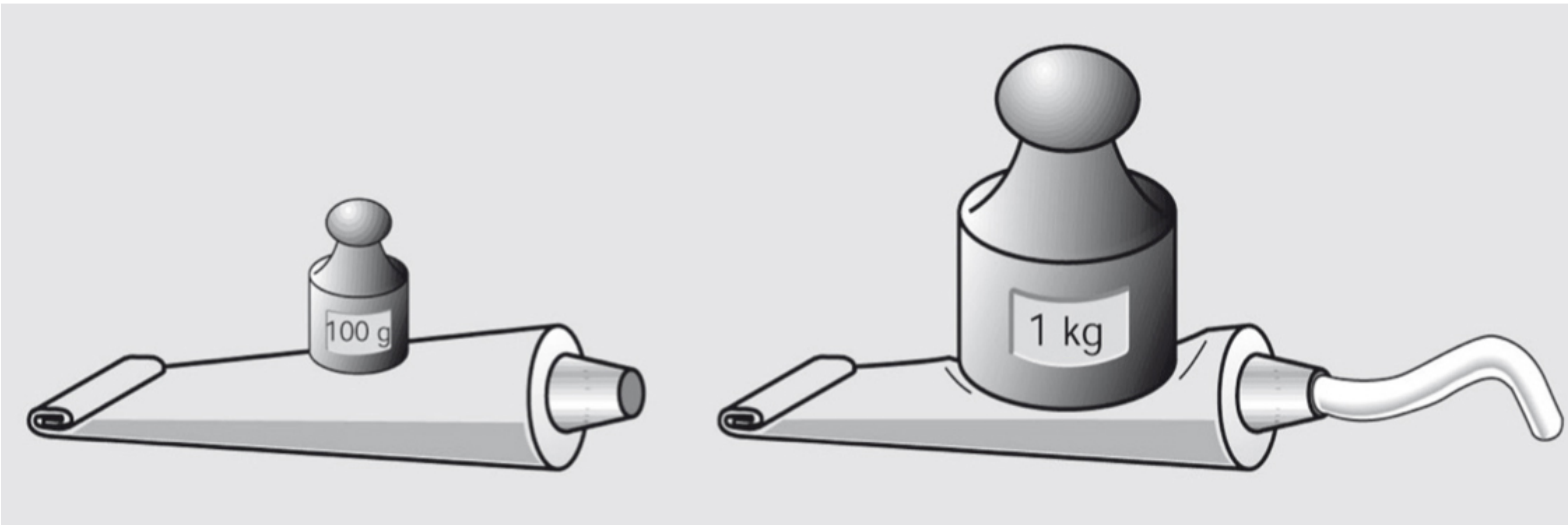
Toothpaste behaves like a solid at rest inside the tube.

Will not flow out when the cap is removed.
Will flow out when you squeeze the tube

On squeezing the tube, acts like a thick liquid

On your toothbrush, don't have to worry about it flowing off the brush

Yield point: Minimum force to be applied to toothpaste tube so it starts to flow



Below the yield point, toothpaste does not flow out of its tube if no force is applied, so behaves solid-like. Above, it flows out.

Bacterial biofilms (plaque) build up on teeth every 12 to 24 hours

Toothpaste makes brushing more effective

Abrasives in them remove stains without damaging teeth

Toothpaste foams because it contains a detergent (surfactant), another type of cleaning ingredient

Loosens and breaks down substances on your teeth that would otherwise not be dissolved and rinsed away with water

Other ingredients that retain moisture in the toothpaste and keep ingredients from separating (binding agents)

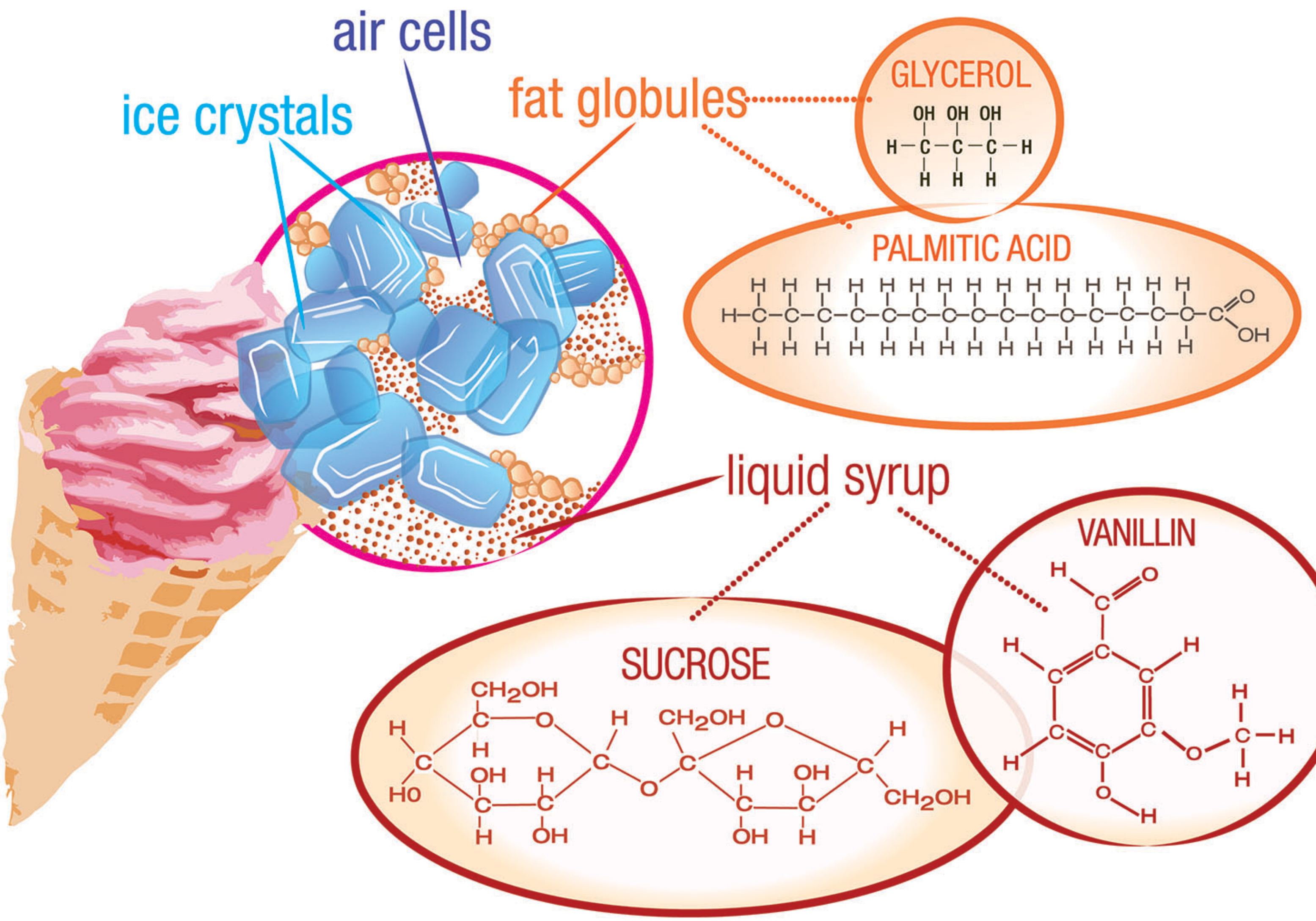
If toothpaste didn't have these components, it would dry out or require stirring

Also flavouring

https://www.calpaclab.com/blog/the-chemistry-of-ice-cream-yum/
https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2013-2014/ice-cream-chemistry.html

Ice cream

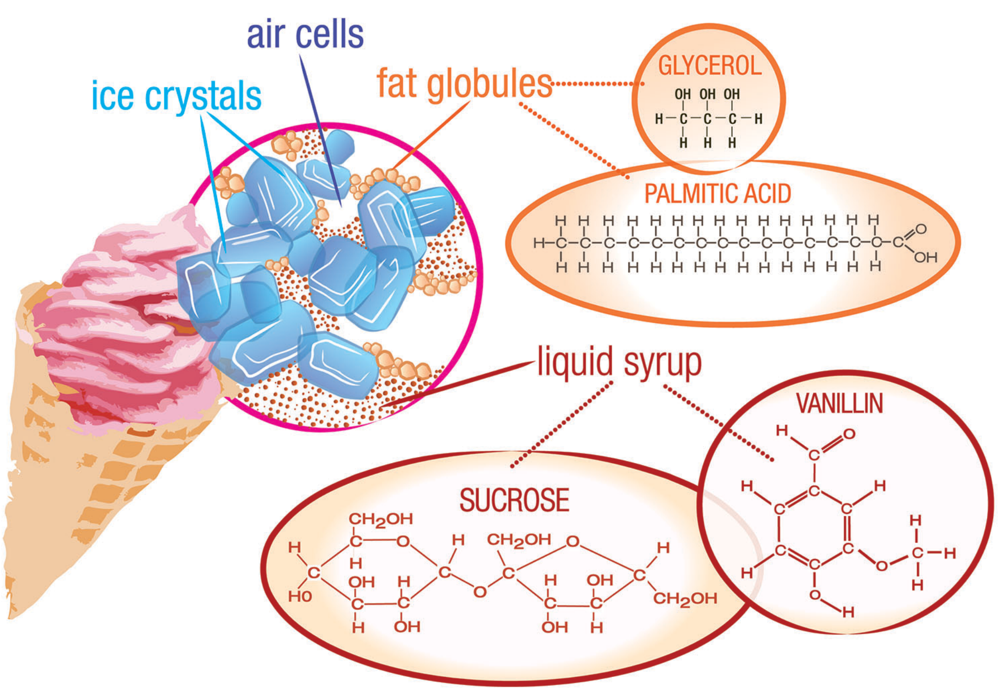
Water, sweeteners, flavourings, emulsifiers, stabilisers, milk fat and milk solids



Ice cream combines two liquids that don't mix

Liquid particles of fat spread through mixture of water, sugar, and ice, with air bubbles

Fat doesn’t mix well. Fat content in ice cream has a tendency to separate out



Small air bubbles and ice crystals in water and a network of fat globules

Emulsifiers: Make emulsions stable, prevent fat droplets clumping (**surfactants**)

Act like a sponge, absorb and lock in place, liquid

Stabilizers: Keep the material uniform. Make texture creamy. Prevent large crystal formation

With stabilizers, ice cream contains small ice crystals that melt more slowly

Ice cream makers add a lot of sugar, usually sucrose or glucose

Cold numbs taste buds, makes them less sensitive. More sugar needs to be added to produce the desired effect at the temperatures at which ice cream is served.

Ice cream at room temperature tastes very sweet.

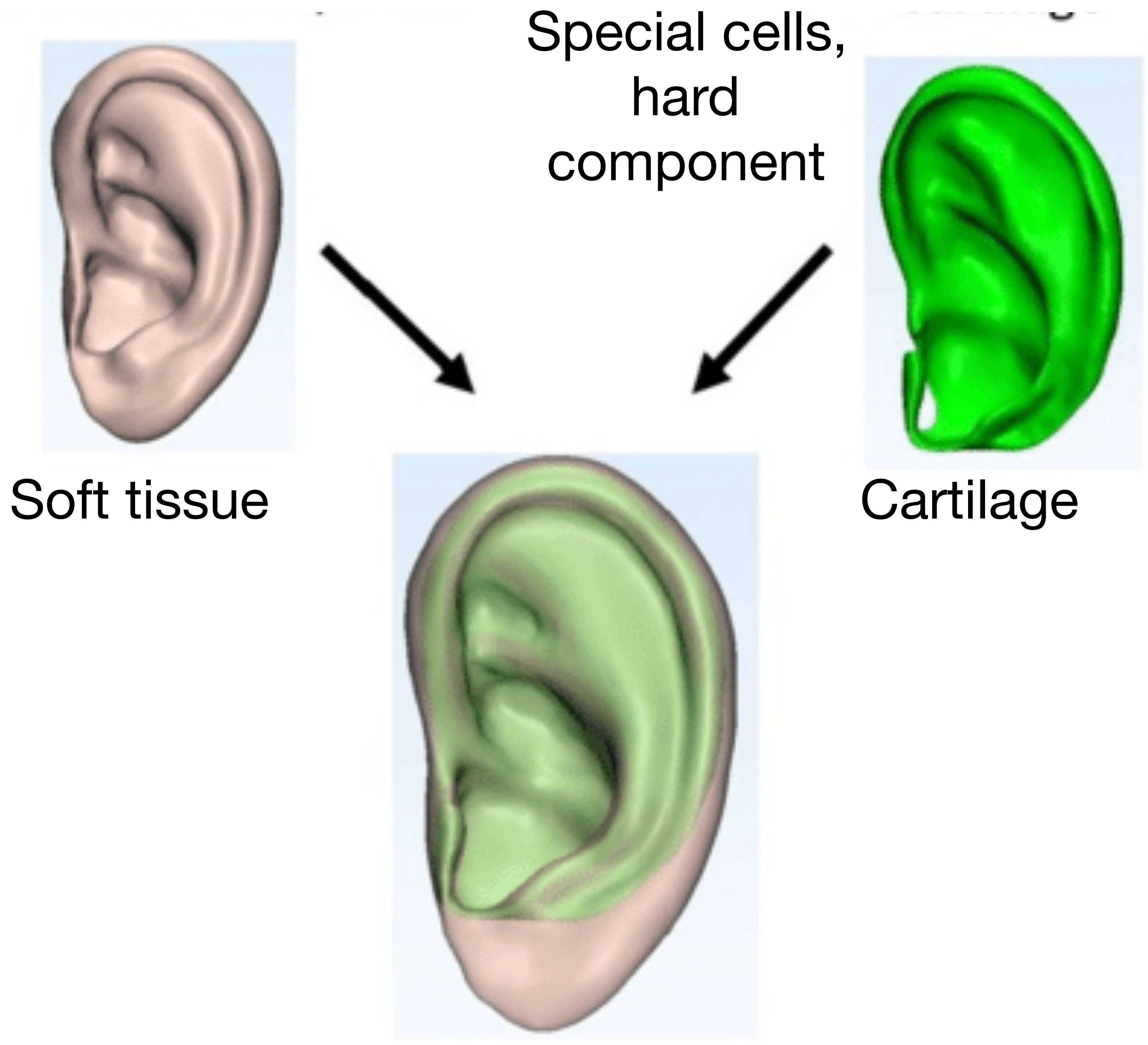
Ice crystals that form when ice cream freezes are important to quality of ice cream

Soft serve ice cream, requires small ice crystals. So ice cream needs to be frozen quickly.

However, ice cream still about 60% water. When served at usual temperatures, not all of it is frozen

Ice cream then “scoopable”

https://i.pinimg.com/474x/cc/69/d5/cc69d5c73dce983a9c6e0d7768802198.jpg



https://www.researchgate.net/profile/Mazher_Mohammed2/publication/310771444/figure/fig3/AS:667625193484291@1536185658379/a-A-classical-medical-diagram-of-the-cartilage-within-the-ear-17-adapted-from.png

Earlobe has no cartilage

Has a large blood supply

Highly elastic

Soft, living, self-repairing material

https://assets.babycenter.com/intl/gb/i/slideshows/INsleepingangels/Sleeping-Angels-38.jpg http://www.asiaphotostock.com/itemimages/149b6813.jpg

A soft but solid material

Can grow and heal

Flows very slowly if you apply a force

https://theconversation.com/health-check-what-you-need-to-know-about-mucus-and-phlegm-33192

The new coronavirus is tiny

Little particles produced by people when they breathe, talk and cough invisible to the naked eye, easily able to float in air.

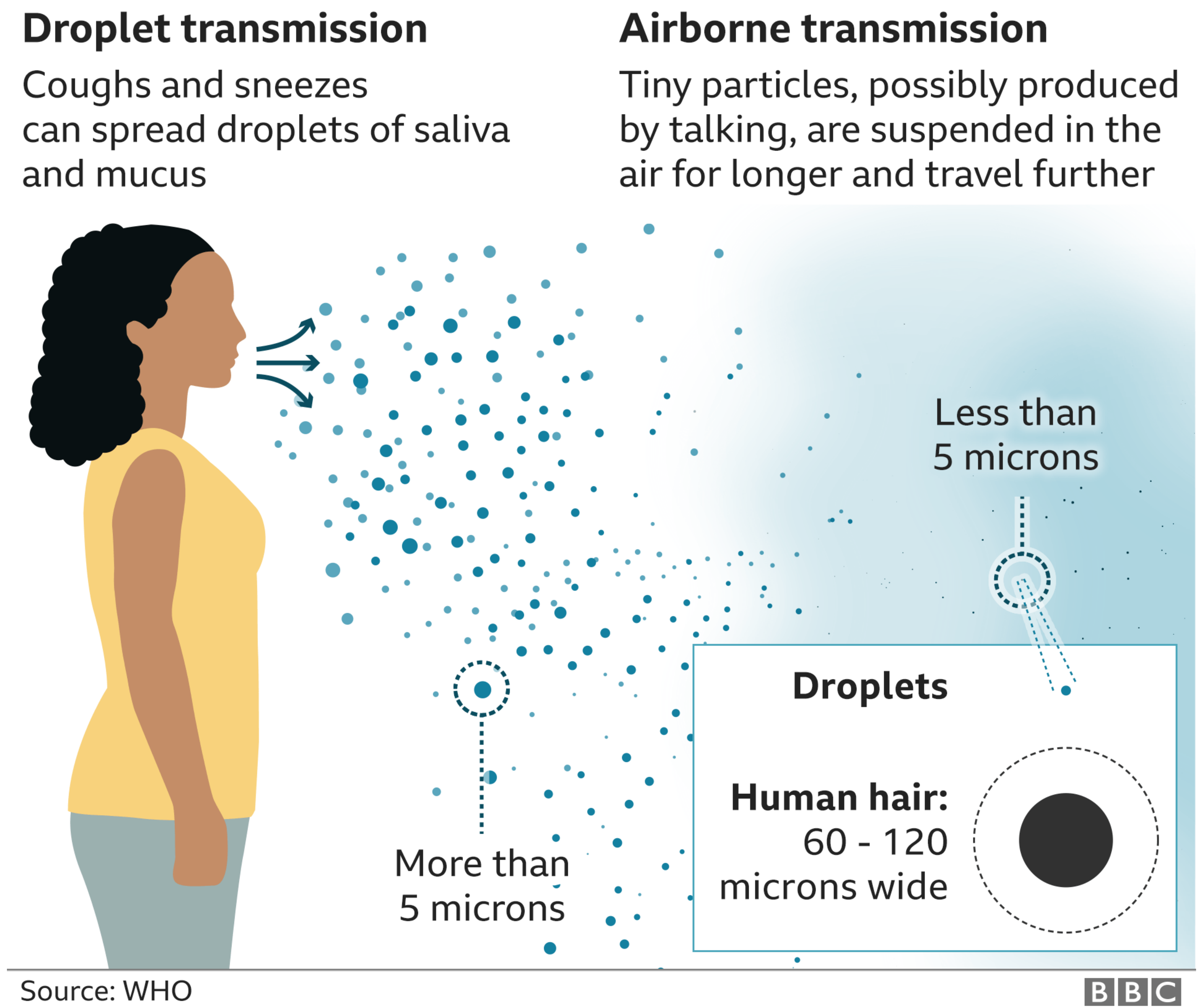
Mostly biological fluids from people’s mouths and lungs

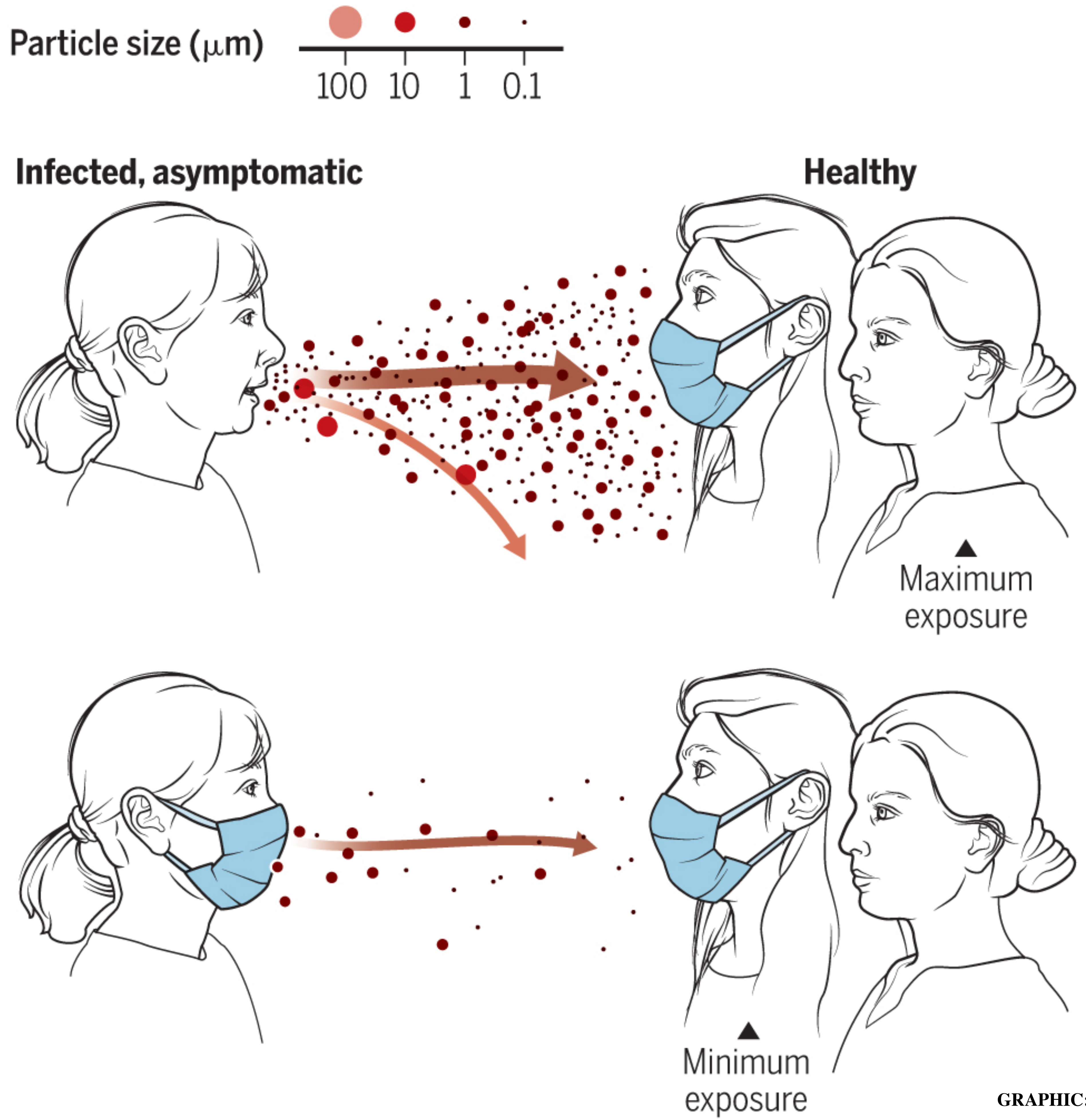
<u>Mucus can carry coronavirus particles</u>

Mucus is 95% water, 3% proteins (including mucin and antibodies), 1% salt and other substances.

Mucin droplets absorb water. Swell several hundred times in volume within three seconds of release from mucus glands.

Mucus strands form cross links, a sticky, elastic gel


Droplet transmission
Coughs and sneezes can spread droplets of saliva and mucus
Airborne transmission
Tiny particles, possibly produced by talking, are suspended in the air for longer and travel further
Less than 5 microns
More than 5 microns
Droplets
Human hair: 60 - 120 microns wide
Source: WHO
BBC



GRAPHIC: V. ALTOUNIAN/*SCIENCE*

Soft and squishy materials are all around us

Spare a moment to think of how remarkable they are

Thank you