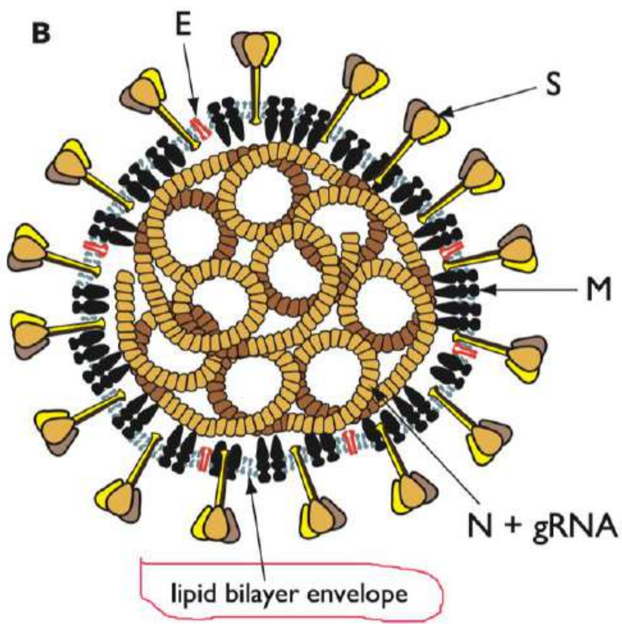
Coronavirus Thread from Twitter 3.8.2020 @PalliThordarson

1/25 Part 1 - Why does soap work so well on the SARS-CoV-2, the coronavirus and indeed most viruses? Because it is a self-assembled nanoparticle in which the weakest link is the lipid (fatty) bilayer. A two part thread about soap, viruses and supramolecular chemistry #COVID19



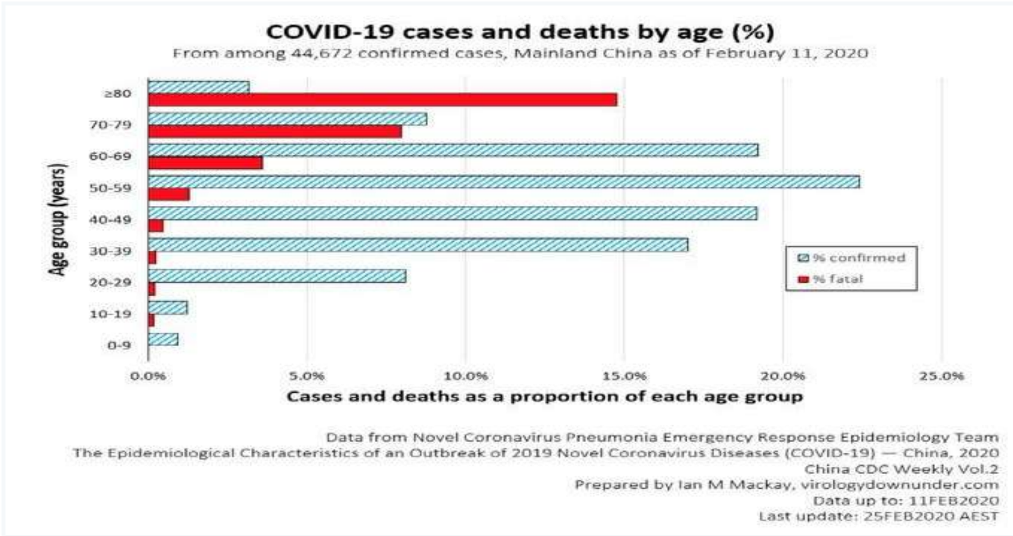
2/25 The soap dissolves the fat membrane and the virus falls apart like a house of cards and "dies", or rather, we should say it becomes inactive as viruses aren't really alive. Viruses can be active outside the body for hours, even days.

3/25 Disinfectants, or liquids, wipes, gels and creams containing alcohol (and soap) have similar effects but are not really quite as good as normal soap. Apart from the alcohol and soap, the "antibacterial agents" in these products don't affect the virus structure much at all.

4/25 Consequently, many antibacterial products are basically just an expensive version of soap in terms of how they act on viruses. Soap is the best but alcohol wipes are good when soap is not practical or handy (e.g. office receptions).

5/25 But why exactly is soap so good? To explain that, I will take you through a bit of a journey through supramolecular #chemistry, nanoscience and virology. I try to explain this in generic terms as much as possible, which means leaving some specialist chemistry terms out.

6/25 I point out that while I am expert in supramolecular chemistry and the assembly of nanoparticles, I am not a virologist. The image with the first tweet is from an excellent post here which is dense with good virology info:



SARS-CoV-2 and the lessons we have to learn from it.

(SARS-2-CoV is the virus. COVID-19 is the disease.)

7/25 I have always been fascinated by viruses as I see them as one of the most spectacular examples of how supramolecular chemistry and nanoscience can converge. Most viruses consist of three key building blocks: RNA, proteins and lipids.

8/25 The RNA is the viral genetic material -it is very similar to DNA. The proteins have several roles including breaking into the target cell, assist with virus replication and basically to be a key building block (like a brick in a house) in the whole virus structure.

10/25 Instead the viral self-assembly is based on weak “non-covalent” interactions between the proteins, RNA and lipids. Together these act together like a Velcro so it is very hard to break up the self-assembled viral particle. Still, we can do it (e.g. with soap!).

11/25 Most viruses, including the coronavirus, are between 50-200 nanometers – so they are truly nanoparticles. Nanoparticles have complex interactions with surfaces they are on. Same with viruses. Skin, steel, timber, fabric, paint and porcelain are very different surfaces.

12/25 When a virus invades a cell, the RNA “hijacks” the cellular machinery like a computer virus (!) and forces the cell to start to make a lot of fresh copies of its own RNA and the various proteins that make up the virus.

13/25 These new RNA and protein molecules, self-assemble with lipids (usually readily present in the cell) to form new copies of the virus. That is, the virus does not photocopy itself, it makes copies of the building blocks which then self-assemble into new viruses!

14/25 All those new viruses eventually overwhelm the cell and it dies/explodes releasing viruses which then go on to infect more cells. In the lungs, some of these viruses end up in the airways and the mucous membranes surrounding these.

15/25 When you cough, or especially when you sneeze, tiny droplets from the airways can fly up to 10 meters (30 ft)! The larger ones are thought to be main coronavirus carriers and they can go at least 2 m (7 ft). Thus – cover your coughs & sneezes people!

16/25 These tiny droplets end on surfaces and often dry out quickly. But the viruses are still active! What happens next is all about supramolecular chemistry and how self-assembled nanoparticles (like the viruses) interact with their environment!

17/25 Now it is time to introduce a powerful supramolecular chemistry concept that effectively says: similar molecules appear to interact more strongly with each other than dissimilar ones. Wood, fabric and not to mention skin interact fairly strongly with viruses.

18/25 Contrast this with steel, porcelain and at least some plastics, e.g. teflon. The surface structure also matters – the flatter the surface the less the virus will “stick” to the surface. Rougher surfaces can actually pull the virus apart.

19/25 So why are surfaces different? The virus is held together by a combination of hydrogen bonds (like those in water) and what we call hydrophobic or “fat-like” interactions. The surface of fibres or wood for instance can form a lot of hydrogen bonds with the virus.

20/25 In contrast steel, porcelain or teflon do not form a lot of hydrogen bond with the virus. So the virus is not strongly bound to these surfaces. The virus is quite stable on these surface whereas it doesn’t stay active for as long on say fabric or wood.

21/25 For how long does the virus stay active? It depends. The SARS-CoV-2 coronavirus is thought to stay active on favourable surfaces for hours, possibly a day. Moisture (“dissolves”), sun light (UV light) and heat (molecular motions) all make the virus less stable.

22/25 The skin is an ideal surface for a virus! It is “organic” and the proteins and fatty acids in the dead cells on the surface interact with the virus through both hydrogen bonds and the “fat-like” hydrophobic interactions.

23/25 So when you touch say a steel surface with a virus particle on it, it will stick to your skin and hence get transferred onto your hands. But you are not (yet) infected. If you touch your face though, the virus can get transferred from your hands and on to your face.

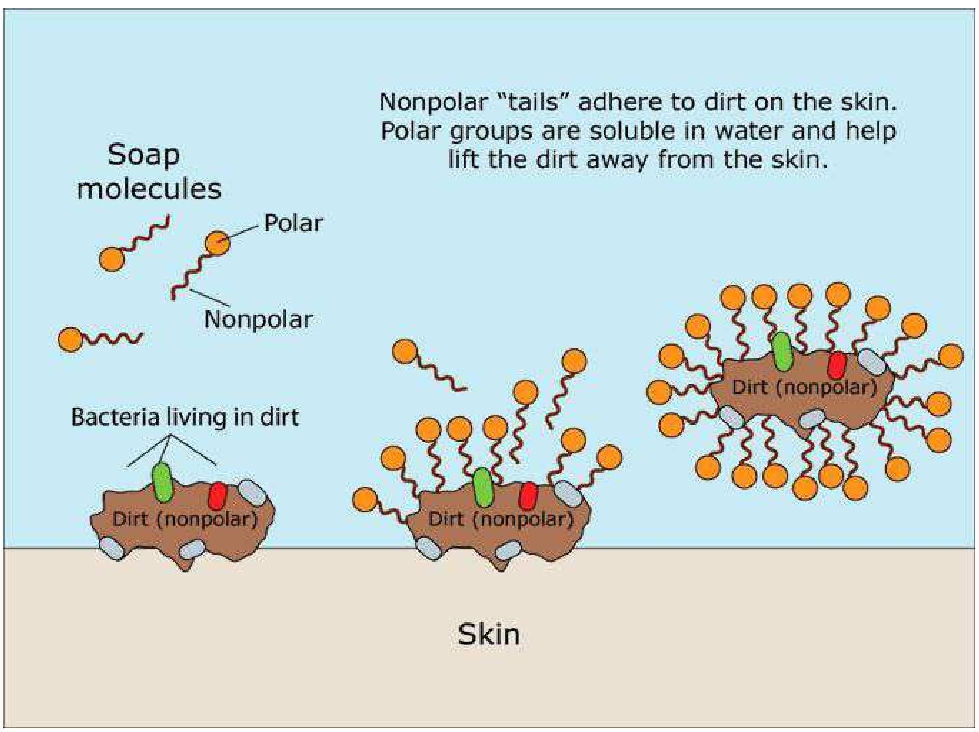
24/25 And now the virus is dangerously close to the airways and the mucus type membranes in and around your mouth and eyes. So the virus can get in…and voila! You are infected (that is, unless your immune system kills the virus).

25/25 If the virus is on your hands you can pass it on by shaking someone else's hand. Kisses, well, that's pretty obvious…It comes without saying that if someone sneezes right in your face you are kind of stuffed. Part 2 about soap coming next (25 post limit reached)!

26/39 Part 2 about soap, supramolecular chemistry and viruses. So how often do you touch your face? It turns out most people touch the face once every 2-5 minutes! Yeah, so you are at high risk once the virus gets on your hands unless you can wash the active virus off.

27/39 So let's try washing it off with plain water. It might just work. But water "only" competes with the strong "glue-like" interactions between the skin and virus via hydrogen bonds. They virus is quite sticky and may not budge. Water isn't enough.

28/39 Soapy water is totally different. Soap contains fat-like substances known as amphiphiles, some structurally very similar to the lipids in the virus membrane. The soap molecules "compete" with the lipids in the virus membrane.



29/39 The soap molecules also compete with a lot other non-covalent bonds that help the proteins, RNA and the lipids to stick together. The soap is effectively "dissolving" the glue that holds the virus together. Add to that all the water.

30/39 The soap also outcompetes the interactions between the virus and the skin surface. Soon the viruses get detached and fall apart like a house of cards due to the combined action of the soap and water. The virus is gone!

31/39 The skin is quite rough and wrinkly which is why you do need a fair amount of rubbing and soaking to ensure the soap reaches every nook and cranny on the skin surface that could be hiding active viruses.

32/39 Alcohol based products, which pretty much includes all “disinfectants” and “antibacterial” products contain a high-% alcohol solution, typically 60-80% ethanol, sometimes with a bit of isopropanol as well and then water + a bit of a soap.

ACTIVE INGREDIENTS:

Ethyl alcohol 70% v/v

INACTIVE INGREDIENTS:

Water (aqua), Isopropyl Alcohol, Caprylyl Glycol, Glycerin, Isopropyl Myristate, Tocopheryl Acetate, Acrylates/C10-30 Acrylate Crosspolymer, Aminomethyl Propanol, Fragrance (Parfum)

33/39 Ethanol and other alcohols do not only readily form hydrogen bonds with the virus material but as a solvent, are more lipophilic than water. Hence alcohol does also dissolve the lipid membrane and disrupt other supramolecular interactions in the virus.

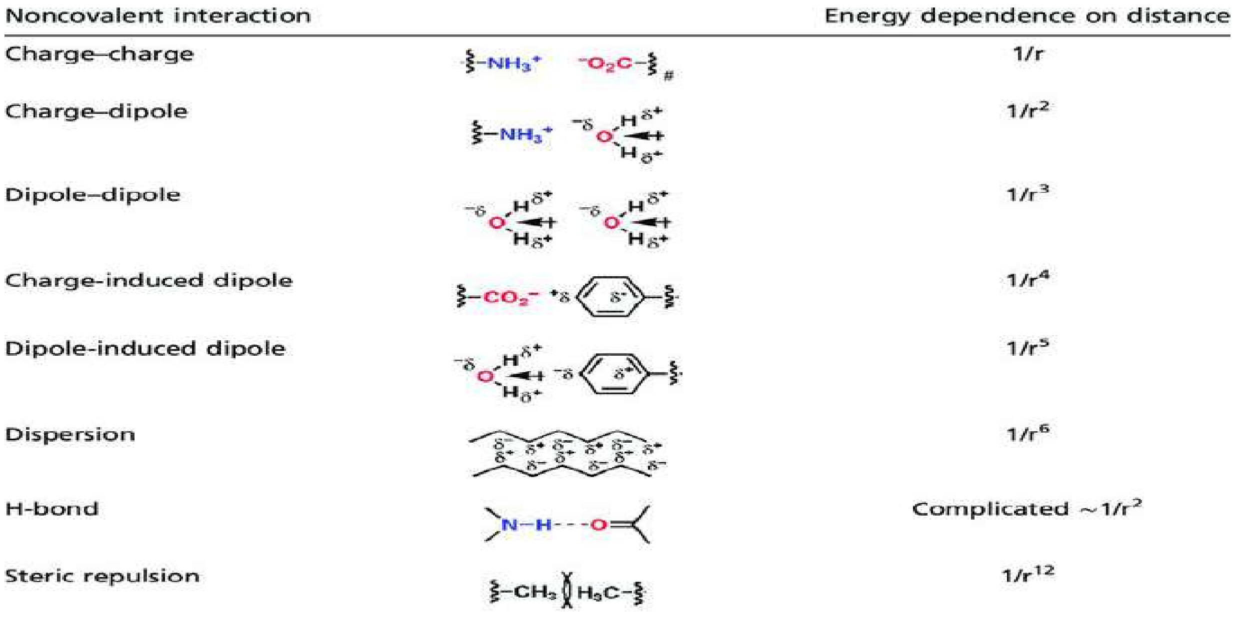
34/39 However, you need a fairly high concentration (maybe +60%) of the alcohol to get a rapid dissolution of the virus. Vodka or whiskey (usually 40% ethanol), will not dissolve the virus as quickly. Overall alcohol is not quite as good as soap at this task.

35/39 Nearly all antibacterial products contain alcohol and some soap and this does help killing viruses. But some also include “active” bacterial killing agents, like triclosan. Those, however, do basically nothing to the virus!

36/39 To sum up, viruses are almost like little grease-nanoparticles. They can stay active for many hours on surfaces and then get picked up by touch. They then get to our face and infect us because most of us touch the face quite frequently.

37/39 Water is not very effective alone in washing the virus off our hands. Alcohol based products work better. But nothing beats soap – the virus detaches from the skin and falls apart very readily in soapy water.

38/39 Here you have it – supramolecular chemistry and nanoscience tell us not only a lot about how the virus self-assembled into a functional active menace, but also how we can beat viruses with something as simple as soap.



Noncovalent interaction	Energy dependence on distance
Charge–charge	$1/r$
Charge–dipole	$1/r^2$
Dipole–dipole	$1/r^3$
Charge-induced dipole	$1/r^4$
Dipole-induced dipole	$1/r^5$
Dispersion	$1/r^6$
H-bond	Complicated $\sim 1/r^2$
Steric repulsion	$1/r^{12}$

Dependencies for entries 2–5 are only valid at values of r several times greater than the lengths of the interacting dipoles. At or near the Van der Waals distances operating in the catalytic reactions discussed in the text, these interactions become largely electrostatic, displaying a ~1/r dependence.

39/39 Thank you for reading my first thread. Apologies for any mistakes in the above. I might have some virology details wrong here as I am not a virologist unlike @MackayIM who I am a big fan of! But I hope this inspires you not only to use soap but to read up on chemistry!

Palli Thordarson

@PalliThordarson

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Replying to @PalliThordarsonWow! That took off quickly. Thanks! I should mention that this thread is based on a Facebook post I did in Iceland yesterday. That one took off too with +1K shares already but Iceland had a very rapid rise in COVID-19 cases the past week or so.