

## Deadly viruses are no match for plain, old soap — here's the science behind it

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The original article is posted at [https://www.marketwatch.com/story/deadly-viruses-are-no-match-for-plain-old-soap-heres-the-science-behind-it-2020-03-08?itm\\_source=parsely-api&mod=mw](https://www.marketwatch.com/story/deadly-viruses-are-no-match-for-plain-old-soap-heres-the-science-behind-it-2020-03-08?itm_source=parsely-api&mod=mw) more headlines

### Soap works better than alcohol and disinfectants at destroying the structure of viruses.

Why does soap work so well on the new coronavirus and, indeed, most viruses? Because the new coronavirus is a self-assembled nanoparticle in which the weakest link is the lipid (fatty) bilayer.

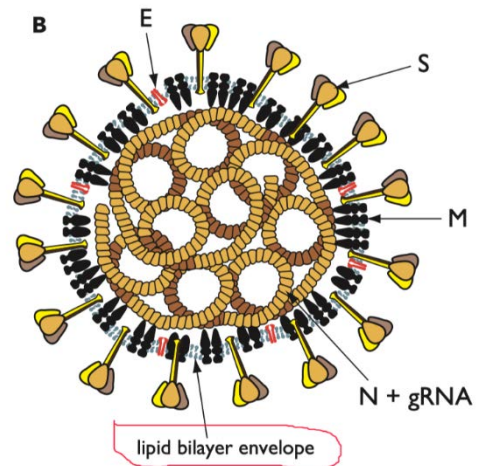
That sounds scientific. Let me explain.

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

Disinfectants, or liquids, wipes, gels and creams containing alcohol (and soap) have a similar effect but are not as good as regular soap. Apart from alcohol and soap, antibacterial agents in those products don't affect the virus structure much.

Consequently, many antibacterial products are basically just an expensive version of soap in how they act on viruses. Soap is the best, but alcohol wipes are good when soap is not practical or handy, for example in office reception areas.

But why, exactly, is soap so good? To explain that, I will take you through a journey of supramolecular chemistry, nanoscience and virology. I will try to explain this in generic terms, which means leaving out special chemistry terms. (I must point out that, while I am an expert in supramolecular chemistry and the assembly of nanoparticles, I am not a virologist.)



**Soap outcompetes the interactions between the virus and the skin surface, and the virus gets detached and falls apart like a house of cards.**

I have always been fascinated by viruses, as I see them as one of the most spectacular examples of how supramolecular chemistry and nanoscience converge.

Most viruses consist of three key building blocks: RNA, proteins and lipids. The RNA is the viral genetic material — it is similar to DNA. The proteins have several roles, including breaking into the target cell, assisting with virus replication and basically being a key building block (like a brick in a house) in the virus structure.

The lipids then form a coat around the virus, both for protection and to assist with its spread and cellular invasion. The RNA, proteins and lipids self-assemble to form the virus. Critically, there are no strong “covalent” bonds (atomic level bonding) holding these units together.

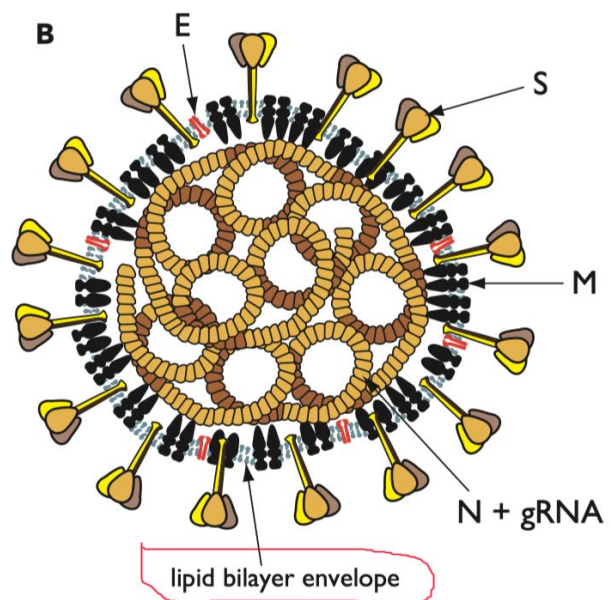
Instead, the viral self-assembly is based on weak “non-covalent” interactions between the proteins, RNA and lipids.

Together, these act together like Velcro, so it is hard to break up the self-assembled viral particle. Still, we can do it — with soap!

Most viruses, including the coronavirus, are between 50-200 nanometers — so they truly are nanoparticles. Nanoparticles have complex interactions with surfaces they are on; it's the same with viruses. Skin, steel, timber, fabric, paint and porcelain are very different surfaces.

When a virus invades a cell, the RNA “hijacks” the cellular machinery like a computer virus and forces the cell to make fresh copies of its own RNA and the various proteins that make up the virus.

These new RNA and protein molecules self-assemble with lipids (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.



All those new viruses eventually overwhelm the cell, and it dies or explodes, releasing viruses that then go on to infect more cells. In the lungs, viruses end up in the airways and mucous membranes.

When you cough, or especially when you sneeze, tiny droplets from the airways can fly up to 30 feet. The larger ones are thought to be the main coronavirus carriers, and they can go at least 7 feet. So, cover your coughs and sneezes!

These tiny droplets end up on surfaces and 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.

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 skin interact fairly strongly with viruses.

Contrast this with steel, porcelain and at least some plastics, such as 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.

So why are surfaces different? The virus is held together by a combination of hydrogen bonds (like those in water) and hydrophilic, or "fat-like," interactions. The surface of fibers or wood, for instance, can form a lot of hydrogen bonds with the virus.

In contrast, steel, porcelain or Teflon do not form much of a hydrogen bond with the virus. So the virus is not strongly bound to those surfaces and is quite stable.

For how long does the virus stay active? It depends. **The novel coronavirus is thought to stay active on favorable surfaces for hours, possibly a day.** What makes the virus less stable? Moisture ("dissolves"), sunlight (UV light), and heat (molecular motions) all make the virus less stable.

**The skin is an ideal surface for a virus.** It is organic, of course, 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" hydrophilic interactions.

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

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.

If the virus is on your hands, you can pass it on by shaking someone's else hand. Kisses, well, that's pretty obvious. It goes without saying that if someone sneezes in your face, you're stuck.

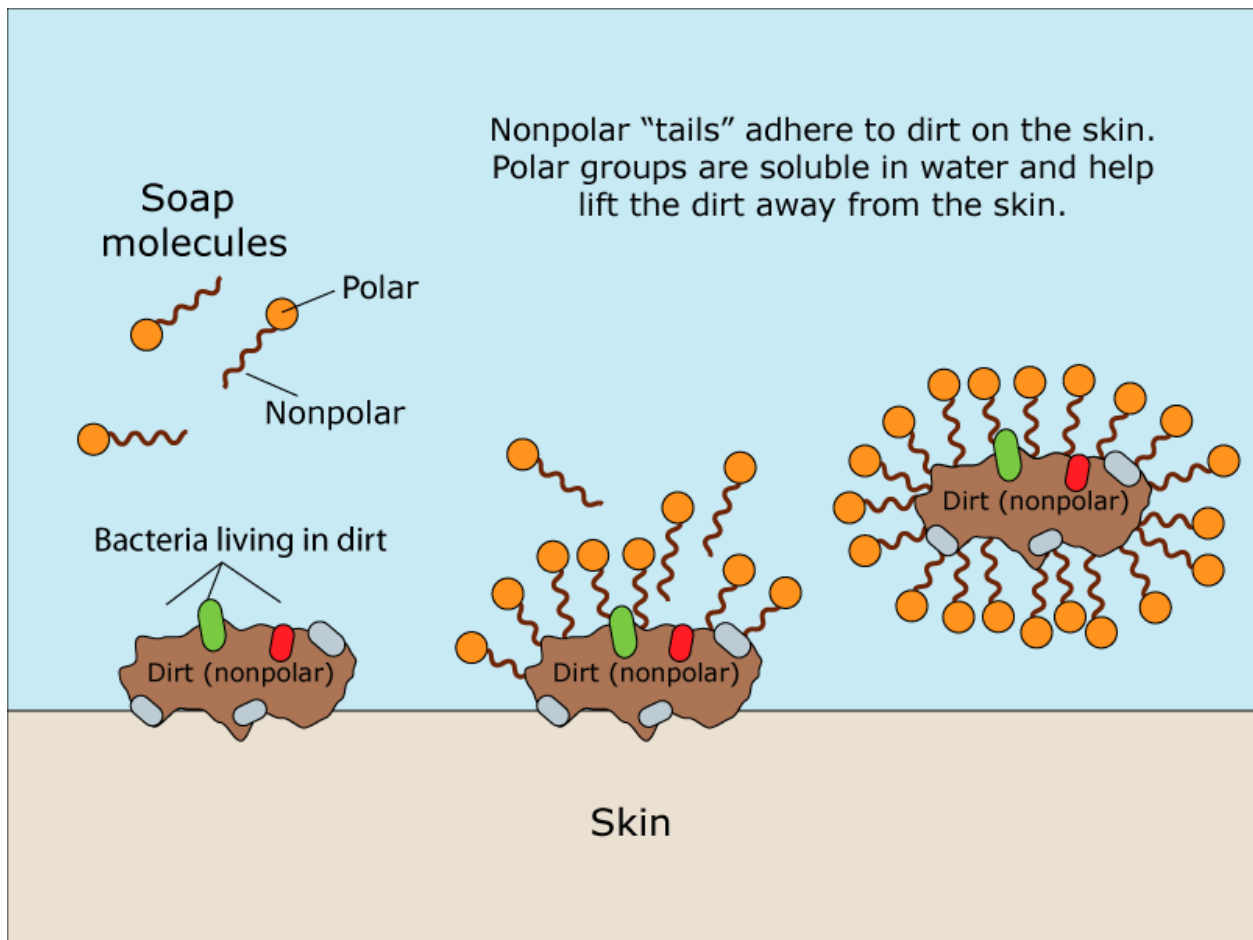
**How often do you touch your face? It turns out most people touch their face once every two to five minutes. So you're at high risk once the virus gets on your hands, unless you wash off the active virus.**

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. The virus is sticky and may not budge. Water isn't enough.

Soapy water is totally different. Soap contains fat-like substances known as amphiphiles, some structurally similar to the lipids in the virus membrane. The soap molecules "compete" with the lipids in the virus membrane. That is more or less how soap also removes normal dirt off the skin.

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.**

The soap also out-competes the interactions between the virus and the skin surface. Soon the virus gets detached and falls apart like a house of cards due to the combined action of the soap and water. Boom, the virus is gone!



*This is how soap removes dirt, and bacteria, from the skin.*

The skin is rough and wrinkly, which is why you 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.

Alcohol-based products include all "disinfectants" and "antibacterial" products that contain a high share of alcohol solution, typically 60%-80% ethanol, sometimes with a bit of isopropanol, water and a bit of soap.

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

However, you need a fairly high concentration (maybe 60%-plus) of the alcohol to get a rapid dissolution of the virus. Vodka or whiskey (usually 40% ethanol) won't dissolve the virus as quickly. Overall, alcohol is not as good as soap at this task.

Nearly all antibacterial products contain alcohol and some soap, and that does help kill viruses. But some also include “active” bacterial killing agents, such as triclosan. Those, however, do basically nothing to the virus.

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

Water is not 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 readily in soapy water.

Supramolecular chemistry and nanoscience tell us not only a lot about how the virus self-assembles into a functional, active menace, but also how we can beat viruses with something as simple as soap.

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*The [author's Twitter feed](#) follows-up on responses to his article.*

Soaps don't differ much really - a bit like rental cars. You need a car to get you from Houston to Austin, Texas? A cheap Hyundai will do the job fine but it would be a slightly nicer ride in a BMW. But it will still take 3 hours in both cars at the legal speed limit.

My personal view is that soaps are now 90% marketing and 10% real product differences. I am yet to be convinced that any soap product is that much better than some other, that just rubbing your hands for 20, instead of 10 seconds in the soap would not make a bigger difference.

A soap is a soap is a soap. There are some indications that bar soaps might be better to kill viruses simply because you will rub your hands more using those than foam. Flip side is they are sometimes slightly harsher on the hands. Just use a soap that you feel comfortable with.

Alcohol-based (disinfectants) wipes, creams or gels are not bad! They do kill viruses. Please use them! They are also very convenient. It is just you need much less of soap so when can use soap, do so. Otherwise use the alcohol-based stuff.

It is probably not a good idea to try to make your own alcohol-based cleaning products for your hands. Very strong whiskey, for instance, might be strong enough to kill viruses but do you really want to wash your hands from a bottle of fine single malt?

Take care of your hands. Soaking them constantly in alcohol based products is not good for them. It's actually the same with soap. Yes, wash them frequently but don't spend all day with your hands in soapy water. If your hands are hurting, something is wrong.

To summarise, just wash your hands with soap! Any soap—as long it is the real deal. Detergents are probably not good for your hands. Alcohol-based products do kill viruses and please use them whenever soap is not practical (e.g. when you are out and about).

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**Let's recap: Soap dissolves the virus by breaking up the interactions that hold it together. The alcohol in sanitisers and wipes does pretty much the same:** "Hence alcohol does also dissolve the lipid membrane and disrupts other supramolecular interactions in the virus".

There is a subtle point here that I didn't explain. Alcohol is a solvent. It is different from water or say petrol. Now, non-covalent interactions are very solvent dependent. The "hydrophobic" interactions that hold the virus together are strongest in water (water = hydro).

So, at say 60% ethanol concentration the hydrophobic effect is greatly weakened. In fact so much that this is probably the main reason the virus "dissolves" in alcohol solutions. Hence, alcohol solutions are very effective at making the virus inactive.

**Therefore, if you can reach every crook and nanny on your skin with the alcohol based sanitizer, then it will get rid of all the viruses just like soapy-water does.** I've been reading papers from infection experts how experimentally have compared soap vs alcohol based products.

There is not much difference - slightly larger number of papers are in favour of soap over alcohol based products (c.a. 60/40). When you read the papers more carefully, **it seems that this mostly about the TECHNIQUE not the product! That is, how you rub & wipe your hands.**

This does make sense from a chemistry standpoint. Both work well. Compare the recommended techniques.



## Hand-washing technique with soap and water



1 Wet hands with water



2 Apply enough soap to cover all hand surfaces



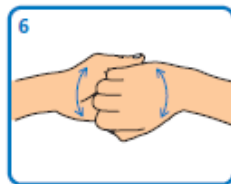
3 Rub hands palm to palm



4 Rub back of each hand with palm of other hand with fingers interlaced



5 Rub palm to palm with fingers interlaced



6 Rub with back of fingers to opposing palms with fingers interlocked



7 Rub each thumb clasped in opposite hand using a rotational movement



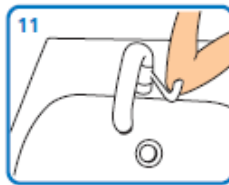
8 Rub tips of fingers in opposite palm in a circular motion



9 Rub each wrist with opposite hand



10 Rinse hands with water



11 Use elbow to turn off tap



12 Dry thoroughly with a single-use towel



13 Hand washing should take 15-30 seconds

The one for hand soap is not that far off the "natural" way I think many of us use soap. Also, because you don't need "much" soap, +20 sec of wash will cover your hands well.



Look at the recommended hand sanitizer method - do you do this? Why is this necessary? Because it is the best way to get the alcohol everywhere on your hands. Remember, you need the virus to "feel" that 60% alcohol, even it is very briefly. This is slightly harder to do.



Use the one you prefer or better, both; sometimes soap, sometimes sanitizer. The latter is a lot more convenient. But it does not always kill 100%. Even if it sometimes "only" kills 95% you still done great. Rub long and well. That's the key with both!

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*We added definitions for these words or phrases.*

## What is a Molecule?

(<https://www.chemicool.com/definition/molecule.html>)

A molecule is a particle made up of two or more atoms that are chemically bonded together, and has the properties of that substance.

For example,

- Hydrogen Chloride gas [HCl(g)] is a molecule made of one hydrogen atom bonded to one chlorine atom. It is made of two atoms and is called a diatomic molecule.
- Carbon dioxide [CO<sub>2</sub>] is a molecule made of two oxygen atoms bonded to a carbon atom. It contains three atoms and is called a triatomic molecule.
- Very large molecules exist; they are known as macromolecules. An example of a particularly large macromolecule is DNA, which contains hundreds of billions of atoms.

## What is Supramolecular Chemistry?

Excerpted from <https://www.pnas.org/content/98/21/11849>

Broadly speaking, **supramolecular chemistry** is the study of interactions between, rather than within, molecules—in other words, chemistry using molecules rather than atoms as building blocks.

From [https://pubs.rsc.org/en/Journals/ArticleCollectionLanding?sercode=CC&themeId=C0CC04096G-J-C0CC04476H\\_THEME&e=1](https://pubs.rsc.org/en/Journals/ArticleCollectionLanding?sercode=CC&themeId=C0CC04096G-J-C0CC04476H_THEME&e=1)

**Supramolecular Chemistry** is all about interactions between molecules: how they can recognise each other, assemble, and function.

## What is nanoscience?

Excerpted from <http://tmi.utexas.edu/resources/what-is-nanoscience/>

**Nano** refers to the metric prefix 10<sup>-9</sup>. It means one billionth of something.

**Nanoscience** is the study of structures and materials on the scale of **nanometers** (one billionth of a meter). When structures are made small enough—in the nanometer size range—they can take on interesting and useful properties.

**Nanoscale** structures have existed in nature long before scientists began studying them in laboratories.

- A single strand of DNA, the building block of all living things, is about three **nanometers** wide.
- The scales on a morpho butterfly's wings contain **nanostuctures** that change the way light waves interact with each other, giving the wings brilliant metallic blue and green hues.
- Peacock feathers and soap bubbles also get their iridescent coloration from light interacting with structures just tens of **nanometers** thick.

**Nanoscience** innovation examples:

- Stain-resistant fabrics inspired by **nanoscale** features found on lotus plants
- Computer hard drives, which store information on magnetic strips that are just 20 **nanometers** thick