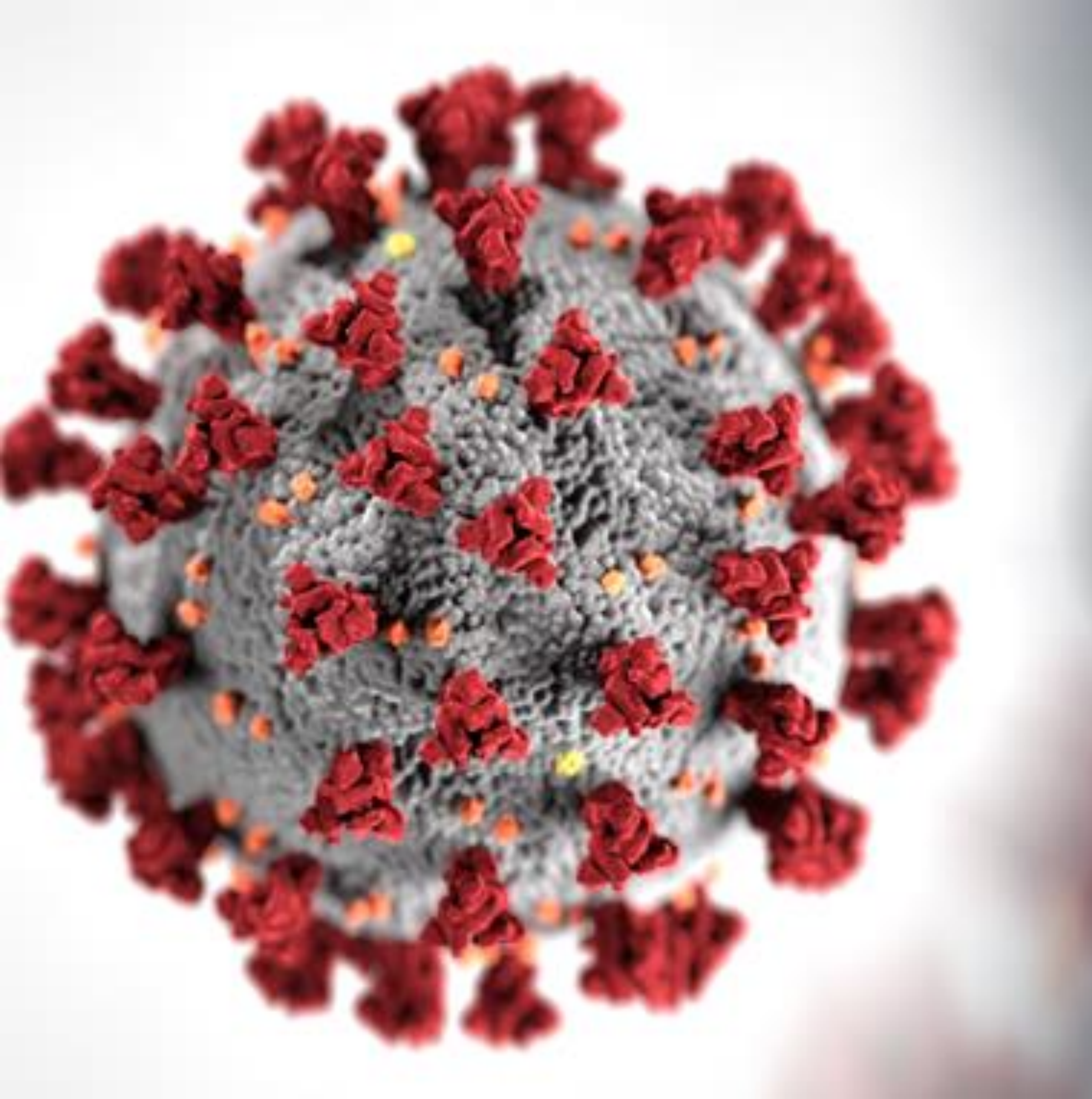
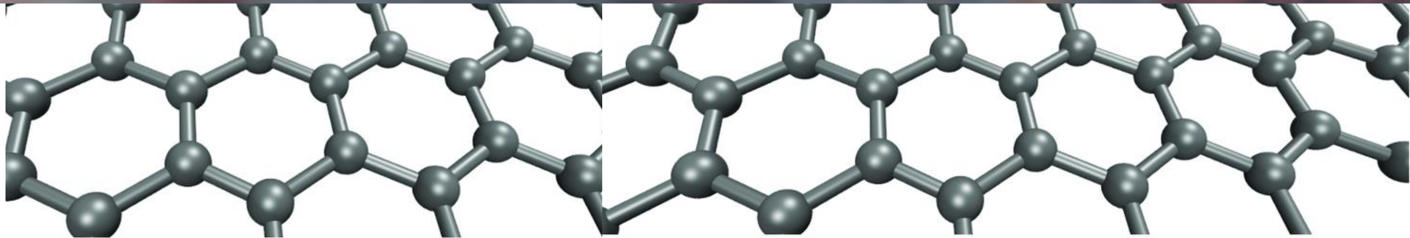


GRAPHENE AND CORONAVIRUS

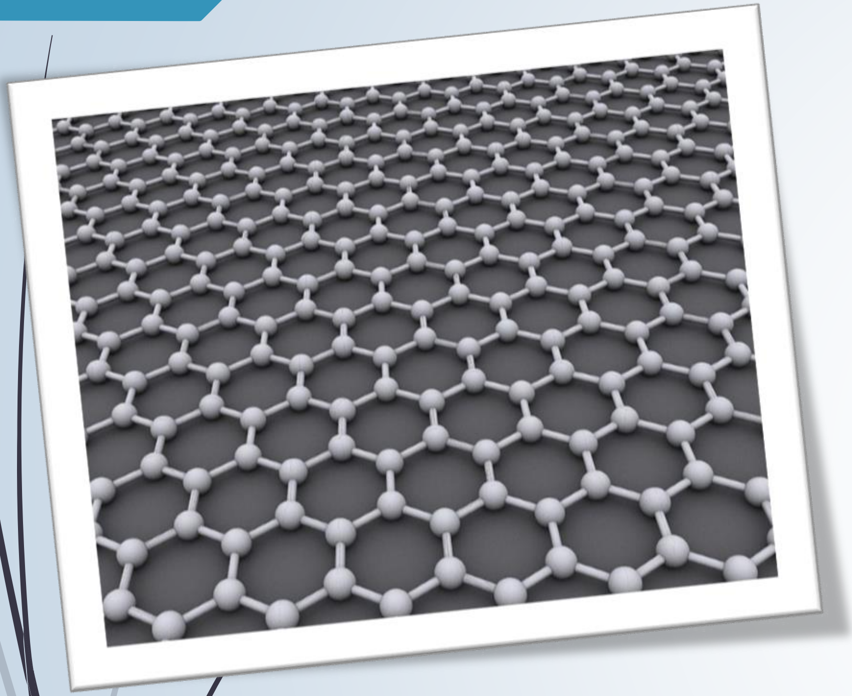
Faisal Amri Tanjung, PhD

Dean, Faculty of Science and Technology

University Associate, Curtin University

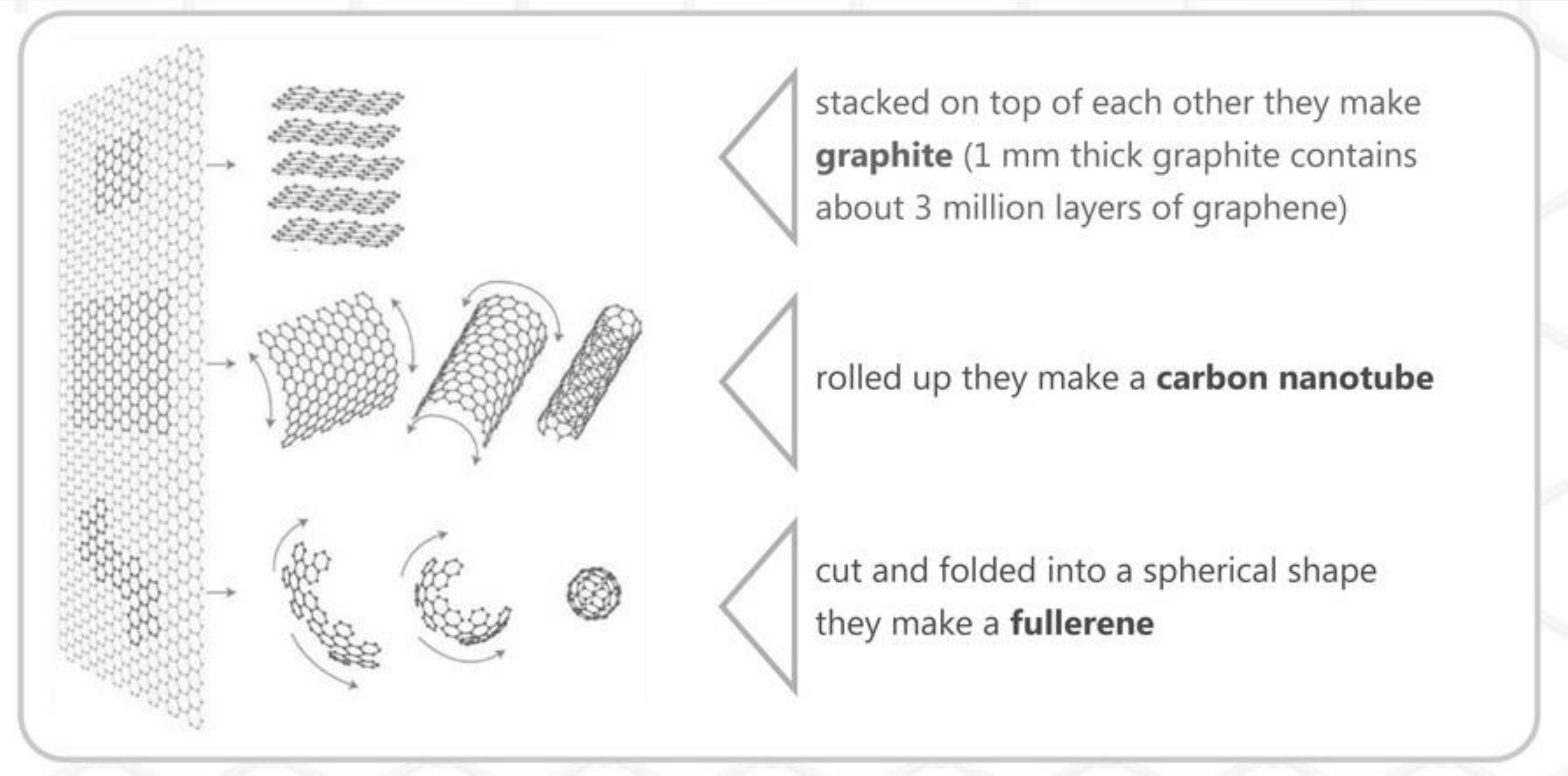


What is graphene?



- Graphene is a material made from carbon
- It represents a conceptually new class of materials that are only one atom thick, so-called two-dimensional (2D) materials (they are called 2D because they extends in only two dimensions: length and width)
- It has many different properties which make it potentially useful
- It is expected to replace common materials (i.e. plastic, silicon) on certain products as early as the next decade

Graphene sheets are building blocks for other graphitic materials

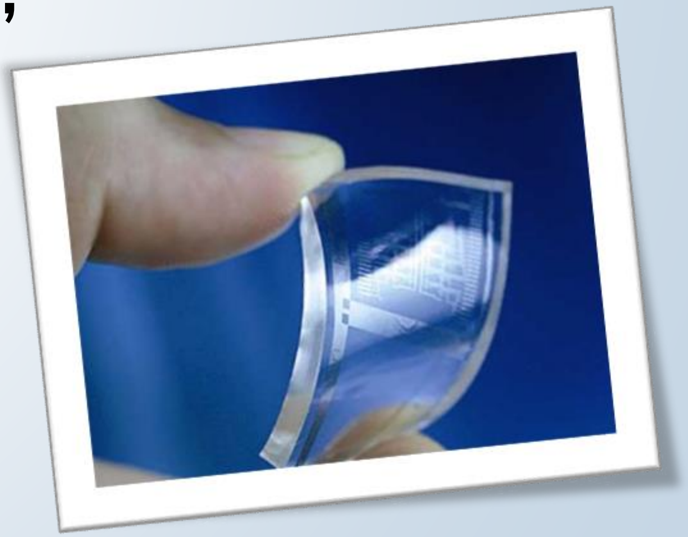


Properties of graphene

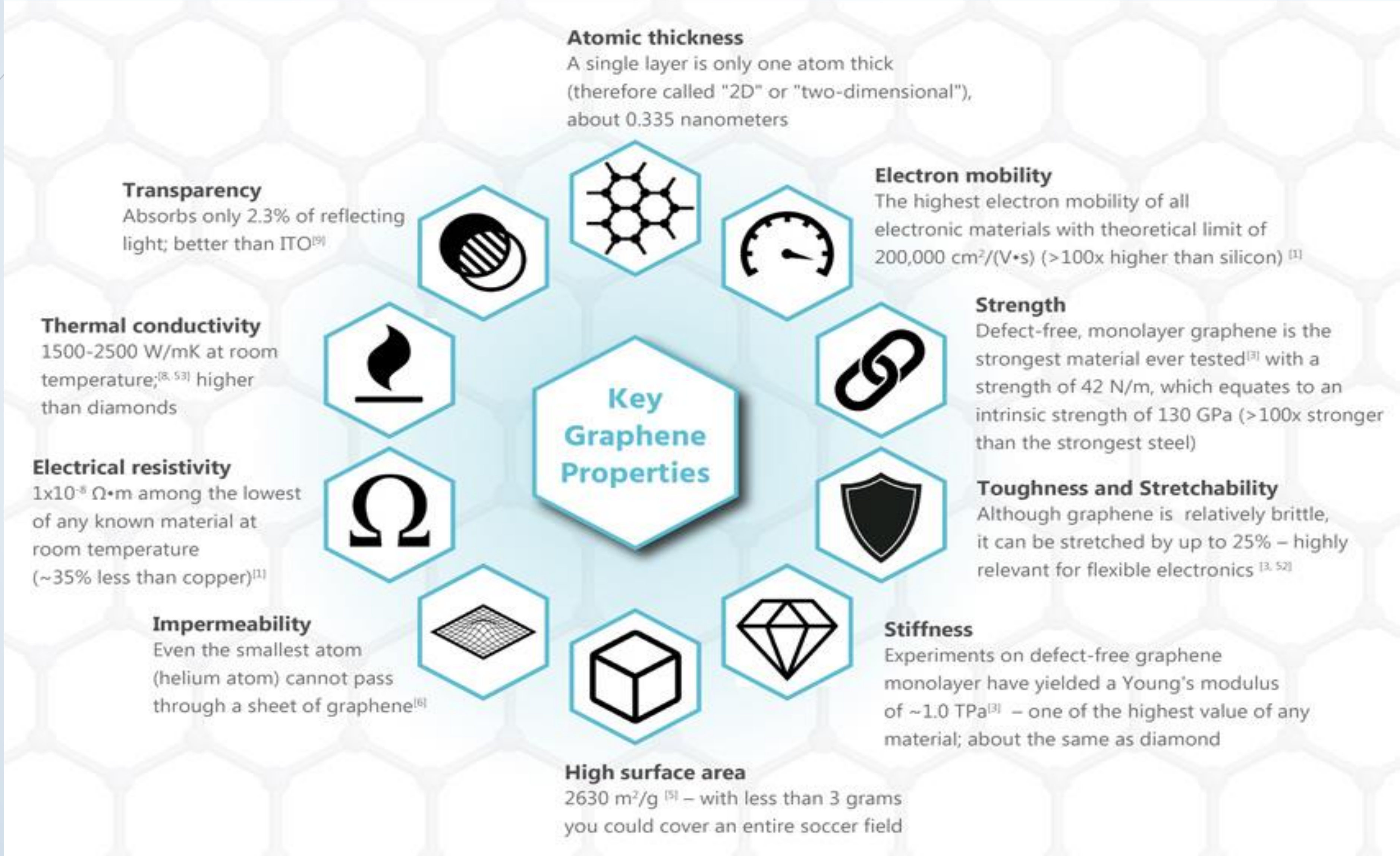
- Great semiconductor – electrons can move with minimal resistance
- Extraordinarily strong – 100x stronger than steel
- Thermal conductor - heat can move 10x faster in graphene than in copper
- Nearly transparent – 97.3% transparent due to it only being one atom thick

Properties of graphene

- Flexible and malleable – attributed to its light weight and thinness, can flex 20% without damage
- Potential to be cheap/affordable – carbon is incredibly abundant on Earth
- Incredibly thin – one atom "thick"

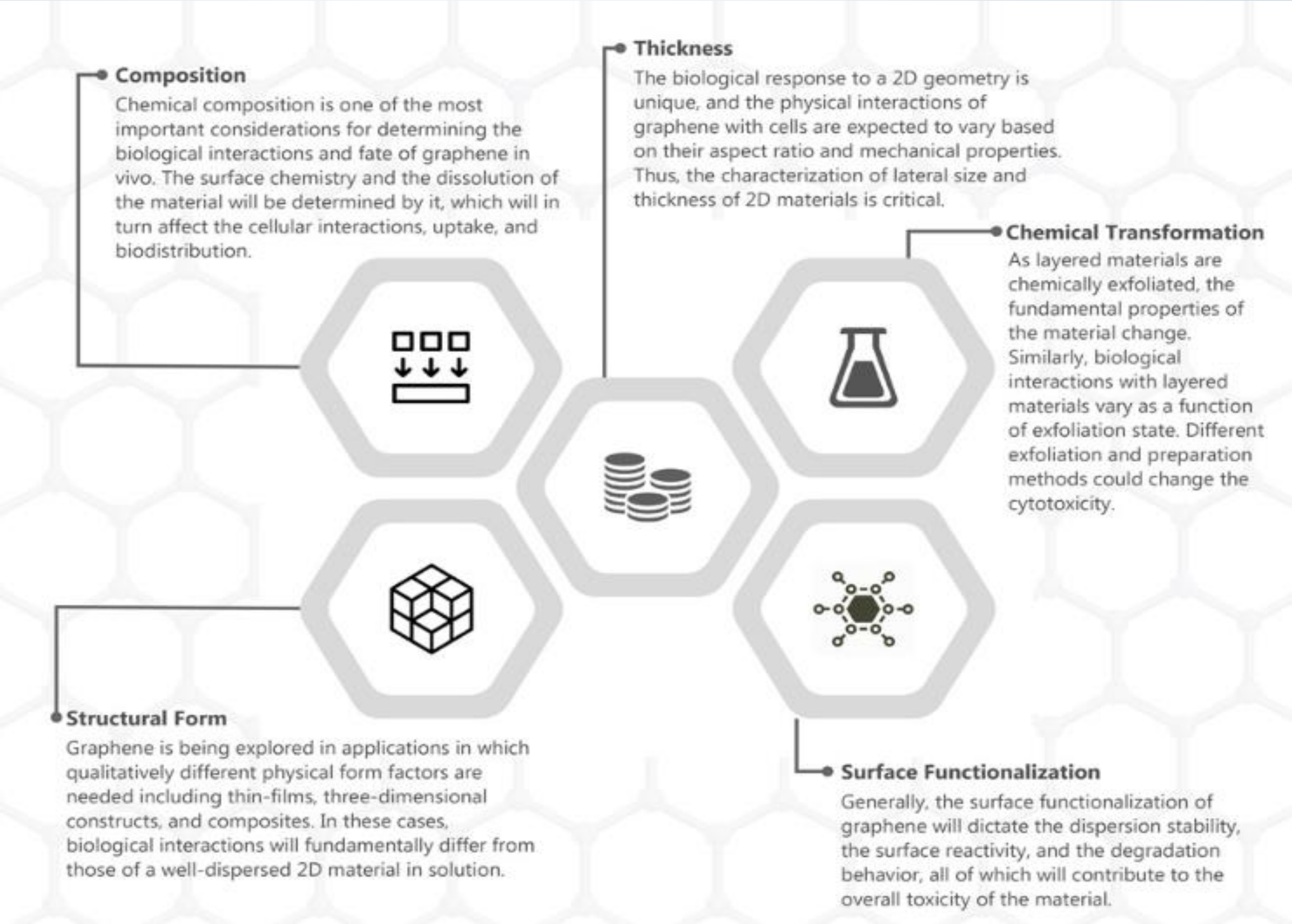


The graphene's extraordinary properties

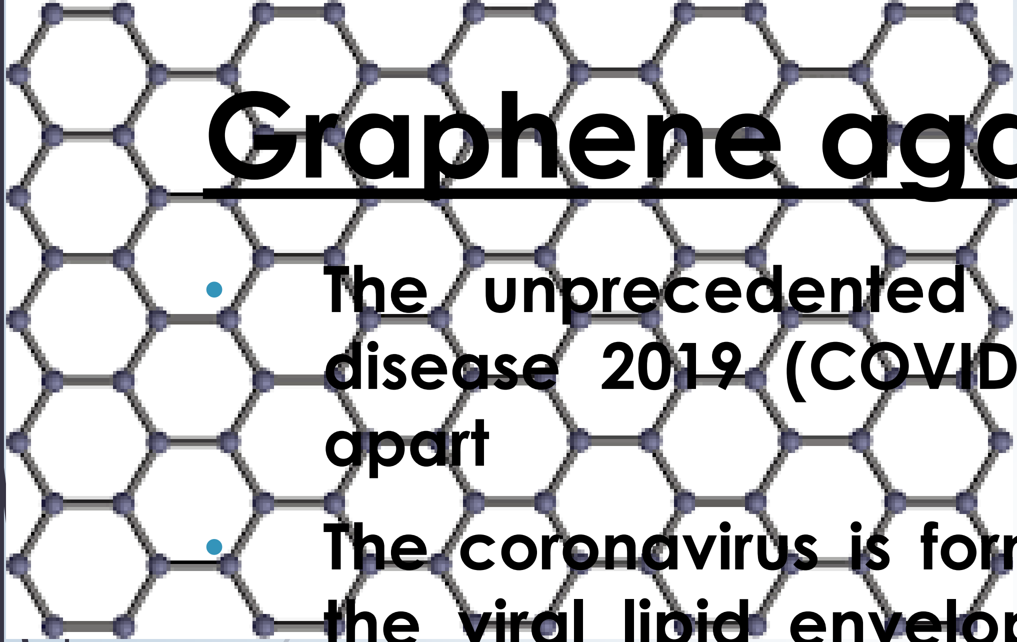


Application of graphene

Based on the current knowledge on hazard of nanomaterials, a number of characteristics can be identified that may be relevant for hazard assessment of graphene



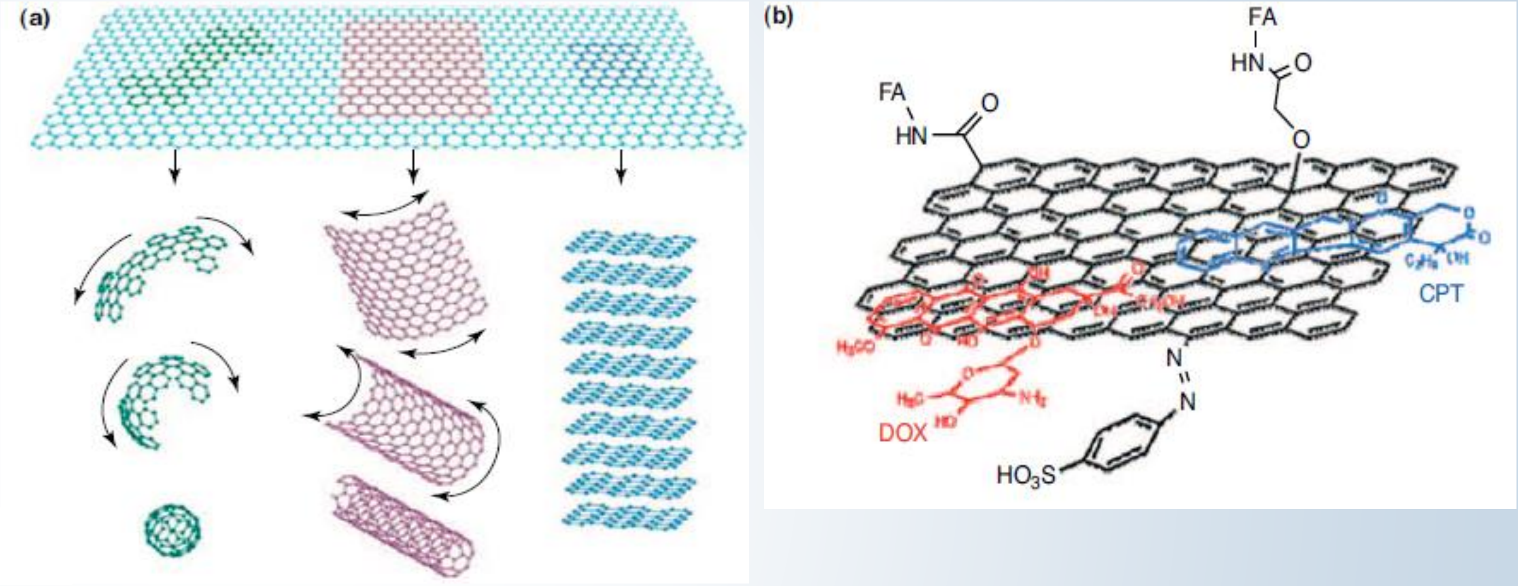
Graphene against Coronavirus



- The unprecedented pneumonia outbreak of coronavirus disease 2019 (COVID-19) is tearing global health systems apart
- The coronavirus is formed by surface proteic projections on the viral lipid envelope enclosing single-stranded positive-sense RNA.
- Graphene has captured much attention due to its superb electronic properties, including approaches to fight or detect drug-resistant bacterial infections.

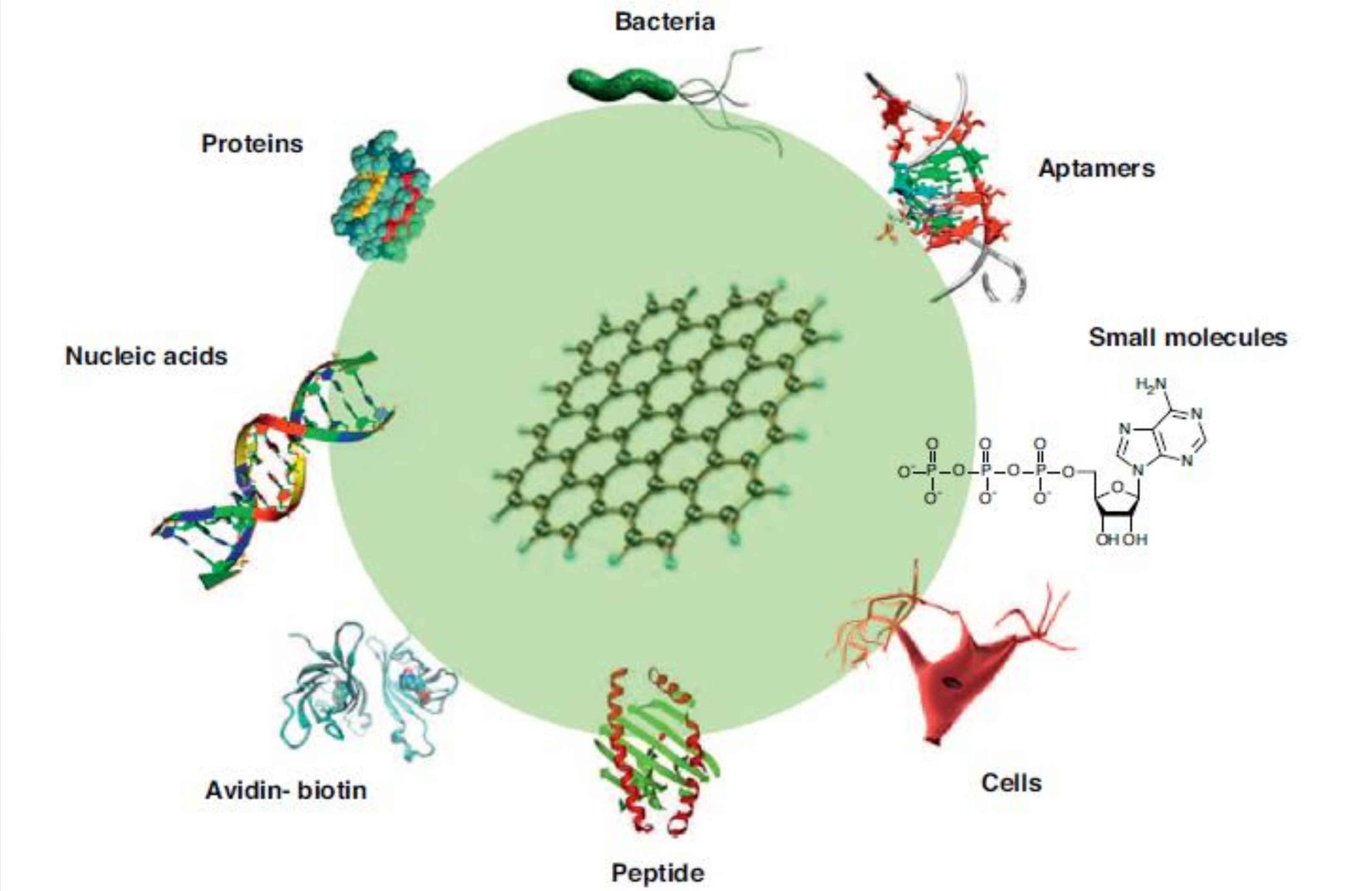
Graphene and Graphene Oxide: Biofunctionalization

- Graphene, graphene oxide (GO), and graphene derivates are promising candidates in biotechnology development
- Biological modification in turn benefits graphene and GO by improving their biocompatibility, solubility and selectivity.



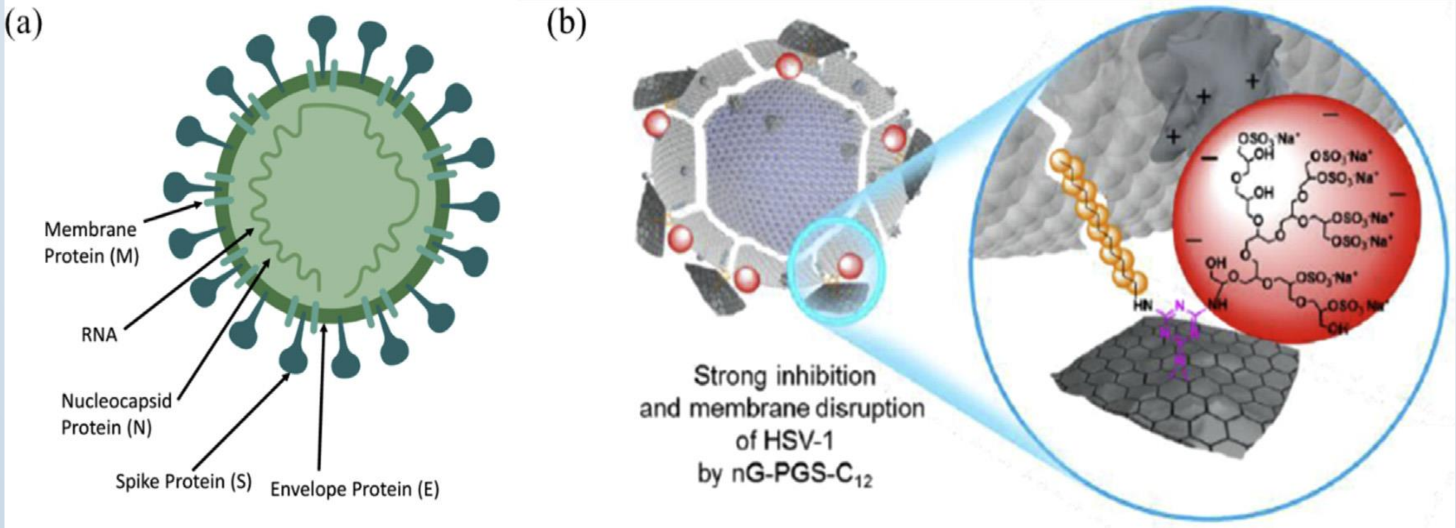
(a) Epitome of graphite forms, **(b)** Schematic image representing the loading of doxorubicin (DOX) and campthothecin (CPT) onto FA-modified GO.

Graphene and its derivatives have been reported to be functionalized with avidin–biotin, peptides, NAs, proteins, aptamers, small molecules, bacteria, and cells through physical adsorption or chemical conjugation. The functionalized graphene biosystems with the unique properties have been used to build up biological platforms, biosensors, and biodevices



Graphene materials interact with viruses

- In 2012, thin films of rGO−tungsten oxide were exploited for photo-inactivation of bacteriophages under visible light irradiation.
- The large surface of graphene provides the highest ligand contact area for the adsorption of negatively charged which can interact with virions' positively charged residues and block microorganisms.
- rGO sulfate derivatives demonstrated their antiviral activity against African swine fever virus, orthopox virus and herpes virus strains.
- β-cyclodextrins-functionalized sulfonated graphene to treat the respiratory syncytial virus (RSV).
- Polyglycerol sulfated graphene functionalized with fatty amine chains wrap and inactivate HSV-1.



a. **Main structure of coronavirus**
b. **Representation of HSV wrapping by sulfated grapheme derivatives and illustration of long alkyl chain disrupting virus envelop**

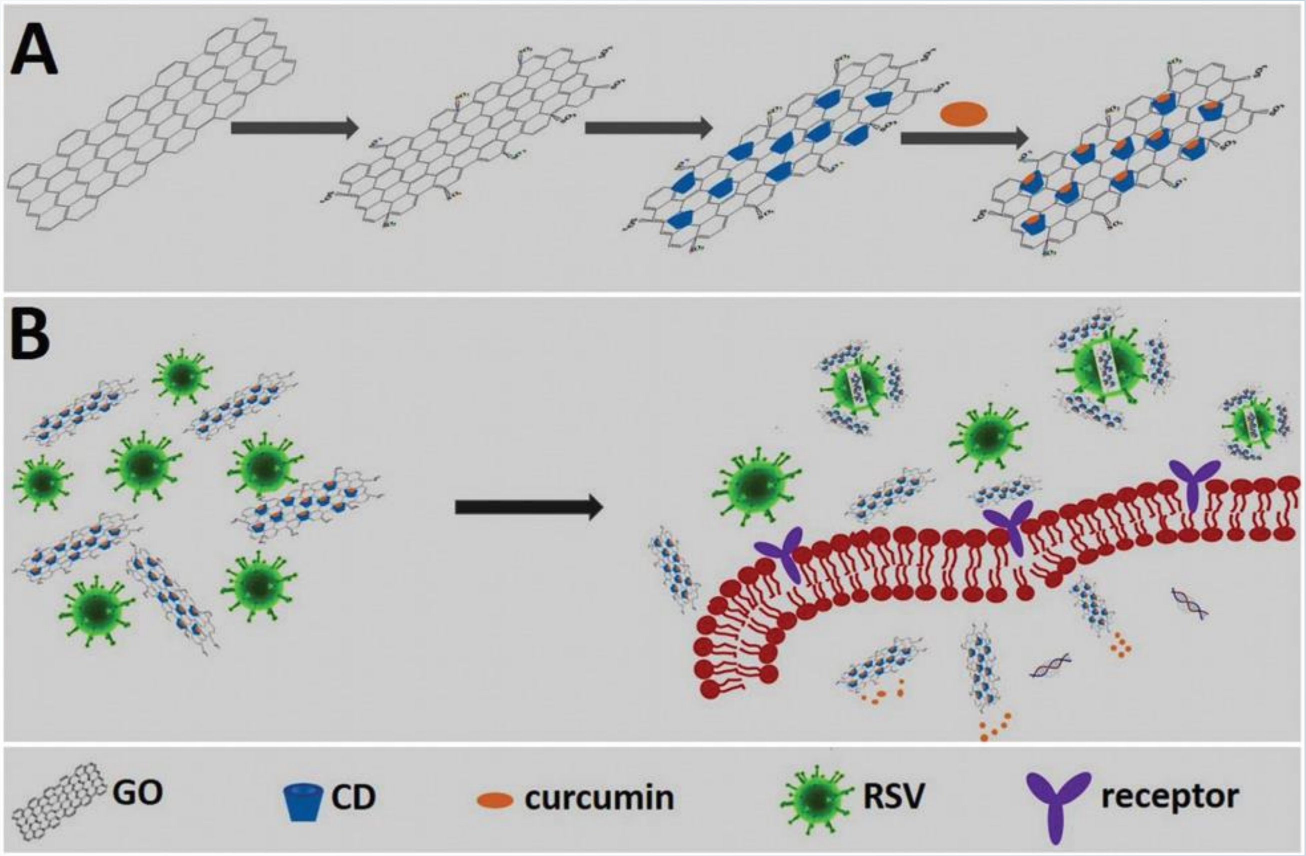
Graphene textile for pandemic spread control

- **Graphene filters have been produced for capturing particulates and bacteria to decrease the transmission of nosocomial infections.**
- **The bacteria blocked on the filter are not able to proliferate and by increasing filter temperature over 300 ºC microorganisms along with molecules that can cause diseases are destroyed.**
- **Filters can be used also for sampling bioaerosols for characterization of transmission in hospital settings and exposure risk of workers in general.**
- **A textile screen-printed biosensor based on a GO transduction film for the detection of environmental exposure to viruses.**
- **GO films are also useful for creating breathable barrier layers in fabrics.**
- **Protective graphene facemasks could be recycled by photocatalysis or heat.**

Sensors arrays implemented on textiles and interfaced with flexible electronics can report the location of positives and identify sources of the outbreak.

Curcumin Functionalized Graphene Oxide against the viruses

- Curcumin, as a natural polyphenol, is isolated from the rhizomes of the perennial herb Curcuma longa and holds various functions including antioxidant, antifungal, antibacterial, anti-inflammatory, and anti viral.
- This polyphenolic compound has gained significant attention due to a variety of biological activities and low toxicity
- The introduction of sulfonate groups to the functionalized GO surface can mimic the cell's surface and inhibit RSV infection through a competitive inhibition mechanism.
- The synergistic antiviral activity is due to the nanomaterials themselves and the drug curcumin



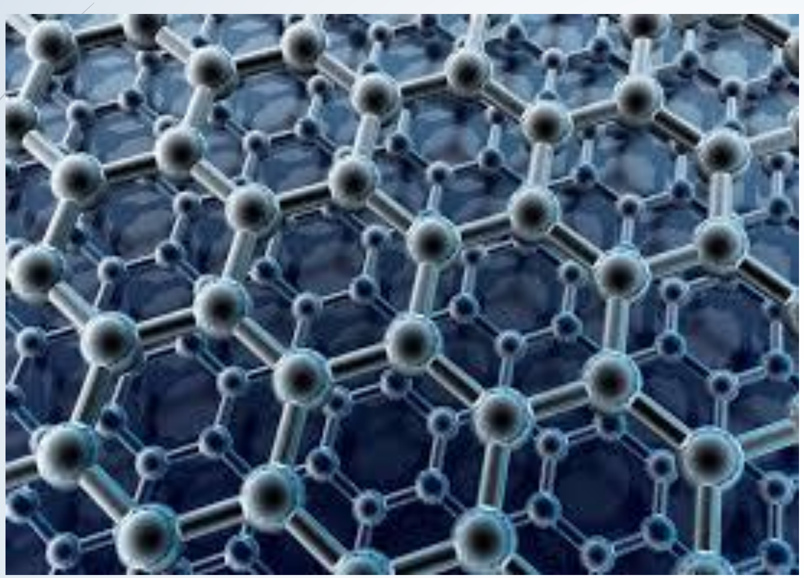
Schematic representation of work principle. (A) The synthesis of functional nanomaterial composite; (B) the proposed inhibition mode of functional nanomaterial composite against RSV infection

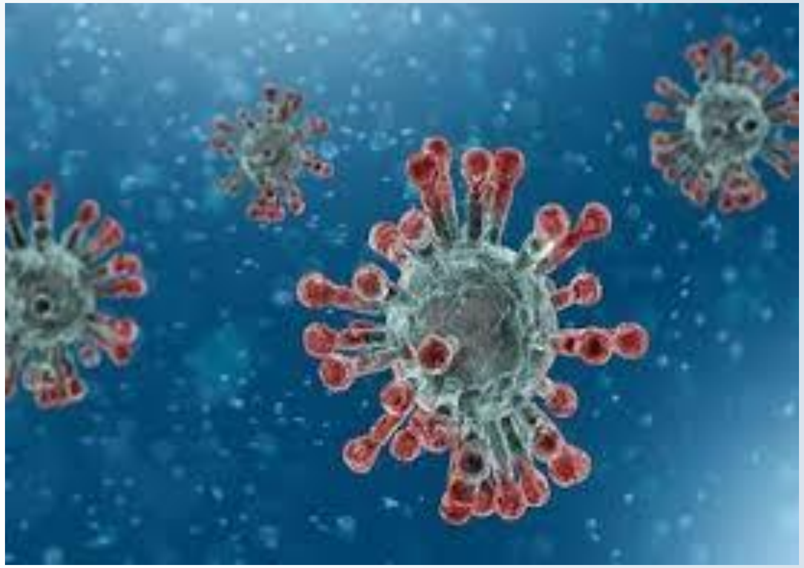
Limitation and Challenges

- The immediate use of graphene for treatment of COVID-19 is unrealistic. The only available *in vivo* test for virus treatment demonstrated the efficacy of GO-hypericin in ducklings infected with the Novel duck reovirus.
- *in vivo* toxicity of graphene is still a matter of debate.
- Graphene toxicity are made difficult due to the infinite combinations of dose, surface chemistry, exposure route used for the evaluation.
- Its instability and aggregation in solution are further problems, given the mandatory stability required for drugs and vaccine storage prior use

References

1. V. Palmieri, M. Papi. Can graphene take part in the fight against COVID-19?. Nano Today 33 (2020) 100883.
2. Ying Wang, Zhaohui Li, Jun Wang, Jinghong Li, Yuehe Lin. Graphene and graphene oxide: biofunctionalization and applications in biotechnology. Trends in Biotechnology 29 (2011) 205-212.
3. Shiyi Ye, Kang Shao, Zhonghua Li, Nan Guo, Yunpeng Zuo, Qin Li, Zhicheng Lu, Lu Chen, Qigai He, Heyou Han. Antiviral activity of graphene oxide: how sharp edged structure and charge matter. ACS Appl. Mater. Interfaces 7 (2015) 21571–21579.
4. Xiao Xi Yang, Chun Mei Li, Yuan Fang Li, Jian Wang, Cheng Zhi Huang. Synergistic antiviral effect of curcumin functionalized graphene oxide against respiratory syncytial virus infection. Nanoscale 9 (2017) 16086.





THANK YOU