New Materials - State of the art

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&
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20
2018

New Materials - State of the art

- Disposition:
- 1. Let's start with the "small stuff"
- 2. Programmable materials
- 3. Quick look at the Carbon atom
- 4. Carbon based materials
- More "small stuff"
- Graphene & Nanotubes
- What is already on the market?

1. The “small stuff”

Apatite nanocrystals

Cellulose Nano Fibers (CNF)

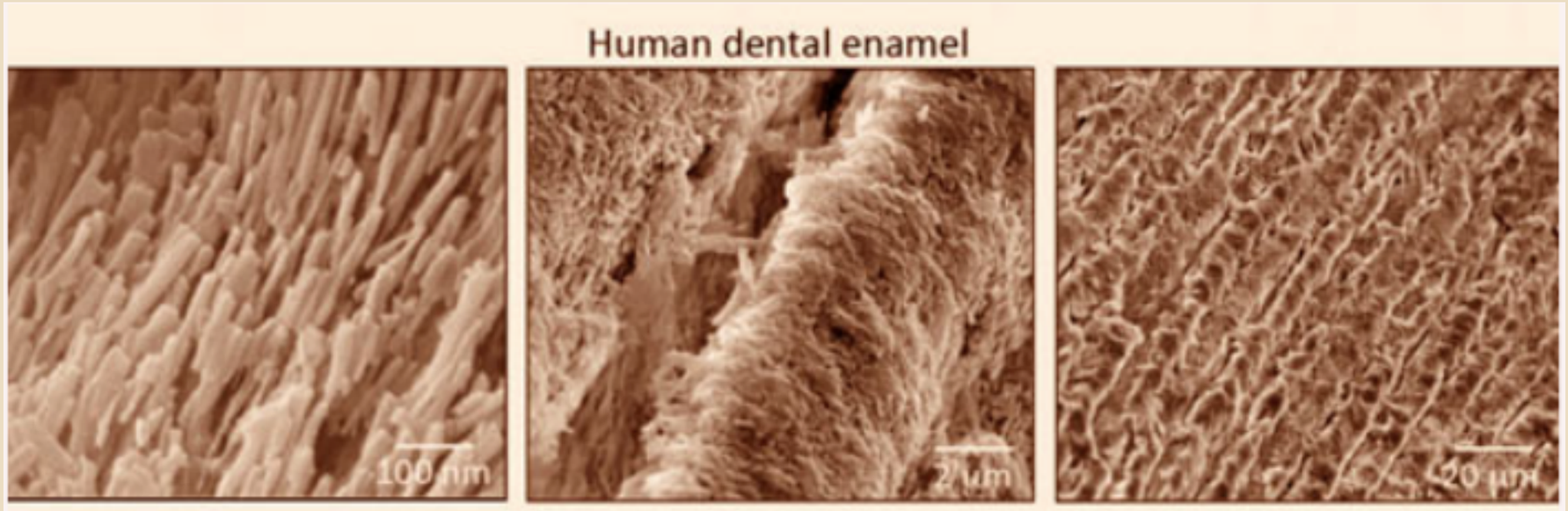
Self-healing materials

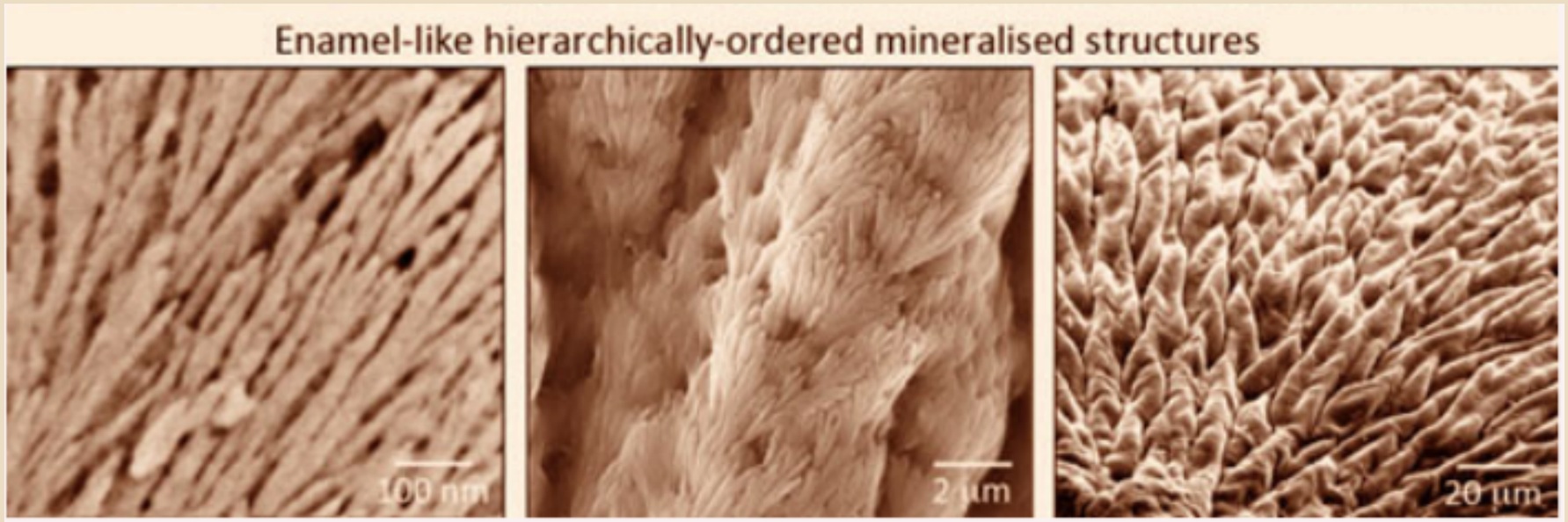
Aerogels

Silicon nanosheets

Programmable materials

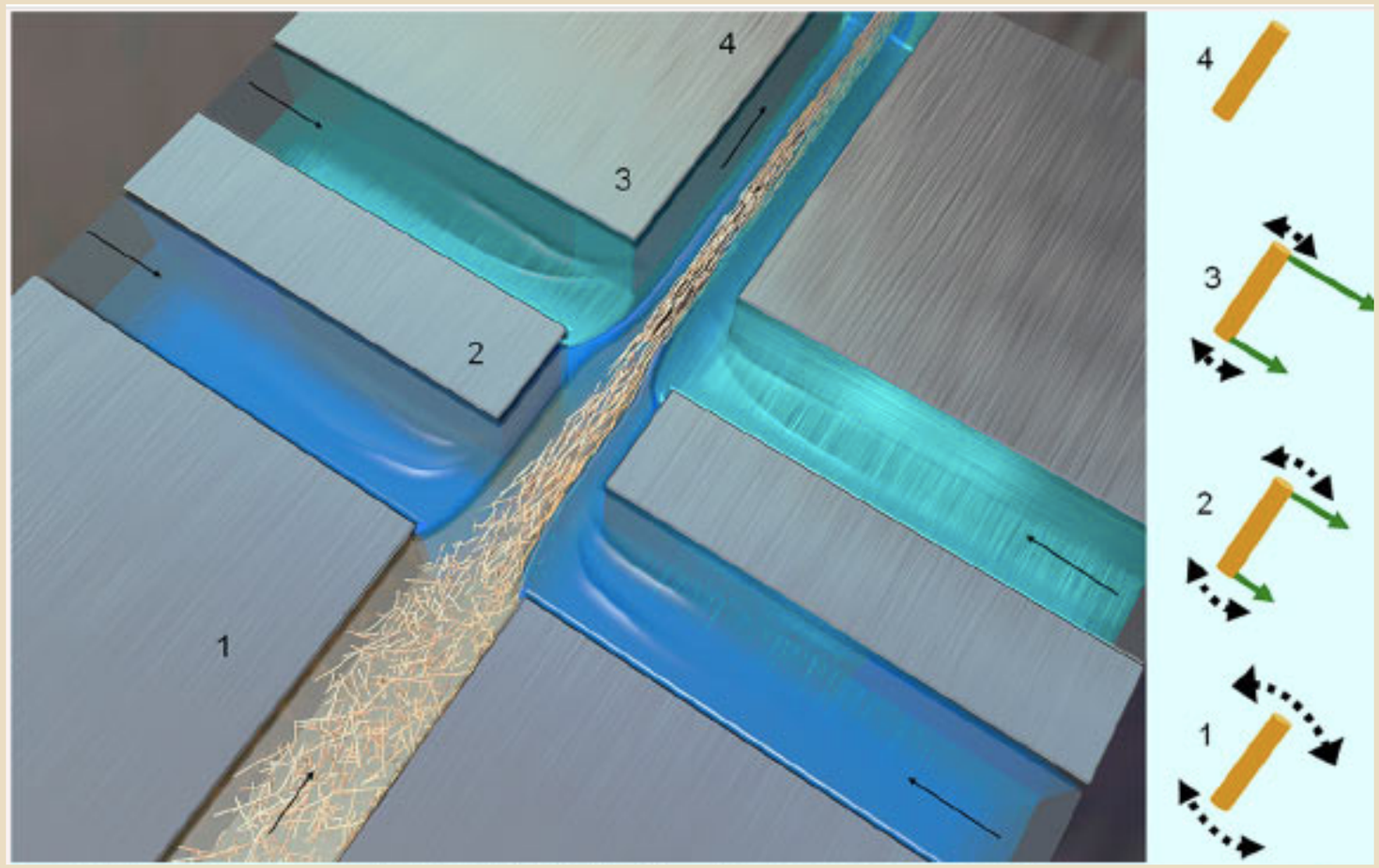
Apatite nanocrystal





Similarity of structure between the enamel-like material and dental enamel. Image credit: Alvaro Mata.

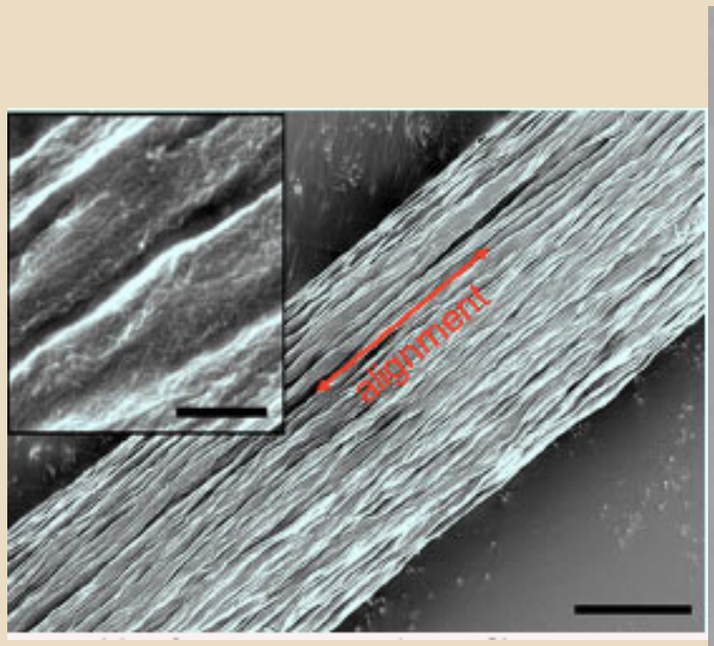
Cellulose Nano Fibers

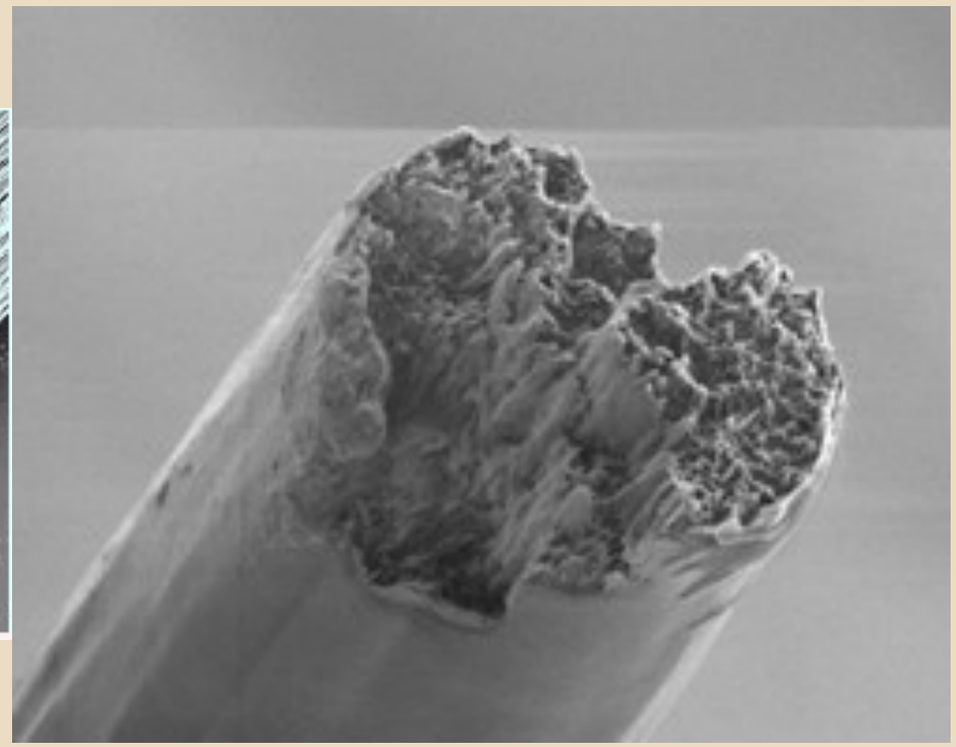


Hydrodynamic focusing

Cellulose Nano Fibers

Cellulose Nano Fibers (CNFs):

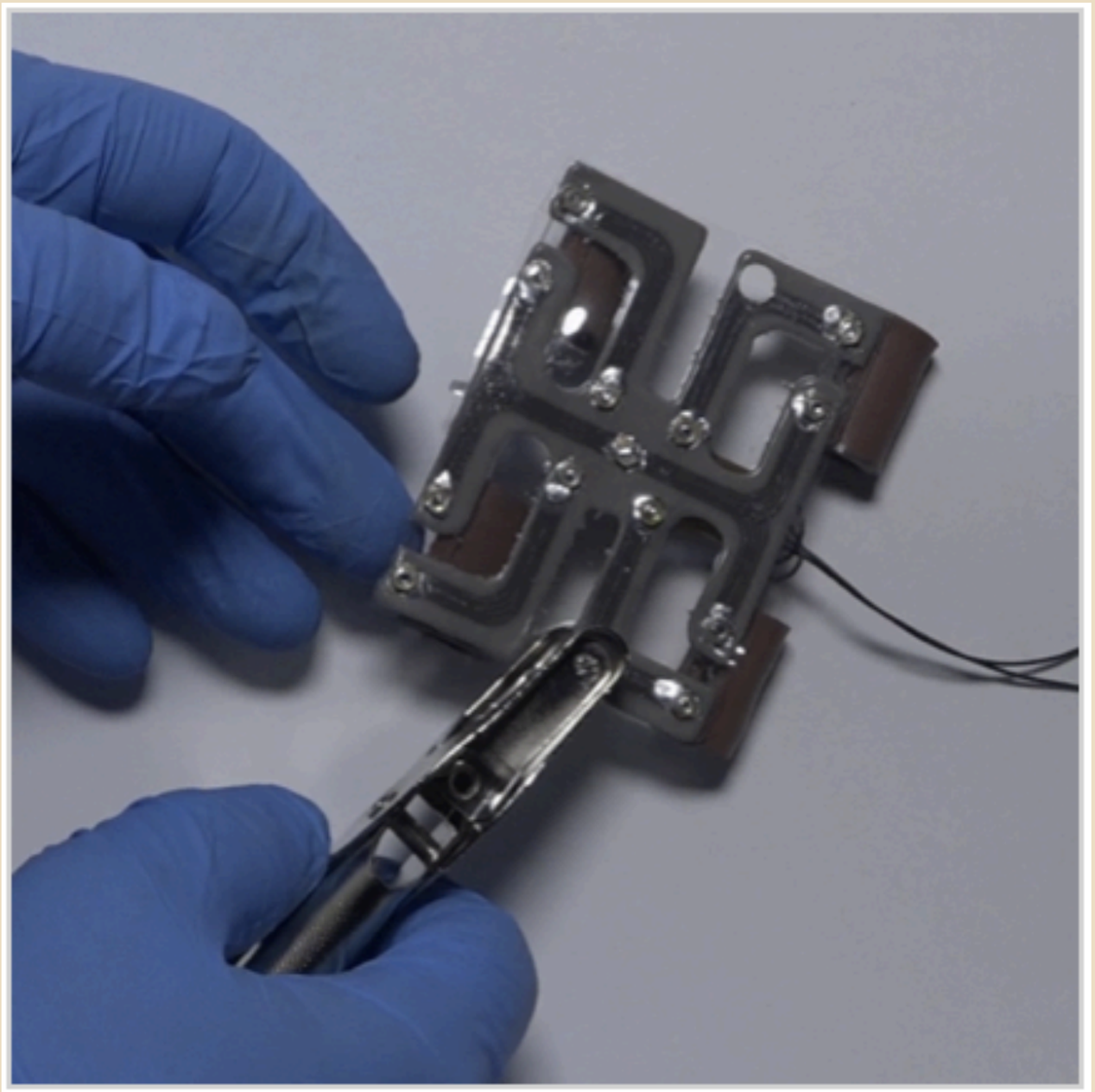




Cellulose-bases CNFs are 8 times stiffer and are stronger than silk threads which are stronger than. . .

- steel wire
- any other metal or alloy
- glass fiber
- most synthetic materials

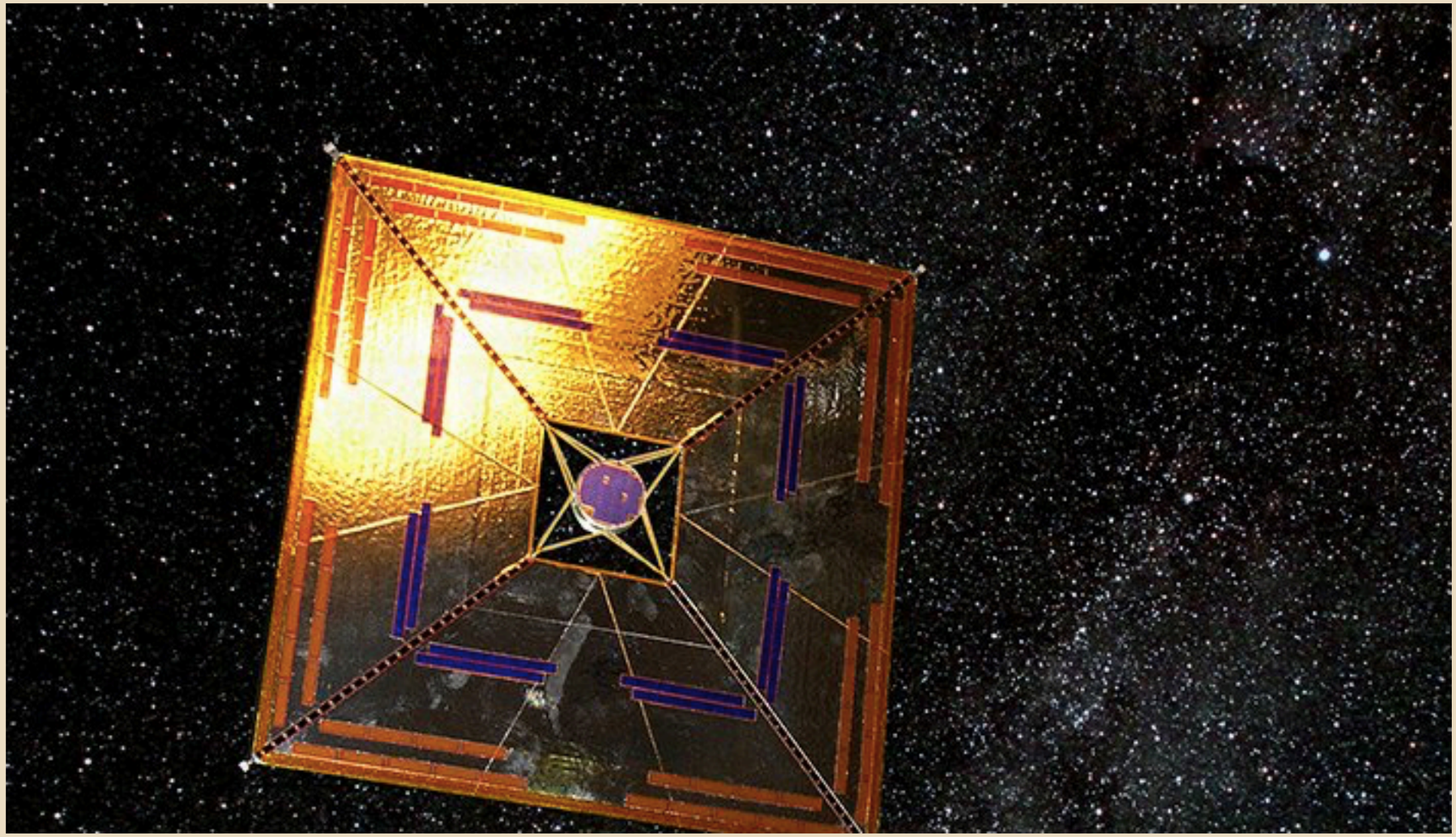
Self-healing materials



A self-healing material that spontaneously repairs itself in real time from extreme mechanical damage, such as holes cut in it multiple times. New pathways are formed instantly and autonomously to keep this circuit functioning and the device moving. (credit: Carnegie Mellon University College of Engineering)

Silicon Materials

Silicon - Silica complex in nanosheets . . .



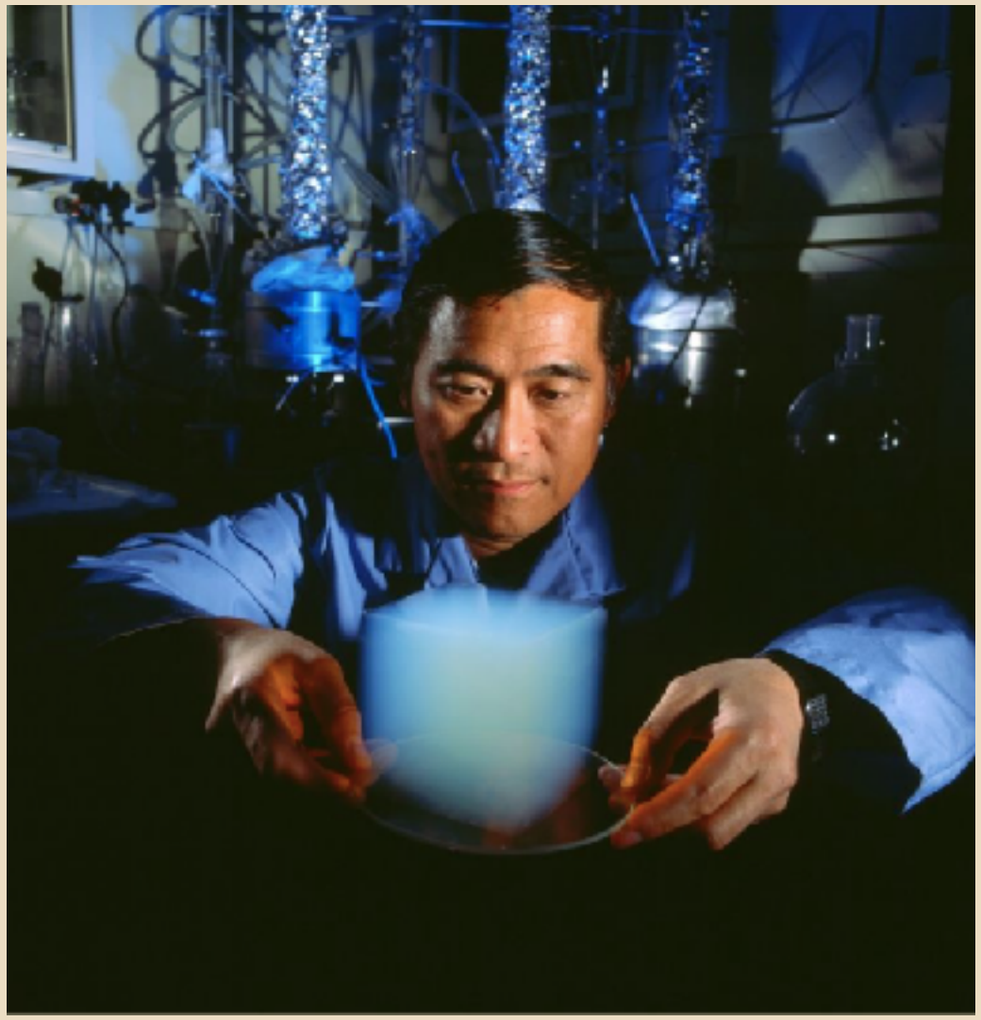
for interstellar travel

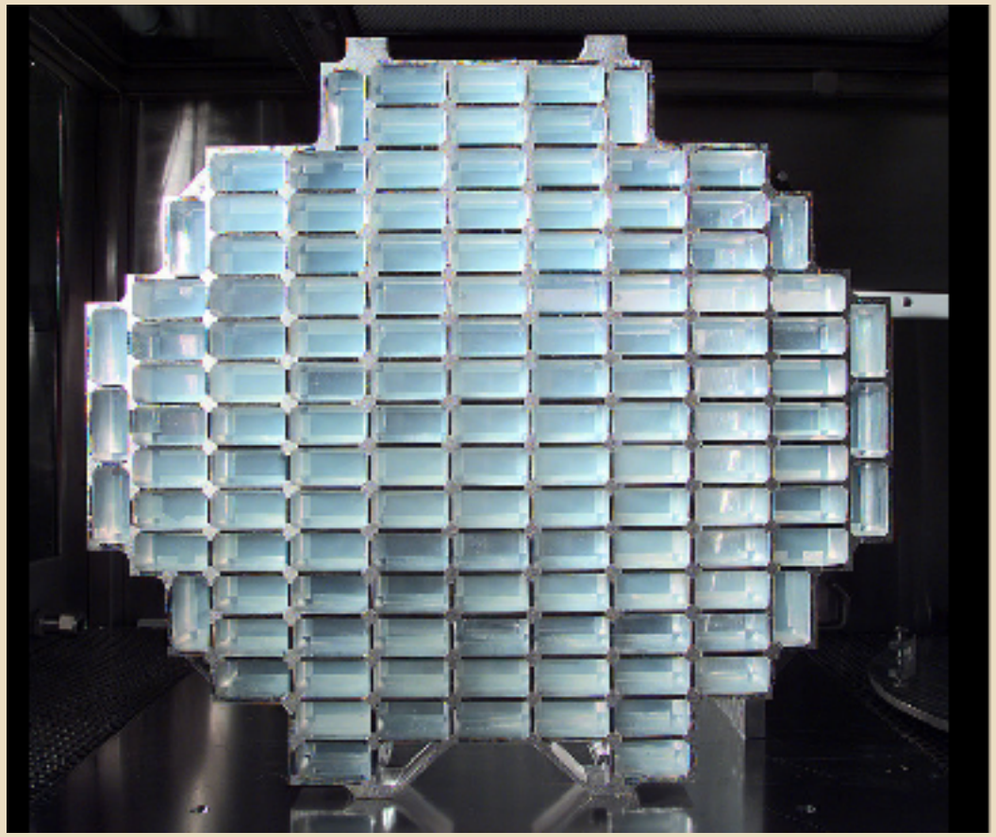
Aerogels

Materials formed by “supercritically” drying gels (e.g. silica gel) so that the material doesn’t collapse due to capillary action . . i.e. maintaining the porosity

Density in the range of 1,200 g/m^3 (at 20 °C and 1 atm)

Graphene aerogel is the least dense material known with 160 g/m^3 - lighter than He and ~ 1/7th density of air

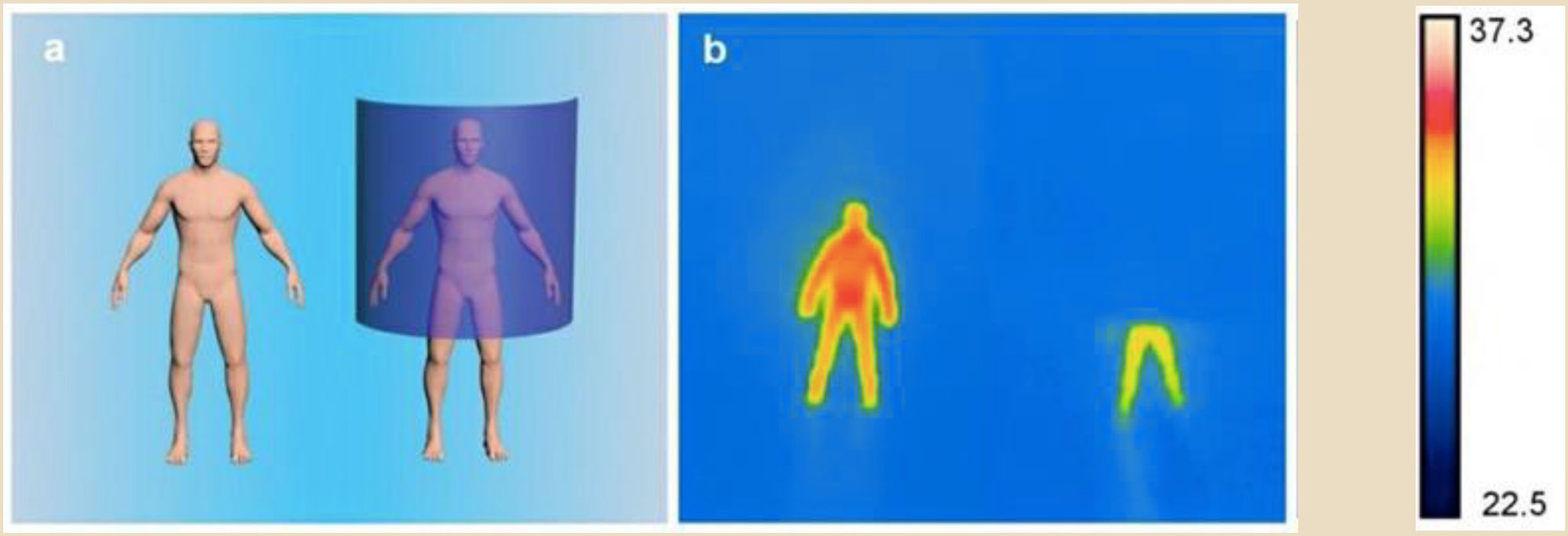




Stealth Materials

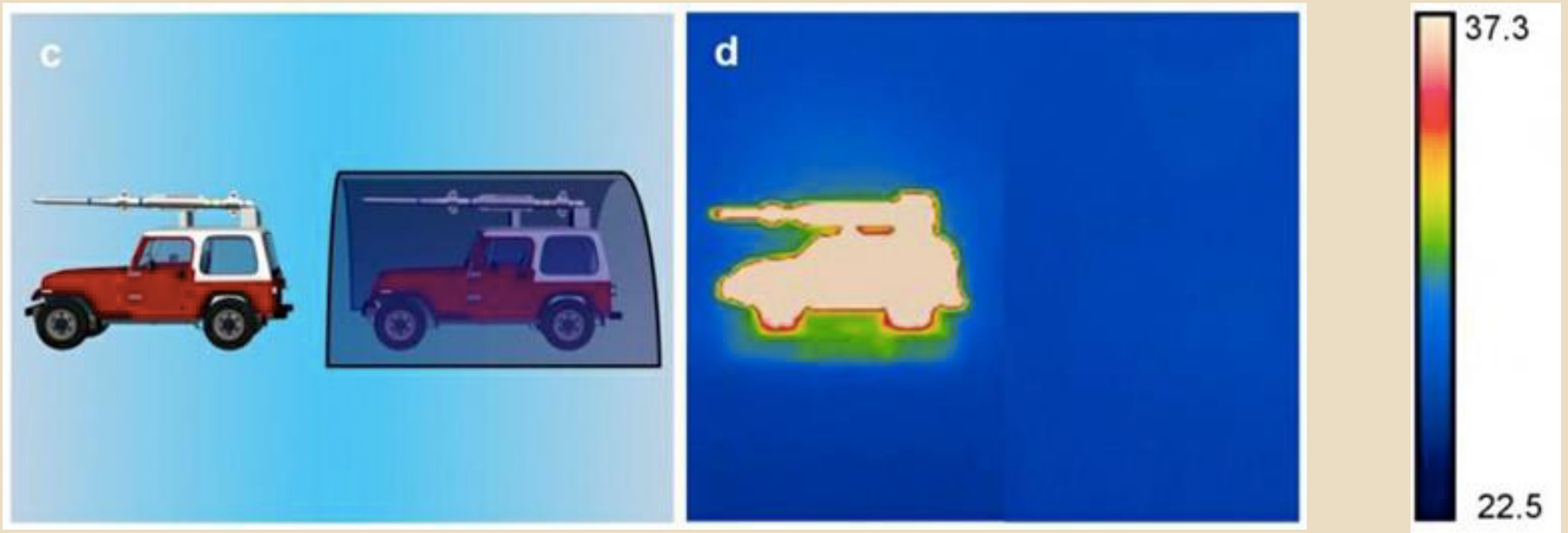
Infrared cameras are the heat-sensing eyes that help people or drones find their targets even in the dead of night or through heavy fog.

A new **cloaking material** renders objects — and people — practically invisible.



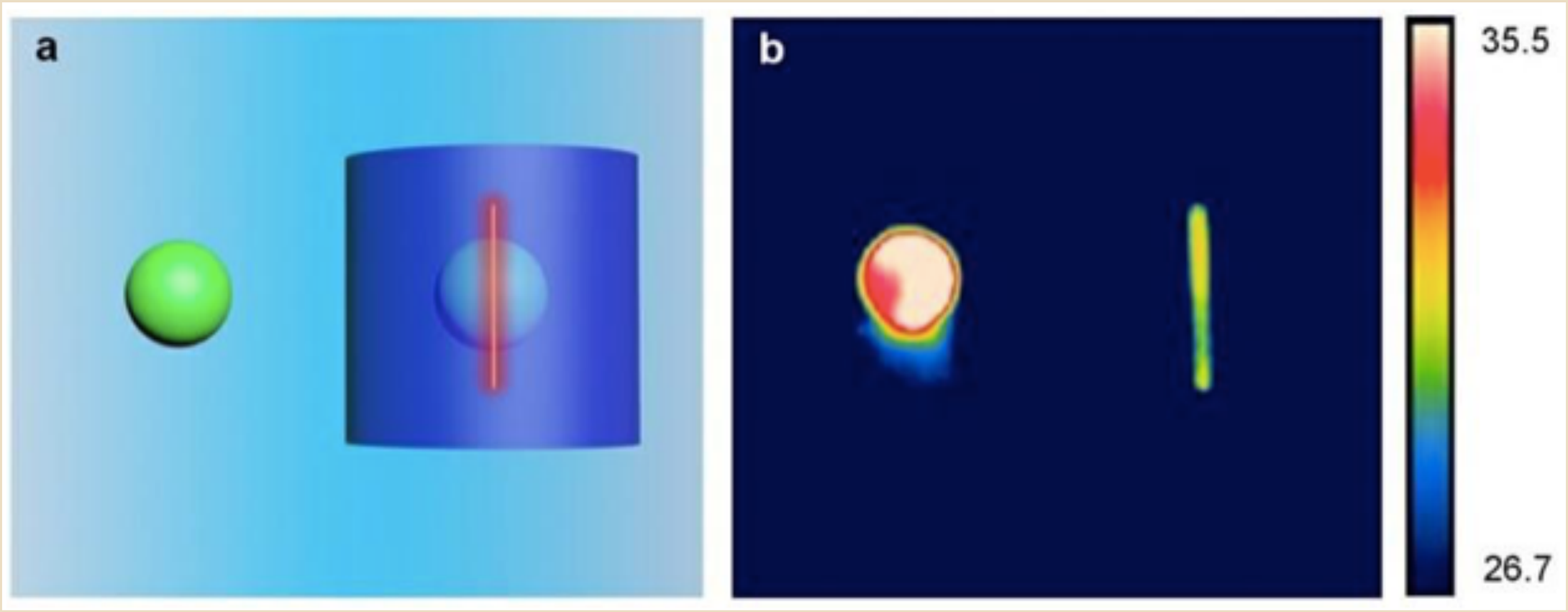
Stealth Materials

Less than 1mm thick, the sheet absorbs approximately 94% of the infrared light it encounters. This means that warm objects beneath the cloaking material become almost completely invisible to infrared detectors.



Stealth Materials

By incorporating heating elements into the stealth sheet, stealth material can also absorb IR light in the mid range, thereby disguising objects from IR cameras by presenting a false image



Black Silicon: vertical nanowires

2. Programmable materials

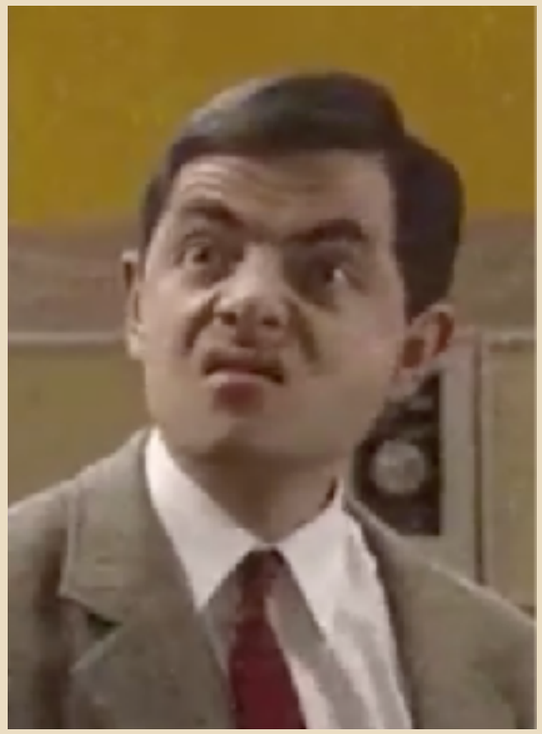
It all starts with

…the squid

2. Programmable materials

The razor-sharp “teeth” on the squid’s tentacle suckers are made entirely by proteins similar to silk - called “suckerins” - giving them strength and stretchiness… and thermoplasticity.

UH? Suckerins?
Thermoplasticity?



2. Programmable materials

“Smart clothes”

Bio-polymers that can be incorporated into textiles that

- has a low thermal conductivity while dry (1)
- has high thermal conductivity when hydrated (2)

  - (1) storing body heat and keeping the athlete warm while not active
  - (2) As soon as the wearer begins to sweat, the material becomes hydrated and instantly allows body heat to escape

2. Programmable materials

Smart clothing/ Intelligent fabrics:

Soft, flexible circuitry can be built in to any kind of textile, offering the capabilities of heat, light and responsiveness to touch to the wearer as well as data tracking applications.

2. Programmable materials

“Smart industrial products”

“Switch technology” will allow

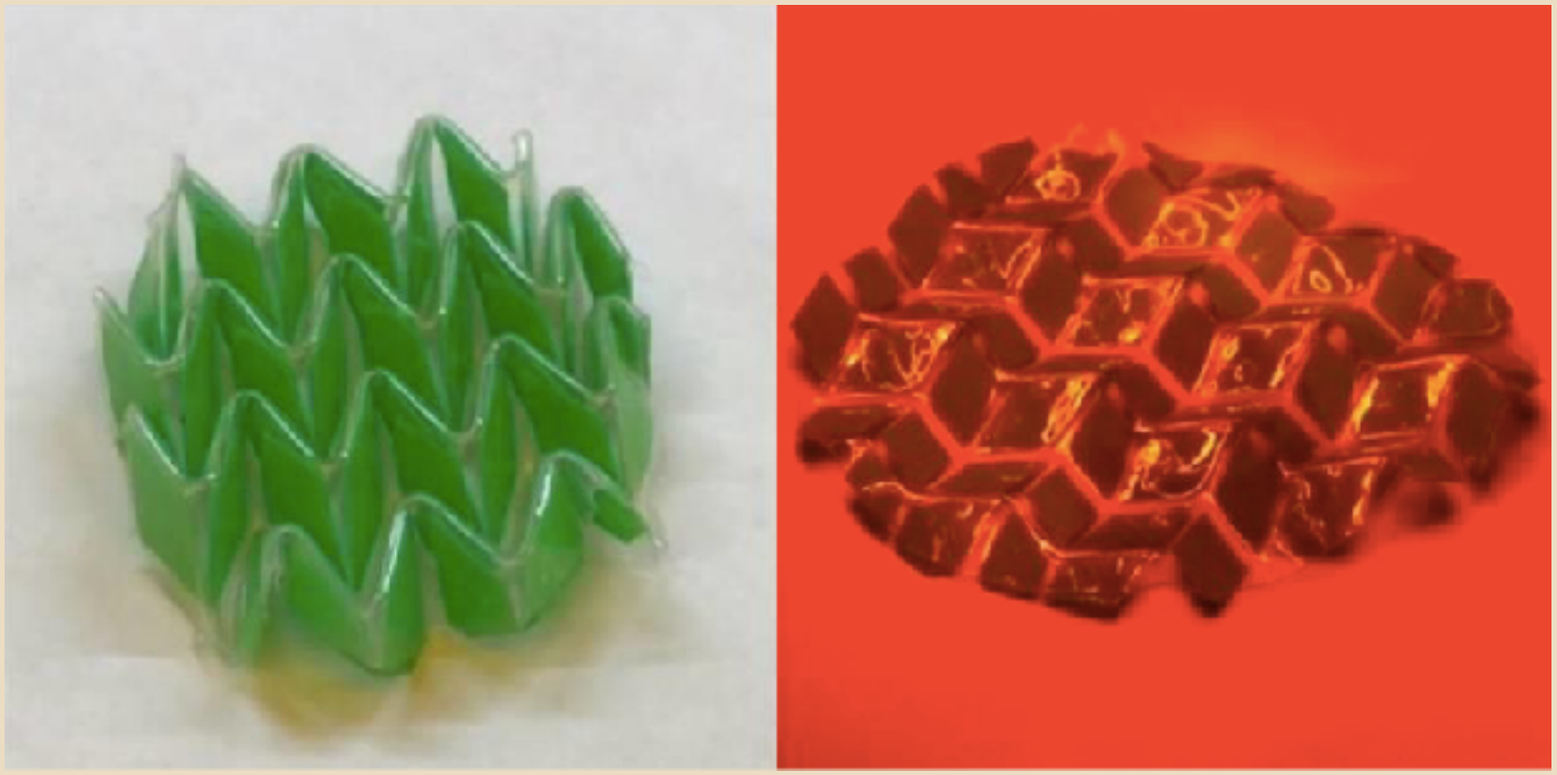
- regulation of temperature and heat flow of devices,
- recycling heat losses to create energy, making thermally them into self-regulating electrical devices and maybe even wind- and hydropower units

2. Programmable materials

A newly developed material achieves readily programmable two-way transformations on a macroscopic level by using liquid crystal elastomers (LCEs) using light and temperature stimuli before reverting to its original form.

Oscillating back and forth between two independent shapes by exposing them to light, opens up new applications such as

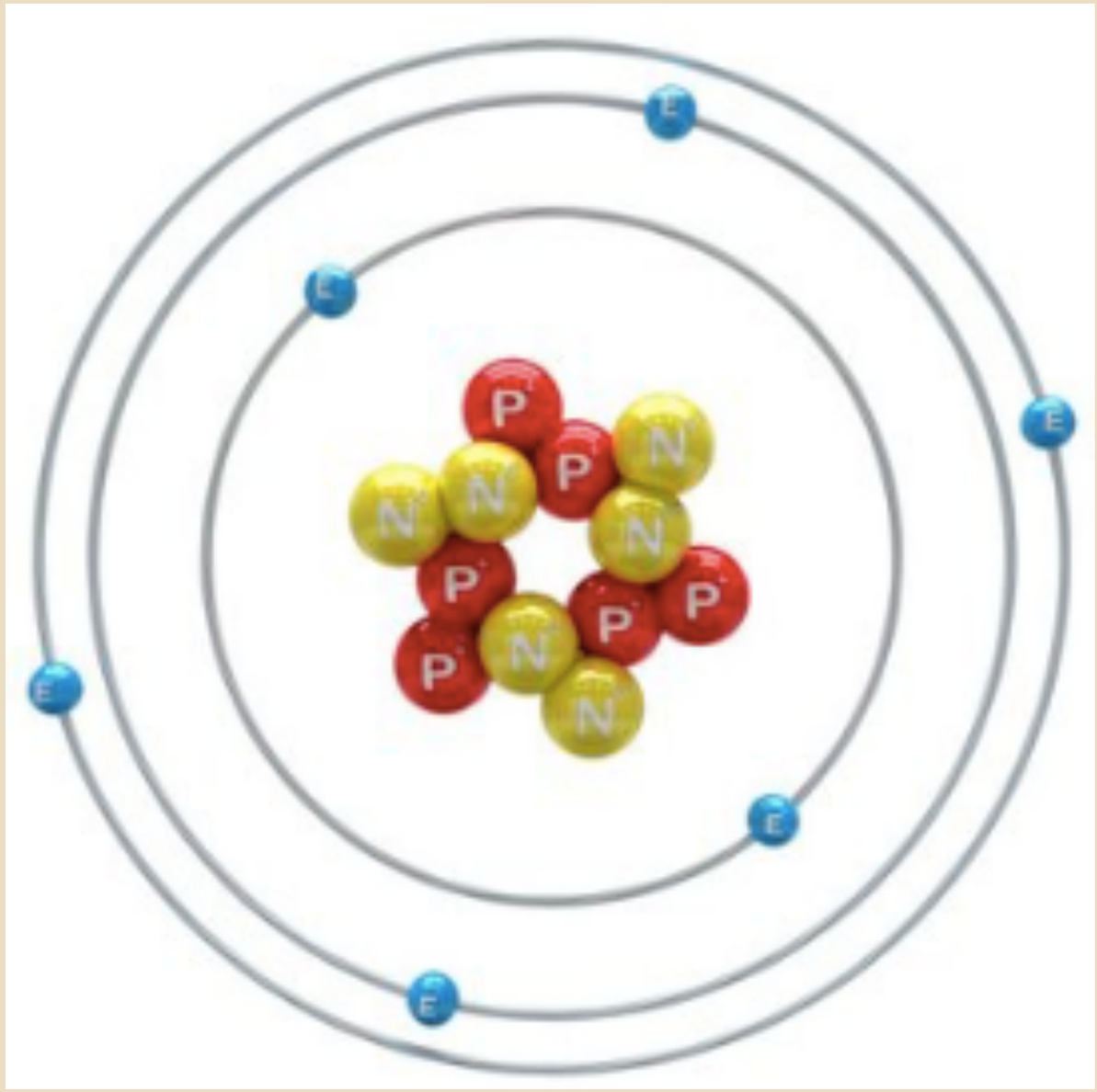
- additive manufacturing (CAD/3D)
- robotics
- biomaterials



New Materials - State of the art

3. The Carbon atom

Carbon - $C_{,12}$ $C_{,13}$ C_{14}



Carbon bonds

4. Carbon materials

Coal

Diamonds

Graphite

Soot

Nearly 10 million carbon compounds have been discovered.
It is estimated that carbon is part of 95% of all compounds

Sugars, carbohydrates, -anes (polymers)

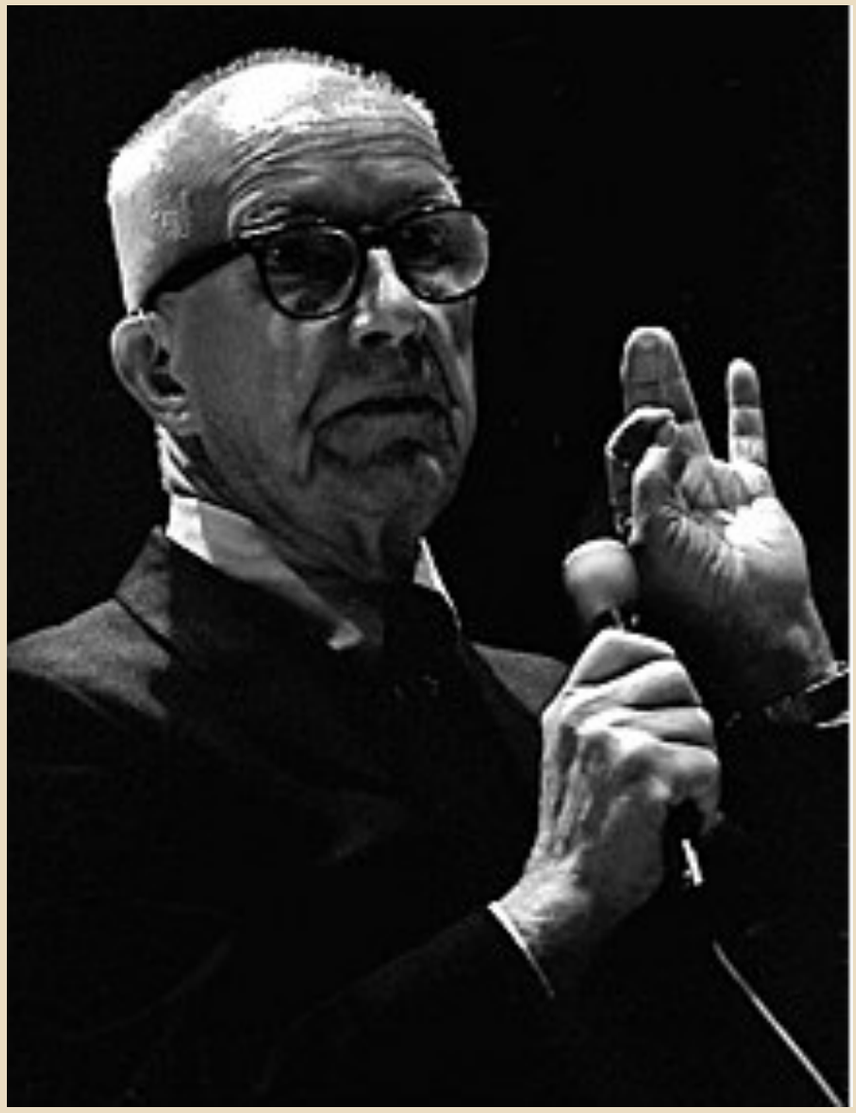
4. Carbon materials

The Small Stuff

Buckyball (fullarenes)

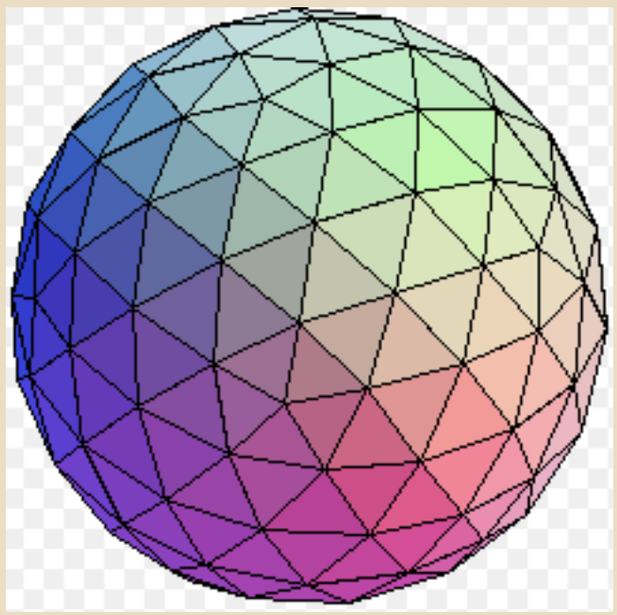
Glassy (non-crystalline) carbon

Fullarenes



Buckminster Fuller
1895-1983

Fuller's design concept
"geodesic"



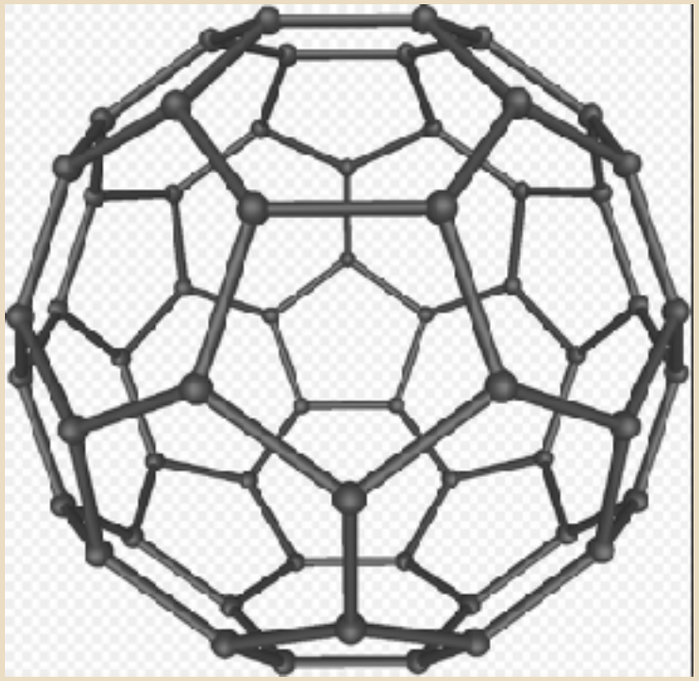
Fullarenes

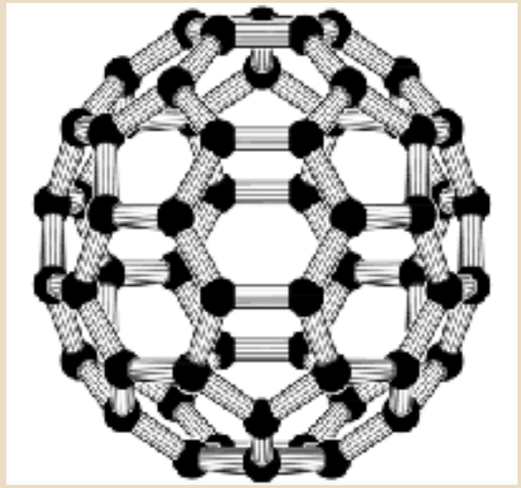
Fuller's home

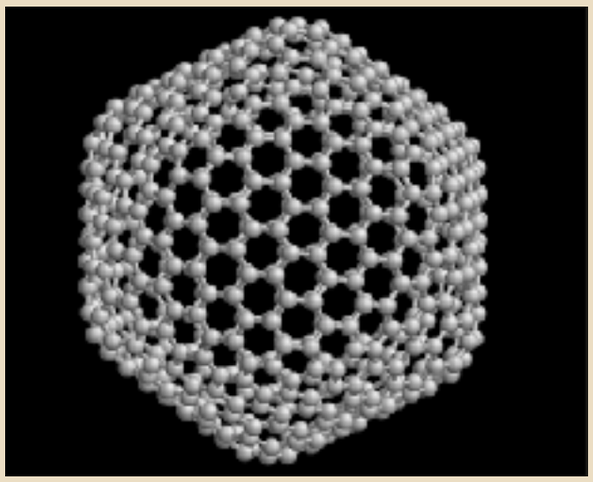
Montreal Biosphere

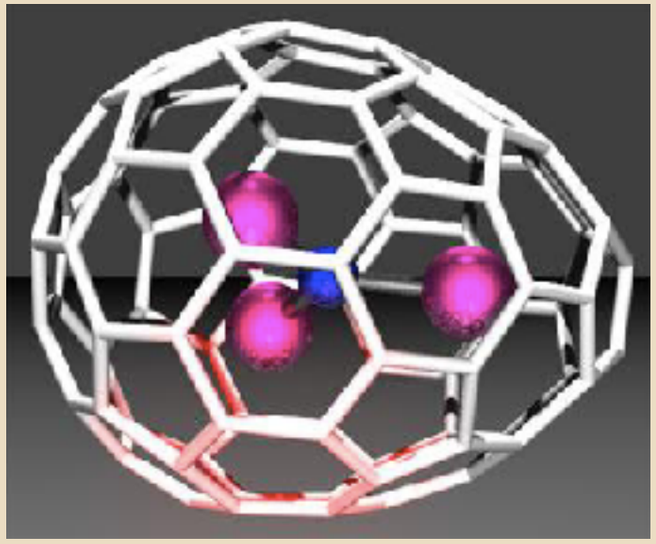
Buckyballs, buckyeggs

By vaporizing graphite with lasers, scientists create a mysterious new pure carbon soccer-ball-shaped molecule with 60 carbon atoms. It earned the Nobel Prize in 1996









Buckyballs, buckyeggs

Usages:

- carriers for drugs (by attachment) to sites where needed

- inhibits spread of HIV

- carbon nano-ink on textile (wearable batteries)

- and . . .

Buckyballs, buckyeggs

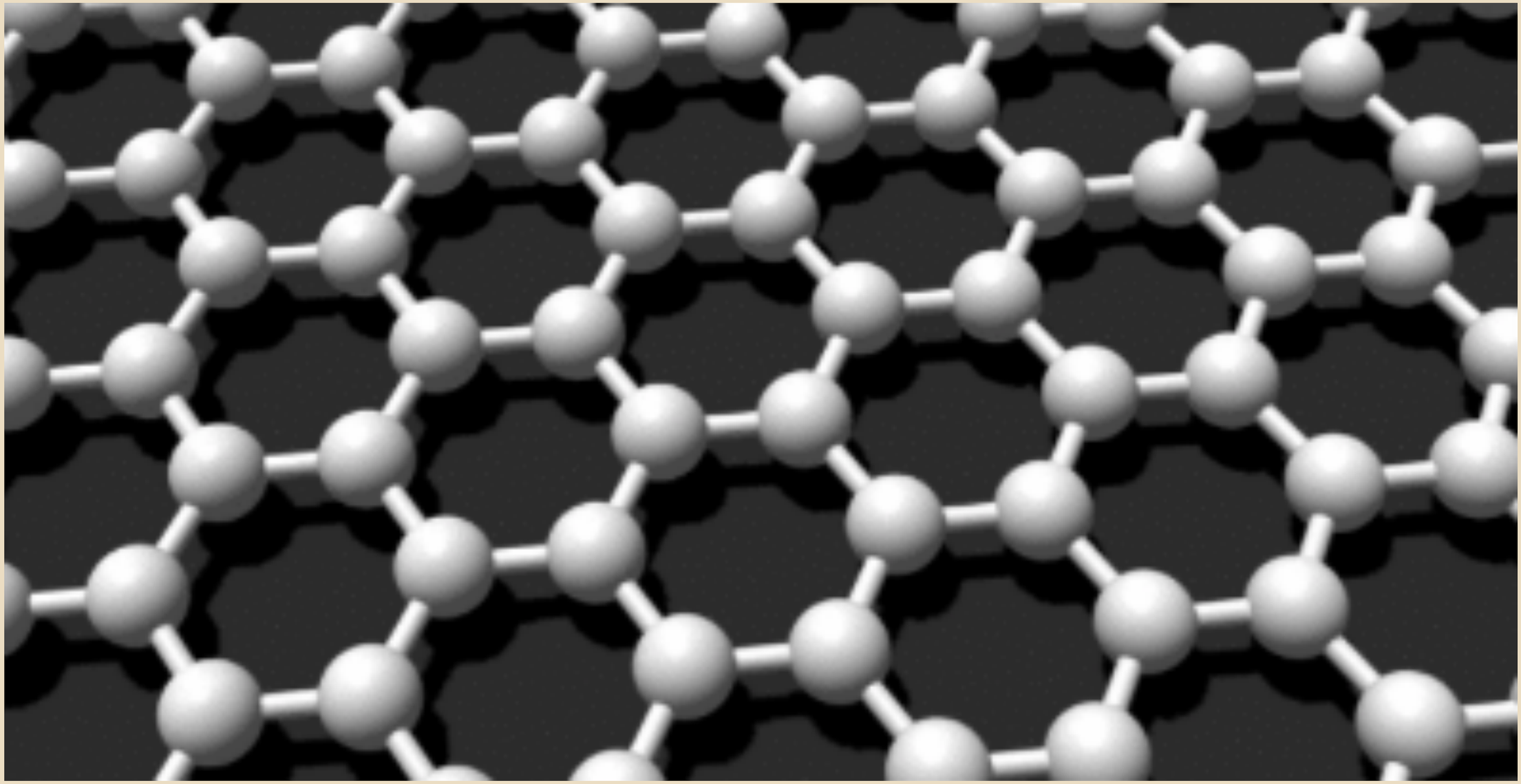
Usages:

- For fun

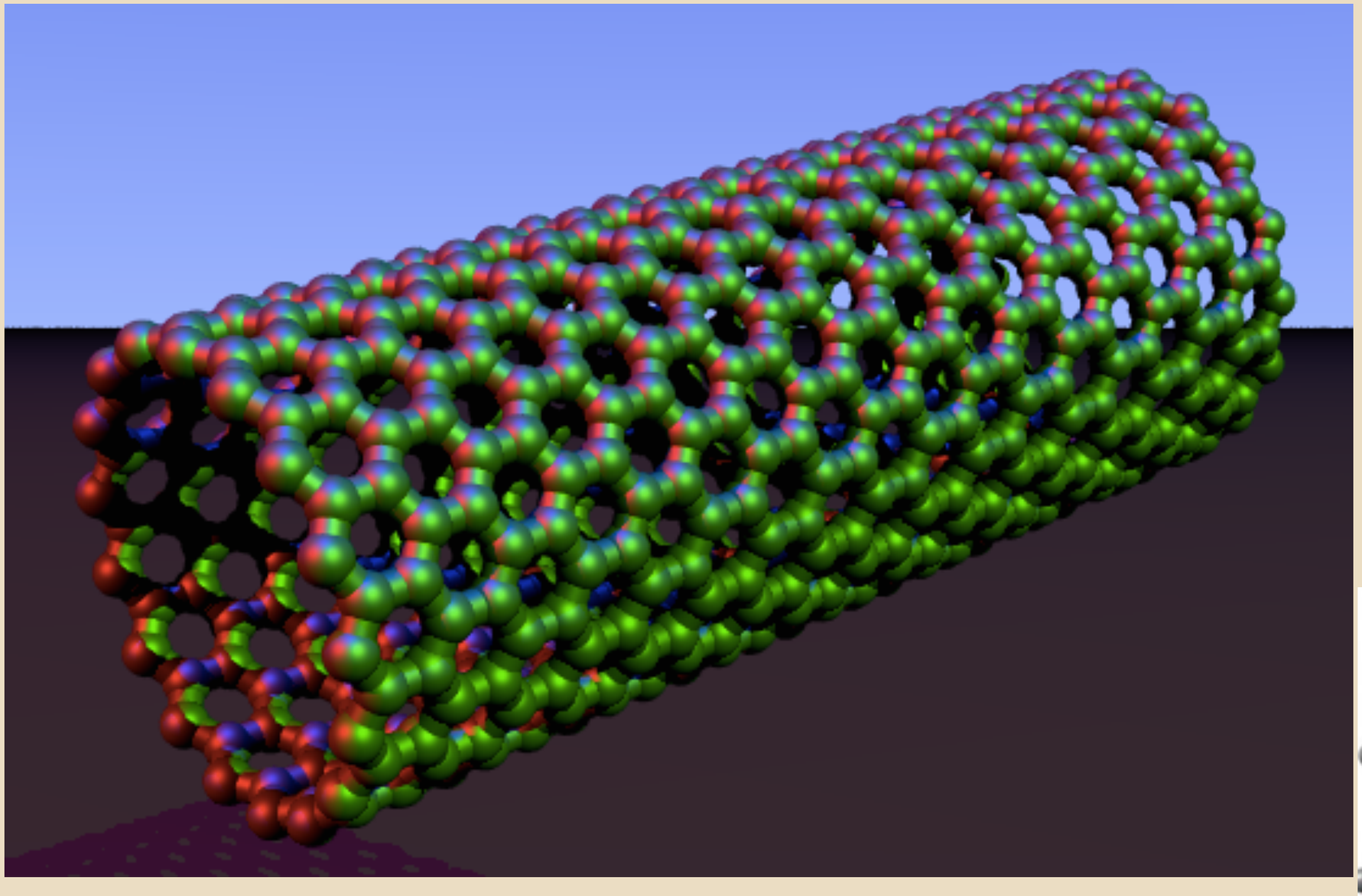
Original blue Buckyballs Magnet Balls Puzzles

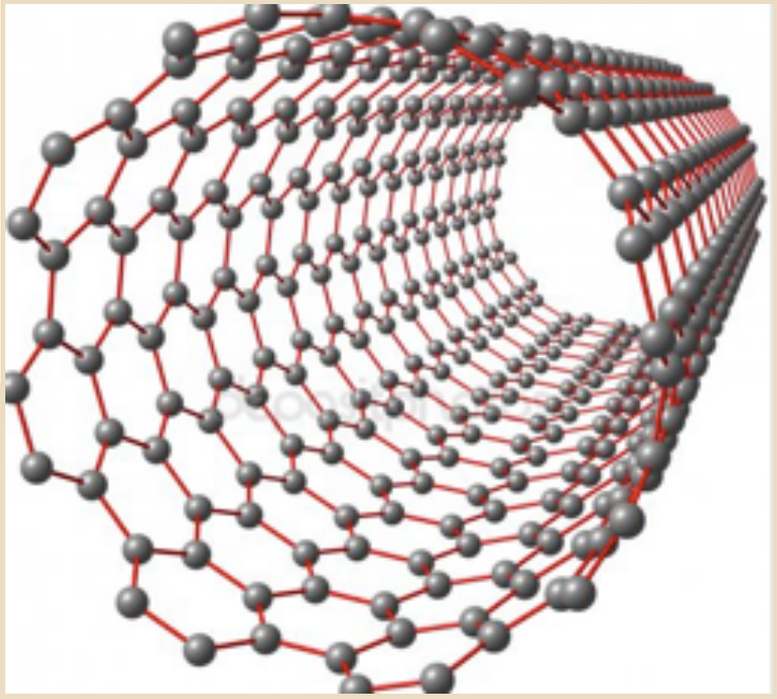
~~$39.99~~ **$24.95**

The Big Stuff - Graphene



Nanotubes





Nanotubes

CARBON NANOTUBES

- Long chains of carbon bonded by sp^2, the strongest bond in chemistry.
- Properties: ballistic electron transport (ideal for electronics); 300 times stronger than steel.
- It's the only material that could be used to build a space elevator.

Graphene

Why Graphene hasn’t taken over the world yet - 7:42 min

https://www.theverge.com/2018/7/10/17548362/graphene-material-breakthrough-science-technology-hype

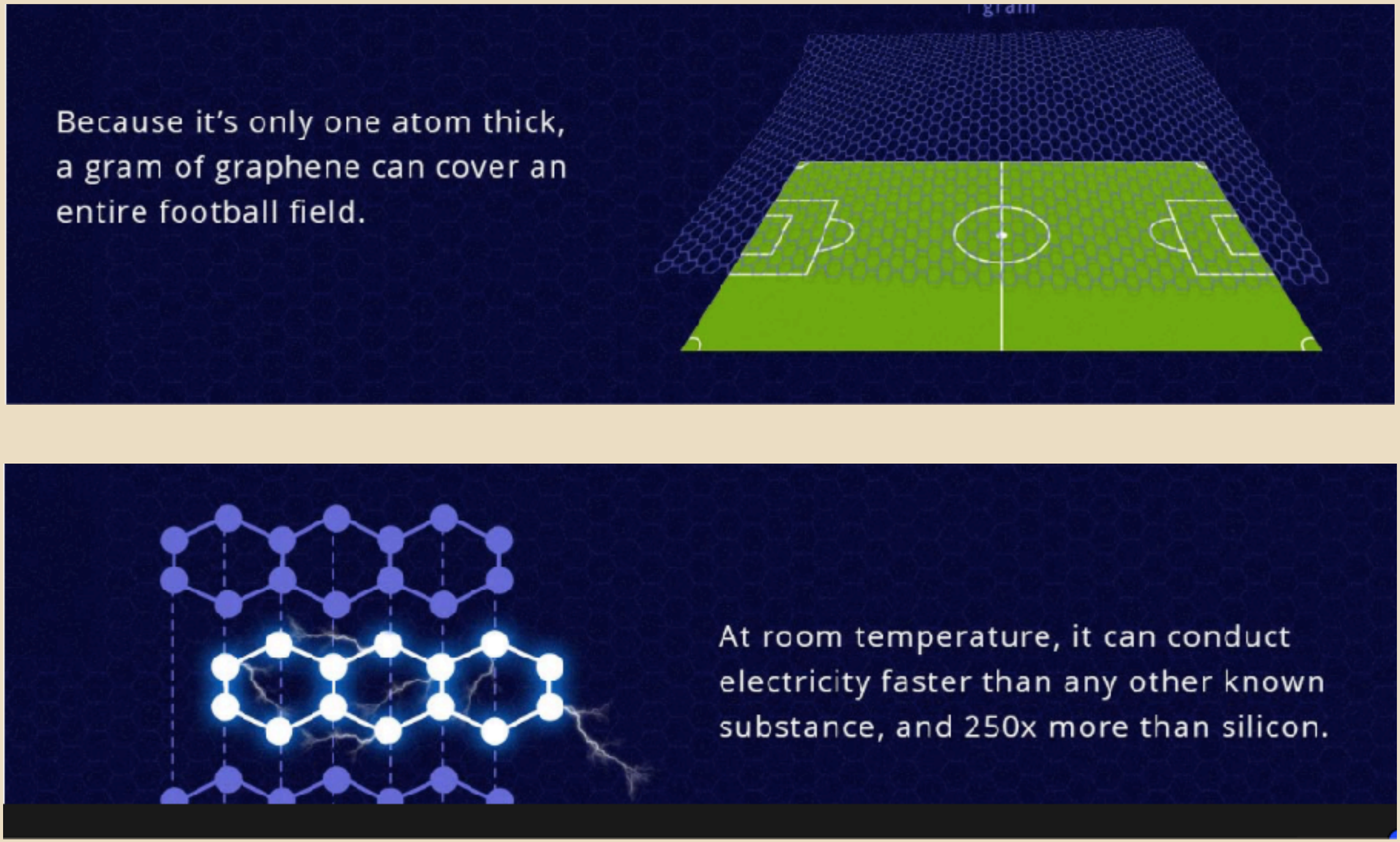
Graphene

Graphene is:

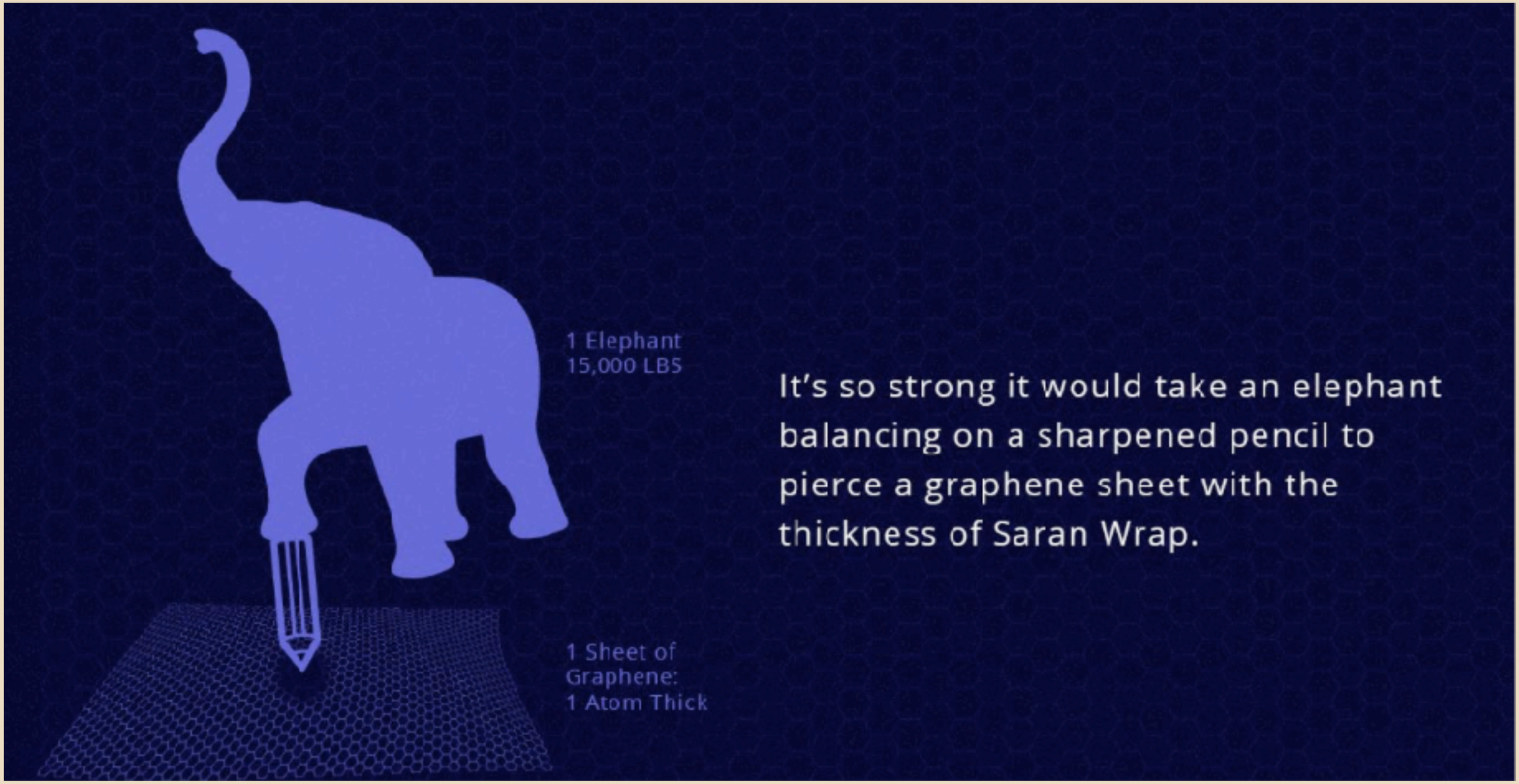
strong
flexible
extremely light
high conductivity

airplane fuselage/wings
girding Cu wires
damage indicator (graphene can be made to change color when it breaks) in bridges, planes, space stations

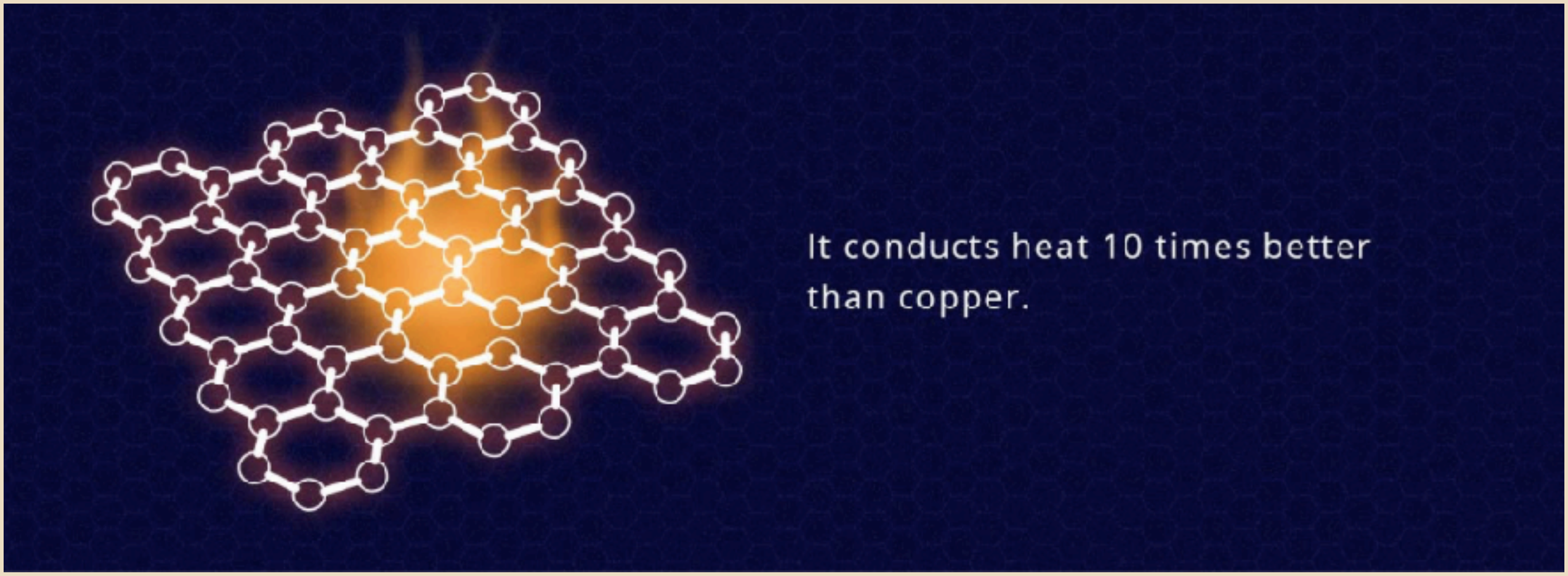
Graphene


Because it's only one atom thick,
a gram of graphene can cover an
entire football field.
At room temperature, it can conduct
electricity faster than any other known
substance, and 250x more than silicon.

Graphene


1 Elephant
15,000 LBS
1 Sheet of
Graphene:
1 Atom Thick
It's so strong it would take an elephant balancing on a sharpened pencil to pierce a graphene sheet with the thickness of Saran Wrap.

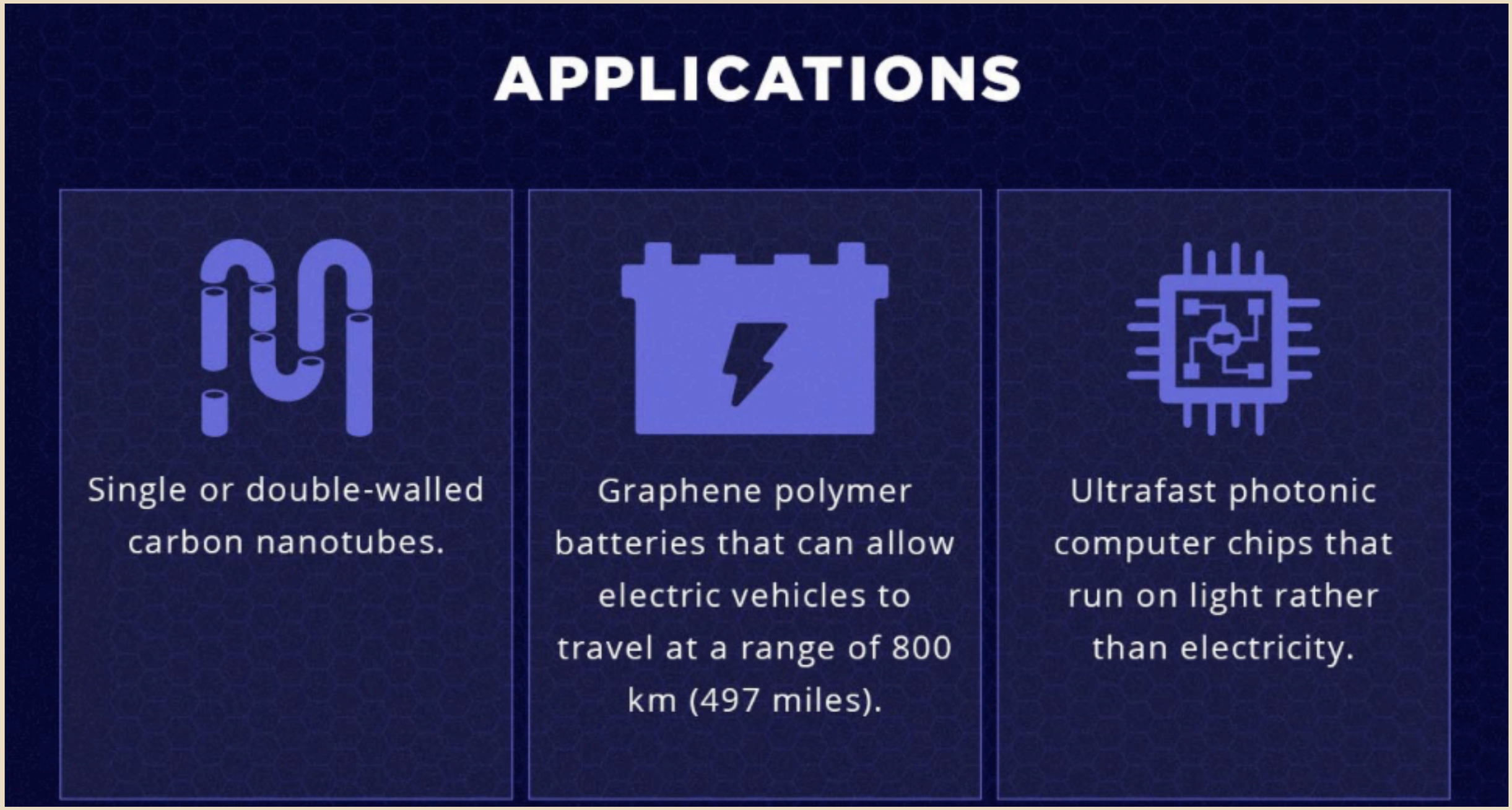
Graphene



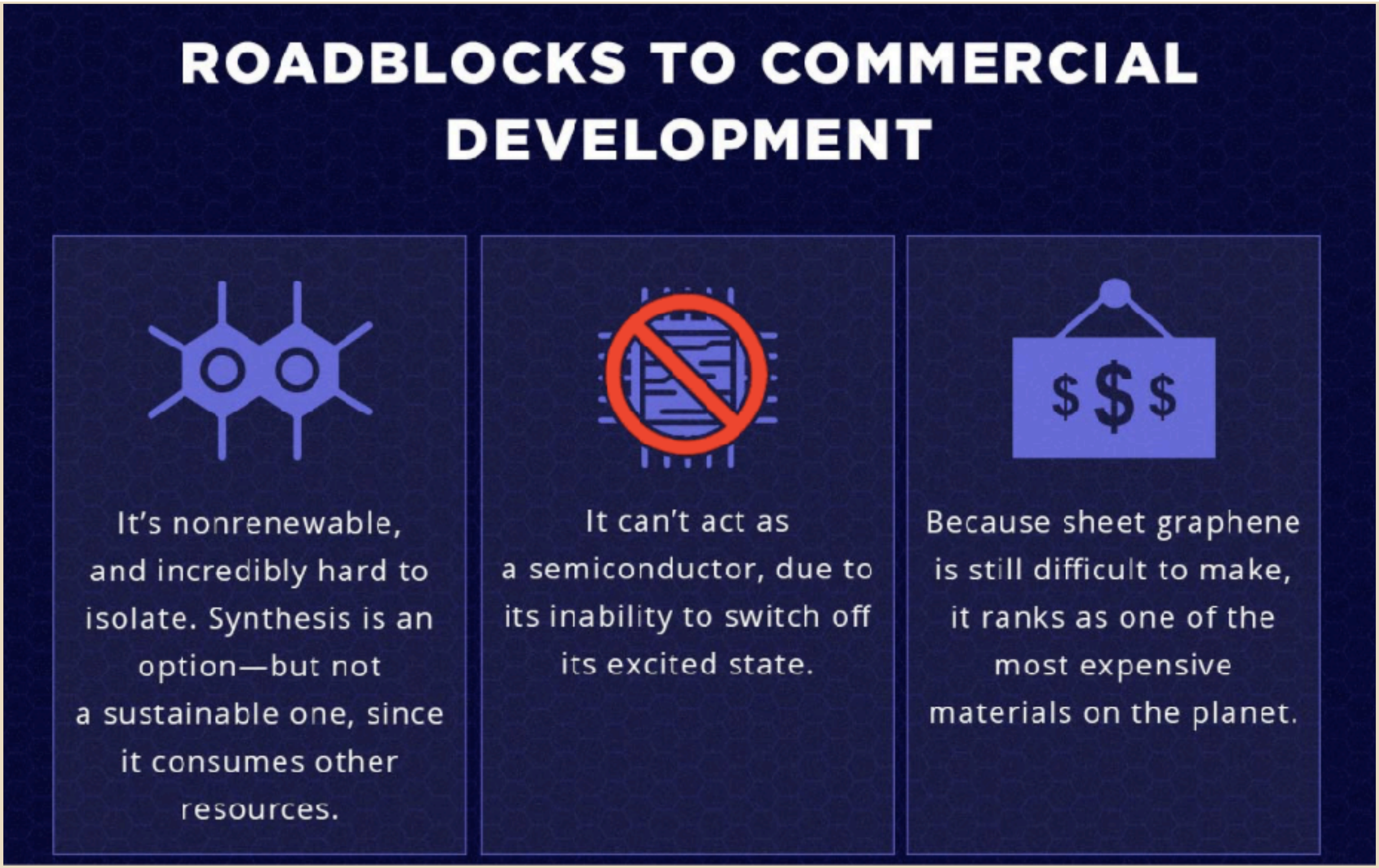
Graphene


APPLICATIONS
OLEDs (Organic Light Emitting Diodes).
Water desalination.
Flexible smartphone displays.

Graphene

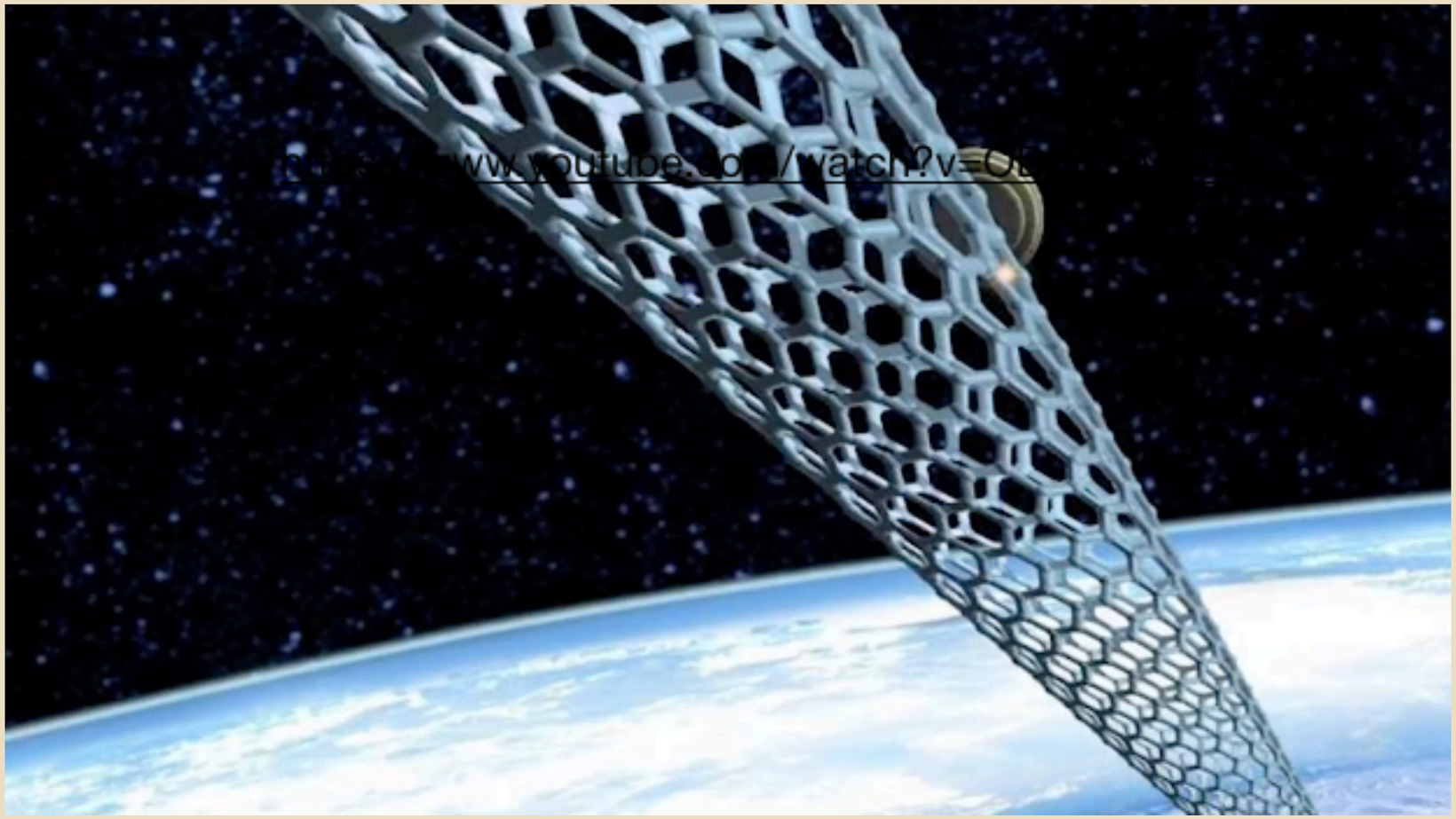

APPLICATIONS
Single or double-walled carbon nanotubes.
Graphene polymer batteries that can allow electric vehicles to travel at a range of 800 km (497 miles).
Ultrafast photonic computer chips that run on light rather than electricity.

Graphene


ROADBLOCKS TO COMMERCIAL DEVELOPMENT
It's nonrenewable, and incredibly hard to isolate. Synthesis is an option—but not a sustainable one, since it consumes other resources.
It can't act as a semiconductor, due to its inability to switch off its excited state.
$ $ $
Because sheet graphene is still difficult to make, it ranks as one of the most expensive materials on the planet.

SUMMARY 1

Graphene video



https://www.youtube.com/watch?v=ODZgSAeLlEQ

SUMMARY 2

Mikael Fogelstrom
11:39 min video

https://www.ted.com/talks/mikael_fogelstrom_graphene_from_a_layer_of_atoms_to_applications

Graphene

So far, so good . . .

but what is ON THE MARKET?

Graphene Shoes

More Strong,
More Elastic,
Wear Resistant

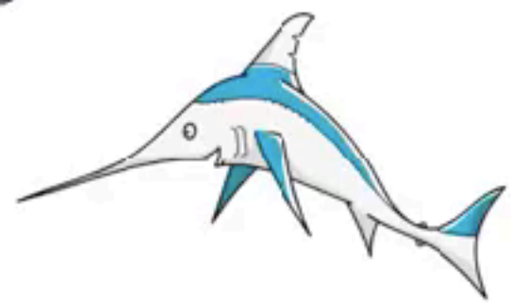
Inov-8

Approximate Cost
$180.00

Graphene Fishing Rod

G-Rods

Graphene with Toray Carbon Fiber



Approximate Cost
$250.00

Graphene Light Bulbs

Makes LED more Efficient

Approximate Cost

$8.00

Symsis

Graphene Batteries

Approximate Cost

$60.00

Turnigy

Lithium Polymer (Li Po)

Graphene Earphones

Ghostek

FiiO

Approximate Cost
$25.00

Graphene Jackets

Colmar

Approximate Cost
$369.00

Graphene Cycle Frame

Dassi

Approximate Cost
$8500.00

Weight 750 gms

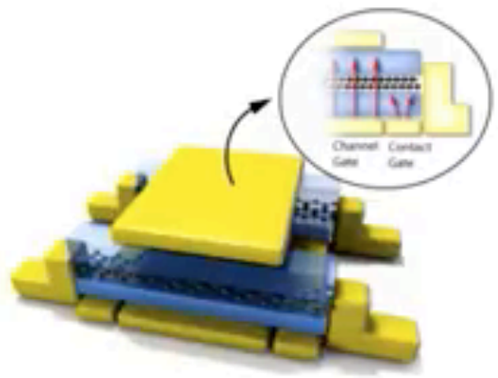
2 times stronger than conventional frames

Graphene Bike Helmet

Approximate Cost
$125.00

Catlike

Graphene cooled Storage Drives



Teamgroup

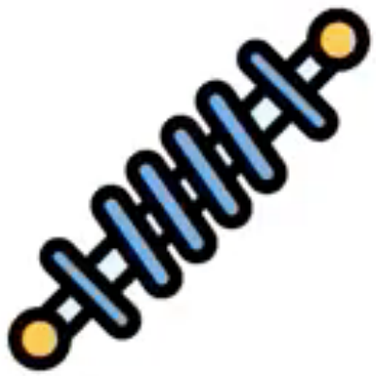
Approximate Cost
$200.00

World's lightest chronometer:
40 grams (incl. strap)

- graphene enhanced composite creates a strong but lightweight case

Graphene Tennis Rackets

HEAD



Approximate Cost

$200.00

In 2014, HEAD launched a line of graphene-enhanced skis for women, called Joy, which are meant to be lightweight and durable. The line includes several models, and is currently about 20% more expensive than traditional skis.

Perpetuus: Graphene enhanced tires
with 40% increased wear resistance

New Materials - State of the art

Sources

https://www.youtube.com/watch?v=IesIsKMjB4Y

https://www.youtube.com/watch?v=675eM-V8t08

https://www.youtube.com/watch?v=z9aF8GcBTZU

Sources:

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