Introduction
A few interesting facts about materials…

MATERIAL SCIENCE

I. SEMESTER
2019/2020 AUTUMN

Interesting (advanced) materials

Aerogels

- frozen smoke

- holds records in the Guiness Book of records

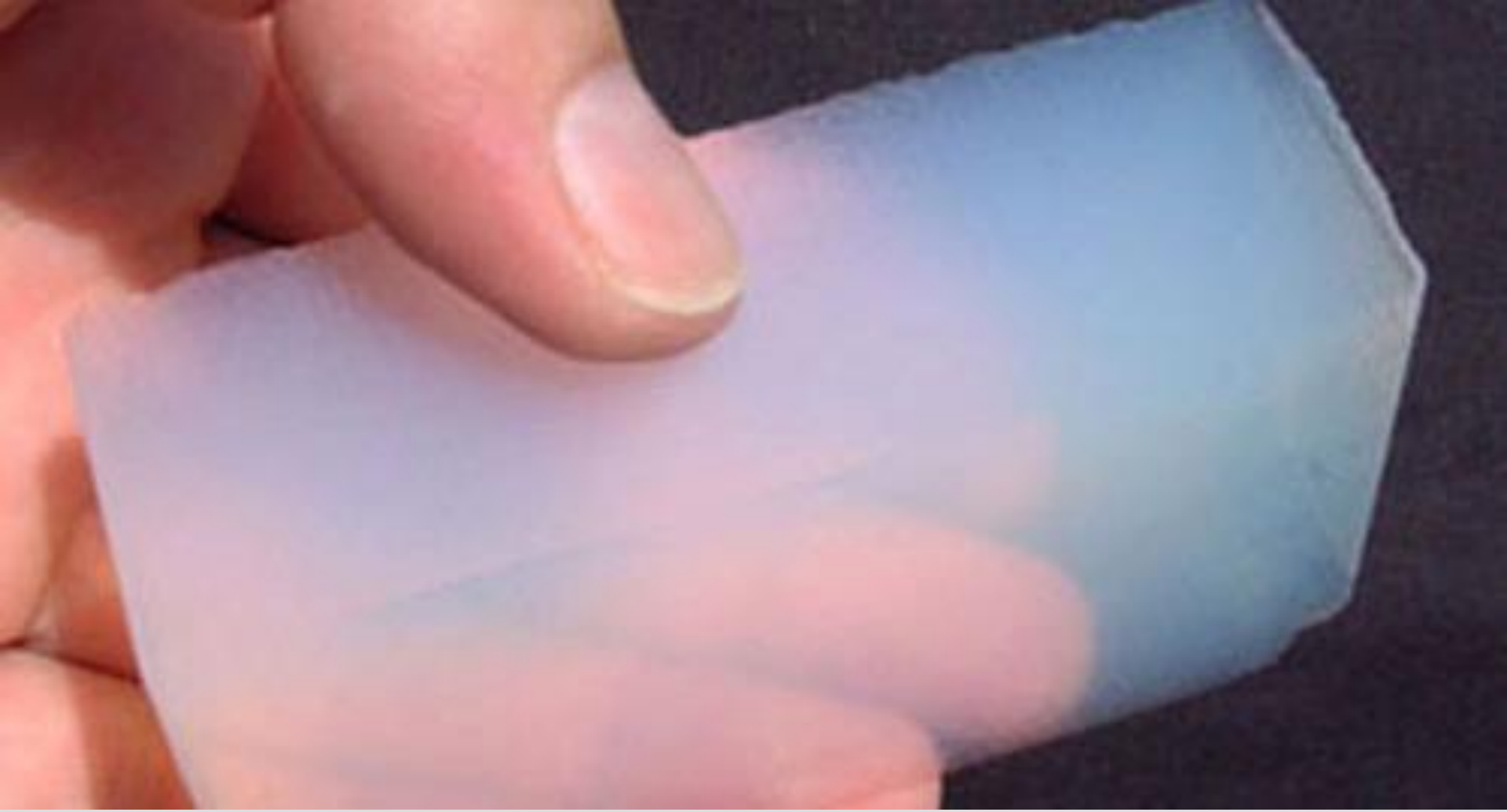
- made up of supercritical dried liquid gels of alumina, chromium, tin oxide

- is 99.8% empty space making it semi-transparent

- good insulator

- big surface area

- small density

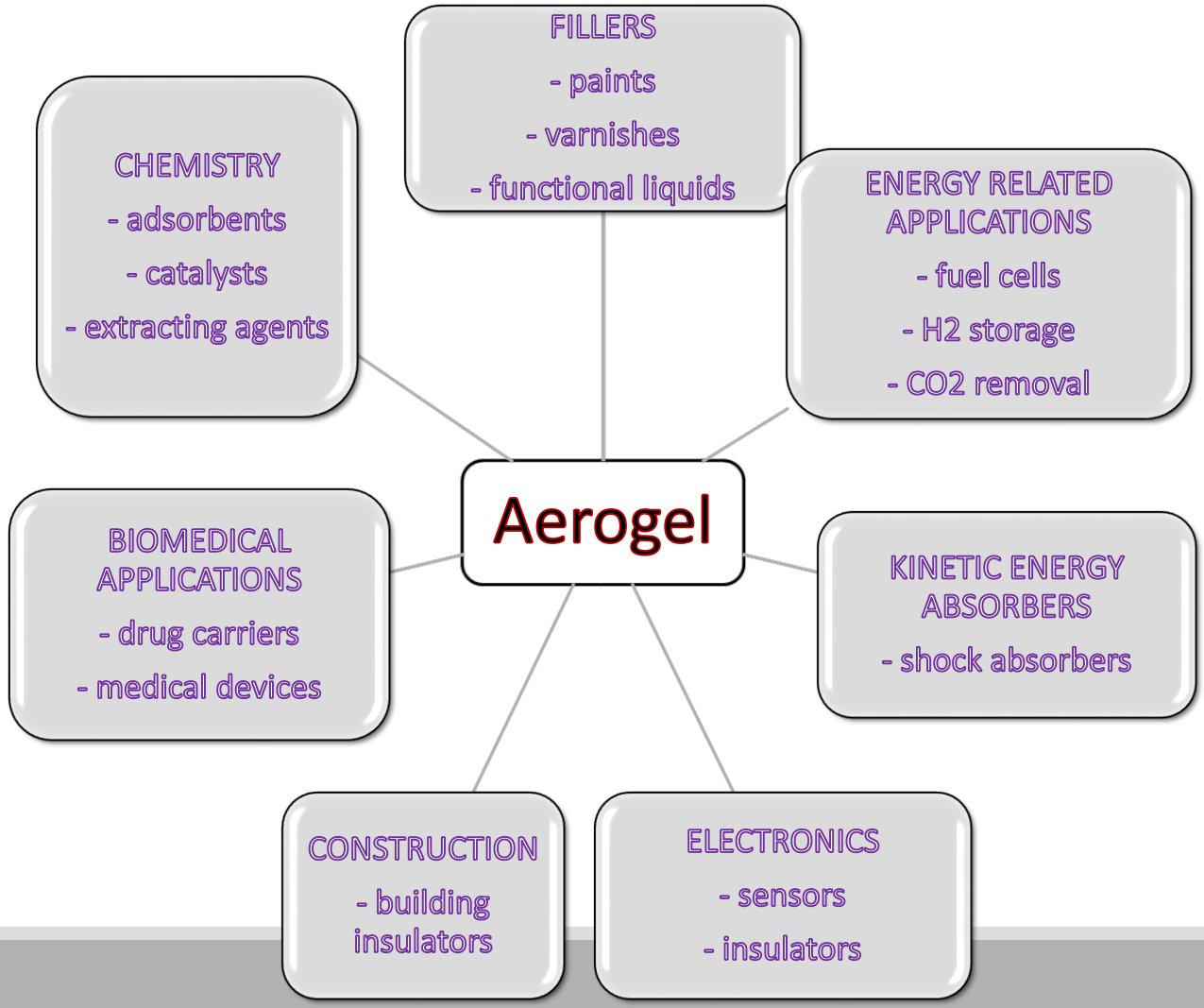


Silica aerogel in block form

https://www.researchgate.net/figure/Silica-aerogel-in-block-form_fig1_271451182

A 2.5 kg brick is supported by a piece of aerogel with a mass of 2 g

Készítette: Courtesy NASA/JPL-Caltech - NASA Stardust Website, Közkincs, https://commons.wikimedia.org/w/index.php?curid=85519



Some applications of aerogels

Interesting (advanced) materials

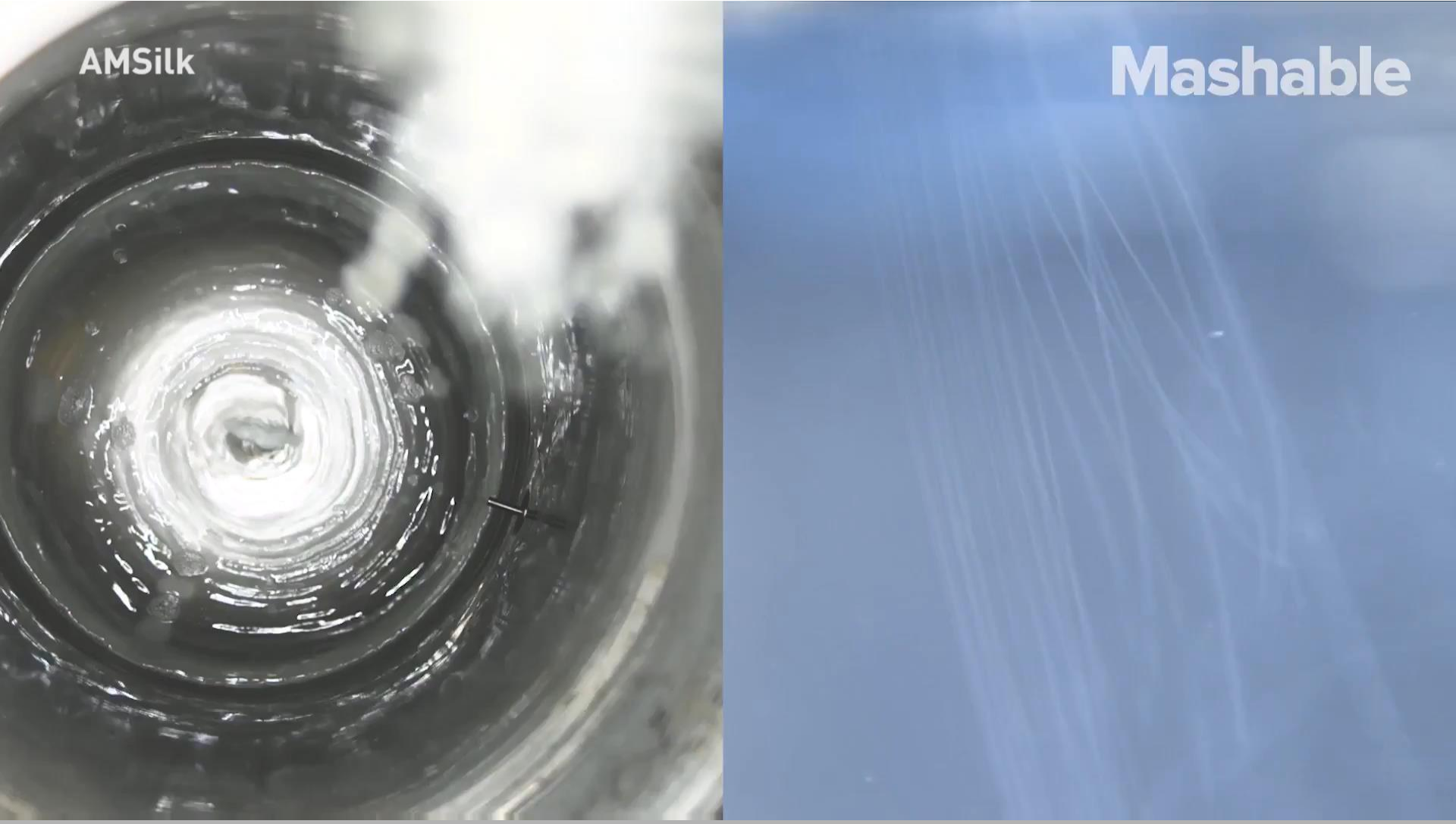
Artificial spider silk

- produced by several companies with different technologies

- protein fibre

- remarkable mechanical strength. Its tensile strength is comparable to that of high-grade carbon steel

- technologies: using a bacteria that produces the protein, then the protein is converted into fibers; using genetically modified silkworms, fermentation technologies etc.



https://www.youtube.com/watch?v=9e1j4b5kIHM

Interesting (advanced) materials

Carbon nanotubes

- long chains of carbon held together with covalent bonds, stronger than the bonds in diamonds- protein fibre

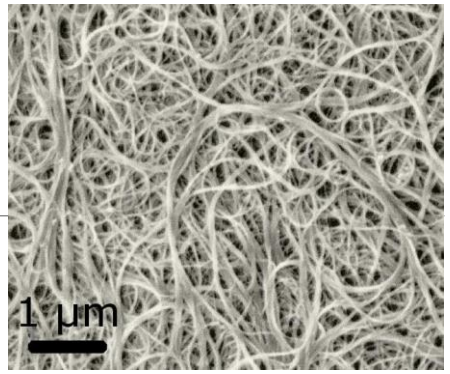
- high tensile strength, 300 times stronger than high –grade steel

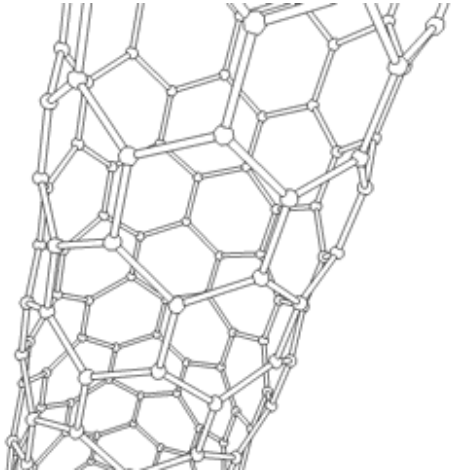
- low density

- high thermal and electric conductivity

- chemical modification is possible (functionalization) – increase the applicability

By Materialscientist at English Wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=12837127

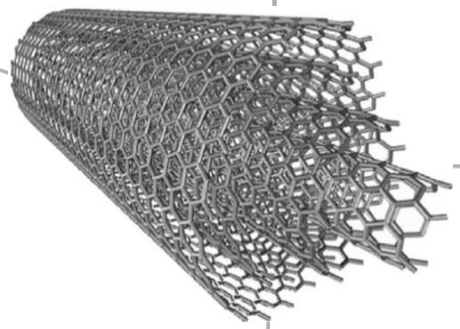




By Original hochgeladen von Schwarzm am 30. Aug 2004; Selbst gemacht mit C4D/Cartoonrenderer, GNU FDL - German Wikipedia, original upload 29. Dez 2004 by APPER, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=350208

ENERGY
- capacitor
- fuel cell
- lithium-ion battery

BIOTECHNOLOGY- biosensors
- drug delivery systems
- cell cultivating



NANOTECHNOLOGY
- various hybrid materials used in the industry (autocars, construction ndustry etc.

ELECTRONICS
- wires
- transistors
- conductive thin films

Some applications of carbon nanotubes

Interesting (advanced) materials

Metamaterials

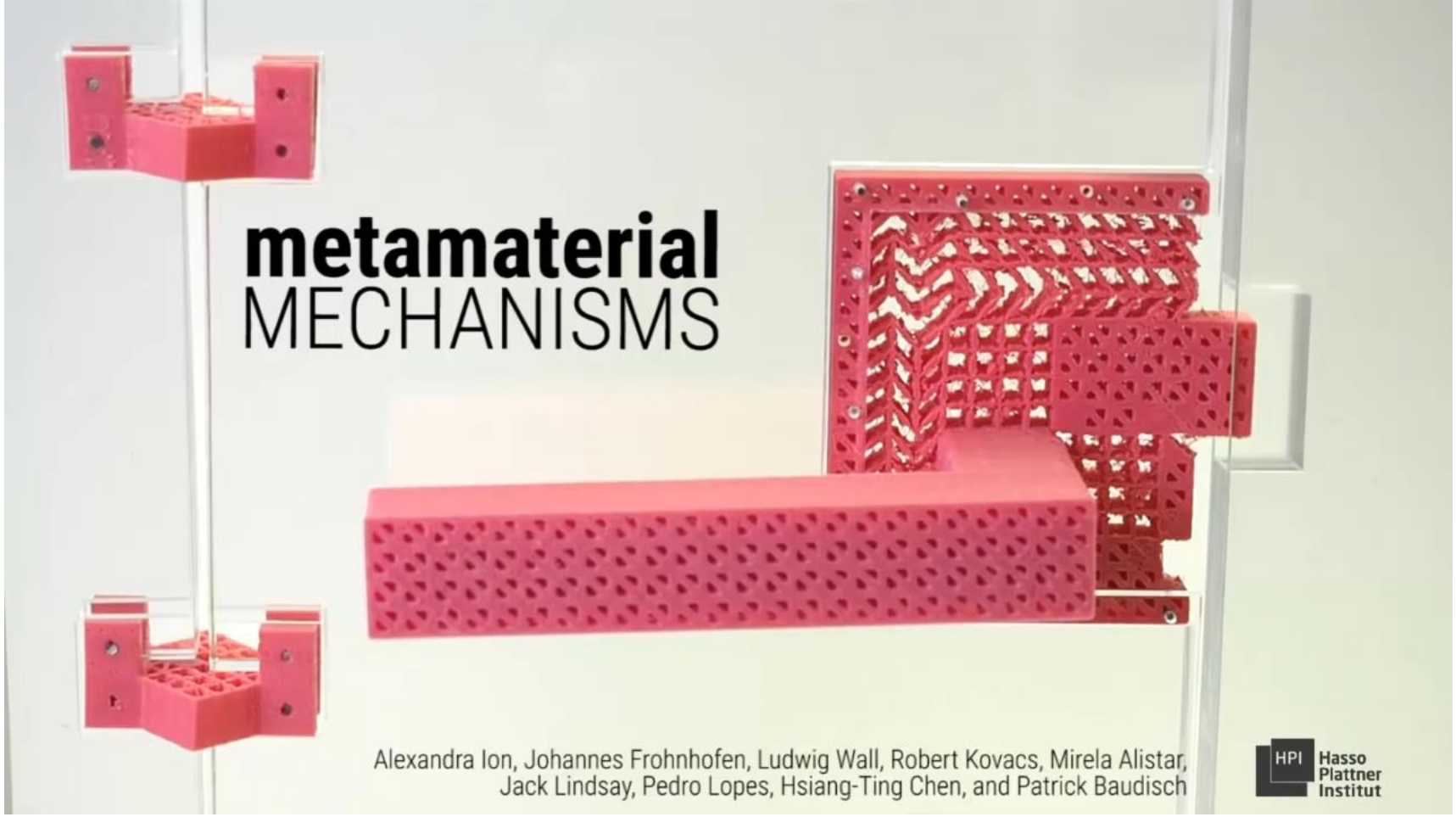
- produced by several companies with different technologies

- they gain their properties from their structure rather than composition

- used to create microwave "invisibility cloaks", 2D invisibility cloaks and other materials with unusual optical properties

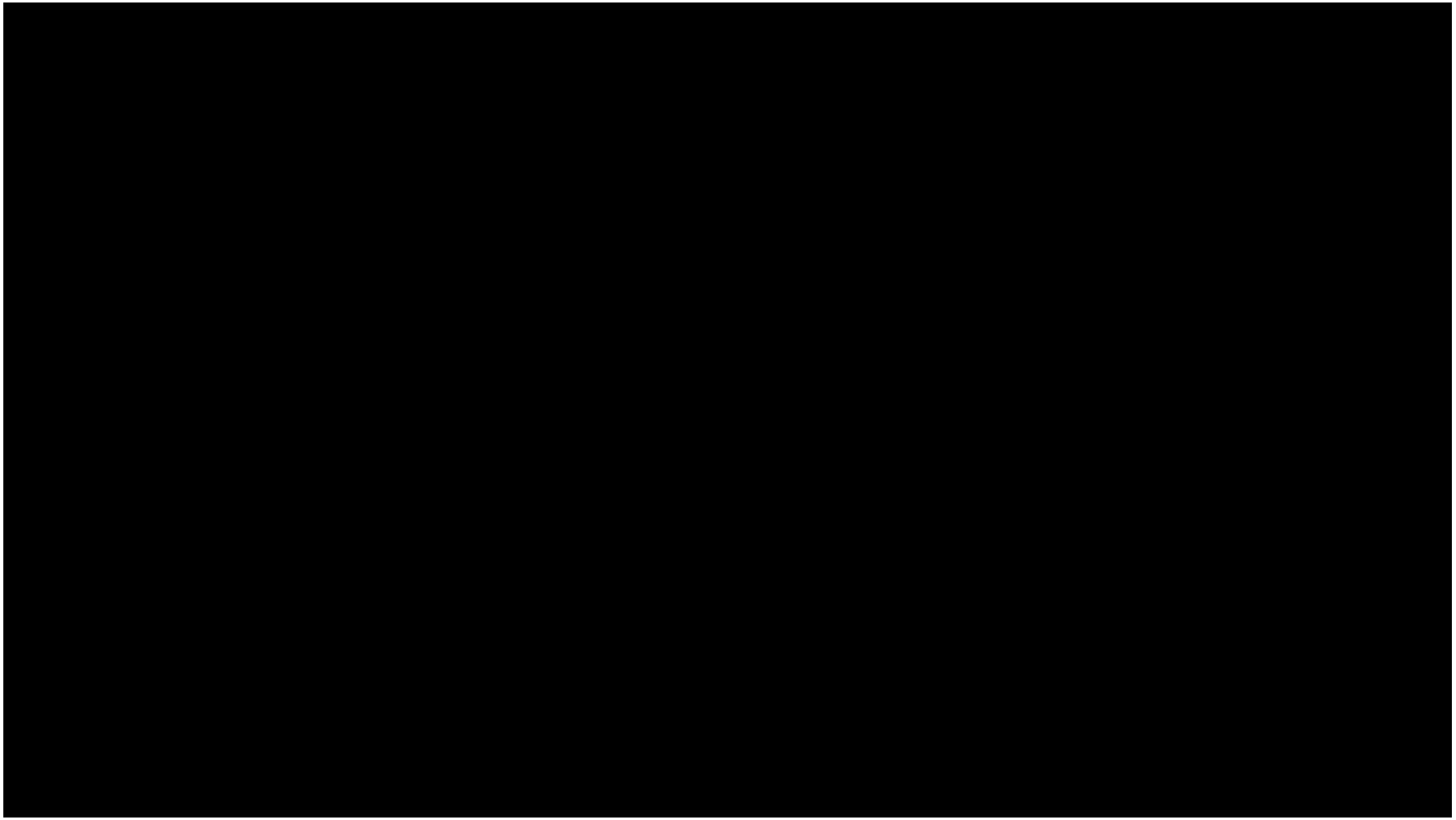
- pearl is a naturally occurring metamaterial

- possible applications in optics, astronautics etc.



Metamaterials Mechanism

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



Lycurgus cup – dychroic effect: The dichroic effect is achieved by making the glass with tiny proportions of nanoparticles of gold and silver dispersed in colloidal form throughout the glass material.

https://www.youtube.com/watch?v=v7jzHttcTG4

Interesting (advanced) materials

Metallic glasses

- are amorphous metals, metals with a disordered structure

- high strength, up to twice the strength of the steel

- shiny and opaque as metals, conduct heat and electricity, resistant to corrosion, shapable

- made by quick cooling of molten metals

- applications as electrical grids, ultrasharp scalpels, hinges, sport equipment (tennis racquets, golf clubs, skies)

- can be made only from some, expensive metals (Pd, Zr). All the other metallic glasses are not workable enough, they are brittle

Metallic glass:
- strong and hard
- shapable

Metal:
- strong and hard
- difficult to shape

https://www.youtube.com/watch?v=SuNR6fUz67U

Interesting (advanced) materials

Metallic composite foam

- created from aluminum, titanium, tantalum

- methods: powder metallurgy, hollow sphere method, lotus type method,

- strong and light, porous, high compressive strength, low thermal conductivity, reciclable,

- proposed as construction material

- important in civil engineering

Prototype/In-Production Applications:	Improved characteristics explored in the given application					Importance to civil engineering
	W weight	*K* stiffness	*En* energy	*c* damping	*f* frequency	
  steel foam bars, rods, sandwich plates [58]	X	X		X	X	Proof-of-concept, demonstrates steel foam bars, rods, sandwich plates, foam filled tubes can all be produced; demonstrates essentially all aluminum foam applications could be extended to steel foam.
  wall/floor foam sandwich panels [60]	X	X		X	X	Mass production of metal foam panels is possible. Great variety of bending stiffness-to-weight regimes opened up by this possibility.
  balcony platform, parking floor slab [62]	X	constr		X		Metal foam panels may take significant, even localized, loads, thus appropriate for floor slab, even heavily loaded parking garage (as load redistributes adequately).
 crane lifting arm and support [61]	constr	X				Metal foam beams can be produced that support high/typical structural loads and fatigue is not a unique problem as crane arms were fatigue tested.

http://www.steelfoam.org/arwade_emi_11_review_01.pdf

Prototype/In-Production Applications:	Improved characteristics explored in the given application					Importance to civil engineering
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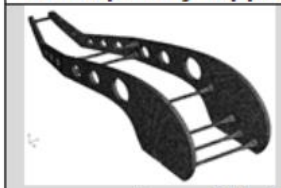
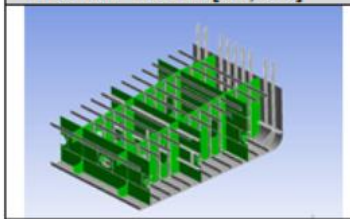
  fabrication equipment [61]		X		X	X	Metal foam panels can be tuned for desired vibration characteristics, could, e.g., be very important for high-speed rail applications.
  Ariane 5 rocket cone prototype [60]	constr	X			X	Shell structures possible with metal foams, tight dynamic performance constraints can be met. Metal foam explicitly cheaper than traditional sandwich panel in this case.
Concept-only Applications						
 race car frame [64, 59]	X	constr	X	X		Design space opened up by metal foams is large, concept-only applications in automotive, demonstrate multi-criteria optimal solutions including energy absorption.
	X	constr				Concept-only application in cargo ship demonstrates strength, stiffness, and weight potential under large demands.

http://www.steelfoam.org/arwade_emi_11_review_01.pdf

Interesting (advanced) materials

E-textiles

- „intelligent” textiles

https://www.youtube.com/watch?v=EAPWFY4_8Eg

GreenBelt

10 INNOVATIVE CONSTRUCTION MATERIALS

THAT COULD REVOLUTIONIZE THE INDUSTRY

The much awaited and anticipated revolution in construction is gaining momentum. We now have drones, virtual reality, augmented reality, BIM, project management solutions. Each branch of our field researchers and various institutes are taking technology to the next level. Developments in cutting and various other construction materials that have aggressive and drastic.

1 TRANSLUCENT WOOD

The much abandoned and anticipated revolution in construction is gaining momentum. We now have drones, virtual reality, augmented reality, BIM, project management solutions. But it doesn't stop here! Researchers and various institutes are taking technology to the next level. Developments in concrete and various other construction materials that have aggressive and drastic.

Invented by: A Scandinavian company

2 COOLING SYSTEM IN BRICKS

Through the consideration of clay and hydrogel, students at the Swiss Federal Institute of Technology in Zurich have created a new material that has a cooling effect on buildings similar to the cooling effect comes from the evaporation of sweat. The bricks absorb water, up to 250 times its weight. The absorbed water is released to reduce the temperature during hot days.

Unfortunately how the ability to reduce indoor temperature by up to 3 degrees celsius.

Developed by: Institute of advanced architecture of Catalonia

3 CIGARETTE BUTTS TO MAKE BRICKS

The impact of the cheap plastic in cigarette butts – filtration, toxic as arsenic, chromium, lead and cadmium when they enter the water supply.

In order to reduce the impact of cigarette butts on the environment, researchers at the Delft University of Technology in the Netherlands have developed a way to make different bricks made of cigarette butts. In fact, researchers say that bricks made from cigarette butts are more thermally insulating.

30 cigarette butts & 1 kilo ingredient (i.e. manufacturer) and the producer (...) without traces of cigarette butt vapor.

Developed by: Delft

4 MARTIAN CONCRETE

It's finally done! We have concrete that can be used to build structures on Mars. Scientists at Northwestern University have created concrete that can be made with the materials available on Mars.

In order to make the martian concrete, sulphur is heated at 130° celsius which melts it into a liquid.

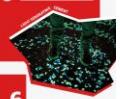
Developed by: Northwestern University

5 LIGHT GENERATING CEMENT

Dr. José Pedro Ferrer Pedro from the Universitat Jaume I de Castelló, Spain, has created cement that can generate light. The cement is called Lucelem light. With this new light generating cement the potential uses and applications of it are limitless.

Energy efficient, as it only requires the energy from the sunlight to store and release it during the night or even on cloudy days.

Developed by: Universitat Jaume I



6 THE CADKOMA STRAND ROD

The Hachinohe Sekisui Heavy Laboratory Research Center has created a new material called the Cadkoma Strand Rod. It is a thermoplastic carbon fiber composite.

The strand is the lightest seismic reinforcement and is also aesthetically pleasing.

A single strand of Cadkoma tested had of 144 kilonewtons (kN) which is more than 4 times lighter compared to a steel rod.

Developed by: Hachinohe Sekisui Heavy Laboratory

7 BIOLOGICALLY PRODUCED FURNITURE

Another very beautiful homeowner in the form of furniture. Dubbed the Biologically Produced Furniture. So far there are two pieces of furniture created through the material – a chaise lounge and a chair. Click To Tweet

The process is the energy pollution free and requires less technology for the manufacturing.

Developed by: Hackitect Duo and Company

8 FLOATING PIERS

Over the waters of Italy's lake Iseo, you can see another great innovation in the construction industry – Floating piers by artists Christo and Jean-Claude. It is a 3 km long walkway that floats on the surface of the waters of Lake and is wrapped around it. The colors celebrate during the events of the lake.

The Floating brick system is composed of 3 basic polyethylene cubes of high density.

Developed by: Christo and Jean- Claude

9 POLLUTION ABSORBING BRICKS

The Graviky Labs works in pollutants. The air and tobacco filtered air. The innovative material is designed to be part of the city's infrastructure and pollution system. It has a skin layer formed, which with the sprouted bricks on the outside and the pollutants are absorbed by the bricks.

Tested during which tested Delhi, it was proven that the system can filter 160 thousand cubic meters of air per day and collect the soot in an ink.

Developed by: Cal Poly

10 SELF HEALING CONCRETE

Dutch civil engineer, Dr. Veldmeijer at Delft University has created a self healing concrete. This is demonstrated by breaking the material in two. Then, the two pieces are put back together and the concrete is left to heal. Over the months between the two pieces fuses together.

It is estimated that this innovative technology could save 200 million annually.

Developed by: Delft University

References

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Innovative construction materials

Translucent wood

- made by removing the lignin from the wood

https://www.archdaily.com/785482/translucent-wood-meet-the-new-material-developed-by-kth

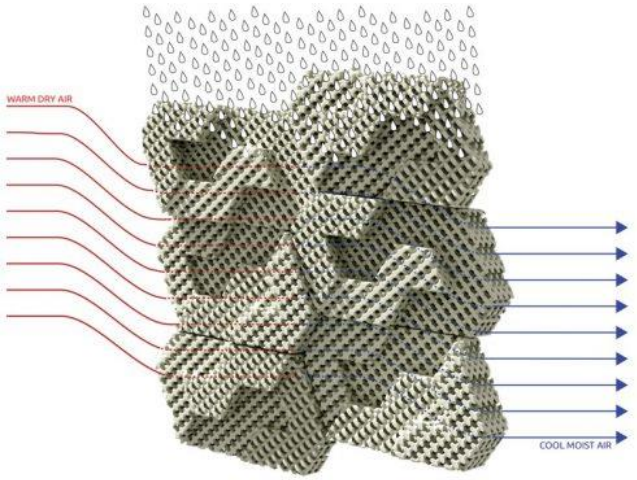
Innovative construction materials

Cooling system in bricks

- combination of clay and hydrogel

- has cooling effect in the interior of buildings by absorbing the water in the interior of the hydrogel. The water is released to reduce the temperature during hot days

https://theconstructor.org/building/cool-bricks-hot-dry-climates/32475/



Innovative construction materials

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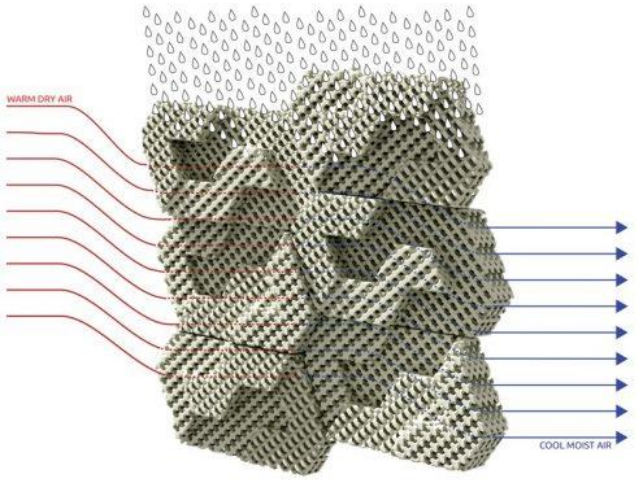

Innovative construction materials

Cigarette butts to make bricks

- light and energy efficient

- As, Cr, Ni, Cd waste is used in an eco-friendly manner

-

https://www.treehugger.com/clean-technology/cigarette-butts-make-better-bricks.html

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Innovative construction materials

Martian concrete

- concrete that could be used to build structures in Mars

- made with materials available on Mars

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Innovative construction materials

Light generating cement

- absorb and irradiate the light

- „low energy usage”

https://www.sustainabilitymatters.net.au/content/sustainability/case-study/light-emitting-cement-360126584

Innovative construction materials

Light generating cement

- absorb and irradiate the light

- „low energy usage” ???

https://www.sustainabilitymatters.net.au/content/sustainability/case-study/light-emitting-cement-360126584

Innovative construction materials

The CABKOMA STRAND ROD

- thermoplastic carbon fiber composit
- lightest seismic reinforcement
- 160 m long, 12 kg

https://www.komatsumatere.co.jp/cabkoma/en/

Innovative construction materials

Pollution absorbing bricks

- designed to be part of a building standard ventillation system

- it can filter 30% fine particle polluants, 100% coarse particle polluants

Innovative construction materials

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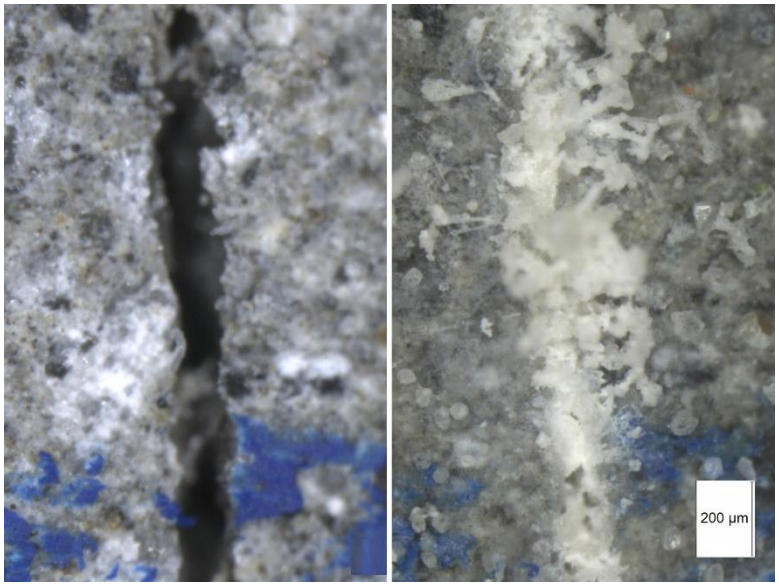
Innovative construction materials

Self healing concrete

- works with bacteria that is activated by the water penetrating through a crack, and the bacteria produces $CaCO_3$



https://www.ugent.be/ea/structural-engineering/en/research/magnel/research/research3/selfhealing

From quarks to atoms
Electron structure

MATERIAL SCIENCE

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What the matter is?

What the matter is?

Matter

- **classical definition:** something that has **mass** and takes up **space**
- **modern physics**, **matter is not a fundamental concept** because a universal definition of it is elusive: elementary constituents of atoms may not take up space individually, and massless particles may be composed to form objects that have mass
- physical or corporeal **substance** in general, whether **solid, liquid or gaseous**, especially as distinguished from incorporeal substance as spirit or mind, or from qualities, actions etc.
- the substance or substances of which any physical **object consists or is composed**
- something that occupies **space**
- matter can be defined as anything that is affected by **gravity**, that has **weight** or would have weight if it was near the Earth or another star or planet massive enough to produce measurable gravity

Substance, mass, space

Substance

- that of which the things consist (phylosophy)
- species of matter of definite chemical composition (physics)

Mass

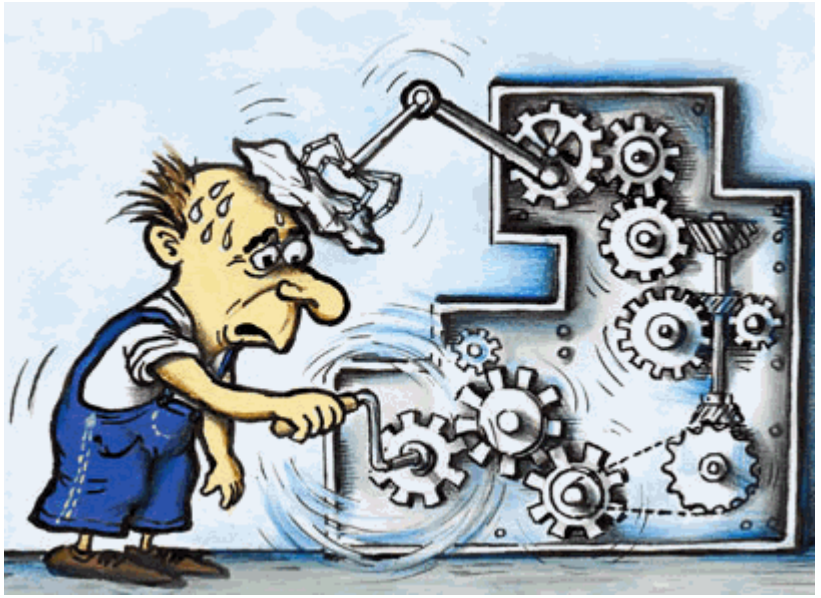
- In physics, **mass** is a property of a physical body. It is the measure of an object's resistance to acceleration (a change in its state of motion) when a net force is applied

Space

- Is the boundless three-dimensional extent in which objects and events have relative position and direction

How the science „works”?

- in material science, in physics, in engineering the definitions can only be accepted if they can be proved
- the method of proving is the: EXPERIMENT
- Conditions and effects:
  - have to be reproducible
  - not disputable (TRUE)



What the matter is?

- **Natural sciences: everything that is able to interact with one of the fundamental interactions (forces) or with the combination of these, is MATTER (Manuel Carreira, Spanish physicist and philosopher)**
- The matter:
  - has a place in space
  - has some quantity of energy
  - can interact with physical instruments
  - it constructs the Universe