Superhero Science

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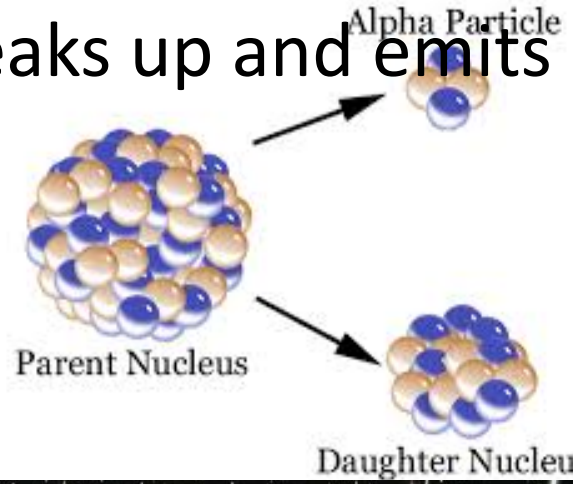
How to become superhero?

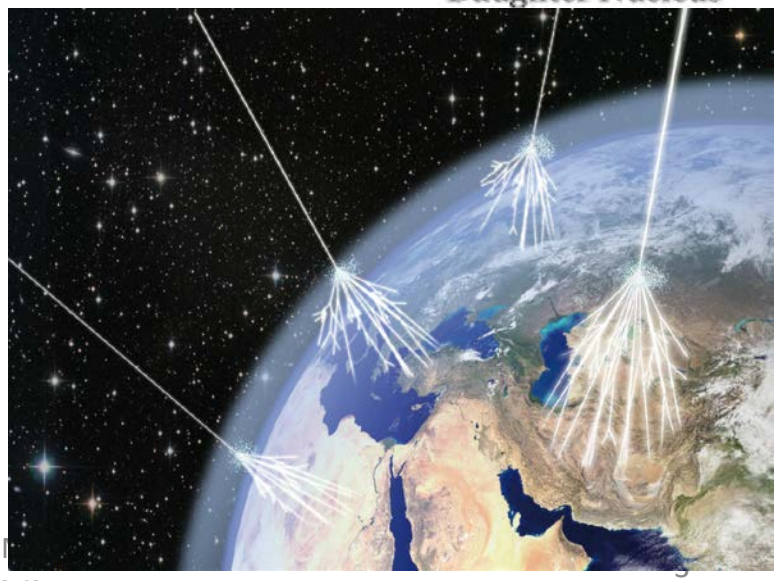
- **Radiation!** No 1 cause of accidents that create superheroes!
- Peter Parker & Spiderman
  - Bitten by radioactive spider
- Fantastic four
  - Cosmic rays
- Bruce Baner - Hulk
  - Gamma rays

Radiation

- Radioactive decays – nucleus breaks up and emits
  - Electrons and positrons
  - Alpha particles (helium)
  - Gamma rays (light)
  - Exposed at Earth



- Cosmic Rays
  - Radiation from Space
  - electrons, protons (hydrogen)
  - Gamma rays
  - Exposed in atmosphere and Space

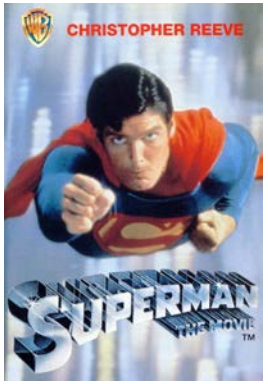


Super radiation?

- Exposure →mutations→super powers?
- Radiation damages cells and DNA, sometimes even death
- Visible, direct consequences
  - Large radiation doses
  - Burns, radiation sickness, sickness, hair loss
  - Death

- Invisible, delayed consequences
  - Damages to DNA and cells
  - Mutations – cancer, cataract, effects on future children
- **Radiation does not cause superpowers!** ☹

Superman

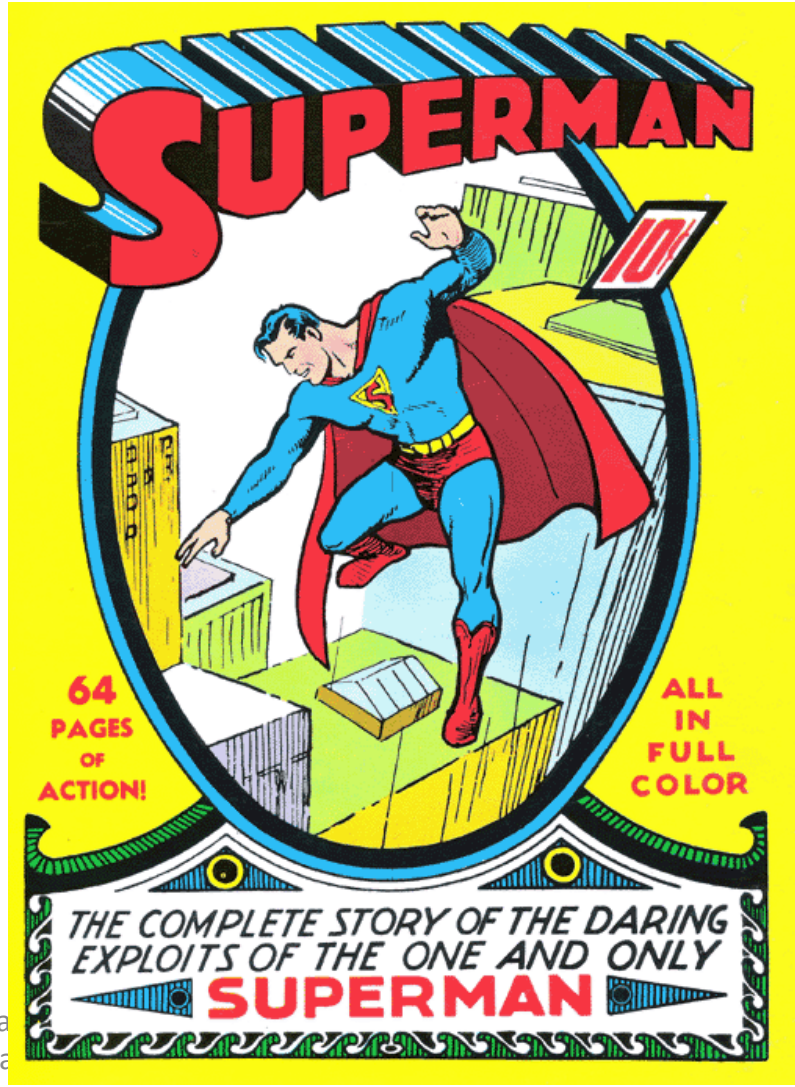


- Natural superhero!
- From other planet (Krypton)
- Super powers
  - Can fly
  - Faster than a bullet
  - Stronger than a locomotive
  - X-ray and heath vision
- Super science or super fiction?

Is it a bird? Is it a plane?

- Super power: flying
- Not possible without wings or engine...
- But original Superman could “just” jump very high
- **Explanation: gravity of planet Krypton is stronger than Earths?**

First Superman comic from 1939



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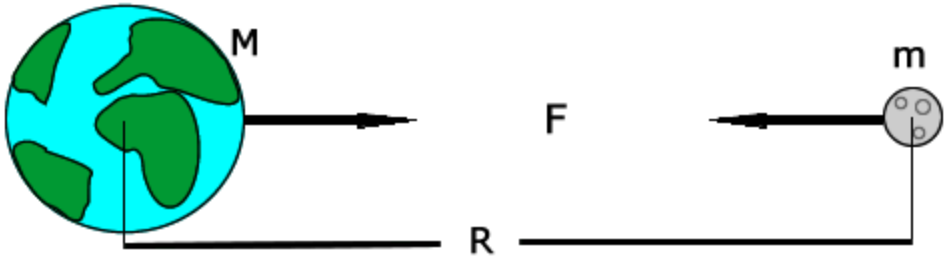
Gravity

- **Gravity** – attractive force between massive bodies
- Newtons law of gravity:

$$F = G\frac{Mm}{R^2}$$

F – force of gravity
M – mass of the first body
m – mass of the second body
R – distance between bodies
G – gravitational constant

Force is stronger for more massive and closer bodies



Gravity and Weight

- **Weight** = **force of gravity** between a body and an object it stands on

  Weight is larger on more massive and smaller objects (planets, satellites etc.)

$$F = G\frac{M}{R^2}m$$

- **Weight changes, but not mass (without a diet)!**

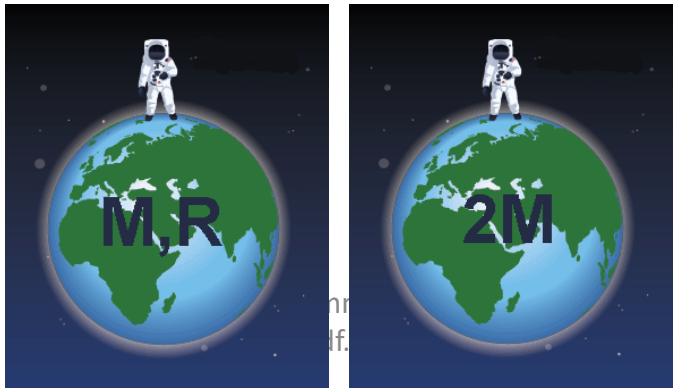
Gravity and Weight

- **Weight** = **force of gravity** between a body and an object it stands on

  Weight is larger on more massive and smaller objects (planets, satellites etc.)

$$F = G\frac{2M}{R^2}m$$

- 100 kg on Earth
  - On a planet twice as massive as Earth = 200 kg



Gravity and Weight

- **Weight** = **force of gravity** between a body and an object it stands on

  Weight is larger on more massive and smaller objects (planets, satellites etc.)

$$F = G\frac{M}{(2R)^2}m$$

- 100 kg on Earth
  - On a planet twice as large as Earth

    = 25 kg

Gravity and Weight

- **Weight** = **force of gravity** between a body and an object it stands on

  Weight is larger on more massive and smaller objects (planets, satellites etc.)

$$F = G\frac{M/100}{(R/4)^2}m$$

- 100 kg on Earth =
  - On Moon (1/4 radius of Earth
    1/100 Earths mass) = 16 kg

Gravitational acceleration

- **Gravitational acceleration** – tells about the strenght of gravity on a body

$$g = G\frac{M}{R^2} = \frac{F}{m}$$

F – force of gravity
M – mass of the first body
m – mass of the second body
R – distance between bodies
G – gravitational constant

- **Same for all objects around that body**
  - A feather and a hammer will fall at the same time!

Apollo 15

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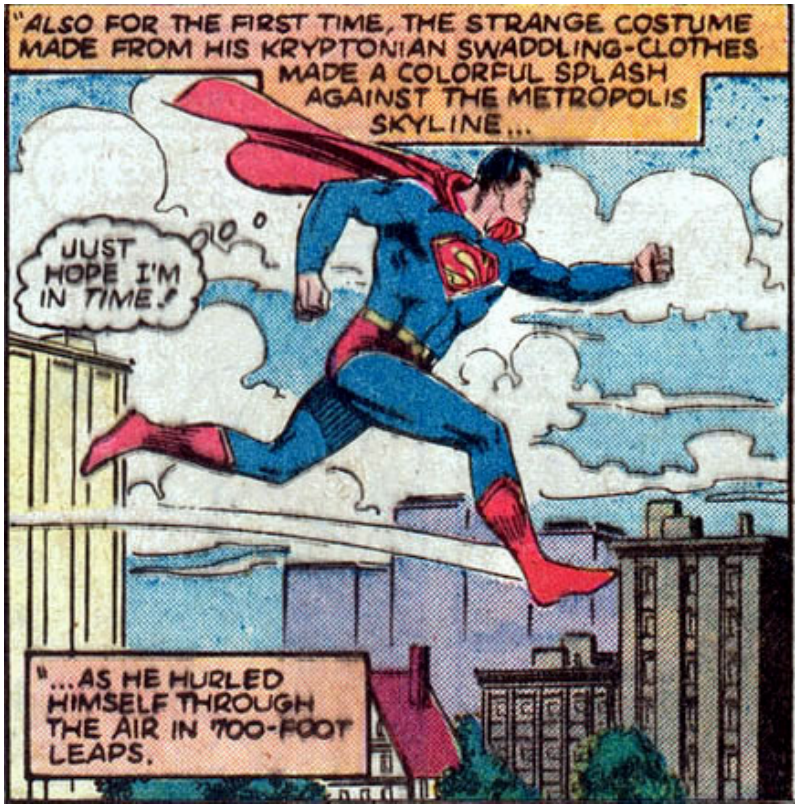
Superman and gravity

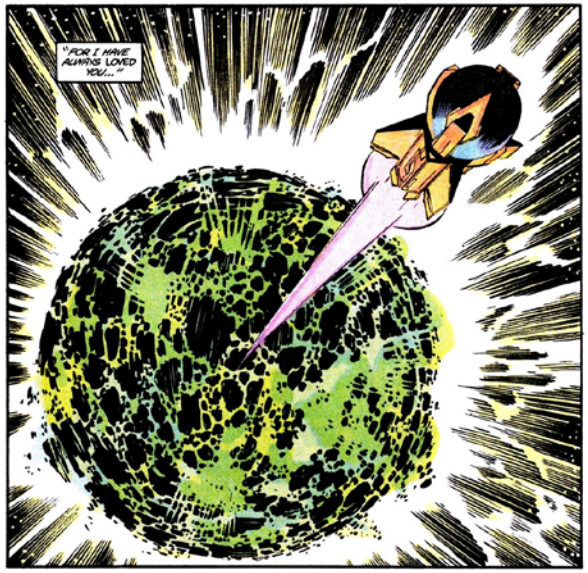
- Our muscles used to Earth
- Superman's muscles used to Krypton
- Superman jumped more than 200m in height!
- How big should Krypton be for that to be possible?



Jump on Krypton

- Stronger the grav. Acceleration of Krypton is the higher would Superman jump on Earth

$$\frac{g_K}{g_Z} = \frac{R_K}{R_Z} = \frac{\text{height of jump on Earth}}{\text{height of jump on Krypton}}$$



- Superman on Krypton like Rožle Prezelj jumps 2,32 m
- For Superman to jump 232m on Earth

Krypton must be 100 times larger than Earth!

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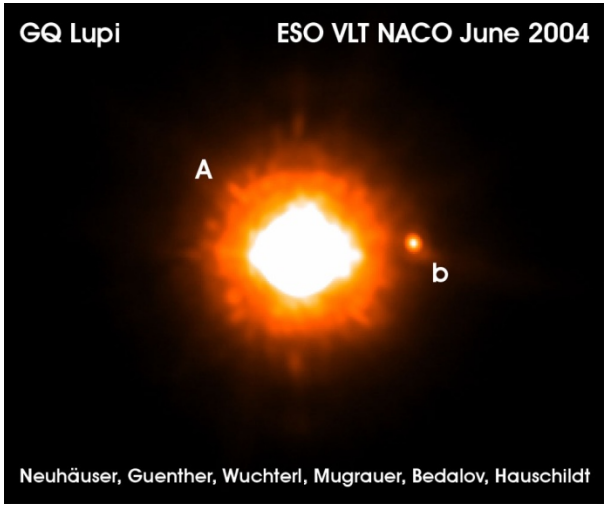
Planet Krypton = Flying/jumping?

- Planet Krypton at least 100 times larger than Earth so mass is 1.000.000 times greater!
- "New" Superman jumps/flys even more = Krypton even bigger!
- **Planet Krypton al large as Sun!!** ☹
- Not a planet but a star
- Largest found (and possible) planet 10 times more massive than Earth!

Real planet “Krypton”?

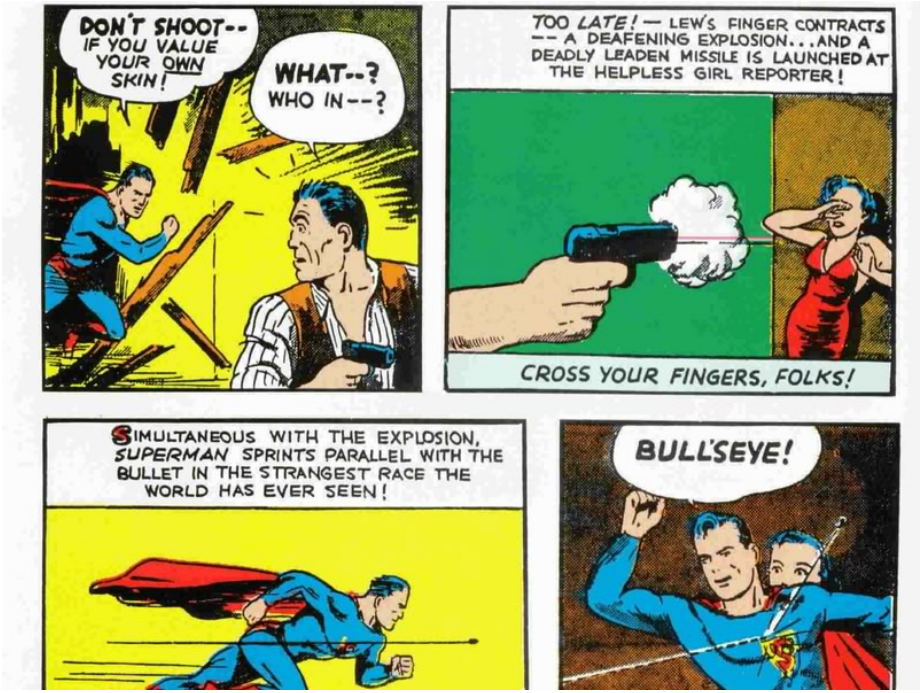
http://planetquest.jpl.nasa.gov

- If Krypton was like the biggest “super Earth”-type planet Kepler 103-b
  - 10 times more massive than Earth
  - 2 times greater radius
  - Would jump only twice higher so about 5m ☹
- If Krypton was like the densest planet found “PSR J1719-1438 b”
  - Mass 330 times greater
  - Radius 4 times greater
  - Would jump 20 times higher about 50m ☺



Faster than a bullet!?

- Bullet speed:
  v~1000 m/s
- 100m sprint record:
  Usein Bolt 9,58 sec
  v~10 m/s
- Superman 100 times faster than Usein Bolt!?



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Speed and energy

- How much we spend on 10 km?
- (my) car uses ~ 1 litar
- Usein Bolt (94 kg) uses by running ~ 1100 calories
  - like 5 pljeskavica's of 100g
  - Like 2 chocolates of 100g
- Superman uses ~ 11.000.000 calories when running!
  - like 50.000 pljeskavica's!
  - like 20.000 chocolades!
- **Needs too much energy ☹**

Fitness Facts Calories burned per 1 hour	
Exercise	**Amount**
Running	**560**
Jogging	**490**
Walking	**245**
Bicycling	**420**

Estimated amount of expended, calories based on example body weight of 155 lbs.

Power of "Yellow Sun"

- But!
- Superman gets energy from Sun
- Sun lights every m^2 as 14 100W light bulbs!
- Superman would need to sunbathe for 12h to get energy that he needs for running
  - If he absorbs energy 6 times better solar panels...

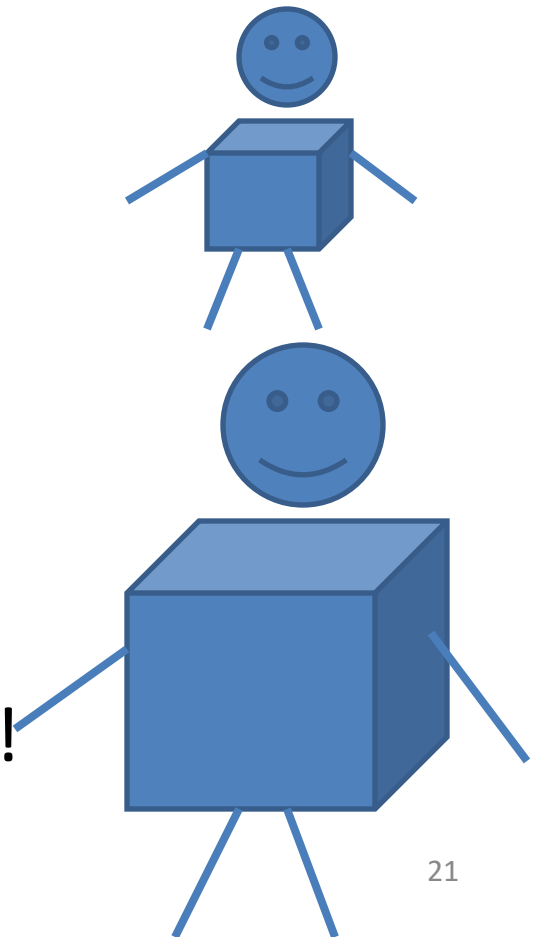
Stronger than locomotive!?

- Like dung beetle!
  - Strongest creature in nature
  - lifts 1000x its weight!
  - as Superman lifting 6 full busses!

Onthophagus taurus

Bigger is weaker??

- Strenght vs mass
  - Dung beetle can lift largest weight compared to its mass
- Mass = volume
- Strength = surface (muscles)
- Duble the size =
  - 8x larger mass
  - 4x larger strength
- Larger organisms have less strength!



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Superman as dung beetle?

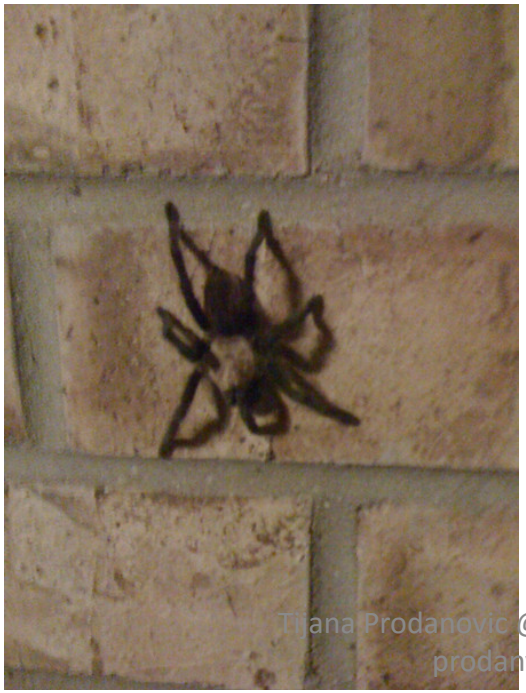
- Dung Beetle (from Earth)
  - Mass 100g (depends on its lunch)
  - length L~3cm
  - strength/mass ~ 1/L~1/3
- Superman
  - 180 cm tall (60x larger than dung beet
  - **60x weaker than dung beetle**
  - **Must be 60x less massive (less dense)**
  - **Or must have 60x stronger muscles**
    - If Krypton was the densest planet PSR J1719-1438 b, he would have 20x stronger muscles

Spiderman

- Accidental Superhero
  - Bitten by radioactive spider
- Powers of Peter Parker
  - genius
  - “super geek”
  - inventor (net thrower)
- Super powers
  - Climbs walls
  - Super strength
  - 6th sense
- Super science or super fiction?

Wall climbing

- Not all spiders!
  - Predator spiders
  - E.g. tarantula



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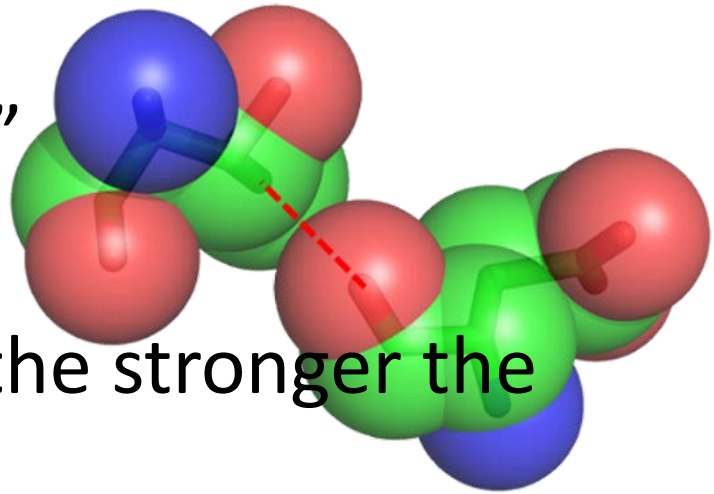
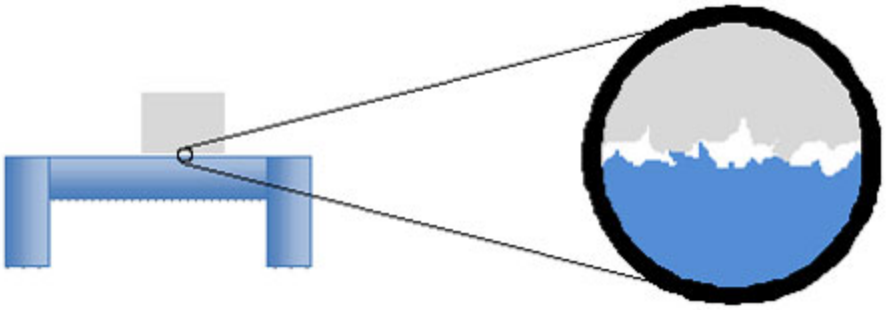
“Sticking to walls”

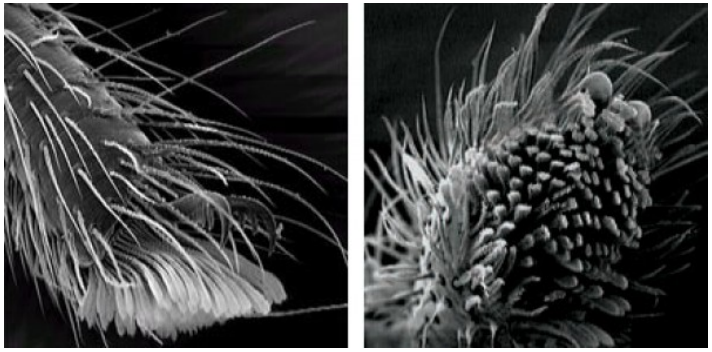


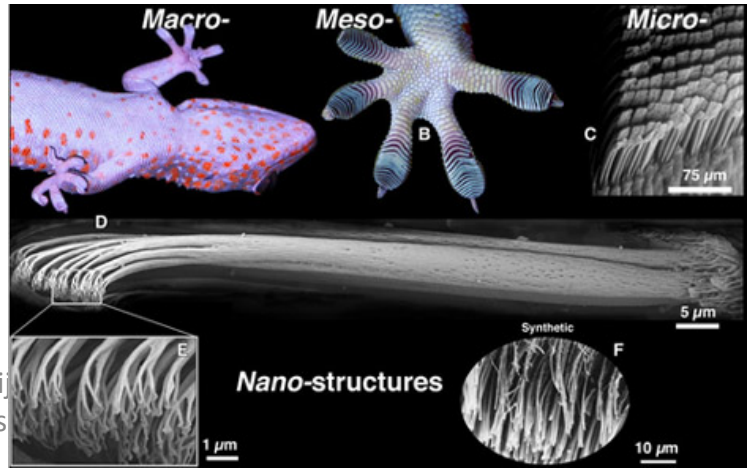
- Molecules attract and “stick”
  - Van der Vaals force
- The larger the contact area the stronger the “sticking” is
- But things not smooth – molecules are far away



“Brush” climbing

- A brush goes into cracks!
- Hairs on feet for clinging
  - Every hair has thousands of micro filaments
  - strong clinging
- More hairs better sticking
  - 170 times their weight
- Geckos and spiders!





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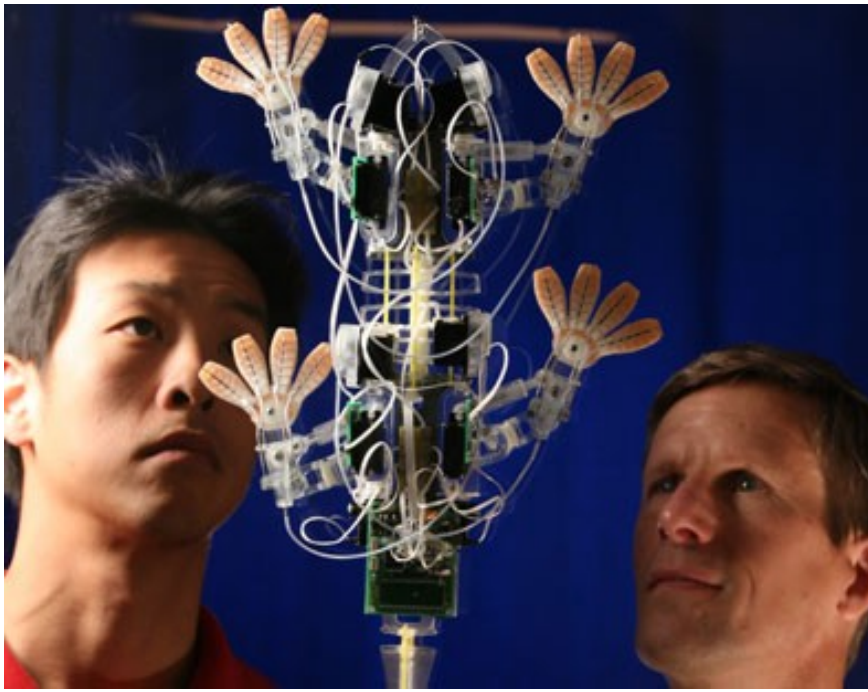
Super climbing?

- **Possible!** ☺
- Gloves with many hairs that super cling
- Synthetic nano materials that cling very strong



Stickybot sa Stanforda

Super climbing

- … but only for geckoes ☹
- New studies of scientists from Cambridge show – man would have to wear spider shoes of size 145!

Super possible - Super (im)possible

- Super trength possibe but body has to be less dense
- Climbing walls possible but only for small organisms

- Creating superpowers with radiation and mutations
- Flying
  - No engine
- Jumping over buildings
  - No such planet
- Faster than bullet
  - Uses too much energy

The only thing we can do is…

- Become super geeks
- …like Bruce Wayne or Kickass ☺

Super hvala! ☺