Mike Lockwood

RAS President, University of Reading

Diversity & Inclusion: Why they are Essential

NAM, Durham 2025

Special Thanks To The Durham NAM LoC

- It's been a wonderful NAM: I've loved the community theme and the enthusiasm
- Real action not just words
- Paintings and poems in Ogden Center were inspirational
- and the PULSE dance troupe of TiN charity were simply sensational

Special Thanks To Professor Kevin Fong, OBE

- contributed the inspiration, information & ideas to this talk
- consultant in anaesthesia & intensive care at UCLH
- co-founder and co-director, Centre for Aviation, Space and Extreme Environment Medicine, UCL
- professor of Innovation & Engagement for Science & Medicine
- broadcaster and author
- pilots an air ambulance for Kent, Surrey & Sussex Helicopter Emergency Medical Service

Special Thanks To Professor Kevin Fong, OBE

- at major incidents need a diverse team to solve the many urgent problems
- need inclusion as team members need to feel enabled to act on their own initiative
- diversity and inclusion saves many lives
- diversity and inclusion are not just the right & decent policies – they work and are often essential

Diversity & Inclusion: Why they are Essential

1. Scientists, Discrimination & Dogma

2. Nuns & Neuroplasticity

3. Astronauts & Decision-Making

Diversity & Inclusion: Why they are Essential

1. Scientists, Discrimination & Dogma

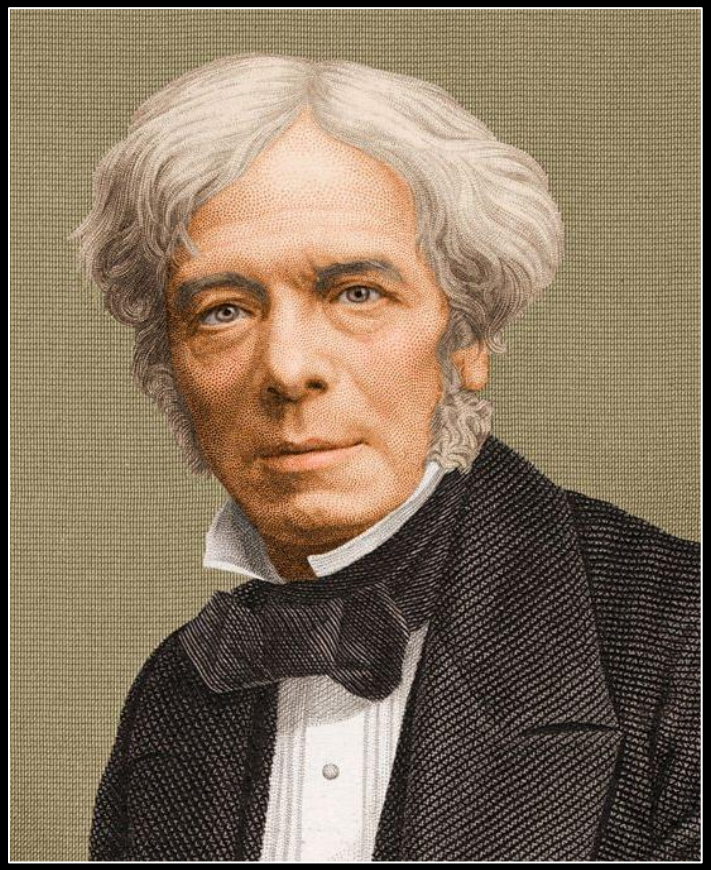
scientific genius can, has, does and will come from absolutely anywhere

2. Nuns & Neuroplasticity

3. Astronauts & Decision-Making

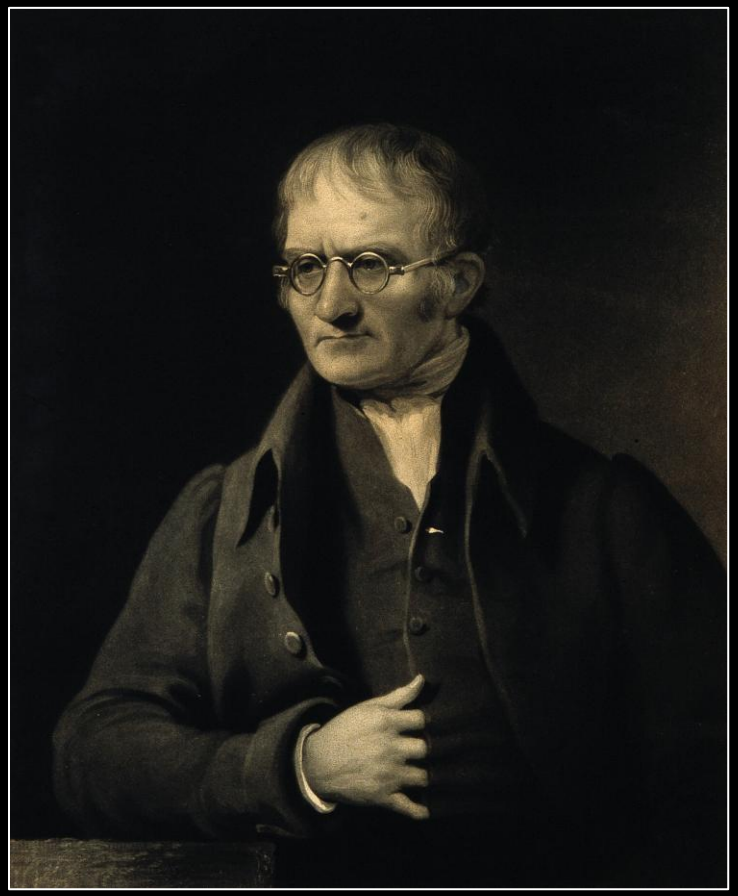
For Every Type Of Discrimination
There Are Truly Great Scientists
Who We Very Nearly Lost To
That Discrimination

Class Discrimination: Michael Faraday



- a blacksmith's son
- Employed by Humphry Davy as a valet and to perform demonstrations
- the founder of electro-magnetism, had as much influence on science as Newton or Einstein
- pioneer of public engagement
- paused work on electro-magnetism for 8 years because of personal attacks from his former mentor Davy brought on by jealousy and feeling Faraday was "acting above his station in life"

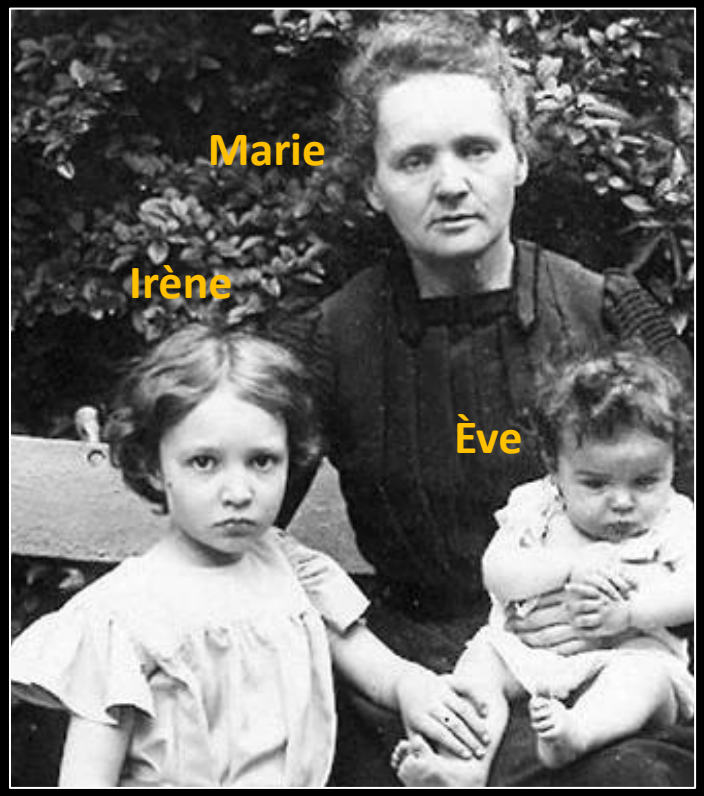
Religious Discrimination: John Dalton



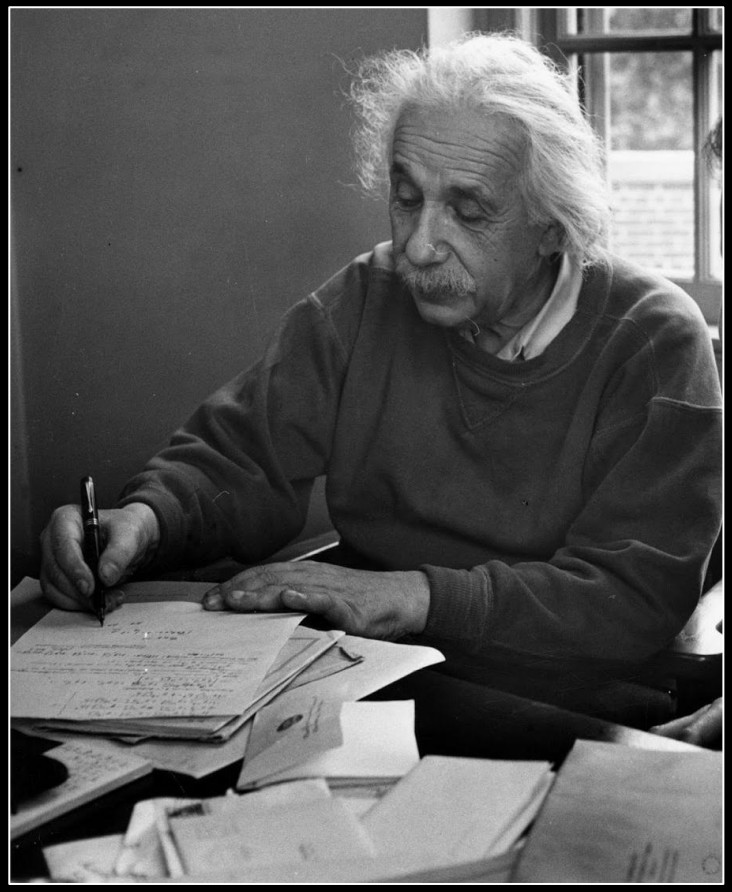
- A Quaker (“Dissenter”)
- Barred from UK Universities
- Ran his own dissenter school (he gave latin lessons at age 12!)
- Father of atomic theory, first to study colour blindness, seminal work on Meteorology, gas laws, aurora, & grand solar minimum
- Initially declined his FRS as could not afford the subscription
- died in poverty, living in a friend’s attic in Manchester

Gender Discrimination: Marie Curie

- Born Maria Skłodowska in Warsaw, Poland
  - first female Nobel Laureate
  - One of only 2 winners of different Nobel Prizes
  - Her & Irène Joliot-Curie are the only mother-daughter pair to win Nobel Prizes
  - With Irene, Marie funded & operated mobile X-ray units that saved thousands of lives in WW1
  - Marie died age **66,** Irène died age 56: both from X-ray exposure

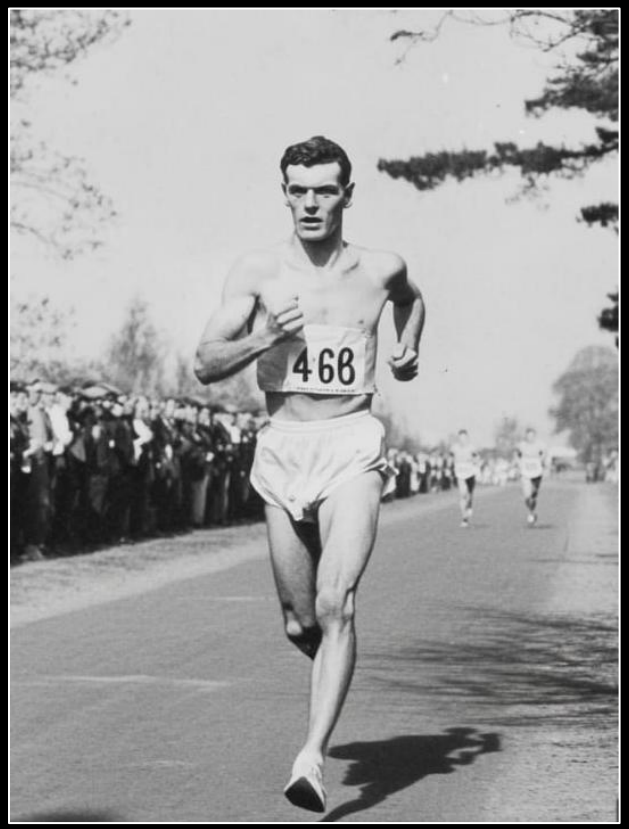


Antisemitism: Albert Einstein



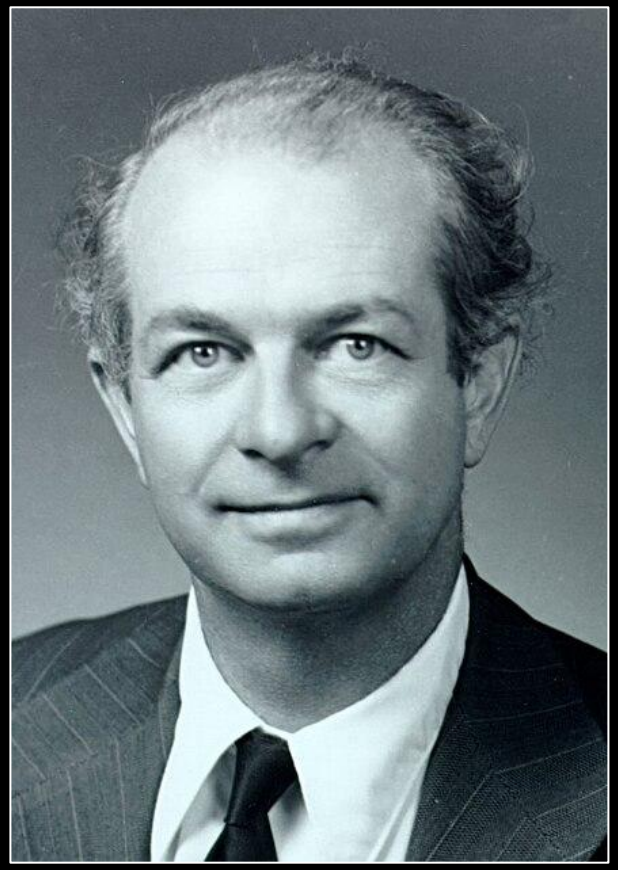
- Relativity (special & general), spacetime, photelectric effect, Brownian motion .....
- His astounding achievements were denounced in NAZI newspapers and rallies (by e.g. Stark and Lennard) as “Jewish Physics” amid calls for “Ayrian Physics” (!)
- Arguably the greatest & most famous scientist of all time

Sexuality Discrimination: Alan Turing



- WW2 codebreaking genius
- developed the Turing machine concept on which modern computers are based & the "Turing test" of computers (passed by AI)
- Founded mathematical biology
- Committed suicide (?) in 1954 suffering from depression induced by chemical castration – chosen to avoid prison on charges of homosexuality which was illegal at the time

Economic Discrimination: Linus Pauling



- Father died in 1910 when he was 9 & his mother struggled to fund his education
- Founder of fields of molecular biology & quantum chemistry
- Developed the theory of molecular bonding
- Only man to win 2 different Nobel prizes (the peace prize for studies of radioactivity in milk led to nuclear test ban treaty)
- Often rated as one of the top 20 scientists of all time (despite his vitamin-C obsession in late life)

Ethnic Discrimination: Srinivasa Ramanujan

- born in 1887 in Erode, India
- Age 2 almost died of smallpox
- A child prodigy by age 11
- despite extreme poverty, his mother employed a maths tutor who returned the money saying the boy was teaching him
- Arguably the greatest mathematician of all time: derived 3,900 ground-breaking relations
- died in Cambridge, UK aged 32, suffering from malnutrition and diet problems of the kind seen in many diasporas around the world

Disability Discrimination: Stephen Hawking

Stephen Hawking: gravitational singularity theory, prediction that black holes emit 'Hawking radiation'

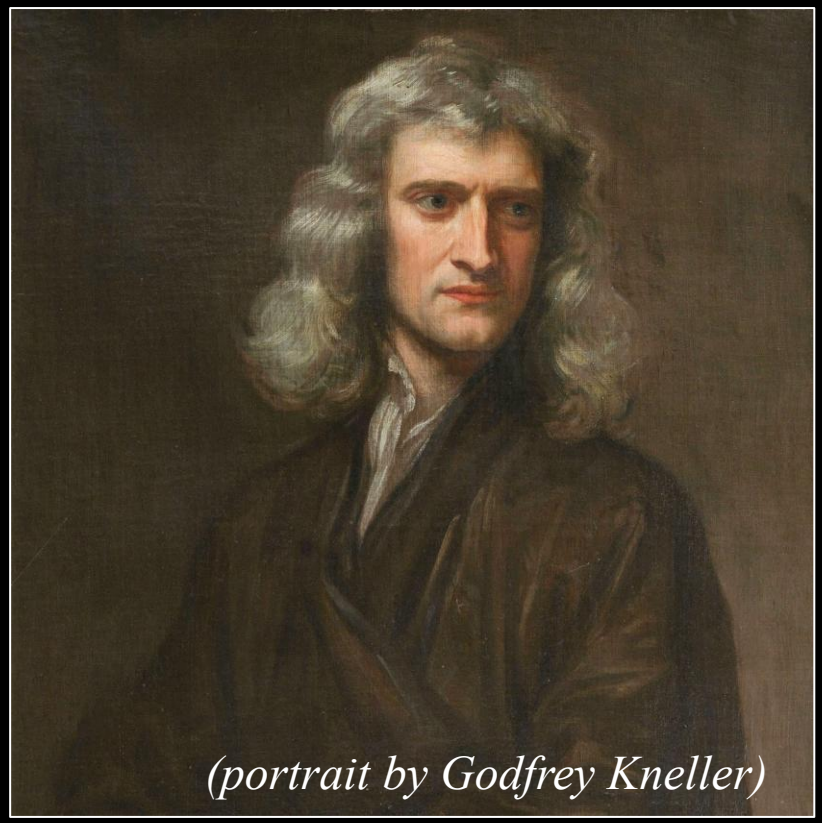
Transgender Discrimination: Lynn Conway & Ben Barres

Ben Barres: discovered how 'glial' cells influence neuron development, synapse formation, and brain health, transforming neuroscience's understanding of brain circuitry ▶

◀ Lynn Conway: revolutionised microchip design with Very Large-Scale Integration (VLSI)

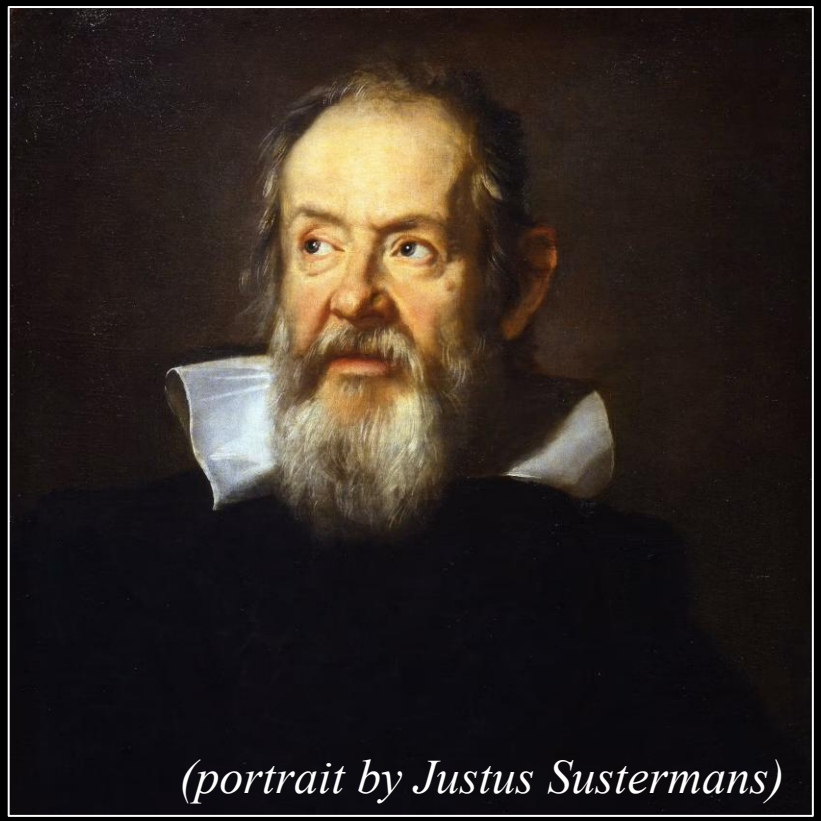
Age Discrimination: Isaac Newton & Galileo Galilei

- Basis for his best work done in his early 20's (during plague "lockdown")



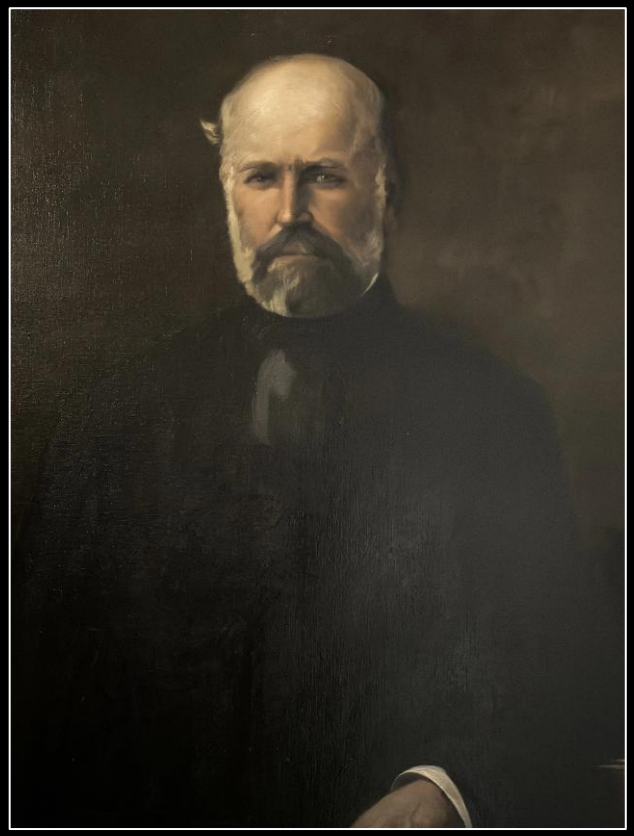
(portrait by Godfrey Kneller)

- Best work done in his 70's (under house arrest)



(portrait by Justus Sustermans)

Dogma Discrimination: Ignaz Semmelweiss

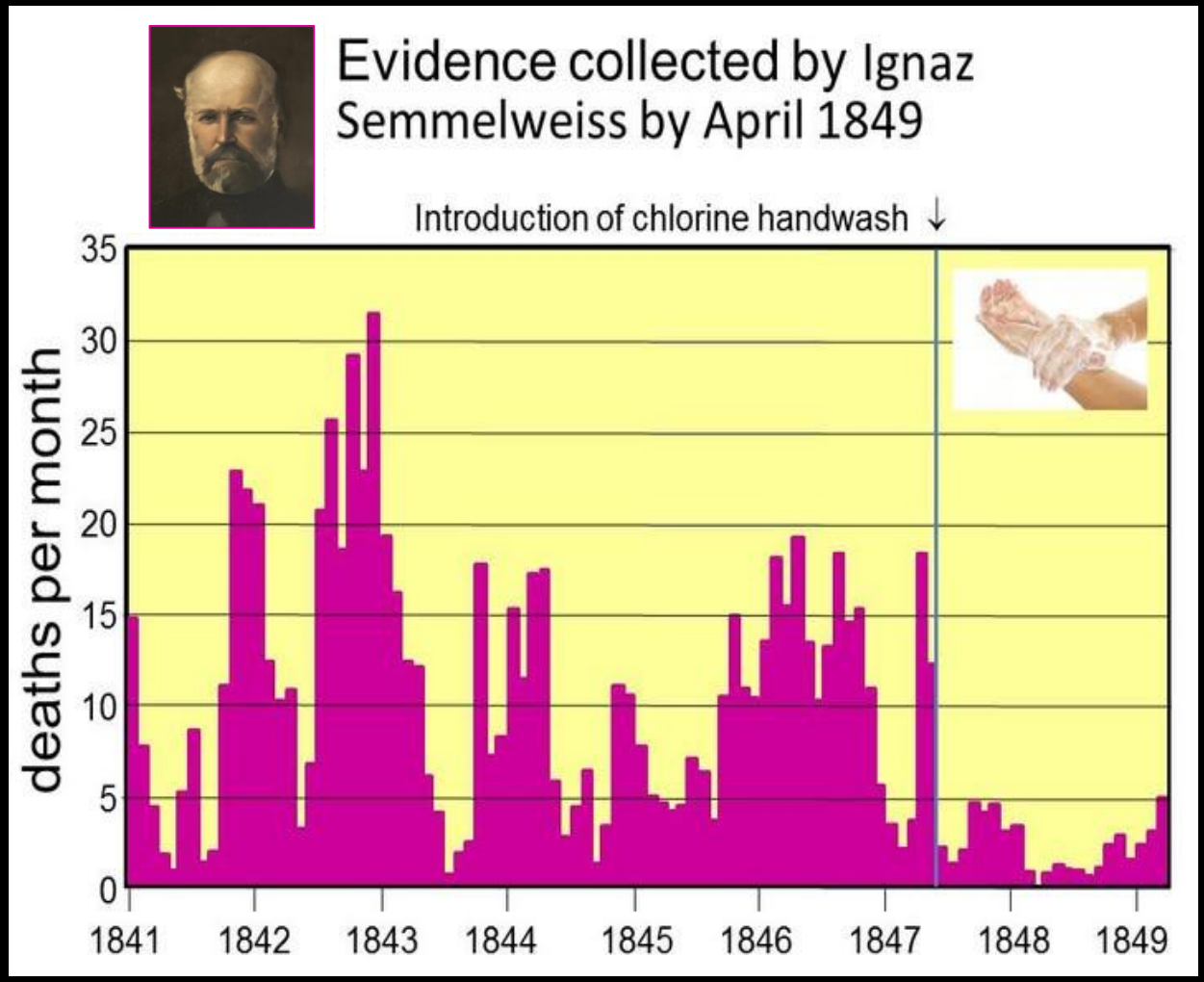


(portrait by Louis Jambor)

- Hungarian-born Medic
- Worked in maternity clinics of the Vienna General Hospital
- Noted that death rate of women was 3 times higher if attended by doctors rather than midwives. Also that doctors went straight to natal clinic from dissection studies without washing their hands
- in 1847, a colleague cut himself while dissecting, and soon after died with symptoms shown by many of the the women who died

Dogma Discrimination: Ignaz Semmelweiss

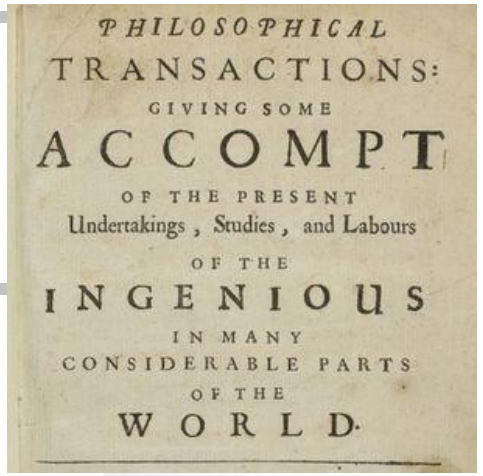
- realised that fever was caused by an infectious agent ("germ theory" - later proved by Pasteur in 1880) & so he insisted that all doctors wash their hands in chlorinated lime before entering the maternity clinic



Dogma Discrimination: Ignaz Semmelweiss

- knew handwashing saved lives
- tried to persuade others but his idea was contrary to dyscrasia (evidence-devoid dogma that disease caused by imbalance of the "four humours" in the body, generally "treated" by bloodletting
- had a nervous breakdown in 1865 & was committed to an asylum
- died 2 weeks later from injuries inflicted by the asylum guards
- handwashing introduced 30 years later by Joseph Lister at Glasgow Royal Infirmary

How science expunges errors & bad ideas: peer review

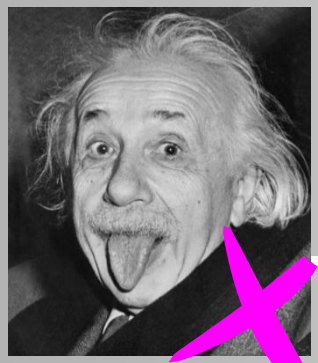

PHILOSOPHICAL
TRANSACTIONS:
GIVING SOME
ACCOMPT
OF THE PRESENT
Undertakings, Studies, and Labours
OF THE
INGENIOUS
IN MANY
CONSIDERABLE PARTS
OF THE
WORLD.

- Peer review is Britain's single greatest contribution to science - bar none!

- first introduced in 1665 by German immigrant, Henry (formerly Heinrich) Oldenburg, the founding Editor of *Philosophical Transactions of the Royal Society*

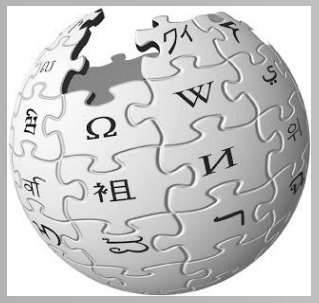
- formal peer-review procedures as we know them today, developed from his ideas by Sir Francis Bacon & applied to *Medical Essays and Observations* published by the Royal Society of Edinburgh in 1731.

- It is how science forms a consensus



Science Consensus

sʌɪəns kən ˈsɛnsəs
(compound noun)

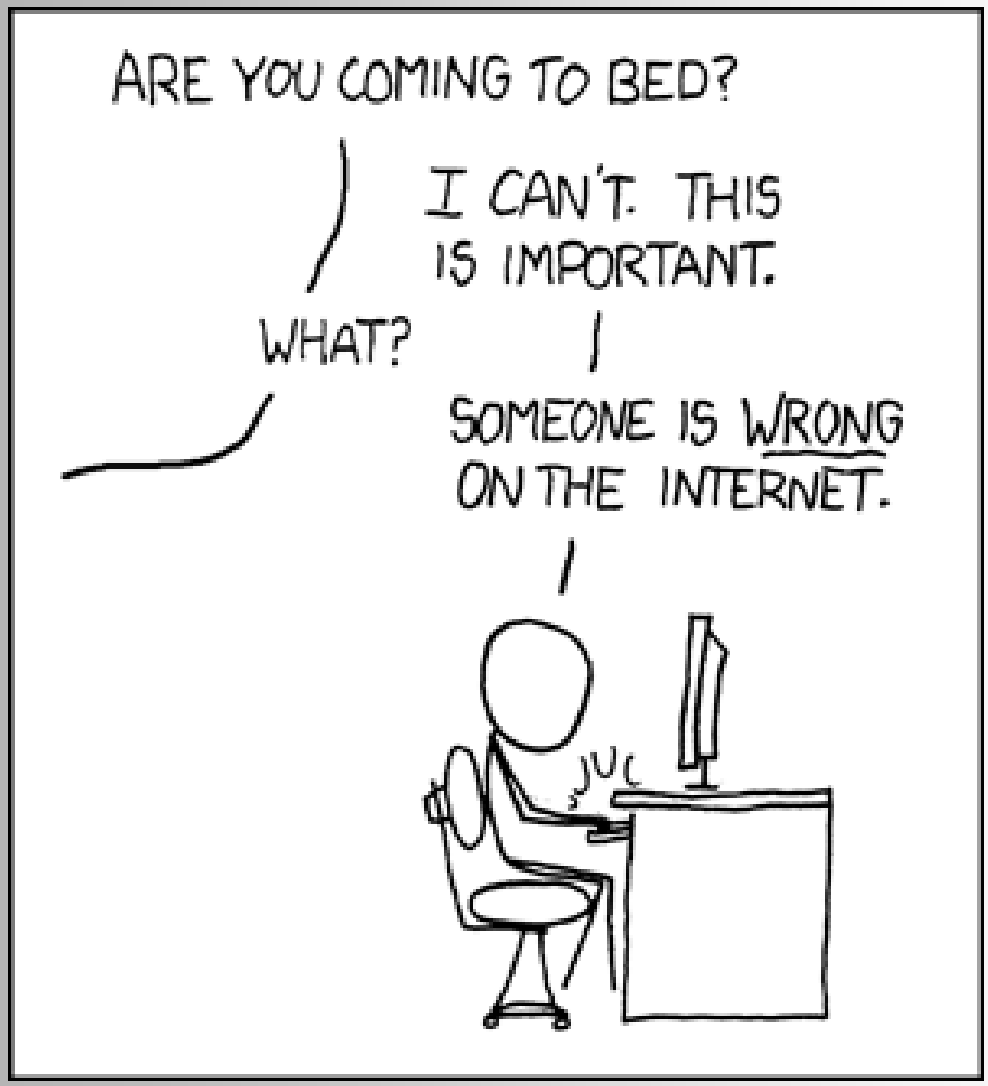


- Wikipedia: “the collective judgment, position, and opinion of the community of scientists in a particular field of study. Consensus implies general agreement, though not necessarily unanimity”

- Peer review is slow, inefficient and makes mistakes – but attacks on it are often promoted by pressure groups with a vested interest in undermining a science consensus

The solar science community at the STEREO-3/SOHO-22 Workshop: “Three Eyes on the Sun: Multi-spacecraft studies of the corona and impacts on the heliosphere” Bournemouth, UK April/May 2009

Peer review avoids the information “wild west” we now have on the internet



- As famously observed by xkcd (Randall Munroe)

“Duty Calls”
1st December 2011

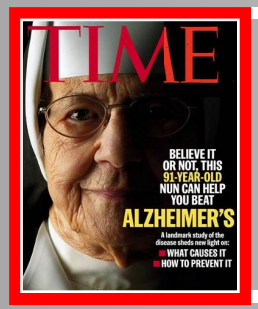
Diversity & Inclusion: Why they are Essential

1. Scientists, Discrimination & Dogma

2. Nuns & Neuroplasticity

What influences how we think and diversity of thought?

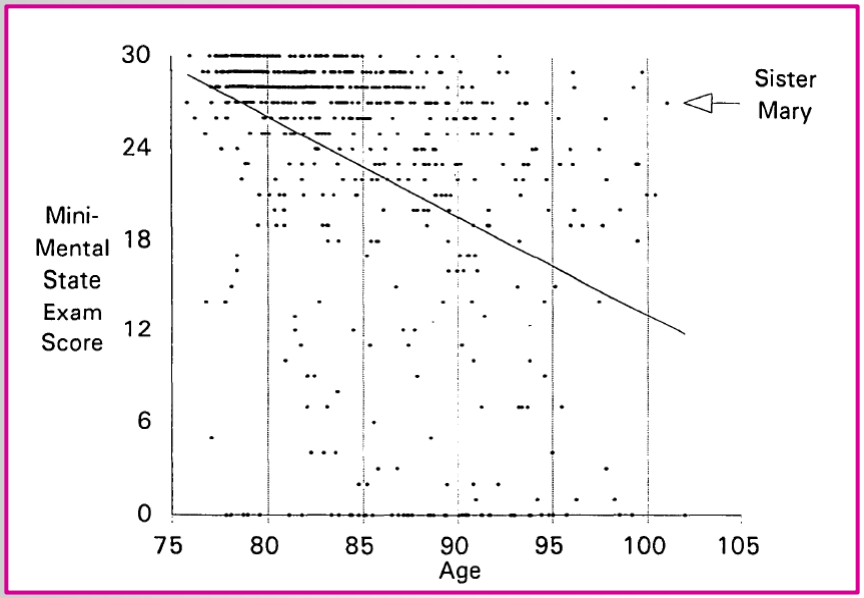
3. Astronauts & Decision-Making



The Nun Study

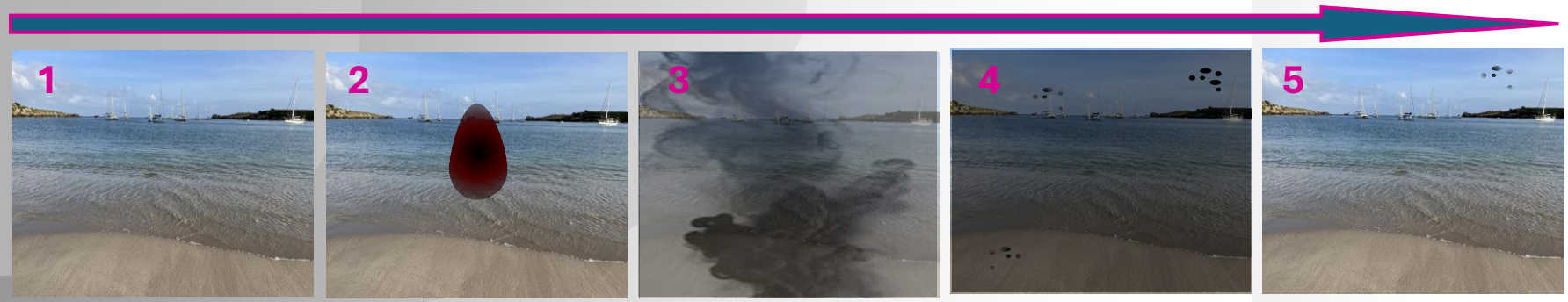
David A. Snowdon (1997)

- started in 1982 and still ongoing
- Nuns have similar lifestyles, diets and life experiences
- started with 687 women who did a variety of cognitive tests
- sister Mary was 101 , 4.5 ft. tall weighed 6 stone (38.5 kg), was sharp, knowledgeable with a fantastic memory
- after her death it was found she had one of the most highly damaged brains



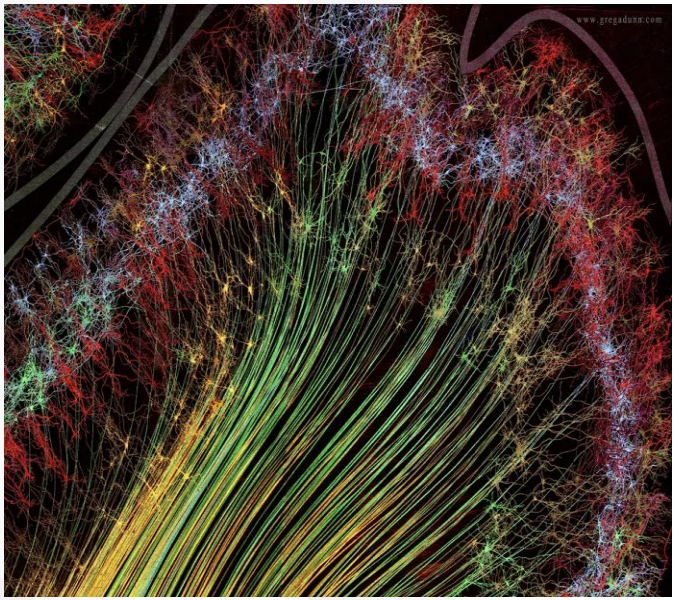
An Example of Neuroplasticity

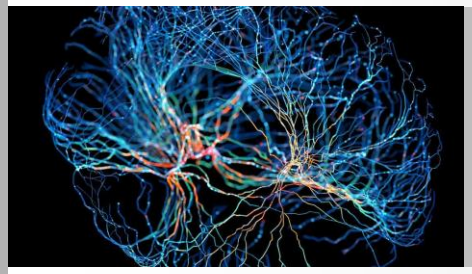
Recovering from a PVD



▲ Posterior Vitreous Detachment (PVD) in my right eye

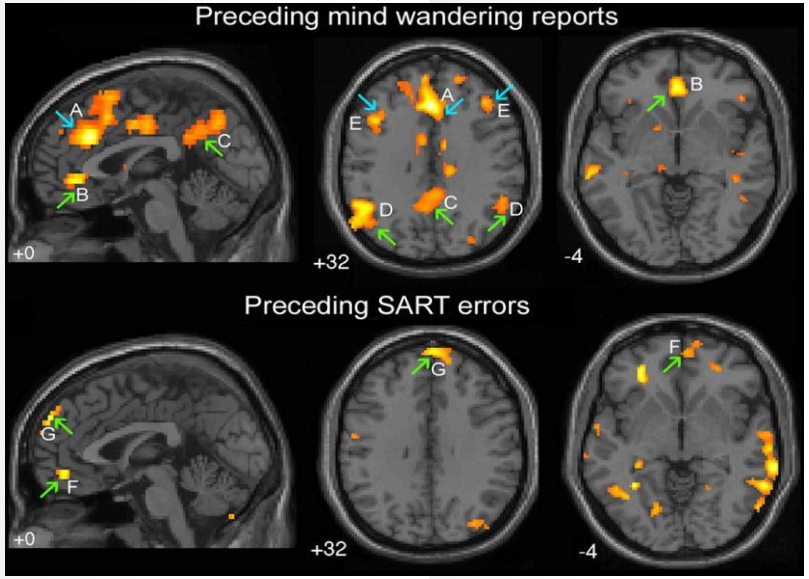
- A PVD is a small bleed at the back of the eye when the retina pulls away from a blood vessel
- Everything turned black in that eye as the blood mixed with the vitreous fluid (steps 1 → 4)
- This largely cleared over the next few weeks (step 4 → 5) as blood is removed from eye but more because the brain-image processing changes to correct for the optical effect of the remaining blood
- To do this my brain had developed new neural pathways in the parietal-gyrus (right) the major sensory processing hub. It combines information from multiple senses into a usable form.



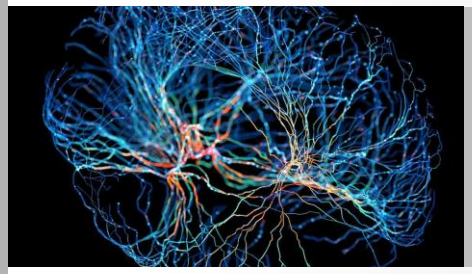


Imagination & Neuroplasticity

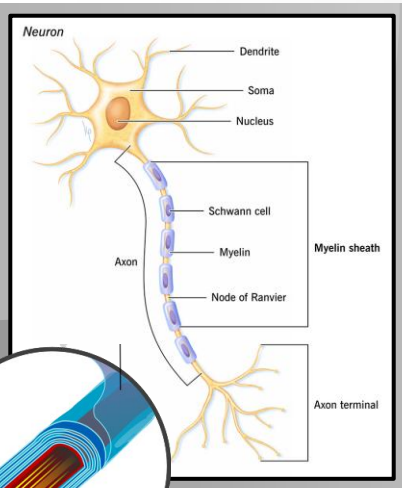
- The Nun Study found that women who had written creatively in early life were more likely to be able to use neuroplasticity to ward off dementia symptoms

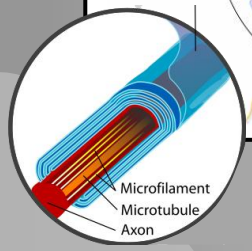


- MRI Scans show more of the brain is engaged during mind wandering than when concentrating of a task *(Kalina Christoff et al, PNAS, 2009, doi: 10.1073/pnas.0900234106)*
- They also show brain connectivity is enhanced by meditation *(Zongpai Zhang et al.,Sci Rep, 2021,doi: 10.1038/s41598-021-90729-y)*
- It is thought neurons that fire simultaneously stay linked
- Hence it seems neuroplasticity is promoted by creativity and inventiveness, daydreaming, dreaming, problem solving, meditation, and prayer & is inhibited by (dis)stress and boredom



Myelin & Speed of Thought



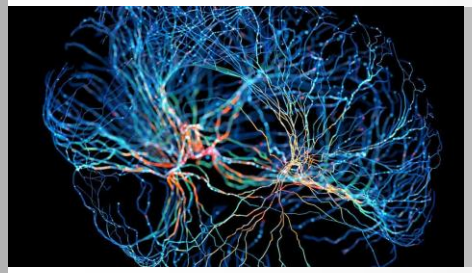


- Myelin is a protective sheath wound around neural fibres
- Largely established in infancy but can be added in later life
- Also speeds up signal transmission

- "L'esprit de l'escalier" a French expression for when you think of something just a bit too late – comes from Denis Diderot's "Paradoxe sur le comédien" (1777)

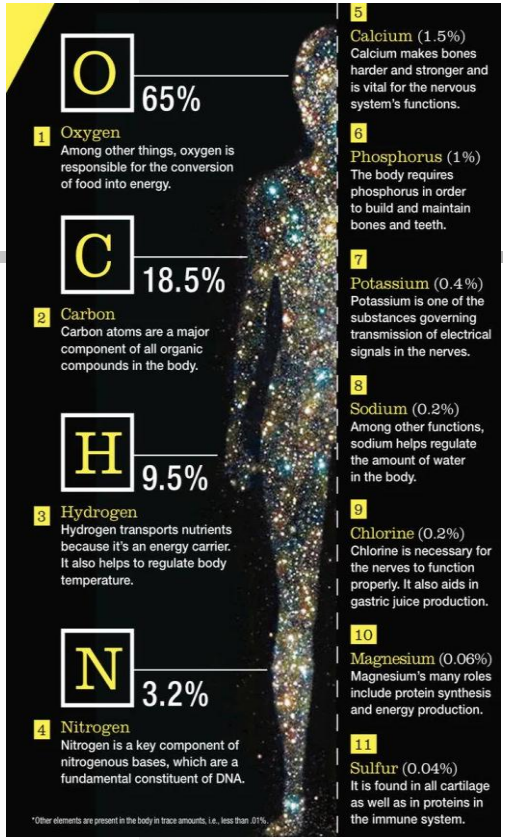
- The Germans have a word for it: "Treppenwitz" (staircase joke)

L'esprit de l'escalier – that's the expression I couldn't think of !

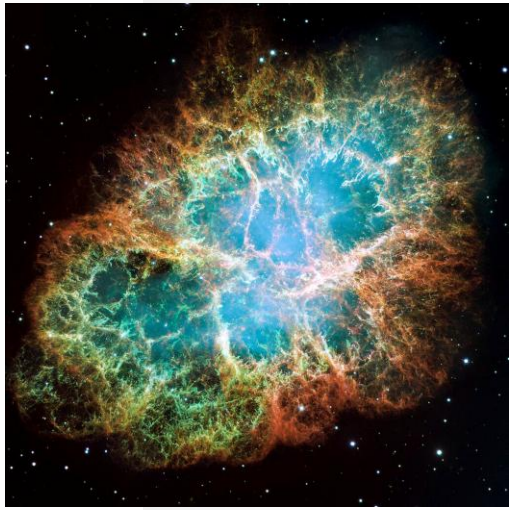


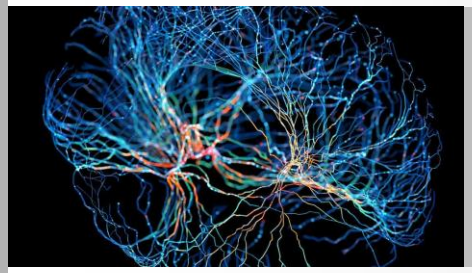
Neuroplasticity

"We are Stardust ...."



The Crab Nebula – the remnant of the 1054 supernova, which releases elements heavier than helium synthesised by the star ▶





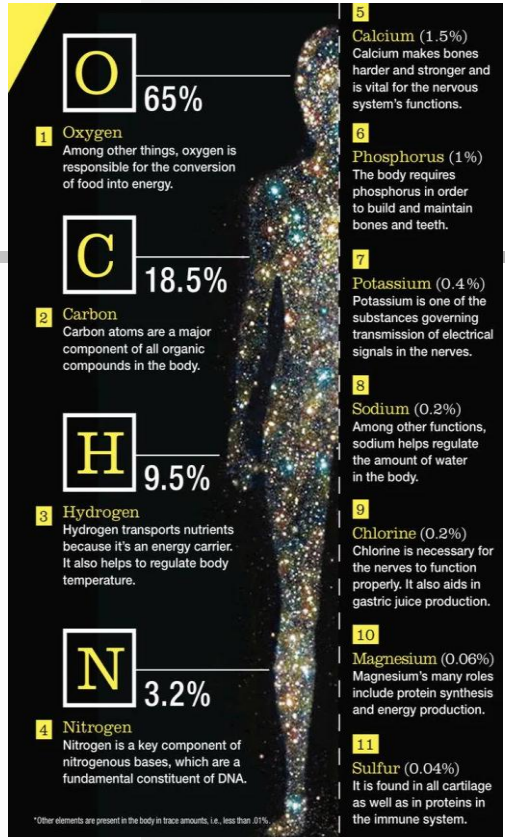
Neuroplasticity

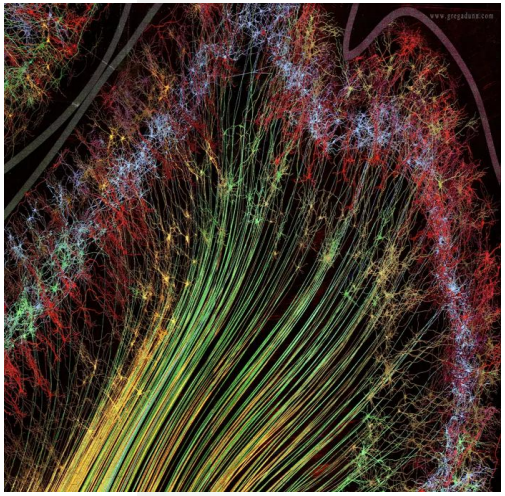
"We are Stardust ...."

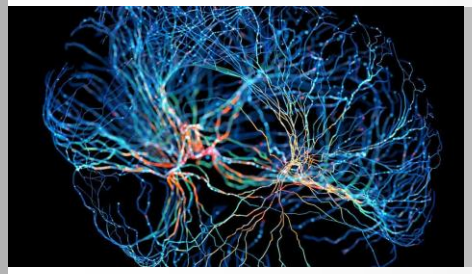
"... We are Golden"

?

Neurons and neural fibres in the parietal-gyrus of the human brain. Each neuron contains, of average, 2 atoms of gold ▶





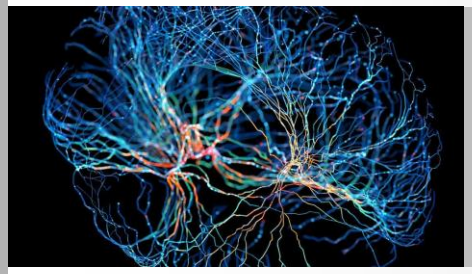


Gold, Au (Atomic number Z = 79)

Actually too heavy to be formed inside Stars - but is when stars collide or explode

- There are at least 2 gold atoms in every neuron
- On average, there are 86 billion neurons in a brain
- At present , there are 8.2 billion humans on Earth
- # gold atoms in human brains $N_G \approx 2\times8.6\times10^{10}\times8.2\times10^{9} = 1.41\times10^{24}$
- Atomic mass of gold $N_G = 196.966$ u (atomic mass units)
- 1kg of gold contains 1000/196.966 = 5.08 moles
- 1 mole contains $N_A = 6.022\times10^{23}$ atoms (Avagadro's number)
- Total mass of gold in human brains

$m_G = N_G/(5.08\times N_A)$ kg $= 1.41\times10^{24}/(5.08\times6.022\times10^{23})$ kg $= 0.5$ grams

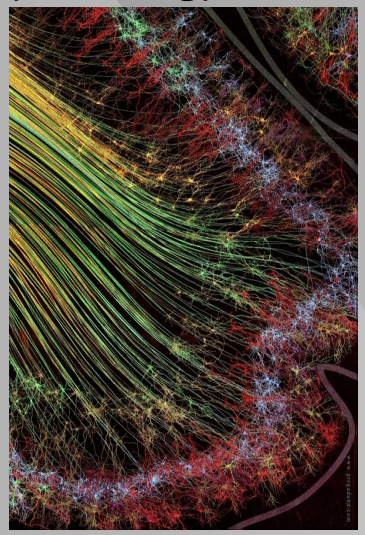


Gold, Au

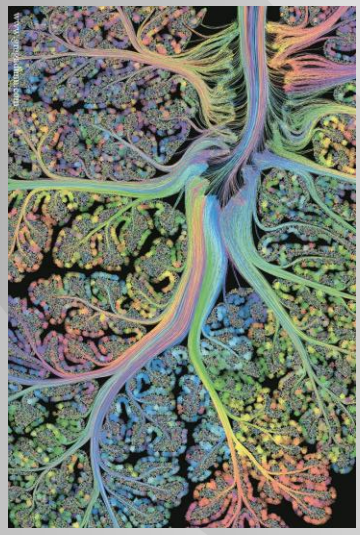
- cost of gold at today's prices = £75 g^{-1}
- value of gold in human brains = £37.50p

- Gold seems to stimulate the creation of new neurons and aid repair of damaged parts of brains in mice (e.g. Chang et al. 2021) and humans (Chiang et al., 2024)

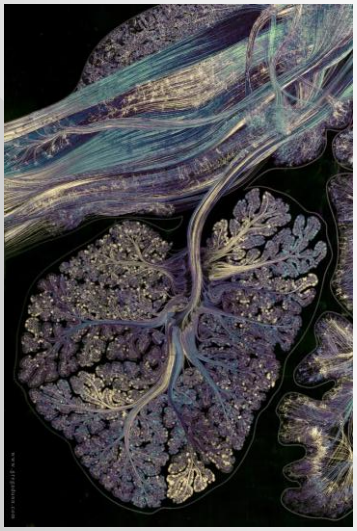
parietal-gyrus



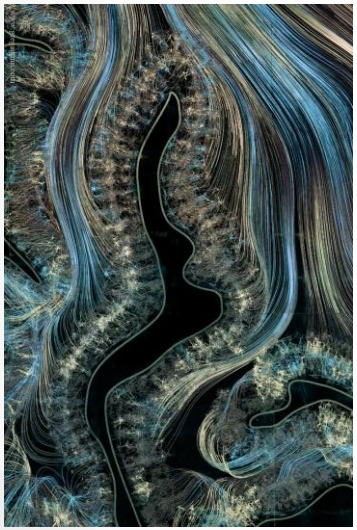
cerebella folia



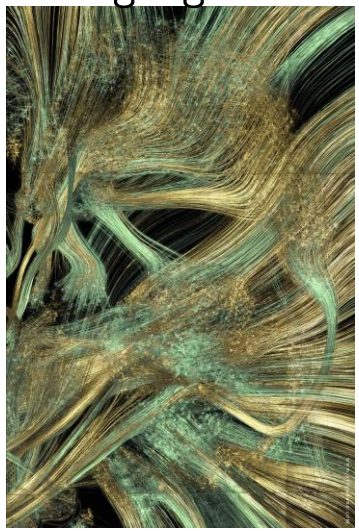
brain stem & cerebellum



visual cortex



thalmus & basal ganglia



Meaningful Neural Diversity

(a technical term for ‘diversity in neural configurations’ in neuroscience and in AI)

- Cognitive science shows people literally think in different ways and there are many factors in that diversity: ethnic, cultural, education, life experiences, diet, exercise, even which viruses have infected us in the past.

- The benefits of diversity policies ARE real as long as the implementation is real and not superficial

- Anthropologist Steven Vertovec warns against token diversity: “it becomes a marketable asset rather than a meaningful engagement with difference. For example, corporations or universities can use ‘diversity’ as a brand image without addressing structural inequalities

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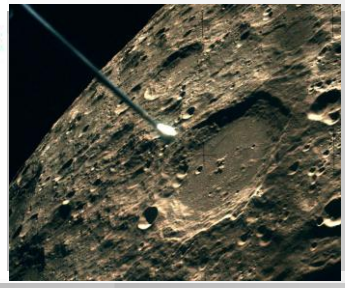
How Diversity and Inclusion were vital elements in winning the space race

Katherine Johnson, Dorothy Vaughan, Mary Jackson, & Christine Darden

- 4 hugely talented black women who became vital to NASA's manned spaceflight programme
- All Congressional Gold Medal winners
- In WW2 skills and labour shortages led to the employment of black women as "computers" for warplane design. In 1958 when NASA was formed, many transferred from NACA (National Advisory Committee for Aeronautics) to NASA
- Honourable mentions to: Kazimierz (Kaz) Czarnecki (encouraged MJ to go to court to win the right to go to night classes) & first US astronaut in orbit John Glenn (refused to fly until KJ had personally checked the re-entry orbit) calculations)

Apollo 13

- Problem after problem solved to save the lives of the three astronauts
- Loss of oxygen tank caused loss of air to breathe, water to drink and power to operate systems
- Very nearly failed – astronauts reduced to 0.17 litre a day and Fred Haise, in particular, was hours from delirium with a urinary infection when they landed
- Information and ideas provided by thousands of individuals around the globe
- All channelled through two flight directors, Eugene Kranz and Glynn Lunney
- Lunney, in particular, gave what is considered to be a true masterclass of inclusive management



Apollo 13

"welcome home"

Joe Kerwin, 18:07 UTC, April 17, 1970

(Time after explosion, dt = 3 days, 15 hours)

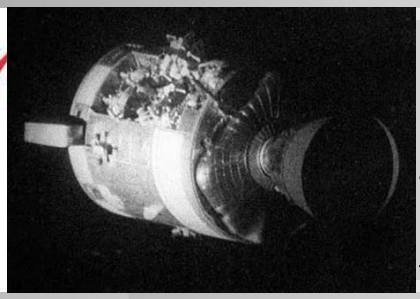
Mission Control ▲

I-to-r: Fred Haise, Jack Swigert & Jim Lovell ▼

0.17 litre of water ▼

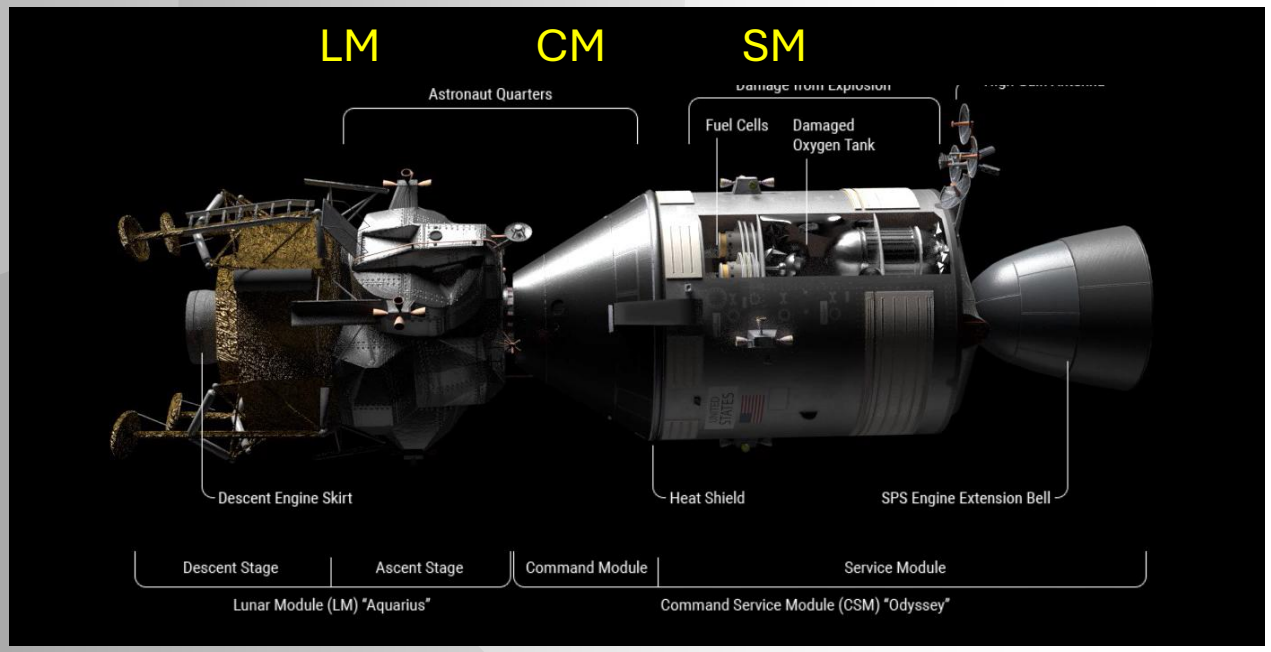
Apollo 13

"this is Houston, say again, please"
"uh, Houston, we've had a problem"
Jim Lovell, 04:08:36 UTC, April 14, 1970 (dt = 37s)



Apollo 13

"OK, Houston, we've had a problem here"
Jack Swigert, 04:08:20 UTC, April 14, 1970 (dt = 21s)



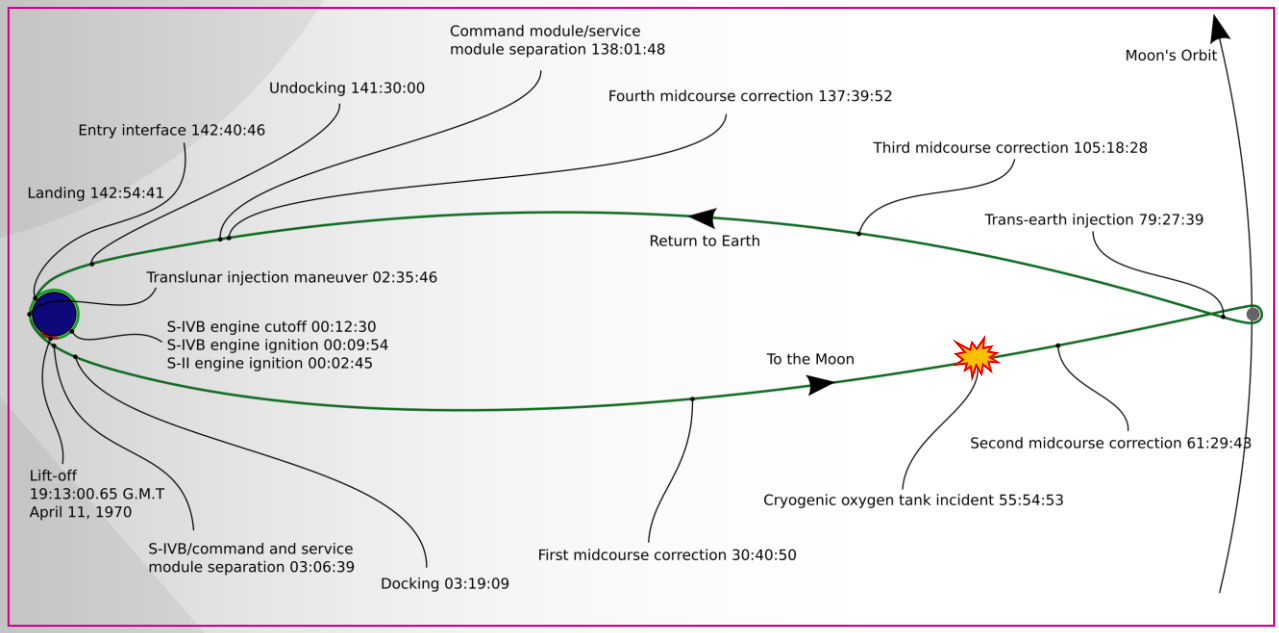
- problems start 2 months before launch when Service Module (SM) of "Odyssey" is accidentally dropped by 2cm
- wiring damage in oxygen tank made worse when too much current passed through it in a test
- 04:07:59 UTC (mission time 55:56:59, dt = 0) tank explodes when wiring used in routine operation, damages pipe to other tank with loss of all CM/SM oxygen
- O2 needed for energy & water as well as breathing

Apollo 13

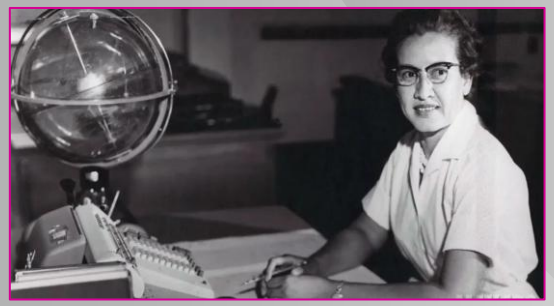
"Whatever planning you do, I 'wanna do assuming that we're going around the Moon and we're using the LM"

Gene Kranz, 04:03 UTC, April 14, (dt = 56min.)

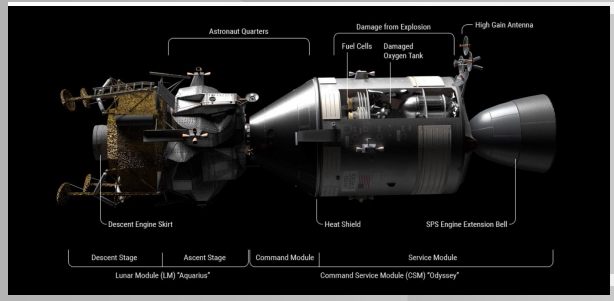
Mission control chiefs Cristopher Columbus Kraft & Eugene Kranz wisely chose the swing round the moon option rather than the direct return option ▶



Calculations for re-entry done by Katherine Johnson in 3 days rather then the usual 3 months. She also devised an emergency "3 star" navigation method that the astronauts used in the LM ▼



In Australia, Parkes telescope director John Bolton heard of accident in real time and instantly knew they would be needed: mobilised Australian tracking and comms. network ▶



Apollo 13

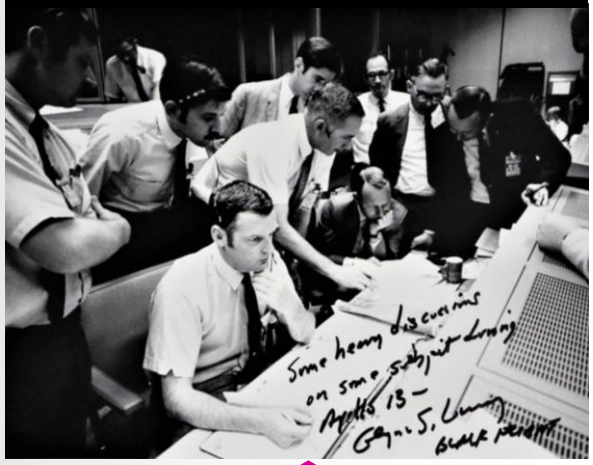
"It's obvious we'll have to fire up the lunar module to make it a safe lifeboat for the crew"

Merlin Merritt (TELMU) April 17, 1970

White Team, flight director
Eugene Kranz

handover as scheduled, just dt = 1.2 hours after explosion

Black Team, flight director
Glynn Lunney

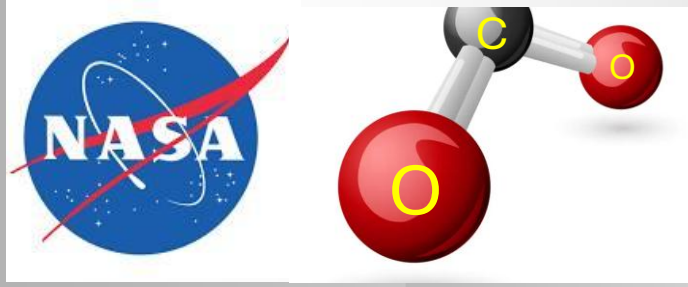


Mission control Team TELMU = Telemetry, Electrical, and EVA Mobility Unit (Officer)

His involvement demonstrates vital role played by INCLUSION

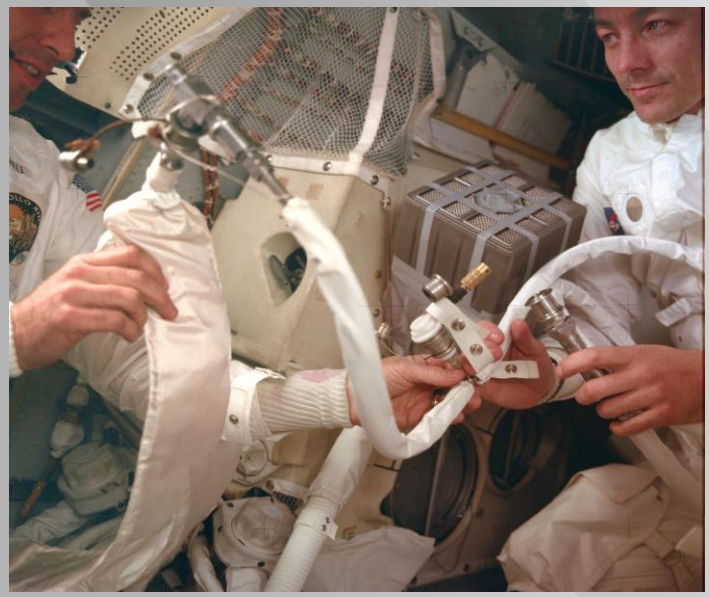
1. MM lobbies GL (off comms) to get the LM powered up immediately. GL agrees: a vital call as CM power loss is fast & not slowing

2. 2hrs later MM lobbies GL (again off comms) to shut down the LM guidance system to save cooling water & GL waits 'till backup system confirmed as viable and then agrees – another vital good call



Apollo 13

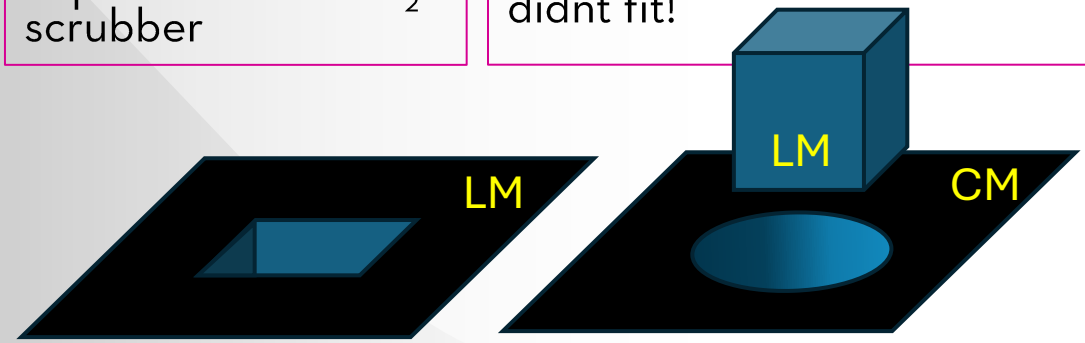
The CO_2 problem solved:
another triumph of diversity and inclusion



◀ Improvised connector to put square canisters into round holes devised by Ed Smylie with a team of 60, using only spare items known to be on board and tested by astronaut T… England, giv… instructions …e ‘phone

◀ Swigert & Lovell on board with their improvised LM CO_2 scrubber

- CO_2 build up in LM threatened the astronauts’ cognitive abilities and, unchecked, their lives
- CO_2 “scrubbers” used canisters of Lithium Hydroxide
- limited supply of LM canisters but had many CM ones
- but LM and CM made by different contractors and LM canisters were square and CM ones were round and didnt fit!



Mike Lockwood

THANK YOU FOR LISTENING