Nuclear Physics Outreach

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What is outreach?

What is Outreach?

Public engagement describes the myriad of ways in which the activity and benefits of research can be shared with the public.

Engagement is by definition a two-way process, involving interaction and listening, with the goal of generating mutual benefit.

Is outreach the same as public engagement?

For example...

- **Presentations** and talks for the public
- Interactive discussion formats eg **public debate**
- Working with the **media**, eg writing for the non-specialist, broadcast, social media
- **Exhibition stands** at festivals or events
- **Workshops** and interactive activities
- **Online** and **in-person** courses
- **Dialogue** exploring the future direction of a particular research topic or **collaborative co-inquiry** research, eg with the public involved in shaping the research question, design and delivery as co-researchers

Binding Blocks
Building the Universe one nucleus at a time

UNIVERSITY of York

Why is outreach important?

Why is outreach important?

Challenge assumptions - on both sides!

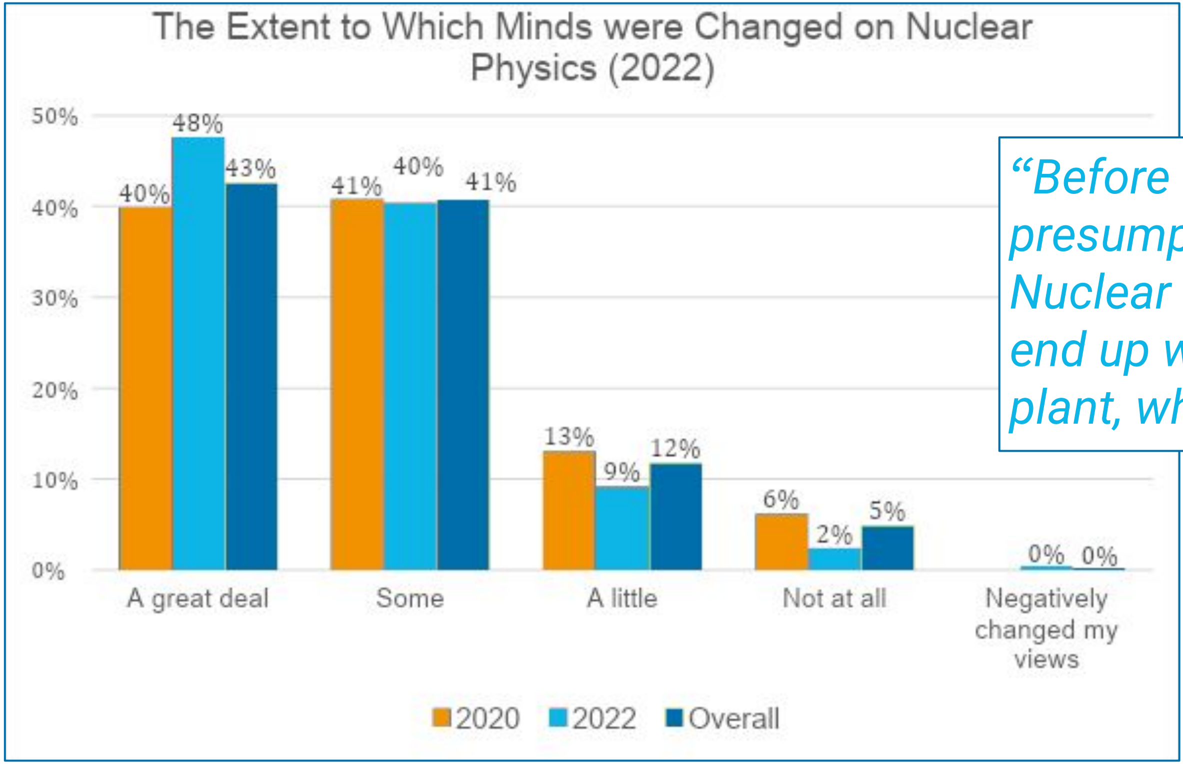
- Nuclear image has an image issue, communicating work in nuclear physics helps challenge the public's assumptions

- Easy to lose perspective on why your research matters. Discussing it with the public can help you examine your assumptions and introduce fresh perspectives

- Reignite your passion for your area - telling the public why it's interesting reminds you why it's interesting!

Vitae 2010

Impact



“Before attending, I was under the presumption that anyone who studied Nuclear Physics is most likely going to end up working in a nuclear power plant, which is definitely not the case.”

Why is outreach important?

Build trust

- Trust between the public and researchers can break down (eg over GM crops)
- Involving the public in discussions of emerging research areas can help avoid such situations
- Help researchers think through the social and ethical implications of their work
    - Nuclear power
    - Nuclear medicine
- Improve relationship between university and neighbour

Vitae 2010

Why is outreach important?

Raise aspirations

- Inspiring the next generation of students to go to university
    - And maybe consider doing nuclear physics
- Suggested 150,000 additional researchers and technicians needed

Vitae 2010, CASE 2023

Why is outreach important?

Funding

- Public funds much of the research in universities and research institutes
    - They should know how the money is being spent
- The STFC recognise the importance of public engagement and ask applicants to detail how they will do this in grant proposals
    - Offer public engagement grants - readily accessible to early career researchers
        - Spark award

Vitae 2010

Audiences

- On your flip chart paper, list as many **different audiences** that you can think of that you'd want to engage with (not just the "general public")

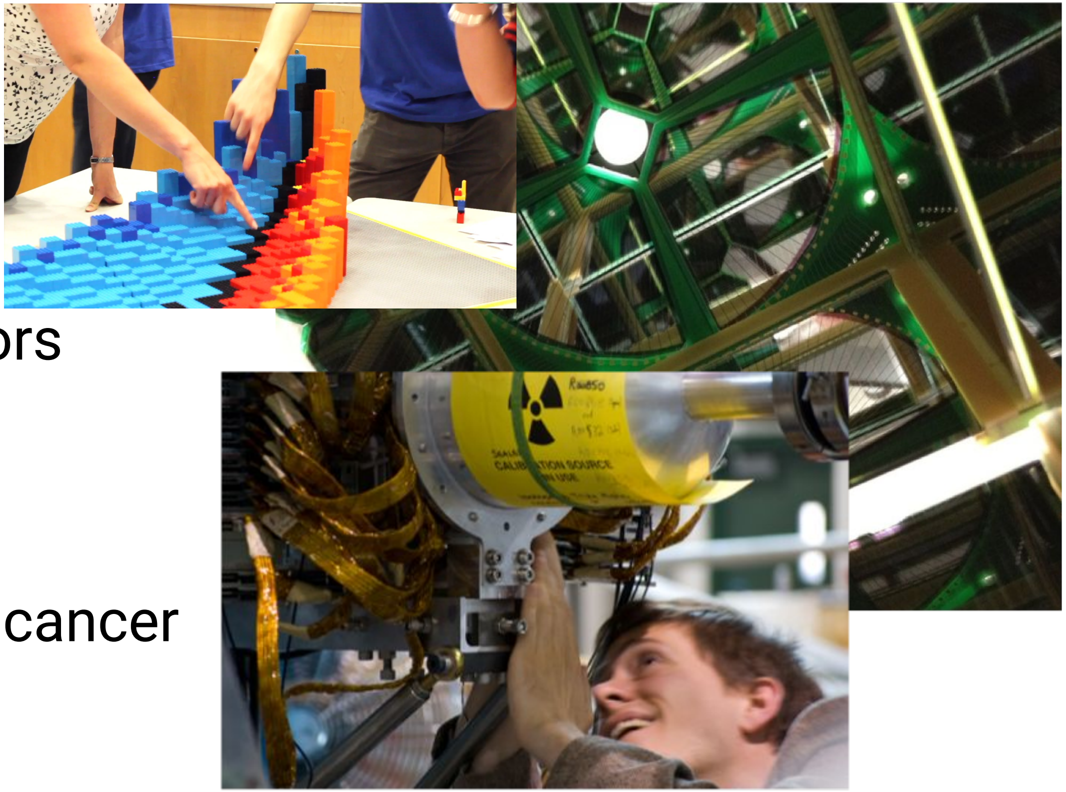
- For each audience you've written, list the **different aims** you'd want to achieve by engaging with these different groups

A little bit about research

Life as a researcher

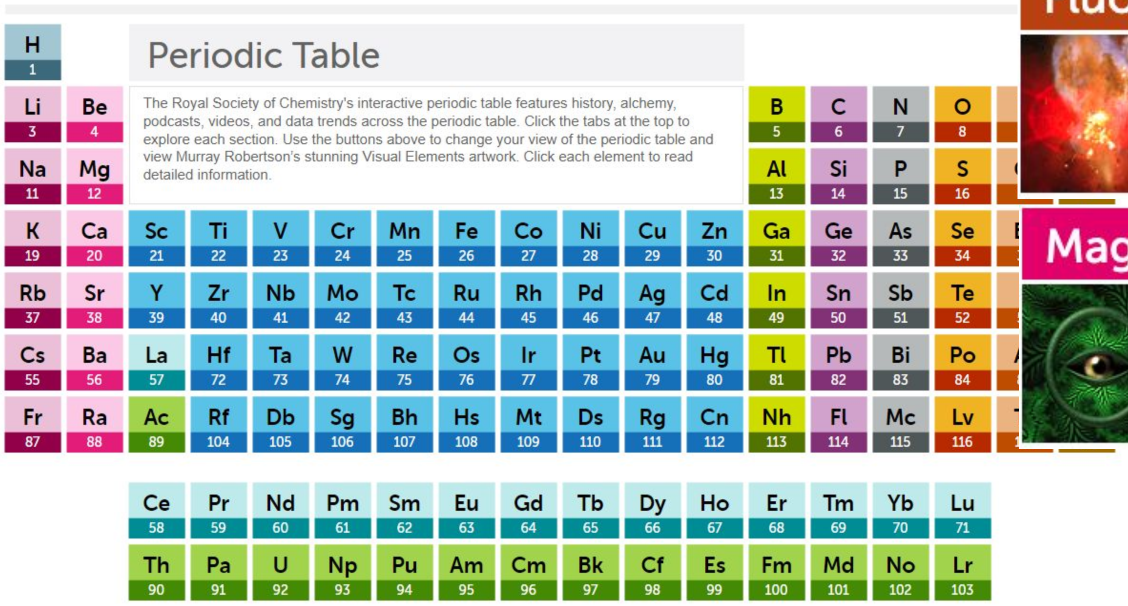
Killing stars and cancer cells

- Exploding stars:
  - Blowing up stars with nuclear reactions.
  - Recreating the same conditions in accelerators around the world
- Curing Cancer:
  - Delivering destructive radiation directly to the cancer
  - Technologies for new pharmaceuticals

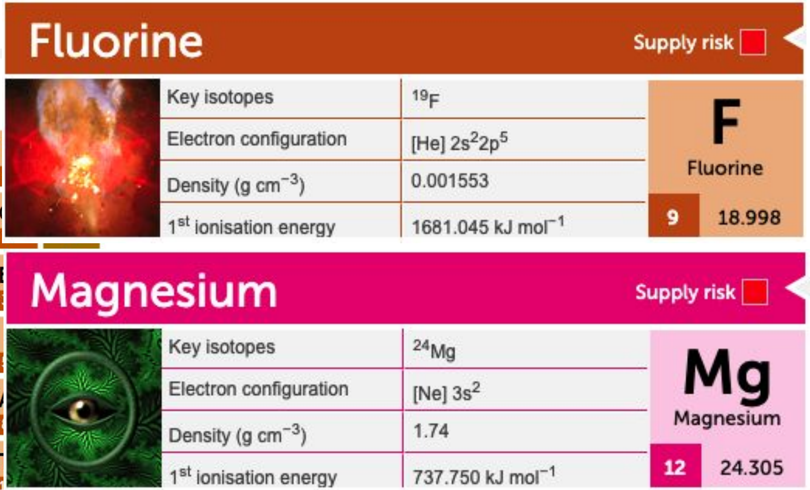


Elements and Isotopes

Nucleons (A), protons (Z), and neutrons (N)



H 1															
Li 3	Be 4											B 5	C 6	N 7	O 8
Na 11	Mg 12											Al 13	Si 14	P 15	S 16
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52
Cs 55	Ba 56	La 57	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84
Fr 87	Ra 88	Ac 89	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Ds 110	Rg 111	Cn 112	Nh 113	Fl 114	Mc 115	Lv 116
		Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
		Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103



Some elements only have a single naturally occurring isotope, some have several.

Periodic table taken from Royal Society of Chemistry. Interactive version available at: https://www.rsc.org/periodic-table

Elements and Isotopes

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Periodic Table

The Royal Society of Chemistry's interactive periodic table features history, alchemy, podcasts, videos, and data trends across the periodic table. Click the tabs at the top to explore each section. Use the buttons above to change your view of the periodic table and view Murray Robertson's stunning Visual Elements artwork. Click each element to read detailed information.

H 1																	He 2
Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
Cs 55	Ba 56	La 57	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
Fr 87	Ra 88	Ac 89	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Ds 110	Rg 111	Cn 112	Nh 113	Fl 114	Mc 115	Lv 116	Ts 117	Og 118
		Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71		
		Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103		

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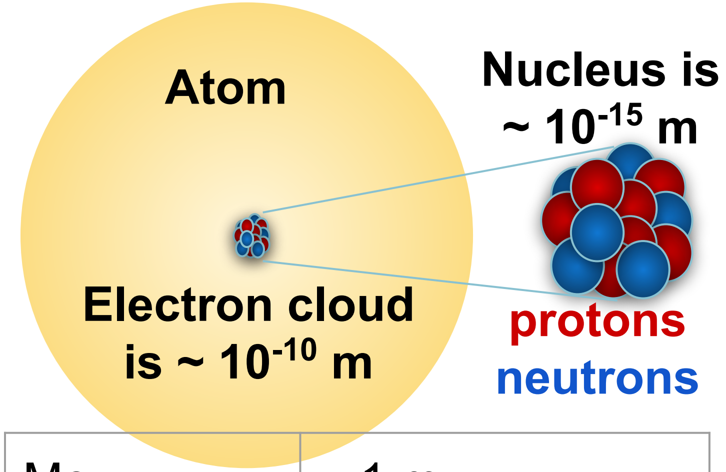

Me:	~ 1 m
Human cell:	~ 10^{-5} m (10 μm)
Atom:	~ 10^{-10} m (Å)
Nucleus:	~ 10^{-15} m (fm)

Elements and Isotopes

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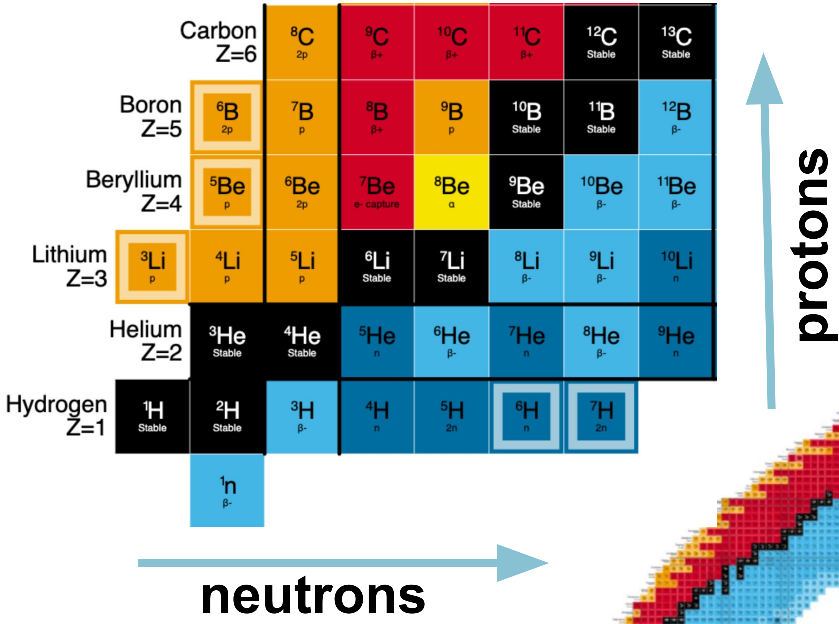
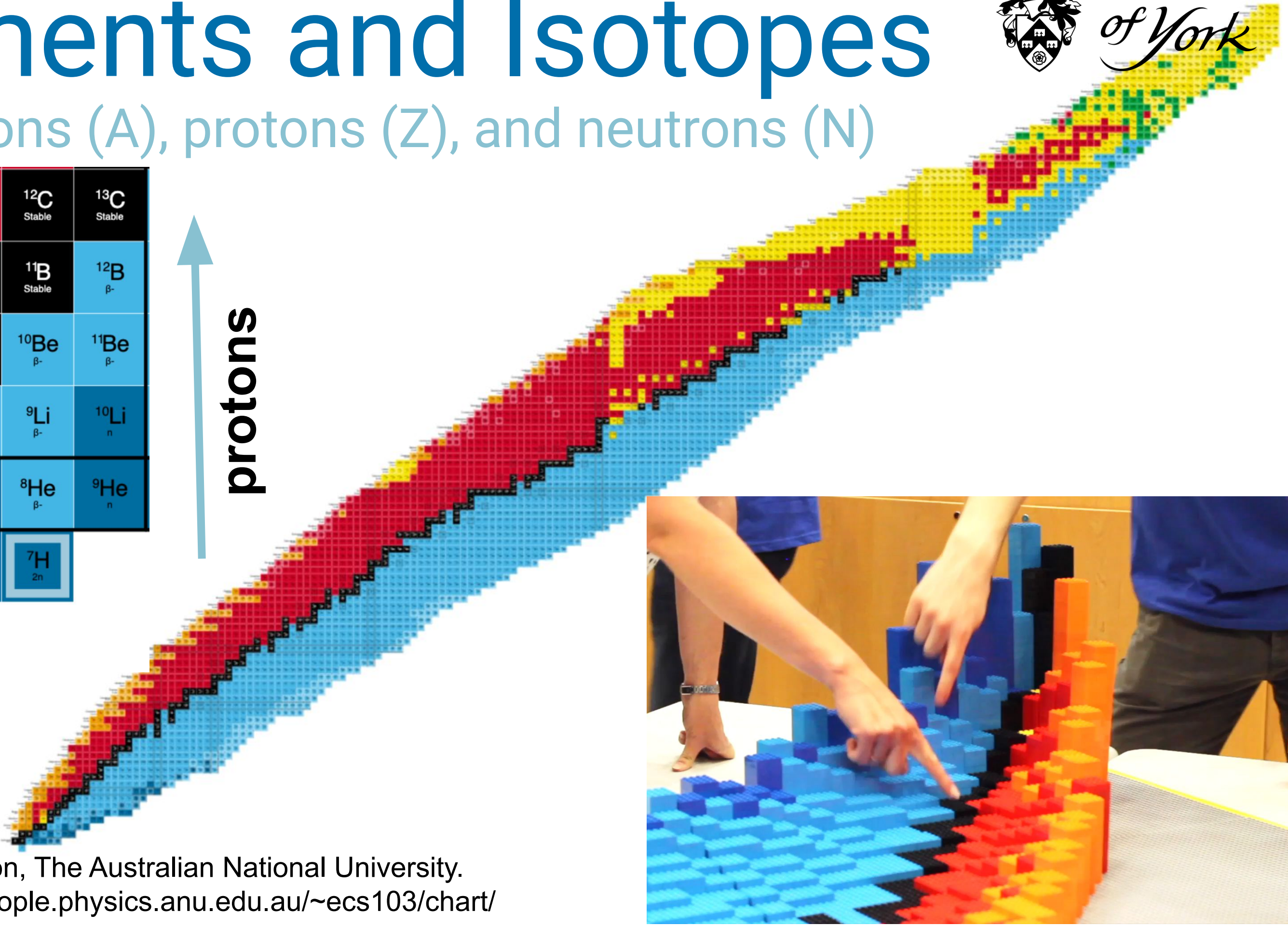


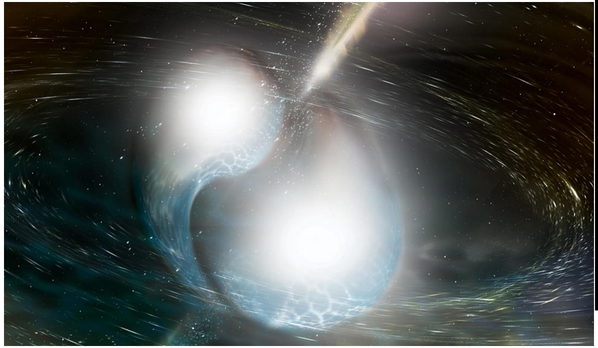


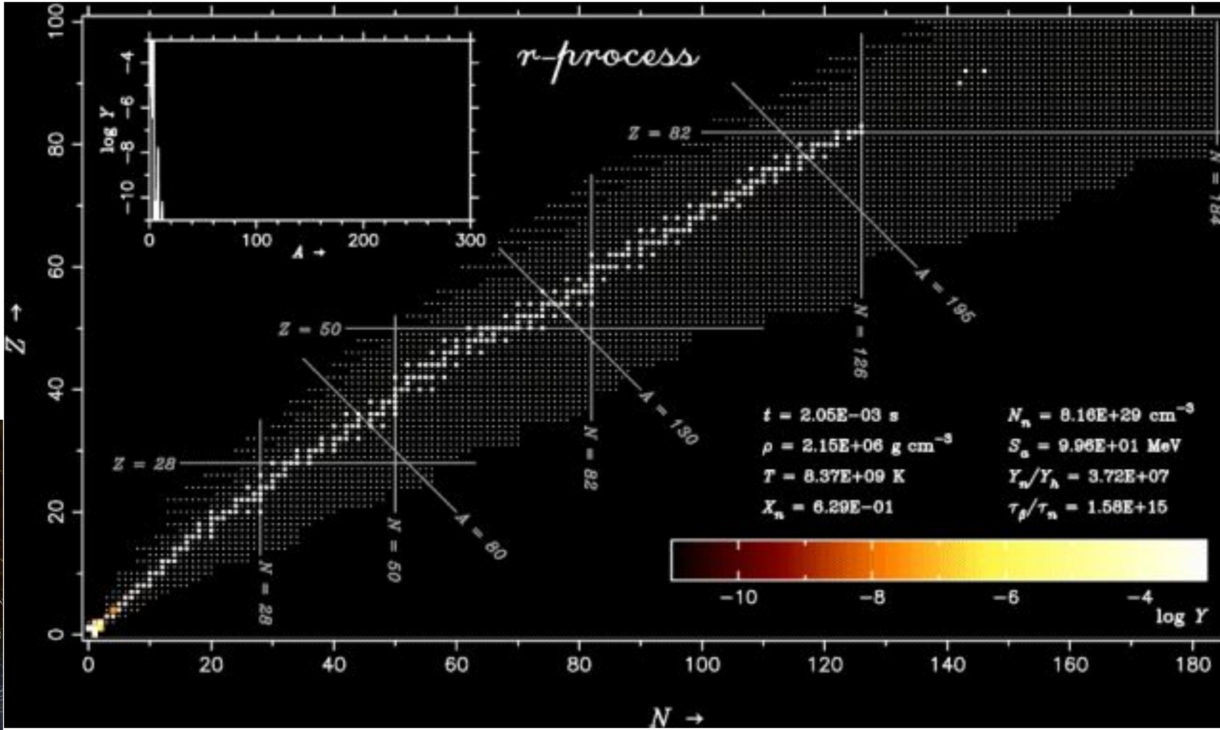
Colourful Nuclide Chart by Dr. Ed Simpson, The Australian National University.
Interactive version available at: https://people.physics.anu.edu.au/~ecs103/chart/

Creating Elements

New elements in stars (in neutron-star mergers)

- Neutron absorption:
  $^{58}Fe + n \rightarrow {}^{59}Fe$ (Z=26)
  → new isotope
- Beta minus decay:
  $n \rightarrow p + e^{-} + \bar{\nu}_e$
  → new element





Creating Elements

The first elements: energy from fusion to helium

4 (Be)		Be	34	17	14	8
3 (Li)	Li	42	29	14	14	13
2 (He)		He	24	7	14	16
1 (H)	H	33	30	24	29	30
0 (n)		(n)	36			
					3	4

- Nuclear energies from Einstein's formula: $E=mc^2$
- ~ 1 kg * $(299{,}792{,}458 \text{ m/s})^2$
  ~ 90,000,000,000,000,000
- Deuterium fusion from just 1L of water: 15 GJ
- Huge destructive potential in cancer treatments

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Fusion energy (D + D → ^{4}He + E):

M_D = 2.014102 u and M_{4He} = 4.002603 u

(u = 1.661•10^{-27}kg, c = 299,792,458 m/s)

E = $2*M_Dc^2 - M_{He}c^2$ = 0.025601 uc^2

= 3.8*10^{-12} J

= 3.8 pJ (excess energy difference)

E (4kg D) = 0.025601kg * (299,792,458m/s)^2

= 2301 TJ

E (1kg D) = 2301 TJ / 4 = 575 TJ.

From deuterium in 1L of water:

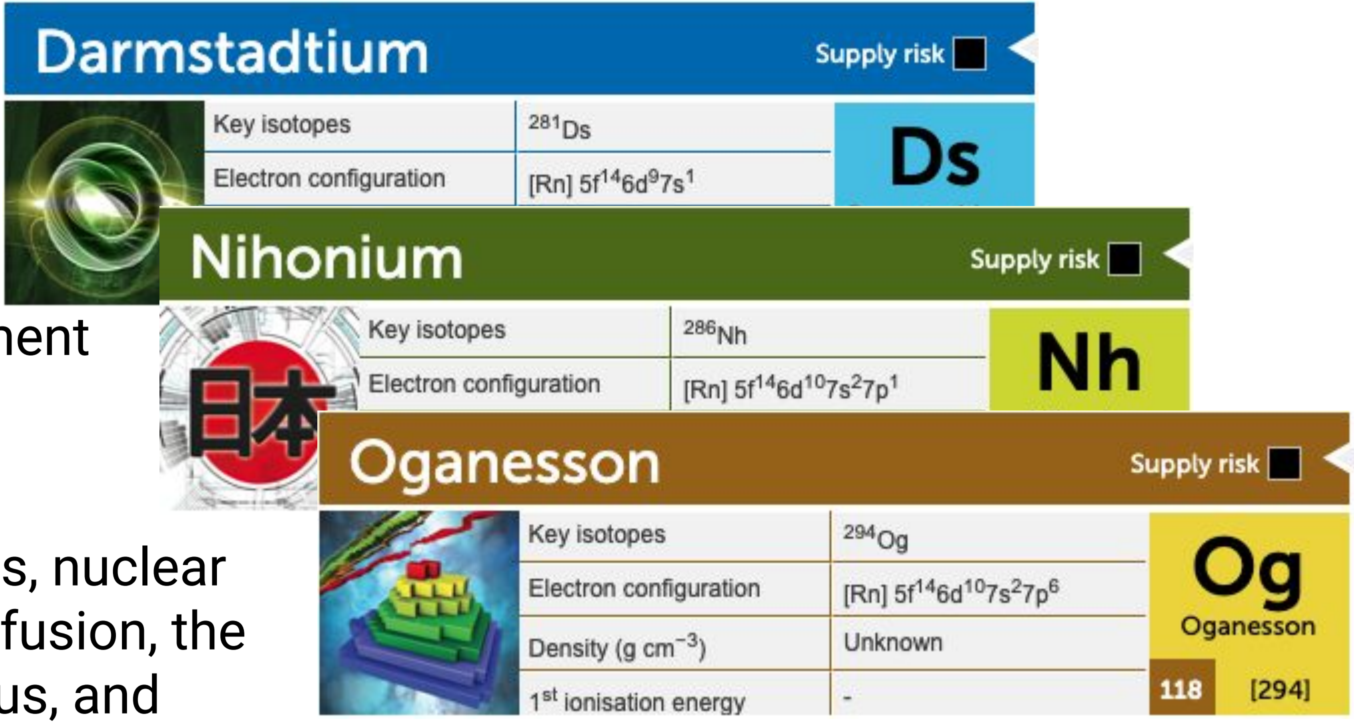
- 1kg * 2/18 * 0.00023 * 575 TJ/kg = 15 GJ

Binding Blocks

From Stars to Medicine

Radioactive decay, isotopes and energy:

- Nuclear energy
- Diagnostics and cancer treatment
- Security and environment

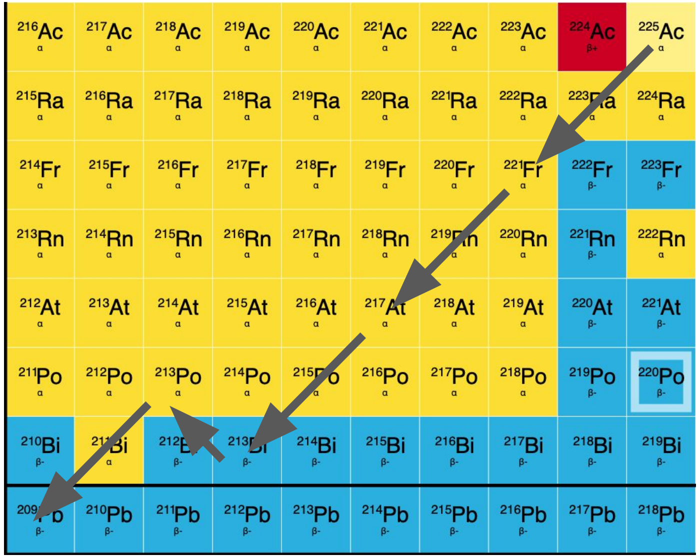


Radiation, accelerators, nuclear medicine, fission and fusion, the structure of the nucleus, and new chemical elements.

Royal Society of Chemistry Periodic table

Novel cancer treatments

- Using radiopharmaceuticals and combination drugs for **therapy** (225Ac) and diag**nostics** (PET) - **theranostics**.
- **Targeted Alpha Therapy** - selectively killing both localised tumours and delocalised cancers by delivering the radiation directly to the cancer cell.
- Delivering the alpha energy over a **very short range**, creating double-stranded DNA breakages.



Actinium

Supply risk

Key isotopes	^{227}Ac
Electron configuration	[Rn] $6d^17s^2$
Density (g cm^{-3})	10
1st ionisation energy	498.830 kJ mol^{-1}

Ac
Actinium
89 [227]

Your own research in ten-hundred words

Explain something about your science, making it as accessible as possible.

- Inspire, excite, clarify, be careful about difficult or words that are new to your audience.
- Try using only (or as closely as possible) the ten-hundred most common words in English: https://splasho.com/upgoer5/.
- Explain any extra words as needed.
- For example: Saturn V rocket (published in Nov 2012)
- Send us your ten-hundred words: https://tinyurl.com/stfc-ten-hundred

Make your own slide

- We want you to produce a slide (maximum of 2) on your own research
- Done individually or in pairs
- Write accompanying text (maximum 200 words)
- Email your slide and text to physics-bindingblocks@york.ac.uk
    - Don’t forget to include your name(s)
- Please email it by the end of Wednesday this week (the 21st)