Building a Universe from Scratch

An Introduction to Particle Physics

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The King Edmund School - 14.01.2026

Matter

Matter - Stuff which has weight

Almost everything you can touch, smell, and see is made of matter. (Solids, liquids, and gasses).

E.g. Rocks, frogs, and soup

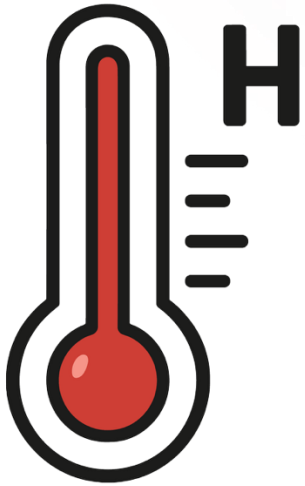
Question: Can you think of anything you can feel or see that *isn't* matter?

Energy

Energy - Something that makes matter move or change

Light and heat are types of energy. We can feel heat and see light.

E.g. Light, heat, motion



Looking Closer at Matter...

Take three Particle Physicists

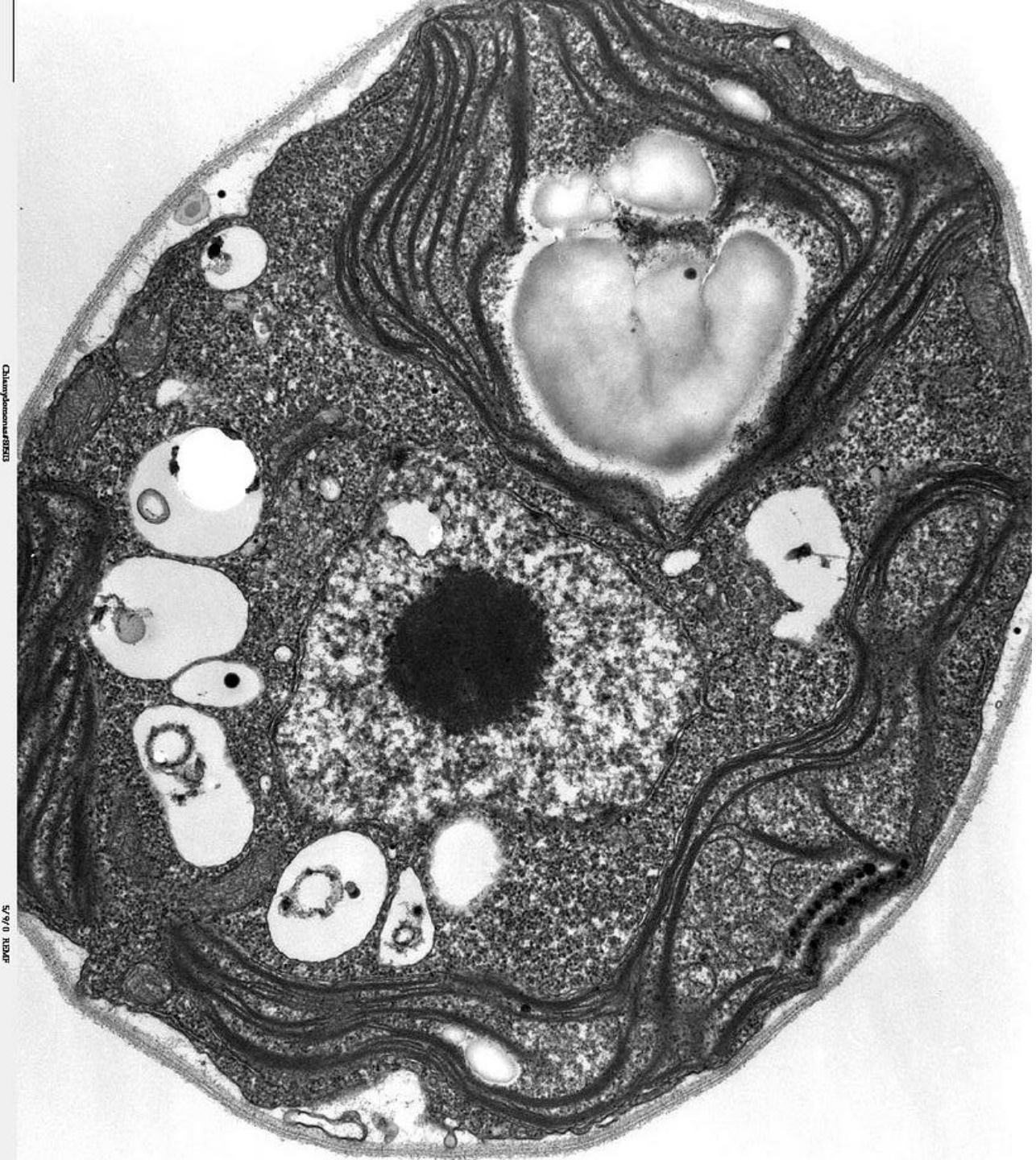
We are all made out of matter

Looking Closer at Matter…

Take three Particle Physicists

We are all made out of matter

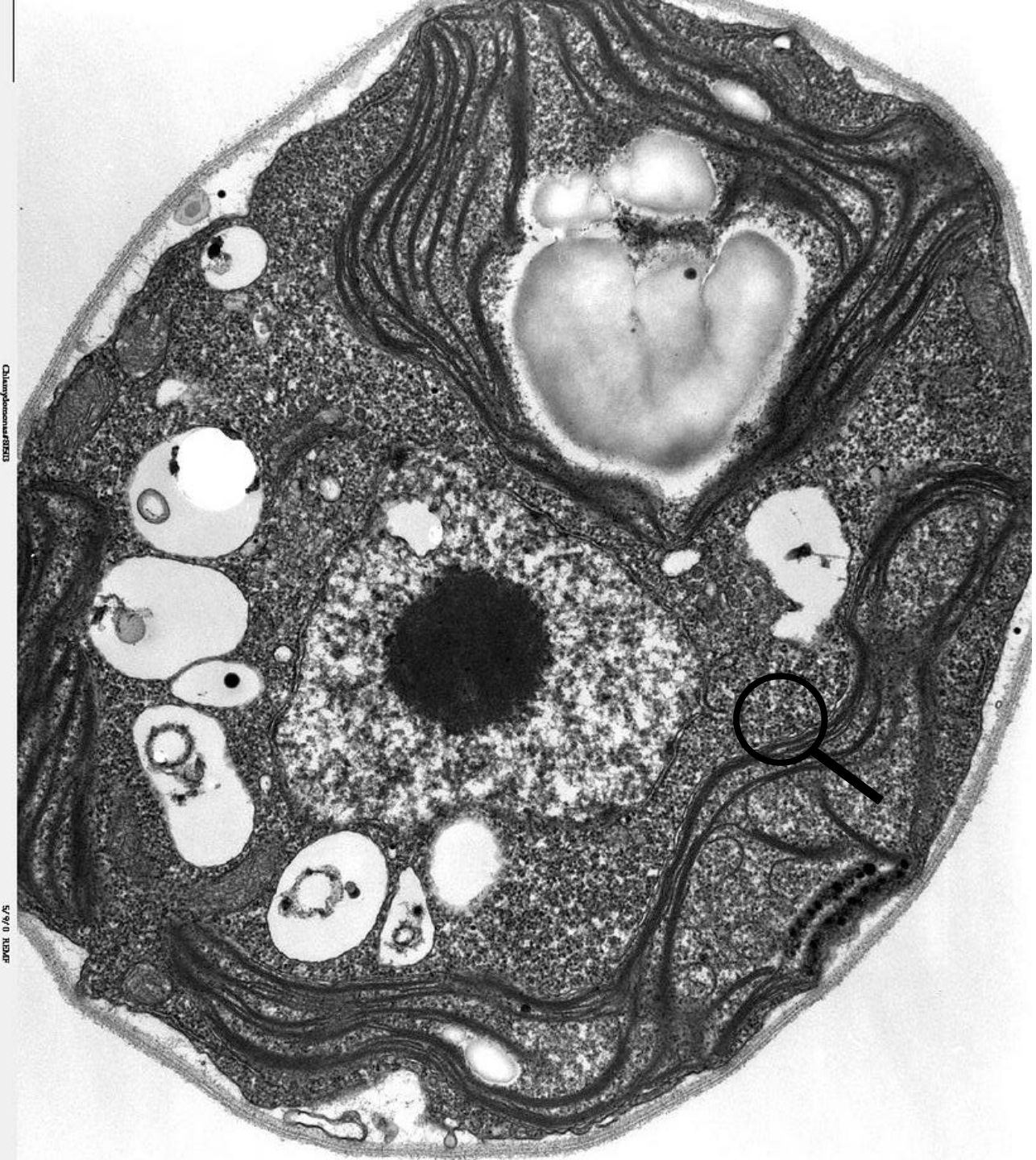
Let’s zoom in a little!



Looking Closer at Matter...

Human Cells

All living matter is made of up '*cells*'

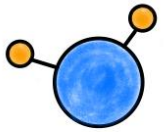


Looking Closer at Matter…

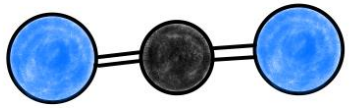
Human Cells

All living matter is made of up ‘*cells*’

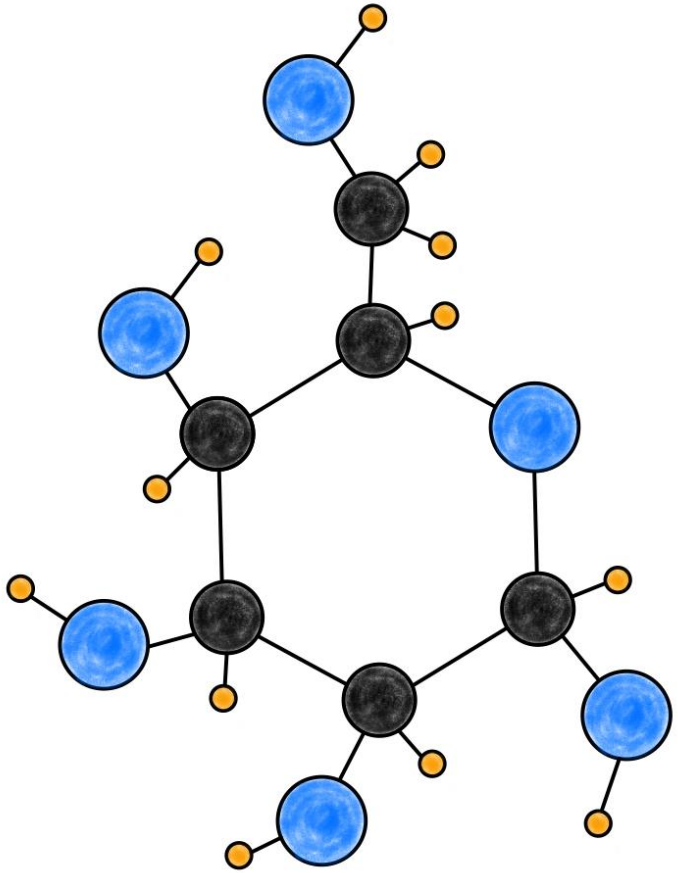
Let’s zoom in even more!



H_2O



CO_2

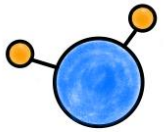


$C_6H_{12}O_6$

Looking Closer at Matter...

Molecules

Also called '*chemical compounds*'. These are combinations of the different elements found in the **periodic table**.



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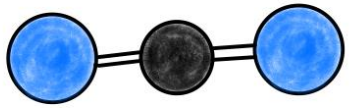

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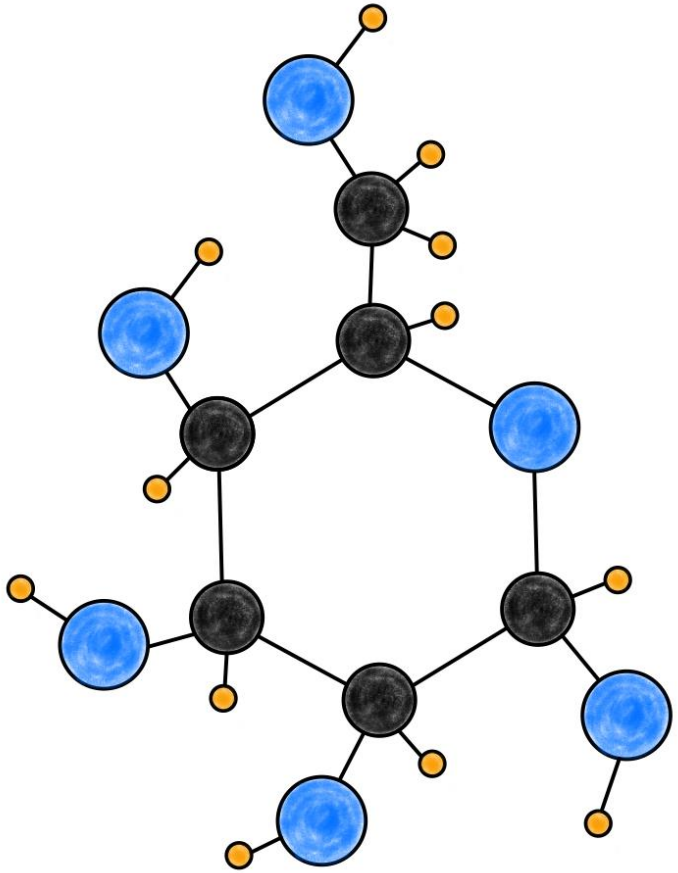


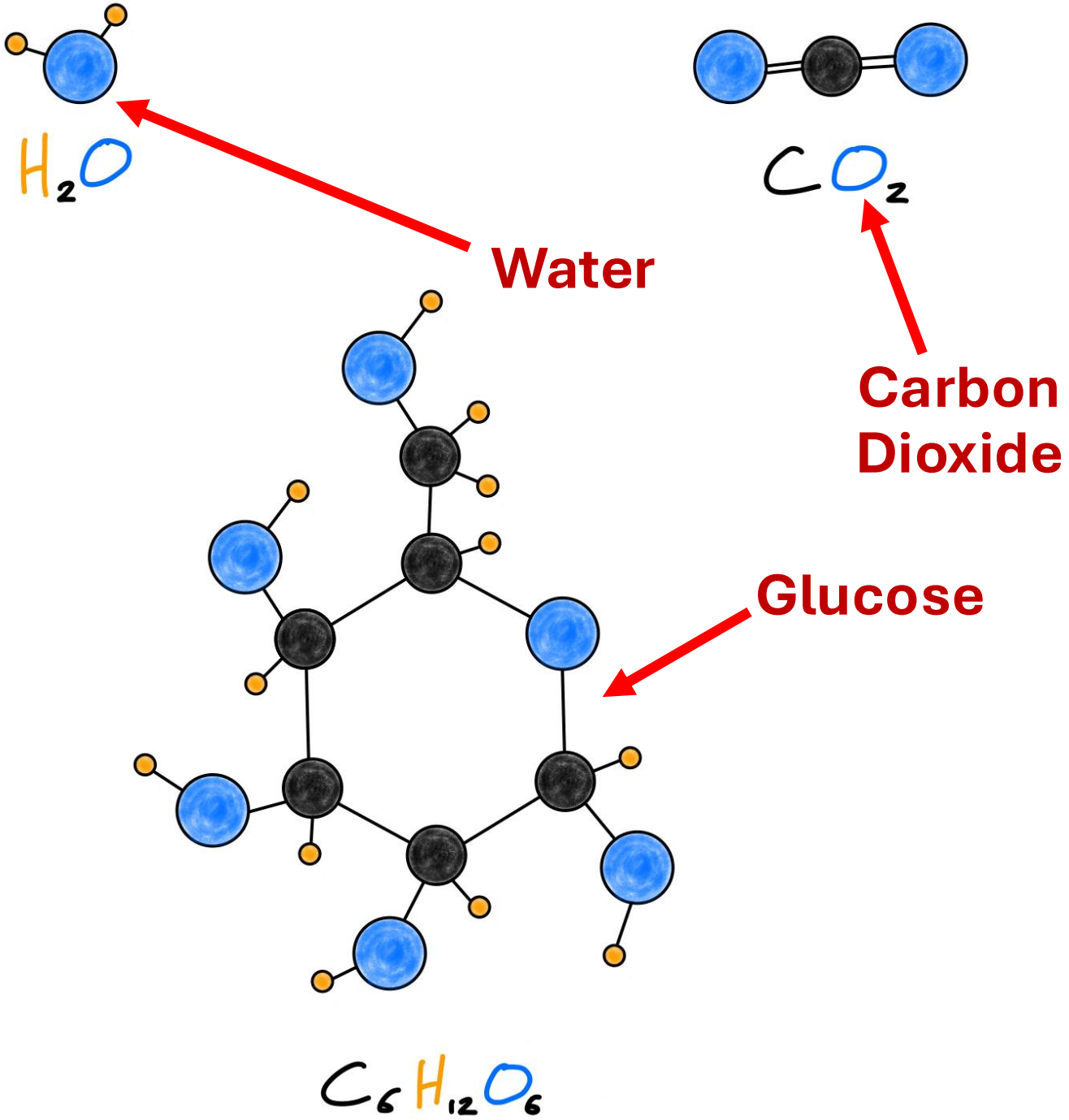
$C_6H_{12}O_6$

Looking Closer at Matter...

Molecules

Also called '*chemical compounds*'. These are combinations of the different elements found in the **periodic table**.

Question: Can you name any of the chemical compounds shown here?



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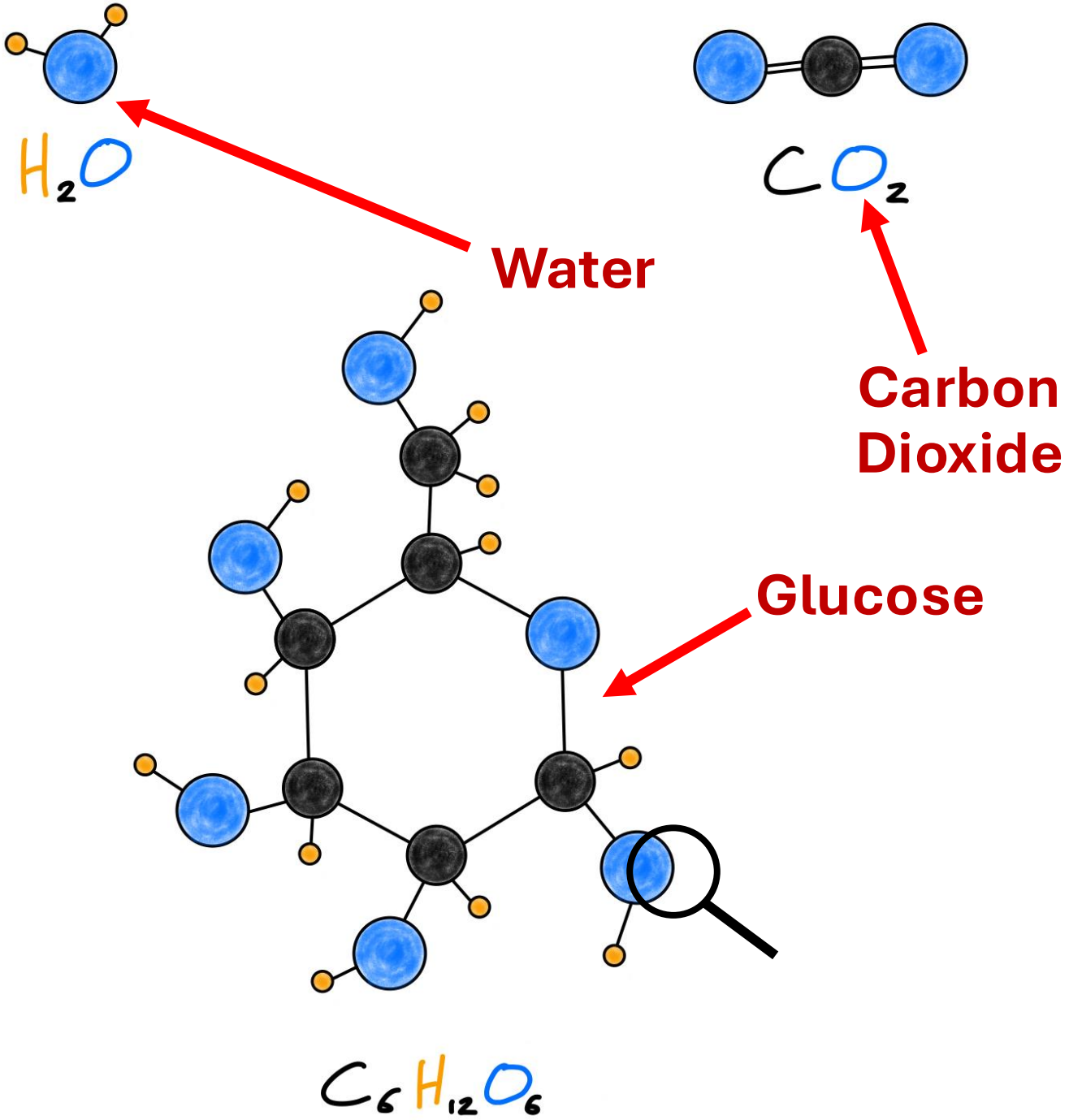

Looking Closer at Matter...

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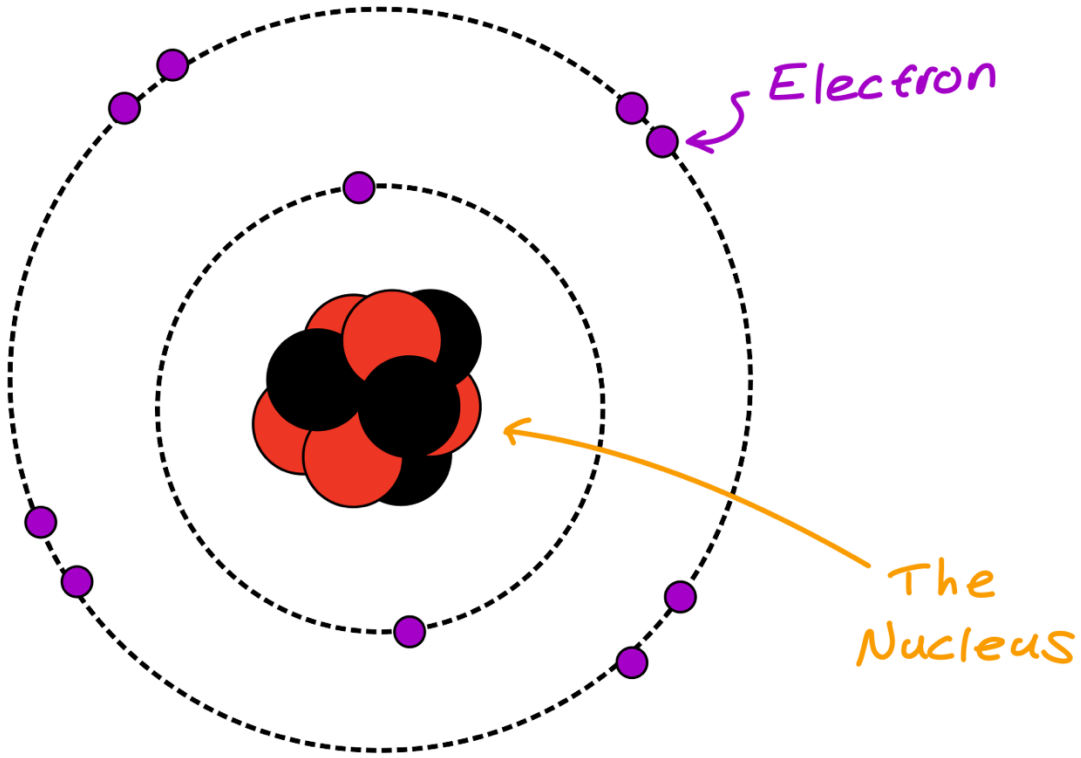
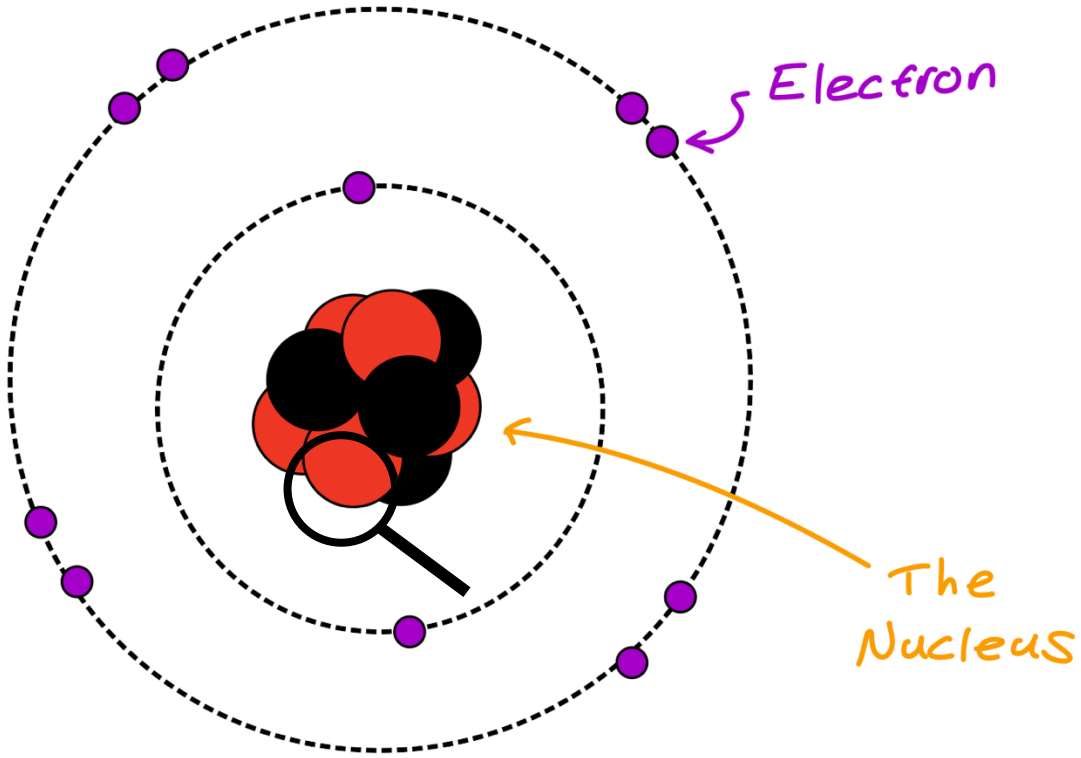


Looking Closer at Matter...

Atoms

All the ‘stuff’ we see on Earth is made out of atoms.



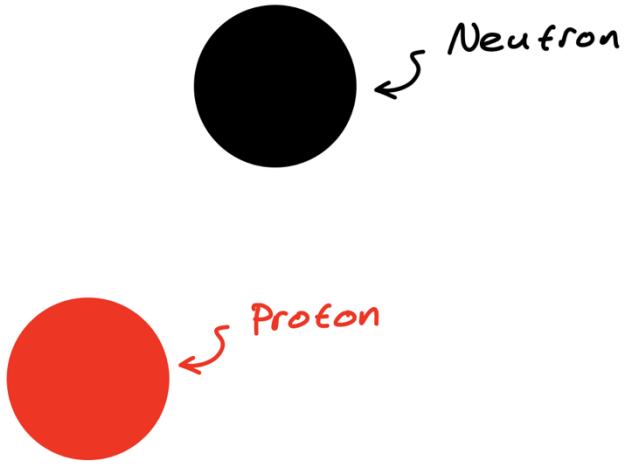
Looking Closer at Matter...

Atoms

All the ‘stuff’ we see on Earth is made out of atoms.

Let’s look even closer...

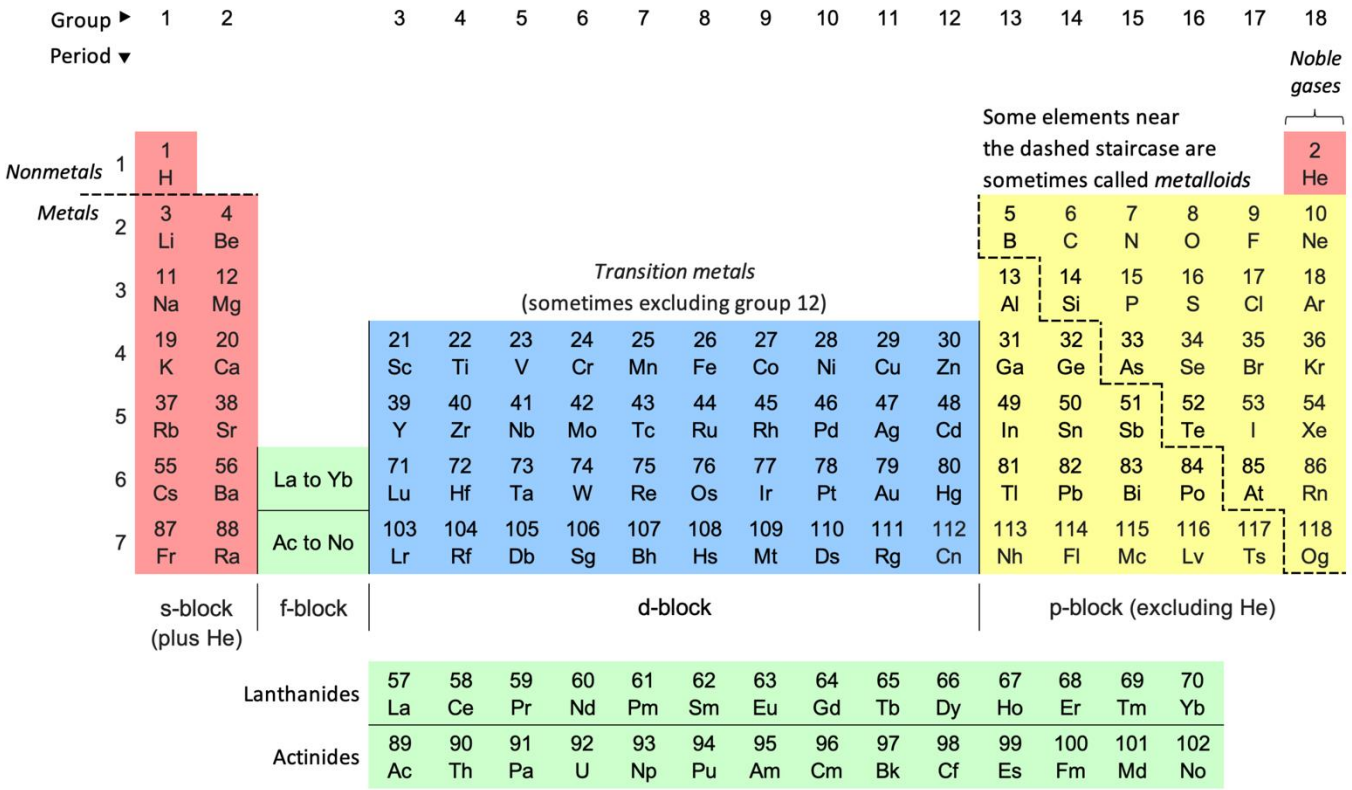
Looking Closer at Matter...



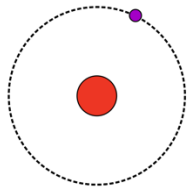
Protons & Neutrons

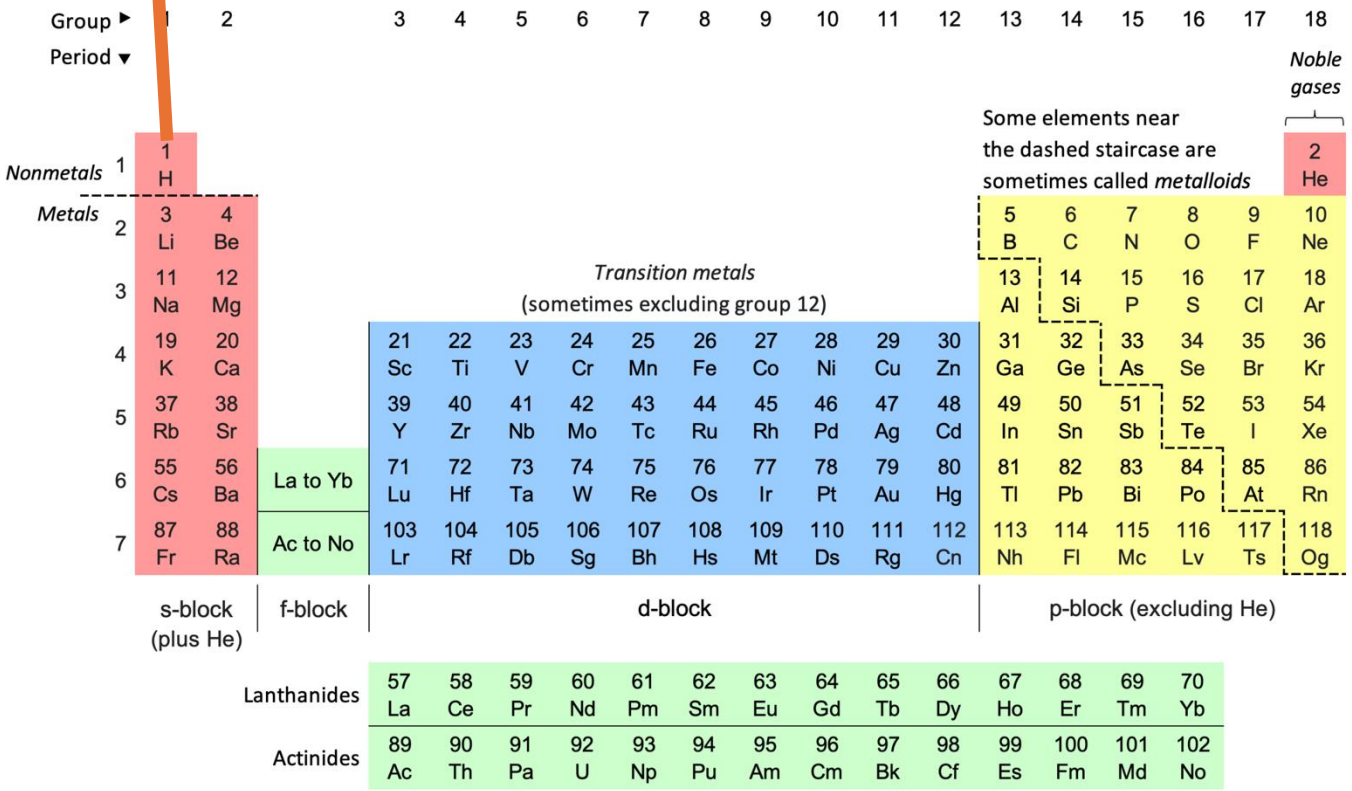
The center of an atom is made out of particles called ‘Protons’ and ‘Neutrons’.

A Side Note on the Chemical Elements...



All the different kinds of matter are organized in the **periodic table**.





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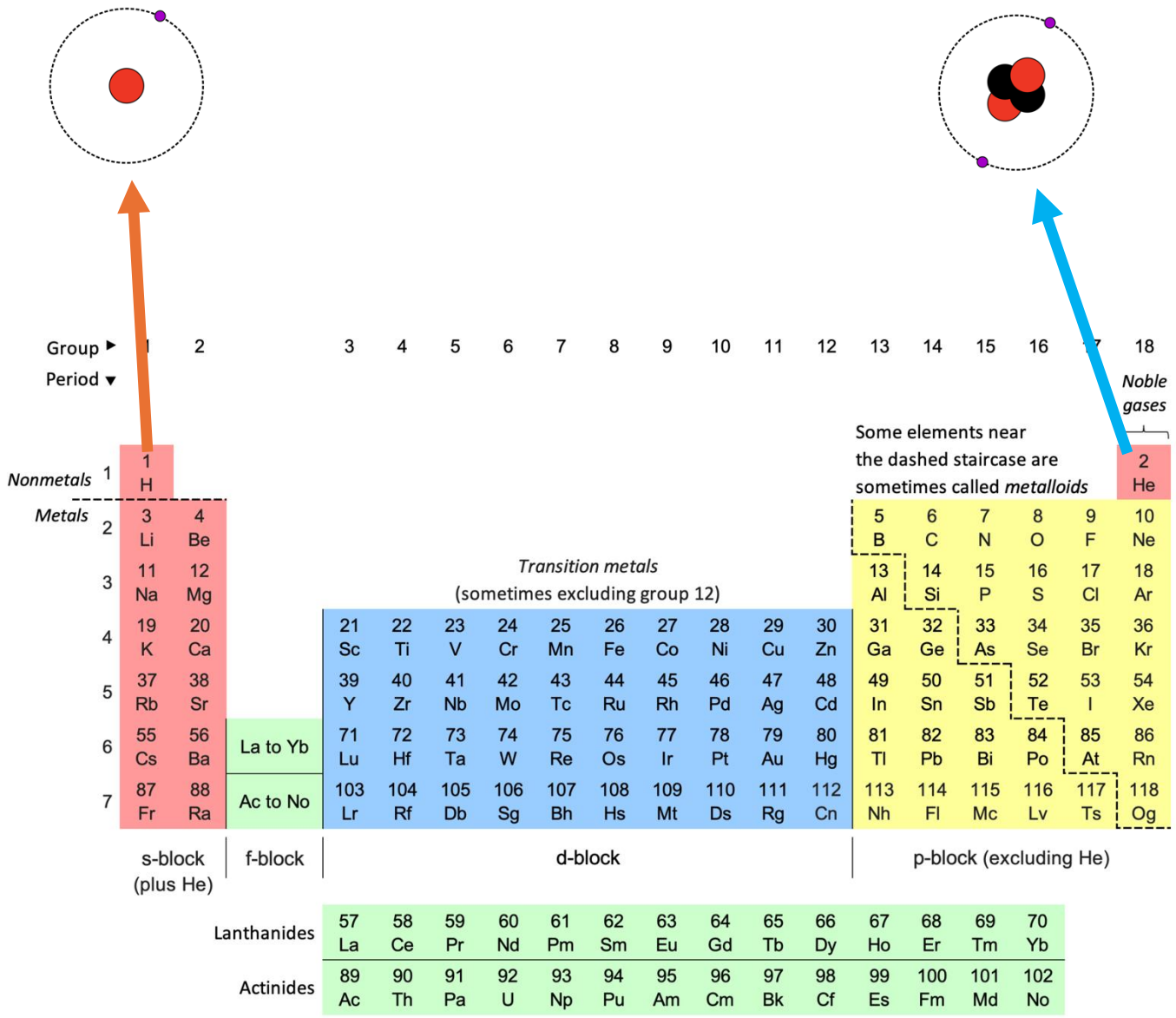

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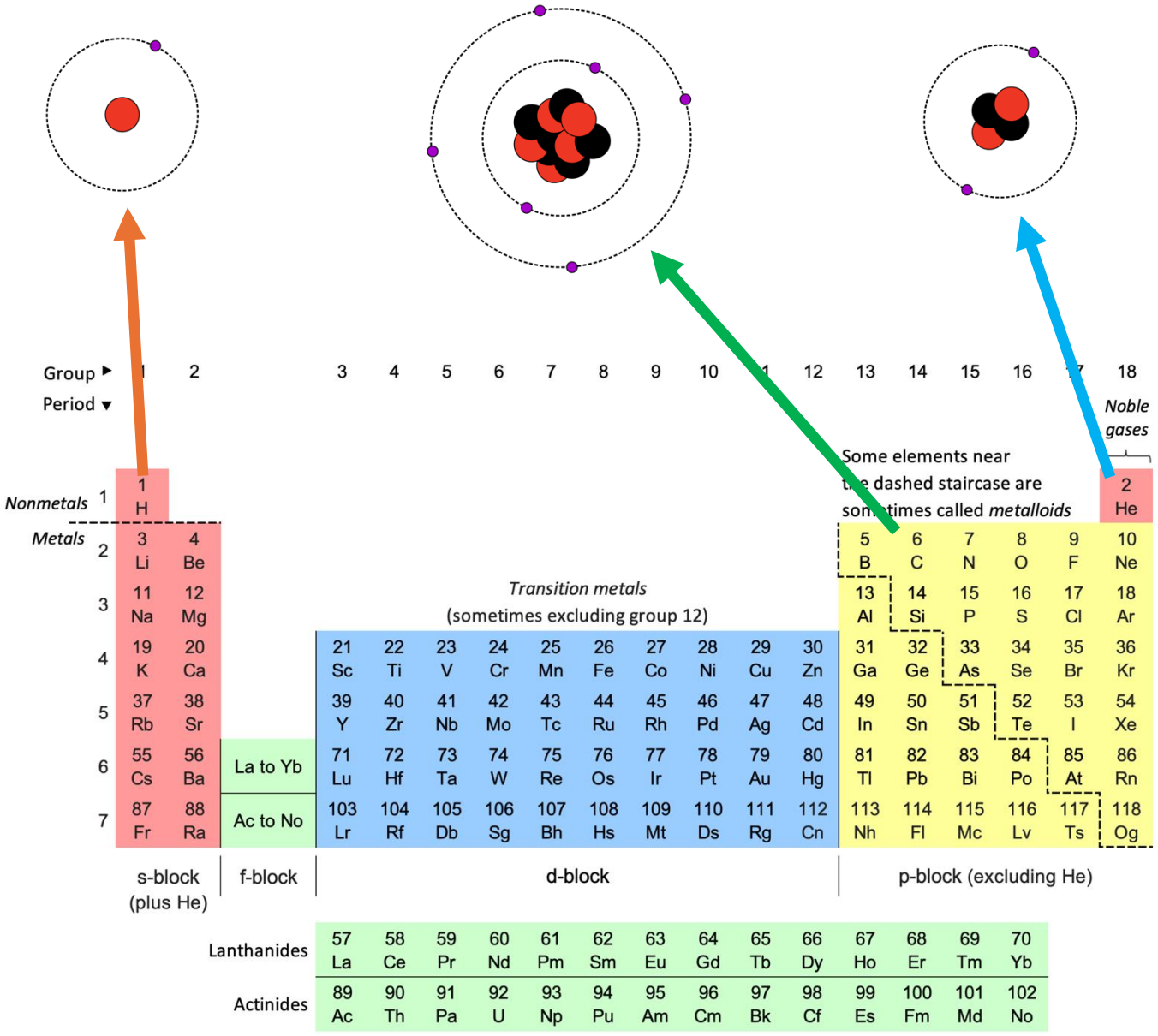

A Side Note on the Chemical Elements...

All the different kinds of matter are organized in the **periodic table**.

Hydrogen atoms are a single electron orbiting a single proton

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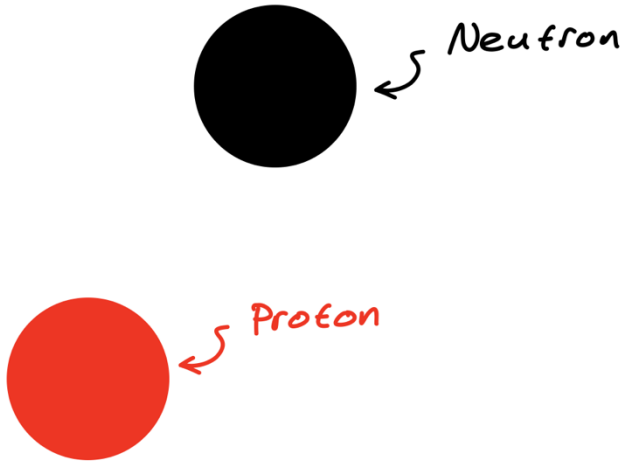
Carbon atoms are six electrons orbiting six protons and six neutrons

Back to zooming!....

Looking Closer at Matter...



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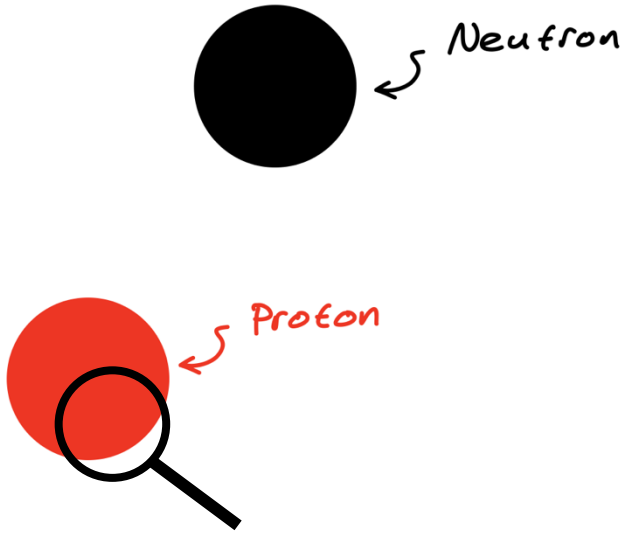

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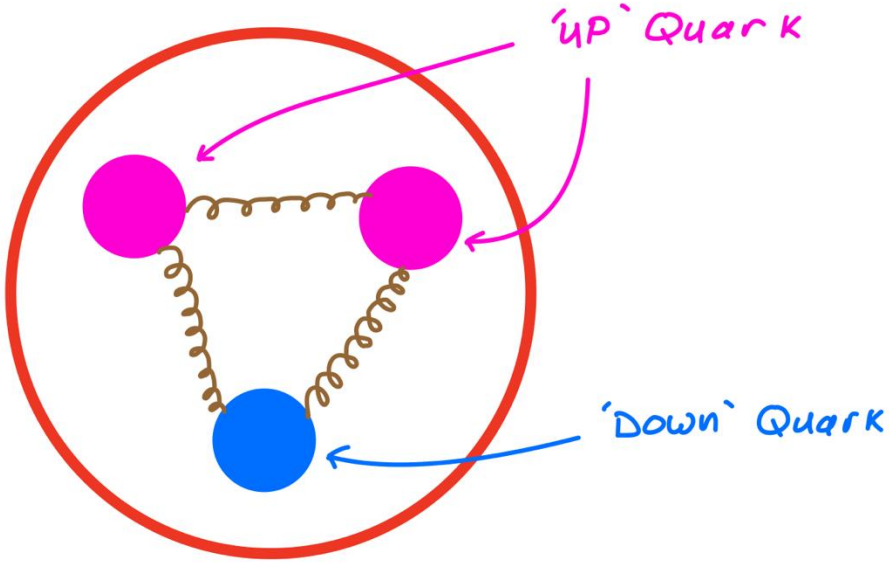
The center of an atom is made out of particles called ‘Protons’ and ‘Neutrons’.

Another zoom in...

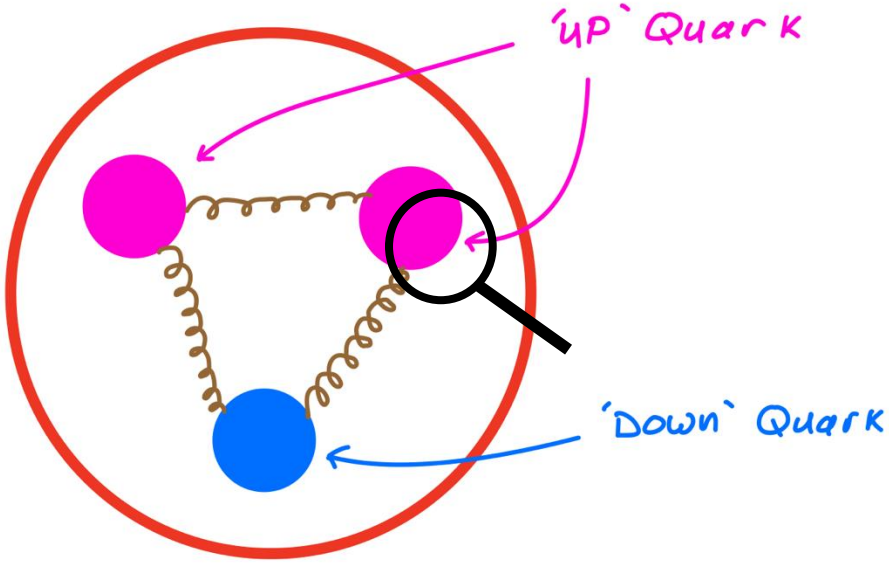
Looking Closer at Matter...



Quarks

Protons and Neutrons are made up of ‘quarks’.

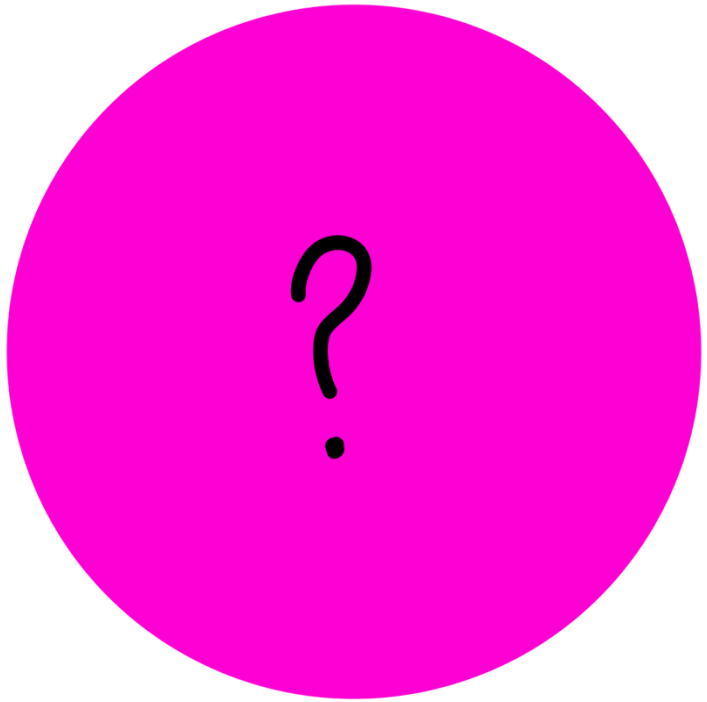
Looking Closer at Matter...



Quarks

Protons and Neutrons are made up of ‘quarks’.

But what are quarks made of?!



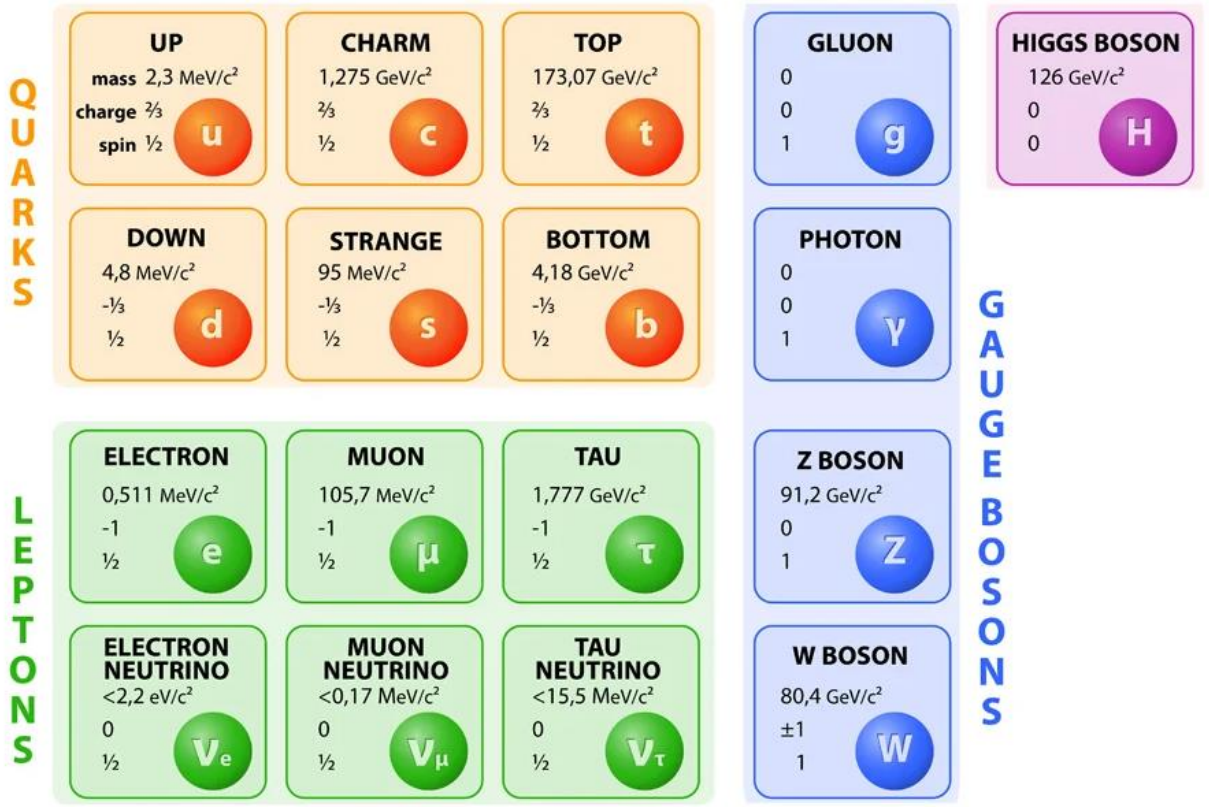
Looking Closer at Matter…

Beyond Quarks?

“But what are quarks made of?!”

We don’t know!

Quarks, ‘***just are***’!



What other things '*just are*'?

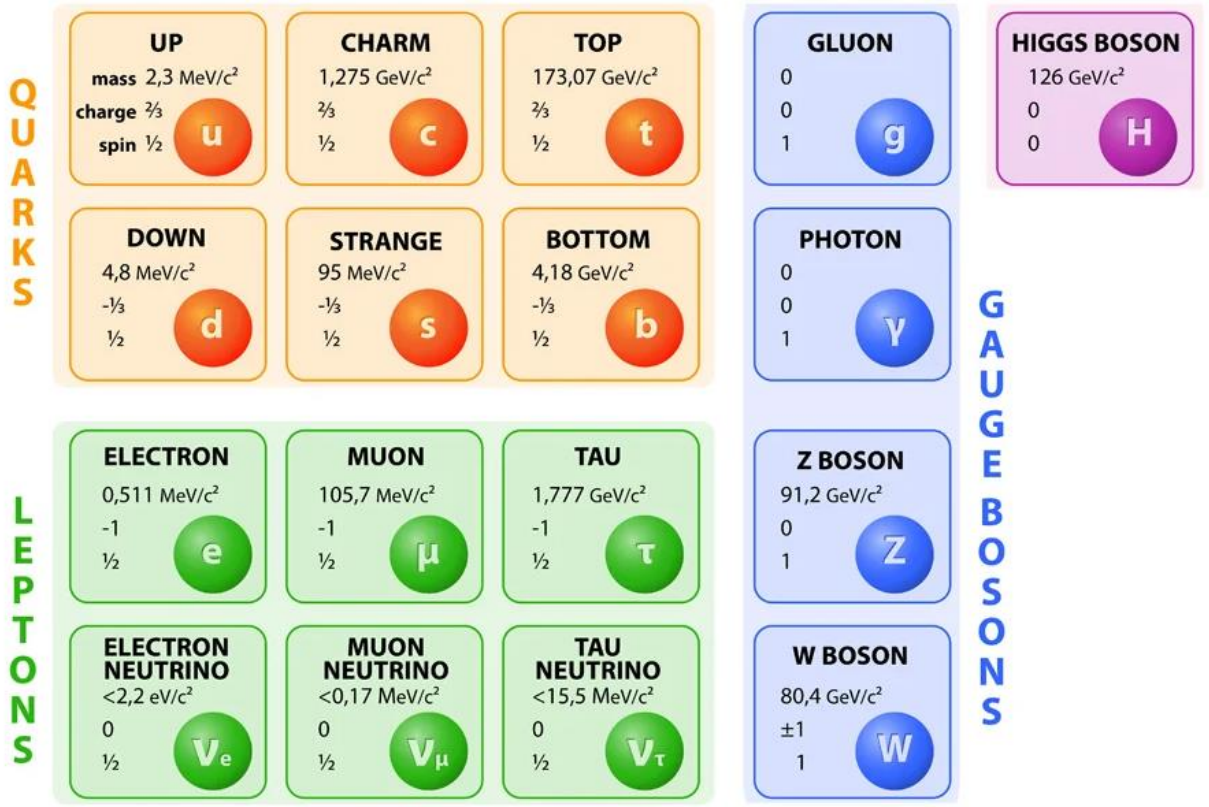
'The Standard Model of Elementary Particles'

If you were cooking up a Universe from scratch, this would be you list of ingredients.

The Particle Physicists Mantra:

"To discover the basic building blocks of all the matter in the Universe, and to understand how these building blocks fit together."

So… is that it?

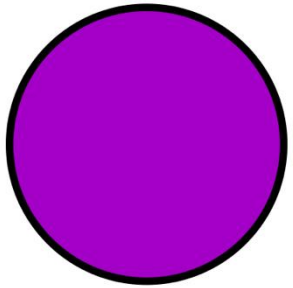


Does '*The Standard Model*' tell us about all the different kinds of matter in the Universe?

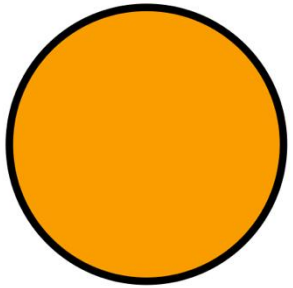
Question: Is that everything? Can you name a kind of matter not shown here?

Not even nearly!

Anti-matter

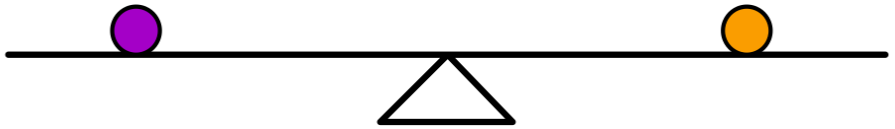


Electron

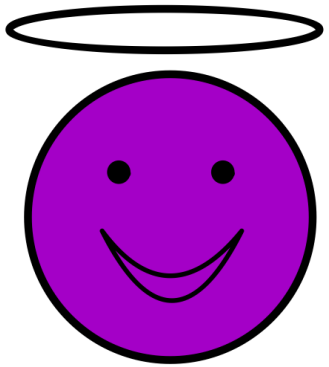


Anti-Electron
"Positron"

Anti-matter weighs the same as normal matter, but some properties are reversed.

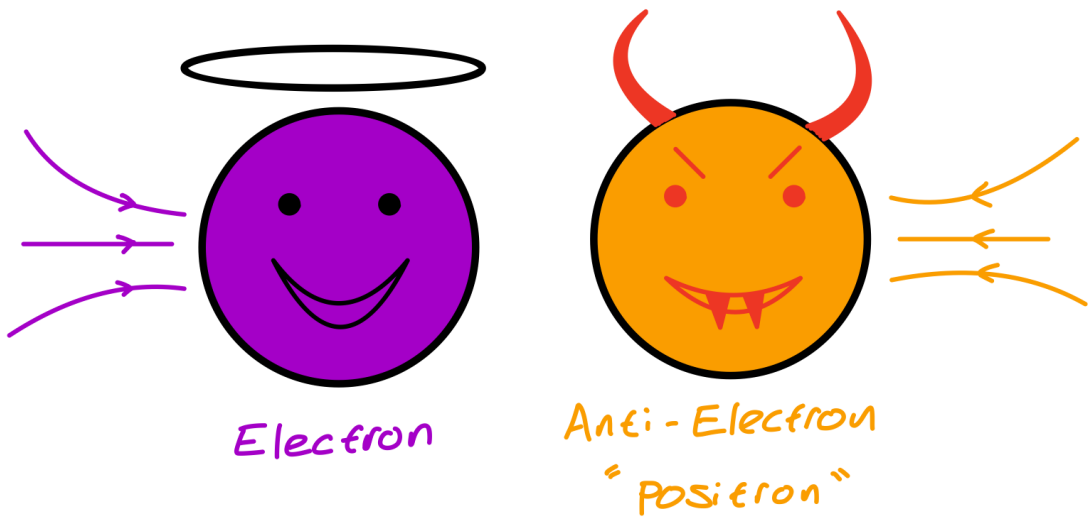


Anti-matter



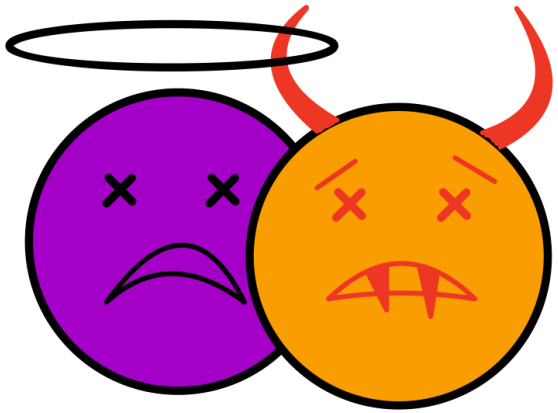
Anti-matter is a bit like matters evil twin!

Anti-matter

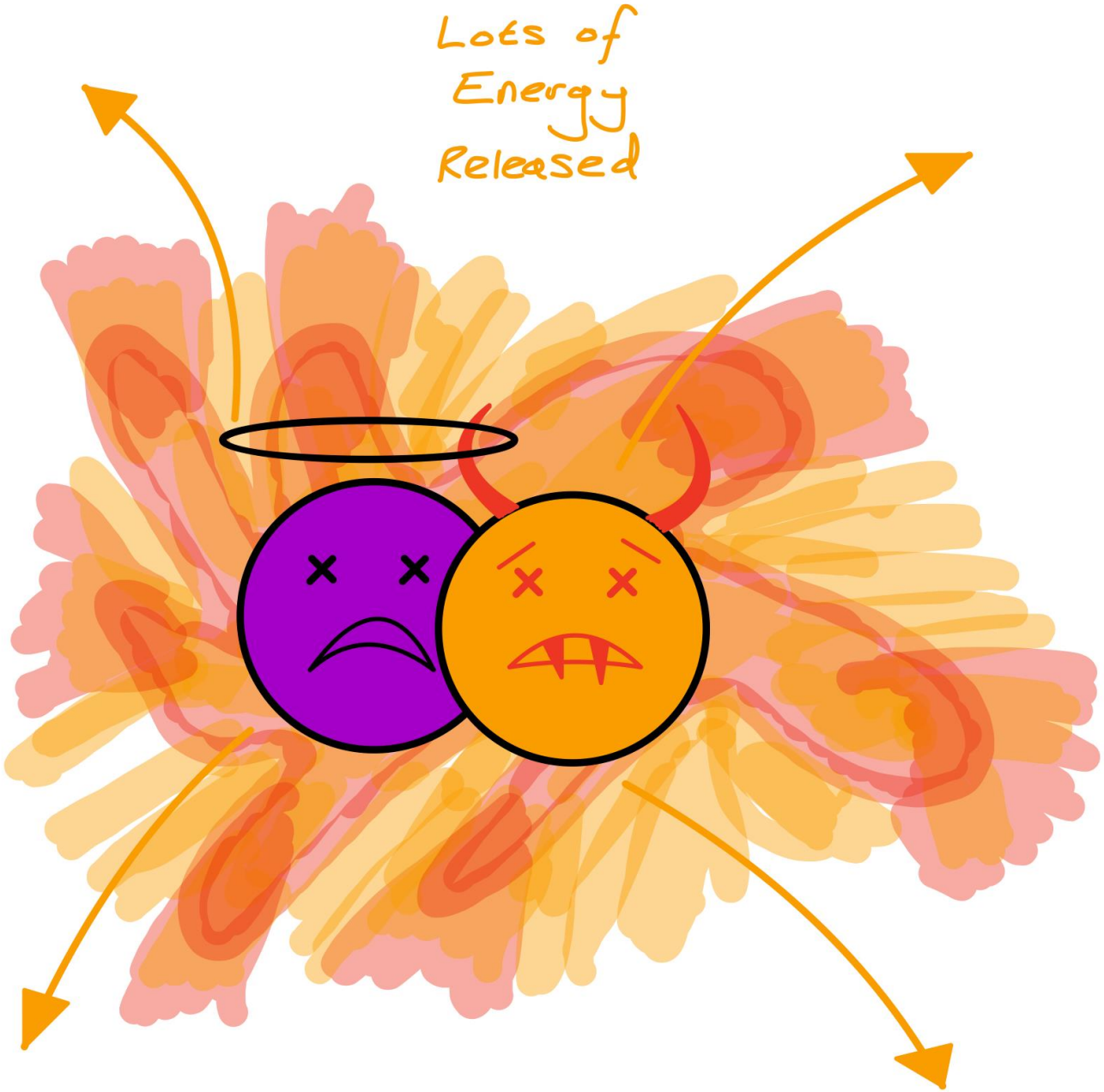


What happens when matter and anti-matter meet?

Anti-matter

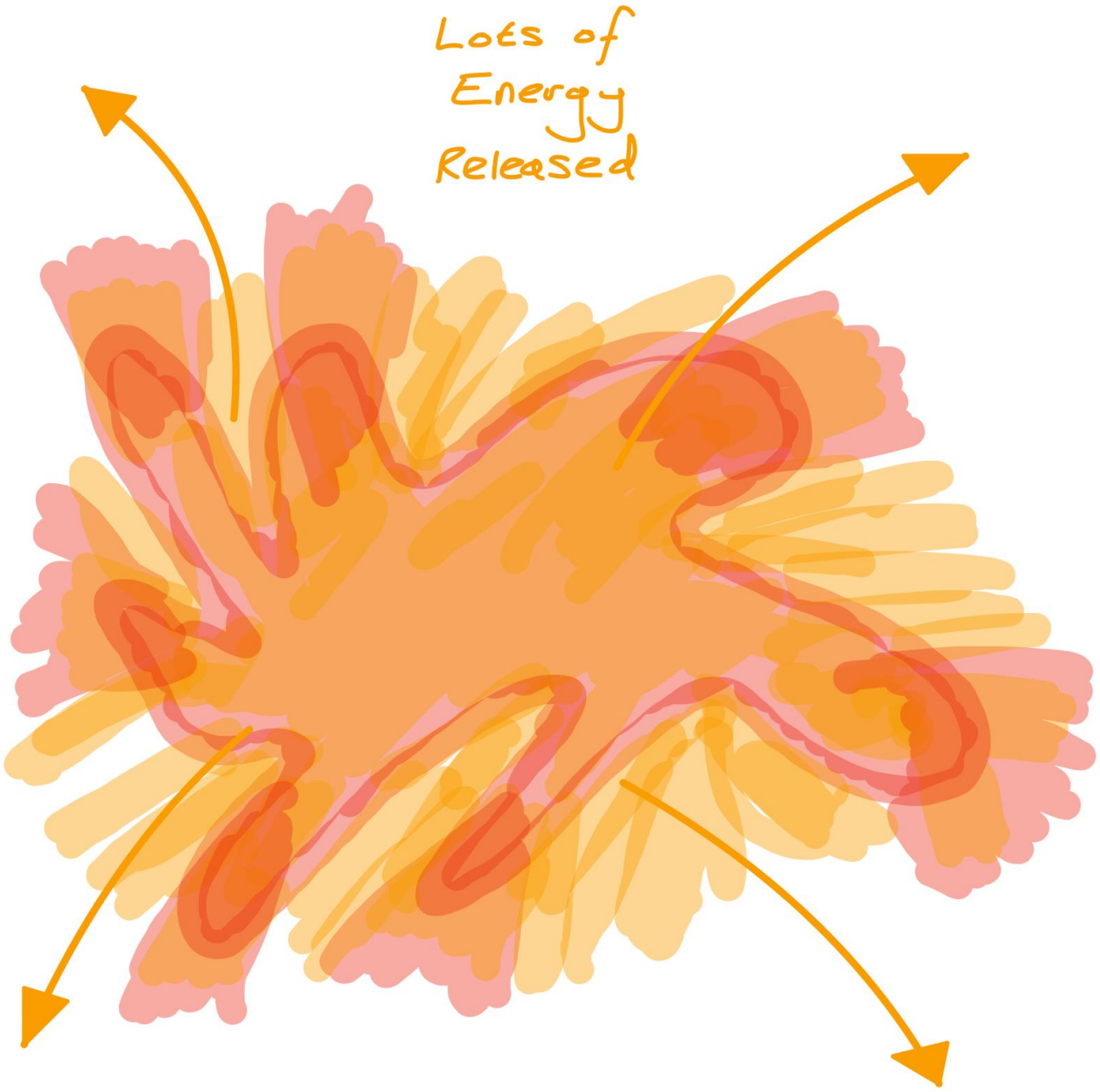


When matter and anti-matter touch,
they **ANNIHILATE**.



Anti-matter

Annihilation destroys the particles, and causes **HUGE** amounts of energy to be released.



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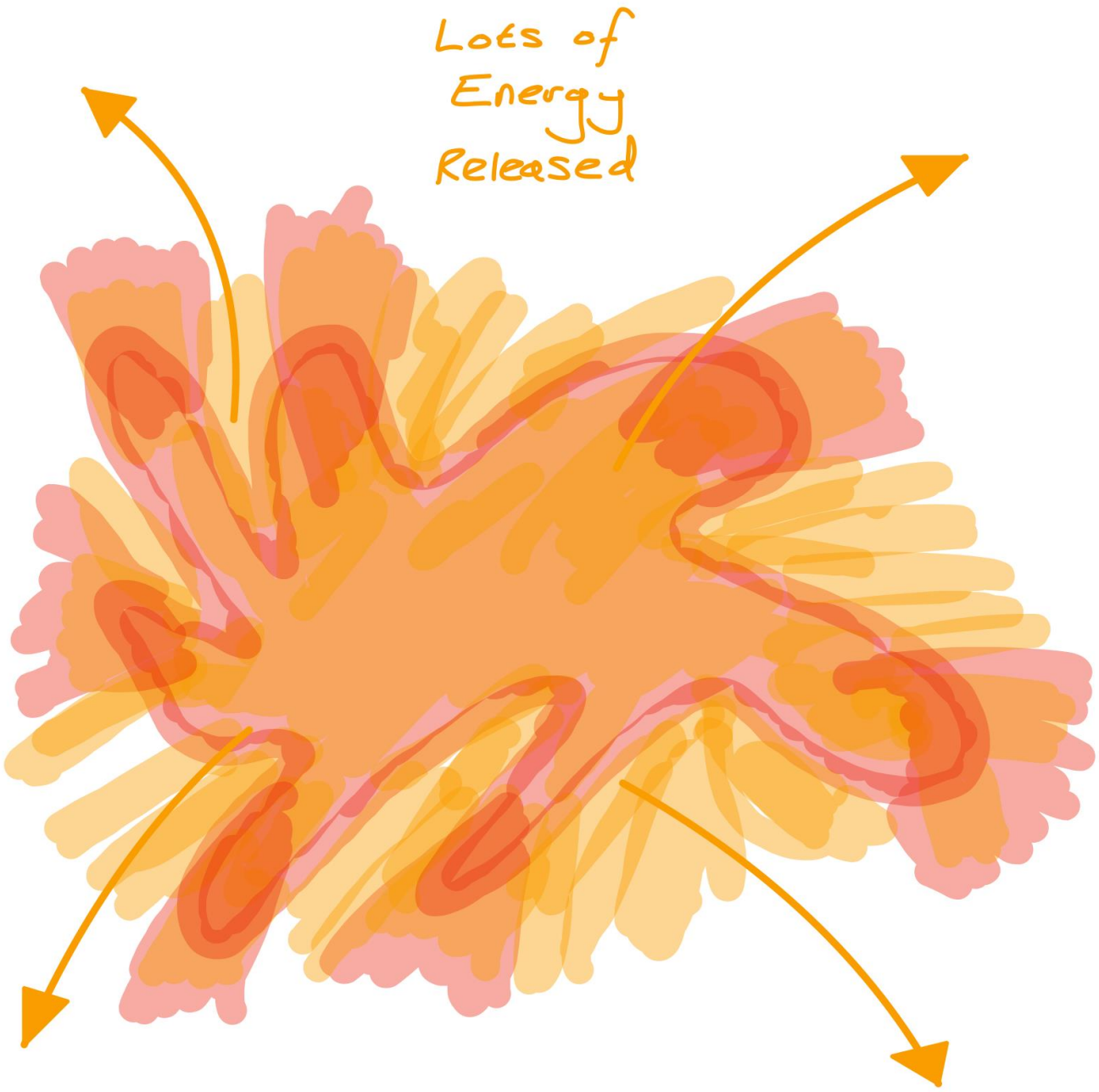


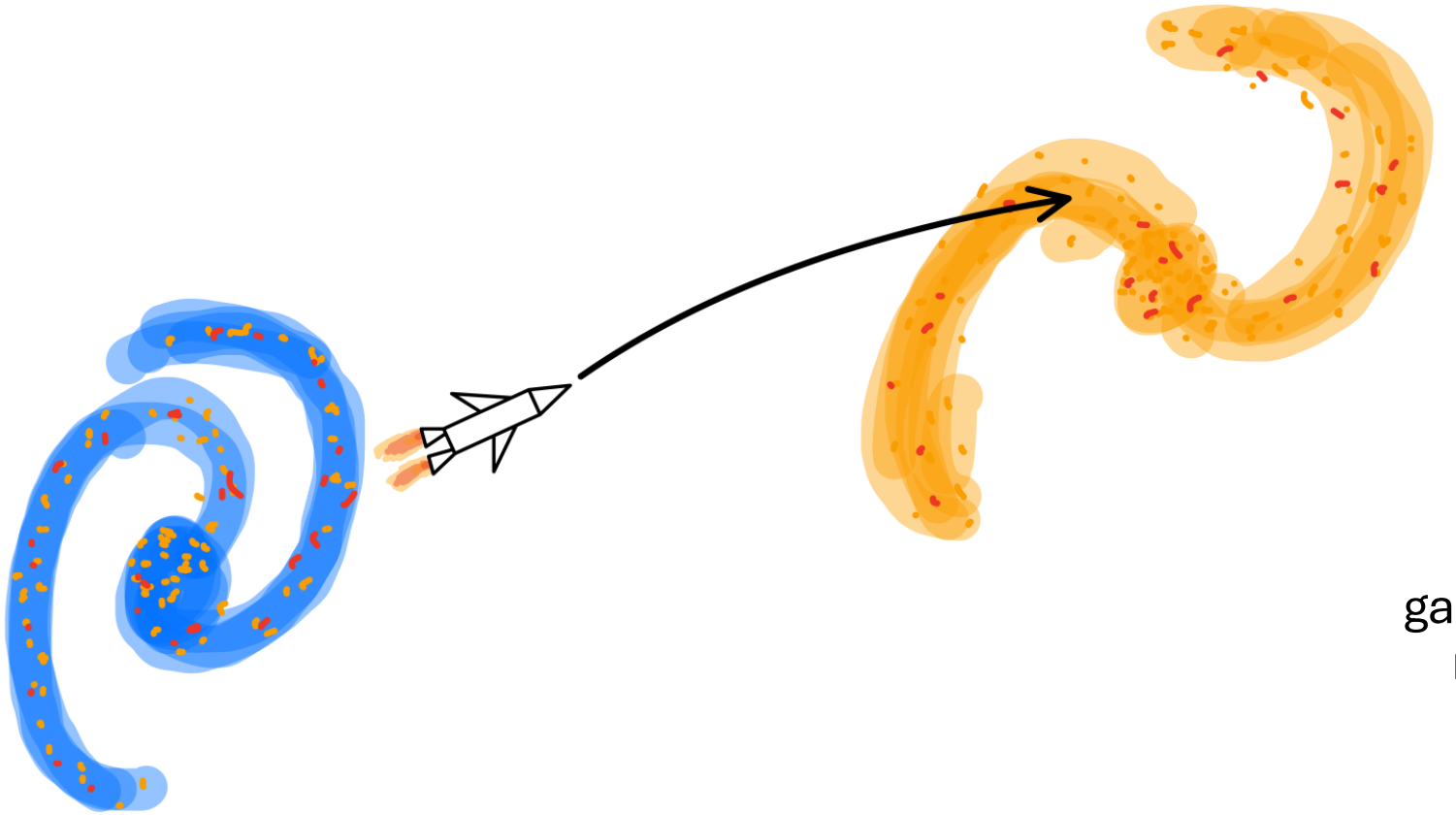
Anti-matter

How much Energy?

We need Einstein's famous formula:

$$E = mc^2$$

"Energy = mass annihilated, times the speed-of-light squared"



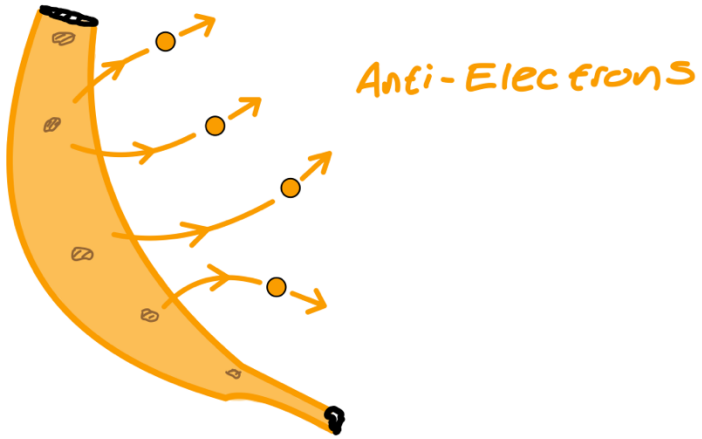
Anti-matter

If humans every develop the technology to travel to other galaxies, we will probably need anti-matter to power our spacecraft.

Question: What is a galaxy?

Anti-matter Generator

Who will volunteer to help me take out my anti-matter generator?

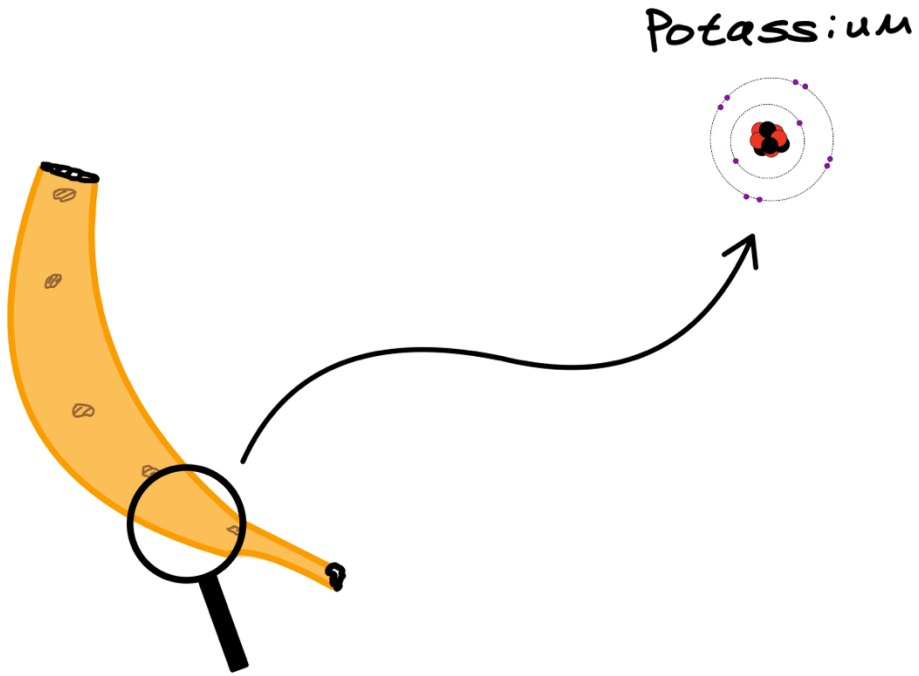


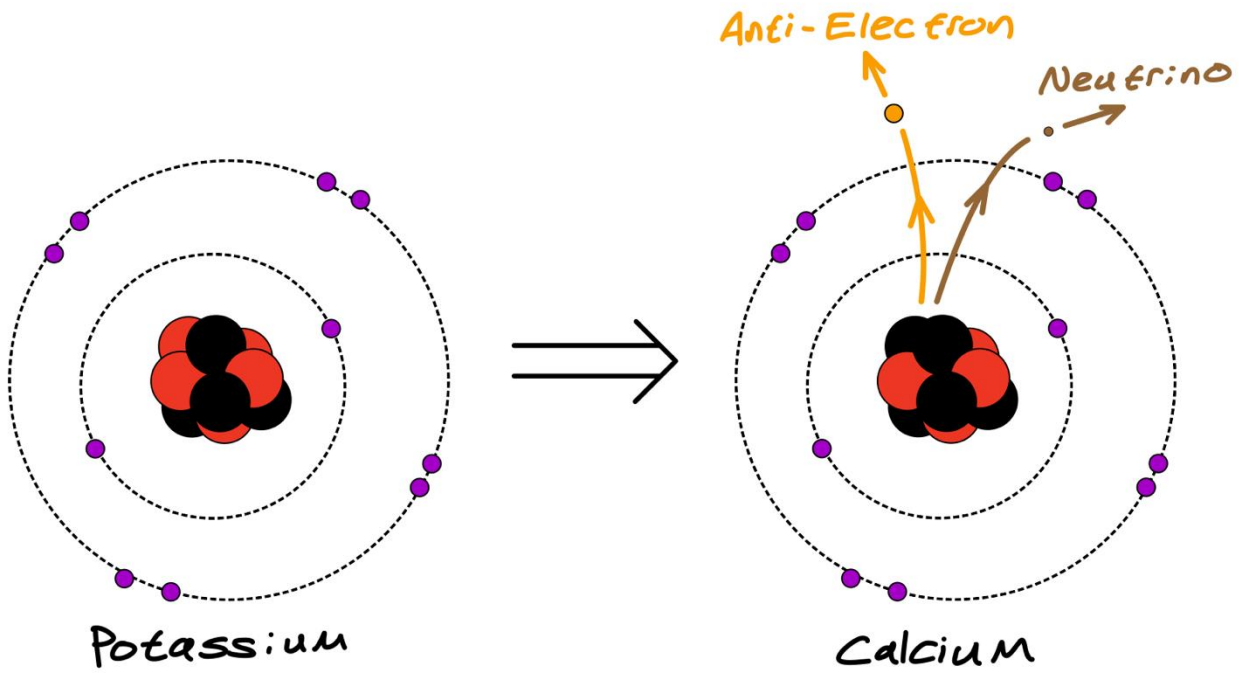
Anti-matter

<u>The Science of our ‘Anti-matter Generator’</u>

Bananas emit anti-electrons!

This is because they contain potassium atoms, which are slightly radioactive.





Anti-matter

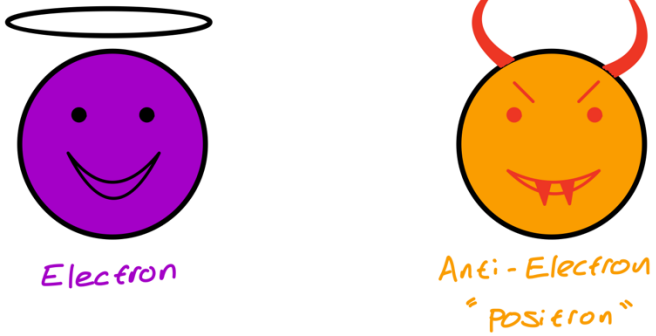
<u>The Science of our ‘Anti-matter Generator’</u>

The radioactive potassium atoms decay into calcium atoms.

In this process, they release a very tiny amount of anti-matter!

So… is *that* it??

Does the matter in the Standard Model + anti-matter cover everything there is in the Universe?



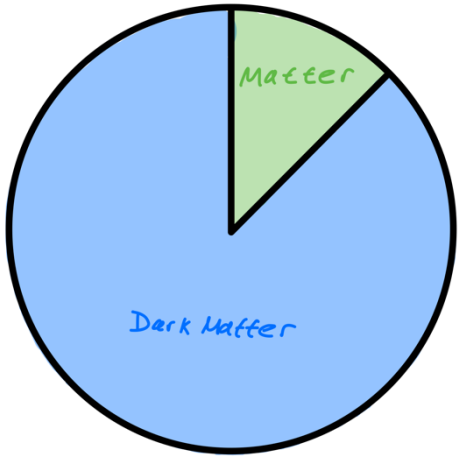
Question: Is there more '*stuff*' in the Universe than we have discussed so far?

Still nowhere near!

Dark Matter

About 85% of all of the matter in the Universe is totally mysterious, and completely invisible.

We call this '***Dark Matter***'.



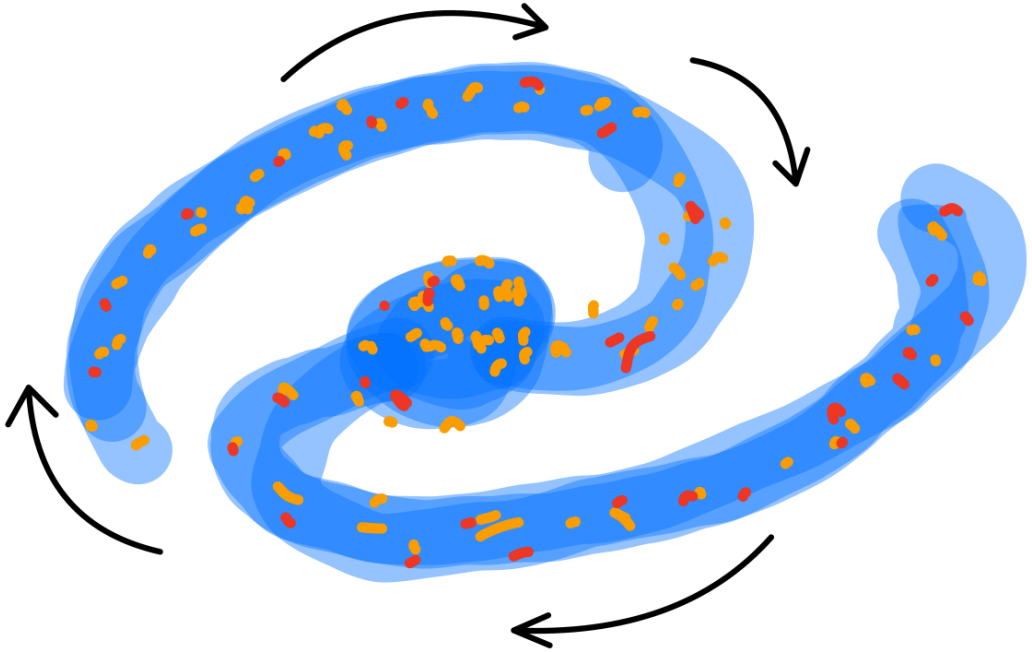
Dark Matter

If it’s invisible, how do we know it’s there?

Dark Matter

We know from looking at all the galaxies in the night sky!

Question: What is the name of the galaxy we live in?



Dark Matter

The way galaxies spin means there is a lot of extra weight in addition to the stars and planets we can see.

This extra weight comes from

Dark Matter.

Some real galaxies!

Our galaxy contains over one hundred billion stars!

Question: How many galaxies are there in the Universe?

“How do I become a Particle Physicist?”

- Work hard in Science and Maths lessons.
- Be curious and ask questions.
- Learn to enjoy solving tough ‘*problems*’.
- Believe in yourself! *Anyone* can be a scientist!

Questions!

Ask me anything you like!

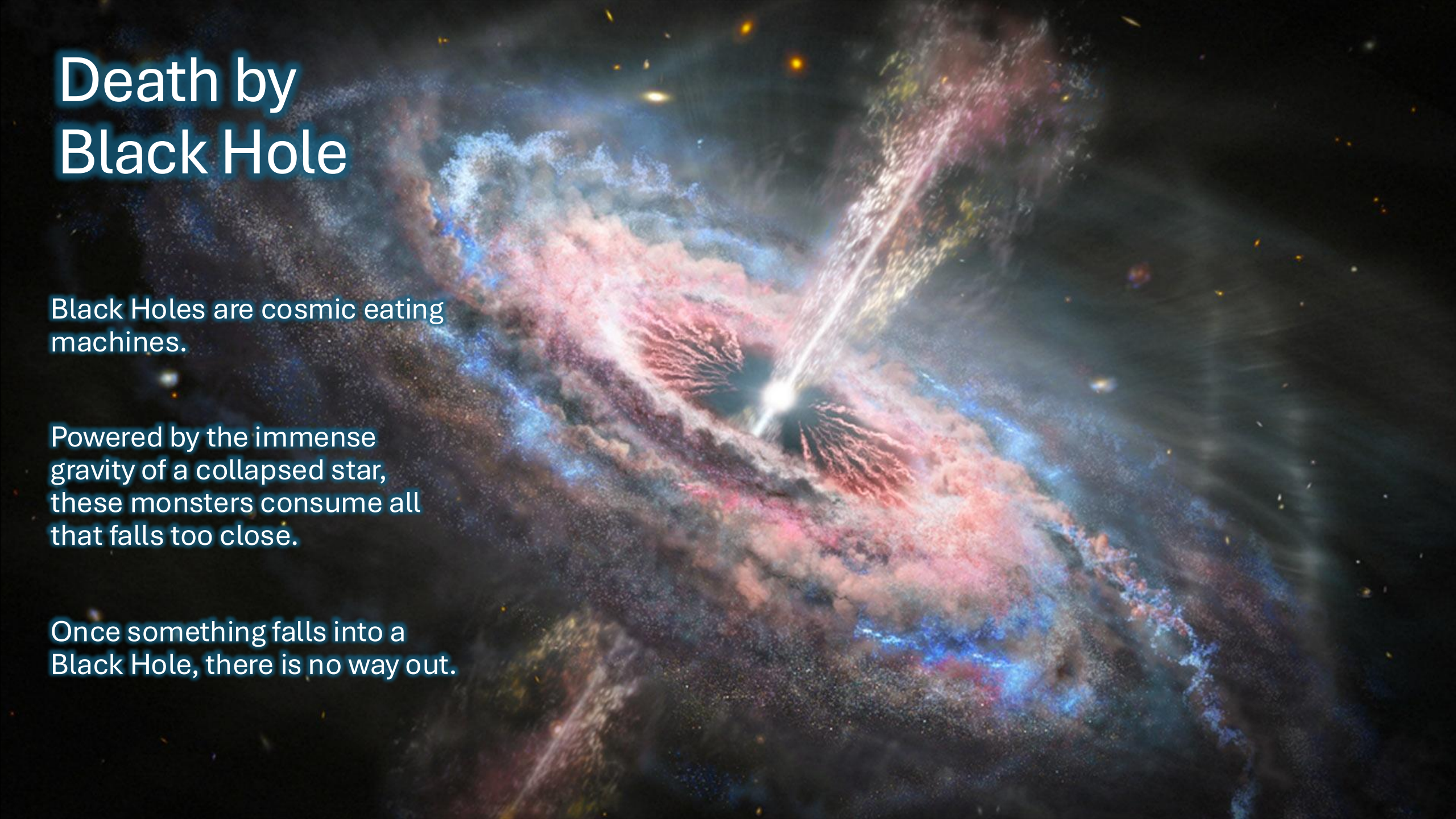
If you don’t want to ask me a question right now, you can send me an email to my KES address

I really want to hear your questions about the Universe!

robertclemenson@kes.essex.sch.uk

(Bonus Slides)

Death by Black Hole



Black Holes are cosmic eating machines.

Powered by the immense gravity of a collapsed star, these monsters consume all that falls too close.

Once something falls into a Black Hole, there is no way out.

Death by Black Hole

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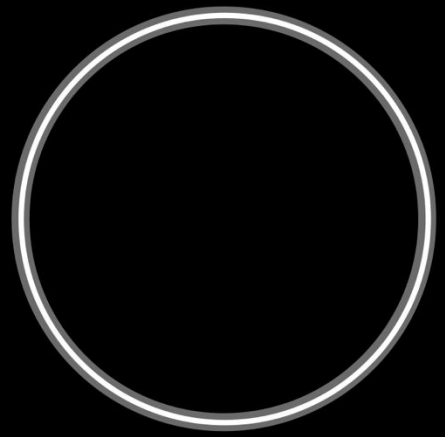
Once something falls into a Black Hole, there is no way out.

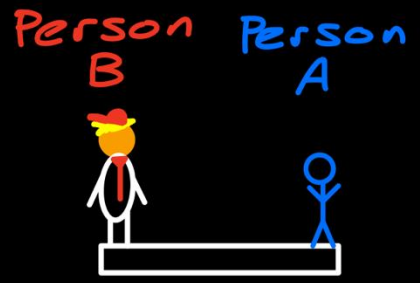
Black Holes are also natural time machines...

Time passes more slowly for people trapped near the horizon of a Black Hole.

Death by Black Hole

Person A pushes Person B into a black hole.





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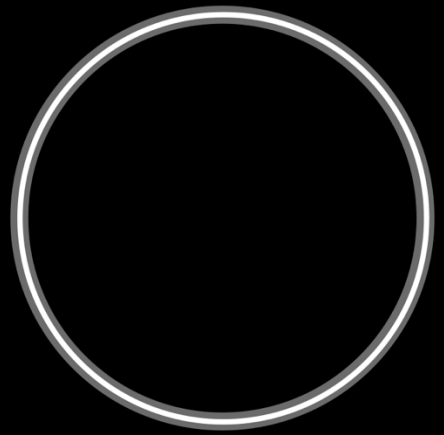


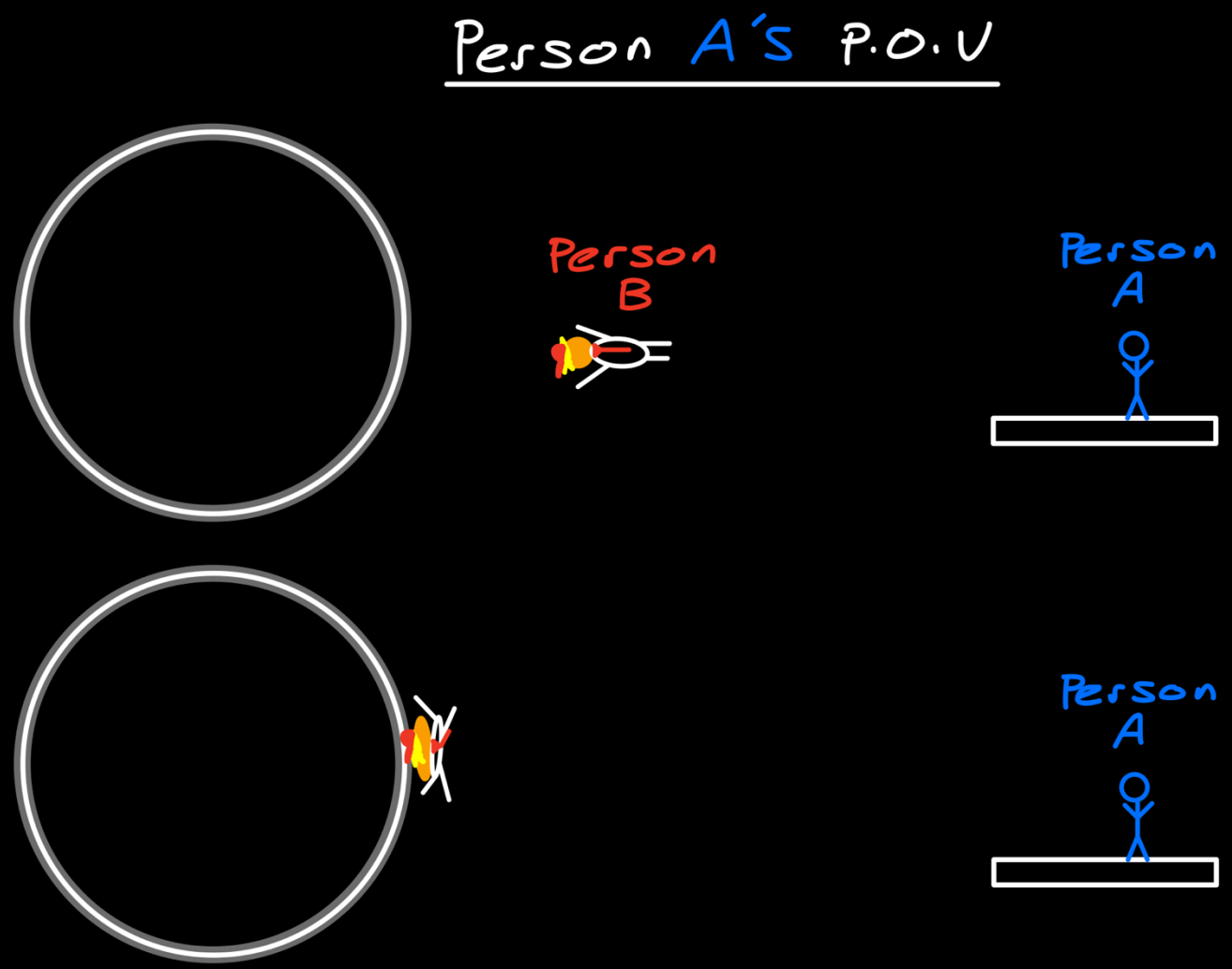
Let’s consider how this looks to each person involved…

Death by Black Hole

Person A's POV

From Person A's POV, person B never crosses the event horizon.

Instead, Person B smears along the horizon, become flatter and flatter over billions of years.



Death by Black Hole

Person B's POV

From Person B's POV, they pass through the horizon without much difficulty.

If the black hole is very small, they will be 'spaghettified' by the fall.

As Person B looks back at Person A, A begins to age rapidly.