

MARVEL THE SCIENCE OF



SUPERHEROES



EXPLORE THE REAL-WORLD SCIENCE BEHIND SUPERHUMAN POWERS

MARVEL THE SCIENCE OF
SUPERHEROES





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STUDIO
PRESS

INTRODUCTION



The phrase “comic book science” is normally used as an insult. It lets you dismiss something as made up, a meaningless fantasy, nutritionally-empty candy compared to the hearty good-for-you whole grain fibre of the real world. That metaphor may have gotten away from me a little bit, but you get the idea.

But you can't actually dismiss comic book science so easily. Because when we're writing comic books, we're not making things up whole cloth – we're looking at the world around us and being inspired by it. Yes, we're writing fiction – but we still want to reflect **the world outside your window**. It's a world that has alien Norse gods and super-powered teens and mutants who fly and mole men and doctors of doom, true, but it's also one that's still recognisably ours.

And that means the science is recognisable too, just... **turned up a bit**.

No, you and I can't produce electrical shocks like Miles 'Spider-Man' Morales can (outside of rubbing our sock-clad feet on the carpet, anyway), but electric eels can – and what if the same principle eels use also applied to human beings? No, you and I can't talk to plants like Mantis can (and get an answer back, anyway), but many animals communicate with each other – and what if the same principle applied here too? And no, you and I can't stick a tiny spider-shaped tracker on a car to track its location like Peter 'Spider-Man' Parker can, but...

...Wait, hold on a sec.

We can do that.

Long after Peter invented spider-tracers in **Amazing Spider-Man #11** back in 1964,

we invented them here in the real world by combining the signals from passive GPS satellites (first launched in 1978) with active mobile internet connections (first launched in 1991) and now they're used around the world to help people do everything from tracking down stolen bikes to locating lost luggage to simply finding their misplaced keys.

Huh.

Maybe some of this fantastic comic book science isn't so impossible after all.

And as you'll see in the pages that follow, many of the things that might seem incredible in a comic book aren't that far from the cutting edge of science where researchers, experimenters and inventors **really are** right now. Because in the end, super hero comics are **speculative**. We take the world and we build on it, imagining what might be – what **could be** – if we all work hard, think hard and maybe have a little good luck along the way. We writers don't always get it right – but then again, we're not trying to. We're trying to awe, to inspire, to supercharge the imagination in our readers in a way that, if we do our jobs right, lasts a lifetime.

And if some of those readers are so inspired that they wake up one day and decide “you know what? I bet there's a way I could **actually** make some of the best parts of my favourite comic books real...”

...Well, all the better.

Ryan North

– MSc and Marvel Comic Writer

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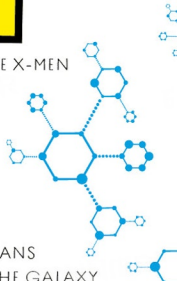
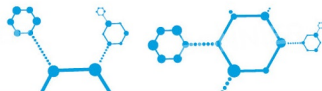
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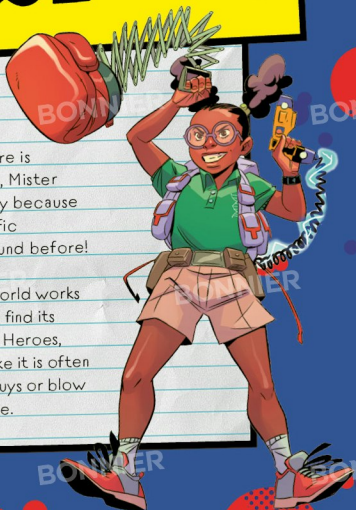


HOW SCIENCE WORKS IN THE MARVEL UNIVERSE

BY LUNELLA LAFAYETTE
(AKA MOON GIRL)

Hi, I'm Lunella Lafayette. I love science and I hope that after reading this book you will too! I might be the smartest person there is (yes, that includes Reed Richards, Mister Not-So-Fantastic), but that's only because I spent ages studying the scientific discoveries that people have found before!

Science is studying the way the world works and using experiments and tests to find its patterns, rules and laws. For Super Heroes, the study of science might look like it is often about finding ways to fight bad guys or blow things up, but it doesn't have to be.



THE MAIN USES OF SCIENCE FOR SUPER HEROES ARE:

SUPER POWERS

It's surprising how many different super heroes got their powers by accident. Spider-Man was bitten by a radioactive spider and the Hulk was blown up in a gamma explosion. That doesn't seem very scientific at all.

SAVING THE WORLD

Super Heroes wouldn't be Super Heroes if they didn't save the world, and sometimes the universe on a regular basis. Reed Richards once rebuilt the entire multiverse when it was destroyed.

EXPLORING

The Fantastic Four are explorers as well as Super Heroes – they got their powers from an experimental rocket flight. They have since visited hidden countries like Wakanda, and hidden dimensions like the Negative Zone.

ACCOMMODATION

Tony Stark has some of the best AI in the world in his house! You can ask it for anything!

ARMOUR

From Captain America's shield to Tony Stark's Iron Man armour, the best forms of defence have a scientific background. Black Panther's vibranium suit is an example of brilliantly applied science.

TRAVEL

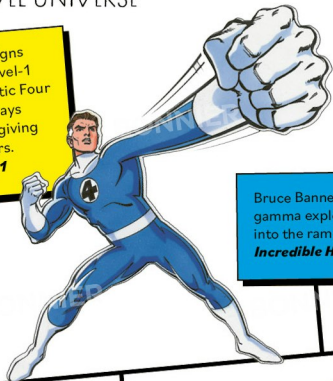
Iron Man has jets, the Falcon has wings and Spider-Man swings using his webs. Super Heroes love finding different ways to get around!



TIMELINE

OF THE GREATEST SCIENTIFIC EVENTS
IN THE MARVEL UNIVERSE

Reed Richards designs and builds the Marvel-1 rocket. The Fantastic Four are hit by cosmic rays on the test flight, giving them super powers.
Fantastic Four #1



Bruce Banner is caught in a gamma explosion, turning him into the rampaging Hulk.
Incredible Hulk #1



Tony Stark creates the first Iron Man armour.
Tales of Suspense #39



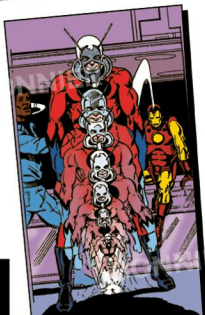
Captain America is thawed from suspended animation.
Avengers #4



Wolverine is given an unbreakable adamantium skeleton.
Marvel Comics Presents #92



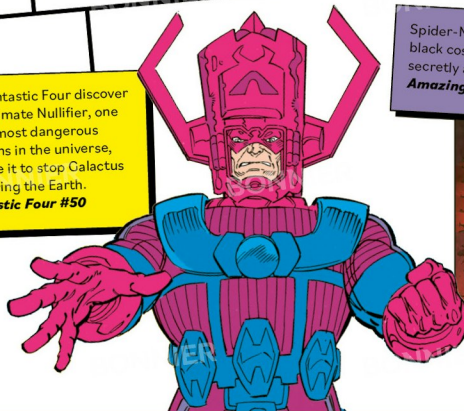
Hank Pym discovers Pym Particles, allowing him to shrink to the size of an ant.
Tales to Astonish #27



Peter Parker is bitten by a radioactive spider, giving him spider-powers.
Amazing Fantasy #15



The Fantastic Four discover the Ultimate Nullifier, one of the most dangerous weapons in the universe, and use it to stop Galactus devouring the Earth.
Fantastic Four #50



Spider-Man brings his black costume to Earth; it is secretly an alien symbiote.
Amazing Spider-Man #252





SPIDER-MAN

The science behind Spider-Man is very interesting. I like him, but I would definitely NOT have named myself after an arachnid. Also, that's not how I would've made those webs, but I like what he did there. It must be some type of polymer. Cool. I've met more than one spider-guy, but I'm not sure how many there are.

- HOW DID SPIDER-MAN GET HIS POWERS?
- WHERE DOES SPIDER-MAN GET HIS WEBS FROM?
- WHAT GADGETS DOES SPIDER-MAN HAVE?
- DO THE DIFFERENT SPIDER-MEN HAVE DIFFERENT POWERS?
- HOW DO DOCTOR OCTOPUS'S ARMS WORK?
- CAN THE VULTURE REALLY FLY?



SPIDER-MAN: POWERS



Bitten by a radioactive spider, Peter Parker gained amazing spider powers. After failing to save his beloved Uncle Ben from a deadly robbery, Peter vowed to use his powers to fight crime, saying that "With great power there must also come great responsibility". But what exactly are his powers, and could they exist in the real world? And how do Peter Parker's powers differ from the powers of Spider-Man Miles Morales?

THE SOURCE OF SPIDER-MAN'S POWERS

Peter Parker and Miles Morales both gained their powers when they were bitten by radioactive spiders. Peter was at a science exhibition when a spider that had been mutated by radiation bit him, forever altering his DNA. Miles was bitten by a different, genetically-modified spider, which gave him his powers.

IN THE REAL WORLD

While almost all spiders can produce venom, only 12 species of spider have been known to bite humans. Spider bites are very uncommon because spiders are not aggressive, and the most common reaction to a spider bite is an itch or low-level pain. The deadliest spider in the world is the *Atrax robustus*, or Sydney funnel-web spider, which is native to Australia. Without medical help, a bite from this spider can kill in just 15 minutes!



SPEED

The fastest species of spider runs at approximately one mile an hour, which doesn't seem particularly fast, especially given that Olympic runner Usain Bolt has been able to reach speeds of 23 mph. However if you take into account that a human is over 140 times bigger than a spider, then proportionally a human-sized spider would be able to run at over 140 mph!



SPIDER-SENSE

One of Spider-Man's most useful powers is a 'spider-sense' that warns him of danger and keeps him one step ahead of villains. It doesn't just work for danger, Spider-Man was once able to detect that the Chameleon had disguised himself as a civilian because he had a strange feeling about him.



IN THE REAL WORLD

Real life spiders' legs are covered in tiny hairs called trichobothria. They can detect tiny changes in the air which warn them of the presence of predators. Spidey could have lots of tiny hairs that we can't see. Though it doesn't account for how he can detect people who are just thinking about attacking him!

WALL CRAWLING

Spider-Man also has the ability to climb up walls and cling onto nearly any surface. He has often used this ability to climb in to villain's secret lairs - or play practical jokes on J Jonah Jameson!

IN THE REAL WORLD

Spiders and geckos can crawl up walls by using special bristles in their feet called setae. Scientists have recreated this effect using patches containing silicones, plastics and arbon nanotubes. These patches can be attached to hands and knees, allowing people to climb almost any surface - just like Spider-Man.



STRENGTH

Spider-Man has the proportionate strength and speed of a spider, which (depending on the type of spider) would mean that he could pick up anything up to the weight of a double-decker bus. This is over 25 times stronger than the best Olympic weightlifter!

IN THE REAL WORLD

Some creatures, such as electric eels, can store and discharge electricity when they feel threatened. The strongest electric eel shock was measured at 650 volts, which is nearly three times the strength of electricity that comes from a wall plug. So handle with care!

VENOM STRIKE

Miles Morales has many of the same powers as Peter but he also has several of his own. Venom strike is a powerful blast of electricity from his hands and is an effective way to bring down bad guys, including Venom!



SPIDER-MAN: GADGETS



Peter Parker isn't just a courageous and incredibly strong super hero, he's also a brilliant inventor. Peter always excelled in science at school and he has often been able to use his advanced scientific knowledge to defeat his opponents.

WEBS

As soon as Peter Parker became Spider-Man he invented a substance to mimic a spider's web. Spider-Man's webbing is strong, can be stored in liquid form in cartridges in his belt and dissolves an hour after being used. This brilliant invention is used to swing through New York, tie up bad guys and even sometimes replace his clothes when they get ripped or lost!

IN THE REAL WORLD

Real spider silk is incredibly strong and is tougher than Kevlar. Researchers at Cambridge University in the UK have developed an artificial spider silk that is stronger than steel. It is environmentally friendly because it uses a material called a 'hydrogel', which is 98 per cent water. At the moment they are only able to create small amounts of artificial spider silk, so it will be a while before anyone can use it to swing around Manhattan.



THE CLASSIC SPIDER-MAN COSTUME

Spider-Man's costume is such a brilliant design that it has been an integral part of the character for over 60 years. It's skin tight, which allows freedom of movement, but covers him completely to allow him to keep his identity secret.

IN THE REAL WORLD

Professional athletes often wear tight-fitting shorts or body suits, similar to Spidey's costume. These outfits are not only comfortable, they can also have benefits in performance. The tight fit helps prevent wind resistance making an athlete more aerodynamic. Compression from the clothes has also been shown to increase muscle efficiency and improve recovery after exercise.



SPIDER-TRACERS

When Spider-Man needs to keep tabs on an escaping villain he uses a Spider-Tracer, a small spider-shaped electronic device that can track bad guys. First appearing in **Amazing Spider-Man #11**, the device was way ahead of its time.

IN THE REAL WORLD

GPS, which stands for Global Positioning System, uses satellites orbiting the Earth to calculate the location and speed of devices that have this technology. As almost all smart phones have GPS, this technology is now very common. If you look for directions or tag a location on social media, you are using a type of tracking. This technology can also be used to find the location of friends or family, if the feature is enabled.

HORIZON LABS

Peter Parker has a brilliant scientific mind and for a while he worked at Horizon Labs, a company at the forefront of technological research. While at Horizon Labs, Peter created technology for Spider-Man, which was then reused in other inventions. The technology for bulletproof Spider Armour was used to create a special motorcycle helmet, and Spider-Man's stealth suit was the basis for noise reducing headphones.

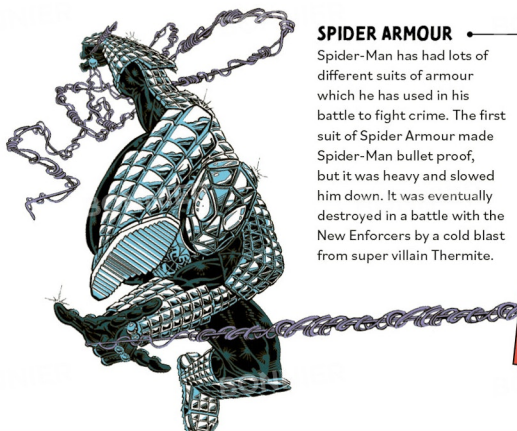


SPIDER ARMOUR

Spider-Man has had lots of different suits of armour which he has used in his battle to fight crime. The first suit of Spider Armour made Spider-Man bullet proof, but it was heavy and slowed him down. It was eventually destroyed in a battle with the New Enforcers by a cold blast from super villain Thermite.

IN THE REAL WORLD

In 1965, a scientist invented a material called Kevlar which is lightweight, heat-resistant and extremely strong. Depending on the type of Kevlar, it is strong enough to stop some types of bullets. Kevlar, and other similar materials are now used by soldiers and law enforcement for protection. Full body suits do exist but they are not fully effective against all weapons.



SPIDER-MAN: ENEMIES

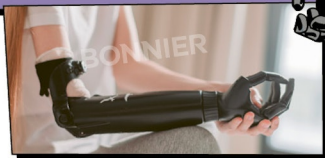
Spider-Man has perhaps the biggest rogue's gallery of any super hero, with a wide range of colourful villains all trying to destroy him. Even when they team up they still can't beat the wall-crawler!

DOCTOR OCTOPUS

In a tragic accident, Doctor Otto Octavius was fused to a set of robotic arms, which infiltrated his mind and led him to a life of crime. The arms are linked to his brain and can be controlled using his mind. They are made from a super-strong titanium steel alloy, can extend up to 24 feet and can even be controlled telepathically when they are not connected to Doctor Octopus.

IN THE REAL WORLD

Prosthetics have been found throughout history - a 3000-year-old Egyptian mummy was discovered with a prosthetic toe made from wood and leather! More recently, researchers have been working to link prosthetic arms to a user's nerves, muscles and skeleton. This amazing technology allows patients to experience the sensation of touch through an electronic limb which is called neuromusculoskeletal prostheses.



VULTURE

Adrian Toomes, known as the Vulture, uses the power of flight to help him commit crimes. The Vulture's wings use an electromagnetic harness that gives him control of his flight. When electric currents interact with a magnetic field this is called electromagnetism. No technology exists that uses electromagnetism for flight but research has shown that some butterflies' wings emit waves that are on the electromagnetic spectrum. After their first encounter, Spider-Man built an Anti-Magnetic Inverter to counter the Vulture's electromagnetic harness, allowing Spider-Man to defeat him.

ELECTRO

Supervillain Max Dillon got his powers after being struck by lightning while working on a power line. Electro is a powerful living electric capacitor; he is able to store electricity and then discharge it in powerful bolts.

IN THE REAL WORLD

Have you ever felt a small shock when you touch something metal or another person? This is caused by static electricity, when a very low-level electric current passes from your body to the object you are touching. Everything is made up of atoms and atoms contain smaller particles called electrons, which spin around the outside of the atom but can break away. When two objects touch each other, electrons can move between them. When these electrons build up with nowhere to go, they can create static electricity.



LIZARD

One of Spider-Man's more tragic villains, Doctor Curt Connors is a researcher who became obsessed with finding a way to replace his missing arm. He injected himself with lizard DNA, which did allow him to regrow his arm, but unfortunately temporarily turned him into the Lizard, a rampaging evil monster. The Lizard has returned many times as one of Spidey's most savage villains.

IN THE REAL WORLD

Some reptiles can regrow their tails if they are cut off. Small reptiles like lizards, geckos and iguanas can sever their tails as part of a self-defence mechanism - there is a line of weakness in their tail where it can break if the reptile is trapped and needs to escape. Although the tail will eventually grow back, it isn't exactly the same and won't have the skeletal structure of the original tail.



SPIDER-MAN: ENEMIES

GREEN GOBLIN

Several villains have taken the identity of the Green Goblin, but the best-known is Norman Osborn, industrialist and father of Peter Parker's college roommate, Harry Osborn. In his first battle with Spider-Man, the Green Goblin attacked him with pumpkin-bombs (bombs in the shape of pumpkins) while flying a specially constructed turbo broomstick, which he would later swap for a Goblin Glider.



IN THE REAL WORLD

Decades after the Green Goblin demonstrated his flying Goblin Glider in the pages of *Amazing Spider-Man #17*, technology has finally caught up with him. An inventor has been able to create a hoverboard with a series of rotors which spin fast enough to support a human hovering over the ground. It's the same technology that you see in small drones, but on a much wider scale. There have even been sightings of this awesome hoverboard in the Green Goblin's home of New York City!

MYSTERIO

Quentin Beck is the master of illusion, a special effects artist who became a villain and used his talents to commit crimes. Misterio doesn't have any super powers or special abilities, but instead he uses stage illusions, special effects and even hypnotism. In one of his greatest feats in *Amazing Spider-Man #67*, he convinced Spider-Man that he had been shrunk to the size of a spider! Misterio's tricks involve elaborate plans and special effects, but as they don't involve super powers they could all work in the real world.



RHINO

Nothing can cut through the skin of Aleksei Sytsevich, a not-very-bright Russian mobster who had super-hard skin permanently grafted to himself as part of an experimental procedure. The Rhino has bulletproof, unbreakable skin and massively enhanced super strength. Although the Rhino thinks he is in the top tier of superhumans, he did end up in a coma when he battled the Hulk. Twice.

IN THE REAL WORLD

Scientists think they have created a type of 'bulletproof skin' by combining human skin cells and spider silk, and early research seems to show it is strong enough to stop a speeding bullet. No human has worn this skin though since it is still very much at the experimental stage.

VENOM

Eddie Brock gets his powers from an alien creature known as a symbiote, a living creature that forms a bond with its host and was originally brought to Earth to be Spider-Man's costume. When Spider-Man split from the costume it resented him, and bonded with Eddie. The Venom suit can change size, shape and colour, and it gives Eddie superhuman strength, speed and reflexes. The symbiote suit has a mind of its own and can bond with other hosts.

IN THE REAL WORLD

Some liquids can mimic the way that the Venom costume moves, in a way that seems to defy gravity. Ferrofluids are made up of tiny magnetic iron fragments suspended in a liquid. They look like a black ooze, which can be manipulated, using magnets, into moving in a way that looks like the Venom symbiote.



SPIDER-MAN: ALLIES



Spider-Man has teamed-up with countless other heroes in his crime fighting career, but there are some that he counts as friends.

DAREDEVIL

A childhood accident robbed Matt Murdock of his sight, but enhanced all his other senses beyond normal human ability. Matt has a 'radar sense' that allows him to perceive the world around him, and his enhanced senses give him abilities far beyond a normal person. A skilled martial artist, he protects Hell's Kitchen in New York as the super hero Daredevil.

IN THE REAL WORLD

Daredevil's radar sense is similar to echolocation, which is used by bats. A bat will send out a sound and then wait for the sound waves to bounce off an object and produce an echo. When the bat hears the sound of the echo, it can determine the size and location of that object. Human ears are less sensitive than bat ears. When sound waves hit a human's ear drum they trigger nerve signals that are sent to the brain and interpreted as sounds. In theory, if someone's ears were more sensitive to sound, their brain could interpret a much wider range of sounds.

BLACK CAT

A brilliant cat burglar, Felicia Hardy was initially one of Spider-Man's villains, but the two fell in love and briefly dated. The Black Cat didn't have any super powers when she first appeared in *Amazing Spider-Man #194*, but later she asked the Kingpin to give her super powers as a way of keeping up with Spider-Man. She developed a 'bad luck' field, which meant that anyone who tried to attack her developed instant bad luck; their guns would jam, they would trip over their shoelaces or something else unlucky would happen to them.

IN THE REAL WORLD

There are lots of superstitions about luck, many involving black cats. In some parts of Scotland and Wales black cats are seen as good luck, bringing prosperity and wealth. However, other cultures have traditionally associated black cats with witchcraft, and see them as unlucky. In the real world you can't change how lucky you are, because if you could then you would win the lottery every week!

BEN REILLY

It isn't easy being Spider-Man, but it's much harder being a clone. Ben Reilly is a clone of Peter Parker created by the Jackal - he has all of Peter's abilities and a copy of his memories. For a long time, Ben thought that he was the original and Peter was the clone, and Ben had a hard time coming to terms with the fact that he is not the original Spider-Man.



IN THE REAL WORLD

No humans have ever been cloned in real life but other animals have been. In 1996 scientists in Scotland cloned a sheep called Dolly, and in 2018 scientists in China cloned two long-tailed macaque monkeys. It is possible to clone a human embryo, but there is no solid scientific evidence that anyone has cloned a human, and it is illegal and unethical. Most of the scientific research into human aging has been about how to stop it, not how to speed it up, so it's unlikely we'll see cloned humans anytime soon.



SPIDER-WOMAN

Jessica Drew was experimented on as a child and was subjected to radiation that contained spider DNA. She developed spider-based powers including super human strength, speed, stamina, agility and reflexes. She is also able to shoot electricity from her hands in discharges that she calls venom blasts. She's also immune to radiation and most poisons.

IN THE REAL WORLD

Scientists have been working on understanding DNA for years. DNA (short for deoxyribonucleic acid) is the code that tells your body how to grow into you. Changing this information is called genome editing, and would involve rewriting the instructions that make up the building blocks of a human being. Scientists have been studying genome editing as a way of preventing diseases, and are looking at how genetic sequences that cause diseases can be altered.





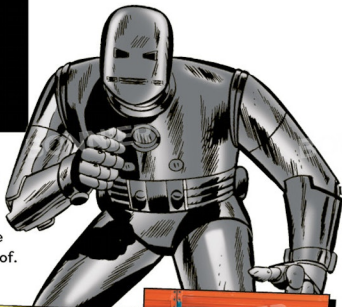
THE AVENGERS

The Avengers have some incredible tech but they seem to mainly use it for blowing things up. What a waste! They're always fighting aliens or time-travellers or monsters or whatever. Black Panther seems nice though, I haven't met him but I HAVE been to Wakanda and seen some of the labs there with Shuri. Note to self: they do NOT like it when you bring a huge red dinosaur into Wakanda. Even if it was a clone. Long story.

- WHEN DID IRON MAN FIRST MAKE HIS ARMOUR?
- HOW MUCH DOES EACH SUIT OF IRON MAN ARMOUR COST?
- WHAT ELSE HAS TONY STARK INVENTED?
- WHAT POWERS DOES CAPTAIN AMERICA HAVE?
- HOW STRONG IS THE HULK?
- WHAT IS VIBRANIUM?
- WHAT IS THE QUANTUM REALM?



IRON MAN: ARMOUR



Genius. Super Hero. Role model. These are all words that Tony Stark uses to describe himself. Tony is Iron Man, the armoured Avenger who uses advanced technology to power his state-of-the-art suit. There is no problem in the world that Tony Stark cannot think his way out of.

MODEL 1

When Tony Stark was injured and captured by terrorists he created a suit of robotic armour. The first Iron Man suit kept Tony alive by keeping his heart beating after shrapnel pierced his chest, but the suit was also strong enough to resist gunfire and gave Tony super-human strength. Tony used the suit to escape his captors, but his fellow captive and the suit's co-creator, Ho Yinsen, died in the attempt. The first suit might seem a little basic, but Tony has been upgrading it ever since.

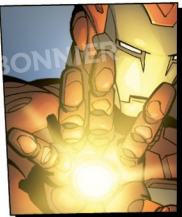
IN THE REAL WORLD

The best metal for constructing an Iron Man-like suit wouldn't be iron, it would be something less dense but stronger, like titanium, that could withstand bullets and blasts. Several engineers have made super-strong, powered armour suits called exoskeletons, that are used in the construction industry to lift heavy machinery, building supplies or equipment.



REPULSOR BLASTS

One of Tony Stark's most powerful inventions is the repulsor technology that powers his suit and the blasts that come from his gauntlets. These powerful beams of energy shoot directly from his palms. Not only do the repulsor rays help Iron Man to stabilise himself when he is flying, but they also act as a weapon with various settings. A light blast from a repulsor ray can stun an enemy, while a strong blast can cut through concrete.



IN THE REAL WORLD

An inventor in Germany has built a palm-mounted laser that runs off two AA batteries. The laser isn't quite as strong as Iron Man's repulsors, but it can set fire to a match and cut through balloons!

FLIGHT

After returning to America with the Iron Man armour, Tony Stark soon added jet boots which gave him the ability to fly or leap incredibly high. As the suit has been upgraded it has become faster, and can now fly several times faster than the speed of sound - much faster than a military fighter plane. Tony has spent years perfecting the skill of flying in an Iron Man suit and is an ace pilot.

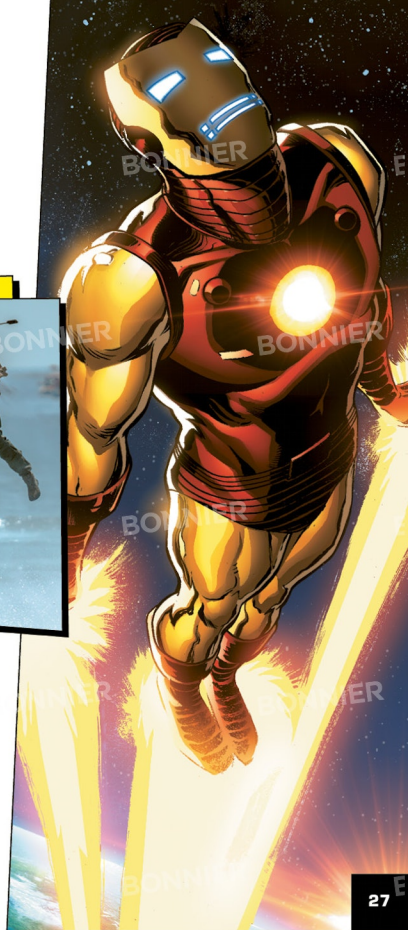
IN THE REAL WORLD

The world record for the fastest speed in a body-controlled jet engine powered suit was set in 2017 and is an amazingly fast 85.06 mph. The suit is powered by five micro-jet engines, two on each arm and one on the back, and can fly as high as 12,000 feet. The downside is that the huge amount of power used to run the suit means that it can only fly for three or four minutes.



COST

How much would it cost to build and run a suit of Iron Man armour? Although money is no object to billionaire playboy Tony Stark, it isn't cheap. At times Tony has claimed that specific suits of armour cost anything up to four billion dollars, but he's not always the most reliable source. A real-life flying suit will only set you back \$450,000, but that doesn't include armour, repulsor rays, an onboard computer or a chest-mounted uni-beam...



IRON MAN: ARMOUR

HULKBUSTER

Tony Stark always hopes for the best but plans for the worst, which is why he built a suit of armour that was capable of taking down his friend Bruce Banner - the Hulk. The Hulkbuster armour was an upgrade that could be bolted on to his existing armour, making it stronger and tougher - he was able to punch with a 175-tonne force, about the same strength as the main engine on Apollo 11, the first space ship that landed on the moon. In its first outing the Hulkbuster was able to land some solid blows on the Hulk but eventually the two heroes were able to calm down and discuss their differences amicably.



IN THE REAL WORLD

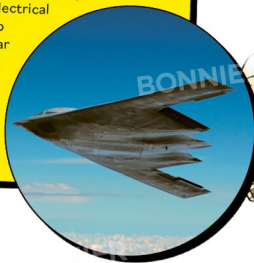
Powered exoskeletons are wearable machines that use motors and hydraulics to give extra strength and stamina to the wearer. The strongest of these powered exoskeletons probably wouldn't be powerful enough to take down the Hulk, but they are strong enough to pick up a human the size of Bruce Banner.

STEALTH ARMOUR

The Stealth Armour was designed to get Iron Man into places where he wasn't meant to be. It is covered in radar-absorbing material and jams incoming radar and sonar signals. It was first used in a rescue mission in East Germany to save Tony's girlfriend at the time, Bethany Cabe. Tony knew that if he was captured it would cause an international incident so he used the Stealth Armour to sneak into a fortified compound without anyone detecting him.

IN THE REAL WORLD

Engineers in America have created a 'meta-material' which can hide an object from radar detectors. This 2.4 mm thick skin is made up of rows of very tiny rings that store electrical energy. It can trap and suppress radar waves at different frequencies, meaning that the object is invisible to radar detectors.



DEEP SPACE SUIT

Tony Stark spent some time as a member of the Guardians of the Galaxy and he needed a suit that could keep up with their adventures in deep space. The suit allows Tony to breathe in space, while keeping his regular weapons like rocket launchers and repulsor rays. It can fly at warp speed, which allows him to travel between planets.

IN THE REAL WORLD

Ever since man has dared venture into space, astronauts have been using space suits to stay alive. The first space suit worn by a human in space was worn by Russian cosmonaut Yuri Gagarin in 1961. It was called the SK-1 pressure suit and was based on a diving suit, but with a nylon oversuit. It had a mirror sewn into the sleeve so he could look at hard-to-see switches and gauges. Current space suits are much more advanced and use state-of-the-art life support technology to monitor astronauts' health while in space.

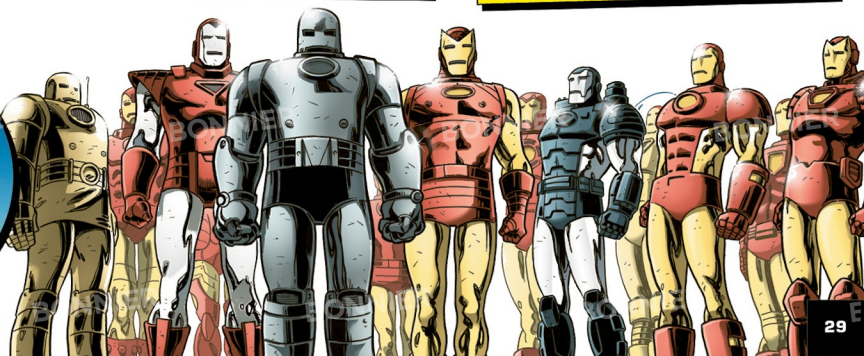
BLEEDING EDGE

Tony Stark has designed an Iron Man suit so advanced that it can fit inside his own body.

The Bleeding Edge armour is made up of nano-machines that Tony can mentally command to turn into anything he wants, be that weapons, shields or even just slightly more fashionable clothing. The nano-machines are self-repairing and are powered by repulsor technology mounted in Iron Man's chest. This armour is immensely powerful, and at times only limited by Tony Stark's imagination.

IN THE REAL WORLD

Nanorobotics is a real technology involving robots that are only a nanometer (one billionth of a metre) in size. Nanomachines are still in the research and development phase and there's a long way to go before they are commercially available, but the potential use in many fields like medicine is amazing. A really tiny machine would be able to reach parts of the body that are currently very difficult or dangerous to reach. Machines the size of molecules could go into a patient's body to deliver drugs, check vital signs and even fight infections by destroying invading cells.



IRON MAN: INVENTIONS

The Iron Man armour is Tony Stark's most well-known invention, but it's almost impossible for Tony to stop creating new things. From new buildings to space stations, Tony Stark is constantly building new and brilliant Stark Tech.

STARK TOWER

A 93-storey building in the middle of Manhattan, Stark Tower is a gleaming beacon of modern architecture. The top three floors were designed to be used as a bachelor pad for Tony, but were instead given to the Avengers. The Tower is full of incredible technology and can monitor and assist Tony and the Avengers with everything they need. Spider-Man liked the building so much that he and Mary Jane moved in there!

IN THE REAL WORLD

Buildings are getting smarter and smarter! A Norwegian architecture firm has recently created an 'energy positive building' which creates more energy than it uses. A technology called photovoltaics converts the light that hits the building into energy, and it does this so efficiently that it actually adds power back into the main electricity grid.



STARK SPACE STATION

Not content with having the best inventions on Earth, Tony Stark ventured into space. The Stark Space Station is a global research station, orbiting 23,000 miles above the Earth and is full of the latest scientific equipment. The Stark Space Station has been attacked several times, and was once destroyed by the Technovore, a parasite made of nanites that can absorb technology. The station has since been rebuilt.

IN THE REAL WORLD

The International Space Station is currently orbiting about 225 miles above the Earth. It is also a research laboratory, where experiments are carried out in microgravity. It doesn't have someone like Tony Stark to bankroll it, so the ISS is a collaborative project involving space agencies from the United States, Russia, Japan, Europe and Canada. The ISS is modular, meaning that whole sections can be added, upgraded or removed. It is the most expensive single item ever constructed, and the total cost is well over \$150 billion.

PROJECT ESCAPE

The eScope was a virtual reality world created by Stark Unlimited, allowing humans and artificial intelligences (AIs) to interact on a digital platform. It was controlled by a sophisticated AI called Motherboard, who eventually tried to trap Tony in the virtual reality simulation.

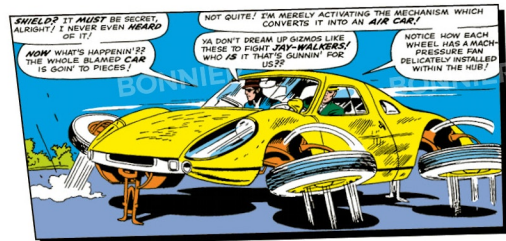
IN THE REAL WORLD

Virtual reality sets can be found in many shops today! As well as video games, virtual reality sets are used for training doctors, soldiers, astronauts, pilots and nuclear power plant operators, as well as conducting scientific research. There are even virtual reality roller coasters, where riders wear virtual reality headsets while sitting on the moving ride.



FLYING CAR

Tony Stark has had a few flying cars; one of them was a version of the Hulkbuster armour that could turn itself into a flying car. Flying cars do exist in the real world, but most of them require wings or rotors to fly, and sadly none of them turn into a suit of armour that could battle a Hulk-level superhuman.



THE AVENGERS: CAPTAIN AMERICA

Several heroes have taken the mantle of Captain America, serving as a sentinel of liberty and a beacon of freedom. Captain America is more than one person, he is a symbol of standing up for what is right. Steve Rogers started the legacy of Captain America during the darkest days of World War II, but other heroes have picked up the shield.

SUPER SOLDIER SERUM

During World War II, Doctor Abraham Erskine created a medical process, known as the Super Soldier Serum, which was designed to unlock the potential of any subject. The first recipient was Steve Rogers who was immediately turned into a peak human specimen. Steve gained superhuman-enhanced strength, durability, speed and endurance, as well as accelerated healing and decreased aging. Doctor Erskine was shot shortly after Rogers was given his powers, and this serum has never been successfully replicated.

IN THE REAL WORLD

Scientists in Ohio have been working on different treatments that increase muscle mass and strength. These treatments could help people with degenerative muscle diseases, where muscles waste away. The treatment works by stopping genes that halt muscle growth, so muscles become bigger, up to a certain point. The treatment takes six weeks, which is much longer than the few seconds it took for Steve Rogers to become a super soldier.



SAM WILSON'S WINGS

The original wings used by Sam Wilson were designed by Black Panther and made of lightweight titanium. They used solar-powered receptors to power jets under the wings and in his boots, allowing him to fly at speeds of up to 250 mph. The wings have since been upgraded and are now strong enough to protect Sam from bullets, projectiles and weapons.

IN THE REAL WORLD

Powered electric wingsuits allow gliders to control their flight to a degree that is pretty close to Sam Wilson, just by using a lightweight battery and two propellers. At the moment, you need to jump out of a helicopter as you can't take off from the ground, which sounds pretty scary!

THE WINTER SOLDIER'S ARM

James Buchanan 'Bucky' Barnes was the best friend of Steve Rogers, before he was captured and brainwashed into becoming a fearsome assassin cyborg. He has since managed to break his programming, and briefly took over as Captain America when Steve Rogers was thought dead. Bucky's left arm is a cybernetic prosthetic, which gives him superhuman strength and speed. It can even work when it is not attached to his body!



CAPTAIN AMERICA'S SHIELD

Cap's red, white and blue shield is an iconic symbol, not only of the character, but of freedom itself. The shield is a disc made of a lightweight Vibranium alloy. It is virtually indestructible and nearly always returns to Captain America whenever he throws it. It's bulletproof and fits neatly on Cap's back whenever he isn't using it.



IN THE REAL WORLD

It's possible to create a heavy-duty shield that can stand most blows, and it's possible to create a lightweight shield that can bounce off things and return to the thrower's hands, but so far nobody has managed to combine the two.

THE AVENGERS: THE HULK

Caught in the heart of a gamma bomb explosion, Doctor Bruce Banner was transformed into something powerful and dark. The Hulk has taken on different forms during his super hero career, but has consistently been one of the strongest beings in the Marvel Universe.

GAMMA RADIATION

Doctor Bruce Banner ran to save teenager Rick Jones from a nuclear explosion, throwing himself in the way of the blast. The gamma radiation from the bomb changed Banner's genetic structure forever, allowing him to manifest his rage as a rampaging, super-strong Hulk. The gamma radiation is stored in his body, powering the Hulk's form.

IN THE REAL WORLD

Gamma radiation is released by nuclear explosions, but it doesn't turn you into a Hulk. Gamma rays are very dangerous - they can quickly damage bone marrow and internal organs and can be fatal. Nuclear power plants have very strict safety procedures in place to prevent any radiation leaking and most people would never be exposed to enough radiation to cause a danger to their health.

ANGER MANAGEMENT

The Hulk is a being fuelled by pure rage, as he puts it, "the madder Hulk gets, the stronger Hulk gets!". The Hulk's strength only seems to be limited by how angry he is and appears to have no upper limit. The Hulk is so strong that his punches can cause earthquakes, destroy asteroids and smash whole planets!

IN THE REAL WORLD

You really do get stronger when you are angry. Studies show that people can be up to 20 percent stronger when they are feeling intense levels of anger. This is due to your heart beating faster which pumps more oxygen around your body, and your concentration increases allowing you to focus better. A study in America showed that players could throw a football harder and further when they were angry.



WORLDBREAKER

Could you destroy a planet with a punch? The Hulk gained the name "Worldbreaker" because of the incredible levels of power that he can channel. Normally the Hulk will control the full force of his power, but during a fight in another dimension he once shattered an entire planet with one punch.

SHE-HULK

Jennifer Walters was given a blood infusion from her cousin, Bruce Banner. His gamma-irradiated blood changed her, turning her into the super strong She-Hulk. While not as strong as her cousin, She-Hulk has much better control of her transformations than Bruce Banner.

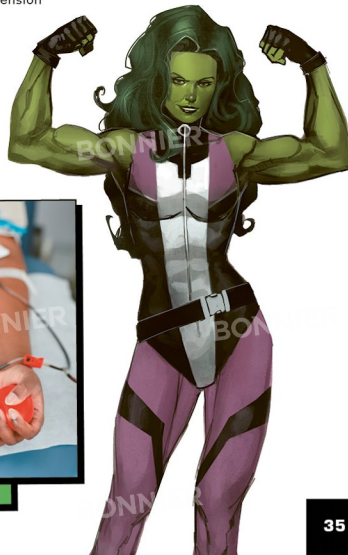
IN THE REAL WORLD

Blood transfusions are normally used to cure radiation poisoning, not transfer it. Some things, such as bacteria, viruses and parasites can be transmitted through blood transfusions, so it's possible that a super power could be passed on if it was carried in the blood. Jennifer and Bruce are cousins, which means they would have some similar genetic material, so maybe being a Hulk runs in the family!



IN THE REAL WORLD

While he might look big, the Hulk is relatively small compared to the size of a planet, and all the force would need to be transmitted through his fist. Even if his fist was as dense as a black hole and moved at the speed of light, it probably wouldn't be strong enough to destroy a planet. The asteroid that killed the dinosaurs was as powerful as 10 billion atomic bombs, and that only damaged the surface of the Earth.



THE AVENGERS: BLACK PANTHER

T'Challa is the king of the hidden African nation of Wakanda, and as the Black Panther he protects and rules over his kingdom. Wakanda is one of the most technologically advanced civilisations in the world, using Vibranium to achieve the impossible.

VIBRANIUM

Vibranium has properties like no other element on Earth. It absorbs vibratory or kinetic energy, which means that things made from Vibranium can withstand incredible blows. Black Panther's suit is made from Vibranium - it's amazingly strong and can store and release kinetic energy on command.

IN THE REAL WORLD

We don't have anything exactly like Vibranium, but the closest thing we have is graphene. Graphene is one of the thinnest substances ever made. It's a single sheet of carbon atoms in a honeycomb pattern. It's very flexible and 150 times stronger than steel. At the moment we can't mould graphene to create a suit like Black Panther's, but as more research on graphene is completed, it could be possible in the future.



THE METEORITE

All the Vibranium in Wakanda comes from a Vibranium meteorite that hit the Earth hundreds of thousands of years ago. Wakandans have been mining Vibranium for centuries, but the Vibranium Mound (known in Wakanda as the Mena Nga) is still strong. It's an important monument in Wakanda, and is often a target for villains like Doctor Doom, who tried to steal the source of Wakandan power.

IN THE REAL WORLD

A meteorite really did hit Africa hundreds of thousands of years ago. The Gibeon Meteorite was a massive iron meteorite that hit Namibia and was made up of an iron-nickel alloy that also contained cobalt and phosphorus, but sadly no vibranium. It was used by the local people to make tools, jewellery and weapons.



HIDDEN WAKANDA

The true nature of Wakanda stayed hidden from the outside world for years - it was a secretly advanced country that isolated itself from its neighbours. T'Challa's father, T'Chaka, saw that the world was changing. To keep his country safe from the outside world he secretly sent his scholars out to study abroad and report back to Wakanda.

IN THE REAL WORLD

Hiding a whole country would be very hard indeed. Either you would have to swear all six million Wakandans to secrecy, or make sure that nobody could ever leave the country. One way to hide Wakanda would be to use a giant hologram. The world's biggest holographic display is only 20 metres long and 5 metres high and to hide an entire country you would need to develop a huge display. This also wouldn't solve the problem of what would happen if someone tried to pass through!

KIMOYO BEADS

One of the most popular forms of technology in Wakanda, Kimoyo beads form a bracelet around the wearer's wrist with each bead taking a different function. One bead might provide medical knowledge, another can be used to communicate via hologram, while other beads can be added for protection, tracking or vehicle control. Kimoyo beads are the pride of many Wakandans, but they will not work outside Wakanda.

IN THE REAL WORLD

You can already buy smart watches that monitor your vital medical signs, can be used for communication and store data, but they aren't as advanced as Wakandan technology. Kimoyo beads use three dimensional holograms and virtual reality in a way that is years ahead of current technology.



THE AVENGERS: ANT-MAN



Hank Pym, the first Ant-Man and founding member of the Avengers, developed Pym Particles which could change a subject's size and mass in seconds. Years later, Scott Lang, a scientist and (semi) reformed criminal took on the mantle of Ant-Man with Hank's blessing.

PYM PARTICLES

Hank Pym discovered Pym particles, which he used to shrink himself to the size of an ant. Pym particles work by moving mass into the 'Kosmos Dimension', which allows Ant-Man to shrink whenever he wants to. Despite being much smaller, Ant-Man still keeps his weight and mass, which means he packs quite a punch!

IN THE REAL WORLD

A tiny Hank Pym would have lots of problems, from being too small to breathe properly, to having his DNA unravel as he shrunk. Hank's lungs and vocal chords would also shrink to the point that it would either be impossible to hear him, or he would be hilariously squeaky and high pitched!

COMMUNICATING WITH ANTS

When he first used Pym particles, Hank Pym got stuck inside an anthill and turned to a friendly ant for help. He created a helmet to help him communicate with and control ants, and has been using them on his Super Hero adventures ever since.

IN THE REAL WORLD

There are ways of reading people's brainwaves! An Electroencephalography helmet (known as an EEG helmet) is a special device that can read human brain waves in much the same way that Ant-Man's helmet works. Talking to ants is a little more difficult, but we do know that ants communicate with each other using chemicals, so the helmet could read Ant-Man's brainwaves and then translate them into the appropriate chemicals.

THE QUANTUM REALM

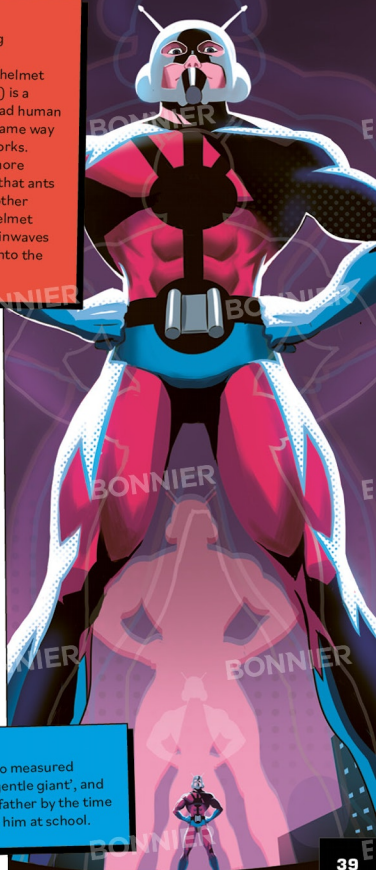
When Ant-Man shrinks smaller than a certain size he enters the Quantum Realm, and starts dealing in quantum physics, which is the foundation that all other forms of physics are based on. Scientists are still exploring how various elements of quantum physics work, so Ant-Man's ability to travel in the Quantum Realm is theoretically possible.

GIANT MAN

Scott Lang and Hank Pym don't just use Pym Particles to shrink, they can also use them to grow extremely tall. When Hank Pym first joined the Avengers, he took on the name 'Giant Man' as a way of standing out from incredible heroes like Thor, Captain America and the Hulk. Hank and Scott have grown over 30 m (100 ft) tall for short periods of time, which is bigger than a 10-storey building.

IN THE REAL WORLD

The tallest man in the world was Robert Wadlow who measured 2.72 m (8 ft 11.1 in) tall. Wadlow was known as the 'gentle giant', and he died in 1940 aged only 22. He was taller than his father by the time he was eight and had to have a special desk built for him at school.



THE AVENGERS: VISION, ULTRON & AI

Artificial Intelligence (sometimes called AI) is the ability for a computer to think and learn from past experiences. There are many different Artificial Intelligences in the Marvel Universe, ranging from heroes like the Vision to planet-threatening villains like Ultron.

ULTRON

Hank Pym created Ultron by uploading an Artificial Intelligence based on his own brainwaves into a super strong robot body. Ultron quickly became independent and rebelled against his creator, and is now a world-class Avengers foe. Ultron is fearsomely intelligent, incredibly strong and enjoys deviously manipulating his enemies.

IN THE REAL WORLD

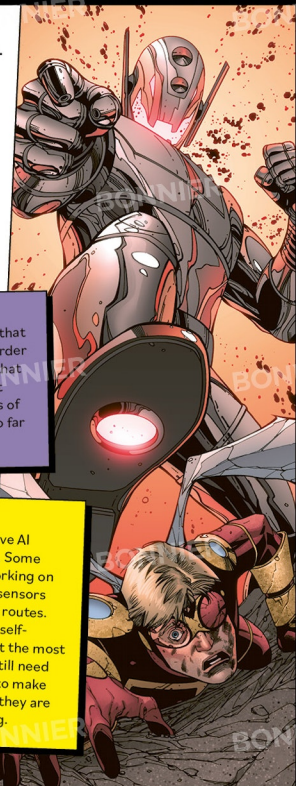
Artificial Intelligence is all around you. Everything from the way that streaming sites recommend TV shows, to how search engines order their results is powered by some form of AI. This doesn't mean that they have personalities and will try to take over the world, it just means that they learn and can adapt. AI is used in robots for lots of things like manufacturing, medical care and exploration, and, so far none of them have become evil and turned on their creators.

FRIDAY

Rather than hire an assistant, Tony Stark decided to create one. He programmed an AI who he called his 'girl Friday' to help him control his increasingly complicated suits of armour, and sometimes even pilot them.

IN THE REAL WORLD

Lots of different vehicles have AI which is used in many ways. Some companies are currently working on self-driving cars which use sensors to learn traffic patterns and routes. There are different levels of self-driving cars - at the moment the most advanced self-driving cars still need a human in the driving seat to make important decisions, even if they are not doing most of the driving.



VISION

The Vision is a second-generation AI. He was created by Ultron to attack the Avengers, but the Vision was able to break free of his programming and became a hero and an Avenger. Vision can alter the density of his own body which means he can alternate from being so light that he can walk through walls to being so heavy that he can crush concrete.

AVENGERS AI

The Avengers take threats from AI so seriously that they created the Avengers Artificial Intelligence Squad. This team was made up of humans and AIs, working together to stop rogue AIs and to prevent a human/AI war. The team included Hank Pym, Victor Mancha, S.H.I.E.L.D. agent Monica Chang and a reprogrammed Doombot.

IN THE REAL WORLD

An AI that can build other AIs already exists. An AI created by another AI is called a 'child AI' and these are used for very specific things. For example, if the main AI wants to write a programme to do something like recognise different objects, then it will write a child AI to do it, then set the child AI running and do something else. The next generation of supersmart machines will be machines that have been made by other machines.

```
const obj = {this: this};
const target = $(this.attr('data-
target')).closest('div');
const options = {target: target,
  interval: 1000};
const child = new ChildAI(target, options);
child.run();
```

IN THE REAL WORLD

Humans and artificial intelligences are good at very different things, and many companies have systems where people and AIs work together. Humans have creative and social skills that machines don't possess, while machines are good at working through different processes and making lots of decisions very quickly.

THE AVENGERS: BUILDINGS



When you get in as many life-or-death battles as the Avengers you tend to go through bases fairly quickly. The Avengers need their buildings to be as technologically advanced as possible, while also providing safety for team members and the outside world.

AVENGERS TOWER

Tony Stark has built several skyscrapers in New York, donating the top floor of his Columbus Circle building to the Avengers. The building is entirely automated and runs on Stark Technology, making sure that the Avengers are comfortable and well looked-after.

IN THE REAL WORLD

Buildings that are run by a computer (also known as a Building Automation System or BAS) are known as 'intelligent buildings' or 'smart homes'. These systems use sensors to automatically control the building's operations including heating, lighting, air-conditioning and security. The system can monitor and change everything that goes on in a building, right down to what is being shown on computer display screens.



AVENGERS MOUNTAIN

The Avengers have a fully operational headquarters in the hollowed-out body of a dead Celestial, located at the North Pole. T'Challa has a penthouse in the crown of the Celestial, while Tony Stark has a loft and forge lower down in the head. The sub-zero temperatures of the North Pole mean that the base needs a lot of power, and it has a power line linking it directly to the Earth's core.

IN THE REAL WORLD

Explorers have been building bases at the North Pole for years - the first North Pole ice station was built by Soviet scientists in 1937. However, the ice is constantly moving and within a year the base had moved over a thousand miles. The shifting ice means that scientists set up 'drifting stations' which move with the ice packs and normally last only two or three years.



AVENGERS MANSION, NEW YORK

Originally built by Tony Stark's father, Howard Stark, the Avengers Mansion was the team's home for years. Located on Fifth Avenue in the middle of New York, the Mansion was the home and training ground for many Avengers. The Avengers Mansion has been destroyed more than once but has always been rebuilt.

IN THE REAL WORLD

The Avengers Mansion is based in New York near Central Park. An apartment in that area would cost over \$100 million dollars, so Tony Stark was very generous!





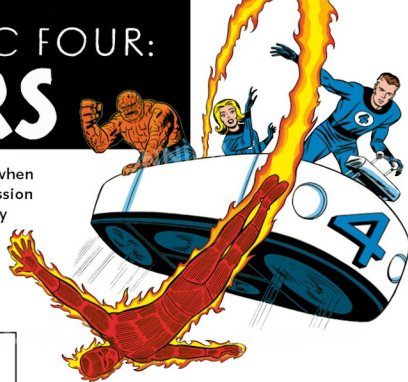
THE FANTASTIC FOUR

Reed Richards can act like he's the smartest man alive, but I'm definitely smarter than him. He has made some pretty interesting tech though. I'd love to spend more time at the Baxter Building where he keeps his inventions. Imagine having a whole floor to yourself where you can just create whatever you want!

- How far can Reed Richards stretch?
- Is Sue Storm the most powerful of the four?
- How hot is the Human Torch?
- Is the Thing made of rock?
- What is the Negative Zone?
- What is the best thing that Reed Richards has invented?



THE FANTASTIC FOUR: POWERS



The Fantastic Four got their powers when Reed Richards took the team on a mission into space where they were blasted by cosmic rays, changing them forever. They are a team of explorers, adventurers and heroes who have saved the world countless times.

REED RICHARDS: MISTER FANTASTIC

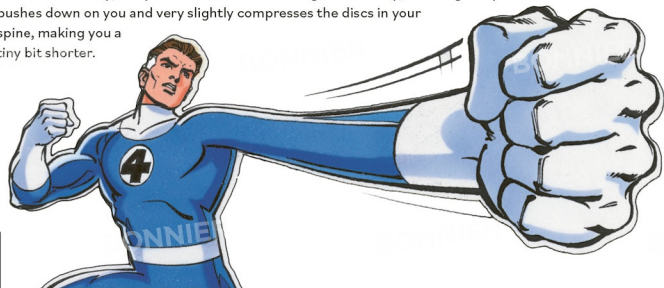
Reed Richards is one of Earth's greatest scientists, and his body is as elastic and malleable as his brilliant mind. After his exposure to cosmic rays, he gained the ability to stretch his body out and make himself hundreds of feet long.

IN THE REAL WORLD

The world record for stretchiest skin was set in 1999 by Garry Turner, who stretched the skin on his abdomen 15.8 cm (6.25 in). His skin was so stretchy that he was able to pull the skin from his neck completely over his lower jaw.

COULD YOU STRETCH LIKE MISTER FANTASTIC?

Your body does change over the course of a day, but only very slightly. You are tallest when you wake up in the morning, and you may be as much as a centimetre shorter by the end of the day; but you haven't shrunk. Throughout the day, Earth's gravity pushes down on you and very slightly compresses the discs in your spine, making you a tiny bit shorter.



SUE STORM: INVISIBLE WOMAN

Susan Storm Richards is perhaps the most powerful member of the Fantastic Four.

She can turn herself invisible and can create weapons and invisible force fields that are limited only by her willpower.

IN THE REAL WORLD

A company in America has created a material which could turn you invisible! It works by bending light through a very thin material so that you cannot see anything behind it. It's not perfect, and at the moment it works more like an invisibility cloak, but they are working on ways to turn it into an invisibility suit.

COSMIC RAYS

Cosmic rays are real but we don't know a lot about them. They are parts of atoms that move through space at nearly the speed of light, which is about 670,000,000 miles per hour. Cosmic rays are harmless, but on Earth's atmosphere we are protected from most cosmic rays by a magnetic field around the planet. Astronauts do get hit by cosmic rays, and to a lesser extent so do airline crew and pilots, but none so far have developed any super powers!



THE FANTASTIC FOUR: POWERS

Ben Grimm and Johnny Storm are the heart and soul of the Fantastic Four, but just like any family they don't always get along!

JOHNNY STORM: THE HUMAN TORCH

Johnny Storm is a hothead in more ways than one. The younger brother of Sue Storm, he was part of Reed Richards' fateful mission into space. Cosmic rays gave Johnny the ability to cover his body with fire, and control any flame in his vicinity. Flames can cover Johnny's body without him feeling any pain and when Johnny heats up to his maximum temperature he can go supernova, which makes him as hot as the surface of the sun!

IN THE REAL WORLD

No animals can create fire but some have developed survival mechanisms to cope with the effects of fire. Echidnas, a sort of spiny anteater, survive bushfires in Australia by curling into a ball and going into a hibernation-like state. This allows them to wait days for a bushfire to die down and the smoke to clear before they need to search for food again.



FLAME ON!

Could you ever become fireproof? Firefighters and people who work around flammable substances wear clothing that is flame-resistant, but not completely fireproof. These clothes reduce the wearer's chances of being burned because they are made of fabrics that extinguish flames. Flame retardant cotton can be found in most homes - just look at your oven gloves!



BEN GRIMM: THE THING

Reed Richards' best friend, Ben Grimm, was most affected by the cosmic rays. Ben was transformed into a being with skin of living rock, and is one of the strongest and toughest beings on the planet. Ben Grimm often sees himself as just the super-strong muscle of the team, but his willpower, stamina and heart mean that he is so much more.

IN THE REAL WORLD

Nowadays armour would not be made out of rocks because, while it is hard and strong, it can also break easily. However, stone armour was found in the tomb of China's first emperor, which dates back to the 2nd century BC. It was made of rectangular stones tied together to form a heavy duty set of armour. Even though it looks cool, historians think it was not practical to use in battle, so it may purely have been ceremonial.



THE FANTASTIC FOUR: INVENTIONS

Reed Richards isn't just a founding member of the Fantastic Four, he is one of the greatest scientists in the world. Reed is almost constantly working on new inventions to help mankind, but they do have a tendency to get the team into trouble!

NEGATIVE ZONE PORTAL

Reed created an entrance into another universe, the terrifying Negative Zone, which is ruled by the brutal Annihilus. The Negative Zone is in an antimatter universe, which means that many of the laws of physics are different to our own.

IN THE REAL WORLD

Antimatter is the opposite of normal matter; antimatter particles are like mirror images of normal particles, with the same mass but opposite charges. Scientists think that before the Big Bang, matter and antimatter were mixed together, and then they exploded apart. There is not a lot of antimatter in our universe, so the idea that it exists in its own universe could theoretically be possible.

THE FIRST SPACE SHIP

Codenamed *Marvel-1*, the original rocket that blasted the Fantastic Four into space was fitted with an experimental hyperdrive. Reed wasn't authorised to test the rocket so he asked Ben, Johnny and Sue to sneak aboard and help him fly it. The rocket didn't have strong enough shields, which meant the crew was bombarded with cosmic rays which gave them their super powers.

IN THE REAL WORLD

The first manned flight into space took place on 12 April, 1961 and sent cosmonaut Yuri Gagarin into space. He completed a full orbit around the Earth and returned after 1 hour and 48 minutes. He didn't crash back to Earth like the Fantastic Four, but had a parachute attached to his space capsule, landing next to a very confused Russian farmer and her granddaughter.

UNSTABLE MOLECULES

One of Reed's greatest contributions to the superhuman community is the creation of Unstable Molecules. These are used to make the synthetic materials that form many super heroes' costumes and mimic their powers. Material made from the Unstable Molecules allows Reed's costume to stretch with him, Sue's to turn invisible and Johnny's to not burst into flames!

IN THE REAL WORLD

Unstable Molecules work by mimicking the properties of other atoms and scientists have discovered something similar. Supercatoms are clusters of atoms that seem to have the ability to mimic the properties of other elements. In theory this could be used to create elements, magnetic materials or be used in electronics.

REAL GENIUSES

Reed Richards is a thoughtful and friendly man, but can sometimes be distracted by the immense scientific problems in his head. What are geniuses like in real life?

ALBERT EINSTEIN

The founder of modern physics, Einstein was often so deep in thought that he didn't pay attention to the world around him. According to some sources he was so preoccupied by his scientific theories that he couldn't remember his own phone number.

ALAN TURING

Turing was a mathematical genius who studied at both Cambridge, UK and Princeton in the US. During World War II, Turing helped to invent a machine that was used to break the German Enigma code. Turing also designed something called the Automatic Computing Engine which is often thought of as the precursor to modern computers.

MARIE CURIE

Marie Curie was a very important scientist who conducted research on radioactivity and shaped the way that scientists look at atoms today. She was the first woman to win a Nobel prize for science and is the only person to win two Nobel prizes for two different sciences - physics and chemistry. She loved working with her husband Pierre, and thought that collaboration was very important to scientific discovery.

THE FANTASTIC FOUR: ENEMIES

The Fantastic Four save the world on a regular basis, which means that they regularly clash with a whole host of villains. Anyone who is powerful enough to be at the Fantastic Four's level tends to hold a grudge.

DOCTOR DOOM

Victor Von Doom grew up in the Balkan country of Latveria but came to America to study at Empire State University where he met Reed Richards. A scientific genius, Victor created a machine to access the realms of the dead, but the machine exploded, scarring him for life. Blaming Richards for his own mistake, Doom now wears a suit of metal armour and rules his homeland of Latveria with an iron fist. Doctor Doom has created Doombots, robots that are exact replicas of himself, designed to replace him in certain situations.

IN THE REAL WORLD

At the moment, it would be almost impossible to replace a human being with a robot, even if they were disguised. Although artificial intelligence (AI) has improved greatly it is still not capable of fully replicating human behaviour. Mathematician Alan Turing created the 'Turing test' which is whether a machine can demonstrate human intelligence and fool a human into thinking they are real. So far, no machine has passed the Turing Test.

ANNIHILUS

When the Fantastic Four first entered the Negative Zone they encountered its ruler, Annihilus. The Negative Zone is a cold, unforgiving place, and Annihilus is a paranoid, despotic ruler. Annihilus commands hordes of alien insectoids using his immensely powerful Cosmic Control Rod.

IN THE REAL WORLD

The Cosmic Control Rod is able to harness and control cosmic energy. Cosmic rays, and the tiny subatomic particles that make them up, contain energy. They are rare on Earth but the energy could theoretically be harnessed.



NAMOR

Namor is the son of an Atlantean princess and a sea captain, and is the ruler of the undersea Kingdom of Atlantis. Though he has been an ally of the Fantastic Four, he has also often fought against them, as the interests of Atlantis do not always match up with those of the surface world.

IN THE REAL WORLD

The deepest dive for a human being is a SCUBA dive at 332 m, but Namor travels to the bottom of the Atlantic Ocean, which has an average depth of around 3500 m (11,482 ft). Any human being would be instantly crushed by the incredible pressure at these depths, which is why Namor has the "strength of a thousand men".

MOLE MAN

Deep below the earth there is a huge underground realm called Subterranea, which is home to a vast range of outlandish creatures. Harvey Elder is an explorer who found Subterranea and became the ruler of a race called the Moloids, calling himself Mole Man. He regularly sends large monsters to attack the surface, which are fought off by the Fantastic Four.

IN THE REAL WORLD

There are underground cities around the world, including a huge, abandoned city of tunnels under Beijing in China. The tunnels cover 33 square miles and were built in case of a nuclear war with the Soviet Union. In Turkey there is a giant underground city in Cappadocia called Derinkuyu. When it was built, it could have held up to 20,000 people for months at a time!





THE X-MEN

The mutant gene is really interesting. So many different powers can come from one tiny piece of information. Mutants are called *Homo superior* and sometimes describe themselves as the next stage in evolution, but where does that put the Inhumans like me?

- WHERE DO THE X-MEN GET THEIR POWERS FROM?
- WHAT POWERS DOES PROFESSOR X HAVE?
- WHO IS THE X-MEN'S STRONGEST ENEMY?
- WHAT ARE WOLVERINE'S METAL CLAWS MADE FROM?
- HOW DOES MAGNETO MOVE METAL?
- WHAT HAPPENS WHEN NIGHTCRAWLER TELEPORTS?



THE X-MEN: PROFESSOR X & THE X-MEN

Some mutants can fly, some can teleport, some can move things with their minds. Mutants are some of the most powerful beings on the planet!

THE MUTANT GENE

Mutants get their powers from the X-Gene, which forms part of their DNA, the blueprint which makes them who they are. Being a mutant is part of someone's genetic material – the X-Gene triggers their mutant powers when they are old enough.

IN THE REAL WORLD

The Human Genome Project is an international project that has allowed scientists to read and understand the genetic information that makes up human beings for the first time. The project has mapped out the human genome, the collection of genes that form the blueprint of who we are. Scientists can use this information to understand what different genes do and use this for medical research. If people were born with powers, this is where the information would be found.

PROFESSOR XAVIER

Charles Xavier had a dream that mutants and humans could live together in peace. Xavier founded the Xavier Institute, a safe haven for mutants and the home of the mutant Super Hero team, the X-Men. Professor X is himself an immensely powerful mutant; he can manipulate minds, move objects with his mind and even completely take over people's bodies.

IN THE REAL WORLD

From the 1970s to the 1990s the US Army spent a lot of time trying to find out if psychic powers were real. One of the things they studied was 'remote viewing', the ability to see hidden or distant objects using only your mind. After many years the programme was shut down because nobody could prove that remote viewing was possible.



CYCLOPS

One of the first class of X-Men, Scott Summers has always been seen as the field leader of the X-Men. His eyes shoot powerful concussive blasts but Cyclops cannot control his mutant power, so wears a special visor (or sometimes ruby quartz glasses) to stop him from accidentally blasting anything he views.

IN THE REAL WORLD

Scientists have created a contact lens that can point a laser at whatever the wearer looks at. It's designed to be used as a laser pointer, not as a weapon, but you could still shoot a laser from your eyes!



ANGEL

Warren Worthington III comes from a wealthy family; he enrolled in Xavier's school after large, feathered wings grew on his back. Later, Angel's wings were replaced with organic metal and he can use them to soar high above his fellow classmates.



IN THE REAL WORLD

It is not just their wings that allow birds to fly. Birds are extremely light, they have hollow bones and a light frame to reduce weight and make it easier to counteract the force of gravity pulling them down. They also have very powerful muscles and lungs so that they can pump enough oxygen around their bodies to keep their muscles working in flight. Angel would need to be very light and have extremely strong muscles to be able to fly.

THE X-MEN: THE X-MEN

Over the years X-Men have developed their powers together, and now work as a close-knit team.

NIGHTCRAWLER

Kurt Wagner has the ability to teleport from one location to another instantaneously. He can bring other people or objects with him, but teleporting more things places a greater stress on him. He has been known to teleport thousands of miles, but it needs to be an area he has seen before so that he doesn't teleport into solid objects.



IN THE REAL WORLD

For years scientists thought that teleportation was completely and utterly impossible, but physicists have discovered quantum teleportation. This is when scientists form a connection between a pair of particles using something called quantum entanglement. Once the particles are linked, scientists can send messages between them, even if they are far apart, essentially teleporting the messages. Unfortunately, at the moment this teleportation is only done on a very, very small scale.

ICEMAN

The youngest member of the original X-Men, Bobby Drake's powers have evolved as he has trained with the team. His power allows him to freeze water vapour in the air but at first he could only create snowballs. As his training progressed, he learned to create ice bridges, armour and even projectiles. He can now turn his body into organic ice, which he can form into powerful shapes.



IN THE REAL WORLD

The record for the lowest body temperature at which a person has been able to survive is 13.2° C (55.7° F). Since water freezes at 0° C (32° F), it's unlikely that a human would be able to turn themselves into ice and survive!

STORM

Ororo Munroe is the daughter of a Kenyan princess, and a leader of the X-Men. She can change the weather at will and can use her powers to strike her enemies with lightning bolts or blizzards.

IN THE REAL WORLD

Weather modification is possible but extremely difficult. Cloud seeding is the most common form of weather modification; it involves an aircraft or drone flying into a cloud and dispersing substances, such as silver iodide particles, to help raindrops form and create rain or snow. Until very recently there was little proof this technique works, but some states in the US have shown it is possible.

SHADOWCAT

Kitty Pryde was once one of the youngest members of the team but has grown to become a leader. She has the ability to phase, which means she can walk through solid objects whenever she wants.

IN THE REAL WORLD

The great magician Harry Houdini would perform a trick where he would appear to walk through a two-and-a-half metre brick wall. His secret? A hidden trapdoor underneath the wall which he slipped through while the audience was looking elsewhere.



THE X-MEN: WOLVERINE

He's the best there is at what he does, but what he does isn't very nice. Born over 100 years ago, James Howlett (also known as Logan) is a nearly unstoppable warrior with razor-sharp, unbreakable claws and a healing factor that can shrug off any injury.

HEALING FACTOR

Wolverine has a mutant healing factor which means he can survive almost any wound and recover from any poison. Wolverine has shrugged off wounds that would kill a normal person - he has even been burned to a crisp and lived to tell the tale!

IN THE REAL WORLD

Scientists have been studying DNA to work out if this could be possible in humans. Some animals can grow back huge sections of their own bodies: jellyfish, sea anemones and some types of worm can even grow back half their body weight if it is cut off. Researchers at Harvard University studied three-banded panther worms and think they have found the genetic code that controls cellular regeneration, but they are a long way off giving healing powers to human beings.

BONES

Wolverine's skeleton is made from adamantium, which is an unbreakable metal. Adamantium was poured into his body as part of the sinister Weapon X project, turning him into an unstoppable warrior.



IN THE REAL WORLD

Strong metals are used in surgery to repair bones; doctors use titanium foam to reinforce bone implants and whole joints, such as hips, can be replaced using titanium. Replacing your entire skeleton with metal probably wouldn't be a good idea - you need bone marrow to create blood cells and store calcium and it's very unlikely a human could survive with a metal skeleton.



CLAWS

Before James Howlett was given an adamantium skeleton, the claws in his hands were made from bone. He can retract the claws inside his arms and bring them out when he needs to fight.

IN THE REAL WORLD

Wolverine gets his name from a small, bear-like animal that is found in Northern Canada and Alaska. Much like Logan, wolverines are ferocious, solitary animals who are known for their strength and their ability to take down prey much larger than themselves.

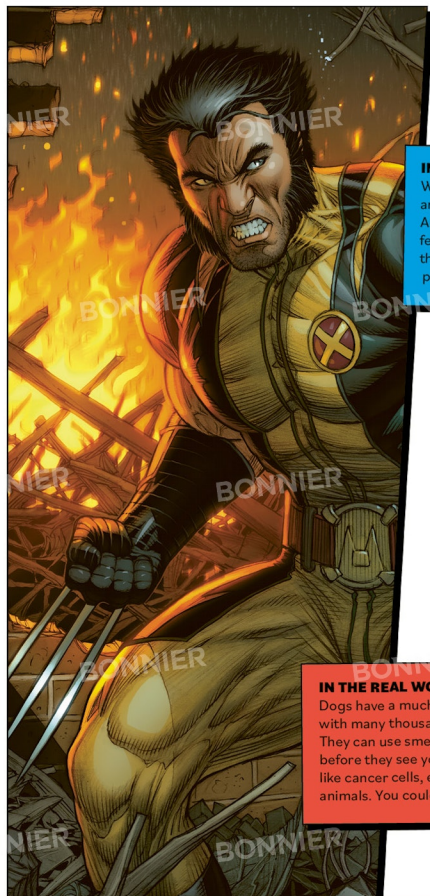


ENHANCED SENSES

As if advanced healing, a metal skeleton and unbreakable claws wasn't enough, Wolverine also has superhuman advanced senses. He is an incredible tracker and can see, hear and even smell people from great distances. He can also identify people just from their scent.

IN THE REAL WORLD

Dogs have a much more sensitive sense of smell than humans, with many thousands more olfactory receptors in their noses. They can use smells to identify people and can tell who you are before they see you. Some breeds of dog can even detect things like cancer cells, explosives or drugs, and track lost people or animals. You could say sense of smell is a dog's super power!



THE X-MEN: MAGNETO

Not all mutants want to live in harmony with humans or share Professor Xavier's dream of world peace. Magneto and his mutant followers believe that mutants are the natural next step in evolution...

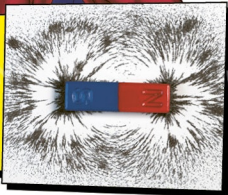
MAGNETO

Magneto believes that mutants are a superior species and must be forcibly protected from a world that fears and hates them. Magneto can manipulate magnetic fields, allowing him to move massive metal objects at will and can even use his mastery of magnetism to fly.



IN THE REAL WORLD

'Human magnet' is the name given to people who claim to be able to attach metal objects to themselves using the power of their own magnetic field. However, no human magnet has ever been able to recreate the feat under scientific, controlled conditions so there is no proof such a thing exists. It is possible that these people simply have very sticky skin!



MYSTIQUE

Mystique's mutant power allows her to look like anyone she wants, which makes her one of the best spies in the world. Her shapeshifting power means that she has no outward signs of aging, but she is estimated to be over one hundred years old.



IN THE REAL WORLD

In the United States, the CIA had a 'Chief of Disguise' whose job was to disguise spies and civilians to help them go unnoticed or gain access to restricted areas. Many blockbuster movies use amazing make up, wigs and prosthetics to create believable characters but no one is able to shapeshift in real life.

JUGGERNAUT

Charles Xavier's half-brother Cain Marko found a gem in a hidden temple and upon touching it, was transformed into a human juggernaut. Once Juggernaut builds up momentum it is virtually impossible to stop him. Juggernaut is strong enough to take down the biggest hitters in the Marvel Universe and is even a match for the Hulk. He has destroyed the Xavier Institute more than once, and can destroy mountains with his fists.

IN THE REAL WORLD

Sir Isaac Newton discovered that every moving object will keep moving and every still object will stay still unless another force acts on it. When you stop or start moving you feel a force called inertia, which is the resistance of any object to a change in its motion. Juggernaut is so powerful that there is no force that can stop him moving.





ALIENS

It took me a while to work out where my powers come from, but I identified the Inhuman gene in my own DNA. Somewhere way back in my family history I am related to an Inhuman, and that's where I get my powers from. Other people can fly, blow things up or destroy things – my power is that I can switch bodies with a big red dinosaur, which can be more inconvenient than useful really!

- WHERE DOES THOR COME FROM?
- WHO ARE THE GUARDIANS OF THE GALAXY?
- IS PETER QUILL HUMAN OR ALIEN?
- HOW DOES GALACTUS EAT PLANETS?
- WHY DOES THE SILVER SURFER HAVE A SURFBOARD?
- HOW DID CAPTAIN MARVEL GET HER POWERS?
- WHO ARE THE INHUMANS?



ALIENS: THOR & ASGARDIANS

Asgardians are a race of extra-dimensional beings who have been visiting Earth for thousands of years and at one point became part of Norse mythology. Thor Odinson protects Earth as a member of the Avengers, but his home will always be Asgard.

ASGARD

Thor and other Asgardians live in Asgard, a magical realm ruled over by Thor's father, Odin. Asgard is one of the 10 realms and is a beautiful place which can only be reached by Bifrost, the rainbow bridge.

IN THE REAL WORLD

Asgard is part of many Norse sagas that are thousands of years old, but it is not a real place. There was a village called Asgard in Norway (known locally as Åsaskard), but sadly no Super Heroes live there, not even Loki.



MJOLNIR – THOR'S HAMMER

Thor wields the enchanted hammer Mjolnir. Only those who are worthy of the power of Thor are able to pick up Mjolnir, and once the hammer has been raised it gives whoever holds it the power of Thor.

IN THE REAL WORLD

An engineer in America has created a hammer just like Mjolnir that only he can pick up! The hammer uses an electromagnet to stick it to the ground and has a fingerprint reader in the handle. When the engineer picks up the hammer it reads his fingerprint and turns off the magnet, allowing him to pick it up!

LIGHTNING STRIKES!

As the Norse God of Thunder, Thor is able to control the weather and summon elements of the storm like thunder, wind, rain and lightning. He can blast his enemies with bolts of lightning, which often come directly from his hammer, Mjolnir.



IN THE REAL WORLD

Scientists have managed to use laser beams to control the path of lightning – working as a 'laser lightning rod'. The laser is pointed in the air and hits clouds in a way that causes lightning to discharge safely, rather than hitting random – and potentially dangerous – targets.



ALIENS: GUARDIANS OF THE GALAXY

The Guardians of the Galaxy are a mismatched team of interstellar heroes who try to stop threats to the universe and maybe make a little money whilst keeping everyone safe. The team has a rotating roster with new members regularly joining and leaving the crew.

STAR LORD

Peter Quill is the son of J'Son, an alien ruler who crash-landed on Earth. Peter has had an exciting life: he was a NASA pilot who was captured by alien pirate Ravagers and escaped. He took the name Star Lord, and now he leads the Guardians of the Galaxy, travelling the universe, looking for adventure.



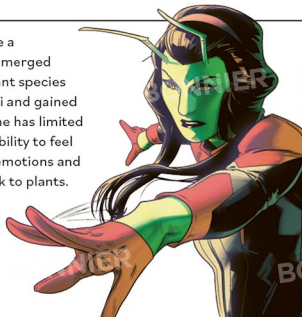
IN THE REAL WORLD

The American space agency NASA (which stands for the National Aeronautics and Space Administration) has sent 355 different people into space over 135 missions, and counting! Training to be an astronaut takes two years and is incredibly hard. NASA only takes the best of the best, so there's a reason that Peter Quill has a high opinion of himself.



MANTIS

Mantis was once a human, but she merged with an alien plant species called the Cotati and gained alien powers. She has limited telepathy, the ability to feel other people's emotions and the ability to talk to plants.

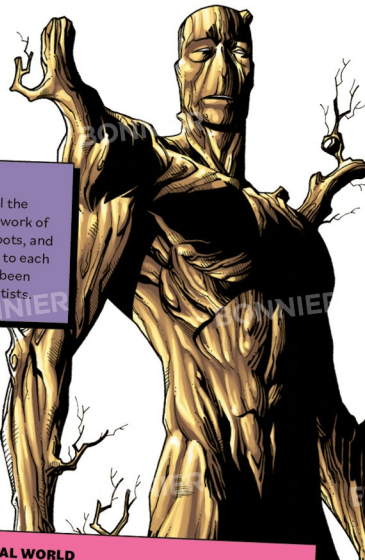


IN THE REAL WORLD

Empaths are people who are highly attuned to the emotions and feelings of people around them. There isn't anything psychic about this; some people have a more developed part of their brain which allows them to mirror the emotions of the people that they come in contact with. It can make them more caring and more sensitive, but it can mean taking on other people's stress and worries.

GROOT

Groot is a giant talking tree - he is a Flora Colossus from Planet X. His unevolved vocal chords make it sound (to the untrained ear) as if he is repeating the phrase "I am Groot" when he is talking, but his teammates can understand him.



IN THE REAL WORLD

Trees are secretly talking to each other all the time! Beneath the ground they have a network of fungi that grow around and inside their roots, and they use this network to pass information to each other. This system of communication has been nicknamed 'the Wood Wide Web' by scientists.



ROCKET RACCOON

Rocket, a raccoon, comes from the planet Halfworld, where he was genetically altered to have human-level intelligence, to be able to talk and to be able to stand on two feet. Though small, he is feisty and when he is not building terrifying weapons he enjoys arguing with the other members of the team.

IN THE REAL WORLD

Raccoons are actually more intelligent than you might think. While not quite as smart as humans or monkeys, they can definitely learn from their mistakes and think their way around problems. They also have evolved vocal chords, and while they can't talk, they can make over 50 different noises. They don't normally build large guns, join Super Hero teams and plan elaborate heists though.



ALIENS: GALACTUS & THE SILVER SURFER

Galactus is one of the oldest and most powerful beings to exist and was alive before the Big Bang that created our universe. Civilisations all over the galaxy fear the arrival of Galactus!

GALACTUS

Galactus is feared throughout the universe, and he uses the Power Cosmic, which is a nearly limitless cosmic energy. A giant, god-like presence, Galactus needs to consume whole planets to survive, sending his heralds out through the universe to find his next meal. The Fantastic Four were able to stop him from eating the Earth when Reed Richards threatened him with the Ultimate Nullifier, the most devastating weapon in the universe.

IN THE REAL WORLD

Even though planets are huge, they can be eaten by lots of different things like black holes, stars or even much bigger planets. Stars, like our Sun, can engulf the planets that they once created. Jupiter, in our solar system, has already swallowed a planet – about 4.5 billion years ago a smaller planet smashed into Jupiter, and Jupiter absorbed it.



UATU

Uatu is from an immortal race of aliens called The Watchers, who have vowed not to interfere in the worlds that they are observing. Uatu broke his code of non-intervention by warning the Fantastic Four that Galactus was about to consume the Earth. For years he had a base on Earth's moon, so that he could closely observe humans.



IN THE REAL WORLD

Uatu lives on the Moon. To date, 12 people have landed and walked around on the Moon over seven different trips. The last manned mission to the Moon was in December 1972, which had the longest space walk on the Moon's surface of 1 hour 5 minutes. Astronauts have brought lots of different things to the Moon. In 1971, Alan Shepard brought a golf club and hit two golf balls!



THE SILVER SURFER

Norrin Radd was given a choice by Galactus – either watch Galactus consume his home planet of Zenn-La or act as his herald, leading the way to find more planets for Galactus to devour. Norrin was imbued with the Power Cosmic, transforming him into the Silver Surfer. He broke free of Galactus and now travels space on his silver surfboard.



IN THE REAL WORLD

A surfboard has a specific shape to allow the person using it to ride across waves as quickly and confidently as possible. The size and weight of the board can give stability and the fins on the bottom can help with control and direction. It's not quite clear how the Silver Surfer rides cosmic waves, but this would be a good shape if he was surfing actual waves!

BIG BANG!

Galactus is a powerful being who existed before the Big Bang that created the universe, but could this really happen? The Big Bang happened 14 billion years ago – the entire universe was compacted thousands of times smaller than a pinhead, then it exploded out, creating everything there is. However, there are still things about the Big Bang that scientists don't understand and can't explain, like why the universe is the shape that it is. Maybe there was a giant planet-eating cosmic entity involved?

ALIENS: CAPTAIN MARVEL

The galaxy is a pretty big place, but not big enough for some alien races to live together peacefully. The Kree and the Skrull races have been at war for thousands of years.

CAPTAIN MARVEL

Carol Danvers was an Air Force officer who gained her powers when she was caught in the explosion of a Kree device called a Psyche-Magnetron, making her a Kree-human hybrid. Carol has superhuman strength, speed, stamina and reflexes. She can also fly, and absorb and shoot energy blasts. Carol was a pilot and spy before she became a Super Hero, and always wanted to explore the stars.



SKRULLS

Skrulls are a race of alien shapeshifters who are able to change their appearance to mimic other people and races. Skrulls can infiltrate the governments of different planets by impersonating their leaders.



IN THE REAL WORLD

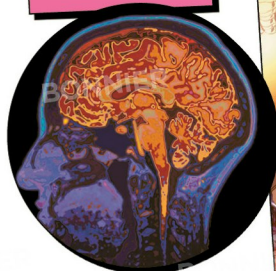
Humans can't change their shape to look like other people, but shapeshifters do exist in the natural world. The mimic octopus was discovered in 1998, and can change its shape and colour to make itself look like a sea snake, jellyfish, lion fish or sole.

KREE

The Kree are a humanoid alien race who are ruled by the Supreme Intelligence, a highly intelligent supercomputer which is made up of the greatest minds of the Kree people. This computer has started wars and caused destruction in the name of the Kree Empire.

IN THE REAL WORLD

Your brain is made up of nearly 100 billion neurons, which come together to make 100 trillion connections. This would be very hard to upload and store on a computer, but supercomputers do exist today that would be able to store this much information.



ALIENS: THANOS & THE INFINITY STONES

The Infinity Stones embody various aspects of existence, each giving the person holding them different powers. When one person holds all six stones, they give the user almost infinite power, and Thanos has tried to wield this power more than once.

TIME STONE

The Time Stone allows the person using it to move around in time.



IN THE REAL WORLD

It is possible to experience time in a different way to those around you – the faster you travel the slower you experience time. Scientists took clocks on planes flying different routes around the world and compared them with clocks that had not moved. The clocks on the planes were slightly different from the clocks on the ground, showing that they had experienced time differently.

SPACE STONE

The Space Stone allows the wielder to instantly move to anywhere in the universe.



IN THE REAL WORLD

Scientists have been researching teleportation for years, but the scale of teleporting a person makes it very complex. You have 32 trillion cells in your body – to transmit that much data you would need more power than has ever existed on Earth.



REALITY STONE

The Reality Stone can change reality and also create alternate realities.



IN THE REAL WORLD

Everybody experiences reality differently, depending on your state of mind, your past experiences and how you view the world.

SOUL STONE

This stone can manipulate the soul of a person, and also contains a pocket dimension called the Soul World.



IN THE REAL WORLD

Some scientists have argued that as we live in an expanding universe, then this could create pocket universes. We can't prove that pocket universes exist, but these would be small, bubble universes created when a bigger universe expands. Think about how water creates bubbles when it heats up and boils – a pocket universe would be created in the same way. These universes might have their own laws of physics, completely different to our own.

POWER STONE

The Power Stone stores huge amounts of power and allows the owner to manipulate different forms of energy.



IN THE REAL WORLD

The world's largest solar-powered battery is in Florida and claims to be able to store as much power as 100 million iPhone batteries.



MIND STONE

If you want to gain mind powers like telepathy, telekinesis and metal control then this is the stone for you.



IN THE REAL WORLD

You can't actually control other people's minds, but you can sometimes influence the decisions they make by subtly suggesting different things.



ALIENS: INHUMANS & MOON GIRL

The Inhumans were created thousands of years ago by the Kree as a potential race of super-powered soldiers to use in their battle against the Skrulls. Inhumans have since spread through the world, and many heroes like Ms Marvel and Moon Girl get their powers from their Inhuman DNA.

MOON GIRL

Lunella Lafayette is possibly the smartest person in the world. She has built lots of cool gadgets like a spring-loaded boxing glove, a sneeze powder gun, powered roller skates and a force field hand. She also has the power to switch minds with her friend, Devil Dinosaur.



IN THE REAL WORLD

We don't have the technology to swap anyone's brains (and that's probably a good thing), but scientists have managed to link the brains of animals to pass information to each other. Scientists have managed to use electrical impulses to pass basic information between brains but are a long way off swapping the minds of humans and animals.

MS MARVEL

Kamala Khan was transformed by the Inhumans' Terrigen Mists. She is able to change her size and shape at will, which she calls 'embiggening'. Kamala got her powers because an ancestor was an Inhuman. Kamala is a massive fan of super heroes and has posters of her favourite Avengers on her wall.

BLACK BOLT

The King of the Inhumans is a man of few words, mainly because his voice is so loud that it can destroy mountains. Black Bolt's power is also his curse, and he is often forced to turn to his wife Medusa to communicate for him.



IN THE REAL WORLD

Sonic and ultrasonic weapons are used by some armies and police forces. Most of these weapons are used to damage people's eardrums and disorientate them and are used to break up crowds. Scientists are also working on a technique to use ultrasonic vibrations to break up hard rock, which would work in a similar way to Black Bolt's voice.

MEDUSA

Queen of the Inhumans, Medusa has incredibly strong, powerful hair that she can command at will. Her hair makes for an impressive weapon!

IN THE REAL WORLD

The world record for the thickest strand of human hair is 772 micrometres (0.03 inches). It was taken from the beard of Muhammad Umihar Khan from Pakistan in 2021.





THE SUPERNATURAL

I come from the world of science, so I haven't studied magic that much. But as I see it, magic is a little bit like science. Mystic energy is all just patterns and rules of organisation, similar to science. All you need to do is learn the patterns and the rules. As far as I can see Doctor Strange's spells are just like computer programmes that manipulate mystic energy.

- HOW DID DOCTOR STRANGE BECOME SORCERER SUPREME?
- WHAT HAPPENED TO STEPHEN STRANGE'S HANDS?
- WHAT IS THE MAGICAL ITEM THAT DOCTOR STRANGE WEARS AROUND HIS NECK?
- HOW POWERFUL IS THE SCARLET WITCH?
- WHERE DOES WANDA MAXIMOFF GET HER POWERS FROM?



SUPERNATURAL: DOCTOR STRANGE

Doctor Strange is the Sorcerer Supreme, protecting our world from supernatural threats. He casts powerful spells and has many magic items.

STEPHEN STRANGE

Egotistical surgeon Doctor Stephen Strange was in a car accident which severely damaged his hands, taking away his ability to perform surgery. Stephen's search to heal his hands brought him to the Ancient One, who trained Stephen in the ways of magic. In one alternate reality Doctor Doom simply cut off Stephen Strange's broken hands and replaced them with prosthetic robot ones!

IN THE REAL WORLD

Prosthetic limbs have been around for centuries. The oldest is over 3000 years old and is a piece of wood carved to replace a lost toe of an Egyptian noblewoman. These days prosthetic hands exist that allow the user to grab and pick things up.



THE CLOAK OF LEVITATION

Doctor Strange wears the Cloak of Levitation, which responds to his thoughts and allows him to fly for long periods of time. The Cloak can act independently of Doctor Strange, and will attack an enemy when Strange is unconscious or incapacitated.

IN THE REAL WORLD

Please don't try this at home, but cloak-like wings could be used as a glider. However, the cloak's wingspan would be about half that of an ordinary hang glider and so it would be very difficult to control and turn in the air.



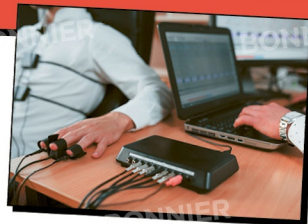
THE EYE OF AGAMOTTO

Stephen Strange wears the Eye of Agamotto around his neck, and it is one of his most powerful magic items. The Eye of Agamotto gives Doctor Strange many magical abilities, and it can see through any lie or deception. You can't lie to Doctor Strange!



IN THE REAL WORLD

Police and law enforcement in some countries use a device called a polygraph to test if someone is lying. The polygraph measures things like blood pressure, pulse and breathing to see if the answers a person gives to a question are true or not. The science backing up polygraph machines is hotly debated, as the machines can often be inaccurate, but because they are in lots of films and TV shows many people believe they work.



SUPERNATURAL: SCARLET WITCH

Wanda Maximoff is a top-level mutant and has been trained to use chaos magic to manipulate energy and matter. Wanda has struggled with her awesome powers but she works hard to control herself.

WHICH WITCH?

Wanda Maximoff and her brother Pietro were raised by Romani travellers in Central and Eastern Europe. Wanda has a natural talent for magic, and was trained by Agatha Harkness, a powerful witch. 'The Scarlet Witch' was originally shouted as an insult to Wanda, but she then took it as her name.

IN THE REAL WORLD

Women have been accused of being witches for centuries, often as the blame for things like poor crops. Other women were accused of being witches because they were able to heal people with herbs and medicines. Witch trials took place in America and the UK, and perhaps the most famous were the Salem witch trials that took place in colonial Massachusetts in America in 1693. The last 'witch' was officially pardoned by the State of Massachusetts in 2022, which was 329 years after her death.

MAGIC ENERGY

Wanda's powers allow her to access various magical energies, including chaos magic. Her power level can change depending on the energies she is channelling, giving her different abilities. She can channel huge amounts of power and has been able to rewrite reality at will. She once wiped almost all mutants off the face of the planet, uttering the words "No more mutants". Wanda's magic removed the powers of thousands of mutants, leaving only 198 mutants with abilities. Thankfully this spell has since been reversed.



LEVITATION

Not only can Wanda use her magical abilities to levitate from the ground, but she can also give other people the ability to levitate as well.

IN THE REAL WORLD

There is a classic magic trick where a magician makes the audience think that they are levitating. It takes a while to master, but it involves standing about eight feet away from your audience with your back to them at a 45-degree angle so they can't see your back foot. Then you raise the heel of your back foot and your whole front foot, so the audience can't see you putting your weight on the front of your back foot. If you get it right, it looks like you are floating off the ground!

ILLUSION

Wanda can cast illusions to fool her enemies and help her friends. Her illusions are incredibly realistic and at times she has even deceived herself.

IN THE REAL WORLD

All theatrical magic is based on illusions that fool the audience. The most popular magic tricks involve making the audience believe that something impossible has happened, like sawing a person in half or pulling a bouquet from a hat. These tricks are normally achieved through special equipment - the person isn't really sawed in half, they are hiding their legs in a special compartment, and the flowers are stored in a secret part of the hat.





THE MULTIVERSE

There are countless parallel universes out there, making up the multiverse and the omniverse. I once met a version of myself from a parallel universe called Devil Girl. I have Devil Dinosaur, but she has a friend called Moon Dinosaur. She was an annoying know-it-all and not at all easy to talk to! Hmm...

- WHAT IS THE MULTIVERSE?
- COULD THERE BE DIFFERENT VERSIONS OF ME IN DIFFERENT UNIVERSES?
- WHAT HAPPENS WHEN UNIVERSES COLLIDE?
- WHY ARE THERE SO MANY VERSIONS OF SPIDER-MAN?
- CAN SPIDERS THINK?
- IS THERE A VERSION OF SPIDER-MAN THAT IS A PIG?



THE MULTIVERSE: THE MULTIVERSE

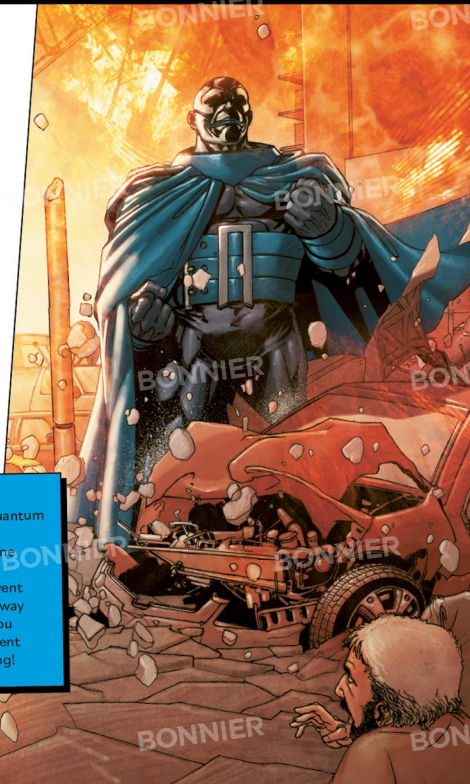
The Multiverse is a collection of different universes, all existing at the same time, but generally not interacting with each other. The main Marvel Universe is known as the 616 Universe, but there are countless other universes that exist with their own histories, physics and inhabitants.

PARALLEL WORLDS

Many different universes in the multiverse come from the same starting point, but then history takes a different direction. For example, the Age of Apocalypse timeline takes place in a universe where Charles Xavier was killed and did not stop Apocalypse from taking over the world.

IN THE REAL WORLD

The Many-Worlds Interpretation of quantum mechanics is a theory that suggests that every time a reaction produces one event, a separate parallel universe is created where the opposite of that event happens. However we would have no way of interacting with this universe, so you shouldn't worry about creating different universes every time you do something!



INCURSIONS

Damage to the multiverse caused different universes to crash into each other - this is called an incursion. These collisions wiped out universes until there was nothing left. Fortunately Reed Richards was able to rebuild everything.

IN THE REAL WORLD

Some scientists have put forward a theory that our universe collided with another universe during the Big Bang. During the Big Bang our universe was being formed at a fantastic speed, and we still don't know how it ended up in the shape that it is now. Maybe it did hit another universe!



ALTERNATE VERSIONS

There are hundreds of different versions of Super Heroes from alternate universes, each with their own exciting backstory. Sometimes these different versions of the same person meet each other. Hank McCoy, Beast from the X-Men, was once replaced by an evil version of himself from another reality, known as 'Dark Beast'.

IN THE REAL WORLD

Many people think that they have seen strangers that look exactly like themselves. Social media has allowed people to find 'twin strangers' that look so much like themselves that they can even fool facial recognition software!



THE MULTIVERSE: THE SPIDER-VERSE

Spider-Man is such an important Super Hero that there are countless different spider heroes across countless different universes. Not every Spider-Man is Peter Parker, but they are all heroes!

PETER PORKER, THE SPECTACULAR SPIDER-HAM

Peter Porker is a talking pig, a hero who comes from a universe of animal versions of Marvel super heroes. He is friends with Super Heroes like Captain Ameri-cat, Iron Mouse and Croctor Strange, and faces villains including Ducktor Doom and Kangaroo the Conqueror.



IN THE REAL WORLD

Pigs are very intelligent and are considered to be much smarter than dogs or cats. They have over 20 different sounds that they use to communicate and sing to their children while they are feeding. They can even play video games better than chimpanzees! Pigs can also be heroic - a pig in America called 'Lucky' saved his human family by waking them up when a fire started in their house during the night. The family managed to get out of the house in time, only because Lucky woke them!



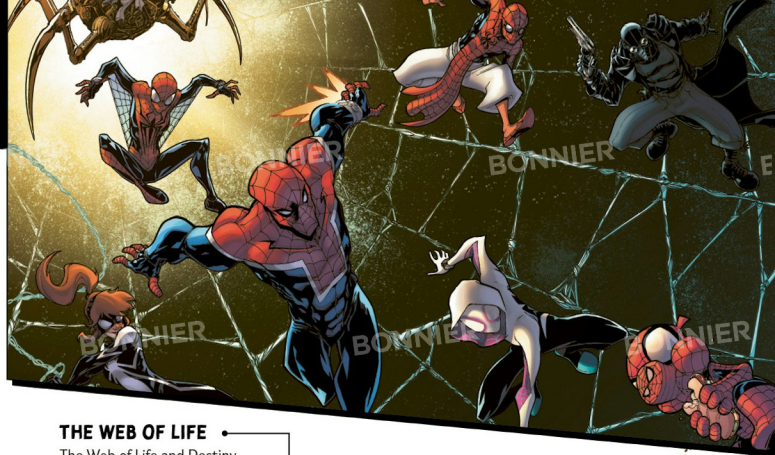
SPIDERS-MAN

The Peter Parker of Earth-11580 wasn't bitten by a single spider, he fell in a colony of spiders. These spiders formed a hive mind that shares Peter's consciousness, and they fight crime as Spiders-Man.



IN THE REAL WORLD

Spiders are able to think and have displayed complex learning. They sometimes 'think' with their webs, creating intricate designs that might look random but are carefully planned. The shape and pattern of a spider's web is based on past experiences, and spiders use the shape of their web to store and filter information - in many ways the web is a physical part of their thought process. The web can store information about types of prey and how to catch them.



THE WEB OF LIFE

The Web of Life and Destiny connects different spider-based heroes (known as spider-totems) across the Multiverse. The Web of Life guides these heroes and helps them access their powers. Some heroes are smart enough to use the web to communicate with other heroes and travel through the Spider-verse!

IN THE REAL WORLD

While most spiders are solitary, some spiders live in colonies where they make one huge web and work together to catch prey like bees and other insects. The spiders use this web to communicate, so it is a little like The Web of Life.

GWEN STACY, SPIDER-WOMAN

The Gwen Stacy of Earth-65 was bitten by a radioactive spider instead of Peter Parker, and gained the same powers as our Spider-Man. This version of Gwen Stacy has crossed into many different universes and has teamed up with the Peter Parker of the main Marvel Universe many times. She is also the drummer in an indie band called 'The Mary Janes'.





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GLOSSARY

AI (ARTIFICIAL INTELLIGENCE)

- Computers, robots or other machines which think for themselves.

ANTIMATTER - Particles that are the opposite of normal matter, such as having a positive rather than negative charge.

BIOELECTRICITY - Generation of electrical charges inside a living organism.

COSMIC AWARENESS - Understanding and perhaps manipulating the building blocks of the Universe.

COSMIC RAYS - High energy particles that move through space at almost light speed.

CLONE - A replica or copy of something or someone else.

CYBERPATHY - Talking to and manipulating technological systems using only your mind.

DIMENSIONAL TRAVEL - The ability to move between different or alternative realities.

DNA - Deoxyribonucleic acid, the coded instructions for a living thing, found in nearly every cell.



ELECTROKINESIS - Storing and controlling electricity in your body.

ELECTROMAGNETISM - An interacting combination of magnetic fields and electric currents.

EMPATHY - The ability to read other people's feelings.

ENERGY BLASTS - Creation and expulsion of powerful forces from your body.

ENERGY MANIPULATION - The ability to internalise and redirect forms of energy.

FLIGHT - The ability to move through the air in a controlled way under your own power.

FORCE FIELD CREATION - Making energy-based barriers to protect yourself and/or others.

GPS - Global Positioning System.

HEALING FACTOR - Being able to heal from wounds more quickly than a normal human.

IMMORTALITY - An immortal will not die from old age. Some immortals can be killed by other methods.

INTANGIBILITY - The ability to move through solid objects.

INVISIBILITY - Cannot be seen by the human eye or undetectable by other means such as X-rays.

MAGIC - The use of mystical arts.

OMNIPOTENCE - Vast, but not always unlimited, powers.

OMNISCIENCE - Vast, but not always unlimited, knowledge.

PYROKINESIS - The ability to control, but not generate, fire using your mind.

REALITY WARPING - Changing the very nature of existence itself.

SHAPESHIFTING - Altering the physical form of your body.

SUPERHUMAN DURABILITY - Being tougher, and able to take more damage, than normal humans.

SUPERHUMAN SPEED - Faster than the upper human limits.

SUPERHUMAN STRENGTH - More powerful than a normal human, for example, in lifting and punching.

SYMBIOTE - An organism that lives in a cooperative relationship with another. Spider-Man's alien suit was a symbiote.

TELEKINESIS - The ability to move objects using your mind.

TELEPATHY - The ability to read (and sometimes control) other people's minds.



SOURCES

Darwin, Charles, *On the Origin of Species*, (1859)

DeFalco, Tom, *Comic Creators on Spider-Man*, (Titan Books Ltd, 2004)

DeFalco, Tom, *Comic Creators on X-Men*, (Titan Books Ltd, 2006)

DK, *How Science Works*, (DK, 2018)

Hawking, Stephen and Hawking, Lucy, *Unlocking the Universe*, (Puffin, 2021)

Isaacson, Walter, *Einstein: His Life and Universe*, (Simon & Schuster UK, 2017)

Gleick, James, *Chaos: Making a New Science*, (Penguin Group (UK) Ltd, 1987)

Gresh, Lois and Weinberg, Robert, *The Science of Superheroes*, (Wiley, 2002)

Lorch, Mark and Miah, Andy (ed), *The Secret Science of Superheroes*, (Royal Society of Chemistry, 2017)



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