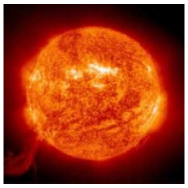
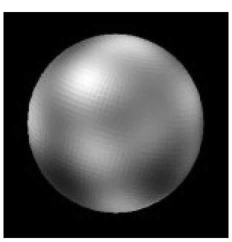
Astronomy



The solar system is the place that is affected by the gravity our sun. Our solar system includes **rocky terrestrial planets** (Mercury, Venus, Earth, and Mars), **gas giants** (Jupiter and Saturn), **ice giants** (Uranus and Neptune), and assorted chunks of ice and dust that make up various comets and asteroids. The eight planets follow a near-circular orbit around the sun, and many have moons. We'll be going into detail about these objects during our hour-long teleclass, so we won't be spending time on it here. However, we will cover the huge number of comets, asteroids, and other objects follow their own path around the sun, many of which have yet to be discovered.

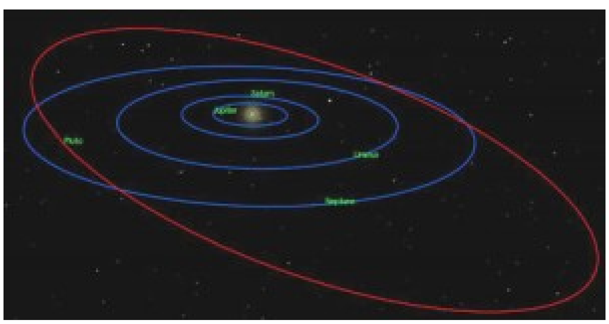
What Happened to Pluto?



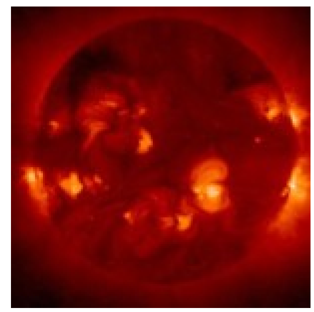
Pluto was once considered one of the planets, but in recent years was demoted to 'dwarf planet' status. (This photo, by the way, is the ONLY picture we currently have of Pluto.) Many people figured it got whacked out of existence; while others thought we had discovered a larger planet X in its place. It turns out that neither are true. But before I talk about Pluto, let's go back in time to the discovery of another planet in our solar system, Ceres.

In 1801, Giuseppe Piazzi was looking in the asteroid belt region between Mars and Jupiter and was startled to find a large object there. He named it Ceres, and over the next several years, ten more 'planets' were discovered… then twenty, then fifty… and then a new definition of planet was defined, which moved all of these new 'planets' into the asteroid belt. Back then, their observational equipment only allowed them to see large objects, and Ceres is the largest asteroid in the belt, so they naturally thought it was by itself and supposed it to be a planet, not a large rock amidst smaller ones.

Today, the same thing is happening with Pluto. Pluto is very small and far away, and it's hard to see things that far and that small. But we keep trying, anyway! Basically, astronomers found Pluto and named it a planet… then they found Chandra, which is roughly half the size of Pluto, so we called it a moon. But then we discovered that Charon orbits a point that is between the Charon and Pluto, owing to the fact that Charon and Pluto are near the same size. For comparison, the moon is 1/4 Earth's diameter, 1/50 Earth's volume, and 1/80 Earth's mass. Then we found two smaller objects (Hydra and Nix) that also orbit around the pair… making it four objects instead of the original one! But it gets worse, because then we found more objects beyond Pluto that were bigger… hundreds more! So at the end of it, scientists had to redefine what it means to be a planet, and Pluto didn't make the cut. But neither did the 700 other objects that we had in our line-up.



If you take a look at all the objects and ask yourself "Which one doesn't belong?", you'd find yourself looking hard at Pluto. It's the only one on a seriously inclined orbit (shown in red), the only one with an elliptical orbit that crosses another planet's orbit (Neptune's), and is extremely small compared to its neighbors. This is exactly what astronomers figured. So Pluto was reclassified and the whole kit and caboodle was chunked as Kuiper Belt Objects (KBOs). This is the sort of thing that happens when you're working in a new field, trying to make sense and define things as you go. Every so often, you learn new things and need to go back and readjust assumptions made in the past.



Our Sun

The sun holds 99% of the mass of our solar system. The sun's equator takes about 25 days to rotate around once, but the poles take 34 days. You may have heard that the sun is a huge ball of burning gas. But the sun is not on fire, like a candle. You can't blow it out or reignite it. So, where does the energy come from?

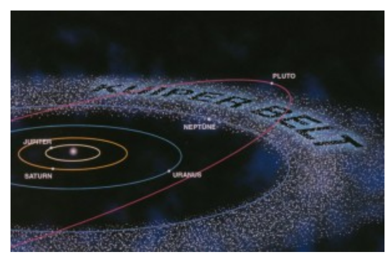
The nuclear reactions deep in the core transforms 600 million tons per second of hydrogen into helium using a chemical processes called the proton-proton chain. This gives off huge amounts of energy which gradually works its way from the 15 million-degree Celsius temperature core to the 15,000 degree Celsius surface. Once at the surface, it takes light only 8 minutes to travel the 93 million miles to reach earth. (So if the sun suddenly blinked out, we wouldn't know it for 8 minutes.) The corona is hundreds of times hotter than the photosphere and extends for millions of miles outward. The only time you can see the corona is during an eclipse because the main part of the sun is so bright.

The visible surface of the sun is called the photosphere, and is made mostly of plasma (remember the grape experiment?) that bubbles up hot and cold regions of gas. When an area cools down, it becomes darker (called sunspots). Solar flares (massive explosions on the surface), sunspots, and loops are all related the sun's magnetic field. While scientists are still trying to figure this stuff out, here's the latest of what they do know…

The sun is a large ball of really hot gas - which means there are lots of naked charged particles zipping around. And the sun also rotates, but the poles and the equator move and different speeds (don't forget – it's not a solid ball but more like a cloud of gas). When charged particles move, they make magnetic fields (that's one of the basic laws of physics). And the different rotation rates allow the magnetic fields to 'wind up' and cause massive magnetic loops to eject from the surface, growing stronger and stronger until they wind up flipping the north and south poles of the sun (called 'solar maximum'). The poles flip every eleven years.

There have been several satellites specially created to observe the sun, including Ulysses (launched 1990, studied solar wind and magnetic fields at the poles), Yohkoh (1991-2001, studied x-rays and gamma radiation from solar flares), SOHO (launched 1995, studies interior and surface), and TRACE (launched 1998, studies the corona and magnetic field).

Kuiper Belt and Beyond



The Kuiper Belt is an icy region that extends from just beyond Neptune (from 3.7 billion miles to 7.4 billion miles from the sun). Most objects in this region take hundreds of years t orbit the sun from this distance. This is where most comets and asteroids from our solar system hang out. The largest object out there is Eris, but we're still finding new ones all the time.

Eris is the largest known dwarf planet (the other dwarfs are Ceres and Pluto), orbiting 10 billion miles away from the sun. It takes Eris 560 years to complete one trip around the sun. **Sedna** is the coldest object we've found in our solar system. It's a tiny rock (930 miles across) about 8.4 billion miles away from the sun, discovered in 2003. It would be like trying to spot a single grain of sand in California from the Moon.

Gerard Kuiper (1905-1973) is known as the father of planetary science for his discoveries of moons in the solar system as well as detecting atmospheres on Titan and Mars.

The Oort cloud lies just beyond the Kuiper belt, housing an estimated 1 trillion comets. The Oort cloud is so large that it occasionally gets stirred up by nearby stars (like Alpha-Centauri, our nearest neighbor). When this happens, the gravitational effect can either bump the comet's orbit toward our sun, or sling it forever out of our system toward other stars. Jan Oort (1900-1992) was one of the world's top astronomers who first figured out that our solar system was surrounded by a cloud of comets. He also figured out the where the center of our galaxy is (in Sagittarius).

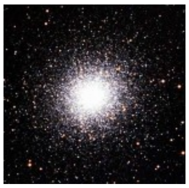
Galaxies

Stars like to live together in families. Galaxies are stars that are pulled and held together by gravity. Some galaxies are sparse while others are packed so dense you can't see through them. Galaxies also like to hang out with other galaxies (called **galaxy clusters**), but not all galaxies belong to clusters, and not all stars belong to a galaxy.

Active galaxies have very unusual behavior. Most galaxies have super-massive black holes in the center, many of which lie dormant. Scientists think active galaxies are the ones where the black hole is actively feeding on in-falling material. What scientists can detect are huge bursts of energy in the form of x-ray and gamma rays spewing up and out of the plane of the galaxy - a sure sign of a voracious black hole. There are several different types of active galaxies, including **radio galaxies** (edge-on view of galaxies emitting jets), **quasars** (3/4 view of the galaxy emitting jets), **blazars** (aligned so we're looking straight down into the black hole jet), and others. Our own galaxy, the Milky

Way, has a super-massive black hole at its center, which is currently quiet and dormant.

Globular and Open Clusters

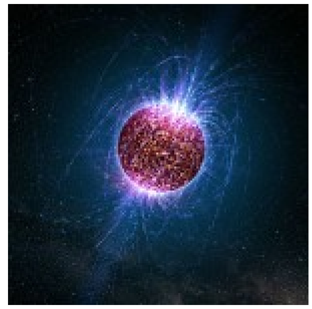


When you look up at the night sky, it seems like the pinpoints of light are each isolated from each other. When viewed through a telescope, however, single stars can actually transform into tens of millions of stars. Globular clusters are massive groups of stars held together by gravity, using housing between tens of thousands to millions of stars (think New York City). Open clusters are made up of stars that all have the same chemical composition, but don't usually stay together for long.

Planetary Nebulae

Dying stars blow off shells of heated gas that glow in beautiful patterns. William Hershel (1795) coined the term 'planetary nebula' because the ones he looked at through 18th century telescopes looked like planets. They actually have nothing to do with planets – they are shells of dust feathering away.

Neutron Stars and Pulsars



When a star uses up its fuel, the way it dies depends on how massive it was to begin with. Smaller stars simply fizzle out into white dwarfs, while larger stars can go supernova. A recent supernova explosion was SN 1987. The light from Supernova 1987A reached the Earth on February 23, 1987 and was close enough to see with a naked eye from the Southern Hemisphere.

Neutron stars are formed from stars that go supernova, but aren't big and fat enough to turn into a black hole. When a star this size explodes, it blows off its outer layers of gases and the inner core collapses down and crushes the atoms together so much that protons and electrons fuse into neutrons. The neutrons are so densely packed together that the space between them is basically gone.

Pick up a strand of your hair right now – feel how heavy it is? If this was made of neutron material, it would weigh the same as the empire state building.

As the neutron star forms, it starts to rotate and form huge magnetic fields. We already know that when you have magnetic fields, electrical fields are not far behind. Neutron stars can wind up spinning very fast, spewing jets of high-energy x-ray particles out the poles. When our telescopes detect the x-rays from a neutron star, we call it a **pulsar**.

Neutron stars with HUGE magnetic fields are known as magnetars, but because they were first modeled in 1992, not a lot is known about them. We currently know about only a handful of these, and thankfully none are near the Earth. To get a better sense of these things, compare the magnetic fields: the Earth registers at 1 gauss, Jupiter is 1,000 gauss, solar flares are 1,000 gauss, and a magnetars has magnetic fields that register 1,000,000,000,000,000 gauss.

Black Holes

Black holes are the leftovers of a BIG supernova. When a star explodes, it collapses down into a white dwarf or a neutron star. However, if the star is large enough, there is nothing to keep it from collapsing, so it continues to collapse forever. It becomes so small and dense that the gravitational pull is so great that light itself can't escape.

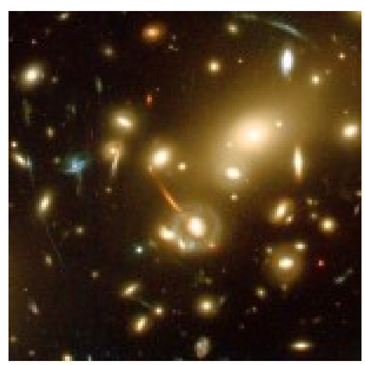
What would it be like to fall into a black hole? Well, there are two different perspectives. Imagine your friend Alice parked her spaceship a safe distance away, just outside the event horizon. She's not in any danger of being pulled in – she just wants to watch you go in. As you float toward to black hole, she sees you drift toward it, picking up speed as you get closer. She sees you going faster and faster, speeding up so that you're going near break-neck speed, and then you get close to the event horizon (the 'point of no return' – think about being in a boat going over Niagara Falls – there's a point that you can't escape going over no matter how hard you paddle). She sees you slow down as you approach the event horizon, turn redder and redder, and slowly fade away. She never actually sees you go in.

From your point of view, however, things went a little differently. First, you headed toward the black hole feet-first, and initially went slowly. As you got closer, your speed picked up faster and faster until the gravitational pull at your feet was different from the pull at your heat, at which time you became '**spaghettified**' (no kidding – that is the real astronomical term for this effect) where you were pulled into a super-thin, super-long string and finally shredded on the subatomic level.

So, how do you avoid such a fate? The only way you can detect a black hole is to look at what happening around it. If a star seems to be yanked about, but there's nothing there to do the gravitational pulling, you can bet it's a black hole. Stuff doesn't just fall straight into a black hole, either. When matter approaches the black hole, it stars to swirl around an accretion disk, which heats up the particles in the disk and lights up the disk so it's visible in the x-ray part of the spectrum (even though the black hole itself is not). You can also detect black holes by the way light is bent when passing by.

Gravity Bending Light

Gravitational lensing is one way we can "see" a black hole. When light leaves a star, it continues in a straight line until yanked on by the gravity of a massive object (like a galaxy or black hole). The gravity will bend the light and change its course, which can show up as streaks or multiple, distorted images on your film where they should be pinpoints of light (see the streaks in the photo?).



Special Relativity

This article on Special Relativity is for grades 9-12.

Space and Time

Most people use common sense when they interact with their world. They know that if they are traveling 60 mph and an oncoming car travels also at 60 mph, the impact will feel like 120 mph. But you'll have to leave all that behind as we step into the world of special relativity.

Problems with Newtonian Physics

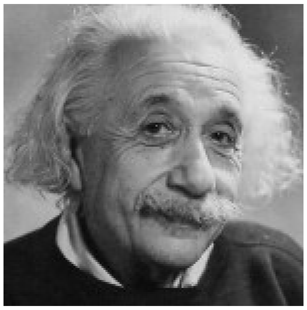
In the late 19th century, a famous experiment (Michelson-Morely Experiment) was conducted to measure the earth's rotation using light beams. The experiment went something like this: if we shine a beam of light in the same direction that the earth is rotating (along the equator), then the two speeds will add and can be measured against a beam of light aimed toward the north pole (where the rotation speed does not factor into the light speed). This was a very plausible idea.

This about this – if you poke your head out the sunroof and toss a ball at 20 mph in the same direction that your 60 mph car is traveling, the ball speed seen by someone standing on the ground would be 80 mph. If you toss the ball out the passenger window perpendicular to your line of travel, then the ball speed is 60 mph in the forward direction (and 20 mph sideways). Notice that they don't add together - they are not supposed to. So, it was logical to expect that light would behave the same way.

Well, it didn't.

The light from both beams actually measured the same exact speed. It would be like your ball staying at the constant 60 mph no matter how hard you throw it. And scientists realized that something very odd was going on. After many years, it was discovered that Newtonian physics are fine when dealing with slow speeds – that is, speeds less than 10% of the speed of light, or 30,000 meters per second. For speeds faster than this, space and time start to get a little weird.

Special Relativity



Albert Einstein in 1905 came up with an idea that shook the entire scientific field. At that time, there were two principles that everyone assumed were true, but Einstein rejected. In a nutshell, everyone believed that every viewpoint is absolute, and time is absolute.

Time is Not Constant

Let's talk about the time idea first: time does not necessarily need to pass at the same rate everywhere. Time actually slows down the faster you go. Recently, scientists sent up fast satellites with highly-accurate clocks inside that were synchronized with clocks back here on earth. When they retrieved the space clocks, they were seconds behind the earth-bound clocks. The space clocks ticked slower than the earth clocks. Nowadays, the atomic clocks in the GPS satellites run about 7.2 microseconds slower a day than earth-bound clocks, so scientists adjust their data to maintain accuracy. This effect is called time dilation.

Different Viewpoints

If you're in a train and dribbling a basketball, the basketball is behaving the same way it would be if you were on the court, right? You bounce it to floor, and it pops back up to your hand. It doesn't fly at the back wall or through the ceiling. As long as the train stays at the same speed (meaning that it doesn't accelerate), you and your basketball practice are doing just fine. However, if you are in a train made of glass so someone at the train station can watch you, they will see the ball trace out a zigzag pattern as you zip past the train station. Because you're moving down the tracks, the ball is moving both up and down and forward at the same time, as seen by the person standing still. But since you're moving forward too, you don't notice it. Einstein stated that all things are relative, and that the person at the train station doesn't see the same things you do. And neither point of view is better than the other – they are both equal. Are you with me so far?

Einstein's theory of special relativity states that the same

laws of physics apply to you on the train as well as the person at the station. Gravity doesn't suddenly stop working, for example. Physics still works the way it should for each person. Sounds good so far, right? Okay , this is where you leave your intuition behind and jump into complete scientific weird-ness…

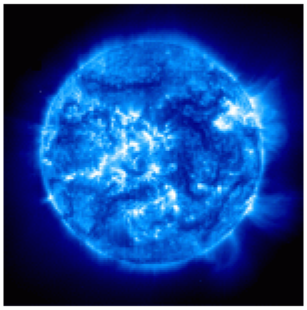
The most important leap Einstein made was stating that the speed of light is always constant, no matter what. This means that you can't add velocities the way we did before with the baseball and moving car. You have to use special math formulas called the Lorentz Transformations, which is way out of the scope of this unit. But that doesn't mean we can't have fun talking about this stuff. So what happens when your train is traveling near the speed of light and you flip on the headlight?

The person at the train station would see your headlight turn on, but it would be a different color depending on if you were heading toward them (blue headlight) or traveling away from them (red headlight). You (inside the train) would see a white headlight, and in all cases, the light travels at 300,000 meters per second.

Let's take an even weirder example: suppose you were inside the train, traveling near the speed of light and you have two light bulbs wired up to the same switch. One bulb is at the front of the car, the second at the back of the car. When you flip the switch, the light from both light bulbs hit your eyes at the same time, just as it you weren't moving. However, if someone sitting at the train station is watching you as you do this, they would see one light bulb turn on ahead of the other, and they would be different colors when they did go on, even if they were wired to the same switch. This is one of the weirdest parts of relativity: events are not conserved (meaning that two different people can see two different things happen) and time rates are not the same in each viewpoint.

Later you'll learn about how distances are not conserved (meaning that space itself will shorten and contract) and mass itself will change. All these things happen in order to keep the speed of light constant. It's one of the odd ways that the universe is wired.

Particle Physics



Matter is anything that has mass. Another way to think about it is that **matter is anything affected by gravity**. The matter you're familiar with is made up of atoms and ions, but that only makes up a small part of the matter in our universe. The matter in black holes is not necessarily made of the same stuff in your fridge.

A Overview of the Atom

All matter is made of some kind of particle. Visible matter (the chair, table, book, car, even you!) is made up of electrons and quarks. **Quarks make up the nucleus of the atom.** They are subatomic particles that you can arrange in certain ways to get protons and neutrons. Most of the mass is inside the atom's nucleus.

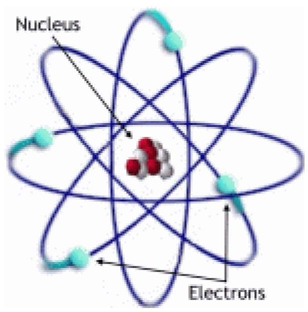
Zipping around the nucleus is the electron, which carries a negative electrical charge and very little mass. Atoms carry the same number of protons (positive charge) and electron (negative charge) so the charges cancel and the atom is usually neutral. If an atom loses or gains an electron, it becomes an ion and takes on a charge.

Free neutrons are generally unstable. It has to do with the way it's built, meaning how the quarks inside the neutron are arranged. If you could put a naked neutron by itself on a shelf, it wouldn't last more than fifteen minutes before it flipped and became a proton. Isn't science weird?

How to Turn Lead Into Gold

The number of protons inside the atom determines what type of element it is. For example, an atom with two protons in the core is a helium atom. An atom with eight protons is an oxygen atom. You can change the atom by adding or taking away protons. To turn lead (which has 82 protons) into gold (79 protons), you would take away three protons. It's that simple. (Or is it?)

What Keeps an Atom Together?



If you think about it, the nucleus of an atom (proton and neutron) really have no reason to stick together. The neutron doesn't have a charge, and the proton has a positive charge. And most nuclei have more than one proton, and positive-positive charges repel (think of trying to force two North sides of a magnet together). So what keeps the core together?

The strong force. Well, actually the *residual* strong force. This force is the glue that sticks the nucleus of an atom together, and is one of the strongest force we've found (on its own scale). This force binds the protons and neutrons together and is carried by tiny particles called **pions**. When you split apart these bonds, the energy has to go somewhere... which is why fission is such a powerful process (more on that later).

The **fundamental strong force holds the quarks together** inside the proton and neutron. Itty bitty particles called gluons hold the quarks together so the atom doesn't fly apart. This force is extremely strong - much stronger than the electromagnetic force. This force is also known as the color force (there is not any color involved - that is just the way it was named.)

The electromagnetic force keeps the electrons from flying away from the nucleus. When a plus (the nucleus) and minus (the electron) charge get close together, tiny particles called photons pull the two together.

What is Particle Physics?

Scientists love to smash things together and watch what happens. Galileo smacked bowling balls together, Newton was hit by an apple, and physicists today want to know what happens when you smack one tiny particle into another. By watching what happen when they collide and how they interact with each other, scientists can puzzle together what happens inside black holes, stars, and pulsars.

Antimatter

You know from science fiction that when matter and antimatter collide, they destroy each other and release a huge amount of energy. The question is, what *is* antimatter? And what makes it 'anti'?

Let's take the example of the electron. An electron is a small bit of matter with a negative charge and a certain amount of mass. **The antimatter component to the electron is called the positron**. The positron has the same mass as the electron, but its charge is positive. That's all there is to it. Antimatter counterparts have characteristics that are opposite from their companion particle.

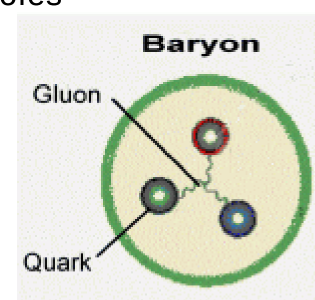
Dark Matter

When you look up at the stars tonight, notice how many bright stars you see. Is there more light or dark space in the night sky? Even though it seems that there's a lot of empty space out there, there is way more matter *inside* stars than anywhere else in our universe. All visible matter is made up of protons, neutrons, and electrons... but there are hundreds of other kinds of particles that make up matter as well.

This invisible mass is called **dark matter**, and some of it takes the form of MACHOs (massive compact halo objects) and WIMPs (weakly interacting massive particles). Scientists are still trying to figure out what they are and how they act. Most of these live only for a very short time (think less than a blink of an eye), so scientists have to be very fast at taking their data.

Surprise!

Matter and antimatter pairs are constantly popping in and out of existence in our universe. One minute, they don't exist, then next second *POP!* there they are... but then faster than you can blink, the pair smacks into each other and *POOF!* both are destroyed and give off a puff of energy. It's just one of the weird ways that the universe is wired. This is also the basis for how black holes evaporate (we'll talk about Hawking Radiation later).



What other particles are there?

Physicists gave these little bits of matter all sorts of odd names. Are you ready for these?

Here are the most common fundamental particles (meaning that you can't split it in half anymore - it's as small as it can get: leptons and quarks. There are six different types of **leptons** but only two of which are stable and show up in ordinary matter. There are also six different kinds (called 'flavors') of **quarks**, but only two can occur in ordinary matter ("up quark" and "down quark"). By the way, the person who named it 'quark' named it after his favorite type of cheese back in the day (quark cheese, anyone?).

There are several different composite particles (particles that have an internal structure - meaning that you can still split it in half): **baryons, mesons, and positive pions**. Baryons are larger particles containing quarks, mesons contain a quark and an antiquark, and a positive pion has one up quark and one anti-down quark. There are hundreds of different kinds of baryons and mesons.

The carrier particles are the ones that carry the force between the particles. Some of these we haven't really seen for ourselves - we're just guessing. They include: the **gluon** (glues together quarks inside a proton or neutron), the **photon** (carries the electromagnetic charge), the **graviton** (our best guess as to what causes gravity), and others.

Your head is probably about to explode, so I'll leave you with just one more thought - **most of these particles also have an antimatter component**... so there are quarks and anitquarks, protons and antiprotons, neutrons and antineutrons, neutrinos and antineutrinos... the list goes on and on! Remember, the positron has a positive charge while the electron has a negative charge. The antiproton has a negative charge and the proton has a positive charge. The antineutron still has no charge (like the neutron), but is made up of antiquarks instead of quarks.

Nuclear Fusion and Fission

In the 20th century, scientist figured out that the core of an atom can break apart or join together with others. If you split an atom (called **fission**), you get smaller parts and a whole lot of energy. When this happens in nature, it's called **radioactivity**. Unstable atoms spontaneously break apart and release particles and energy.

Fusion is taking place inside the sun. The sun is not on fire, like a campfire or stove. So where does it get its energy from? The fusion process smacks particles together, which results in a big release of energy. The core of the sun is about one million degrees Celsius, which the surface temperature is a mere 15,000 degrees Celsius. The fusion process in the sun takes two naked protons (also known as a hydrogen nuclei) and smacks them together in a special sequence that results in the formation of helium. This complicated reaction is called the proton-proton chain, and occurs in all stars burning hydrogen in their core.

In chemistry, when you combine things together, you get different stuff out the other end. For example, when you mix together baking soda and vinegar, you get liquid water and sodium acetate precipitate in the cup, and carbon dioxide bubbles released into the atmosphere. When the core of a star fuses together in a supernova, it creates every element on the periodic table (yes, even gold!) and also spits out high-energy alpha, beta, and gamma particles.

Alpha particles were named long before we ever knew *what* they were. An **alpha particle are two protons and two neutrons stuck together** (also known as helium nuclei). **Beta particles are either electrons or positrons.** Gamma particles, also called **gamma rays, are actually electromagnetic radiation** (photons) of very, very high frequency and energy - high enough to damage living tissue. Fortunately, gamma ray bursts are rare and usually not pointed in our direction.

How Does a Nuclear Reactor Work?

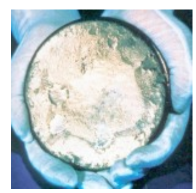
When people think of nuclear power, they often think of disaster-type scenes. Actually, power plants are very similar to coal-burning power plants. They both heat water into steam, which turn generators. The main difference between them is they way they heat the water. Some plants burn fossil fuels (like coal and oil), and nuclear plants use the energy from fission (splitting atoms apart) to heat water.

Remember when we talked when an atom spontaneously undergoes fission, it's called radioactivity? Uranium-235 is the perfect example of this kind of atom. U-235 decays naturally by spitting of an alpha particle or two neutrons and two protons bound together. However, U-235 is one of the few materials that can undergo fission both naturally and artificially, so it's a great choice for nuclear power plants. If a naked neutron zipping along by itself suddenly runs into the nucleus of a U-235 atom, the neutron gets absorbed by the core, which cases the atom to be unstable and split immediately.

Are Nuclear Weapons Different from Nuclear Power Plants?

Yes. Nuclear weapons allow the explosive energy in the atom to essentially run rampant, while power plants harness the atomic energy to heat water. The two types of nuclear weapons use energy from either fission (atomic bombs or A-bombs) or fusion (hydrogen bombs or H-bombs).

Atomic bombs get their explosive energy solely from the core of the atom. An atom by itself usually doesn't spontaneously split - you need to have a certain amount (called the **critical mass**) in order to start the fission process. In an atomic bomb, they separate a small chunk of material (usually plutonium or uranium) from the main lump so that the resulting lump mass is slightly *less* than the critical mass (so it doesn't explode before you want it to). The removed chunk is placed in a shotgun-looking device that will fire directly into sub-critical-mass lump when triggered.



Another way to get the reaction started is to detonate high-energy chemical reactions all around the lump of material, compressing it until it splits on its own.