Plate tectonics is a theory that describes how the solid Earth operates. In this video we will look at details of the two most important plate tectonic processes: the creation of new plates at oceanic spreading ridges and the destruction of plates in subduction zones.

The Earth's outer surface is divided into a mosaic of rigid plates defined by a network of plate boundaries. The boundaries are the main sites of plate tectonic activities. There are three types of plate boundaries: **divergent plate boundaries** where two plates move apart, **convergent plate boundaries** where two plates move towards each other, and **transform faults** where two plates slide past each other. Divergent plate boundaries are also called **oceanic spreading centers** and are where new plate material is continuously created. Convergent plate boundaries mark where one of the two converging plates sinks beneath the other plate in a **subduction zone**. Convergent plate boundaries are deeply submerged, and an oceanic **trench** marks where the downgoing plate bends down to begin its descent. We now look at what happens deep in the Earth beneath divergent and convergent boundaries.

Geoscientists refer to Earth's plates as **lithosphere**. Lithosphere is a rigid shell of rock about 100 kilometers or 60 miles thick. It is composed of Earth's outermost compositional layers - the **crust** and the uppermost **mantle**. Plate tectonics happens because lithosphere slides over deeper, warmer and weaker mantle called the **asthenosphere**. The origin of the force for this motion is the sinking of dense lithosphere in subduction zones.

Let's look at lithosphere creation beneath a divergent plate boundary where new material for two plates is produced. About 50 km under the oceanic spreading center the asthenospheric mantle rises and begins to partially melt. Melting here occurs when rising hot asthenospheric mantle experiences lower and lower pressure. Melting by lowering pressure is called decompression melting. These melts, or **magma**s, separate from the remaining solid mantle and flow up toward the region of plate separation, concentrating beneath the ridge axis. Geoscientists refer to this as **two-phase flow** because two phases – one solid, the other, liquid - move independently: liquid magma flows up while solid residual mantle flows sideways. Eventually, the magma pooled beneath the ridge axis erupts as lava. When this lava cools and solidifies, it becomes the volcanic rock known as **basalt** which makes up Earth's **oceanic crust**. Older basaltic crust moves symmetrically to either side of the spreading axis to create space for the new crust, this is the Plate Tectonic process known as **seafloor spreading**. At the same time, under this new crust. asthenospheric mantle cools and is added to the base of the thickening lithospheric plate. The new plates slide slowly away from the ridge and the top of the plate, which is basaltic seafloor, collects sediments that slowly sink in the ocean. Water infiltrates into the crust and incorporates itself into the structure of the crust's constituent minerals, **hydrating** the aging oceanic crust. Much of this hydration happens at the spreading ridges, where spectacular hydrothermal vents, teeming with life, are found. Sediments and hydrated oceanic crust will become important chemical players in subduction zones.

As the oceanic lithosphere ages and moves away from the divergent plate boundary, it becomes colder, thicker and denser. When oceanic lithosphere becomes denser than underlying asthenosphere, it becomes gravitationally unstable and wants to sink. Eventually oceanic lithosphere does sink into the asthenosphere at a **convergent plate boundary,** in a **subduction zone**. Plate convergence can create enormous strain at the interface between the two plates, causing powerful **earthquakes** in a region known as the **Seismogenic Zone**. As the plate sinks deeper it drags the overriding asthenosphere down with it, inducing **asthenospheric counterflow** that draws in more asthenosphere. At the same time, the sediments and hydrated crust of the downgoing plate are increasingly squeezed and heated as the plate descends, releasing the water acquired over millions of years on the seafloor. The released **water** and **sediment melts** rise from the **subducting plate** into the overlying asthenosphere and cause it to partially melt. This type of partial melting, induced by fluid, is called **flux melting**. The melt produced is also basaltic magma, as in the case at the oceanic ridges, but this magma contains much more water and water-dissolved chemical elements which distinguishes it from magmas produced at ocean spreading center.

The buoyant basaltic magma rises towards the surface. Some reaches the surface and erupts in volcanoes, but some magma stalls and ponds in the **lower crust** of the overriding plate. Ponded basaltic magma heats the crust and causes it to partially melt, forming secondary **granite magma**. At shallower levels in the crust, ponded basaltic magma can excavate one or more **magma chambers** where the magma cools and fractionates, a process where mineral crystals freeze out of the liquid magma and sink to the bottom, changing the basaltic magma's composition towards granite. Basaltic and granitic magmas can mix in magma chambers to form a spectrum of intermediate magma types. Granitic magma has a low density and rises towards the surface in balloon-like masses called **diapirs**. Some magma diapirs stall before reaching the surface, where they cool and solidify to become **plutons**. Plutons can be exposed on Earth’s surface where erosion cuts down into the crust. An example of exposed plutons is the granitic core of the Sierra Nevada of California. It is probable that the Earth's continents are mostly constructed of this type of material.

The key plate tectonic processes just described, the upwelling of mantle beneath oceanic ridges and the sinking of cool lithosphere in subduction zones, is part of a convecting mantle system that dissipates heat from the Earth’s interior. Sinking of lithosphere in subduction zones powers the Plate Tectonic machine and makes the plates move. These processes also regulate Earth's carbon and water cycle, are responsible for forming many ore deposits, and may be linked to the evolution of complex life. Among the planets and moons of our Solar System, only Earth has Plate Tectonics. Perhaps there are other planets in other solar systems that have Plate Tectonics, waiting to be discovered?