STRUCUTRE OF THE EARTH

(VISUAL REPRESENTATION ON A3 SHEET)

Comparing Earth to other planets in the solar system – It's medium sized but rather dense.
During formation, **denser metallic elements** (iron/nickel) were concentrated at the central core, **sinking beneath** lighter minerals which developed into the surrounding mantle. **These two spheres make up 99% of the Earth**.

The veneer of cold, solid rock, the crust, is a very thin skin of the least dense rock, which cooled against the atmosphere. The Earth has many layers separated by named boundaries. There are distinct changes in the composition and physical properties.

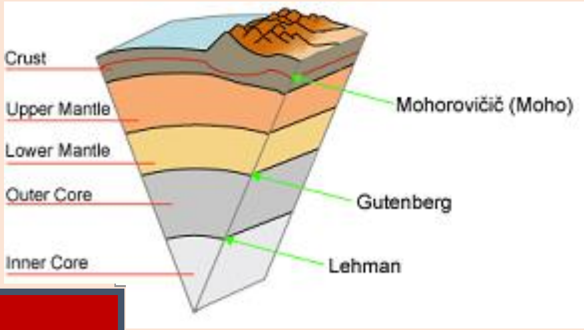
All evidence of the earth's core structure is from earthquakes, meteorites and density measurements.

THE INNER CORE FROM THE CENTRE OF THE EARTH – 6371 KM TO ~ 5100KM

Property	Description	Extra information/ reasoning
State	Solid	High pressures of ~ 3 600 000 atmospheres compared to 1 atm at the surface.
Earthquakes	P-waves and S-waves can pass through	They will increase in velocity due to increase in rigidity of the solid iron/nickel core. S waves are generated by the P-waves here.
Composition	Alloy of iron and some nickel.	Based on evidence of metallic (iron) meteorites and the fact that iron nickel has the correct density of more than 12 gcm^{-3}

THE LEHMANN DISCONTINUITY – ~ 5100 KM

This is a phase boundary between materials of the same composition but of different states. It is not a distinct boundary but is a zone of ~ 100km where rocks change from all liquid in the outer core to solid in the inner core, with a liquid-solid mix in-between. Here there is an abrupt increase in seismic velocity as rigidity increases.



THE OUTER CORE FROM ~ 5100 – 2900 KM

Property	Description	Extra information/ reasoning
State	Liquid	Pressure in the outer core is less than that in the inner core so iron nickel exists as a liquid.
Earthquakes	S-waves cannot pass though and P-waves refracted.	This creates a p and s wave shadow zone between 103^0 and 142^0 and a P wave only zone between 142^0 and 142^0 .
Composition	Alloy of iron and some nickel.	Reduction in rigidity means that S waves slow down. P waves cannot pass through liquid.

THE GUTENBERG DISCONTINUITY AT 2900KM

A distinct boundary where there is a change between material **from metallic iron nickel** to **stony silicate material (olivine, pyroxene (augite) and plagioclase feldspar).**

Property	Description	Extra information/ reasoning
State change	Solid lower mantle to liquid outer core	P wave velocity decreases and S wave stop altogether. Refer to shadow zone above.
Earthquakes	S-waves stop and p-waves slow down	
Composition	Changes from stony silicate material in mantel to metallic iron nickel mix.	

THE LOWER MANTLE 2900 KM TO 700 KM

Property	Description	Extra information/ reasoning
State	Solid	S-waves can pass through.
Earthquakes	S-waves and P-waves increase in velocity steadily.	Seismic wave velocity increases steadily as the increasing pressure causes the rocks to become more rigid and les plastic – less compressible. (increase in incompressibility).
Composition	Stony silicate material (olivine, pyroxene (augite) and plagioclase feldspar). Rich in ferromagnesian. Main rock is peridotite.	Made up of the same material as stony meteorites.

THE UPPER MANTLE 700KM TO AN AVERAGE OF 35 KM

Property	Description	Extra information/ reasoning
State	Lithosphere = Solid Asthenosphere (75 to 25 km) = Rheid (solid mostly with ability to flow)	S-waves can pass through.
Earthquakes	S-waves and P-waves increase in velocity through the lithosphere upper mantle (after the Moho before the asthenosphere) S-waves and P-waves decrease in velocity through the asthenosphere. This is known as the low velocity zone.	P wave and S waves speed up after the Moho as the upper mantle lithosphere is solid peridotite with pressure increasing so it becomes more rigid and incompressibility increases. P and S waves slow down through asthenosphere as there is a slight loss in rigidity from the lower lithosphere (upper part of upper mantle) to the asthenosphere where the rock is rheid and there is a decrease in incompressibility.
Composition	Stony silicate material (olivine, pyroxene (augite) and plagioclase feldspar).	Made up of the same material as stony meteorites. Evidence from ophiolite suites can be examined.

	Rich in ferromagnesian. Main rock is peridotite. However, less dense than lower mantle due to pressure.	Evidence from oceanic volcanoes at MOR Due to the lower pressure compared to the lower mantle, the stony material is less dense.
Layers	The upper mantle includes (the asthenosphere and part of the lithosphere).	Upper mantle lithosphere (above asthenosphere) = solid peridotite Asthenosphere = Plastic/rheid peridotite

The asthenosphere

Most of the mantle behaves as a **solid** that has the **ability to flow very slowly** over millions of years. This type of material is known as **rheid.**

The upper mantle is made of the **rock peridotite**. At depths between **75 and 670km**, but **especially between 75 and 250km (THIS IS THE DEPTH OF THE ASTHENOSPHERE)**, the temperature is high enough **(> 1300^{0}C)** for **roughly 5% of the crystals** in the peridotite to **partially mel**t. This causes a **film of melted minerals** to **surround each solid crystal**, allowing the mantle **to flow** more easily. This upper part of the upper mantle (below lithosphere) shows **plastic properties** even though it is **still solid.**
Some of the **rigidity is lost** so **incompressibility decreases** and so **P and S waves slow down**, which is why it is known as the **low velocity layer.**

THE OCEANIC CRUST OF THE LITHOSPHERE 10KM TO 5 KM (AVERAGE 7 KM)

Property	Description	Extra information/ reasoning
State	Solid	S-waves can pass through.
Earthquakes	S-waves and P-waves increase in velocity steadily.	Seismic wave velocity increases steadily as the increasing pressure causes the rocks to become more rigid and less plastic – less compressible. (increase in incompressibility).
Composition	Silicate minerals rich in ferromagnesian (Fe and Mg). Rock strata is ocean sediments, basalt pillow lavas, dolerite dykes, gabbro in layers.	Olivine is a ferromagnesian silicate mineral.
Ages	Oldest is 200 Ma	Oceanic crust subducts and is destroyed and new oceanic crust forms at the MOR.
Moho	Depth of around 7km	

THE CONTINENTAL CRUST OF THE LITHOSPHERE UPTO 90KM UNDER DEEPEST MOUNTAINS, TYPICAL 35KM TO 50 KM (AVERAGE 35KM)

Property	Description	Extra information/ reasoning
State	Solid	S-waves can pass through.
Earthquakes	S-waves and P-waves increase in velocity steadily.	Seismic wave velocity increases steadily as the increasing pressure causes the rocks to become more rigid and less plastic – less compressible. (increase in incompressibility).

Composition	Rich in AL and Si. Granitic rocks, Intermediate to silicate.	Includes: Igneous, metaphoric, sedimentary. (deformed)
Ages	Oldest is 4000 Ma (4 bil.)	Continental crust is not destroyed, but is weathered and eroded.
Moho	Depth of up to 90km, typically 35 to 50km, average 35km	

Layer	State	Depth	Density
Inner core	Solid	5100 – 6371 km	13 to 12.8
Outer core	Liquid	2900km – 5100km	12.2 to 9.9
Lehmann Discontinuity	Liquid-solid mix	5100km	
Lower mantle	Solid	700km to 2900km	5.6
Asthenosphere of upper mantle	Solid but flows (rheid)	From around 75km to 200km (OC) or 700km (CC)	
Isotherm 1300^{0}C	Solid to rheid boundary	Between lithosphere and asthenosphere. (~ 75km)	
Upper mantle of lithosphere	Solid	Typically from Moho 7km (OC) or 35km (CC) up to 75km	3.3
Crust of lithosphere	Solid	Oceanic = 5km to 10 km (~7km) Continental = 35km to 50km up to 90km (~ 35km)	OC = 2.9 to 3.0 CC = 2.7 to 2.9 (at depth under mountain)