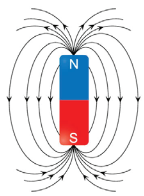
Compasses tell us which way is north. That helps us to find south, east, and west, too.

Earth's Geomagnetism

Compasses align with Earth's magnetic field. No matter where the compass is on Earth or which way you turn it, the needle always points north. This means the needle points in different directions at different places on Earth's surface.

If you've ever used a compass, you've seen that you can turn it in different directions and the magnetic needle inside rotates to point north again, as if it had a mind of its own. This small magnetic needle is actually pushed and pulled by powerful magnetic forces that envelop Earth. Our planet is surrounded by a huge magnetic field that reaches from Earth's core all the way into space.

Magnetic forces like those caused by Earth's geomagnetic field may seem mysterious. These forces act on objects at a distance, and we can't see or touch them. To help visualize magnetic forces, scientists model them using magnetic field lines. These scientific models help scientists predict and explain how magnetic forces work. In a model of a single magnet, lines are drawn looping outward between opposite magnetic poles.



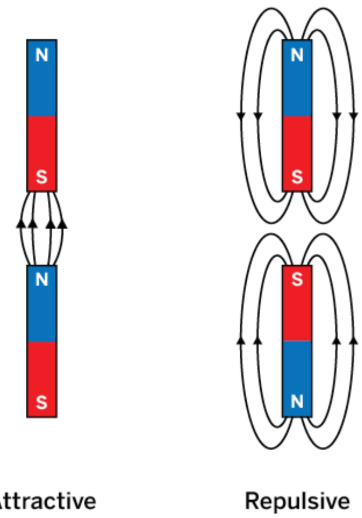
In a model of a single magnet, magnetic field lines come out of the north side of the magnet, loop outward, and enter the south side of the magnet.

In a model with more than one magnet, the field lines are sometimes drawn connecting opposite poles on the magnets. These field lines help predict the direction of the forces pulling or pushing different magnets. A model showing field lines connecting the opposite poles of different magnets indicates that the magnets will be attracted together. A model showing two magnets that are not connected to each other by field lines indicates that the magnets will repel each other.

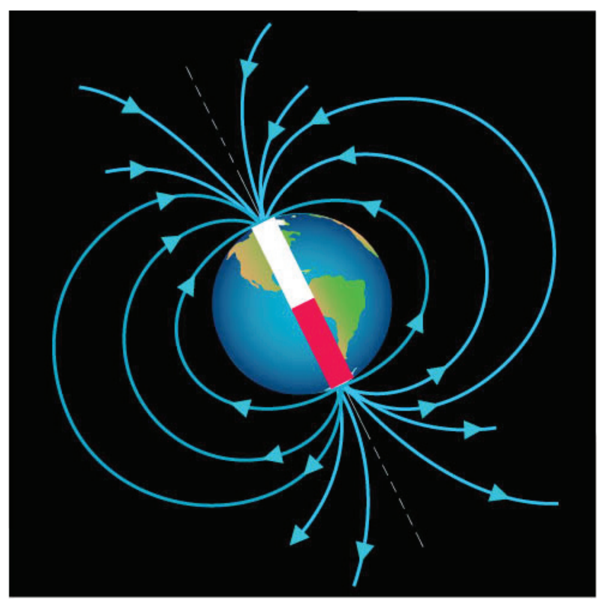
Compasses are helpful in determining which direction the magnetic field is going and where the field lines should be drawn. Field lines drawn to model Earth's magnetic forces are based on the directions compass needles point at different places on Earth. Compass needles spin so that one end points to the north pole. This happens because each geomagnetic pole attracts the opposite pole of the compass at the same time it repels the like pole of the compass. These magnetic forces cause the compass needle to rotate until it points north.

You can see the effect of Earth's magnetic field when you hold a compass in your hand—the needle points north, and knowing which way is north can help you find south, east, and west. Some animals can figure this out without looking at a compass. They have tiny bits of metal in their cells that act like tiny compass needles! These bits of metal rotate to point north, giving these animals a natural sense of which way is north. Animals like bees, bats, and some types of birds use this knowledge to find their way. Some use it for short distances, like bees that have flown away from their hives. Others, like snow geese, use it to migrate thousands of miles every year.

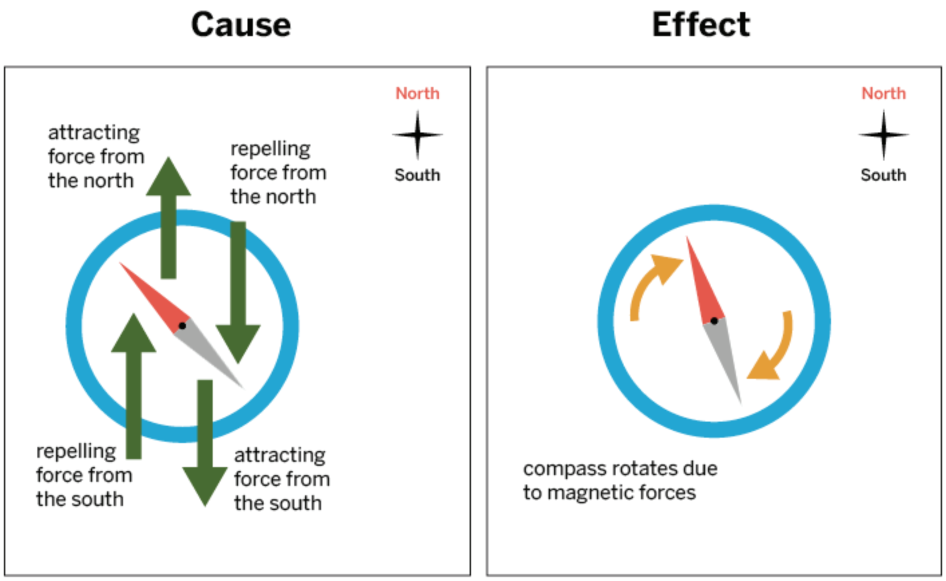
Earth acts like a giant bar magnet, with a north pole and a south pole that affect compass needles, but there isn't actually a bar magnet in the center of Earth. Earth's magnetic field is caused by the planet's liquid iron core moving



This model uses field lines to show what happens to the fields between two magnets. Opposite poles are attracted to each other, while poles of the same type are repelled away from each other.



Earth's magnetic field lines point from the magnetic north pole to the magnetic south pole. Does something look weird? That's because Earth's magnetic poles are backwards! The place we call the North Pole is actually where you find Earth's magnetic south pole.

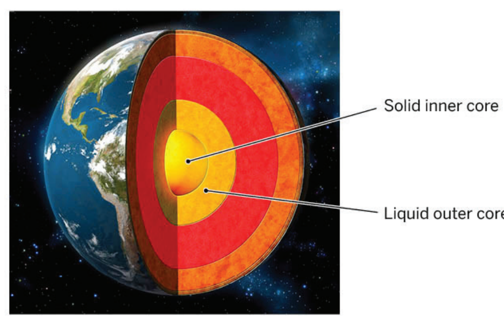


Each end of a compass needle is attracted by the magnetic force of one of Earth's magnetic poles and repelled by the other. Since the needle is attached to the compass in the middle and can't go anywhere, it spins in a circle.

around. The process that creates a planet-wide magnetic field is called geomagnetism.

It may seem amazing that forces produced in the center of Earth could act on objects so far away, but Earth's magnetic field actually reaches much farther than Earth's surface. These forces are acting on Earth all the time, and we use them for everything from navigation to sorting recycling. So although you can't see them, you interact with the forces of geomagnetism every day.

Layers of Earth's Core



Earth has an inner core of solid iron surrounded by an outer core of liquid iron. Heat from the inner core causes the liquid iron to move, producing a magnetic field.