MAGNETS & MAGNETISM

PART 2

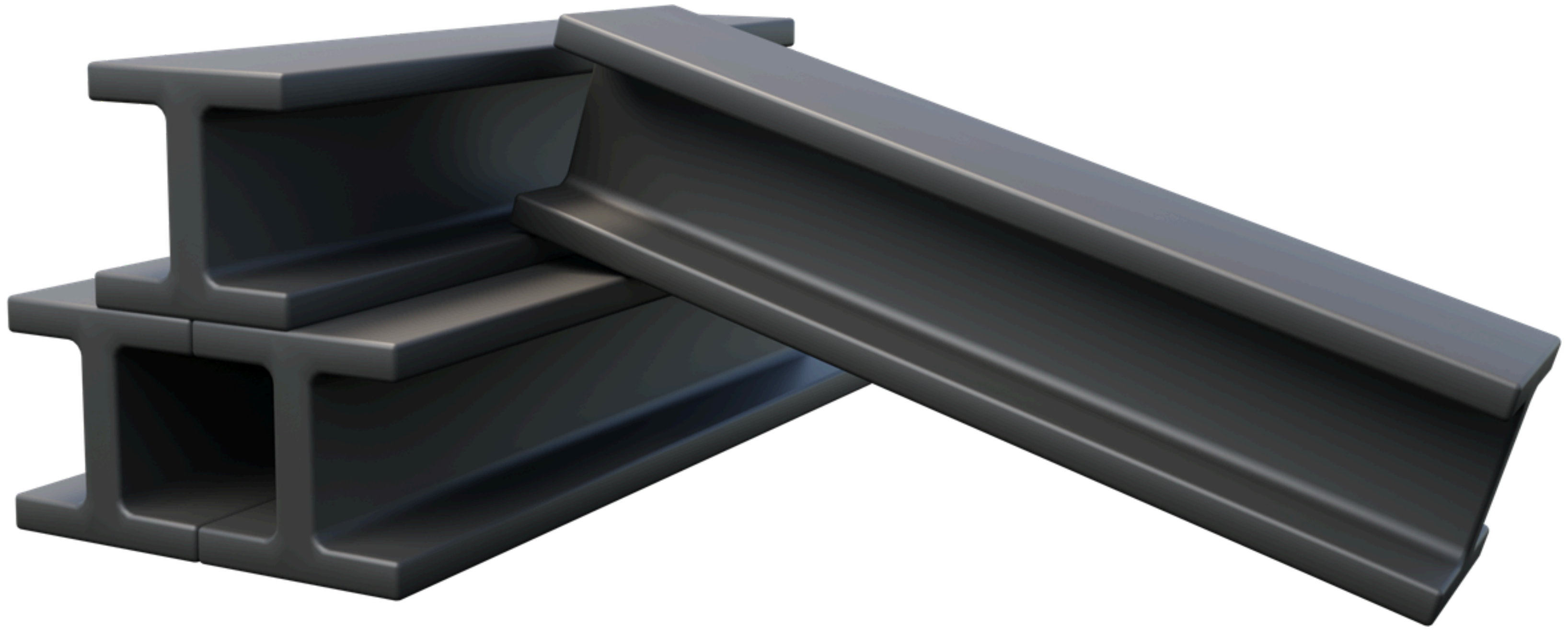
Types of Magnets

There are TWO categories of magnets:

1. Permanent

   and

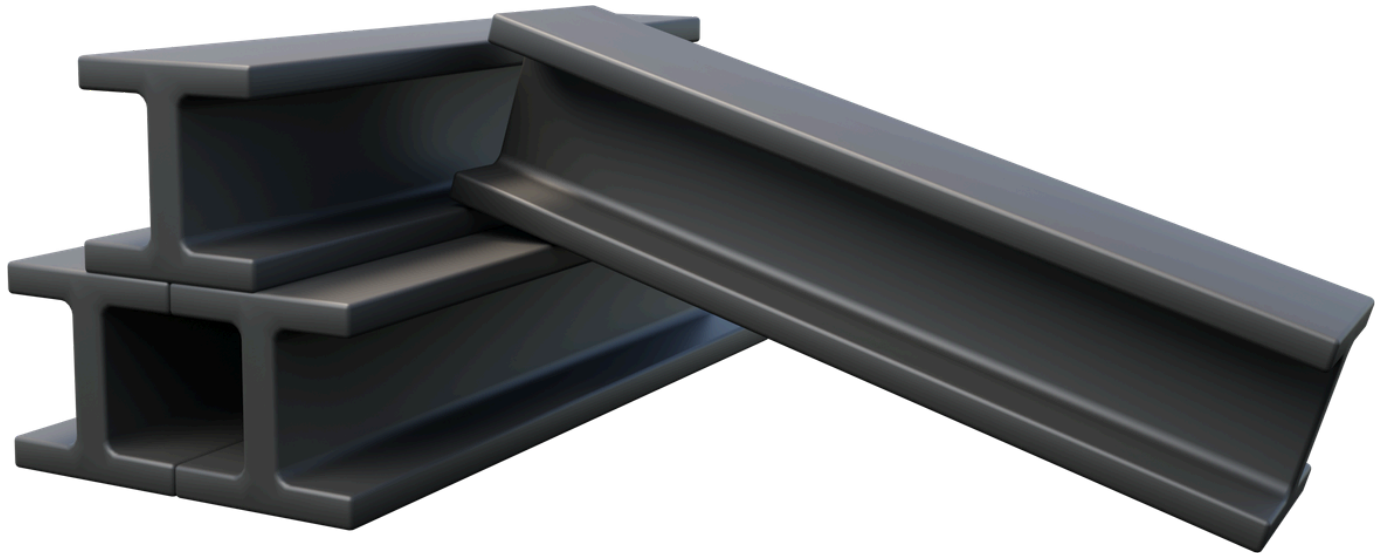
2. Temporary



Steel forms permanent magnets (hard magnets)

Iron forms temporary magnets, (soft magnets)

Examples of Other Permanent Magnets and Their Uses



Other Types of Permanent Magnets	Uses of Permanent Magnets
Magnadur	
Alnico	Directional Compasses
Ticonal	Loudspeakers
Alcomax	

Examples of Other Temporary Magnets and Their Uses

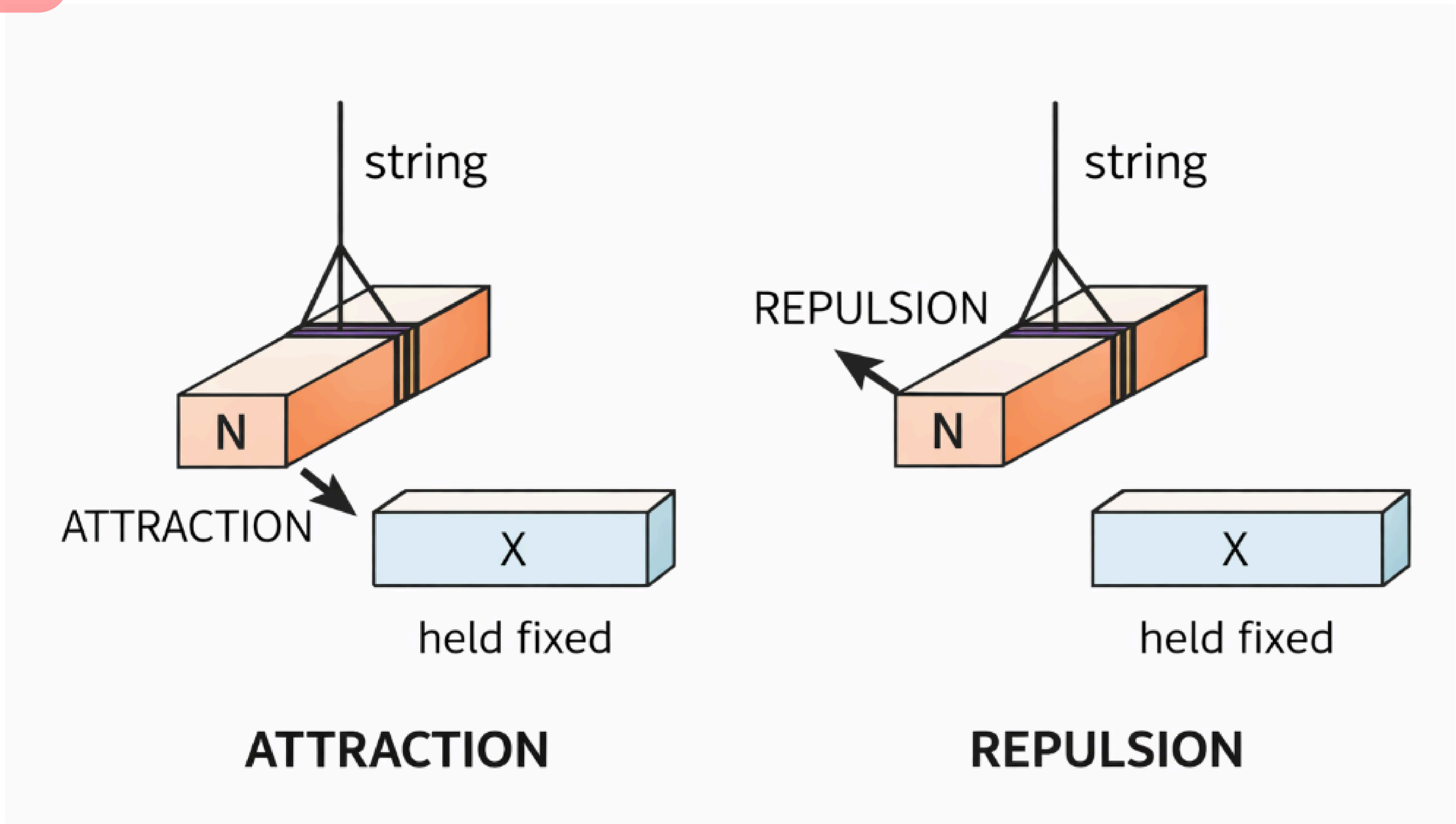
Other Types of Temporary Magnets	Uses of Temporary Magnets
Mumetal Stalloy	These metals are used in electromagnets which are used a. for lifting metal objects b. electric bells c. magnetic relays d. electromagnetic circuit breakers

Permanent Magnets vs Temporary Magnets

Permanent Magnets	Temporary Magnets
A permanent magnet will remain magnetized even after the cause of magnetizing is discontinued	A temporary magnet loses its magnetic properties when the cause of magnetizing is discontinued
Its strength is constant	Its strength is varied
Steel is used to make permanent magnets	Iron is used to make temporary magnets
• Clasps for jewelry, • compasses, credit cards (the black metallic strip at the back), • doors of refrigerators and dishwashers, • ornamental articles attachable to refrigerators etc.	• Cranes, • electric guitars, • door bells, • microphones, • generators, • telephones, • television and • computer monitors, • in industry to lift iron and steel rods and sheets, • motors, • loud speakers, • medicine for MRI (magnetic resonance imaging),

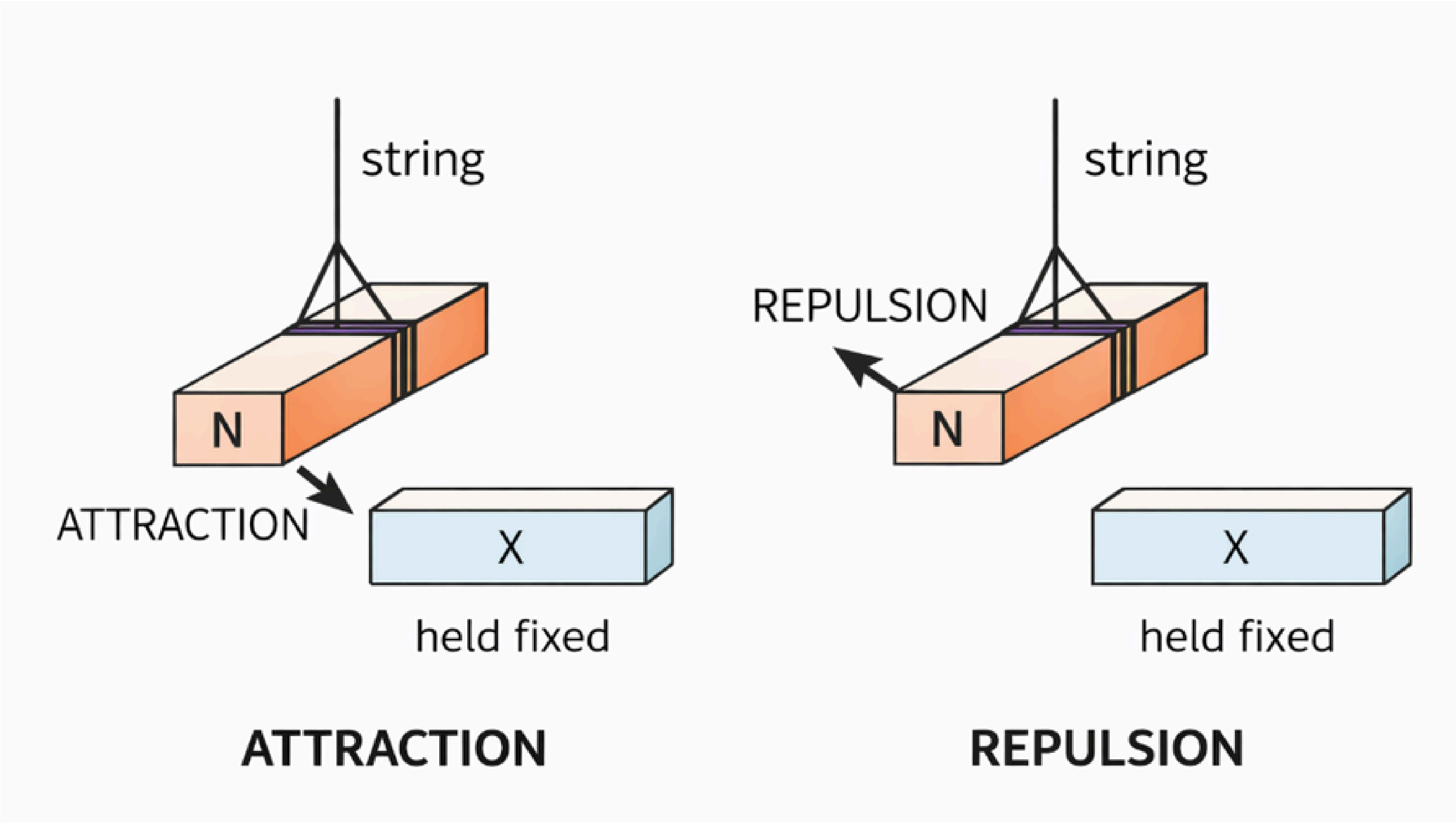
Testing for POLARITY

The only **TRUE** test to determine the polarity of a magnet is **REPULSION!**



This is because

- **Attraction** is not a definite test
- **Repulsion** is the only sure test of polarity

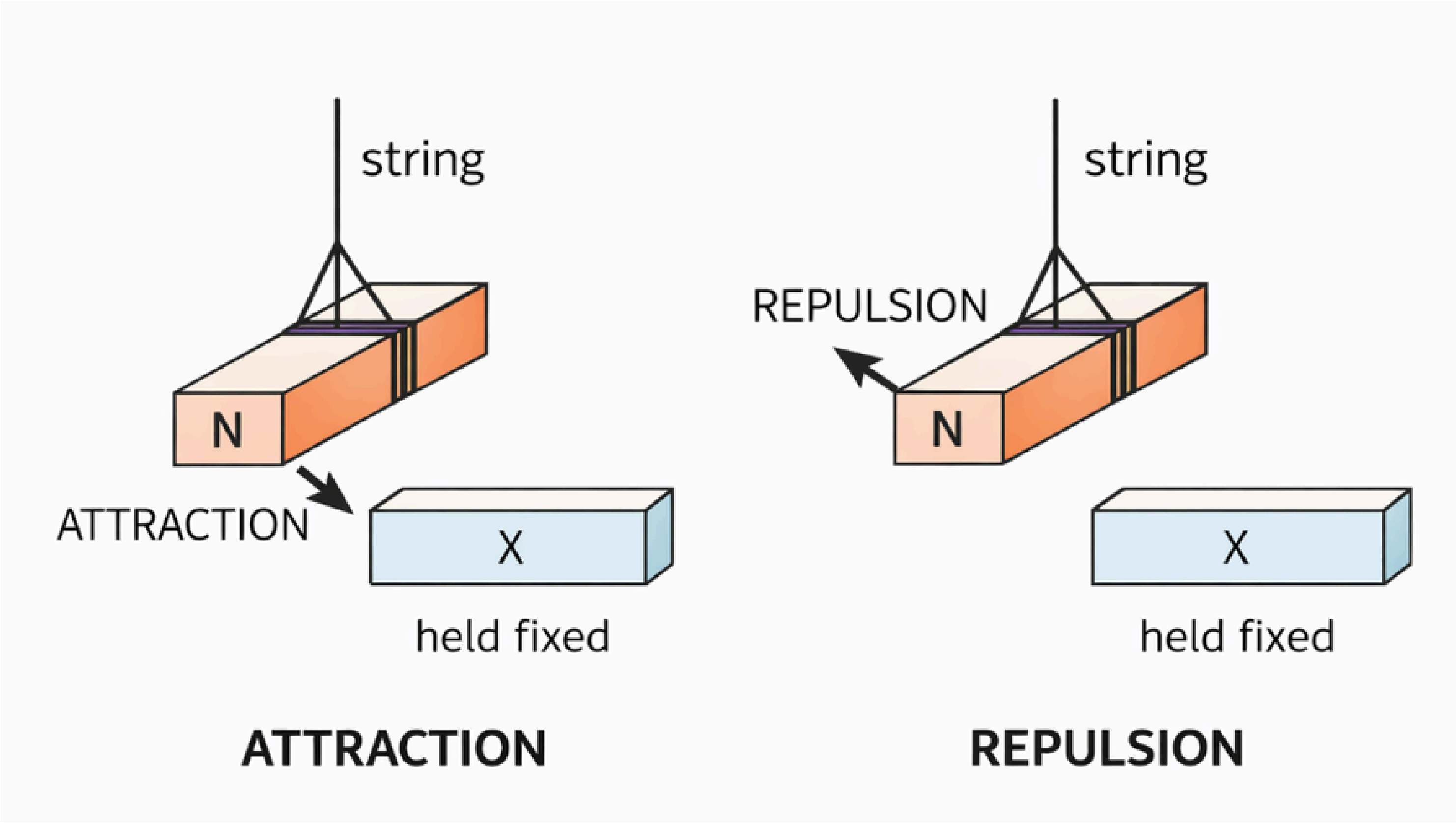


Attraction is not a reliable test because a magnet will attract many things, for example:

- Iron or steel (even if they are not magnets) and
- The opposite pole of another magnet

So if something is attracted, you cannot be sure whether:

- it is an opposite pole, or
- it is just a piece of magnetic material.

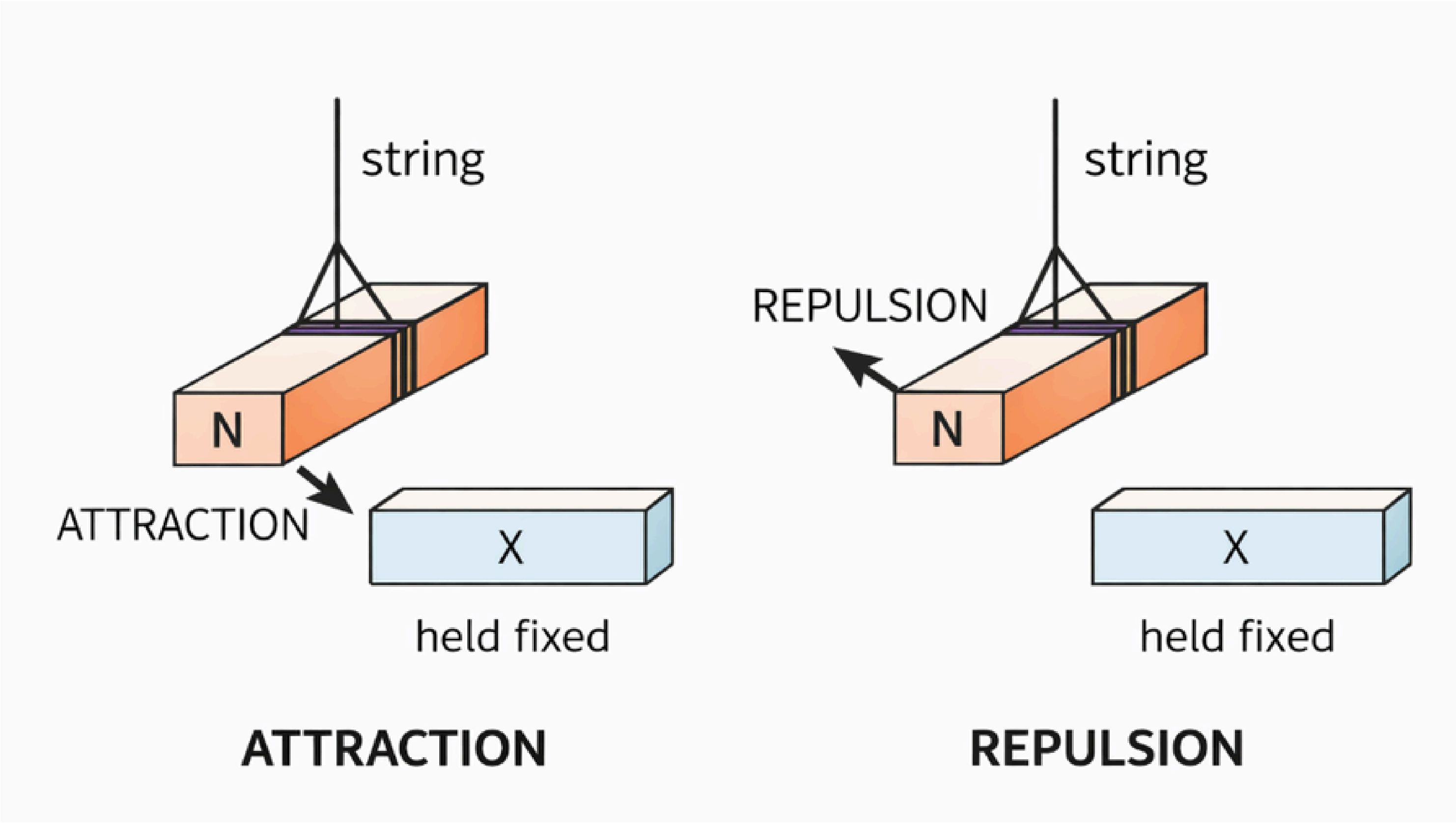


Repulsion only happens between two like poles of magnets.

- North pole repels North pole
- South pole repels South pole

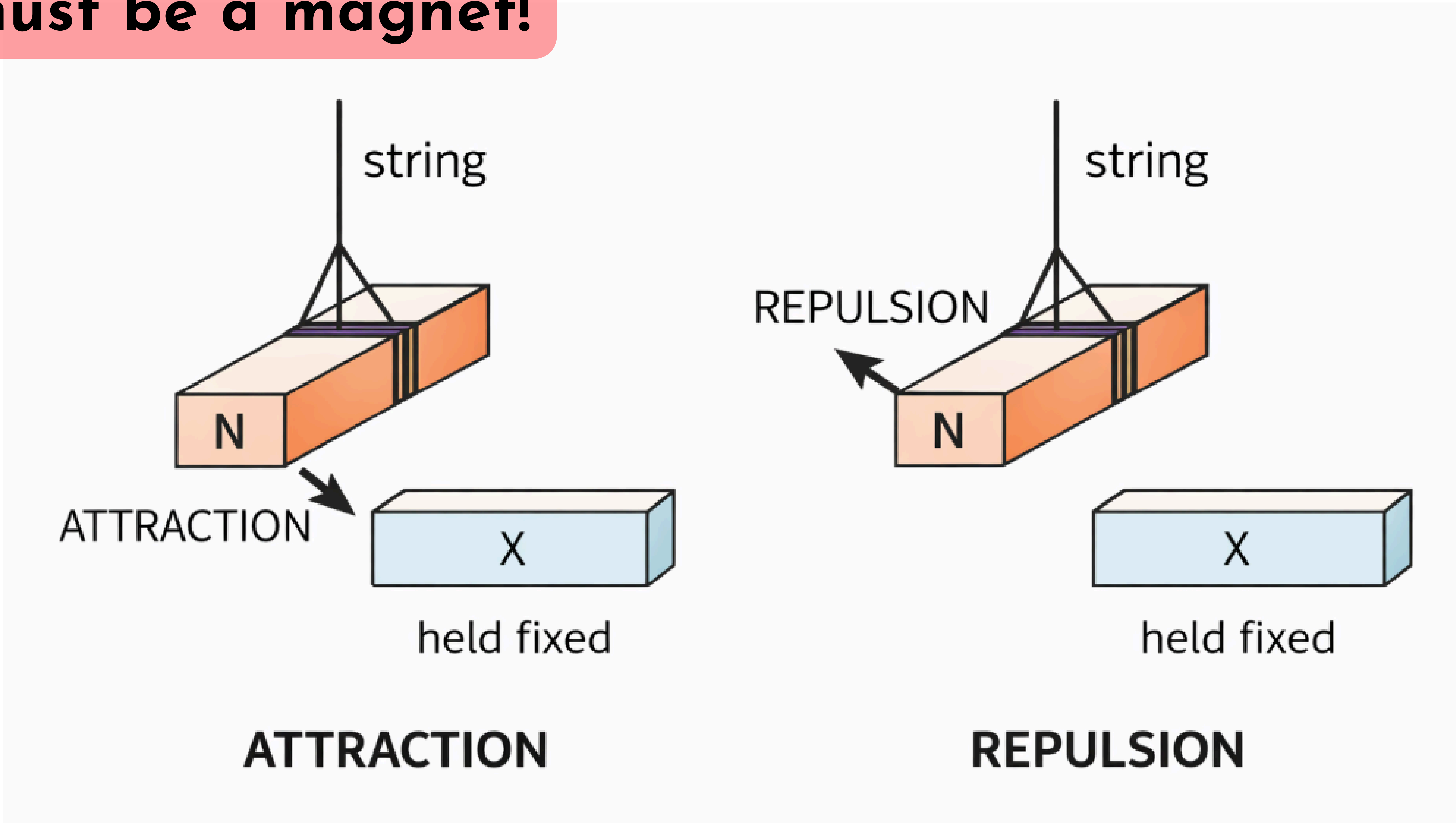
A piece of iron cannot repel a magnet. It will only be attracted.

Attraction is not a sure test of magnetism because it is **NOT** exclusive – many materials can be attracted to a magnet.



Repulsion, however, **IS** exclusive and only occurs between like poles of two magnets, making it the only true test of magnetism.

If it attracts, it might be a magnet... but if it repels, it must be a magnet!



Questions

1. State how a magnetic material may be identified.
2. When the pole of a magnet is placed next to a body X, there is attraction. What does this indicate about the nature of X.
3. When the pole of a magnet is placed next to a body Y, there is repulsion. What does this indicate about the nature of Y?

Questions

4. State TWO temporary magnetic materials and TWO permanent magnetic materials.

5. Define:

a. a magnetic field
b. the direction of a magnetic field

Questions

6. Draw magnetic field diagrams to show two bar magnets:

a. attracting each other

b. repelling each other

7. Draw the arrangement that may be used to set up a uniform field. Your diagram should include magnetic field lines.

Questions

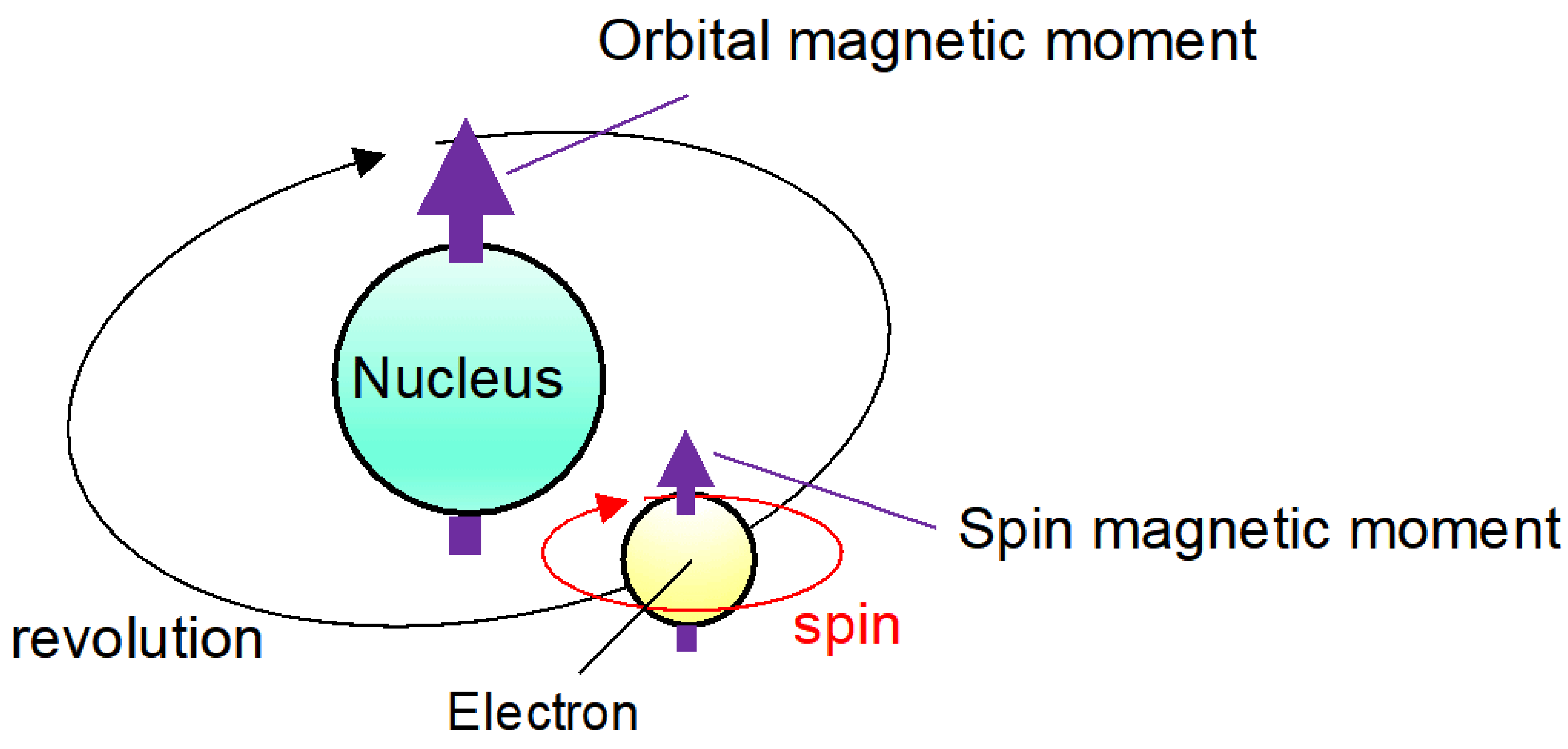
8. Describe how the poles of a bar magnet may be identified using the Earth's magnetic field.

Why Does Magnetism Exist?

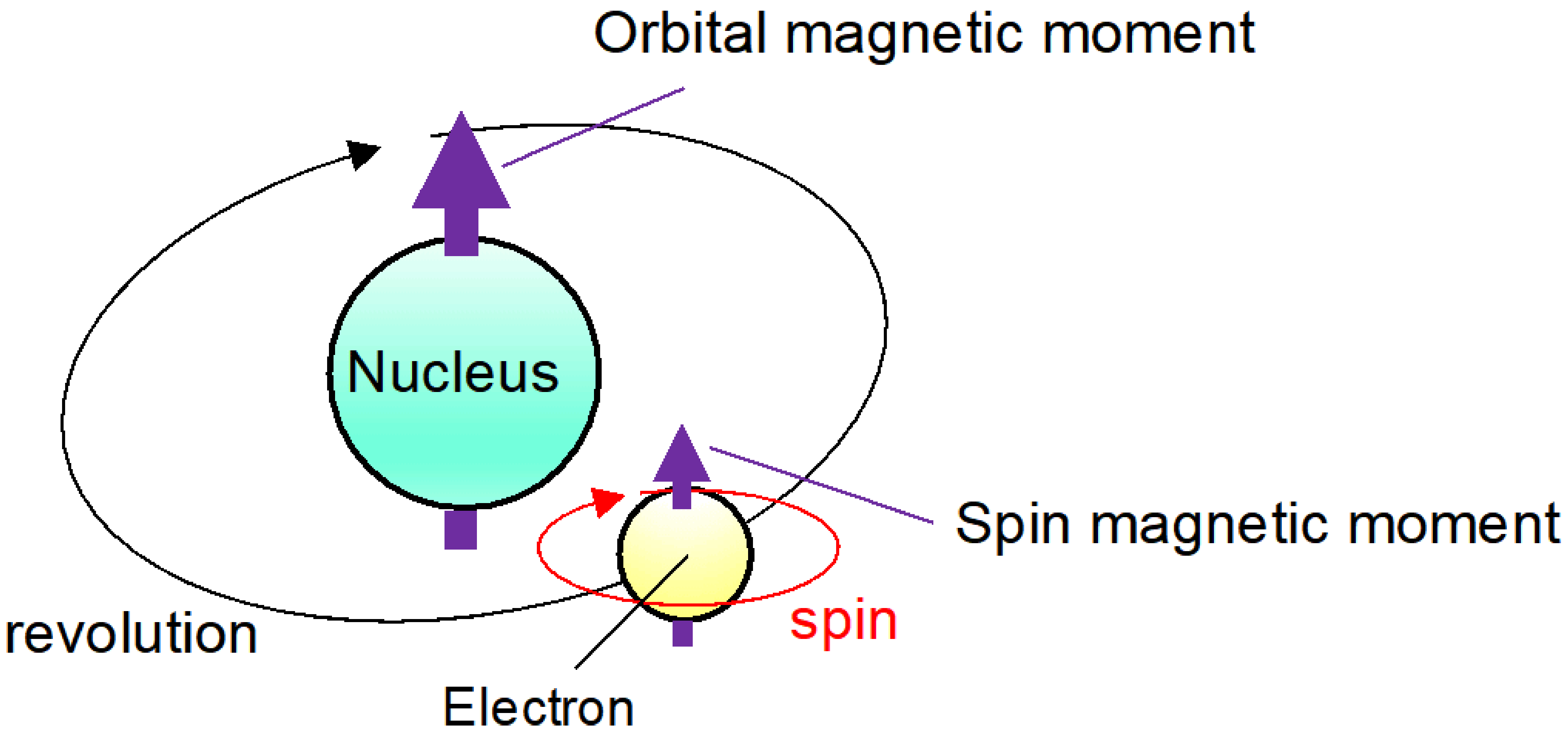
Magnetism exists because electrons are moving charges.

Electrons move in two ways:

1. **Orbital motion** – the electron moves around the nucleus.
2. **Spin motion** – the electron spins on its own axis.



Why Does Magnetism Exist



Because moving electric charges **create magnetic fields**, each electron behaves like a tiny magnet.

Why Magnetism Exists

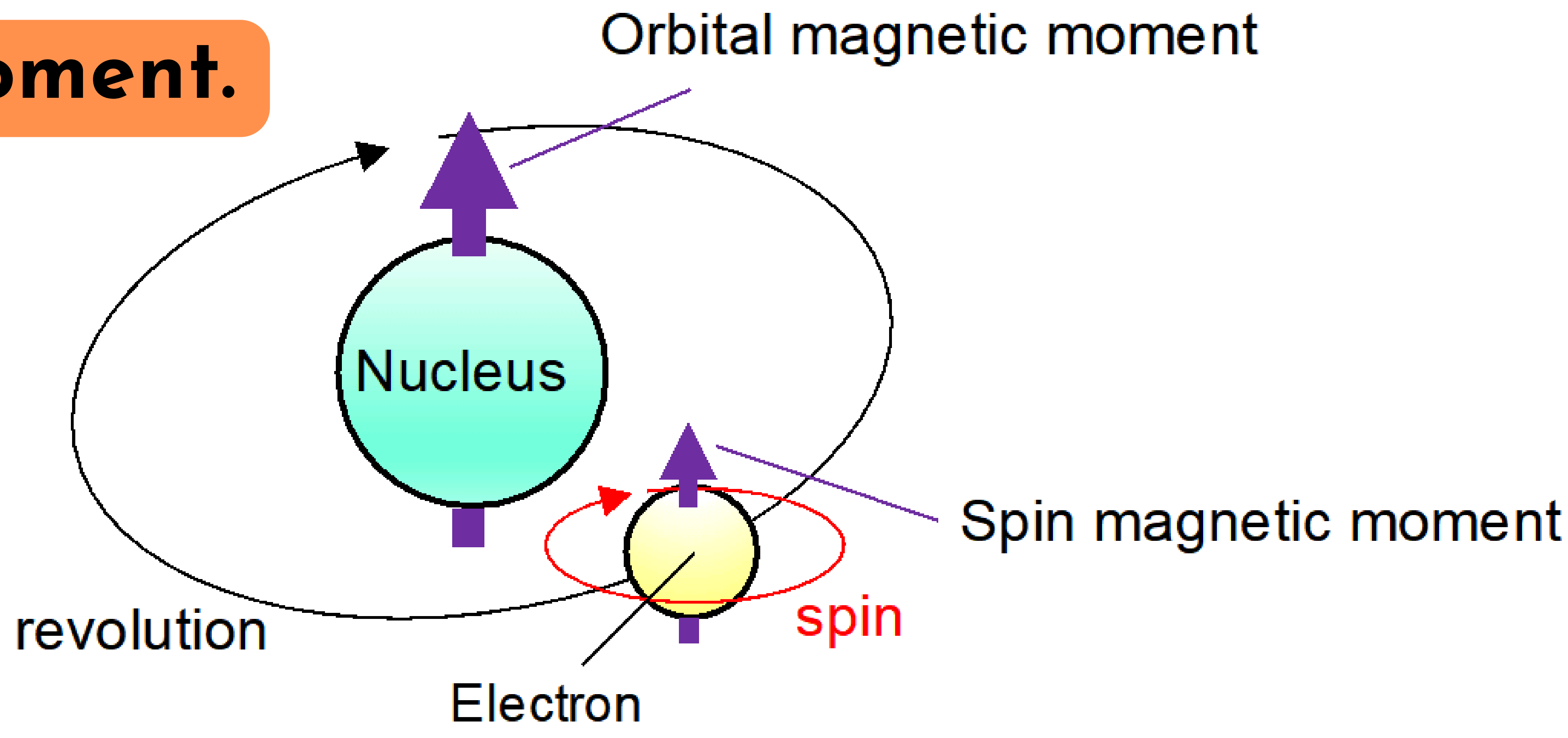
Each electron produces a tiny magnetic field.

This gives the atom a magnetic moment.

But in most atoms:

- electrons pair up and
- their magnetic effects cancel

So, many materials do not appear magnetic.



Why Does Magnetism Exist

In materials like **iron, cobalt,** and **nickel**:

Some electrons are **unpaired**, so their magnetic moments **do not** cancel.

This allows the atoms to behave like tiny magnets.

Why Does Magnetism Exist

Atoms with **magnetic moments** tend

to group together.

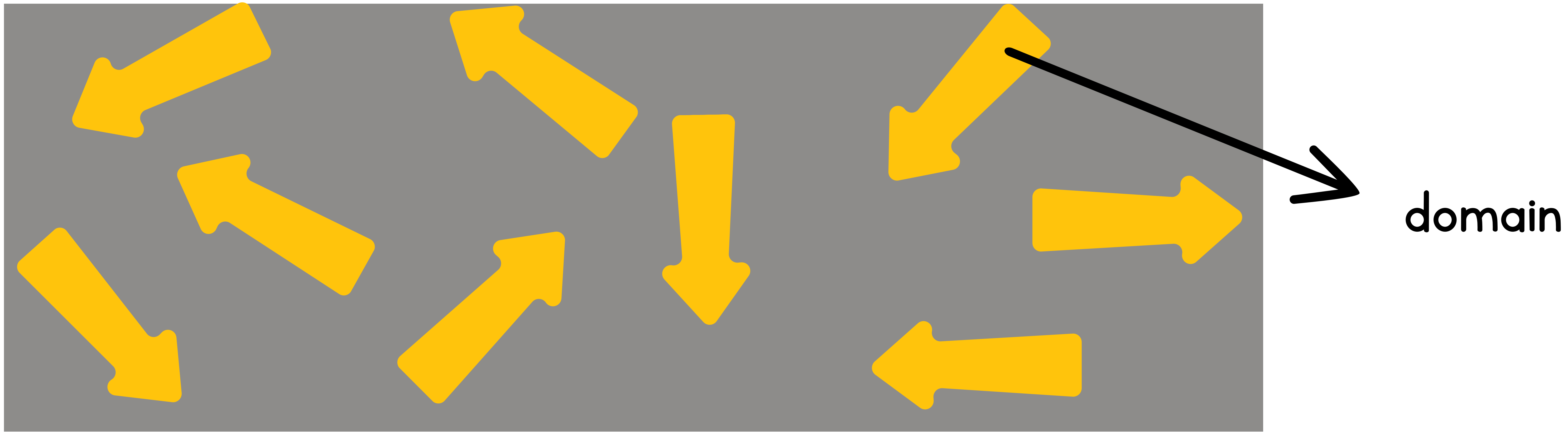
These groups are called **magnetic domains.**

A domain is:

A region in a material where many atomic

magnetic moments point in the same direction.

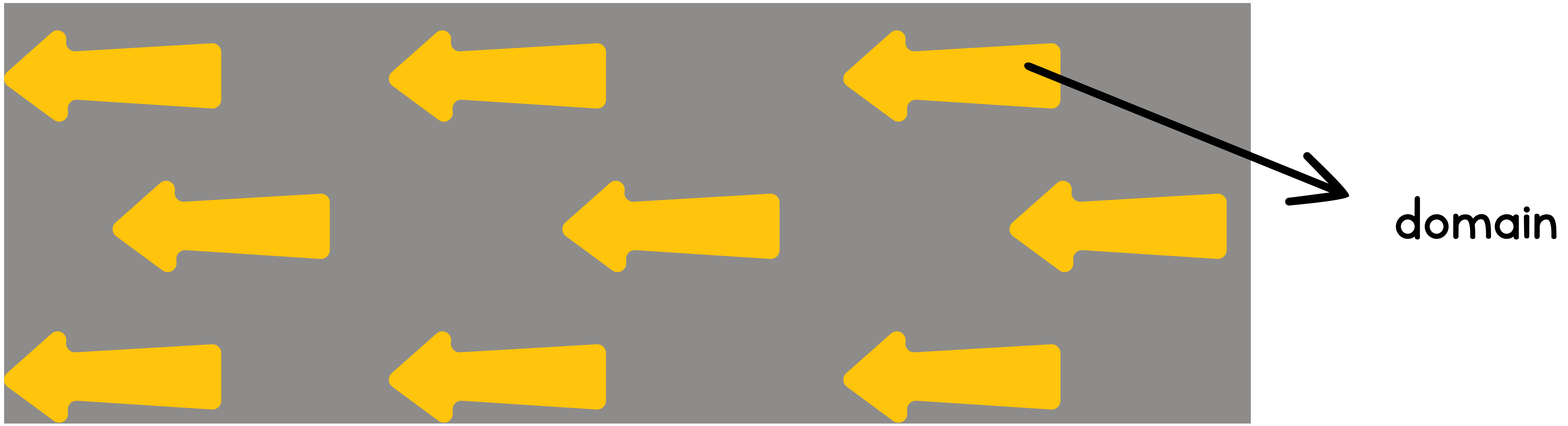
In metals that are **UN-MAGNETIZED**, the tiny magnets referred to as domains/dipoles are **NOT aligned**. Domains point in different directions. They cancel out, so there is no overall magnetism



unmagnetized metal

In **MAGNETIZED** metals the domains/dipoles are **ALIGNED.**

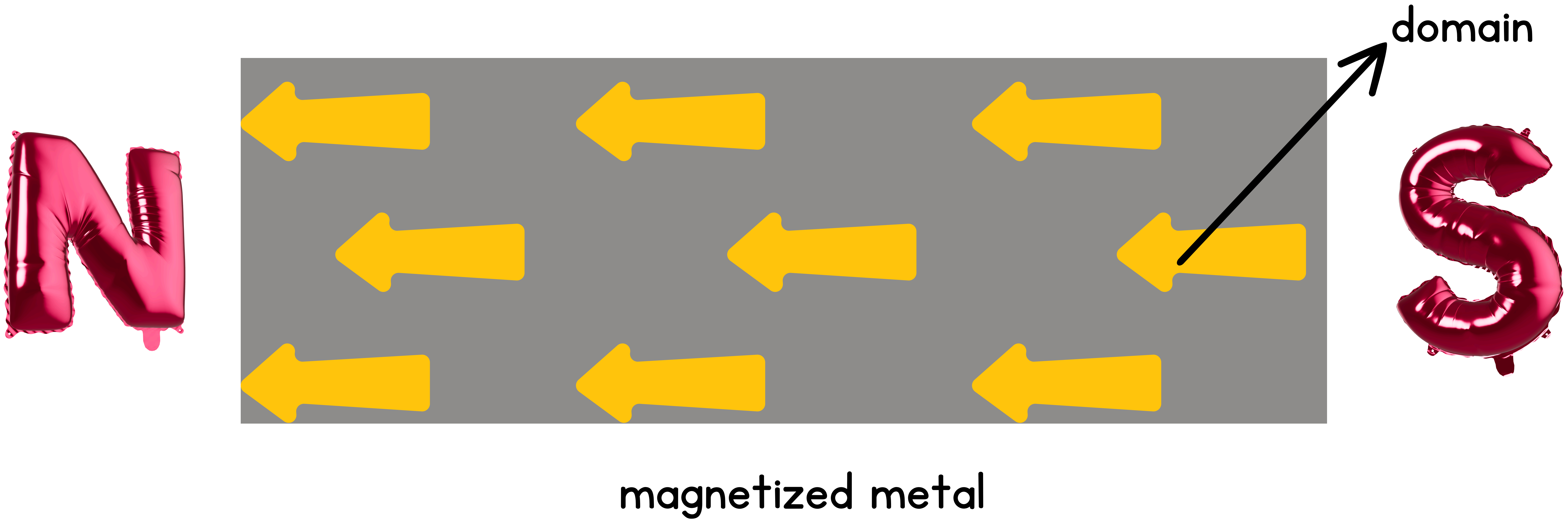
They add together to produce a strong magnetic field



magnetized metal

Every magnet has a **North Pole** and a **South Pole**.

This happens because the aligned domains create a directional magnetic field.



Why Does Magnetism Exist

In summary:

Magnets contain unpaired electrons which produce magnetic moments.

When many of these magnetic moments align, they form magnetic domains, and when these domains align, the material shows magnetic behaviour.

Why Does Magnetism Exist

Magnetic materials:

Unpaired electrons → magnetic moments → aligned magnetic moments → magnetic domains → aligned domains → magnetic behaviour

Non-magnetic / weakly magnetic materials:

Paired electrons → no net magnetic moments per atom → no alignment → no magnetic domains → no overall magnetic behaviour

Methods of Magnetization

Iron, nickel, and cobalt are **ferromagnetic materials**. Their atoms possess magnetic moments that can align into domains. When these domains become aligned, the material becomes magnetized.

Methods of Magnetization

Many other materials (like copper, aluminum, gold) also have electrons with magnetic moments, but:

- Their atoms do not form strong domains
- Their magnetism is extremely weak

So they cannot be magnetized like iron, nickel, or cobalt.

Methods of Magnetization

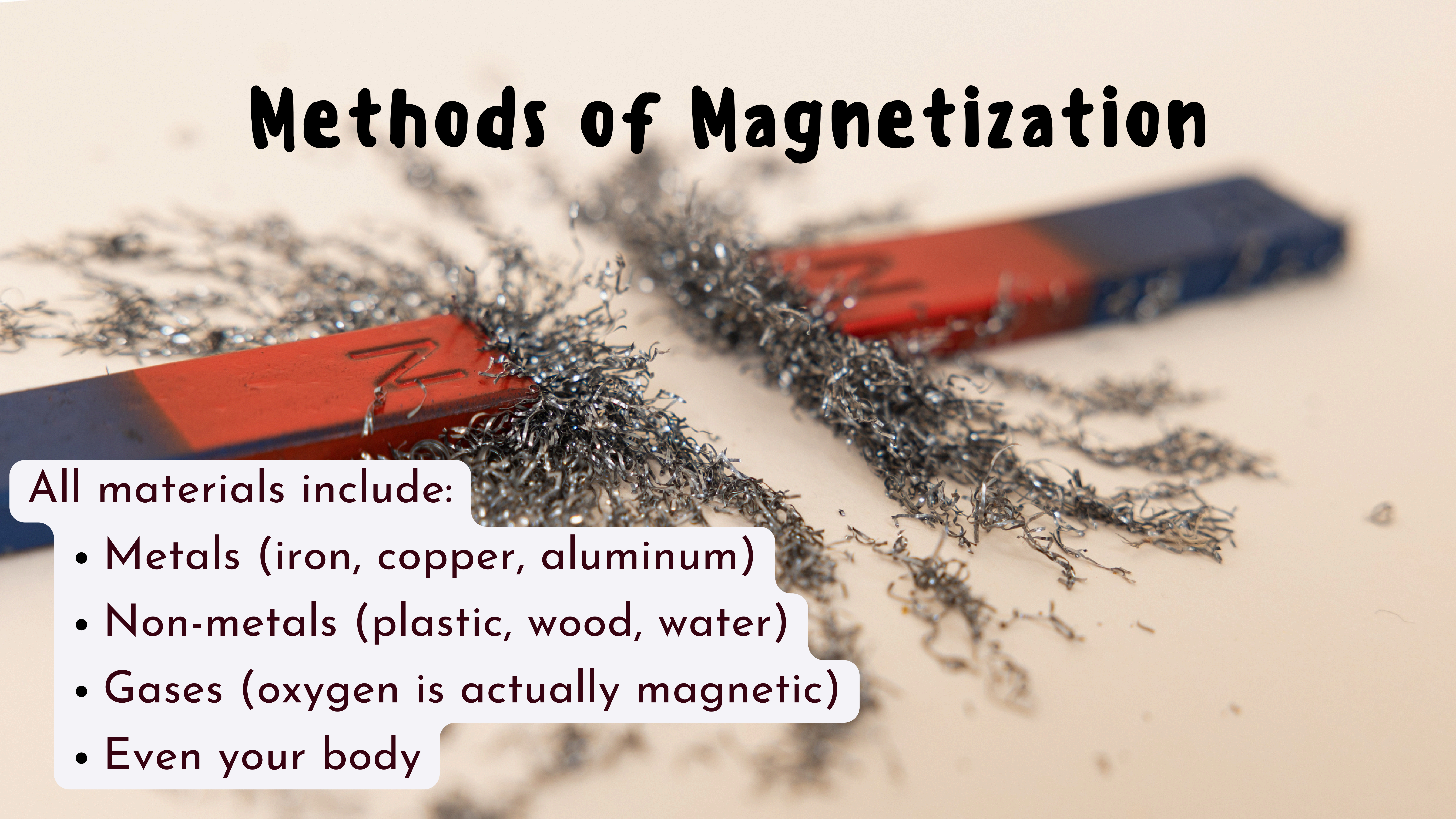
All materials have some magnetism.
Every material has electrons, and electrons have magnetic moments, so technically, all materials respond to magnetic fields in some way. But the effect is usually extremely weak.

Methods of Magnetization

All materials contain electrons, and electrons have magnetic moments.

So all materials — solids, liquids, and gases — can respond to a magnetic field in some way.

Methods of Magnetization



All materials include:

- Metals (iron, copper, aluminum)
- Non-metals (plastic, wood, water)
- Gases (oxygen is actually magnetic)
- Even your body

Methods of Magnetization

All materials include:

- Metals (iron, copper, aluminum)
- Non-metals (plastic, wood, water)
- Gases (oxygen is actually magnetic)
- Even your body'

You don't notice their magnetism without sensitive equipment.

Methods of Magnetization

- All materials → have electrons → can show magnetism
- Most materials → weak (diamagnetic or paramagnetic)
- Few materials → strong (ferromagnetic)

“All materials, not just metals, can exhibit magnetism because they contain electrons with magnetic moments. However, in most materials the effect is extremely weak, so it is not easily observed.”

Methods of Magnetization

Ferromagnetic materials are **strong magnets**.

These are the materials that can become **permanent magnets** because their domains align strongly.

Examples:

- **Iron**
- **Nickel**
- **Cobalt**
- **Steel**

These materials can:

- Form magnetic domains
- Become permanent magnets and
- Produce strong magnetic fields

Methods of Magnetization

Other substances are usually:

- **Paramagnetic** materials, which are **weakly repelled** by magnetic fields

Example: **aluminum, platinum**

- **Diamagnetic** materials, which are **weakly attracted** to magnetic fields.

Example: **copper, gold, bismuth**

But these effects are so small that we usually say they are **non-magnetic.**

Methods of Magnetization

Magnetization is the process of aligning the magnetic domains in a material so that it produces an overall magnetic field.

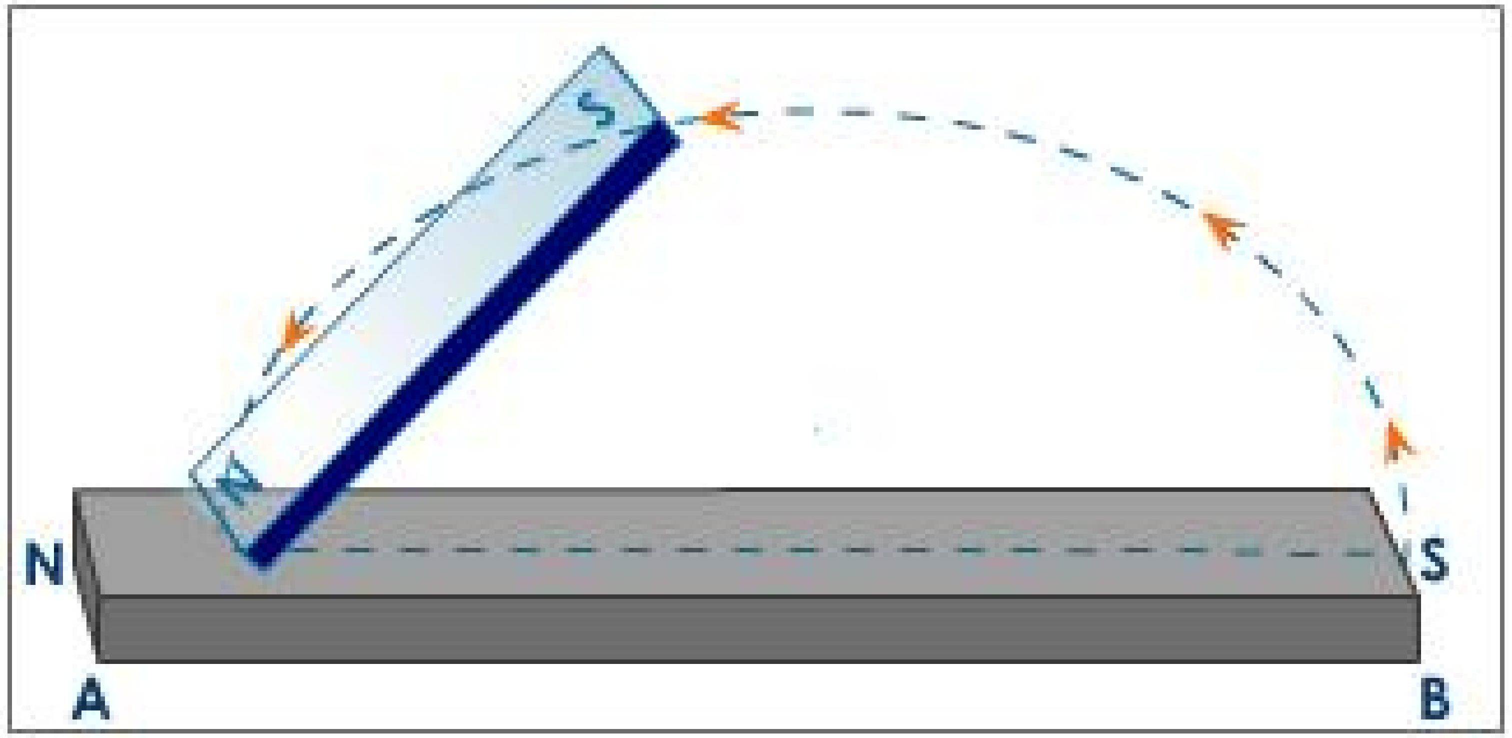
Methods of Magnetization

Magnetization or the alignment of domains can be achieved by:

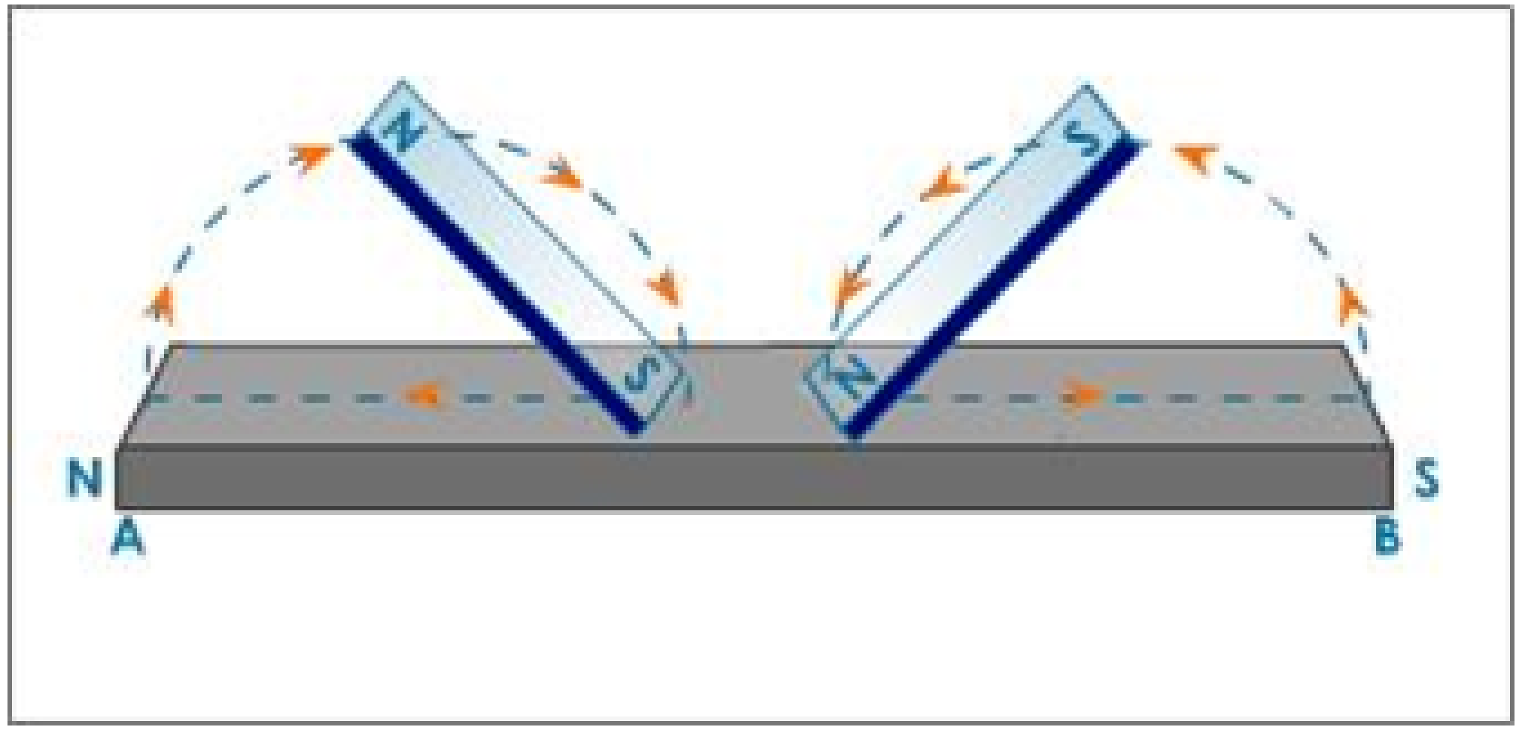
1. **Stroking with a magnet** (CONTACT)
2. **Magnetic induction** (NO CONTACT)
3. **Passing electric current through a coil** (ELECTROMAGNET)

Stroking

The steel bar should be stroked by one pole of a permanent magnet several times in the same direction, each time raising the magnet high before performing the next stroke. This motion aligns the domains in the steel bar.

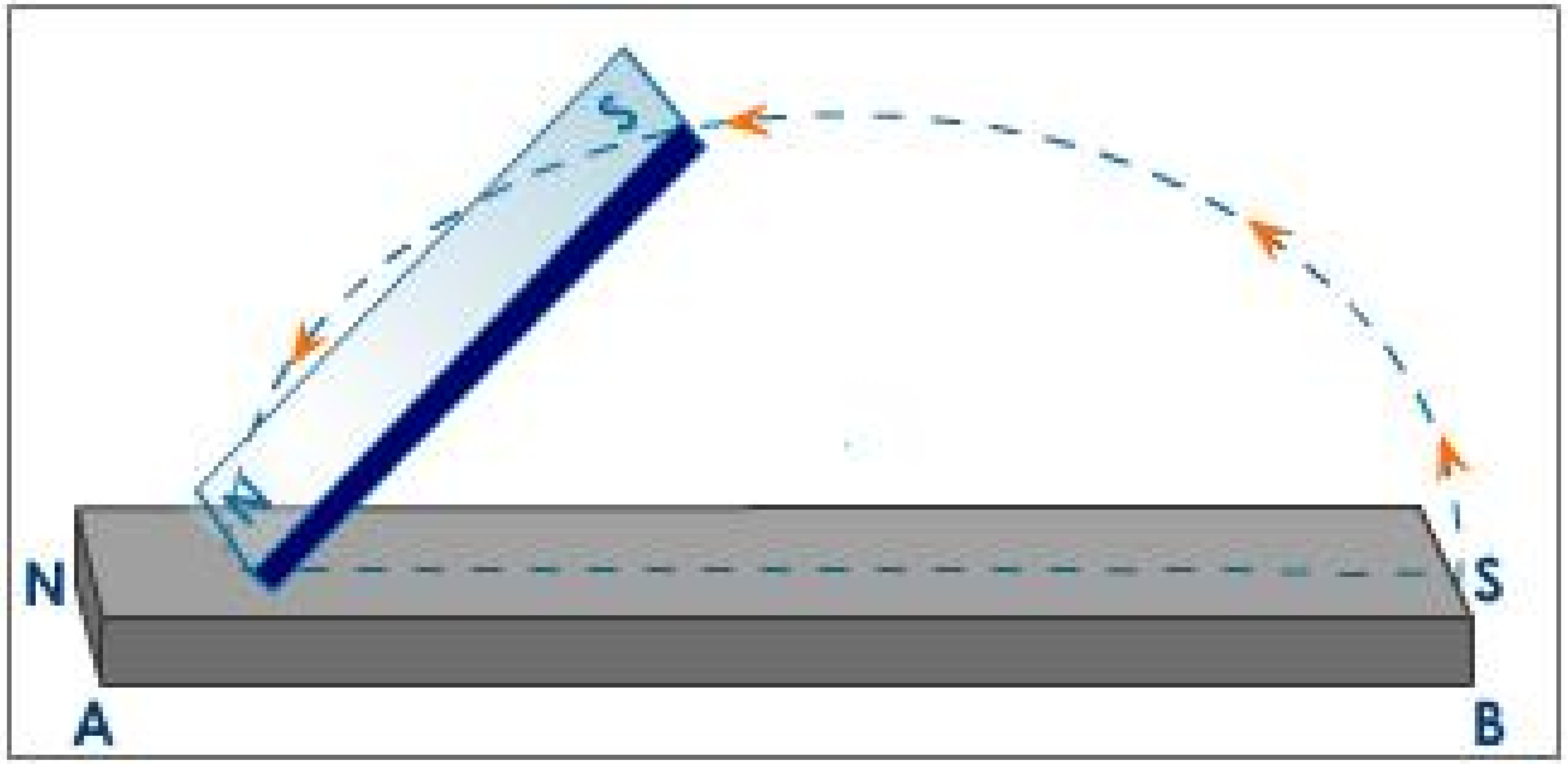


Single Stroking

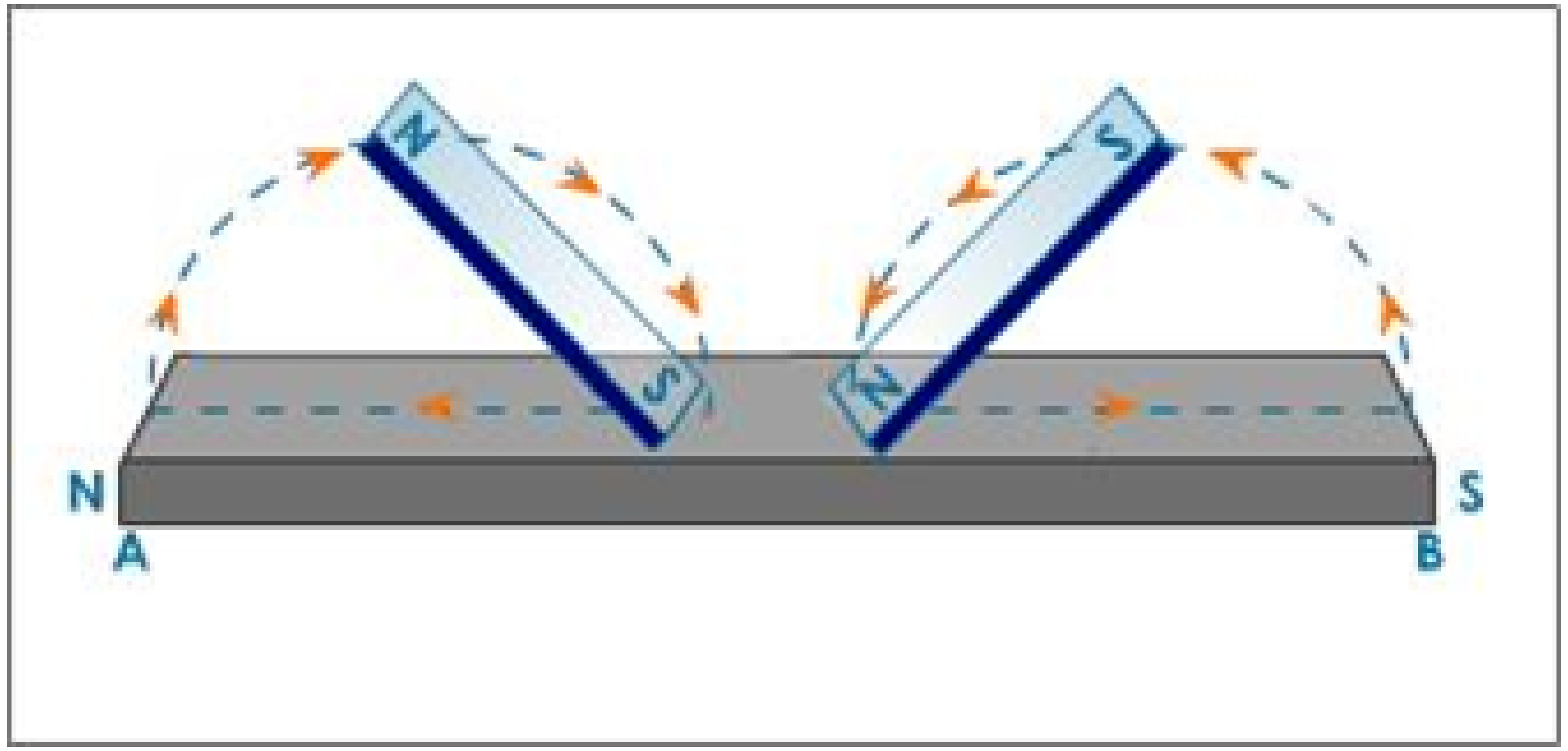


Double Stroking

Where the magnet begins stroking, the poles are the same, but where the stroke ends, the poles become opposite.



Single Stroking



Double Stroking

Magnetic Induction

Because magnetism is a **non-contact force**, it can **INDUCE MAGNETISM** in another object without physical contact. Magnetism may be induced in some metals by a process called **INDUCTION**.

Hence, **magnetic induction is the magnetization of a material caused by the presence of a nearby magnetic field without physical contact.**

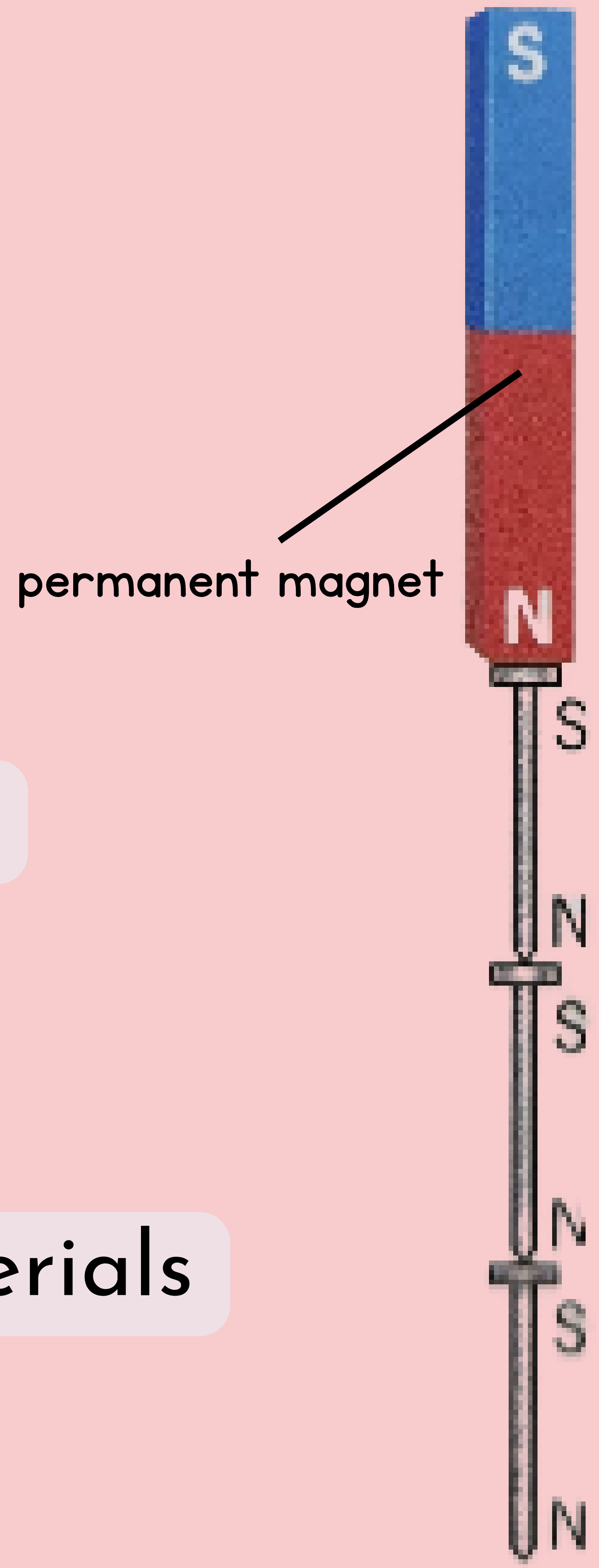
When a magnet **induces** magnetism into a material:

1 A pair of opposite poles is created.

2 The inducing pole is always opposite in polarity to the induced pole facing it

3 Induction occurs at a distance, that is, before the materials are in contact with each other.

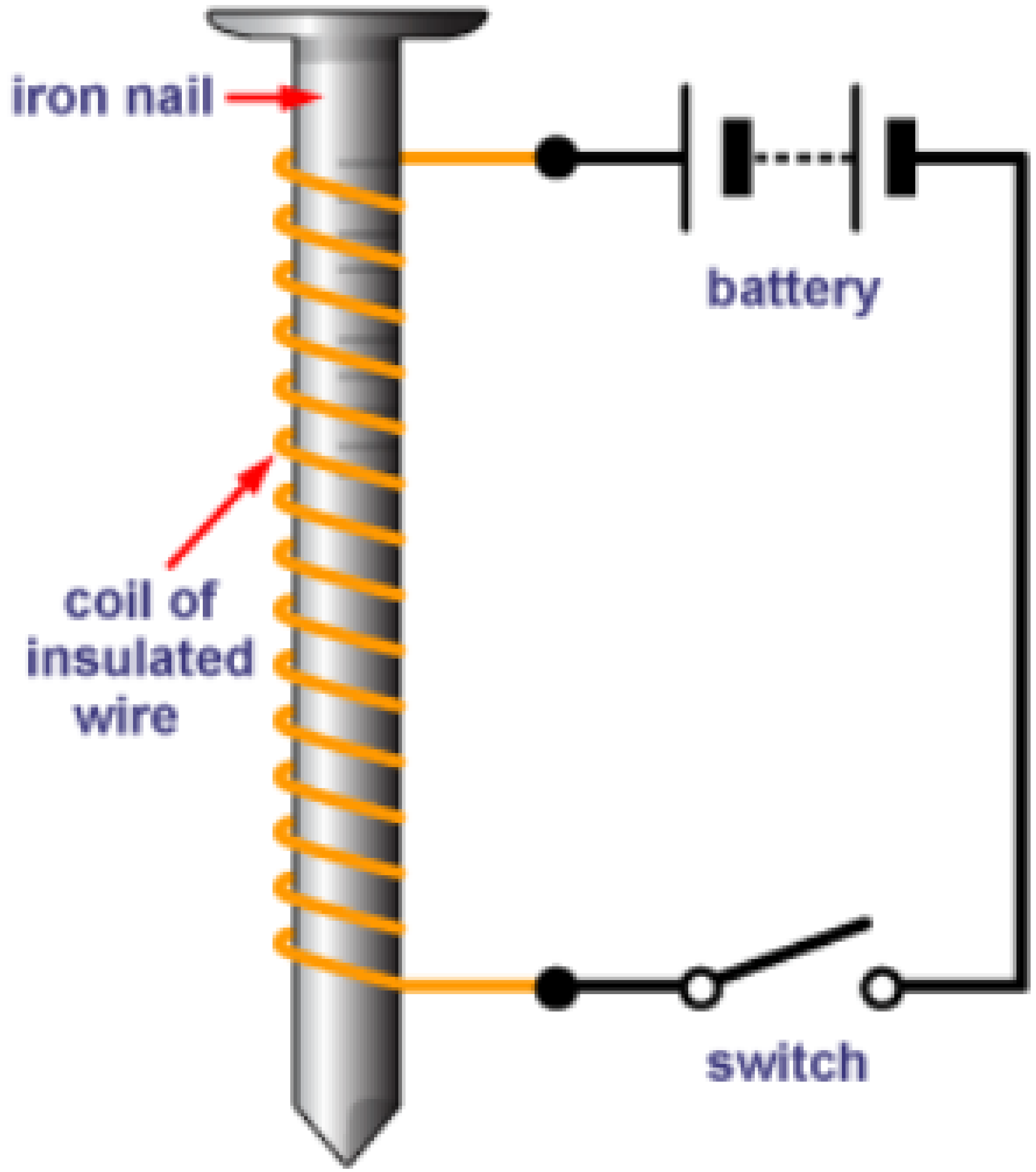
This method aligns the domains in the magnet.



Current

Iron can be magnetized by passing an electric current through a coil of wire to make it an electromagnet.

It achieves this by aligning the domains within the iron nail.



What happens in an electromagnet?

1. Electric current flows through a wire
2. Moving charges create a magnetic field around the wire.
3. When the wire is coiled into a solenoid, the magnetic fields combine to form a strong field.
4. If an iron nail is placed inside the coil, the magnetic field aligns its domains
5. The nail becomes magnetized.

This produces an electromagnet.

Current