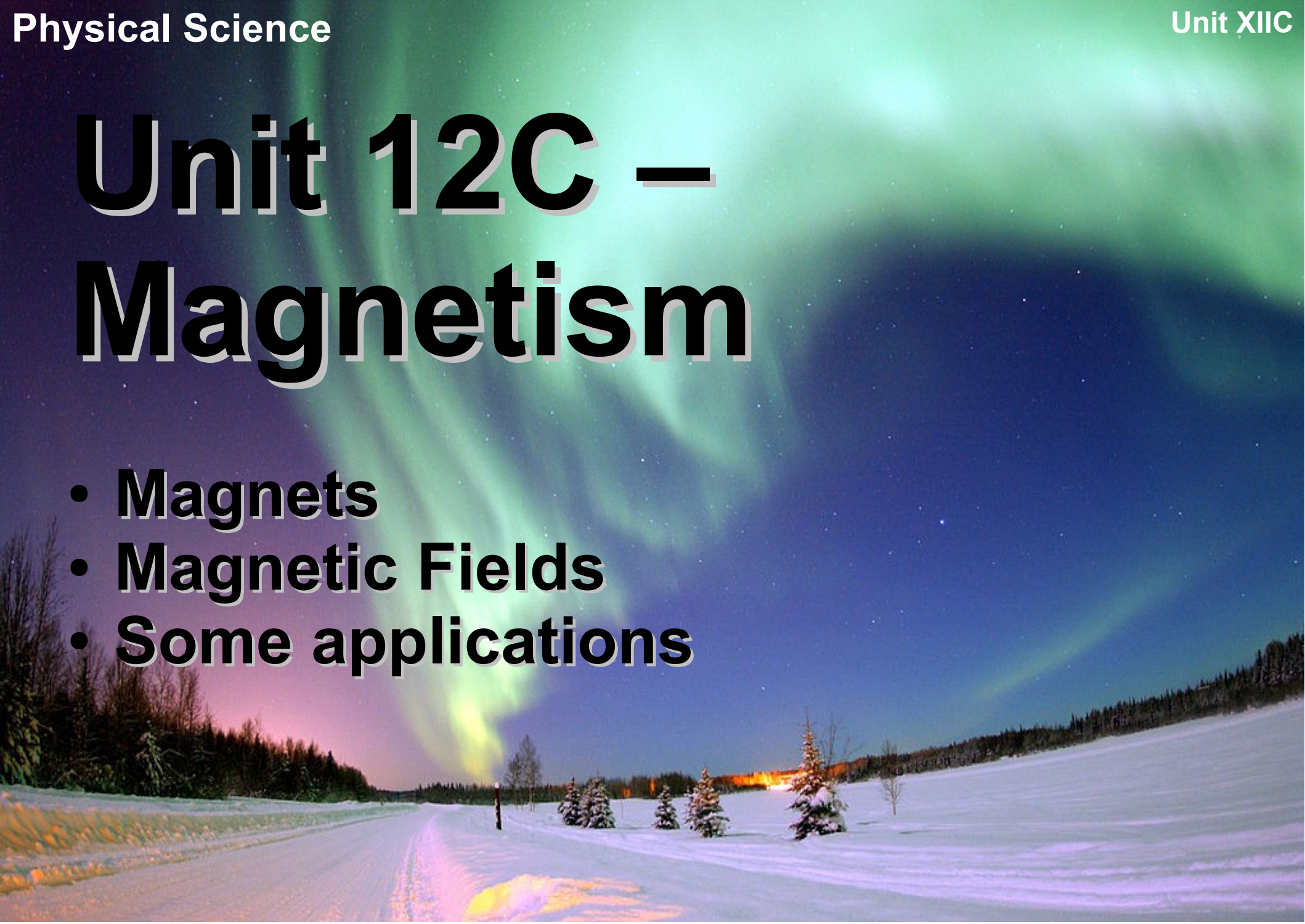
Unit 12C – Magnetism

- Magnets
- Magnetic Fields
- Some applications



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Competencies

The student will be able to:

- **describe experiments that show that the magnetic field is generated by electric currents.**
- use the rule that the magnetic strength of an electromagnet is proportional to the current
- describe the magnetic field of a solenoid

Introduction

1. Take a sheet of paper and draw a vertical line in the middle
2. On the left, write in KEYWORDS, what you know about magnetism
3. Compare your list with your neighbor

Magnetism	

Introduction

For each item on the left, try to find an equivalent from electricity and write it on the right.

Magnetism	*Electricity*

Introduction

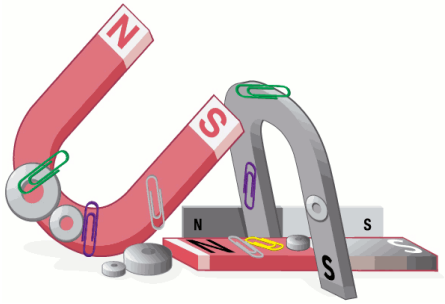
In teams of two, discuss:

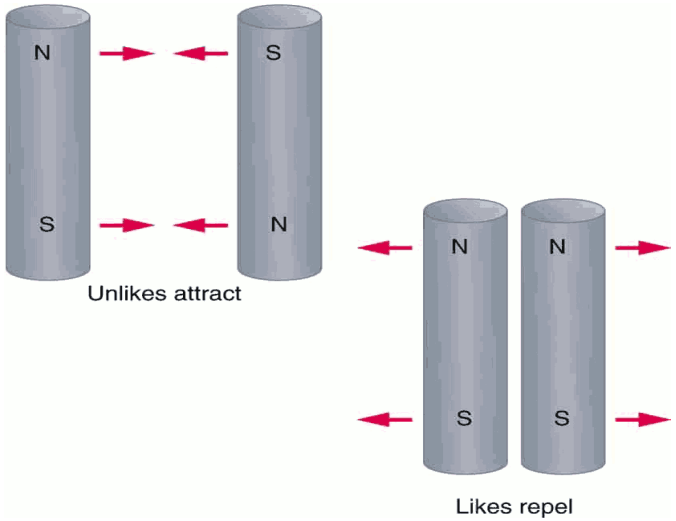
- Like charges repel – do like “magnets” repel?
- What applications of magnetism do you know?
- What is the cause of electrostatics? What is the cause of magnetism?
- Do you think that there is such a thing as an elementary magnetic “charge”
- How does a compass work?
- Electromagnetism: What is the connection of the two phenomena?

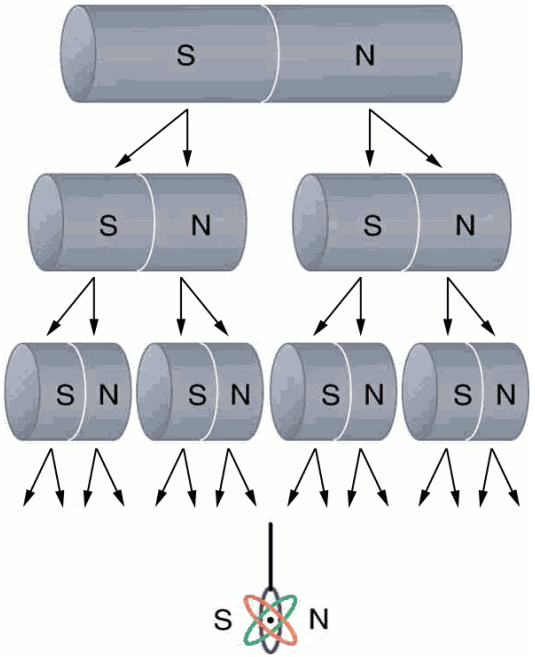
Magnets

Magnets:

- All magnets have a north and a south pole
  (An isolated pole (monopole) does not exist)
- Unlike poles attract, like poles repel
- It is <u>impossible</u> to separate north and south poles







→ Compare with electric charges

Images: **OpenStax, College Physics. OpenStax CNX. April 21, 2016**
http://cnx.org/contents/Ax2o07UI@9.31:UIsk7BfH@2/Introduction-to-Magnetism
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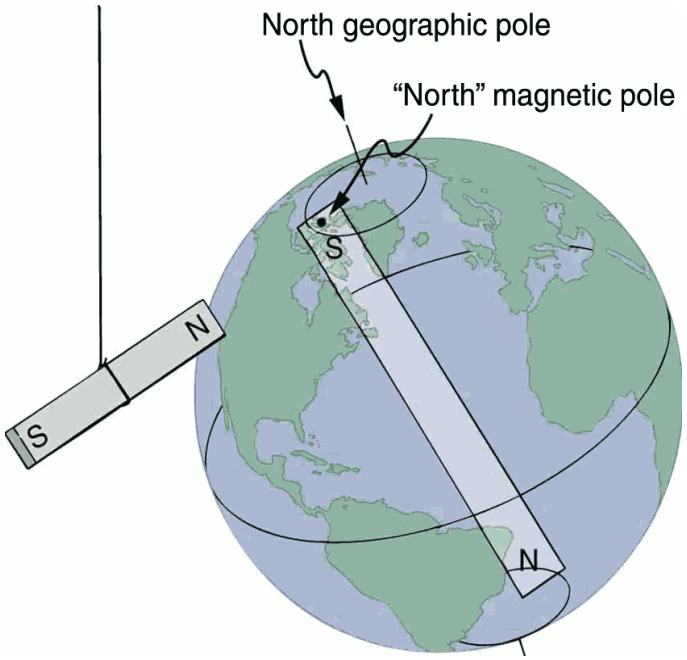
Magnets

North magnetic pole: The end of a magnet attracted toward Earth's geographic north pole (north seeking)

South magnetic pole: The end of a magnet attracted toward Earth's geographic south pole (south seeking)



Magnetic Poles of the Earth
OpenStax, College Physics. OpenStax CNX. April 21, 2016
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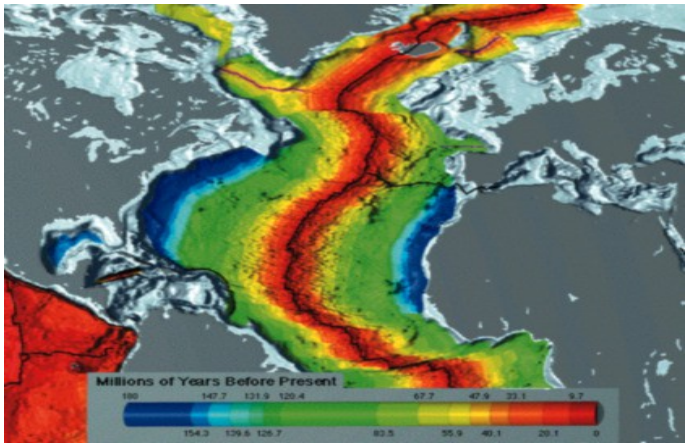

Age of North Atlantic oceanic crust
By Pasixxxx (Earth_seafloor_crust_age_1996.gif) [Public domain], via Wikimedia Commons
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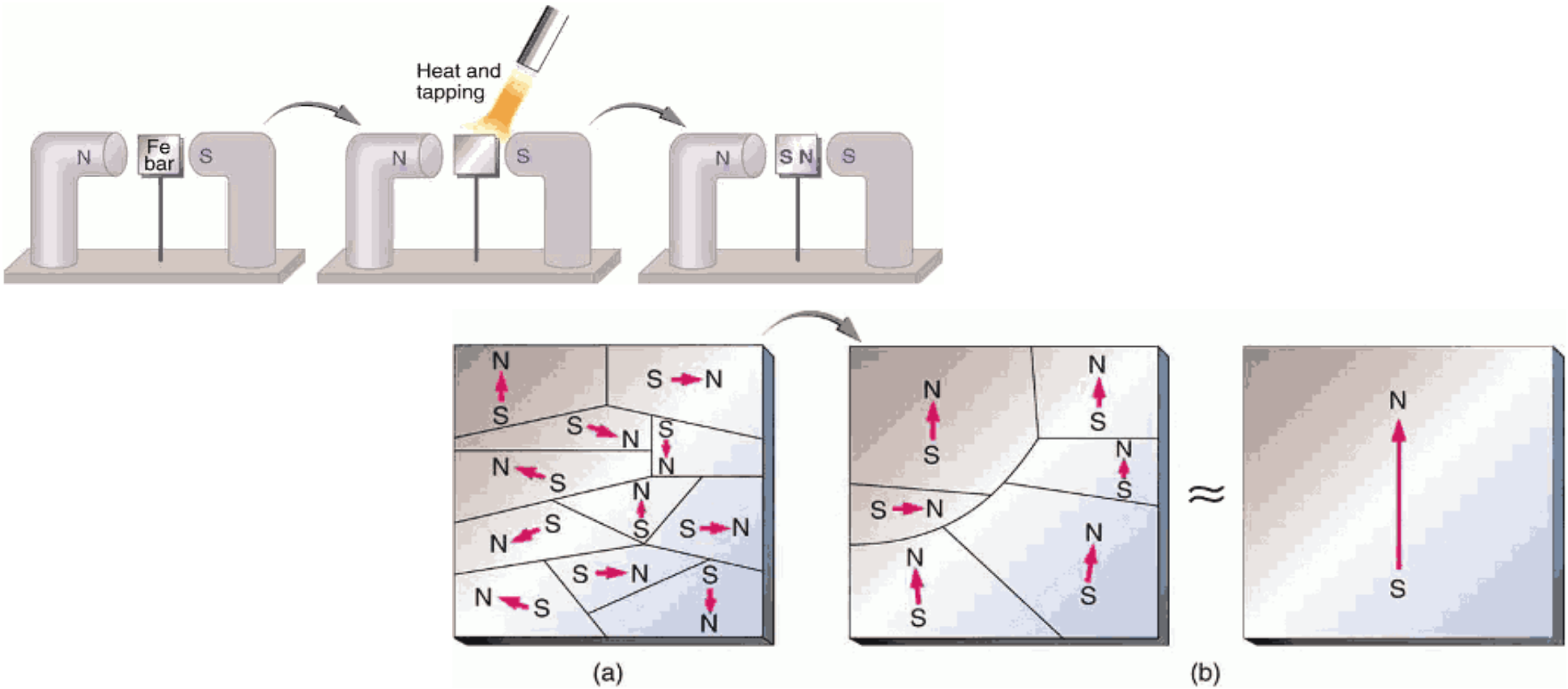
Magnets

Ferromagnetic substances:

- Respond strongly to magnets (attracted to magnets)
- Can be magnetized (made into **permanent magnet**)



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http://cnx.org/contents/Ax2o07Ul@9.31:UcUWmn05@4/Ferromagnets-and-Electromagnet
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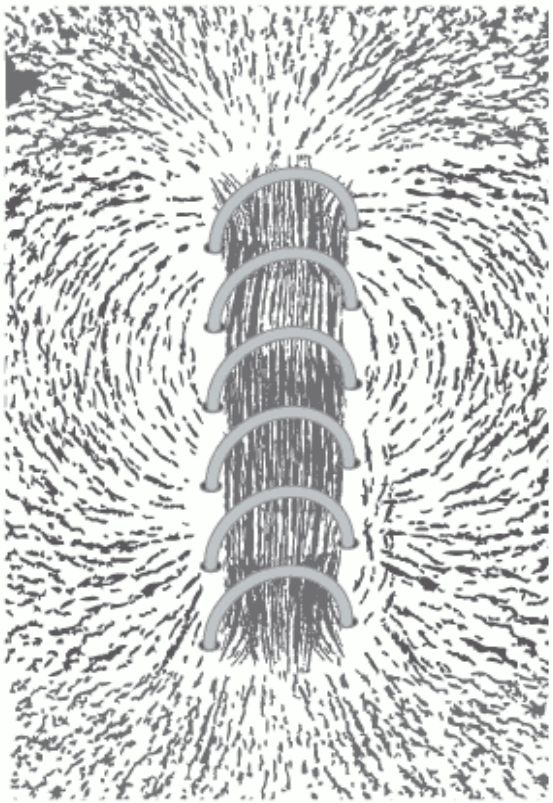
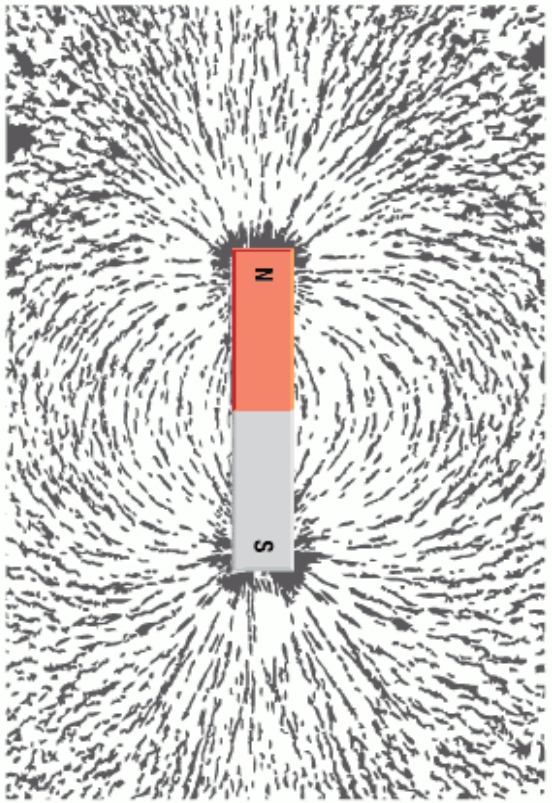
Magnets

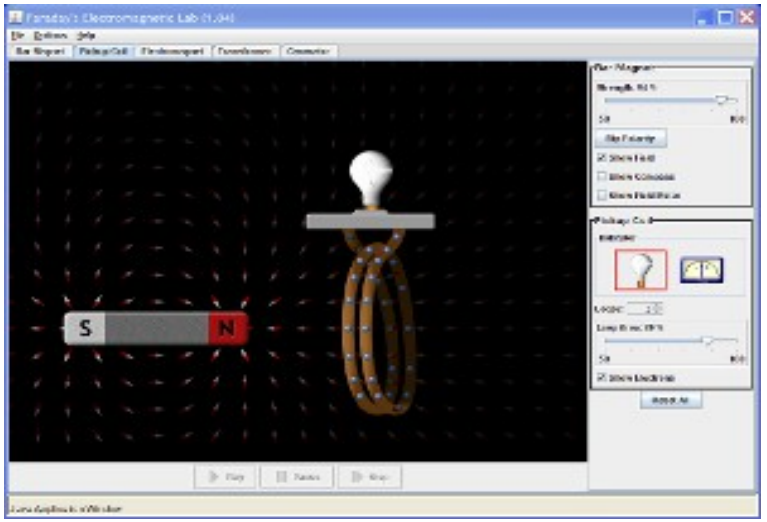
Electromagnets: - Electric currents cause magnetic effects
- Current loops produce magnetic dipoles
(Magnetic “monopoles” do not exist)



(a)



(b)



Phet-Simulation: Faraday's Electromagnetic Lab
http://phet.colorado.edu/en/simulation/faraday

$$B = \frac{\mu_0 N i}{\sqrt{(L^2 + D^2)}}$$

N= turns
L= length [m]
D= diameter [m]
i= current [A]
μ_0 = $4\pi \times 10^{-7}$ H/m

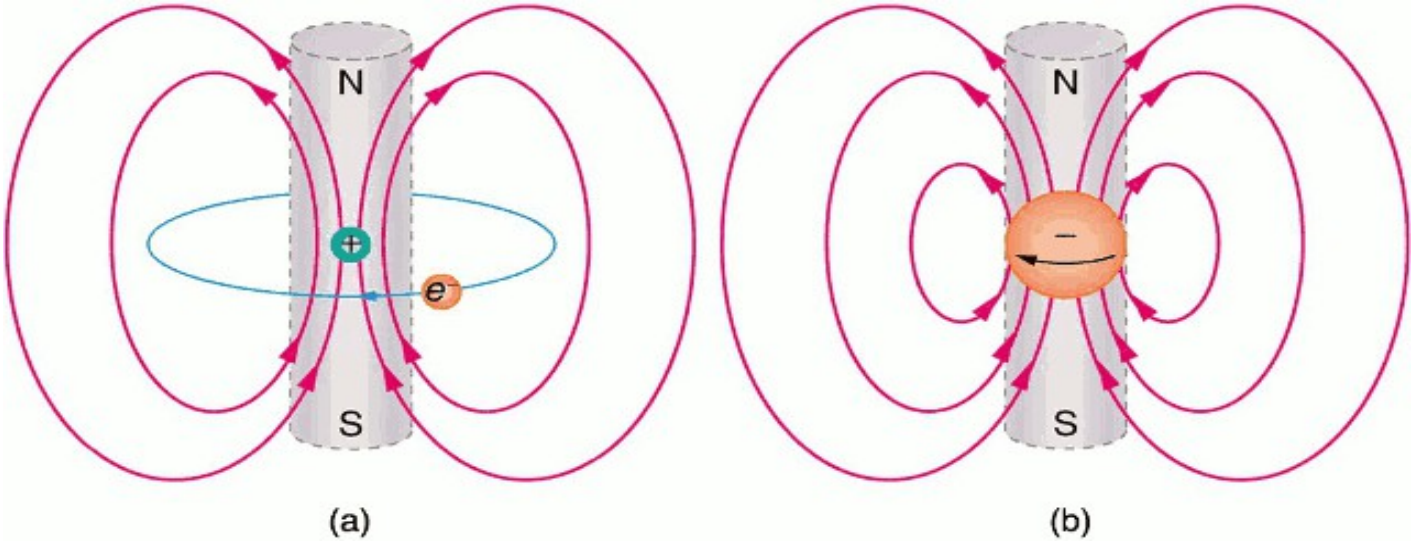
Images: **OpenStax, College Physics. OpenStax CNX. April 21, 2016**
http://cnx.org/contents/Ax2o07UI@9.31:UcUWmn05@4/Ferromagnets-and-Electromagnet

What causes magnetism?

Planetary Model: (left image) Electrons orbit a nucleus, forming a closed-current loop, inducing a magnetic dipole.

Electron Spin: (right image) Electrons have spin (rotating charge), forming a dipole.

Both models are simplifications!



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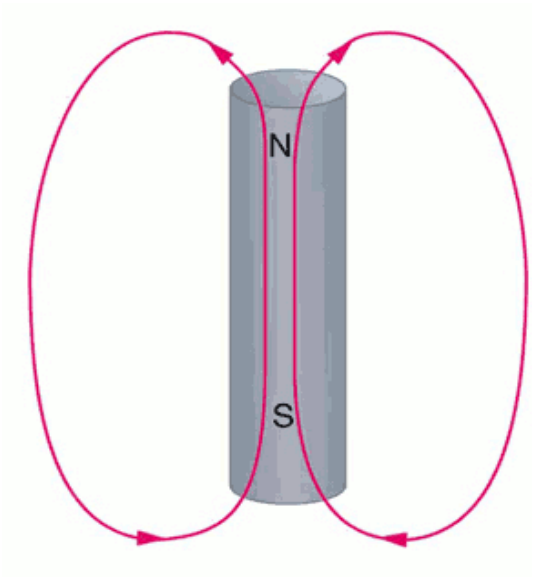
http://cnx.org/contents/Ax2o07UI@9.31:UcUWmn05@4/Ferromagnets-and-Electromagnet

Magnetic Field

Field Lines:

- represent magnetic forces
- go in the direction a compass would point (N → S outside a magnet)
- density proportional to the field strength
- can **never** cross
- form **loops** (no beginning, no end)

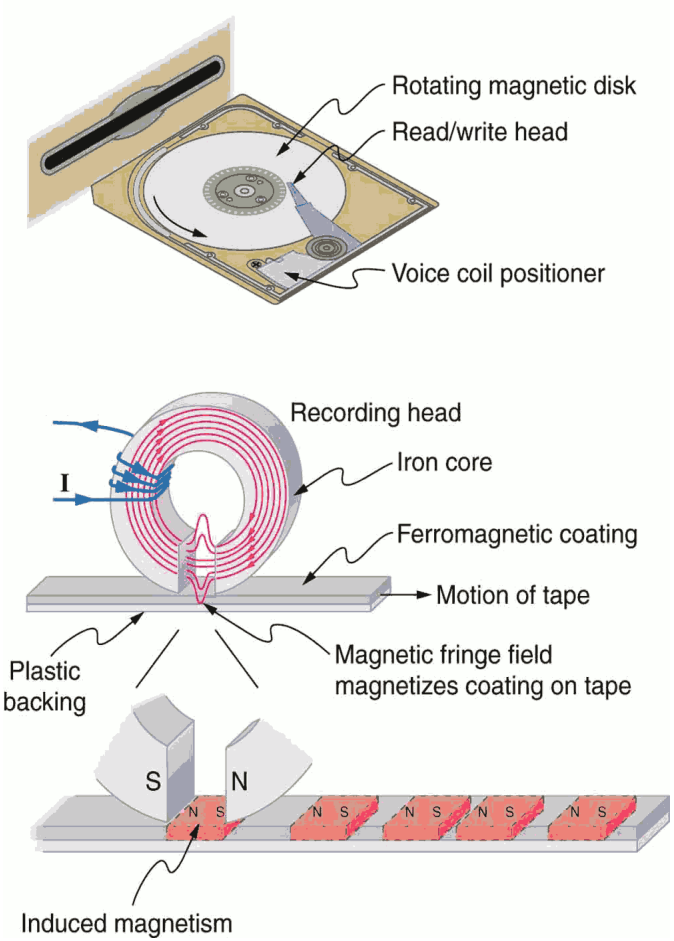


→ Do Unit 12C Problems 1-7

Image: **OpenStax, College Physics. OpenStax CNX. April 21, 2016**
http://cnx.org/contents/Ax2o07UI@9.31:UcUWmn05@4/Ferromagnets-and-Electromagnet

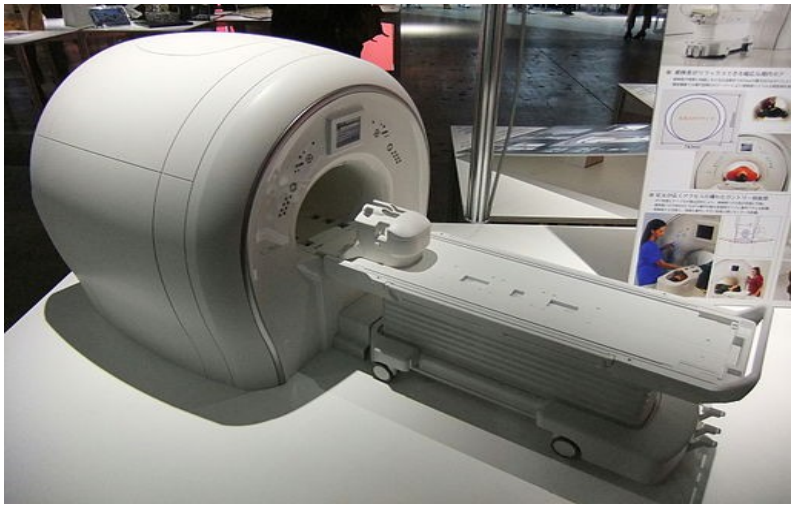
A few applications

Data Storage



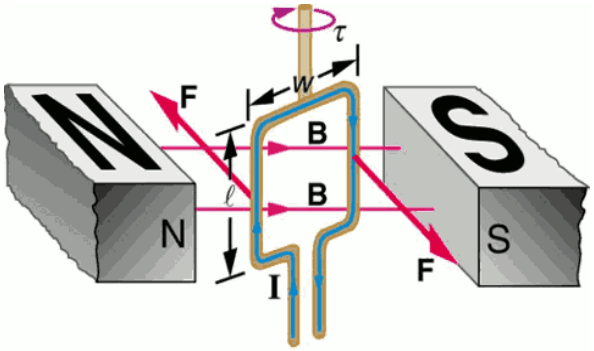
[1]

Magnetic resonance imaging



[2]

Electric Motors



[1]

[1] **OpenStax, College Physics. OpenStax CNX. April 21, 2016**
http://cnx.org/contents/031da8d3-b525-429c-80cf-6c8ed997733a@9.31
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[2] Magnetic Resonance Imaging, By Mj-bird, via Wikimedia Commons
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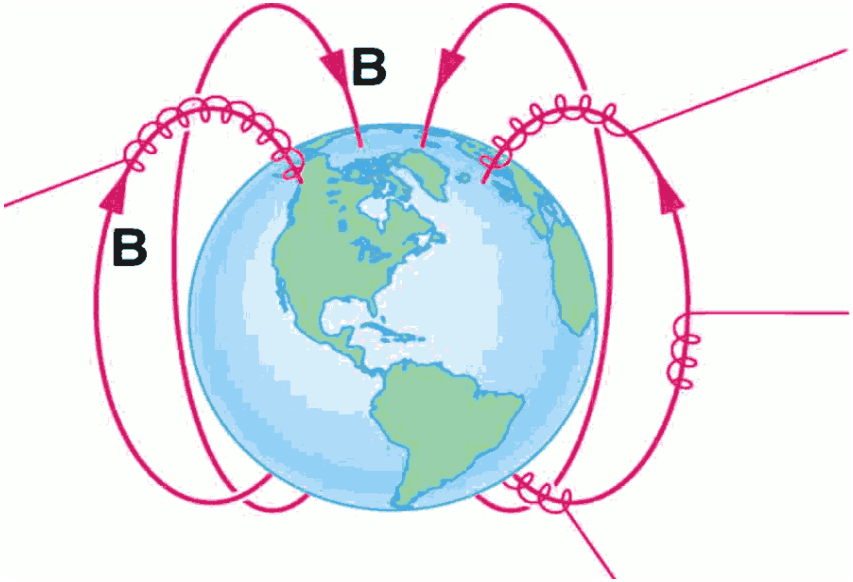
Trapped particles

Aurora Borealis:

- Charged particles approaching magnetic field lines may get trapped in spiral orbits
- Upon entering the earths atmosphere, they cause ionization → northern and southern lights
- Higher cosmic radiation at the poles than the equator



Left: **OpenStax, College Physics. OpenStax CNX. April 21, 2016**
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https://commons.wikimedia.org/wiki/File%3AAurora_Borealis_Alaska.jpg

Additional Resources

- “Magnetism”, OpenStax „College Physics“
http://cnx.org/contents/Ax2o07UI@9.31:UIsk7BfH@2/Introduction-to-Magnetism