

General Science



Scope

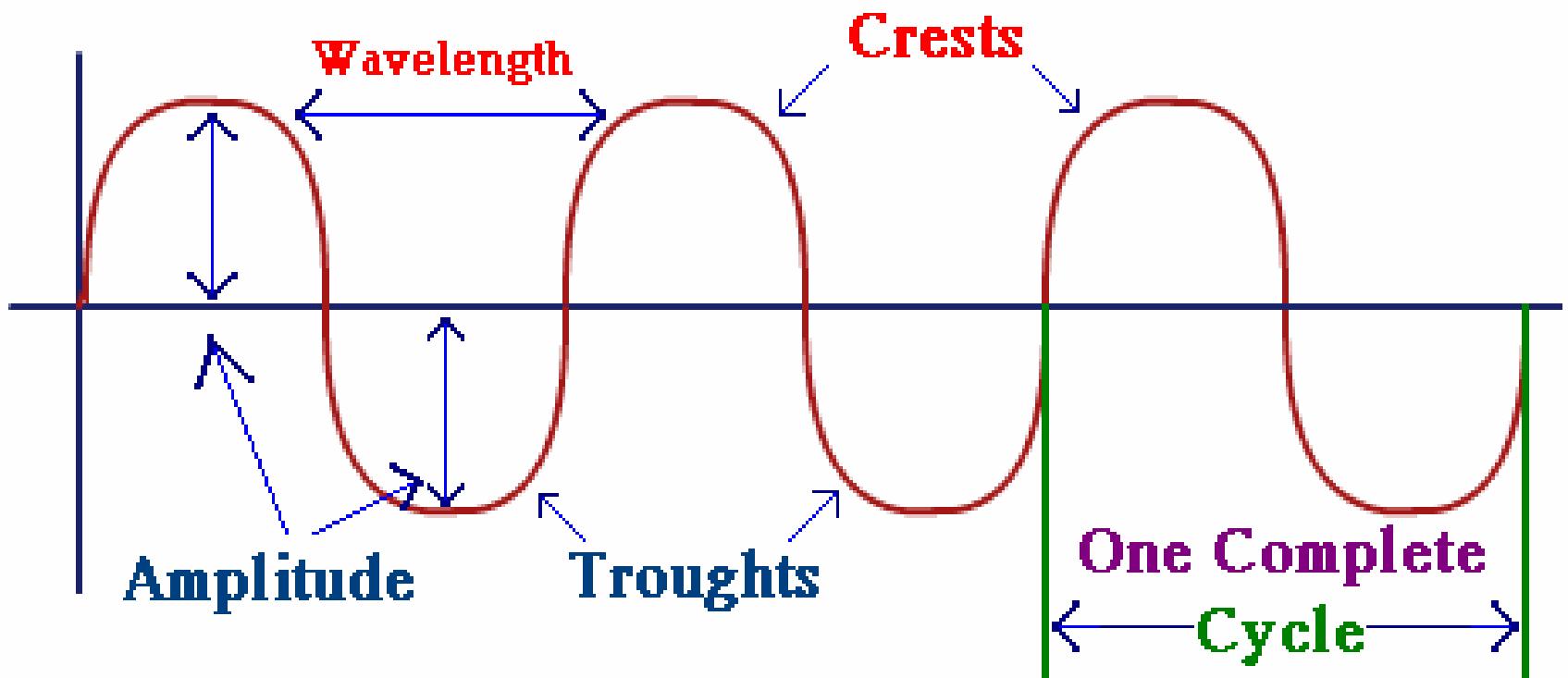
- Prelims
- Understanding Technology
- Understanding geography (Magnetism of Earth, advection etc)



Agenda

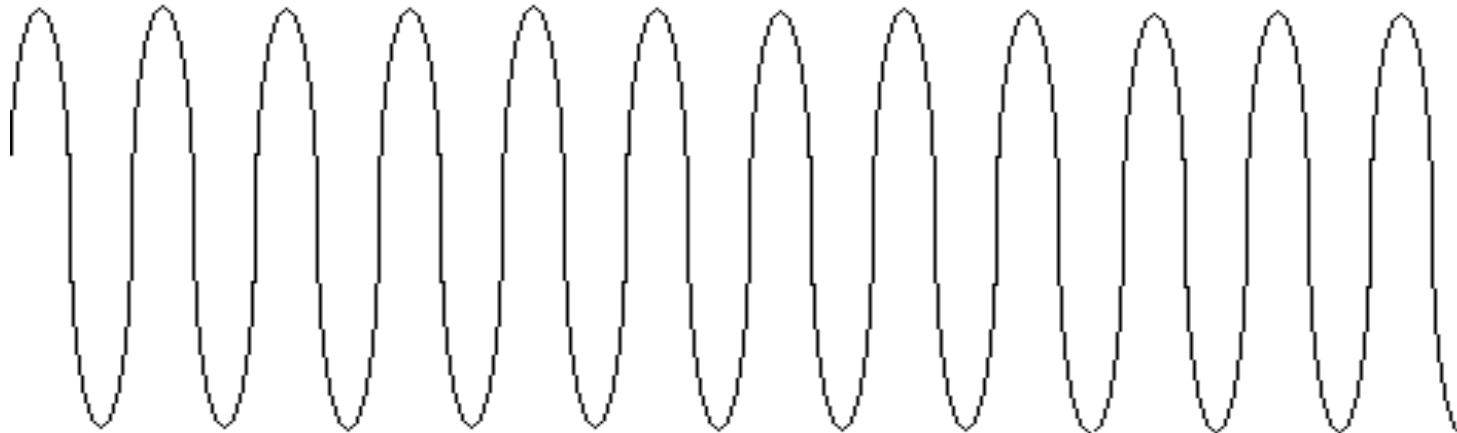
- Electromagnetic waves- concept of wavelength, frequency, bandwidth etc
- Electromagnetic spectrum
- Ray Optics- Reflection, refraction, total internal reflection, critical angle, type of mirrors and lenses
- Defects of vision

Waves

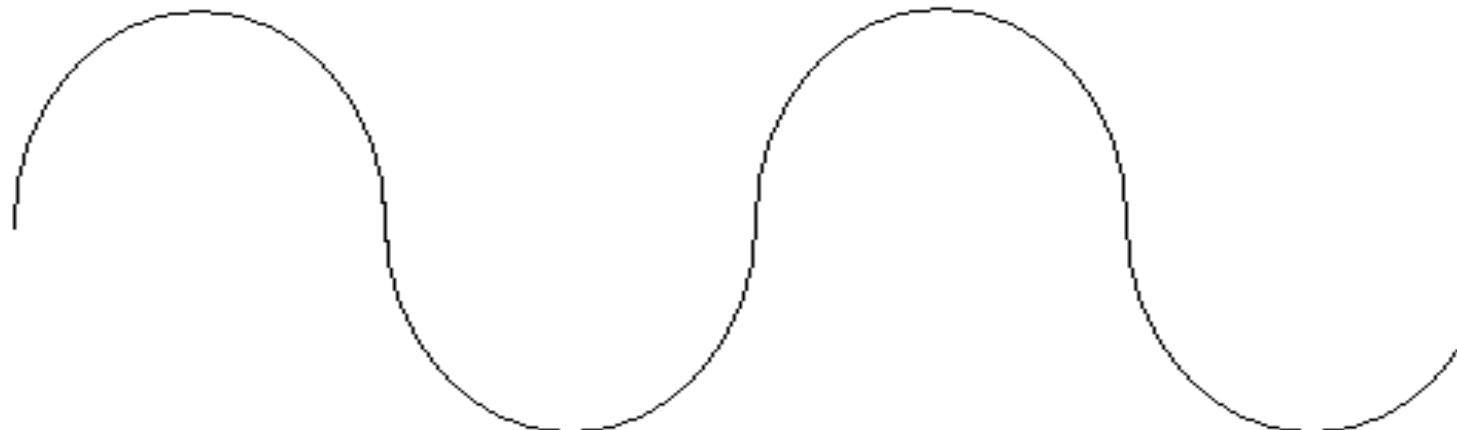


This wave is moving
in this direction —————→

Frequency

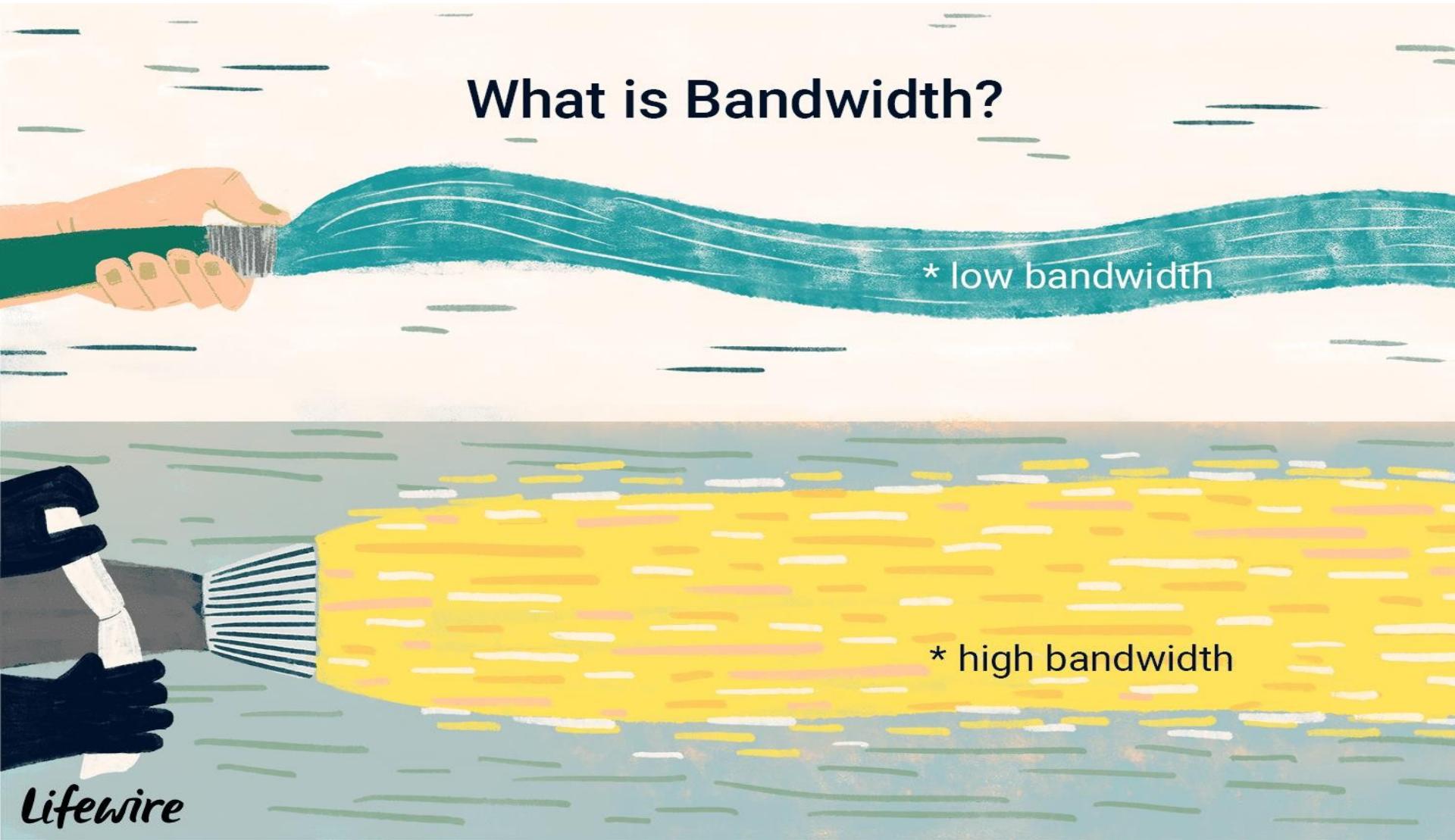


**High
frequency
radio waves**



**Low
frequency
radio waves**

Bandwidth

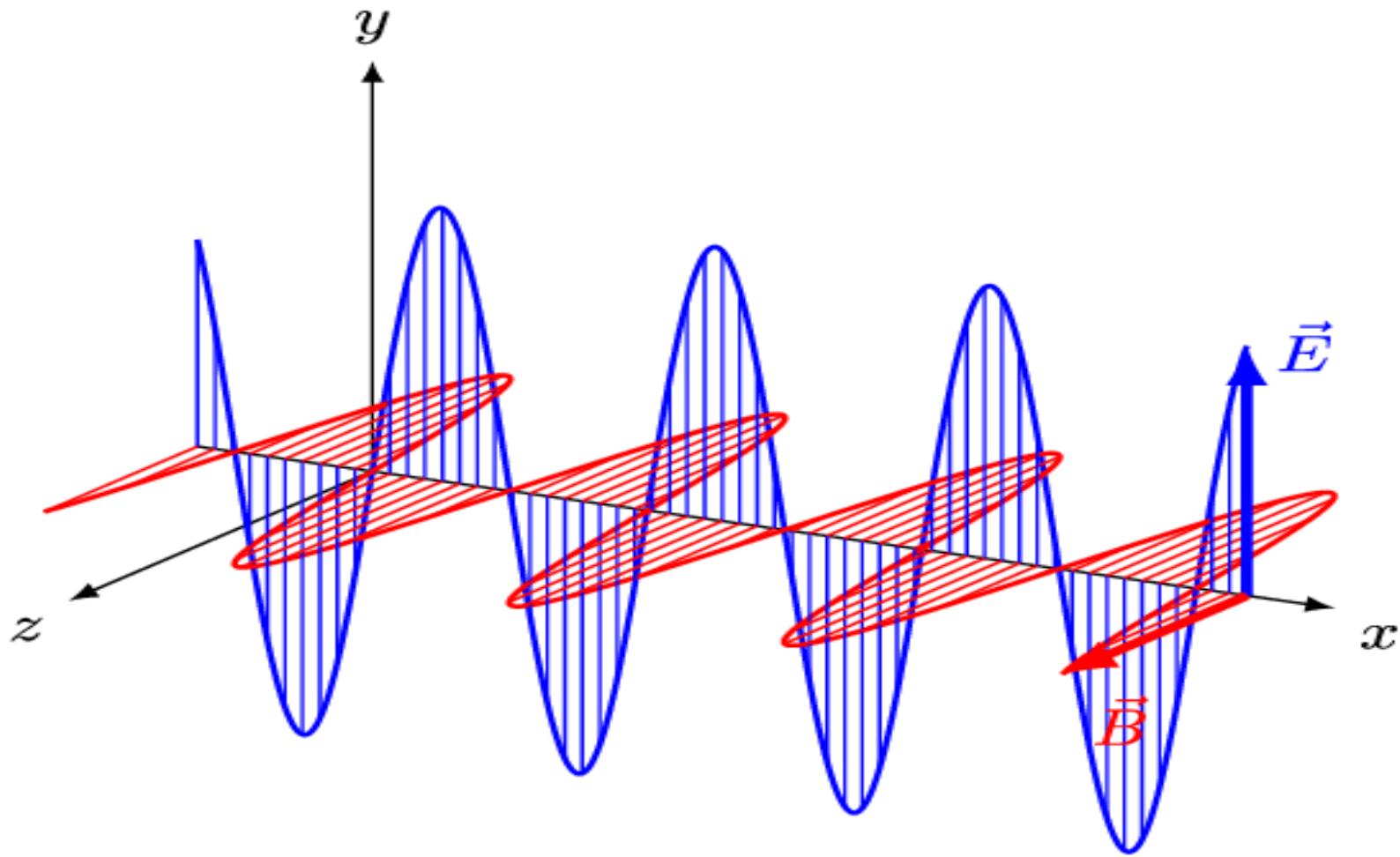


What is Bandwidth?

* low bandwidth

* high bandwidth

Light



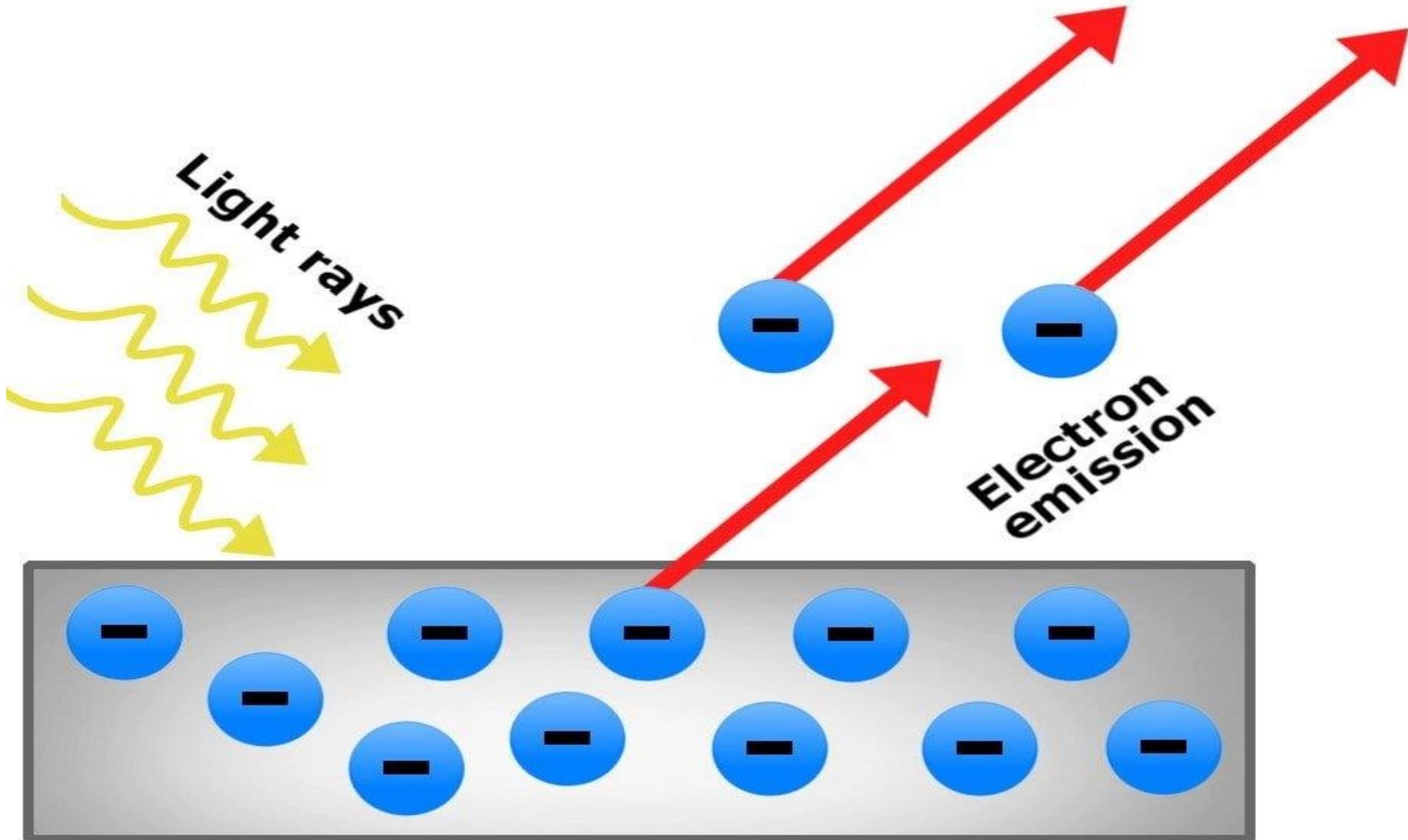


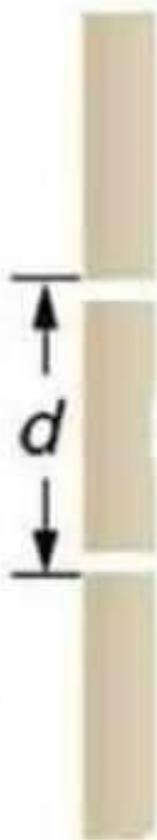
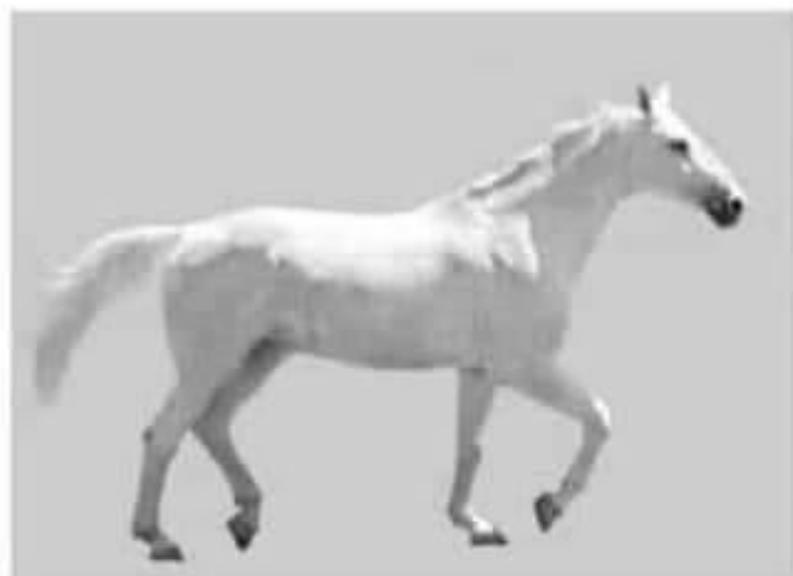
Being a particle

Light

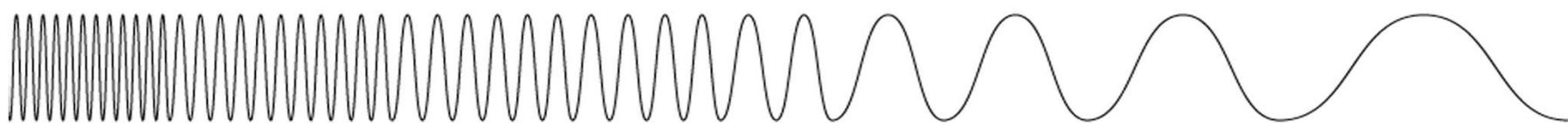
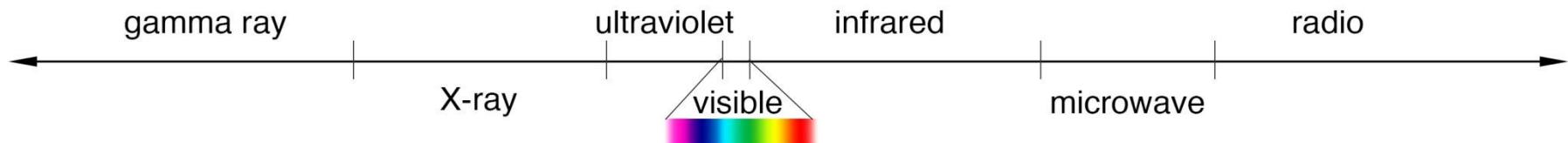
Being a wave

Photoelectric effect





Double Slit
experiment

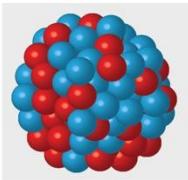


Wavelength in centimeters

10^{-12} 10^{-10} 10^{-8} 10^{-6} 10^{-4} 10^{-2} 10^0 10^2 10^4

Similar in size to...

atomic nucleus



10^{-10}

water molecule

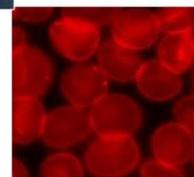


virus



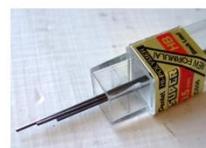
10^{-6}

blood cell



10^{-4}

pencil lead



10^{-2}

ladybug



10^0

human



10^2

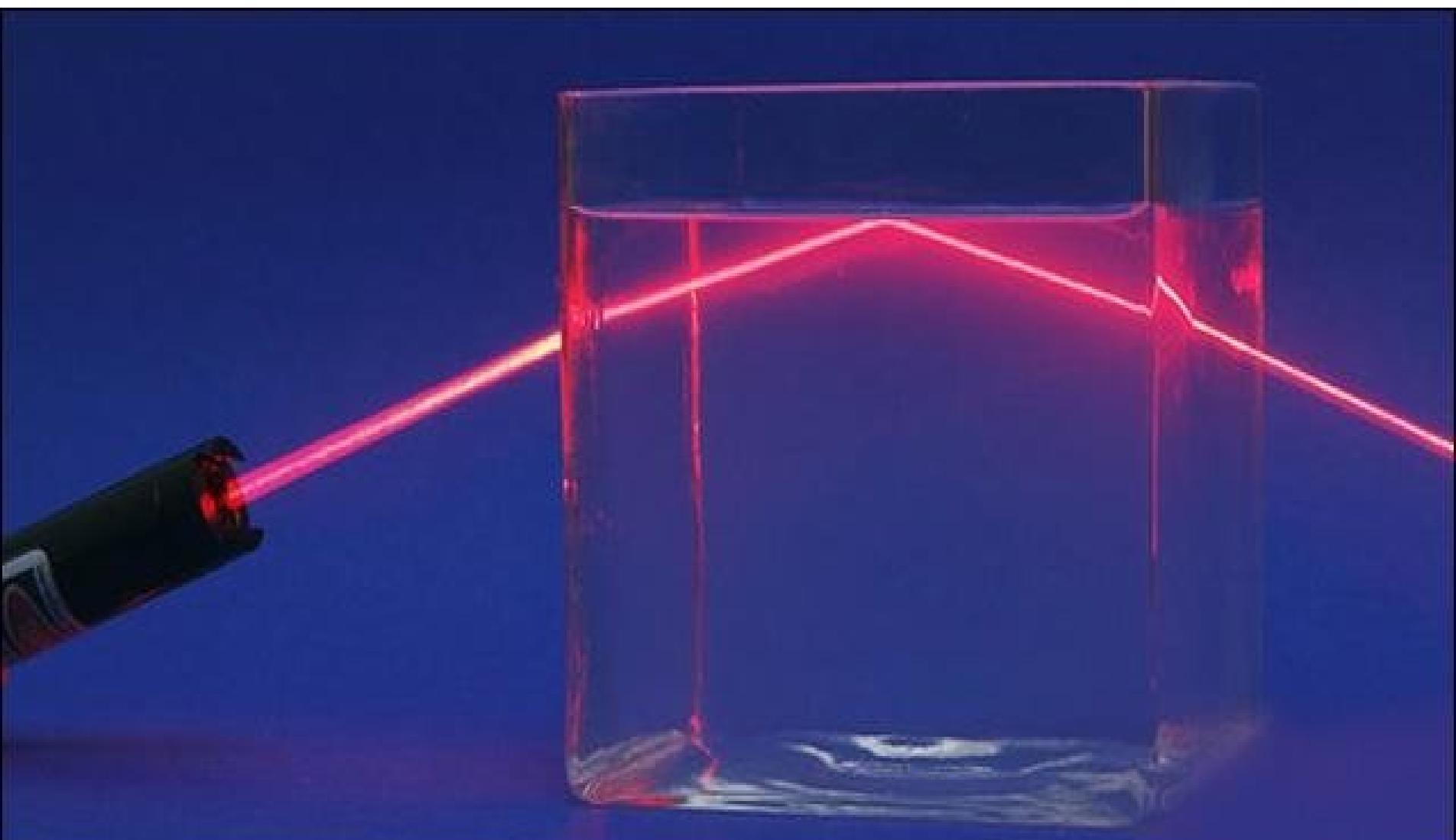
Statue of Liberty



10^4

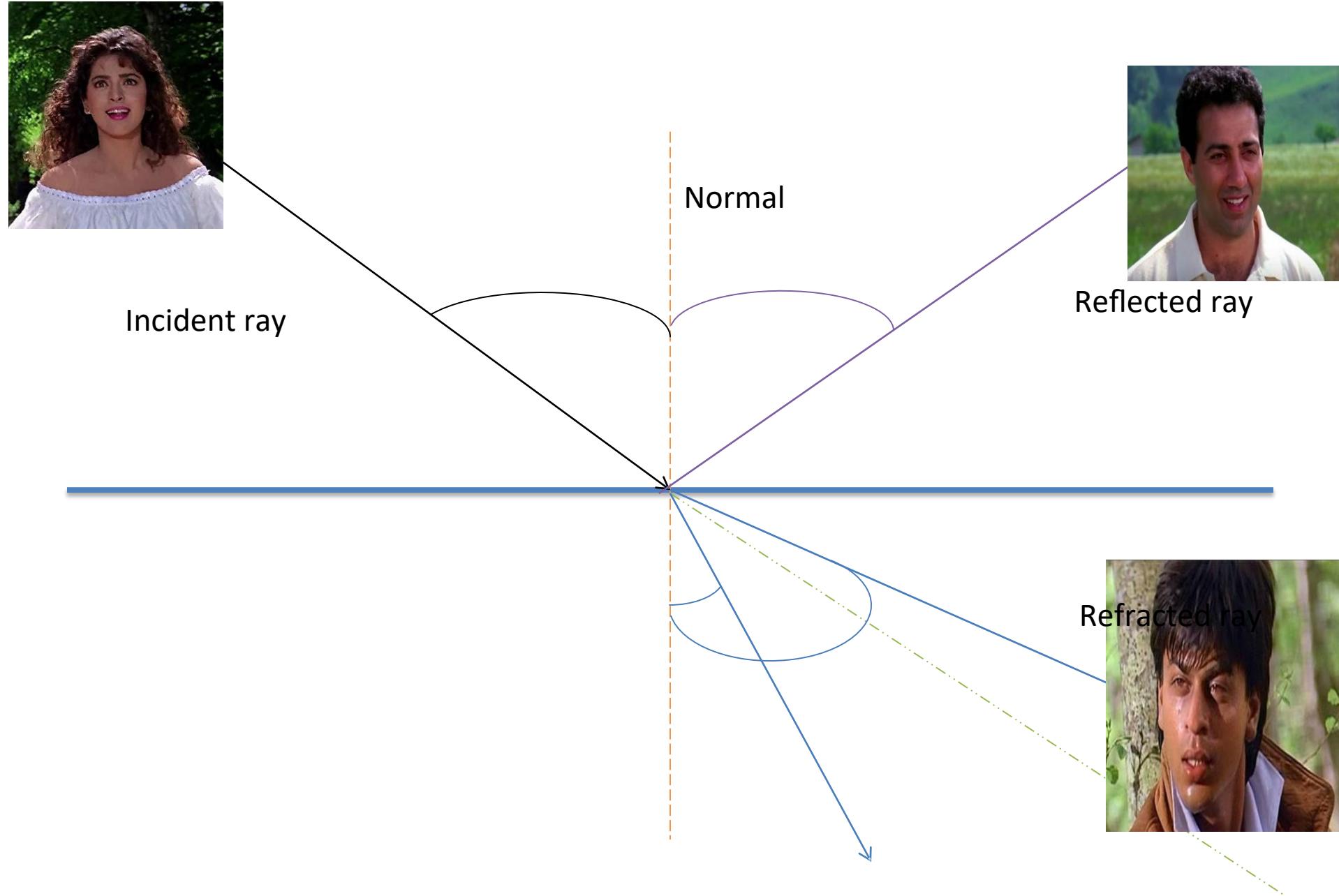
- **What is the role of ultraviolet (UV) radiation in the water purification systems? [UPSC Civil Services, 2012]**
- **1. It inactivates/kills the harmful micro-organisms in water.
2. It removes all the undesirable odours from the water.
3. It quickens the sedimentation of solid particles, removes turbidity and improves the clarity of water.**
- **Which of the statements given above is/are correct?**
 - 1 only
 - 2 and 3 only
 - 1 and 3 only
 - 1, 2 and 3
- **Ans- A**

Ray Optics

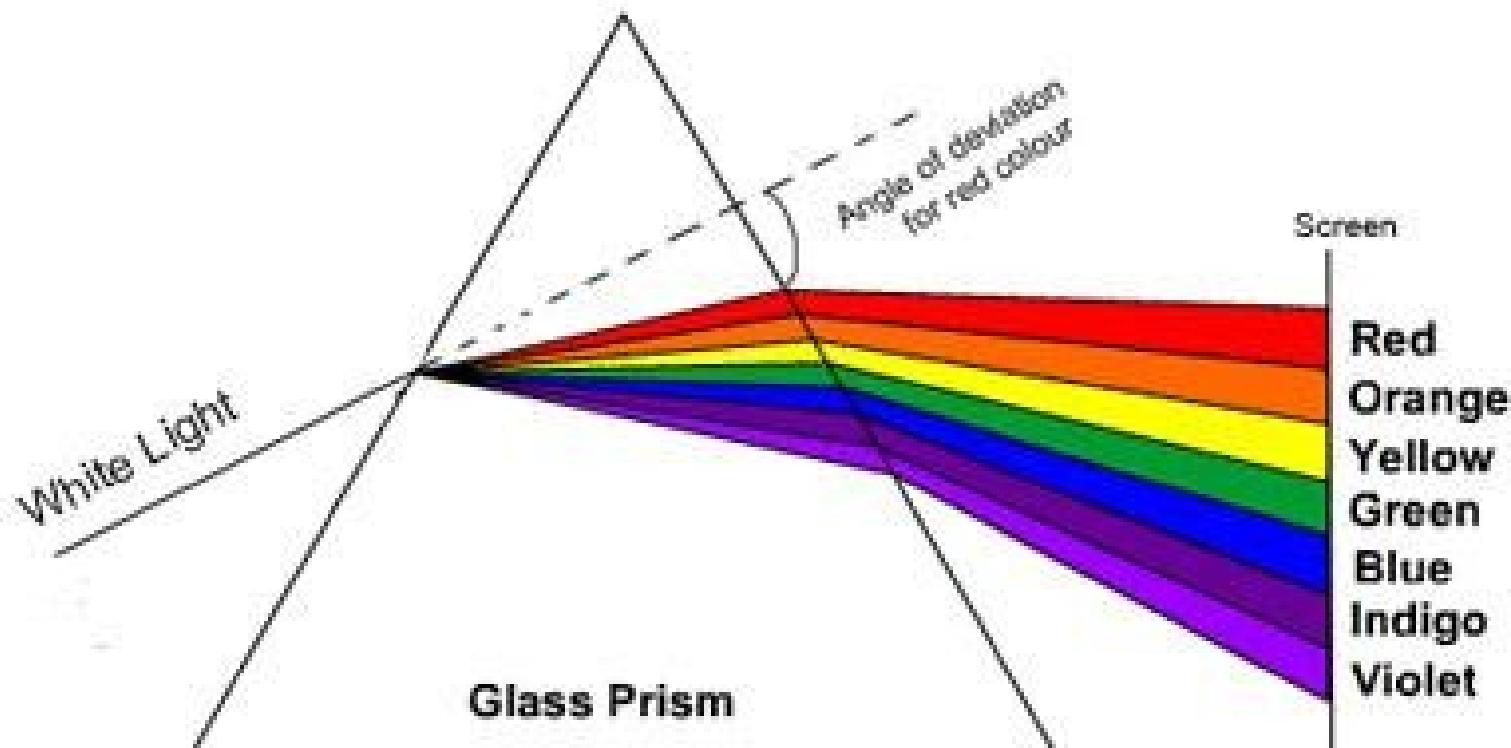


Reflection





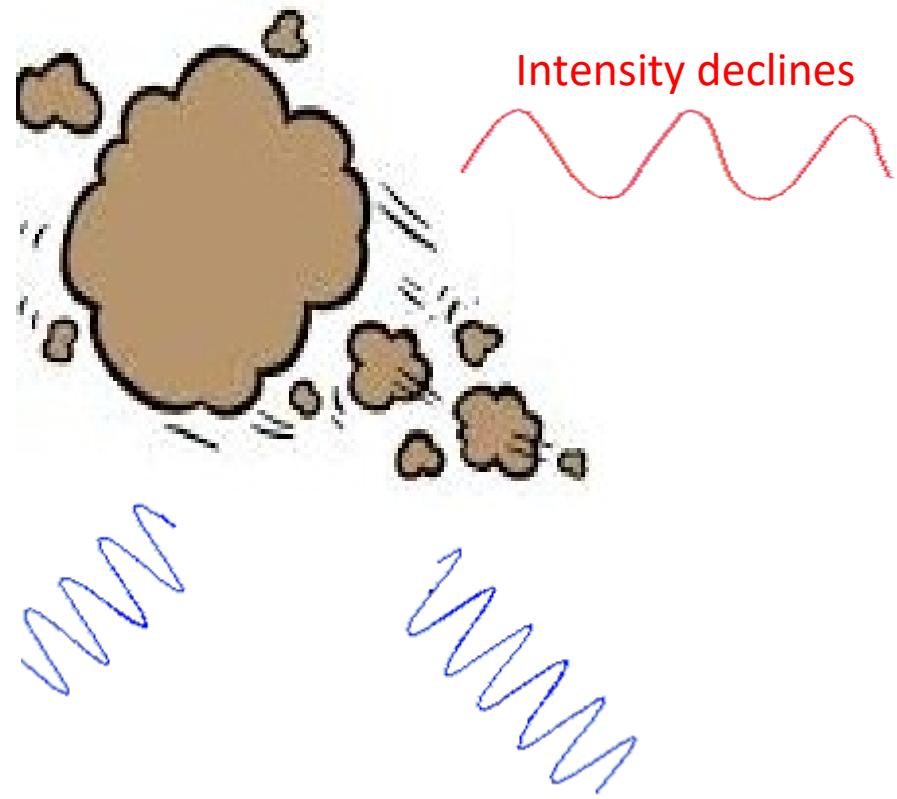
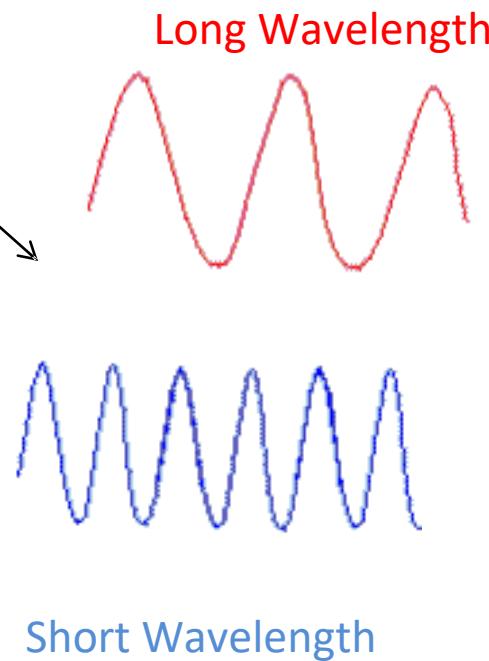
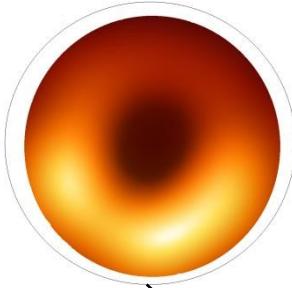
Dispersion



Dispersion of light

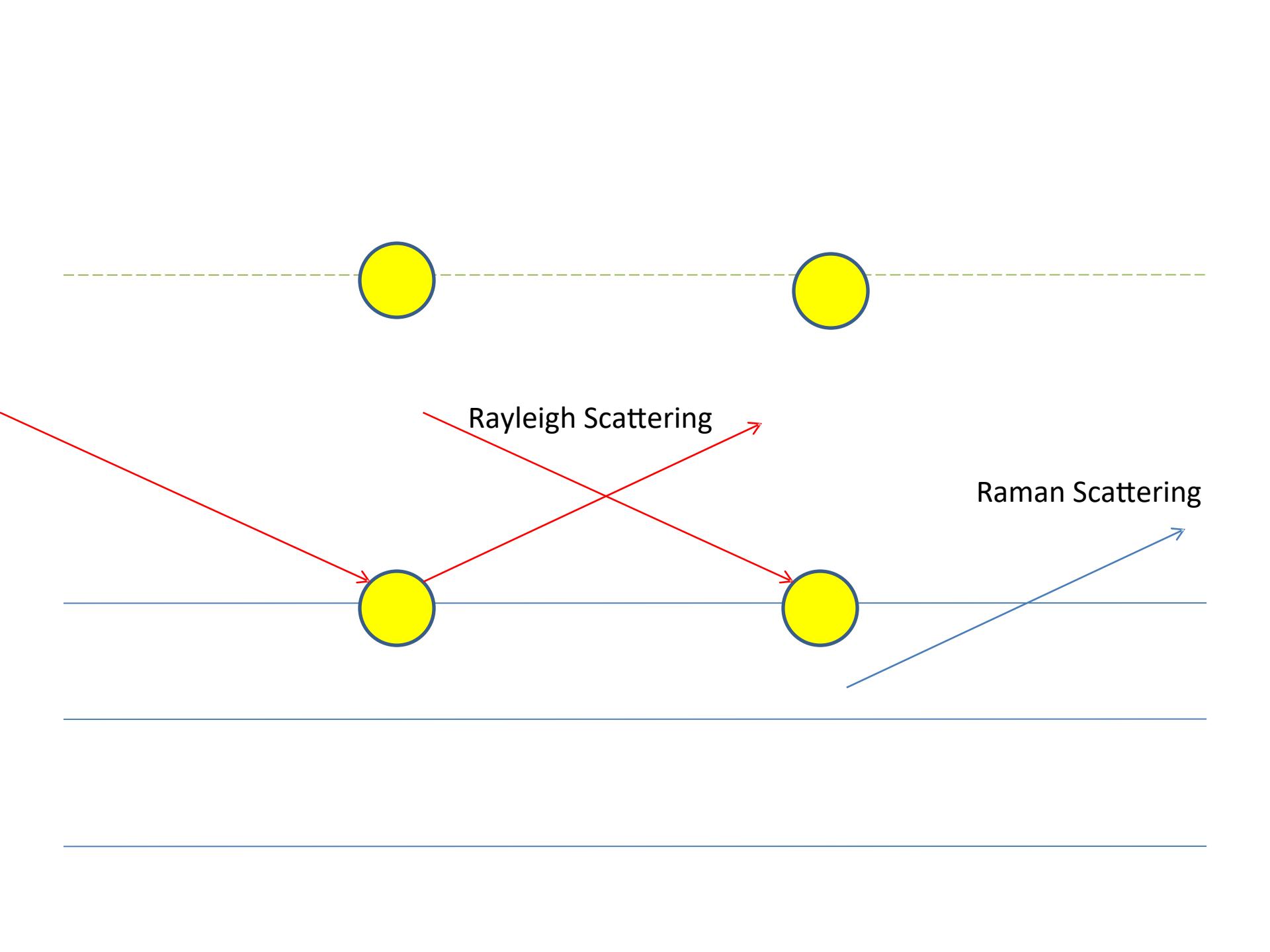
Elastic scattering

Scattering of light

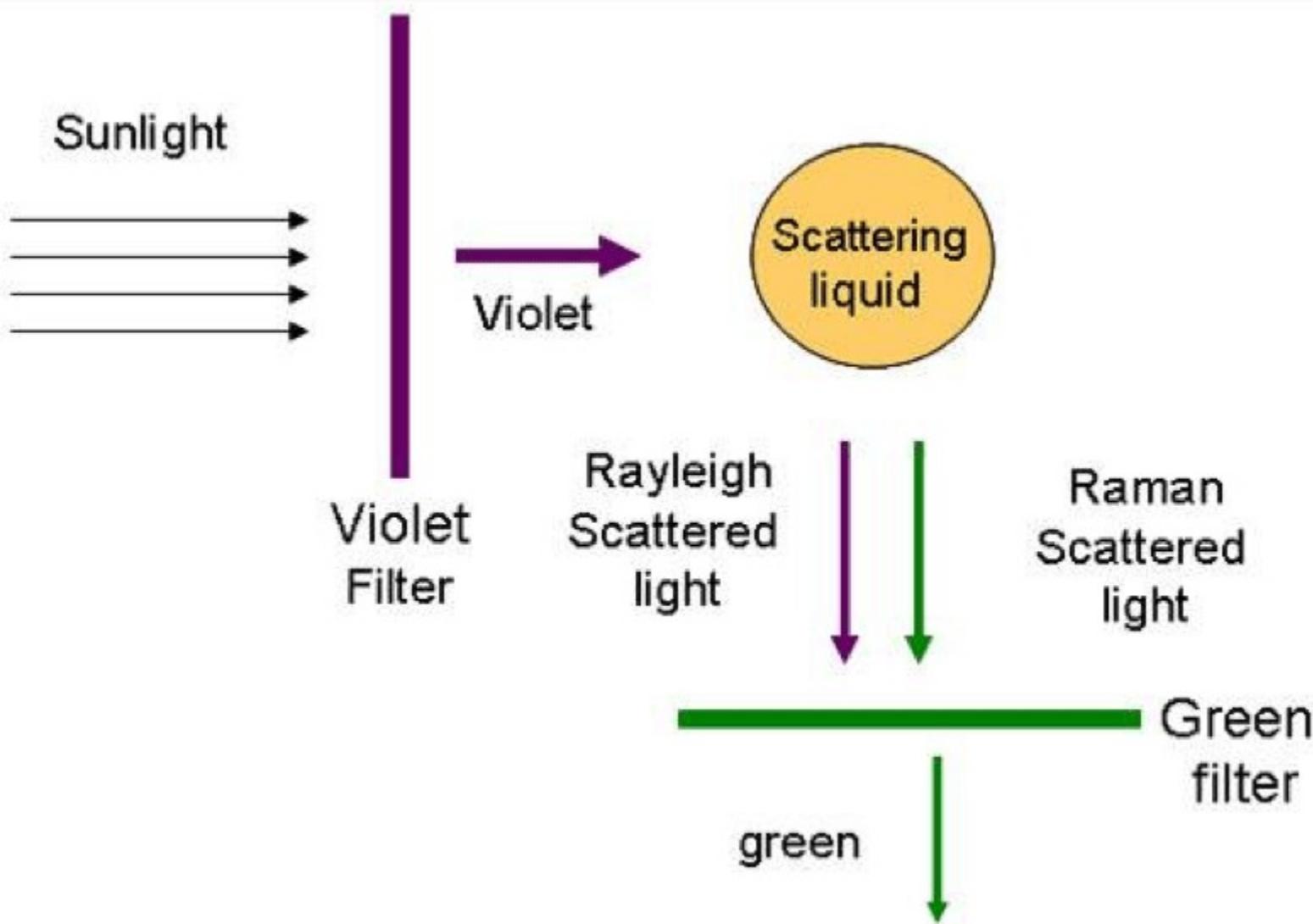


Scatters & Intensity enhances

Scattered photon has same frequency as incident photon

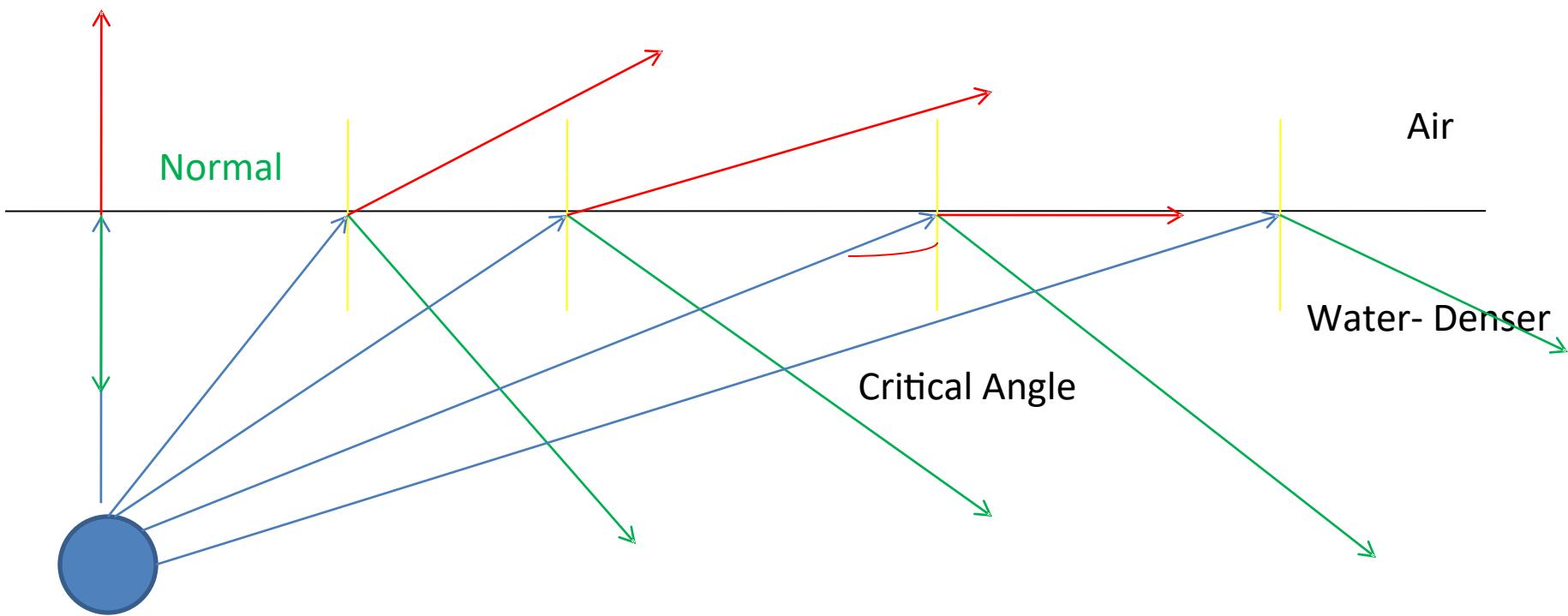


Raman effect



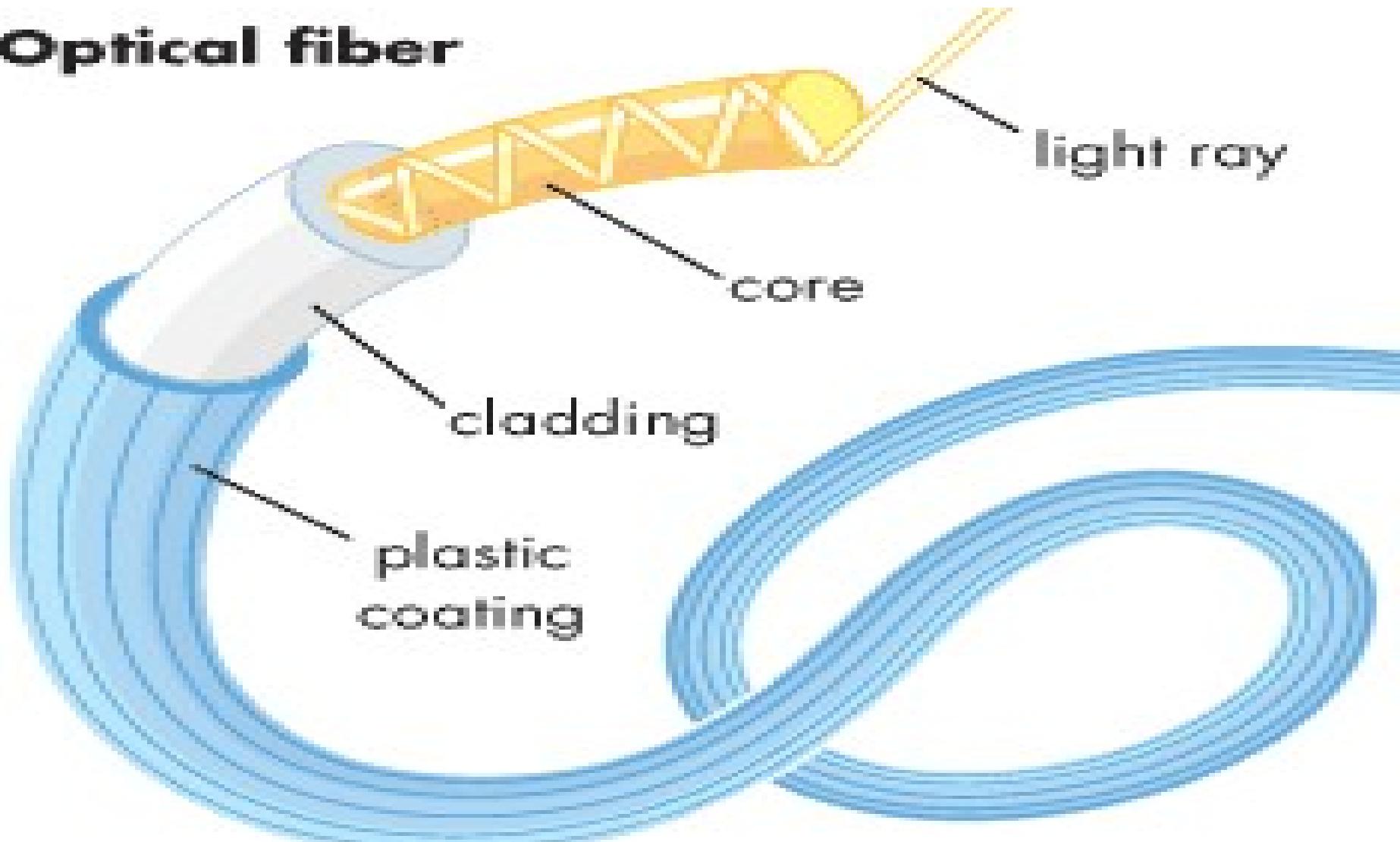
- Consider the following differences between Raman Scattering and Rayleigh scattering:
 1. While Raman scattering is all about elastic scattering of light, Rayleigh scattering of light is all about inelastic scattering of light
 2. While Raman scattering leads to change frequency, Rayleigh scattering leads to unchanged frequency
- Which of the above statements is/are correct?
- [A] 1 Only
- [B] 2 Only
- [C] Both 1 & 2
- [D] Neither 1 nor 2
- Ans B

Total internal reflection

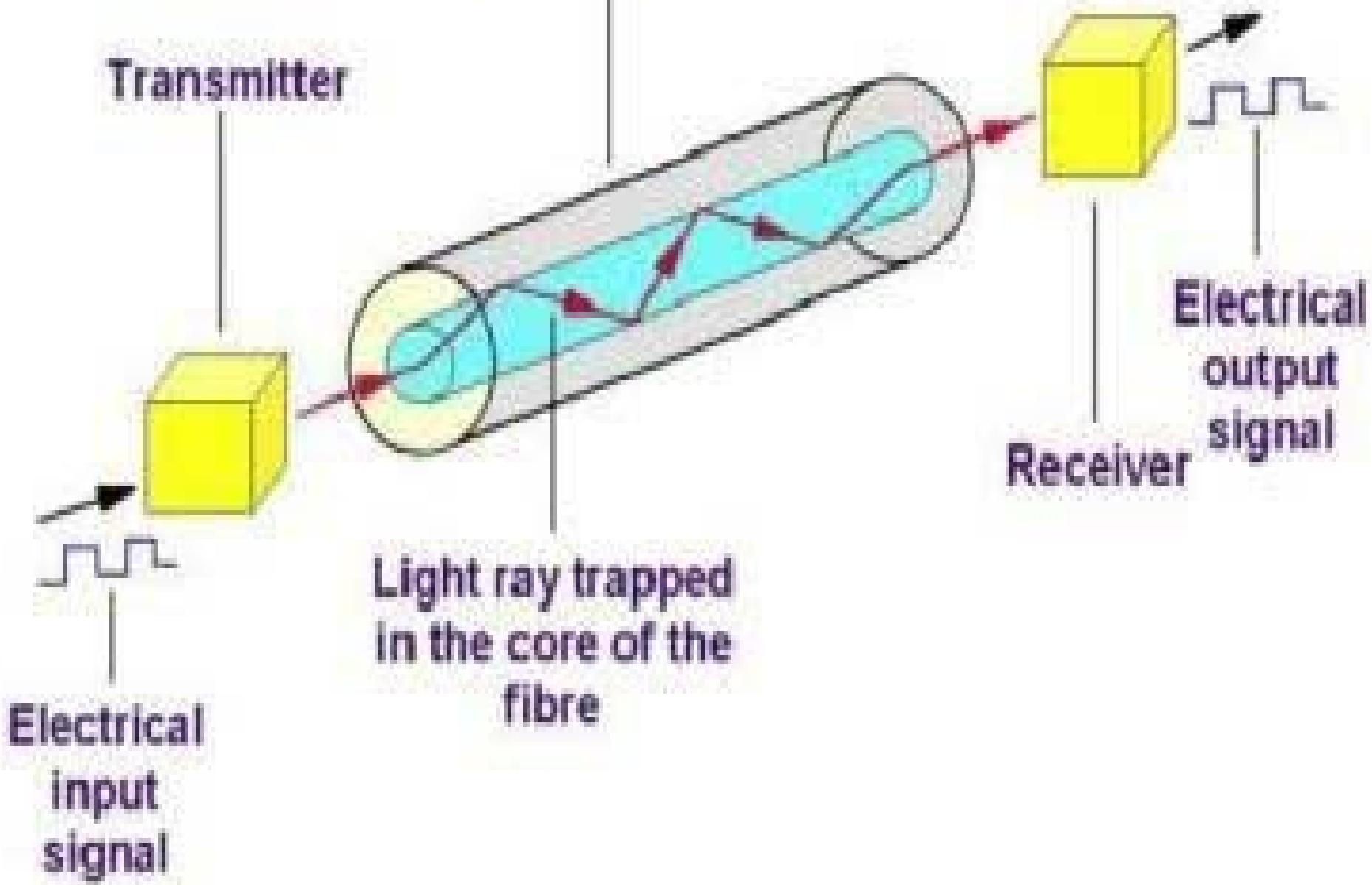


Optical fibre

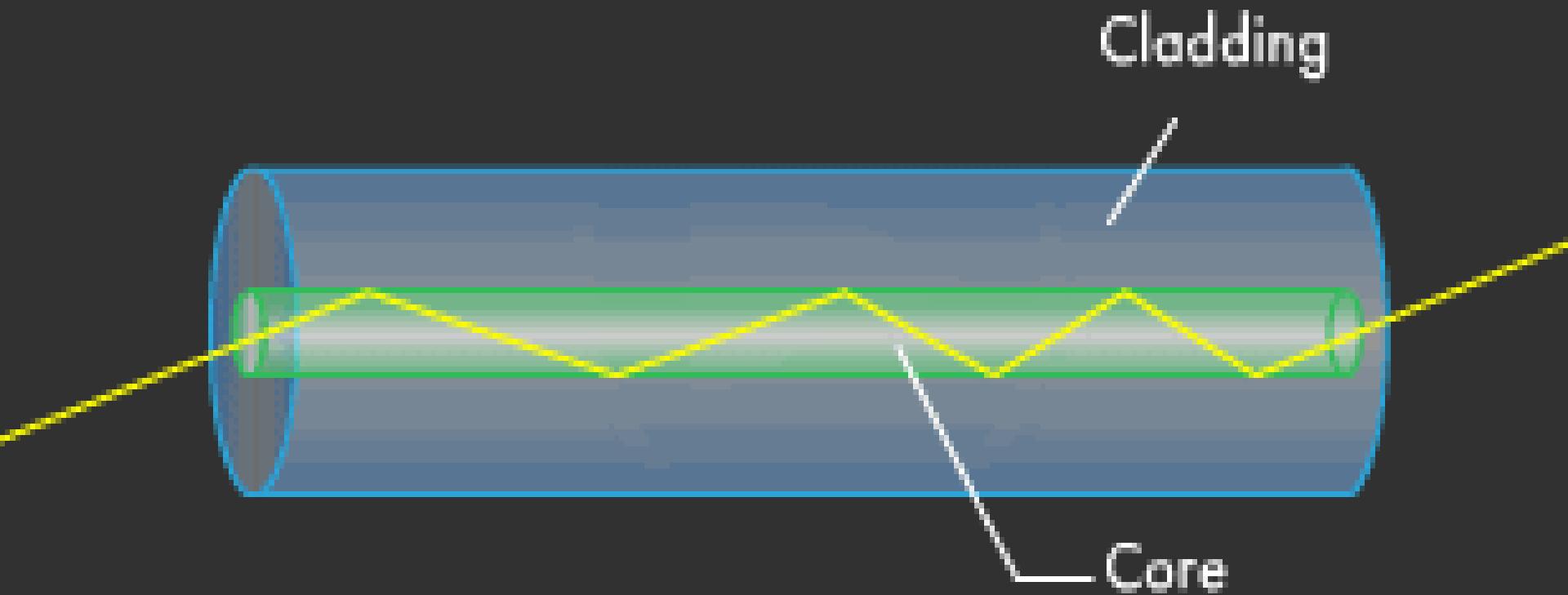
Optical fiber



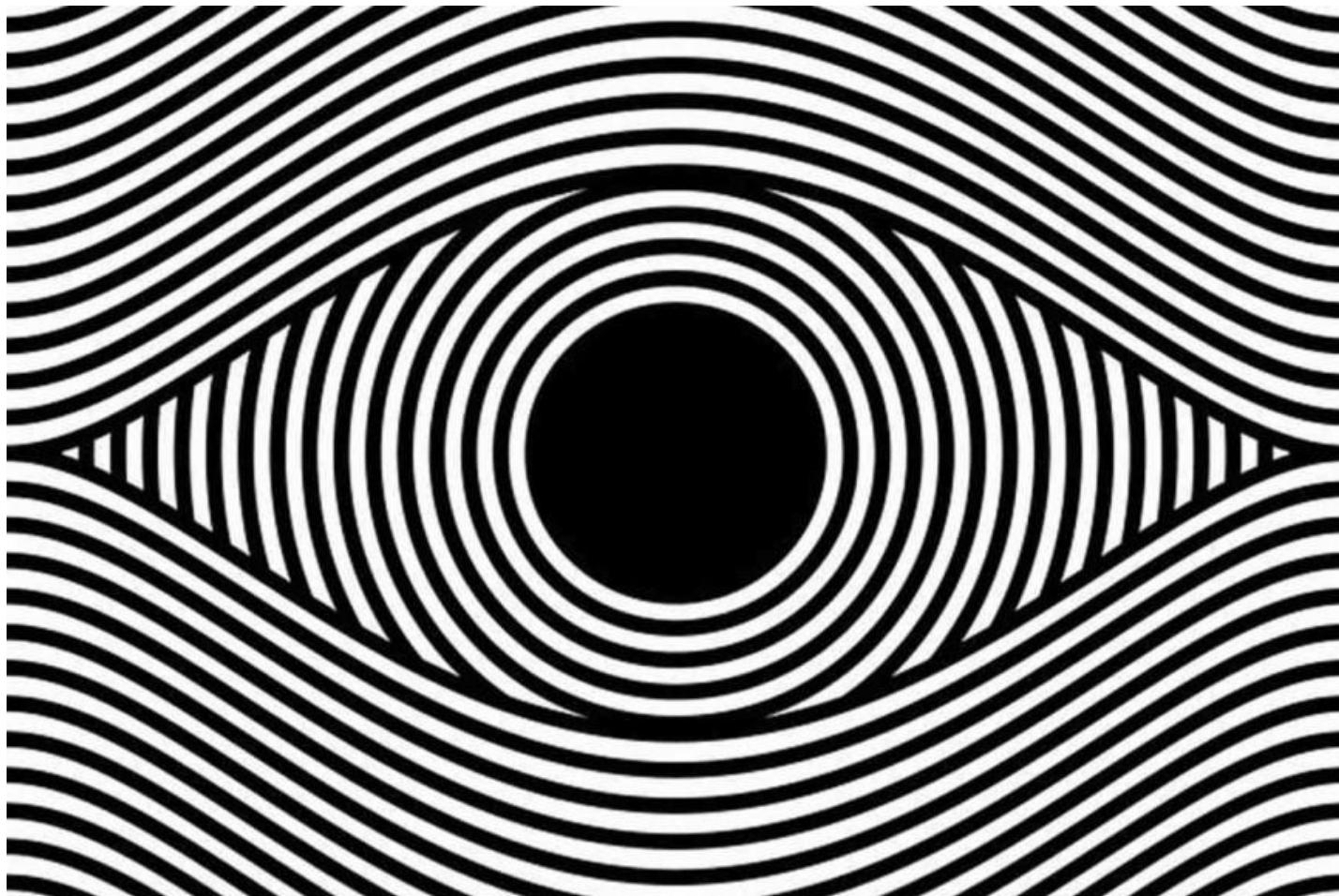
Optical Fibre



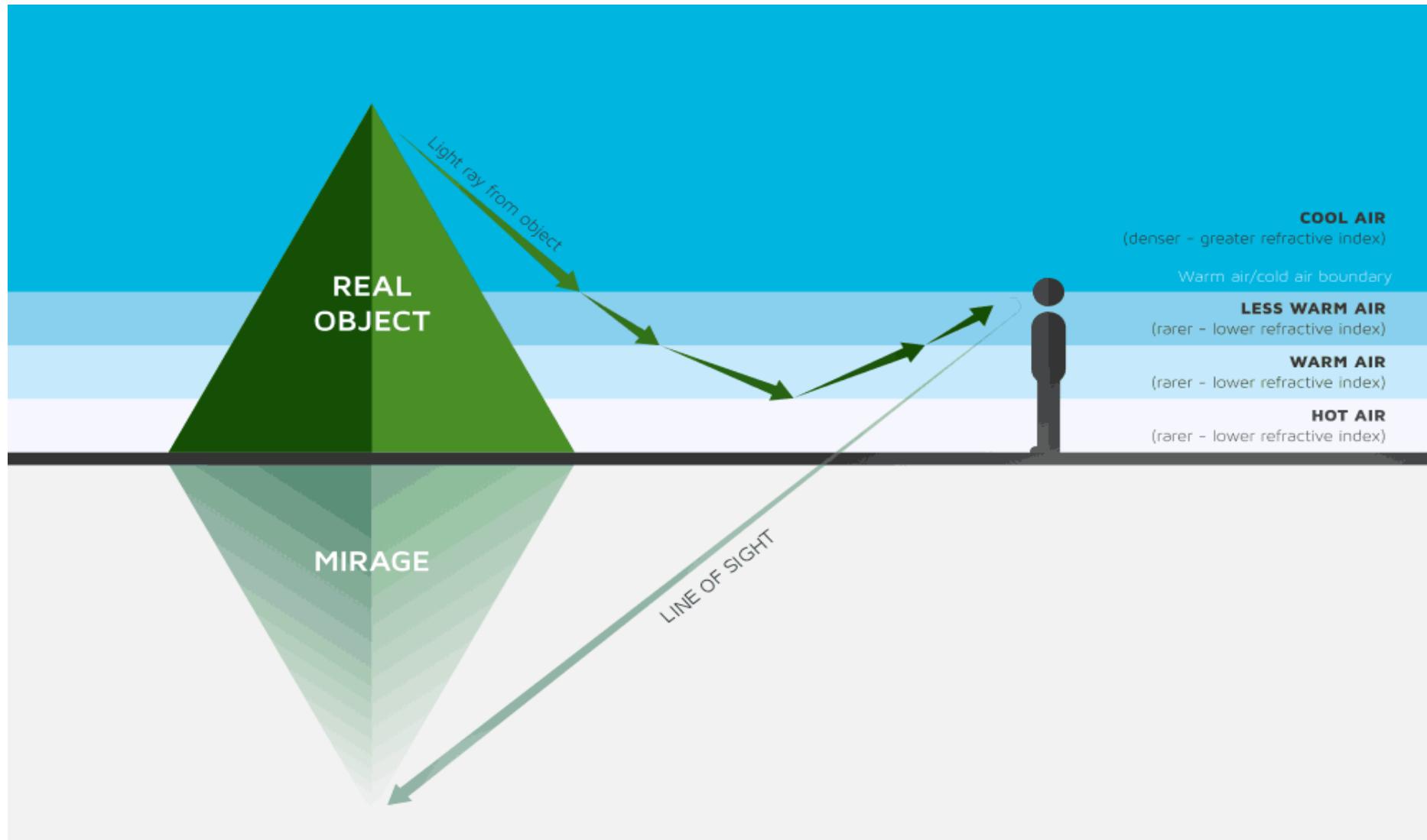
Principle of total internal reflection

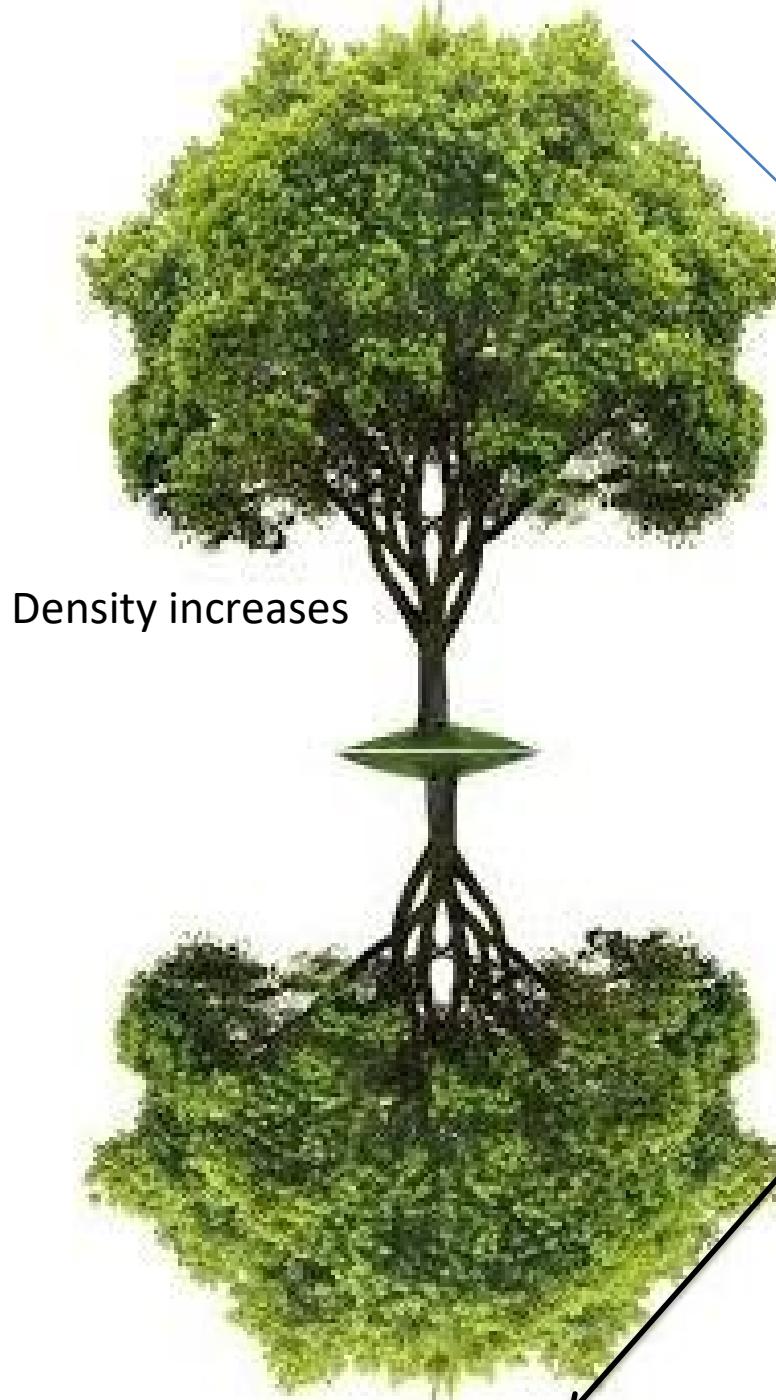


Optical illusion



Mirage





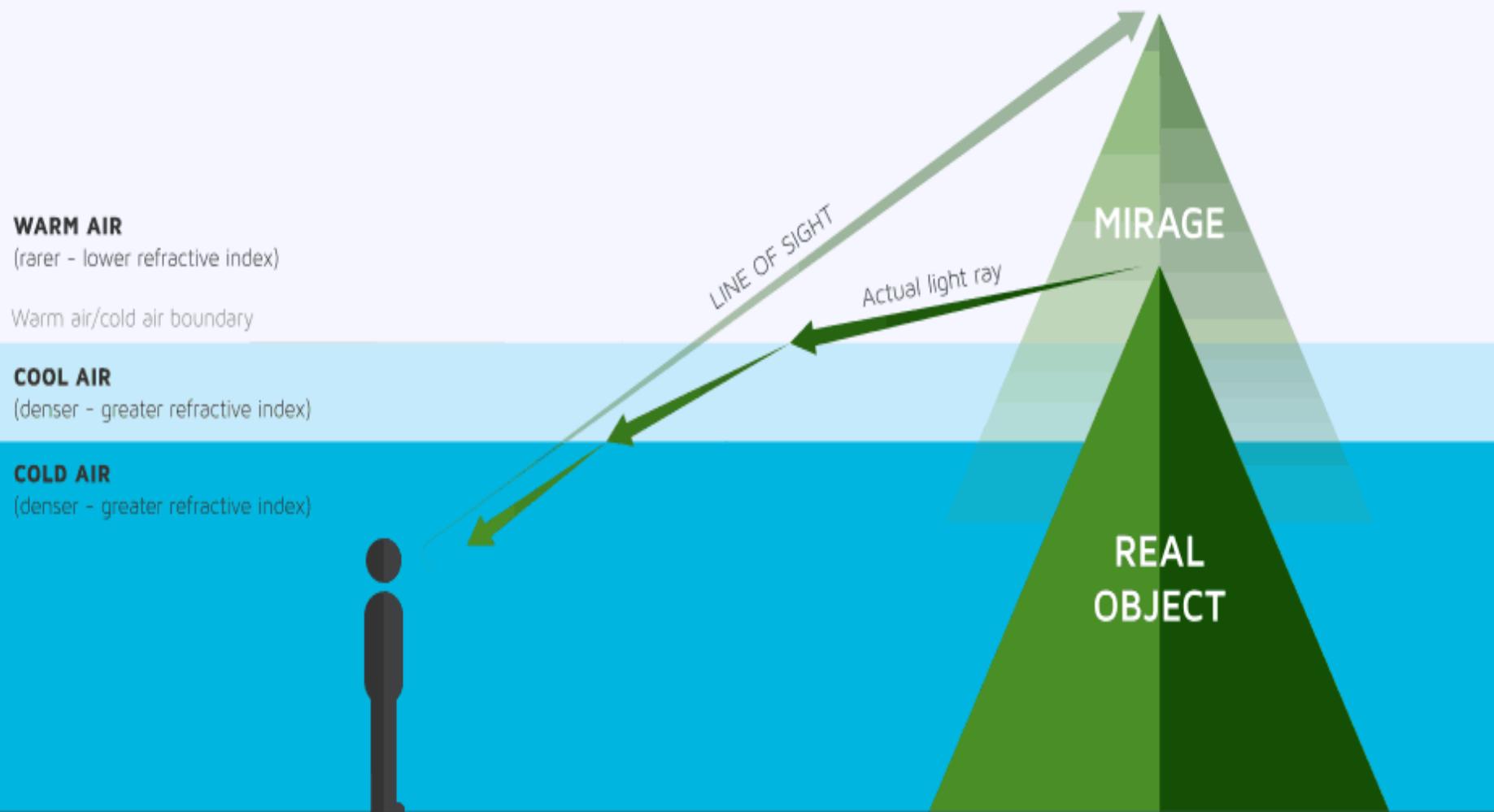
Density increases

Normal

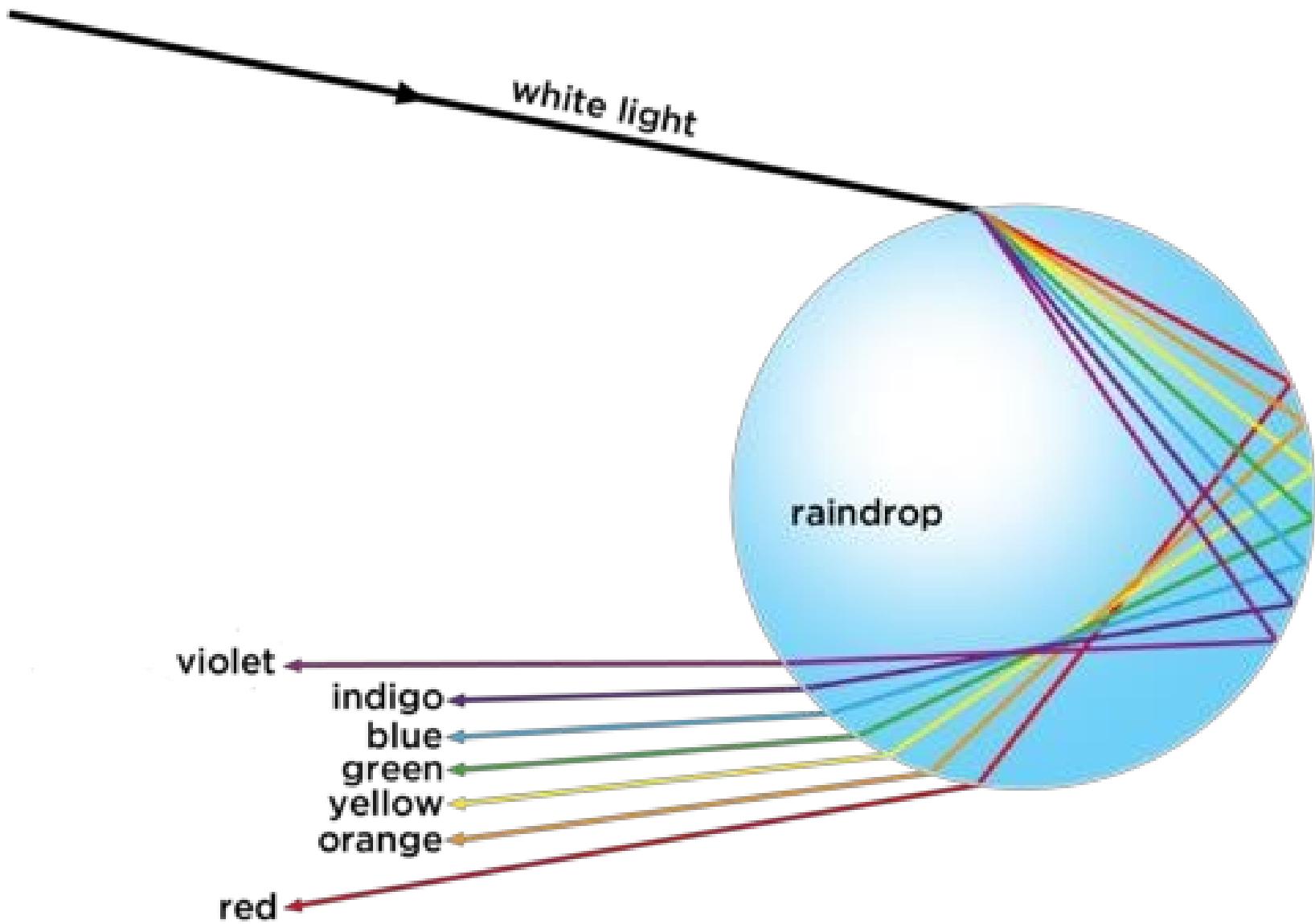
Line of sight



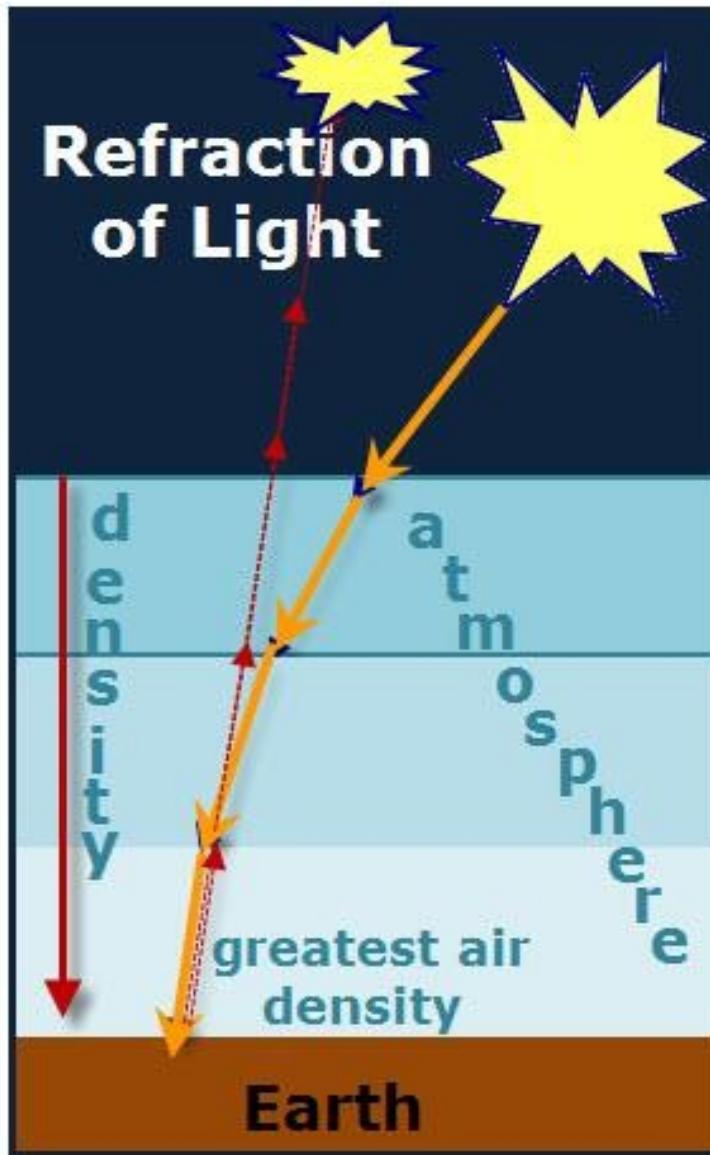
Looming



Rainbow

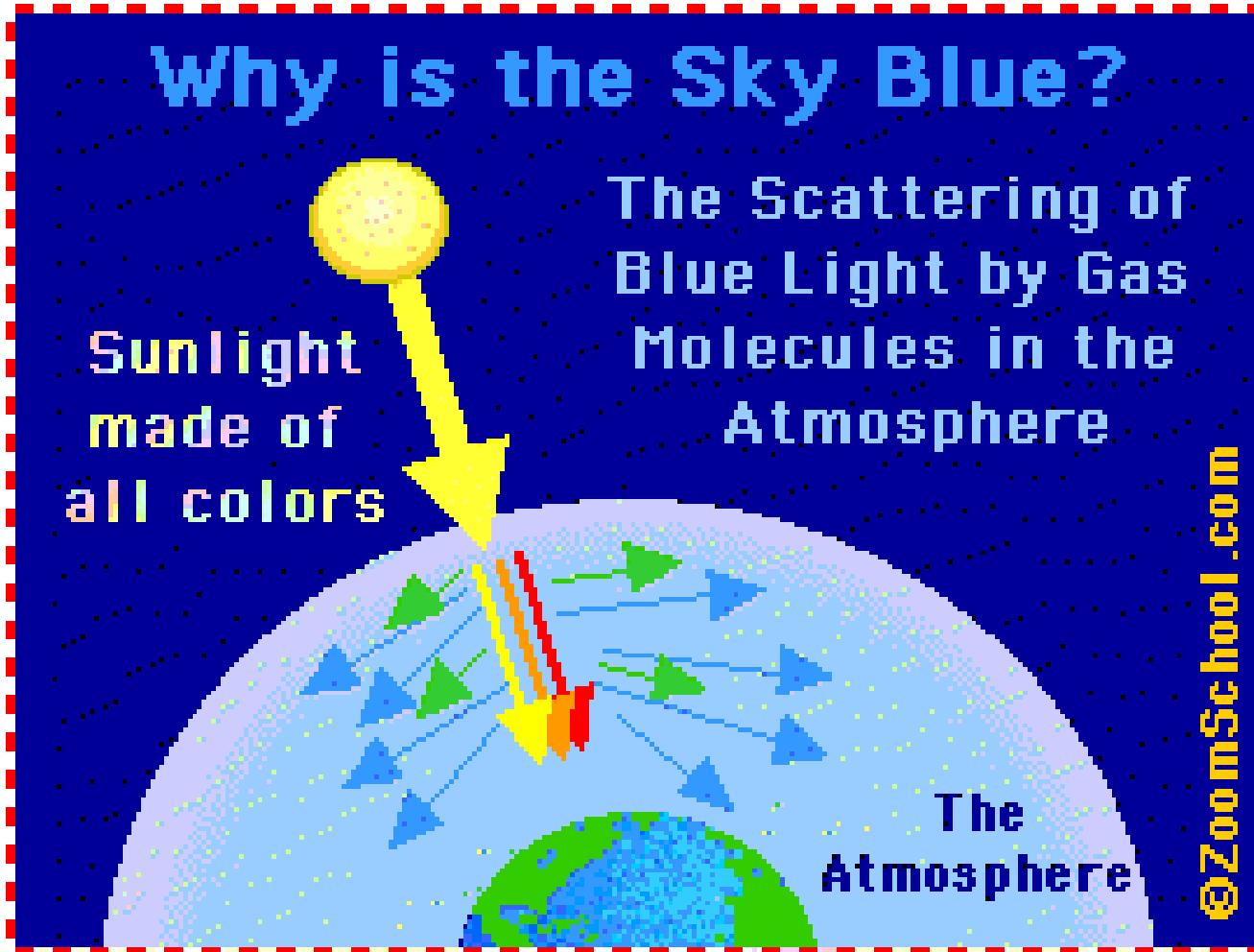


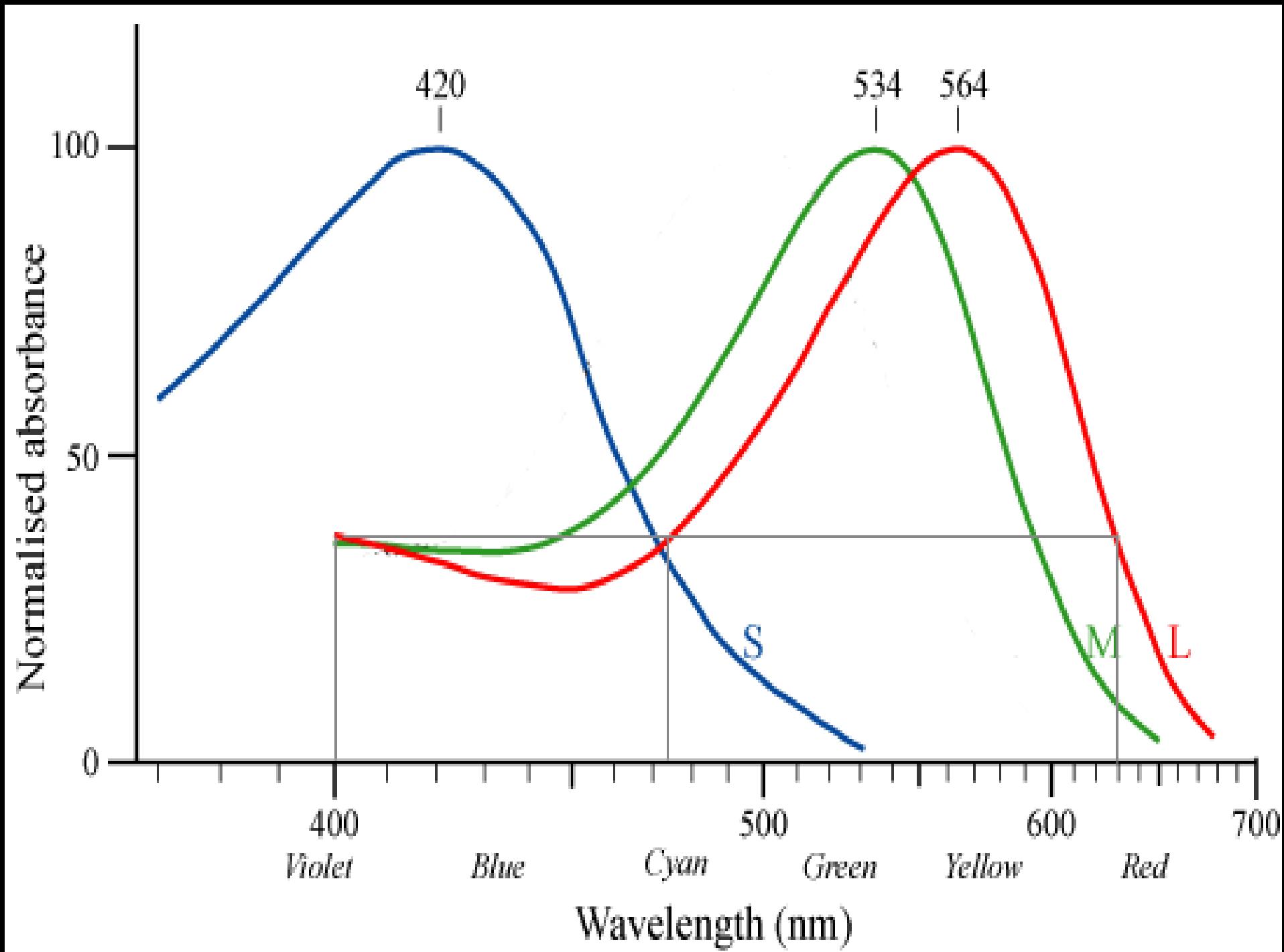
Twinkling of stars

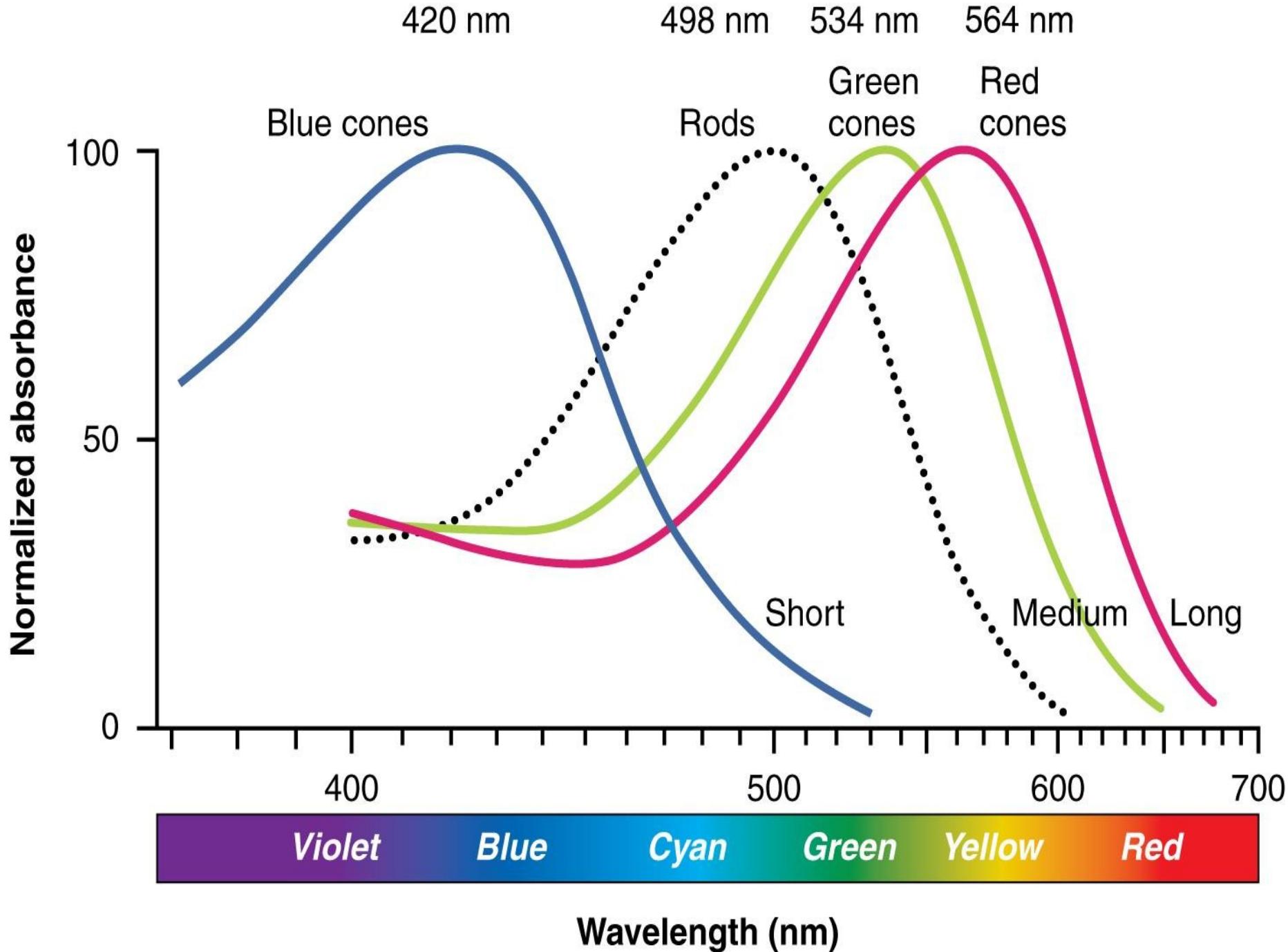




Why is sky blue?





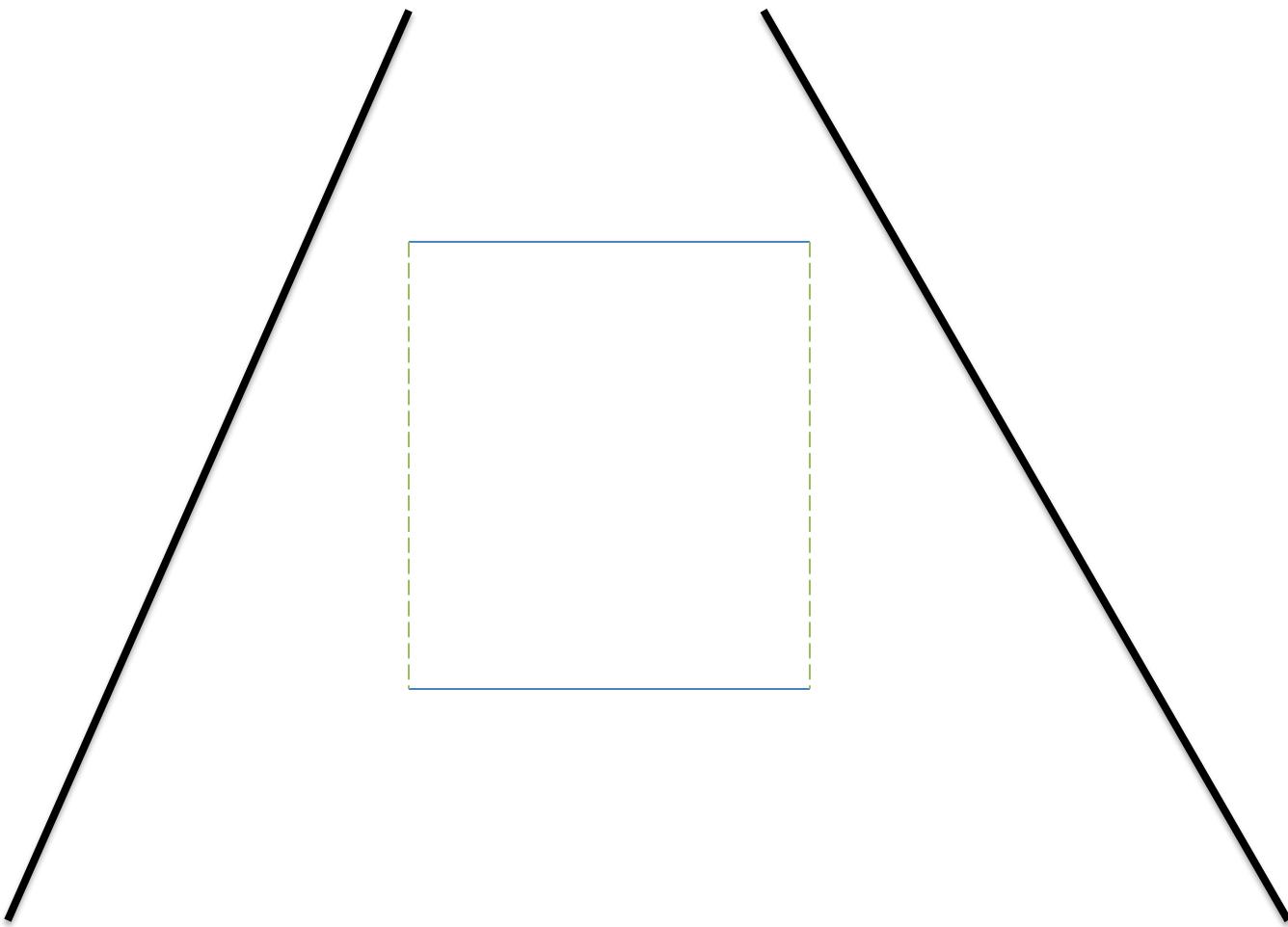


atmosphere

atmosphere

Atmospheric layers





- Optical fibre works on the principle of _____.
- refraction
- scattering
- interference
- total internal reflection
- Ans- D

- Diffusion of light in the atmosphere takes place due to _____.
- helium
- dust particles
- carbon dioxide
- water vapours
- **Ans - B**

- Consider the following phenomena: [UPSC Civil Services, 2013]
- 1. Size of the sun at dusk
- 2. Colour of the sun at dawn
- 3. Moon being visible at dawn
- 4. Twinkle of stars in the sky
- 5. Polestar being visible in the sky
- Which of the above are optical illusions?
- 1, 2 and 3
- 3, 4 and 5
- 1, 2 and 4
- 2, 3 and 5
- Ans- C

- **Rainbow is produced when sunlight falls on drops of rain. Which of the following physical phenomena are responsible for this? [UPSC Civil Services, 2013]**
- **1. Dispersion
2. Refraction
3. Internal reflection**
- **Select the correct answer using the codes given below?**
- 1 and 2 only
- 2 and 3 only
- 1 and 3 only
- 1, 2 and 3
- Ans- D

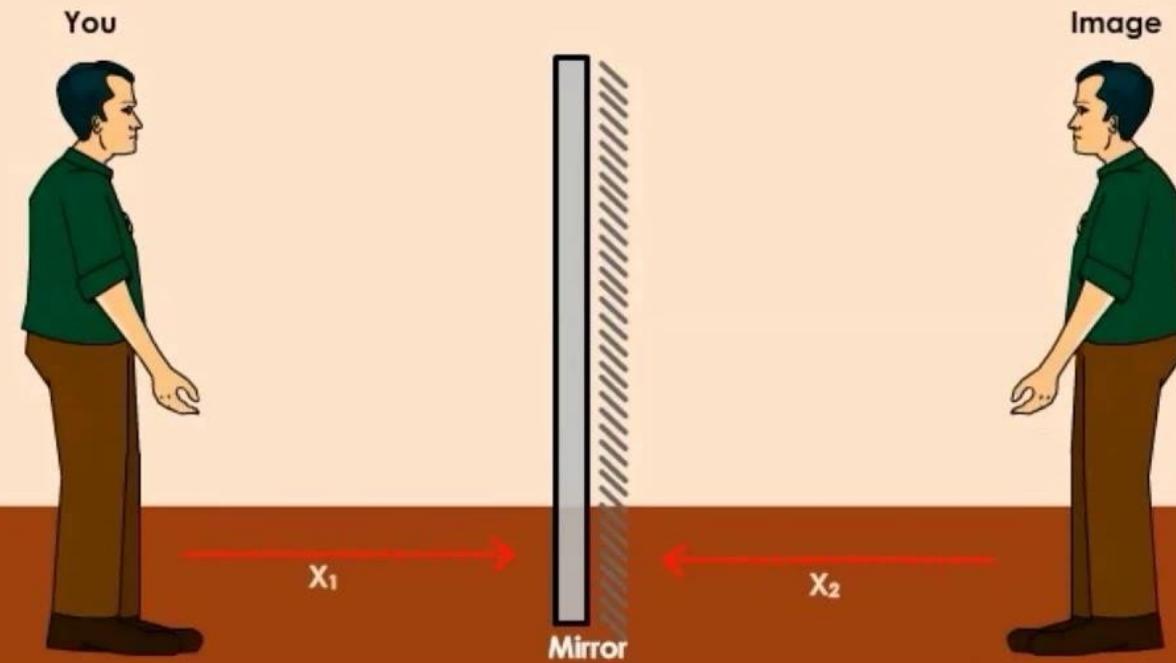
Mirrors

- Plane
- Spherical

Plane mirror

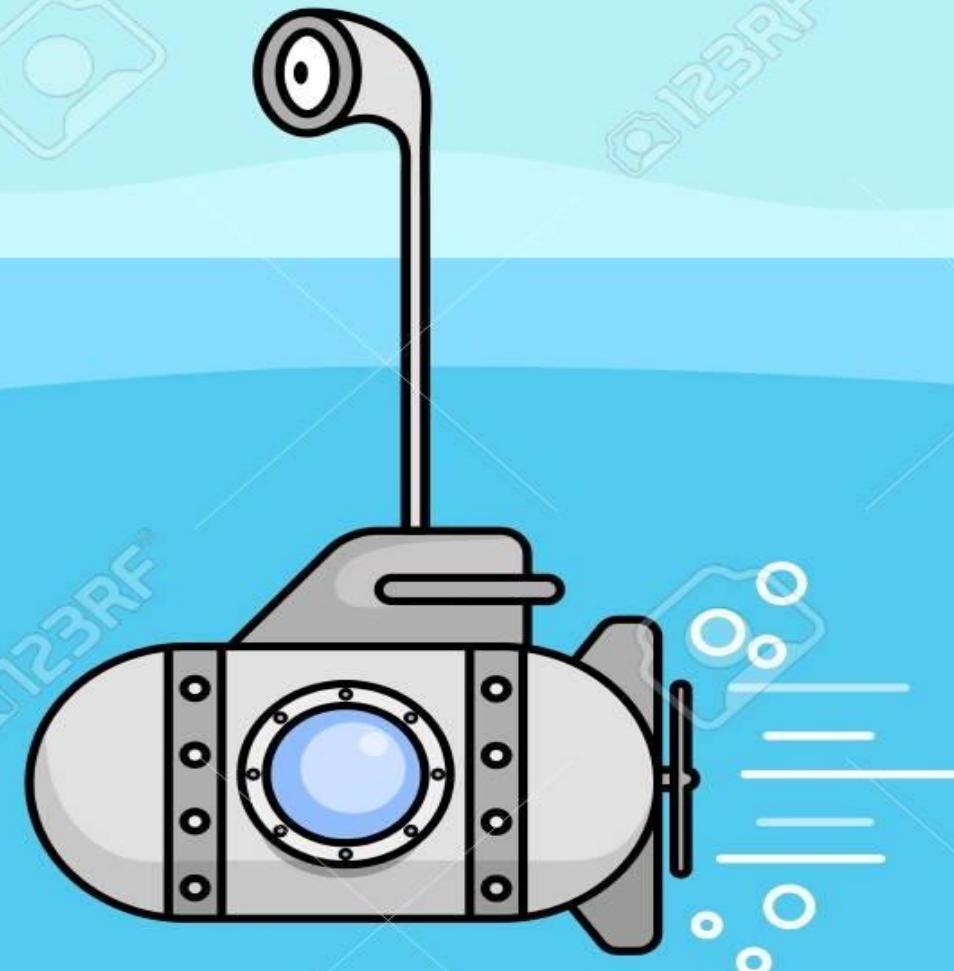
Plane mirrors

Nature of image formed by a plane mirror



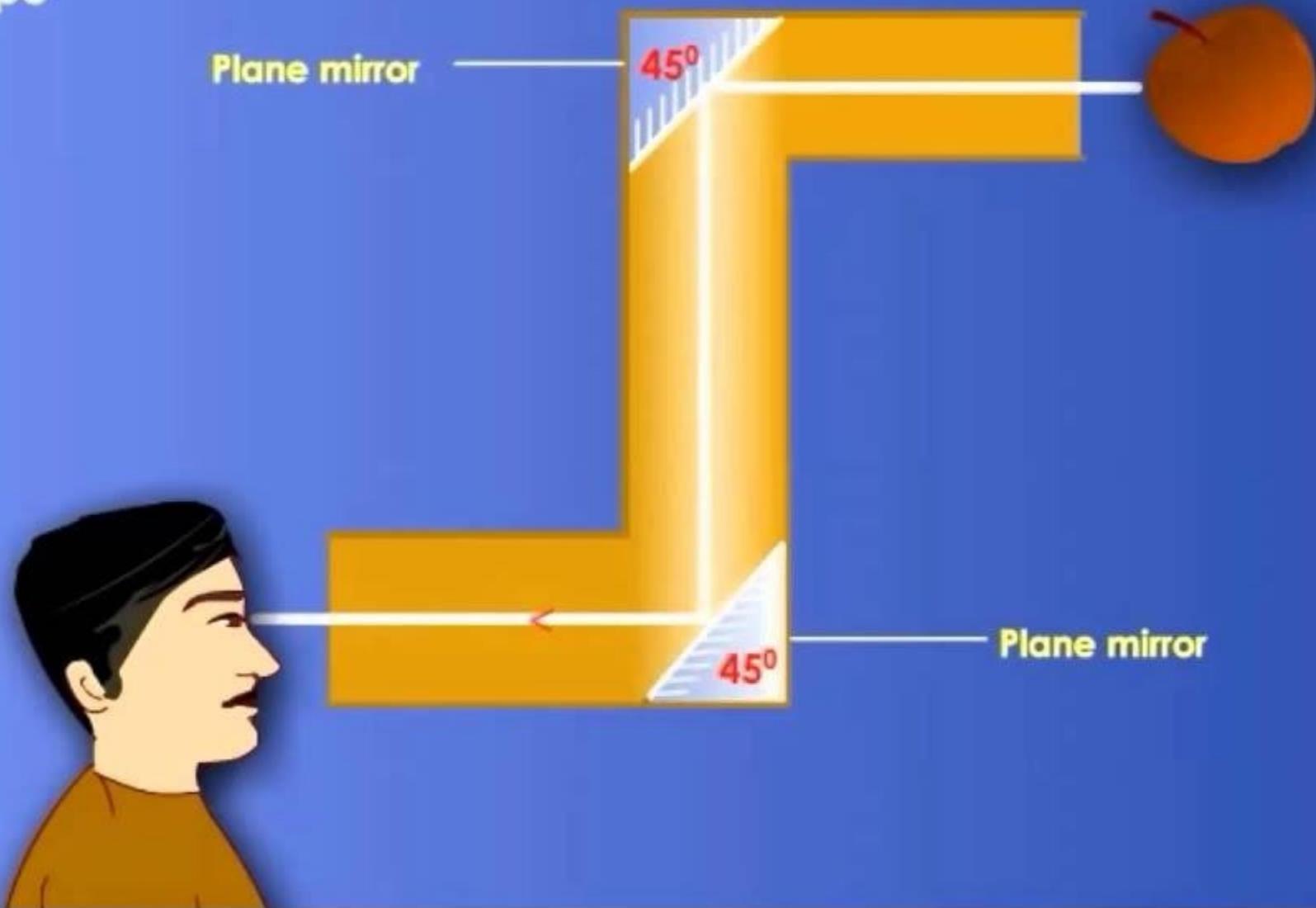
If you move your right hand, your image in the mirror moves its left hand.

Periscope



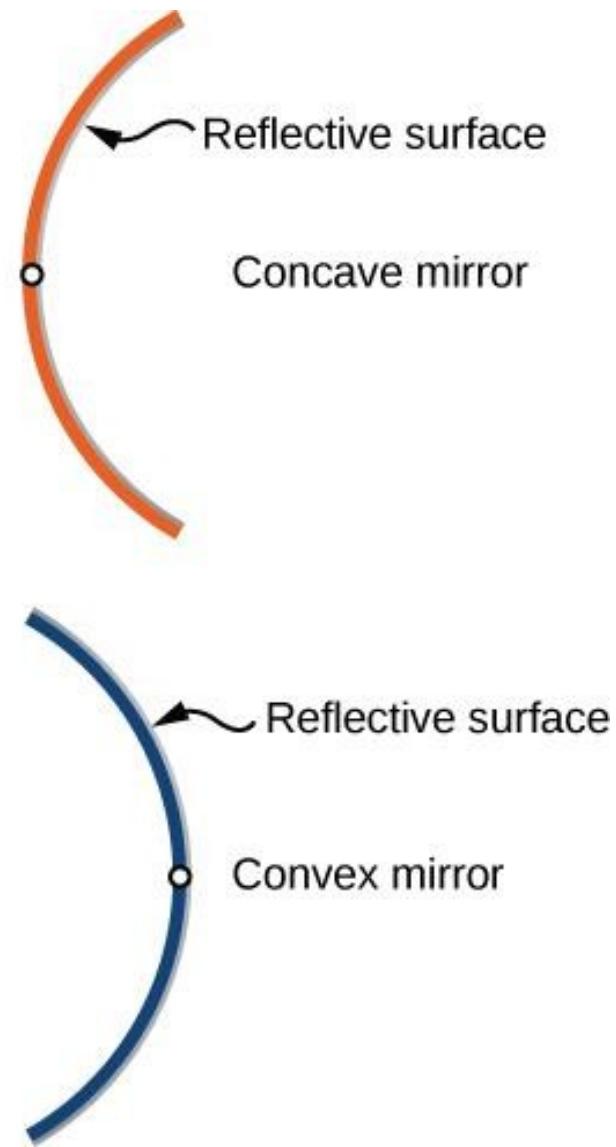
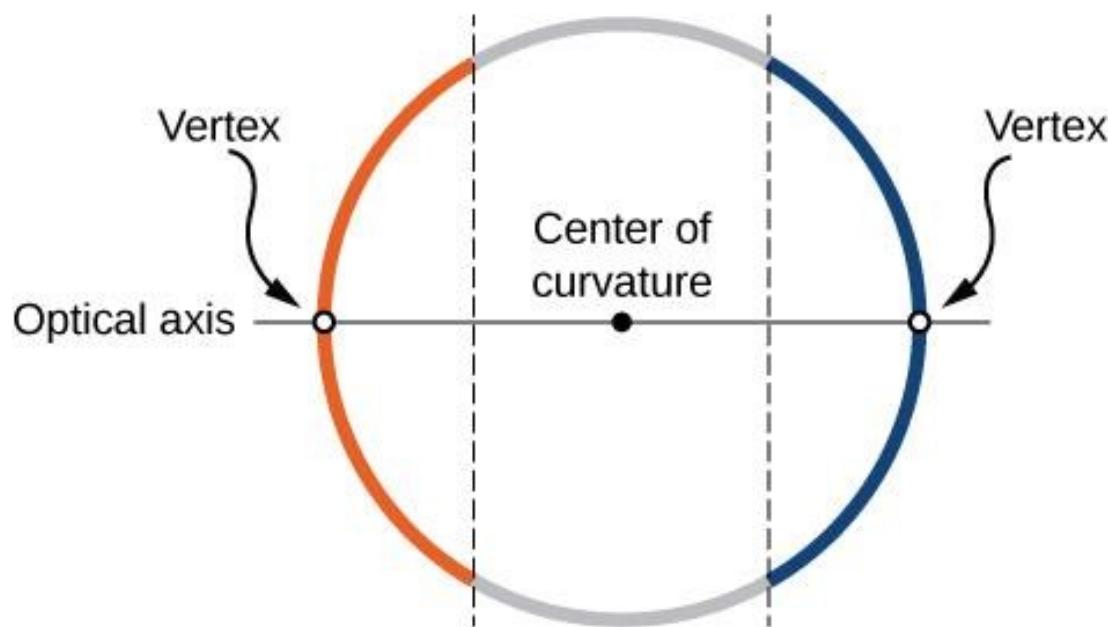
Plane mirrors

The periscope

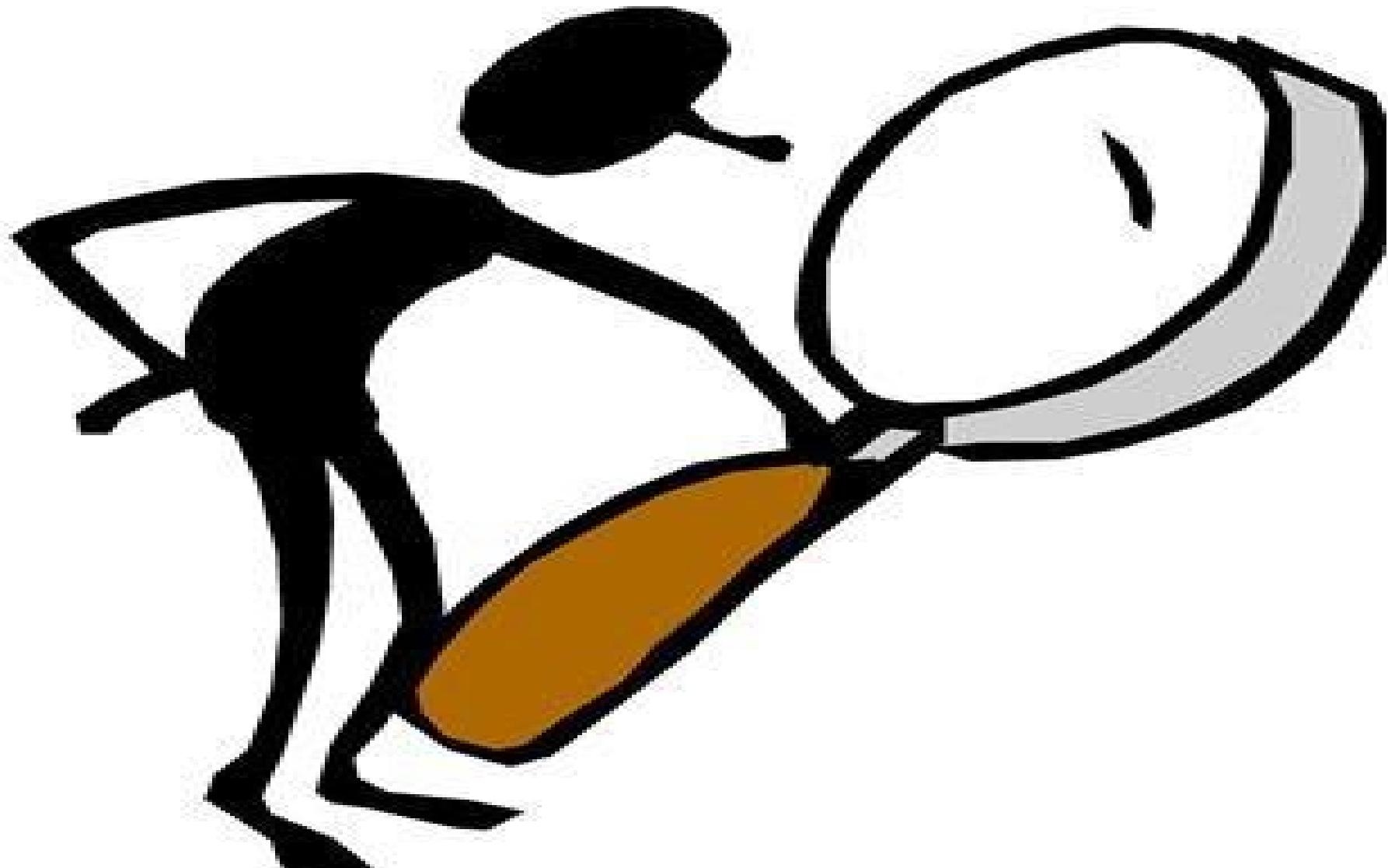


A periscope consists of two plane mirror strips fixed at 45° to the ends of a long narrow tube. They are parallel to each other.

Spherical mirror



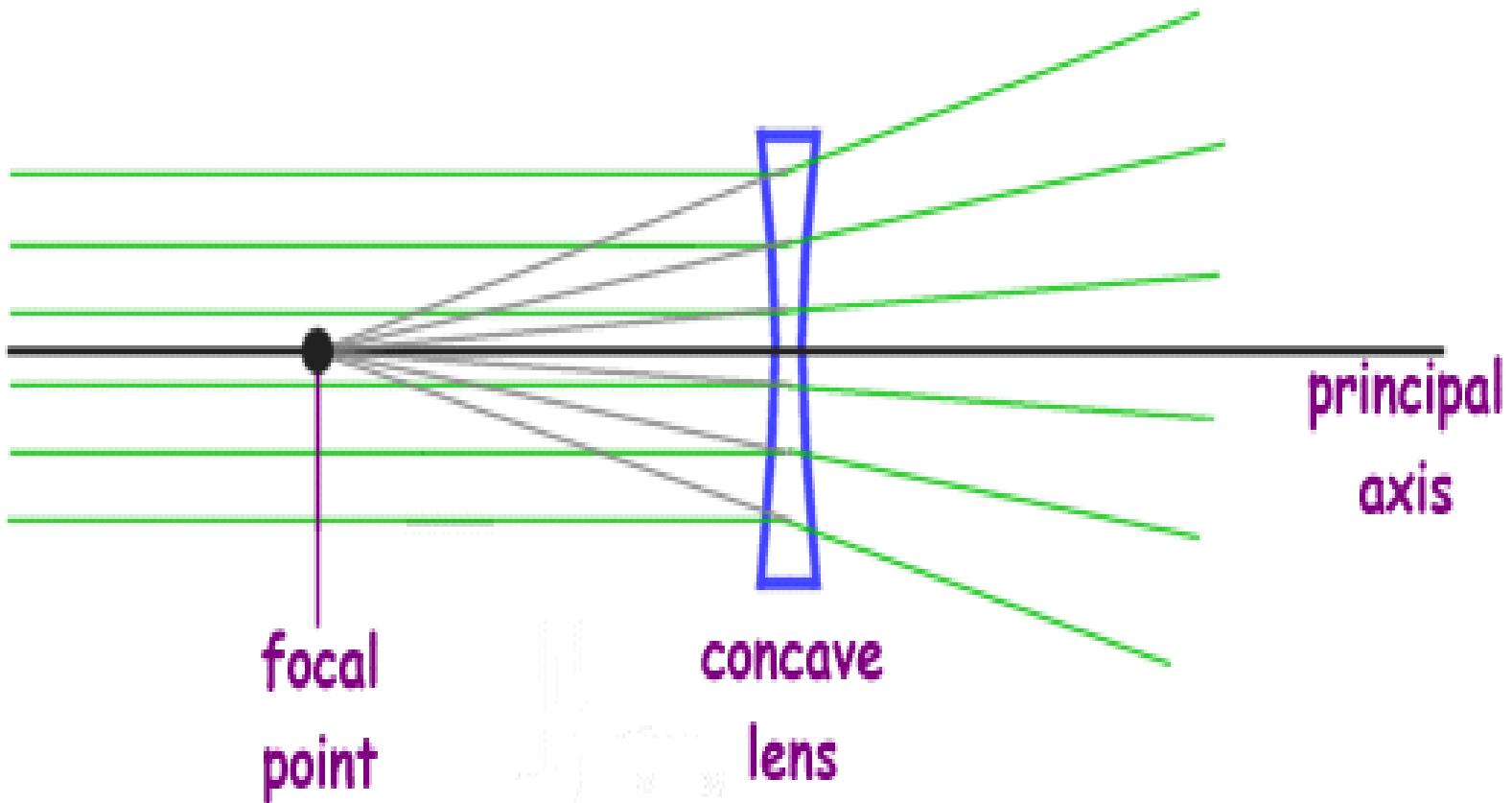
Uses of spherical mirrors



Lenses

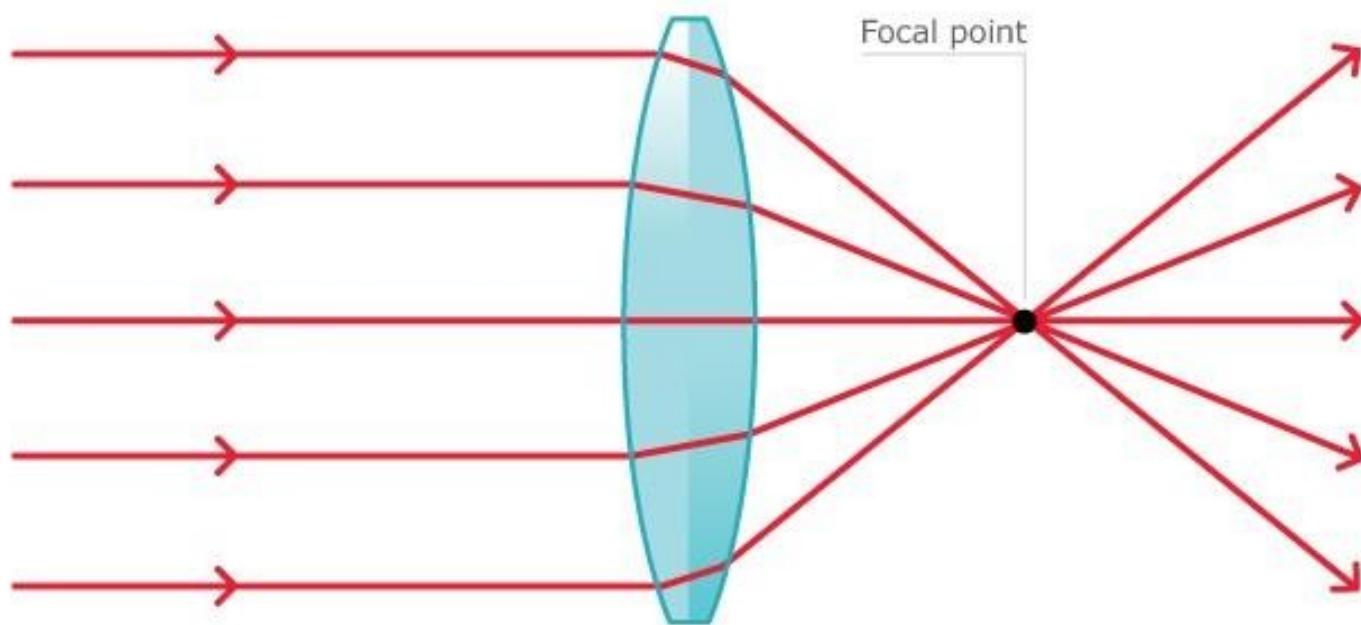
- Concave
- Convex

Concave lens



Convex lens

Refraction of light through a converging lens

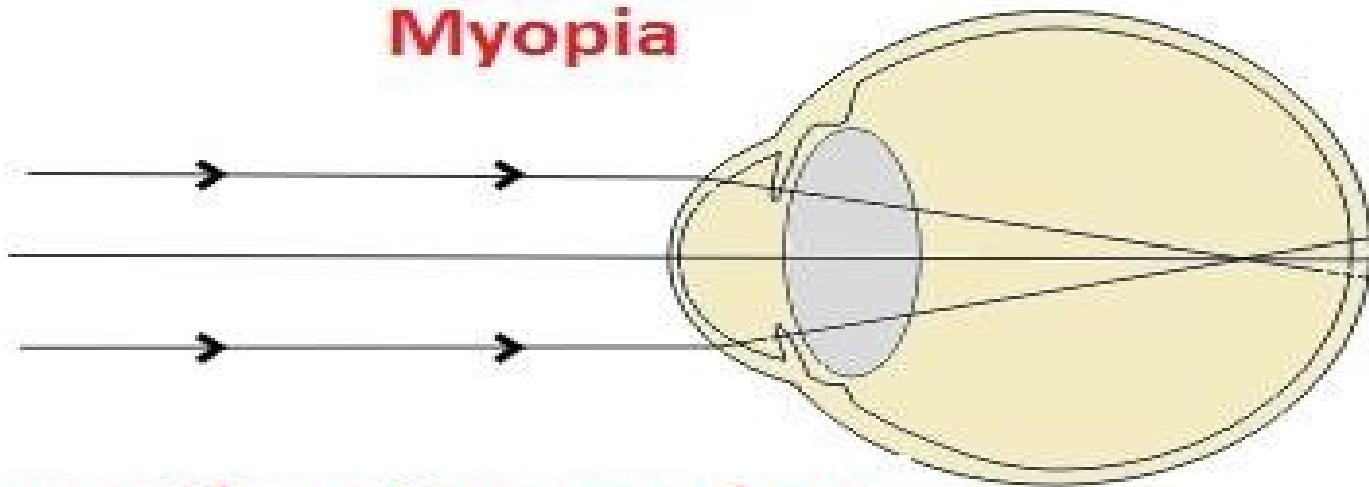


- **What is a zoom lens? [UPSC 2008]**
- It is a lens having fixed focal length
- It is a lens having variable focal length
- It is a lens used in radio telescopes
- None of the above
- Ans-B

Defects of vision

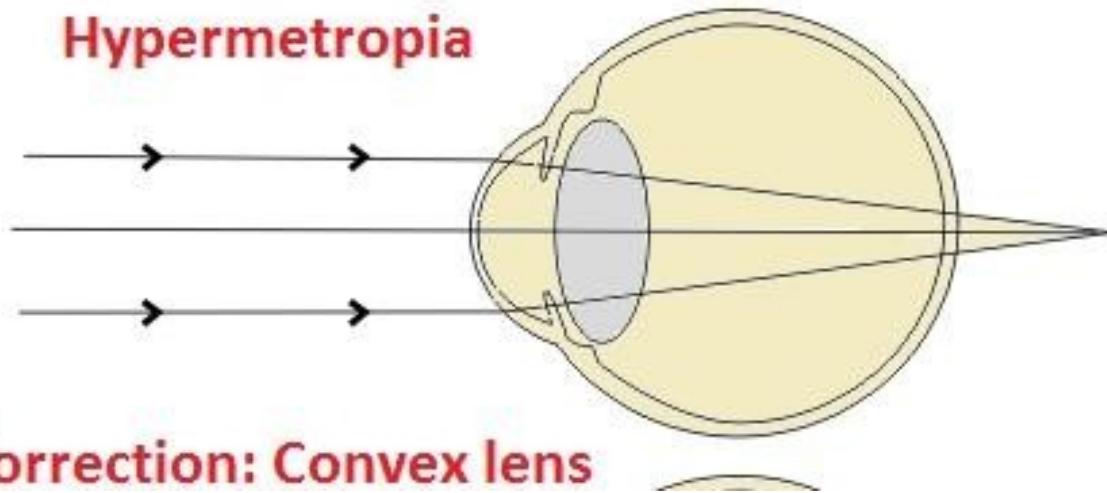
- Myopia
- Hyper metropia
- Astigmatism
- Cataract

Myopia



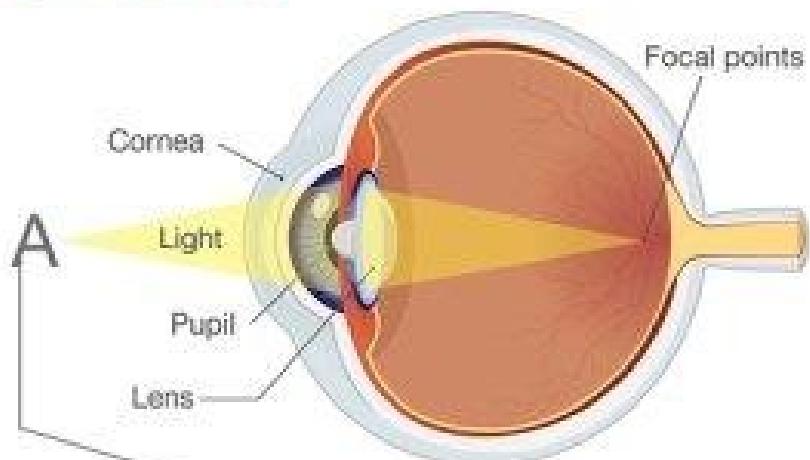
Correction: Concave lens

Hypermetropia

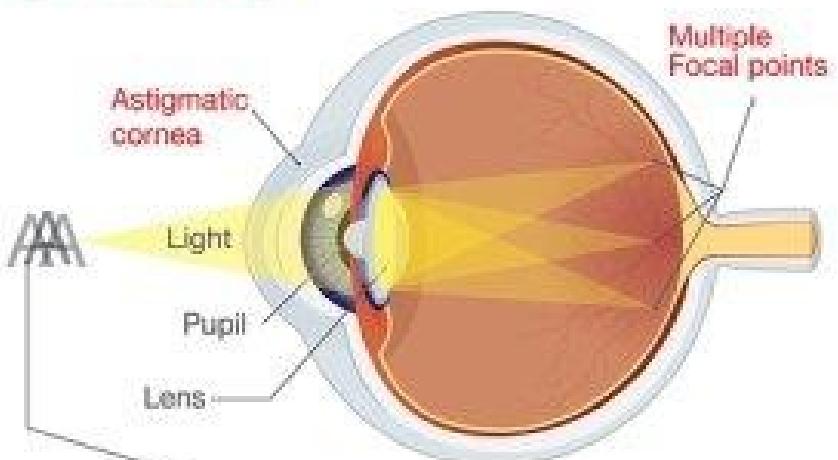


Correction: Convex lens

Normal Eye



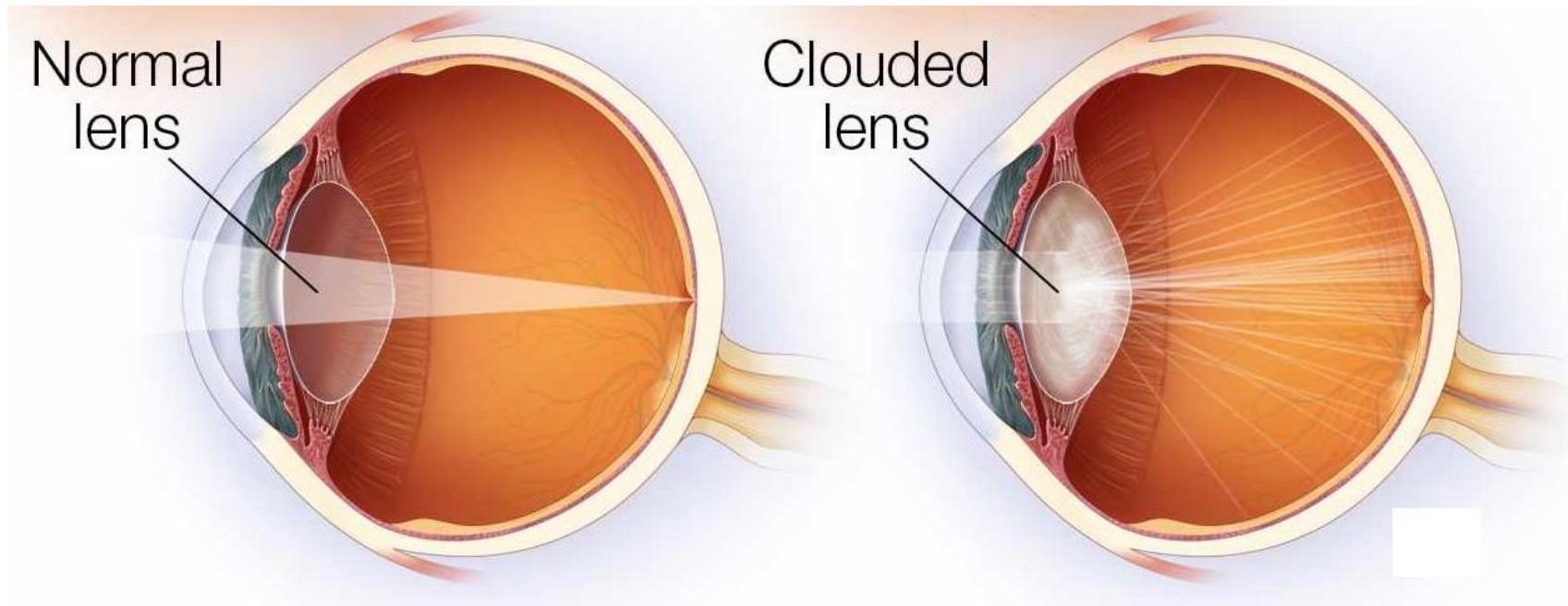
Astigmatic Eye



Normal Vision

Astigmatic Vision

Cataract

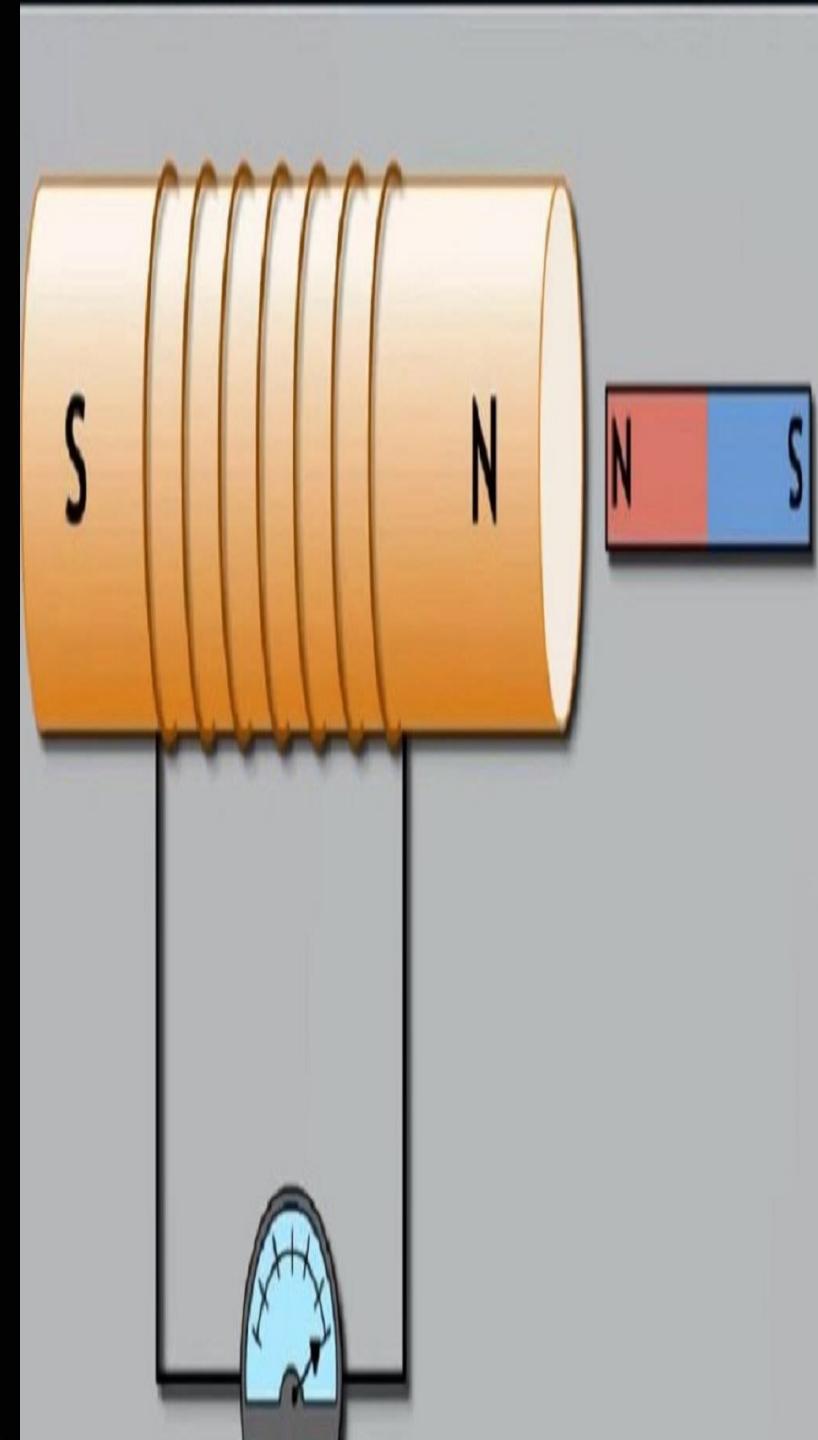


- Defect of colour blindness can be remedied by the use of [UPSC 2008]
- Concave lens
- Convex lens
- Cylindrical lens
- None of the above

Ans-D

Agenda

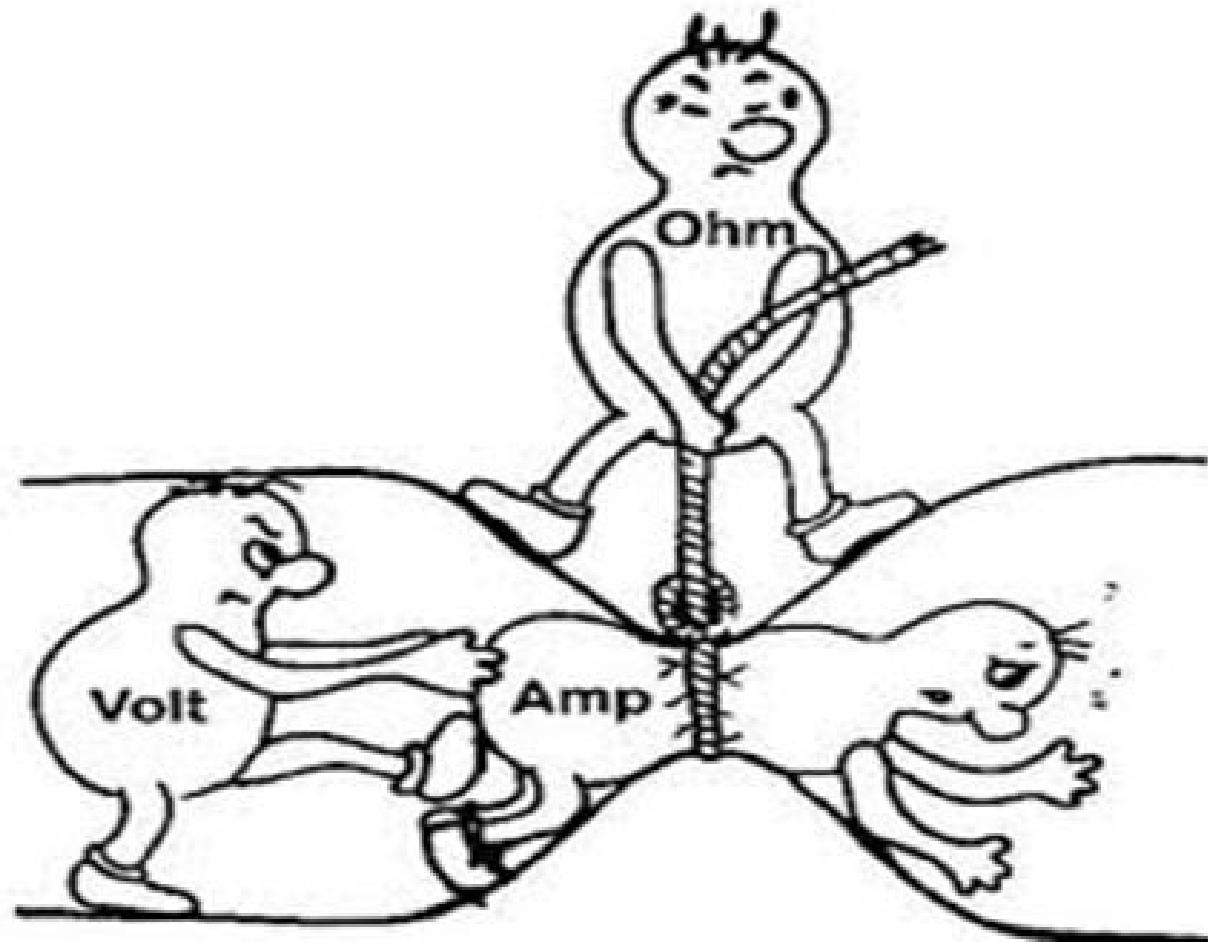
- Electric current- Ohm's law, Concepts like Resistance, voltage
- Magnetic effect of current- Earth's magnetism, Ferromagnetism
- Electromagnetic induction- Faraday's law, Eddy current
- Latent heat
- Surface tension and applications
- Archimedes Principle



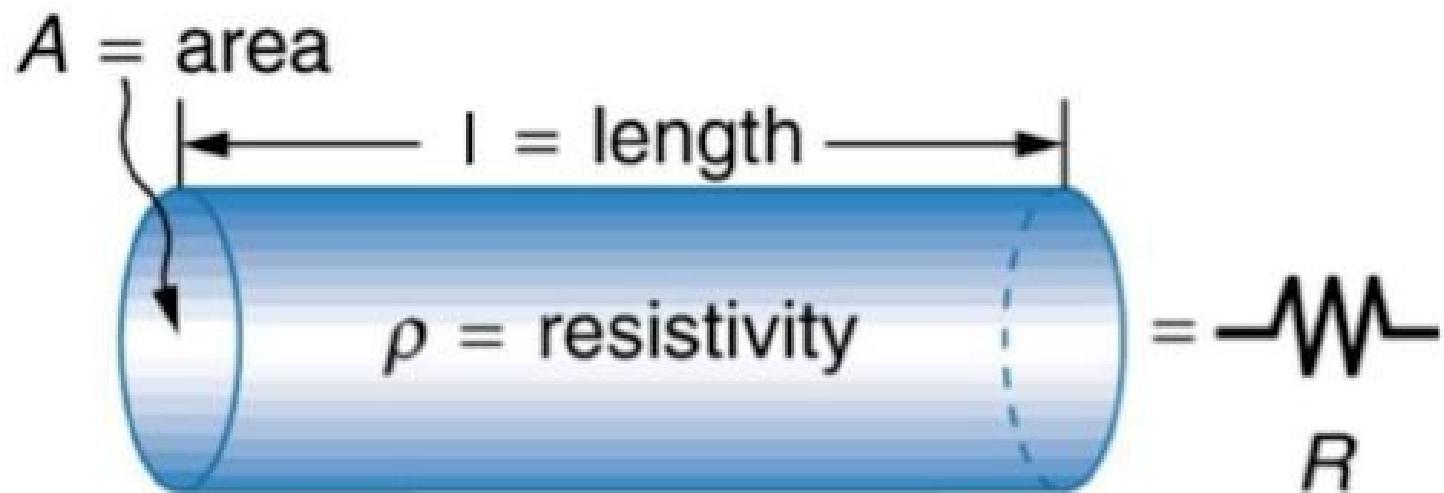
Electric current



Ohm's law

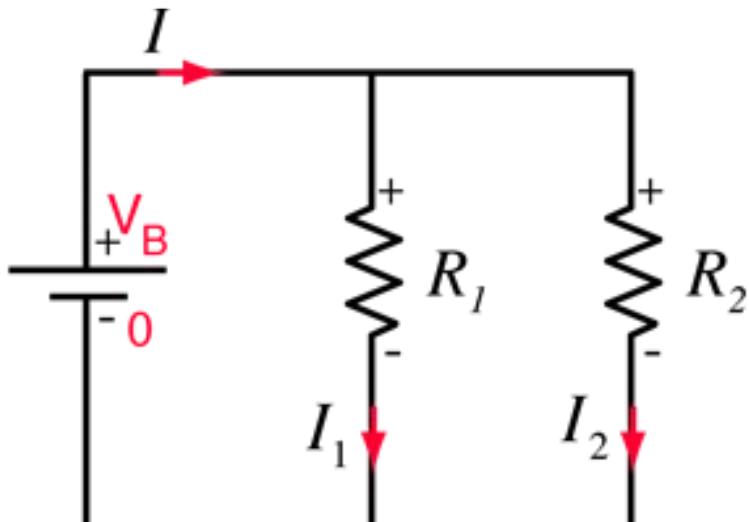


Resistivity



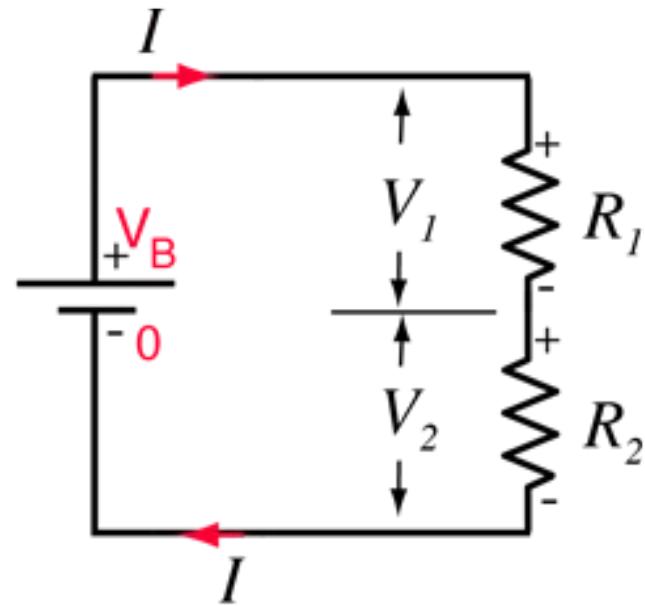
$$R = \rho \frac{l}{A}$$

Series and parallel



Parallel resistors

$$\frac{1}{R_{\text{equivalent}}} = \frac{1}{R_1} + \frac{1}{R_2}$$



Series resistors

$$R_{\text{equivalent}} = R_1 + R_2$$

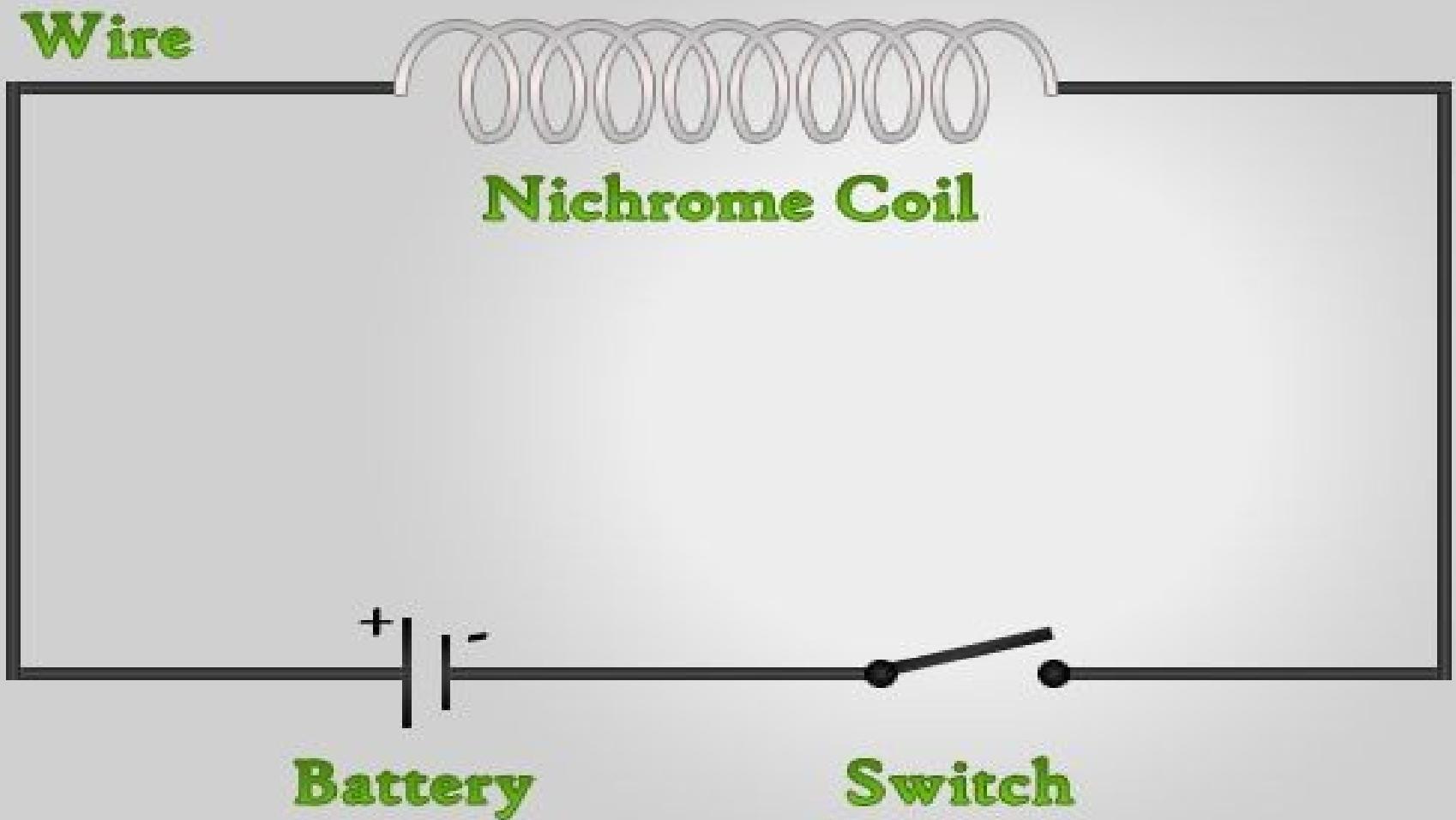
Fuse



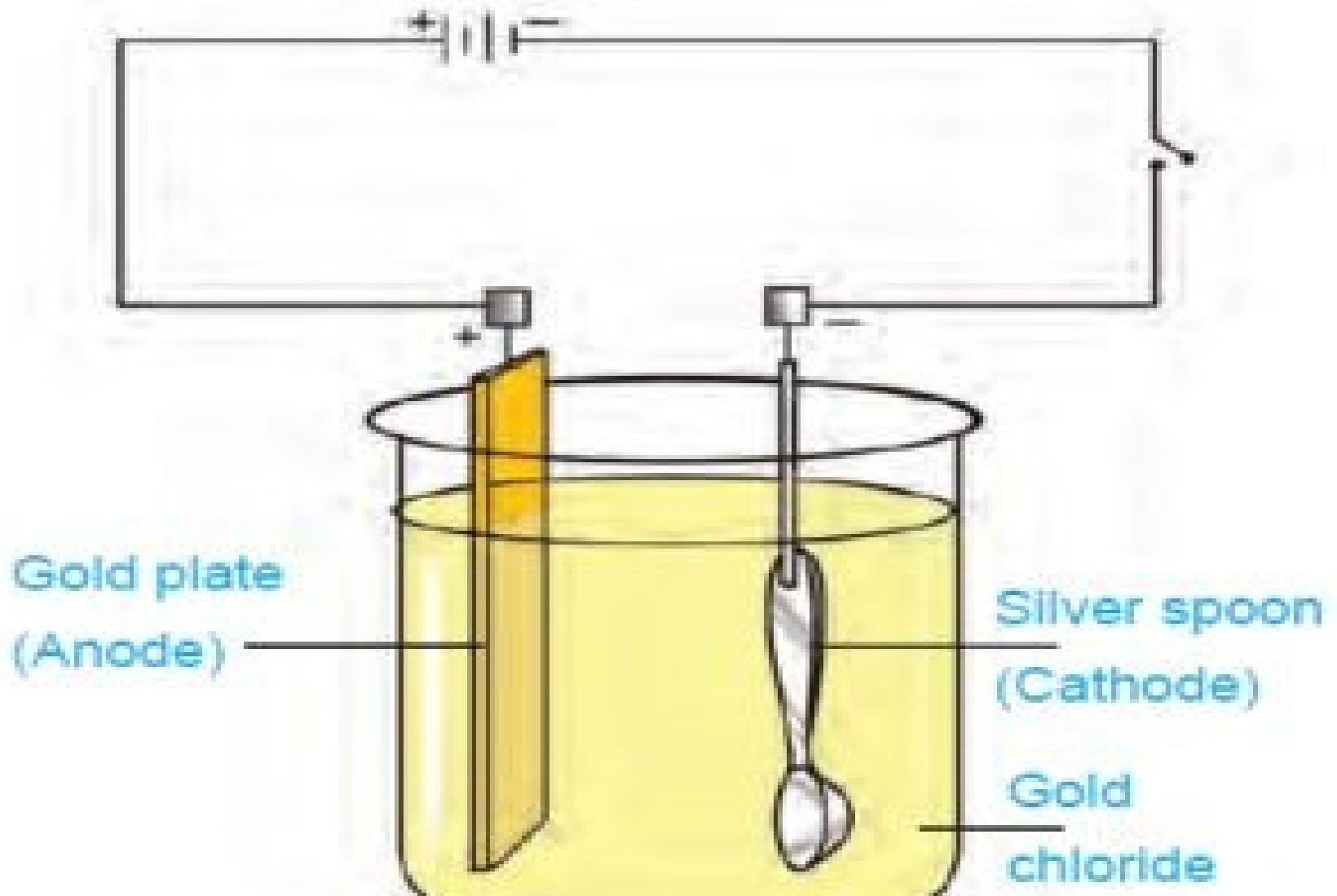
Effects of Current



Heating effect



Chemical Effect of current

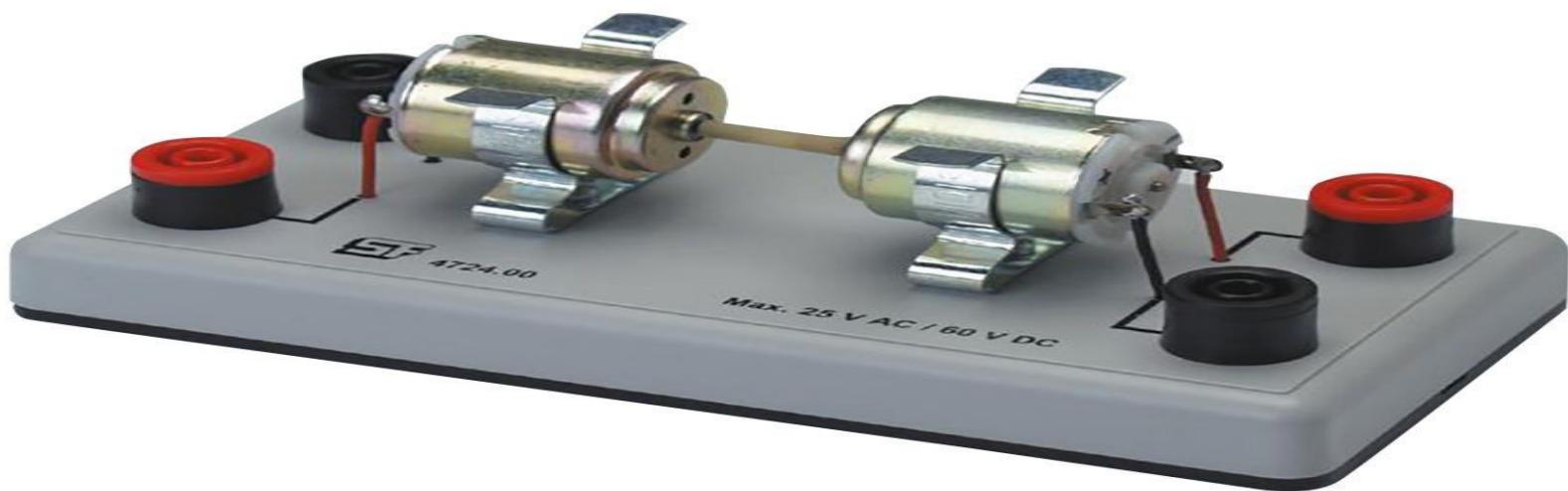


Anode during electroplating



bewajah marta main hi hoon

Dynamo



Motor



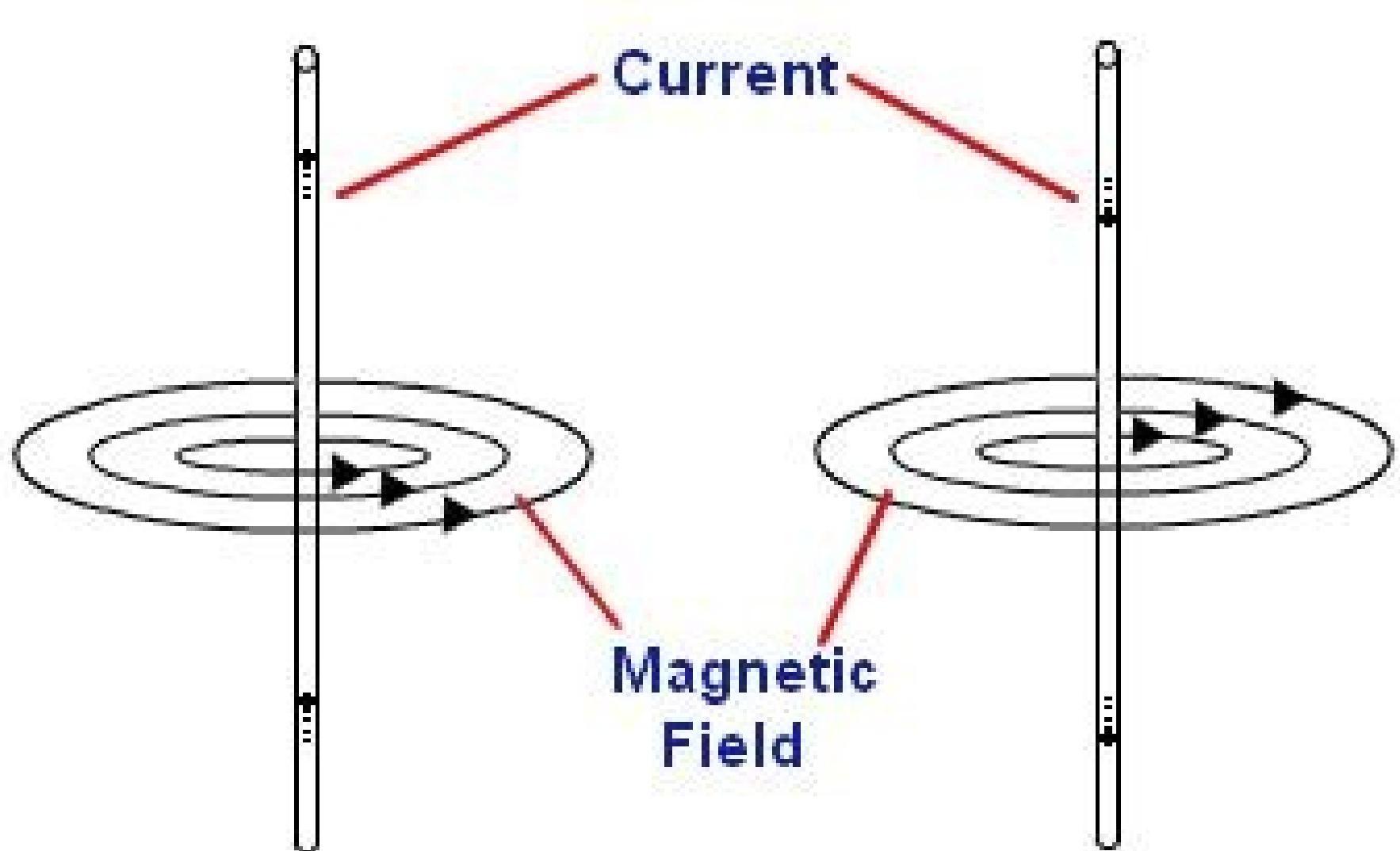
Inverter



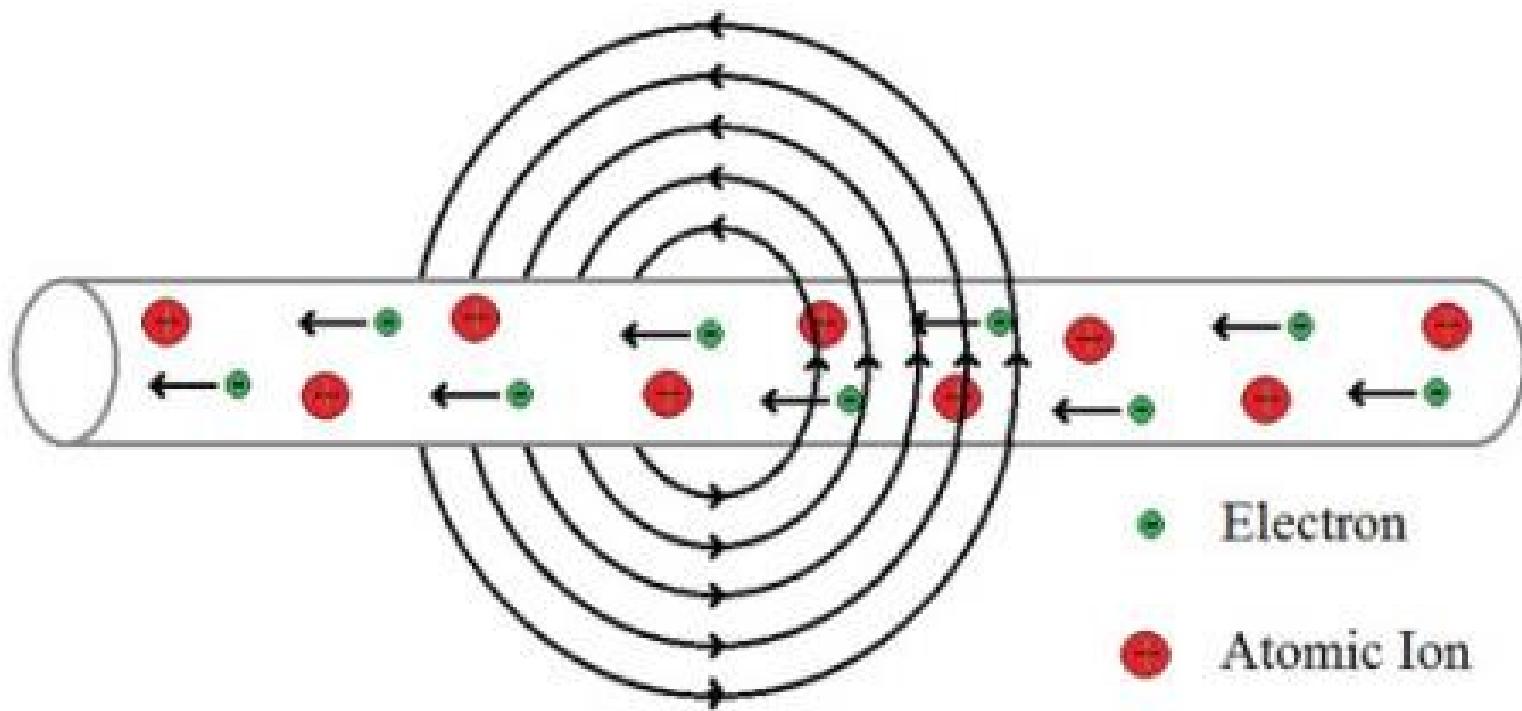
- With reference to ‘fuel cells’ in which hydrogen-rich fuel and oxygen are used to generate electricity. consider the following statements :
 - 1. If pure hydrogen is used as a fuel, the fuel cell emits heat and water as by-products.
 - 2. Fuel cells can be used for powering buildings and not for small devices like laptop computers.
 - 3. Fuel cells produce electricity in the form of Alternating Current (AC).
- Which of the statements given above is / are correct? [Prelims 2015]
- (a) 1 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

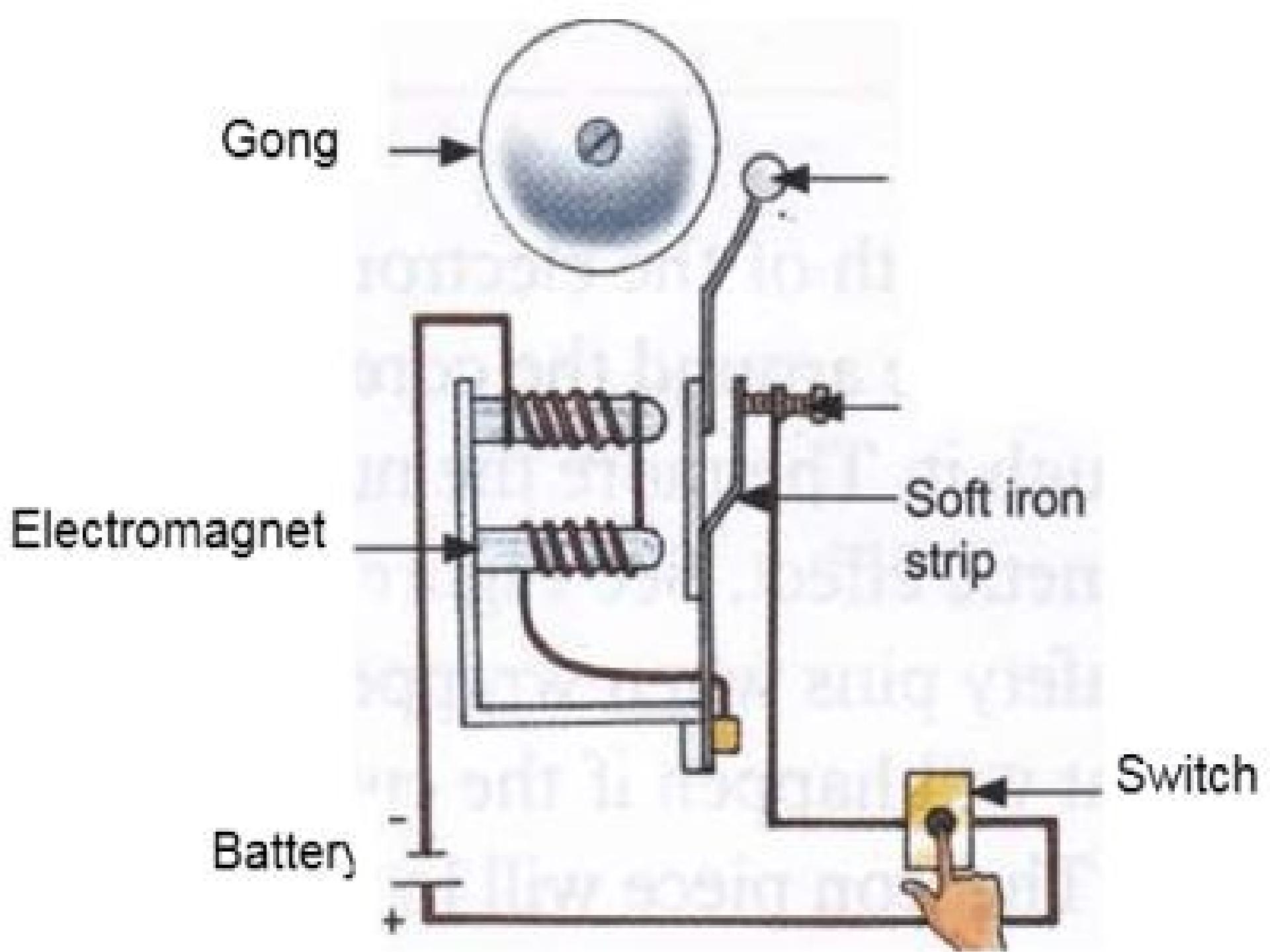
Ans A

Magnetic effect of current

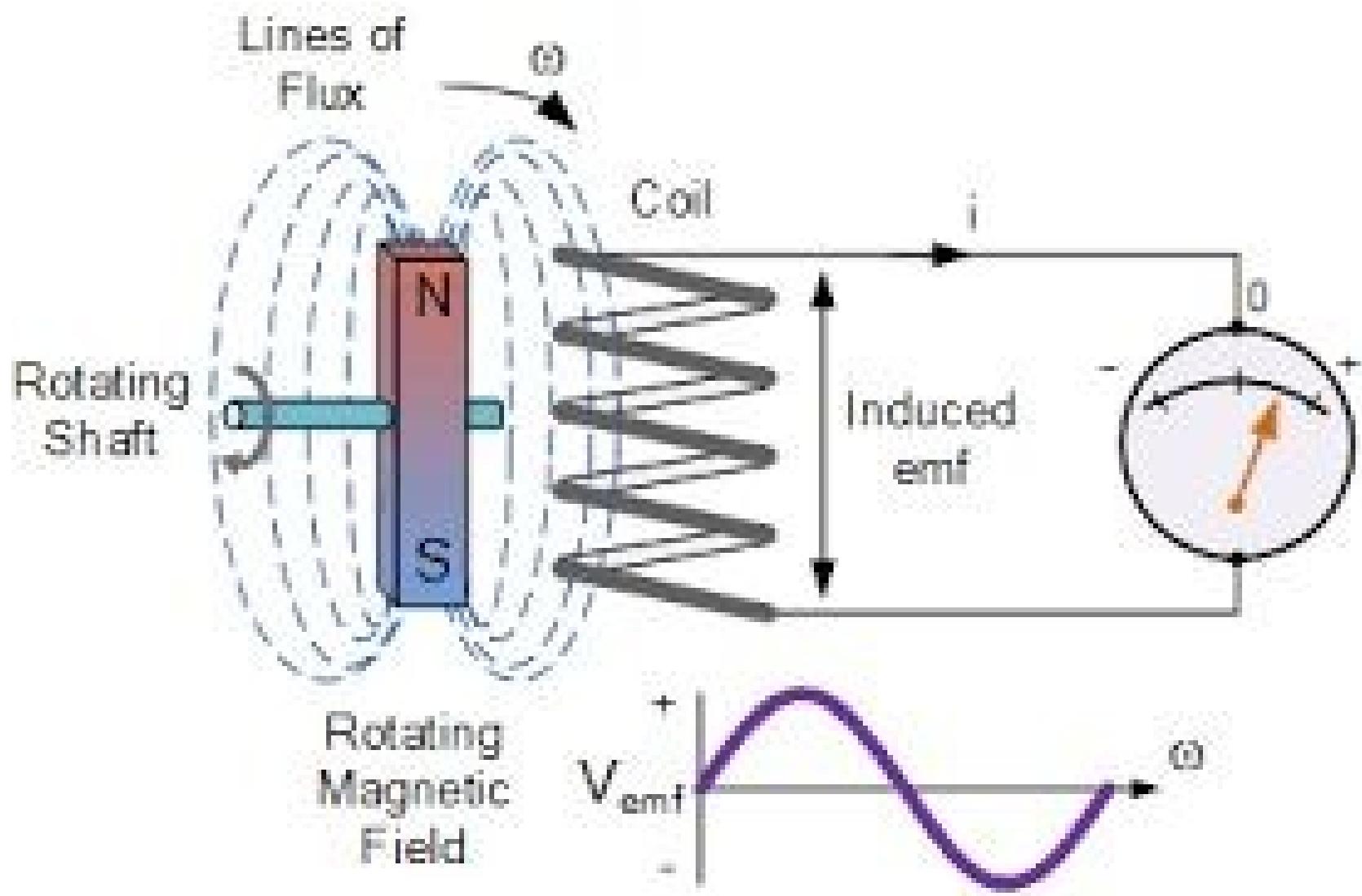


Electromagnetism

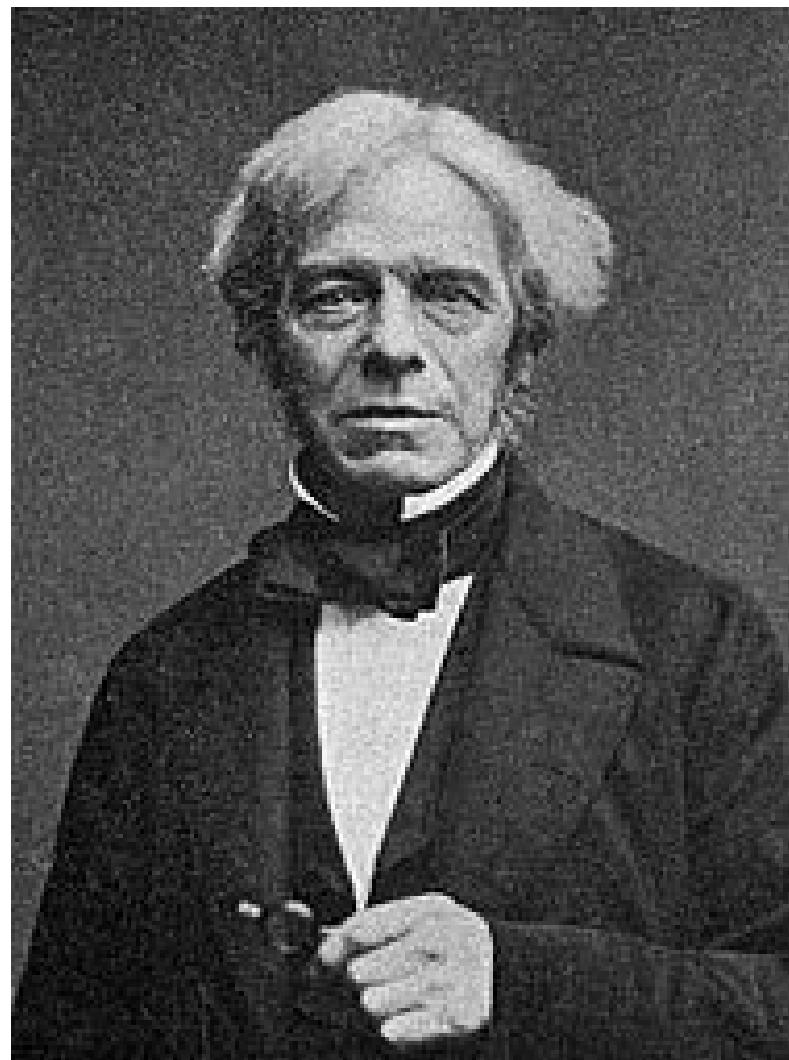




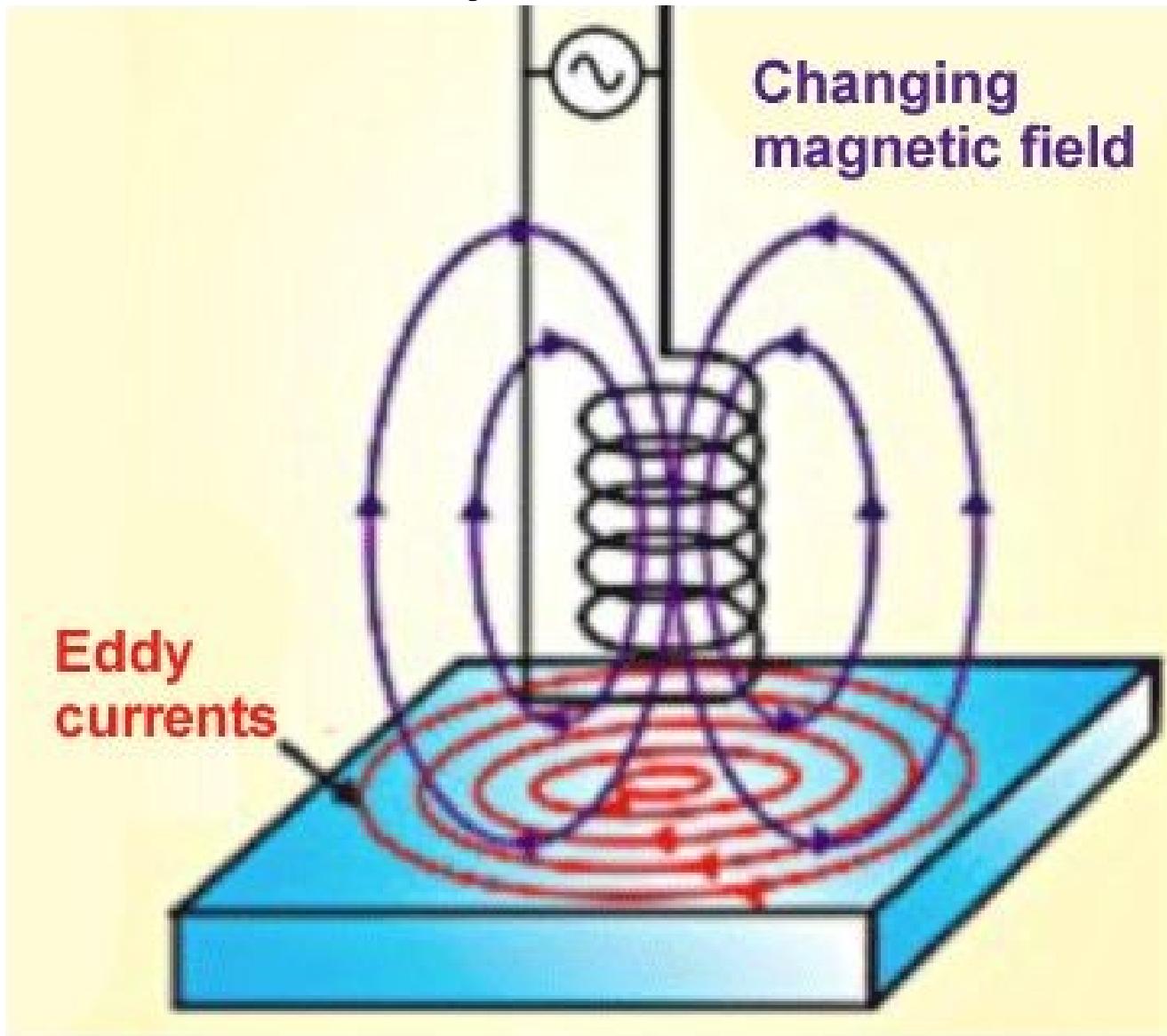
Electromagnetic induction



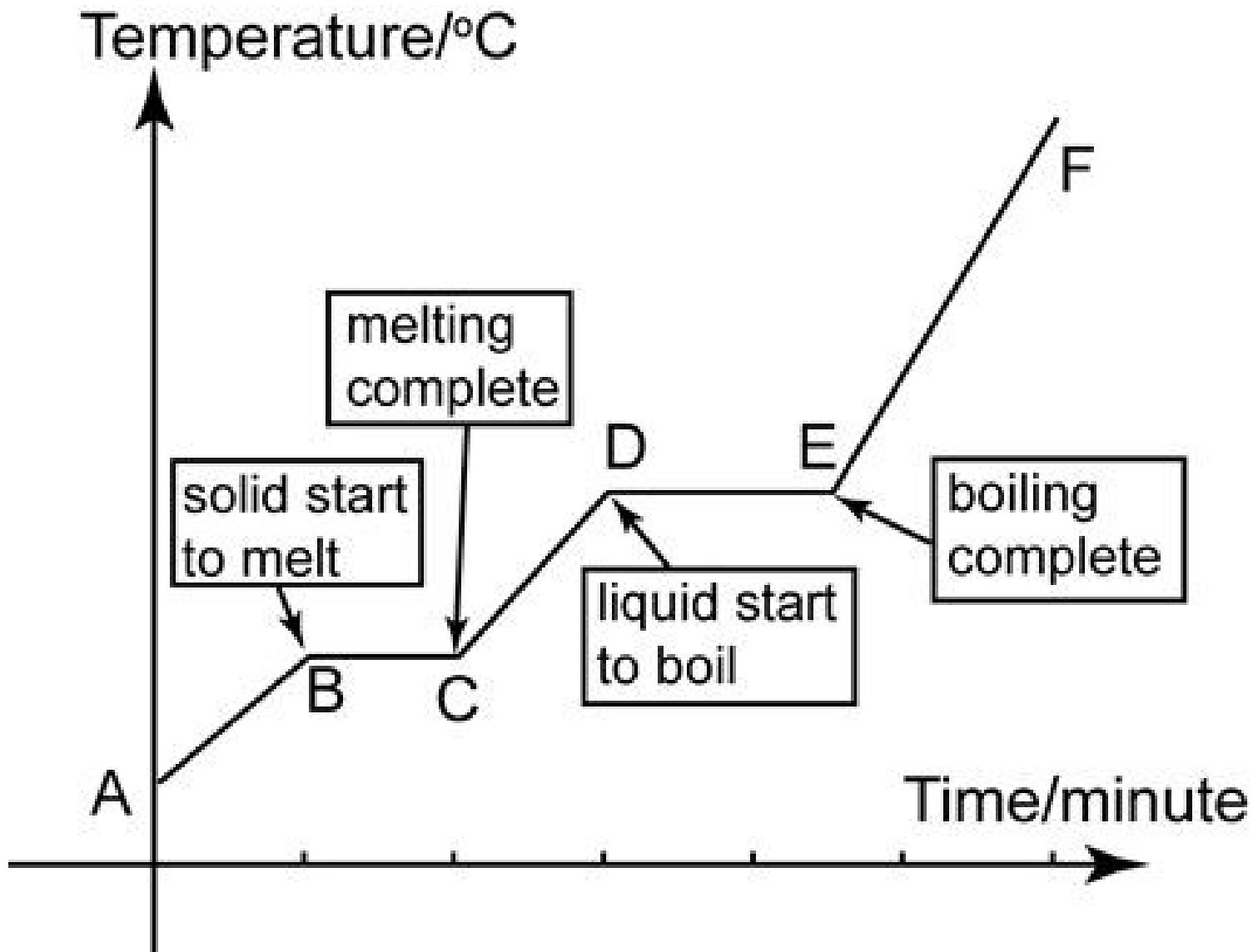
Faraday's law

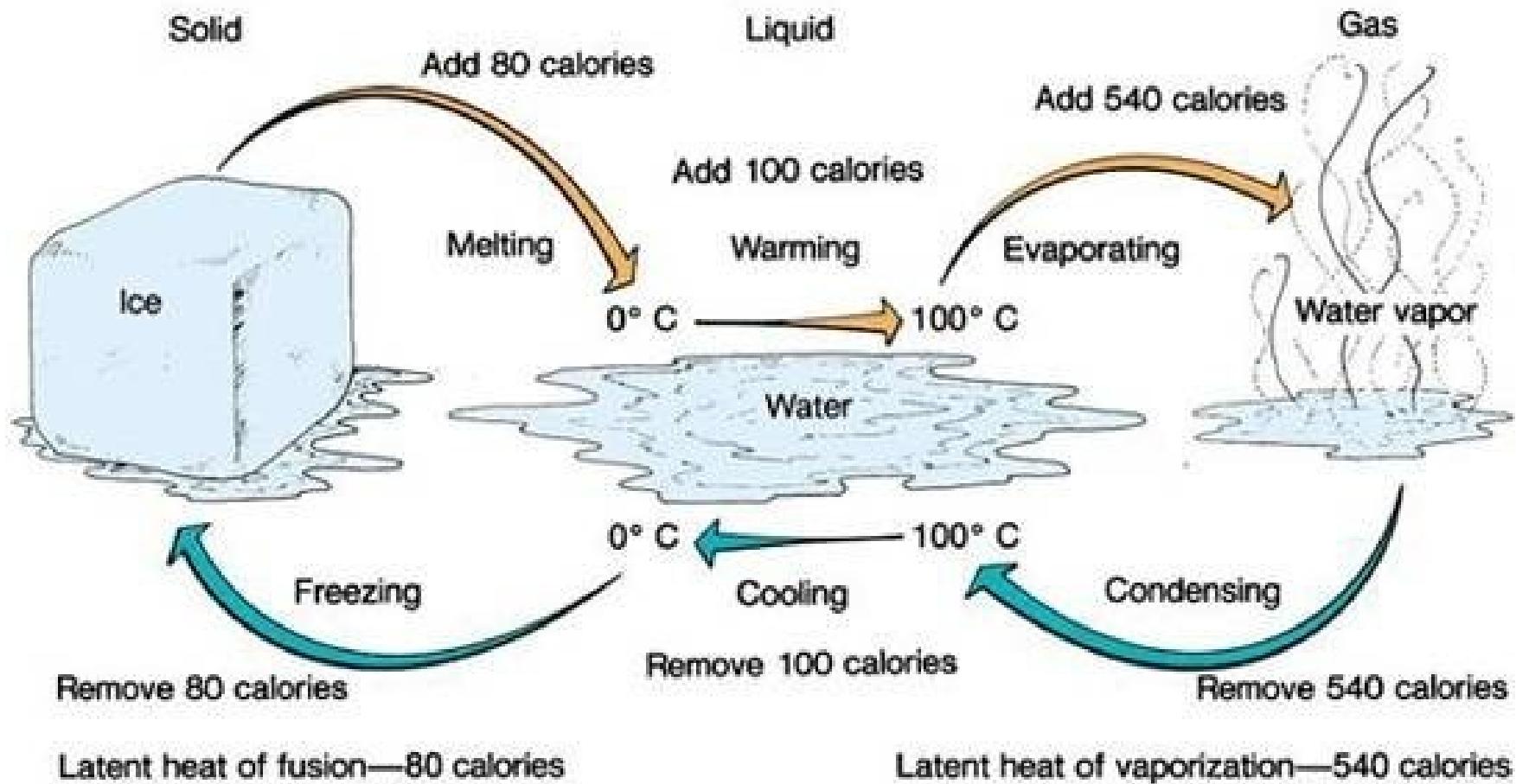


Eddy current

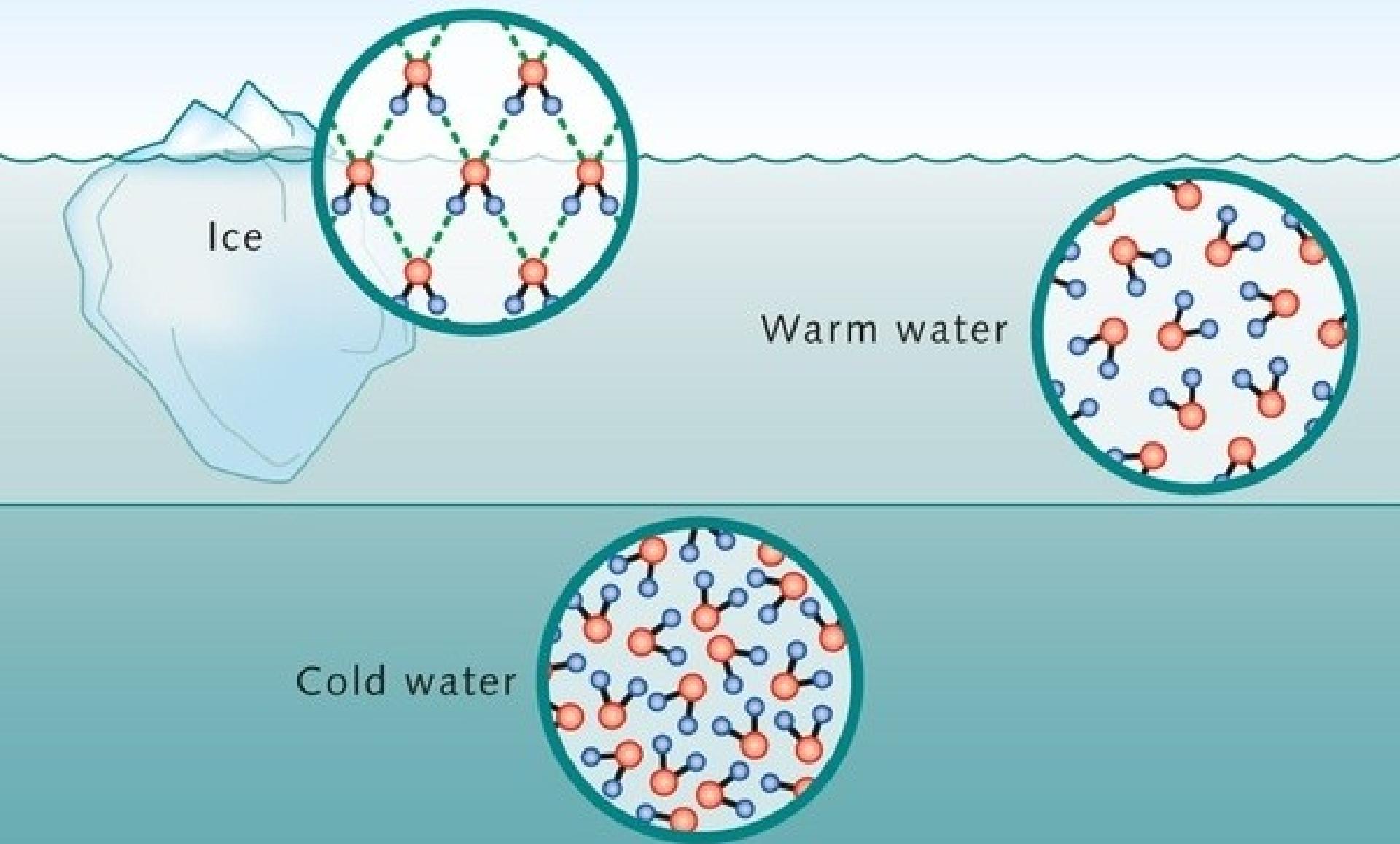


Latent heat

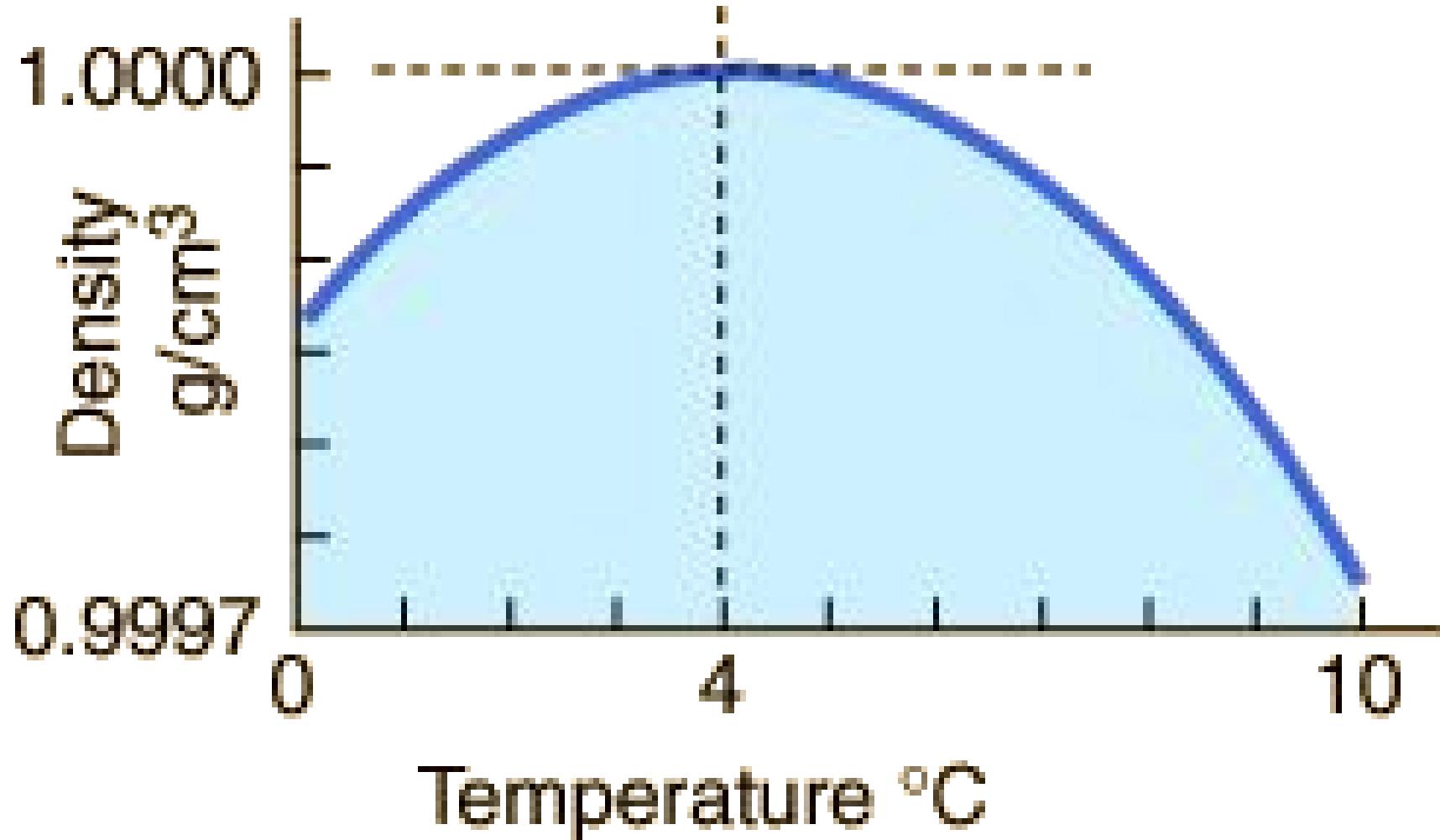




Water at 4 degree Celcius



Maximum density
at $3.98\text{ }^{\circ}\text{C} = 39.2\text{ }^{\circ}\text{F}$



- When water is heated from 0°C to 10°C its volume _____.
 - increases gradually
 - decreases gradually
 - first increases and then decreases
 - first decreases and then increases
- Ans -D

- **The surface of a lake is frozen in severe winter, but the water at its bottom is still liquid. What is the reason? (2011)**
- (a.) Ice is a bad conductor of heat
(b.) Since the surface of the lake is at the same temperature as the air, no heat is lost
(c.) The density of water is maximum at 4°C
(d.) None of the statements (a), (b) and (c) given above is correct
- **Solution: C**

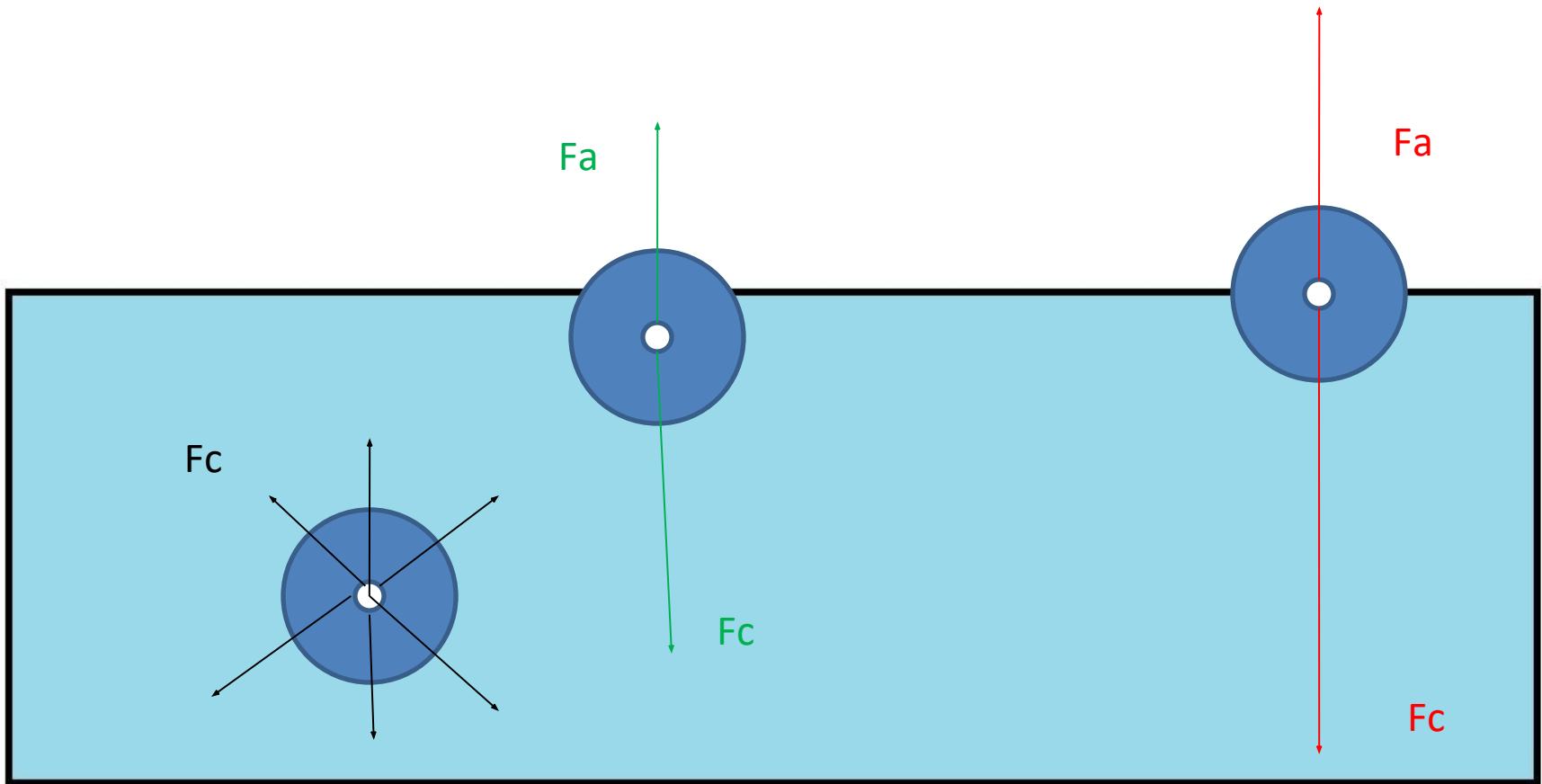
Cohesive and adhesive forces

COHESIVE FORCE

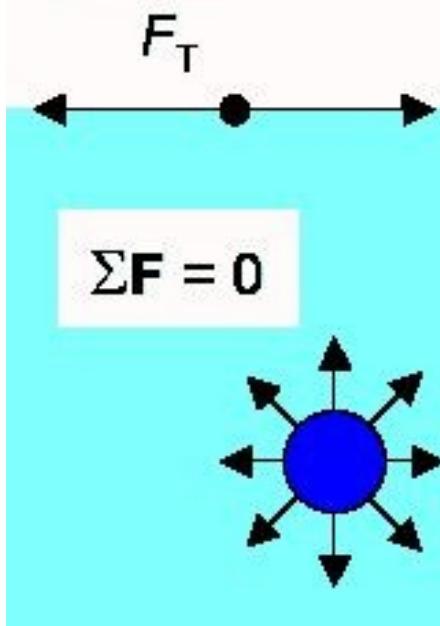


ADHESIVE FORCE

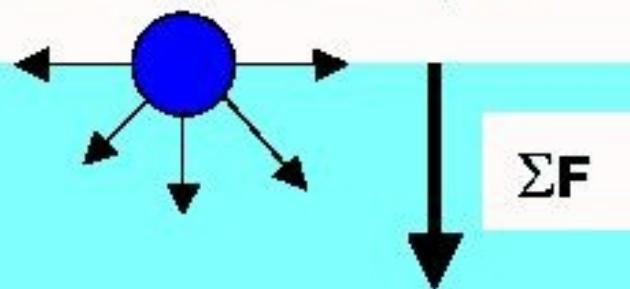
Surface Tension



Surface of any liquid
behaves as though it is
covered by a stretched
membrane



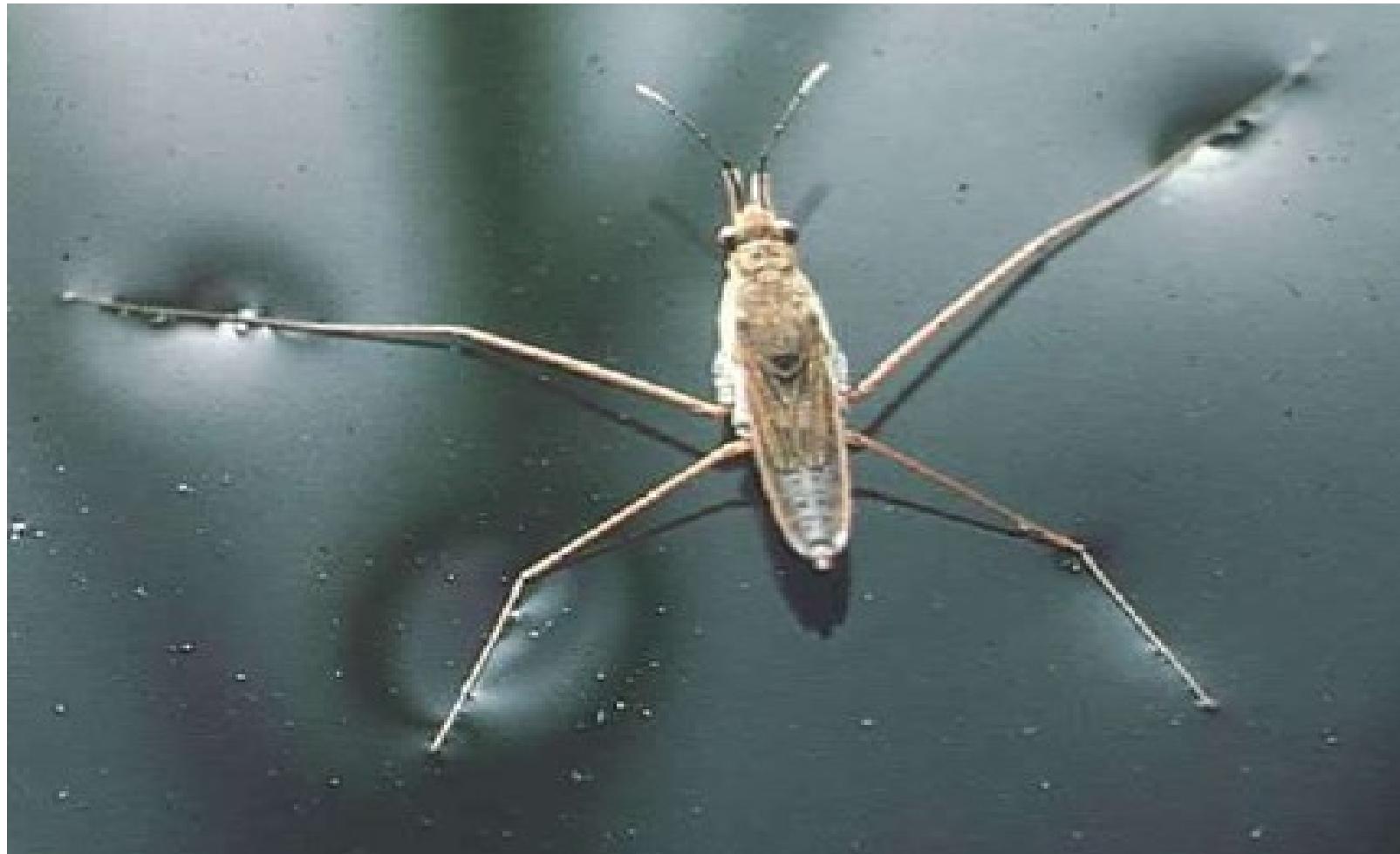
Net force on molecule
at surface is into bulk of the liquid



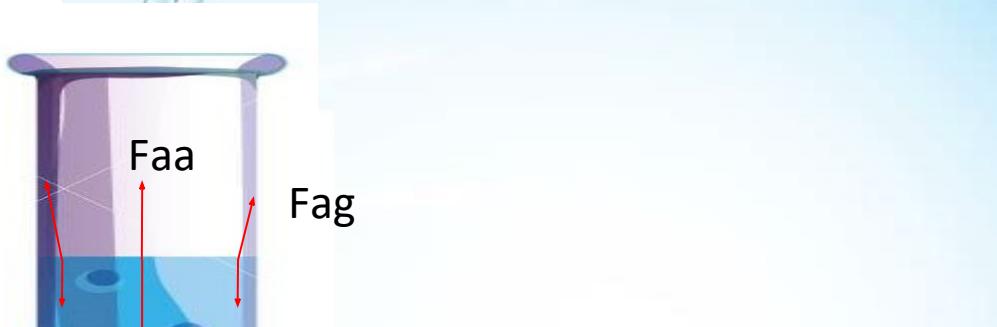
Effect of temperature on Surface Tension

Temperature (°C)	Surface tension (mN m ⁻¹)
10	74.01
15	73.26
20	72.53
25	71.78
30	71.03

Applications of surface Tension



Cappillarity



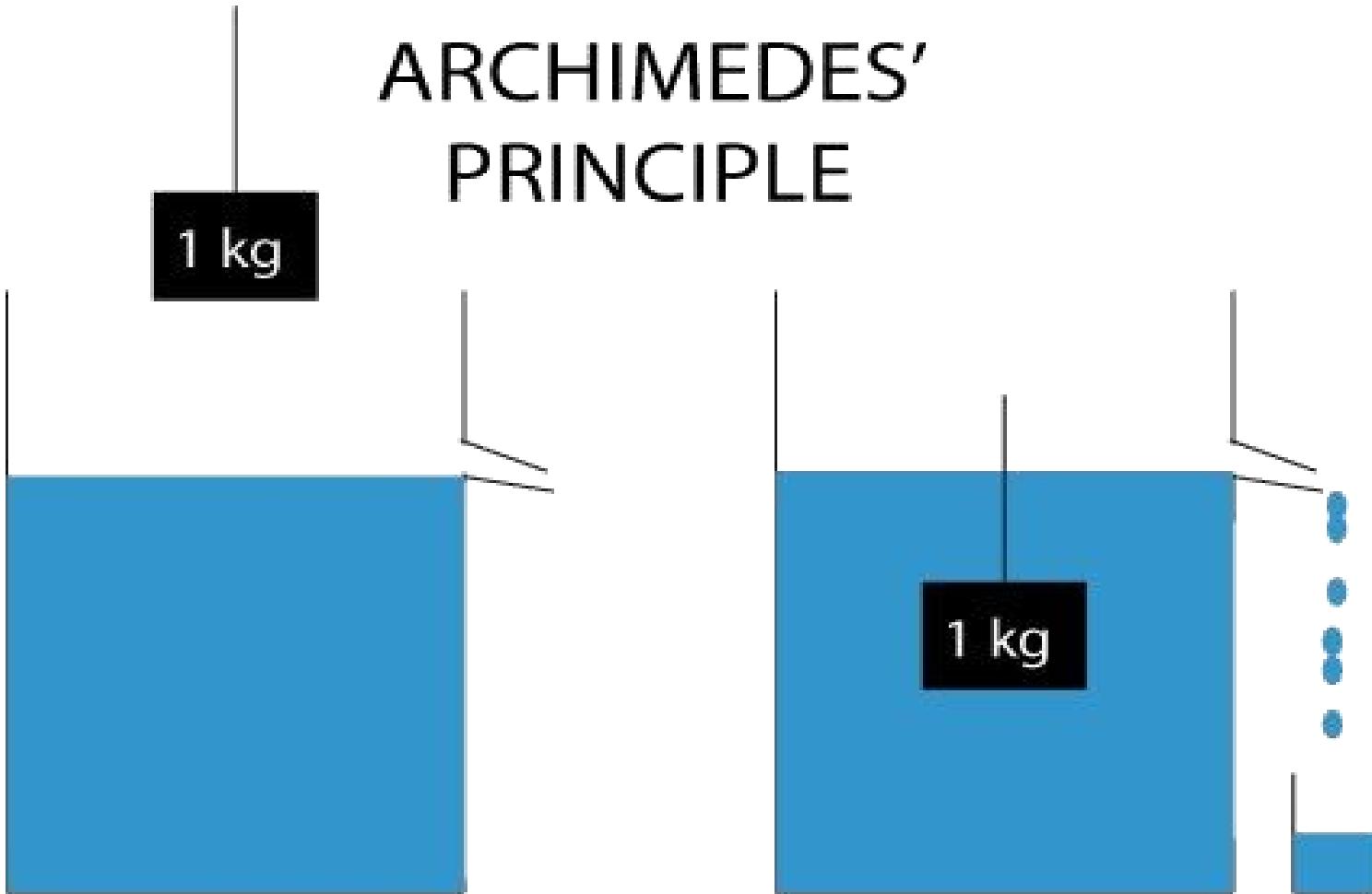
$$F_c > F_{aa} \text{ && } F_c < F_{ag}$$

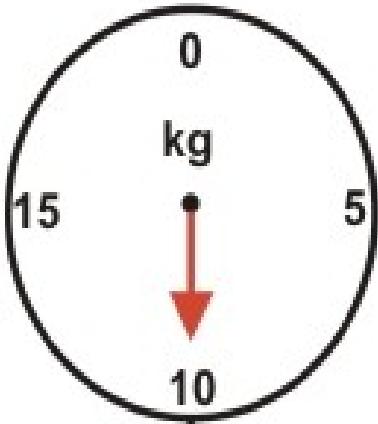


- If there were no phenomenon of capillarity.
- 1. it would be difficult to use a kerosene lamp.
2. one would not be able to use a straw to consume a soft drink.
3. the blotting paper would fail to function.
4. the big trees that we see around would not have grown on the Earth.
- Which of the statements given above are correct? [UPSC Civil Services, 2012]
 - 1, 2 and 3 only
 - 1, 3 and 4 only
 - 2 and 4 only
 - 1, 2, 3 and 4
 - Ans - B

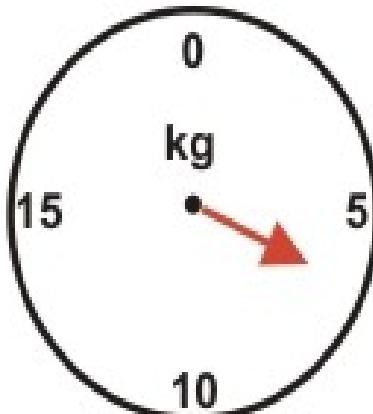
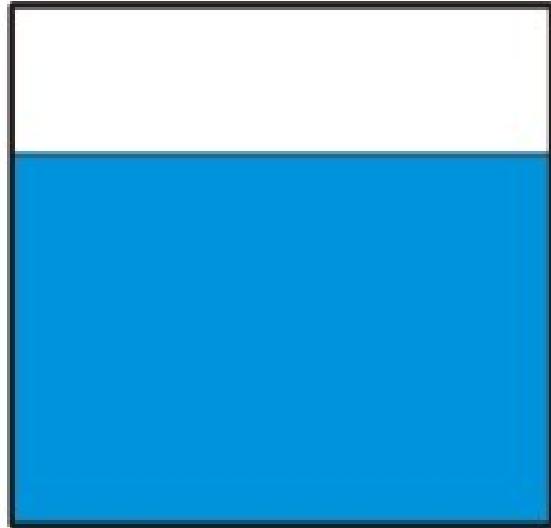
Archimedes Principle

ARCHIMEDES'
PRINCIPLE



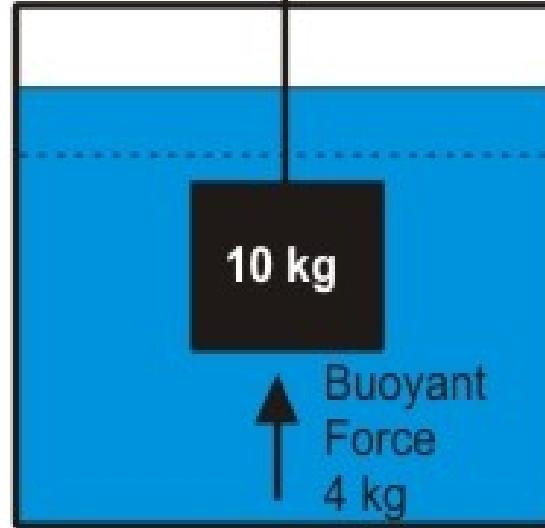


10 kg



10

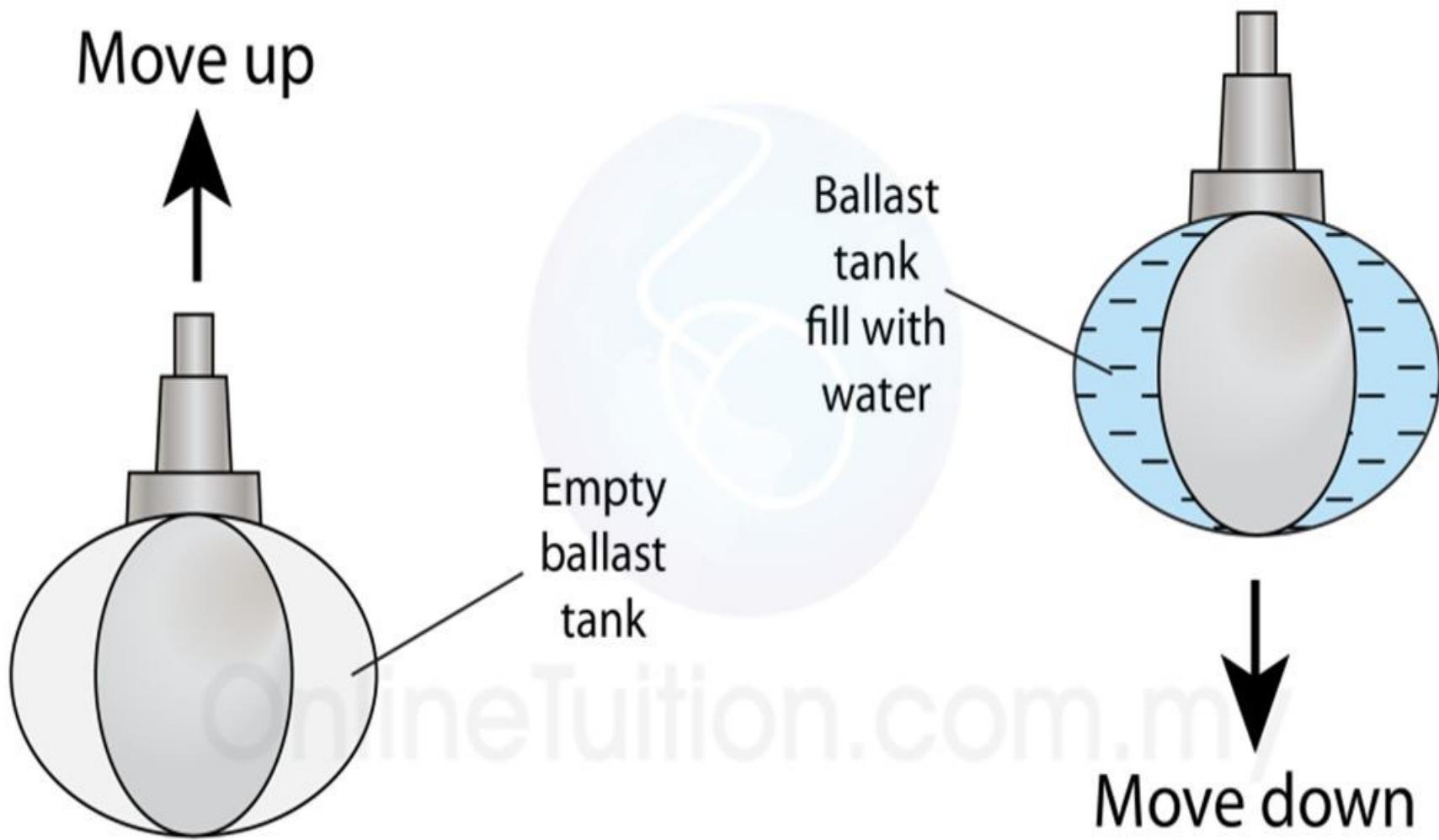
Therefore because this 10 kg object displaces 4 kg of water, it feels like it only weighs 6 kg under water.



↑ 4 kg of water displaced

Buoyant force is equal to the weight of displaced water.

Submarine



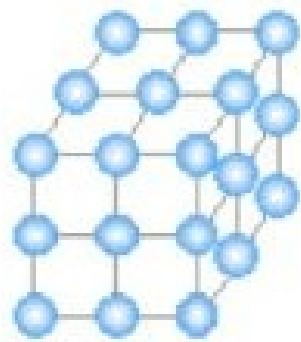


Agenda

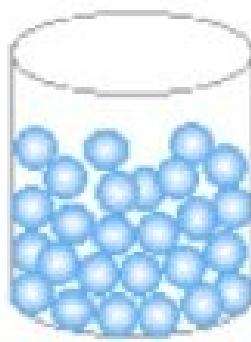
- States of matter
- Structure of atom – Definitions and introduction to basics like proton, neutron, lepton, quarks etc
- Radioactivity- alpha, beta and gamma ray, nuclear fission and fusion
- Periodic table
- PH scale- acids, bases and salts
- Concepts like osmosis
- Hydrocarbons in daily life – fuels, soaps etc
- Bioluminescence

Matter

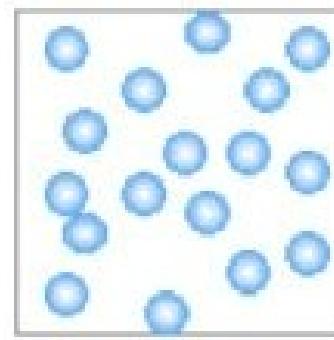
States of Matter



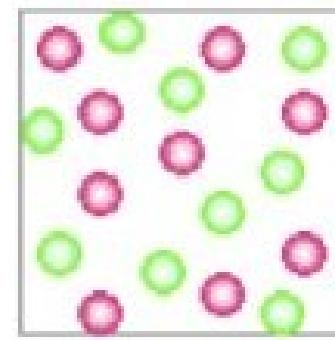
SOLID



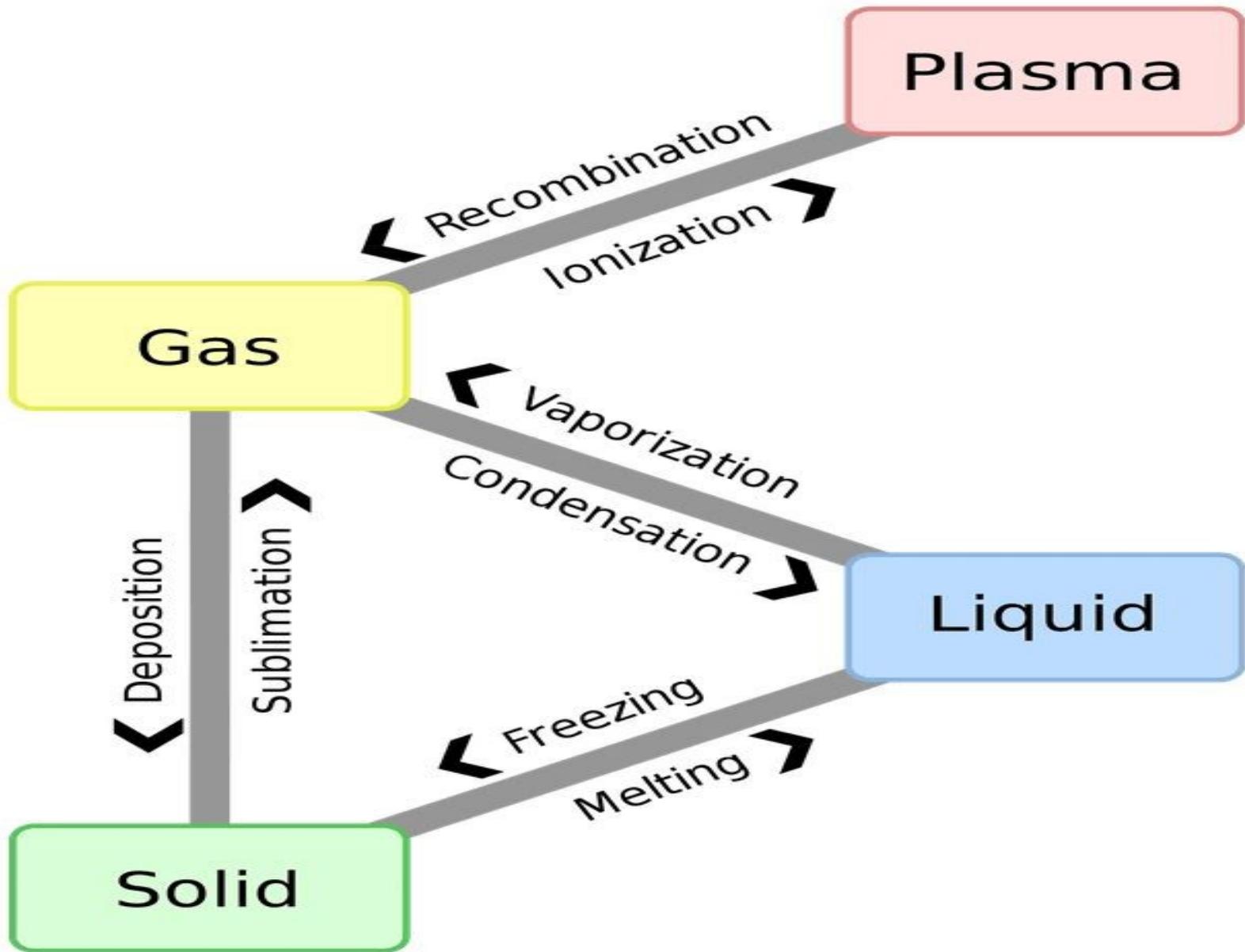
LIQUID



GAS



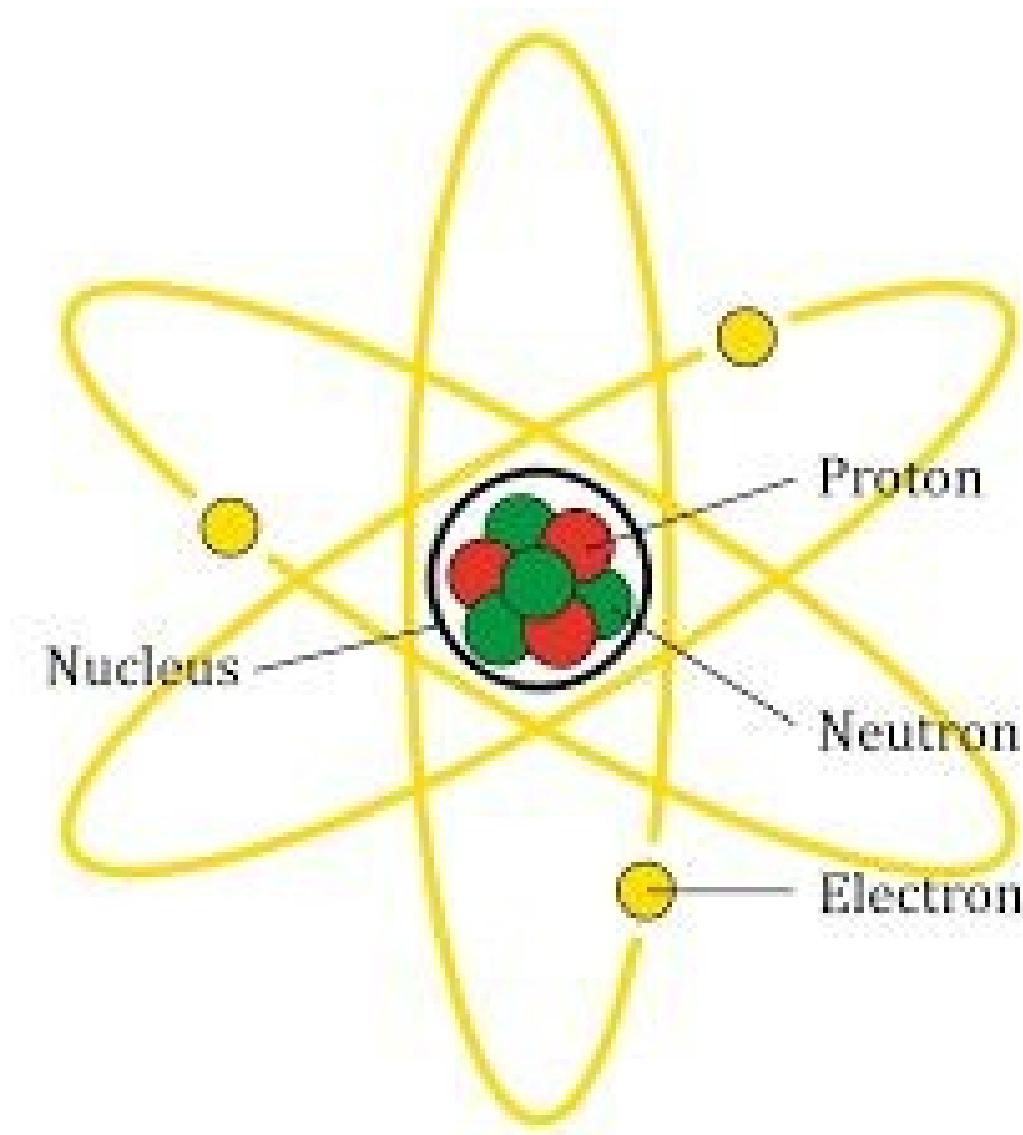
PLASMA



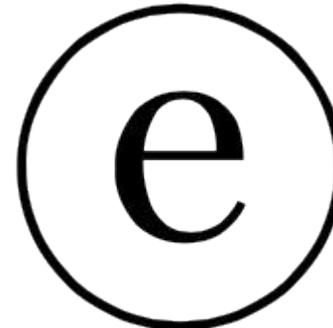
Plasma



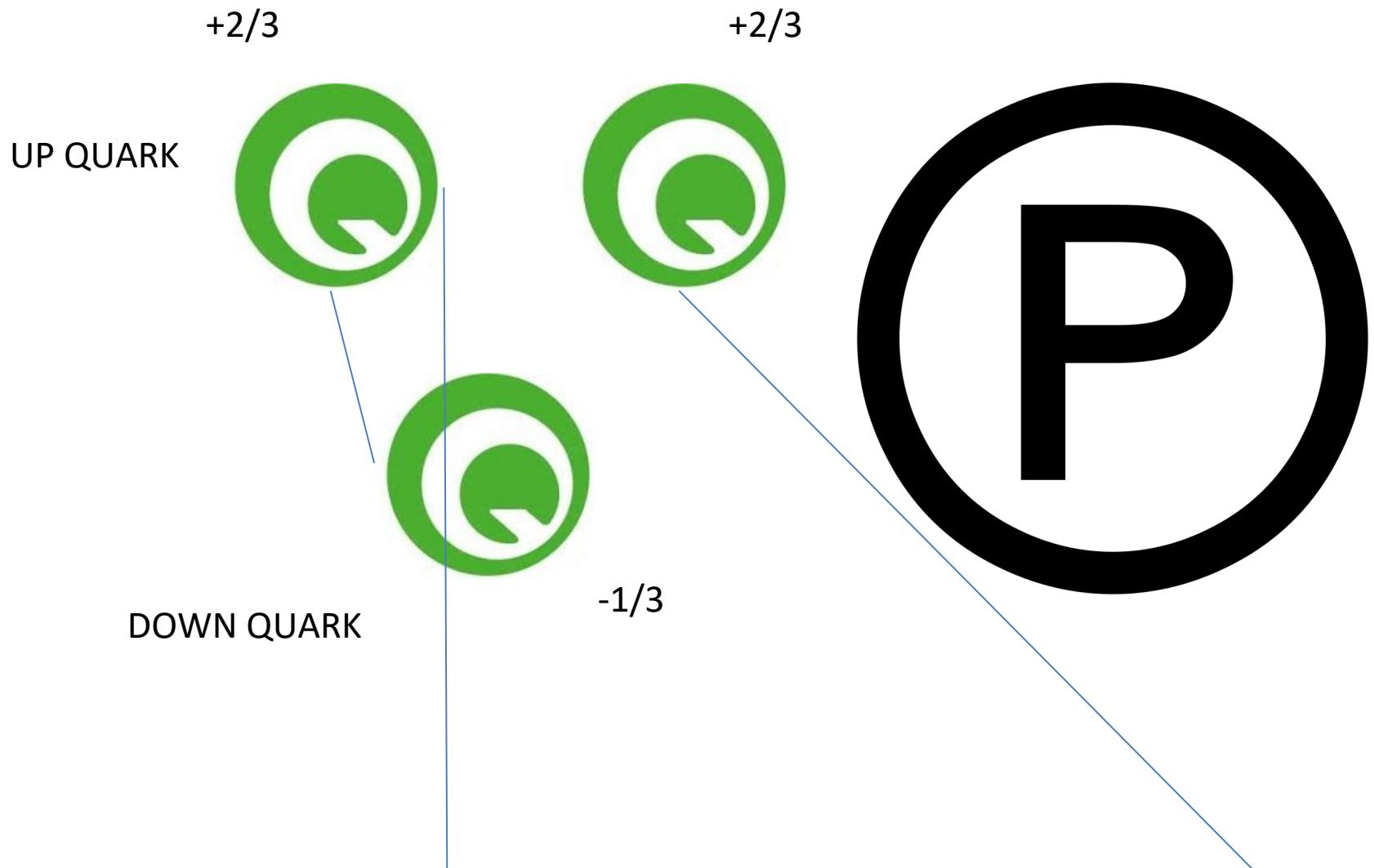
Atom

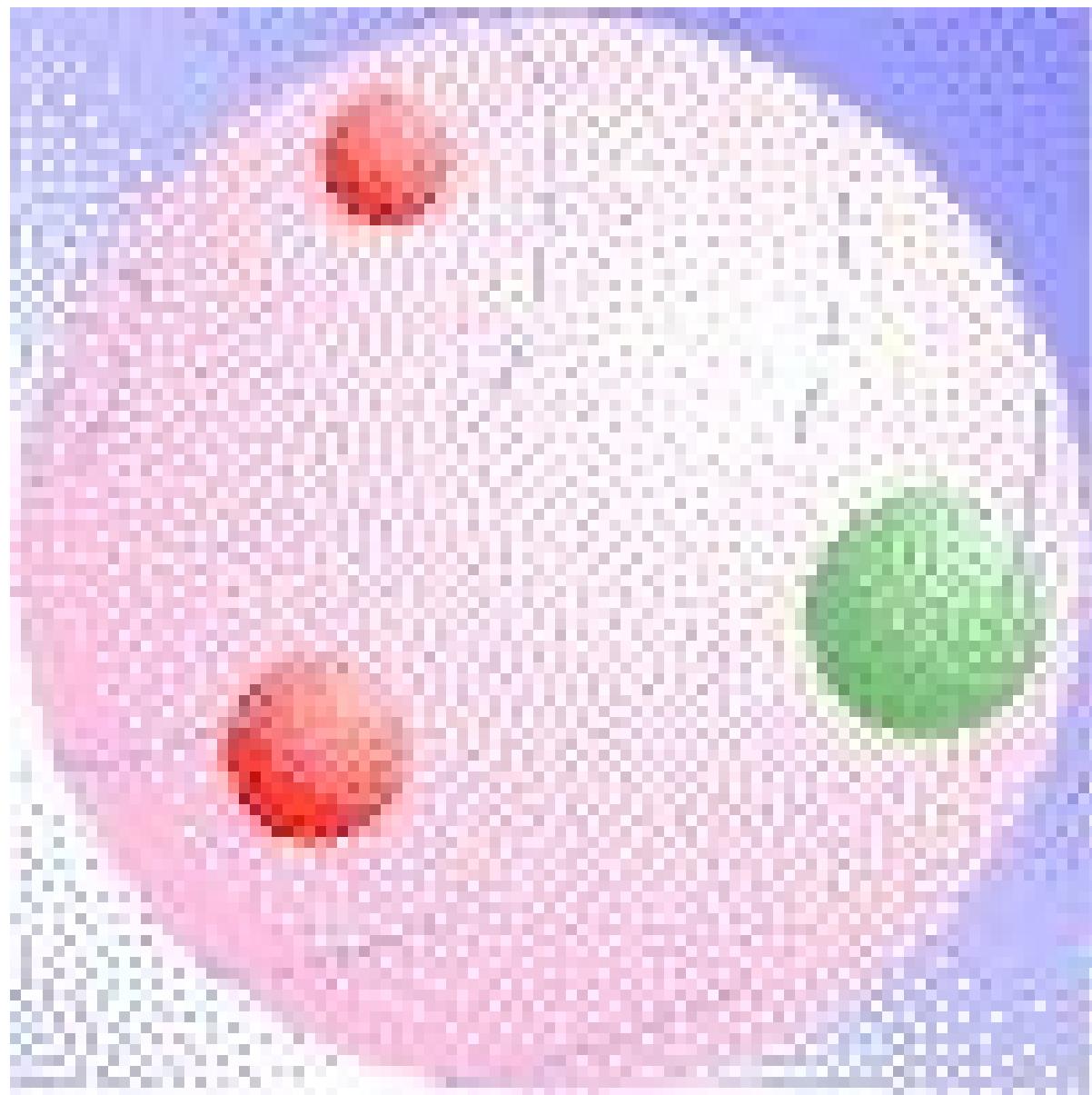


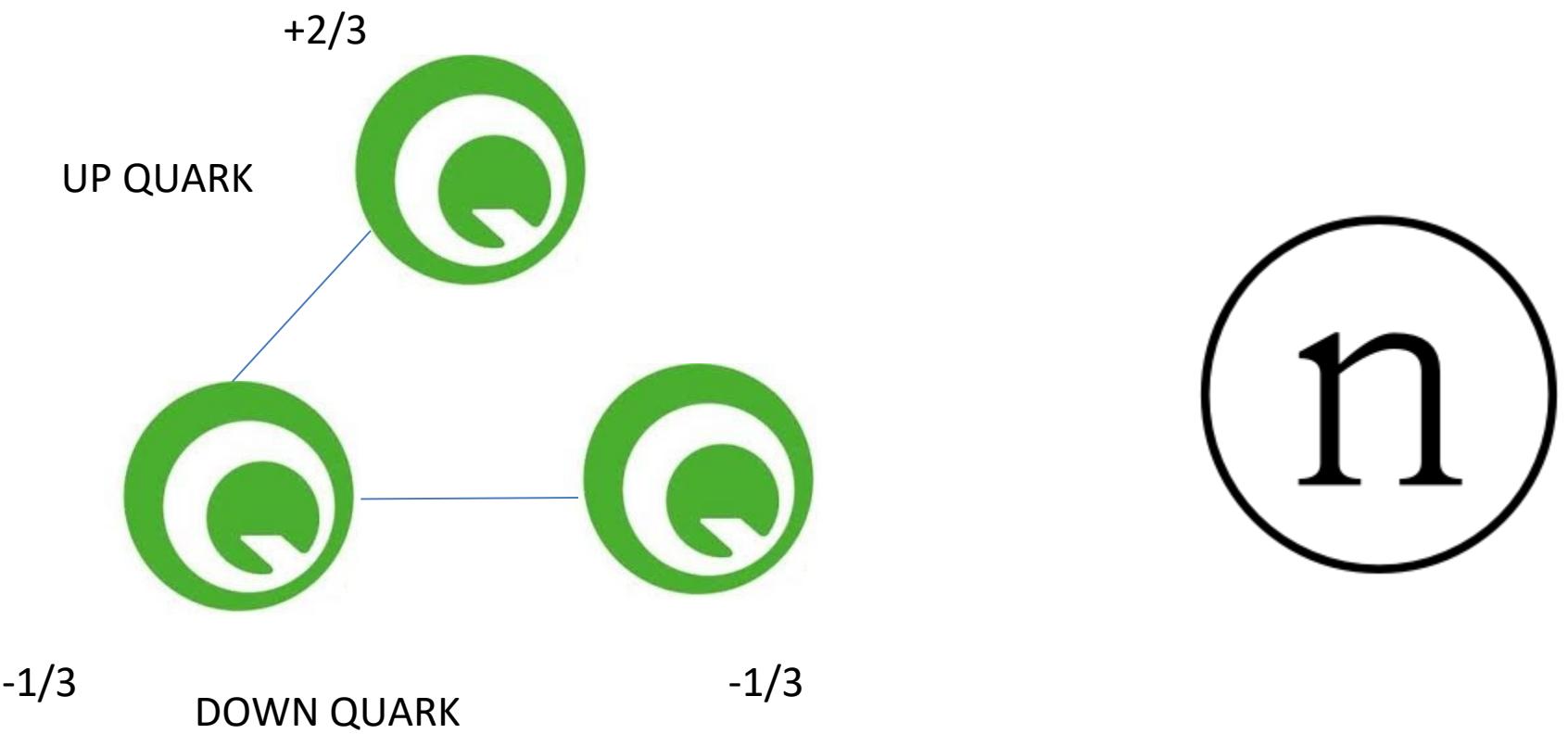
Lepton



Quark

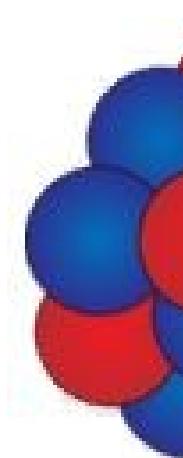






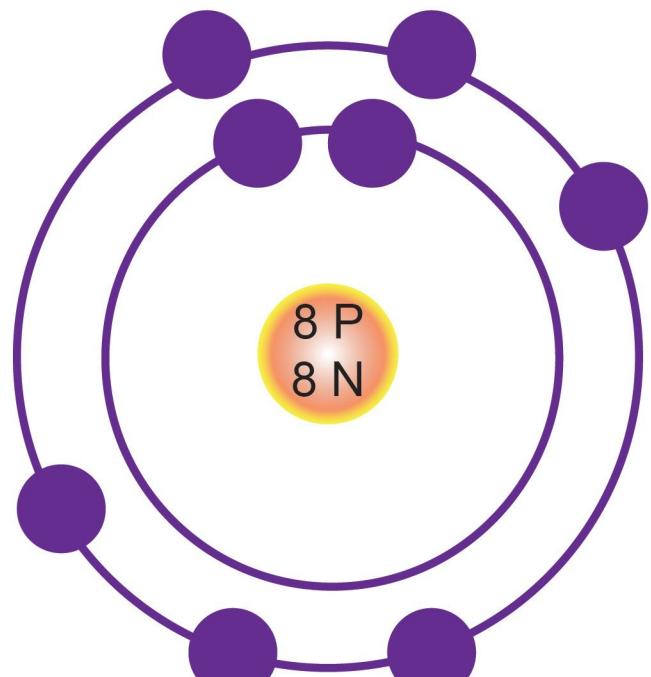


Isotope

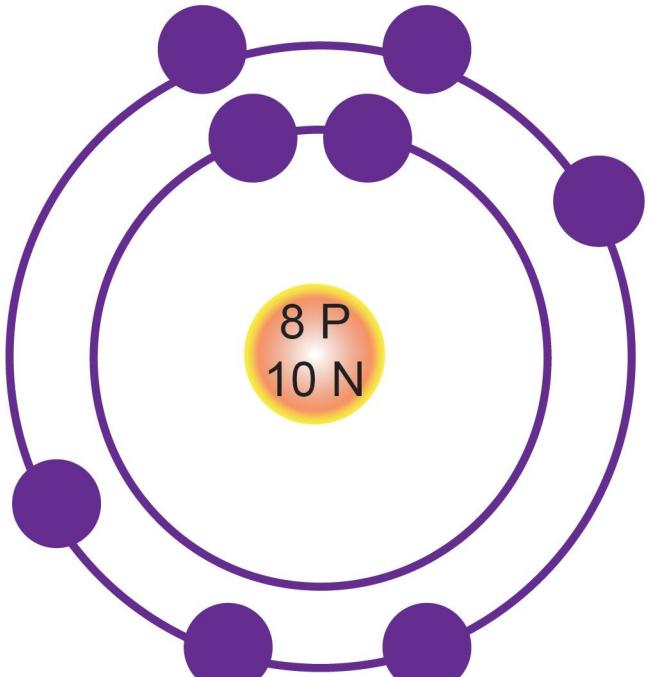


Ca

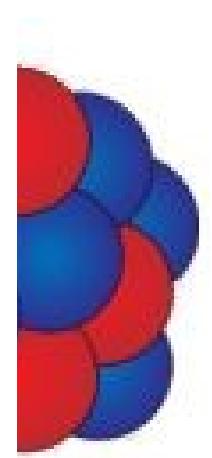
6
6



^{16}O Isotope



^{18}O Isotope



1-14

%

OOS

ons

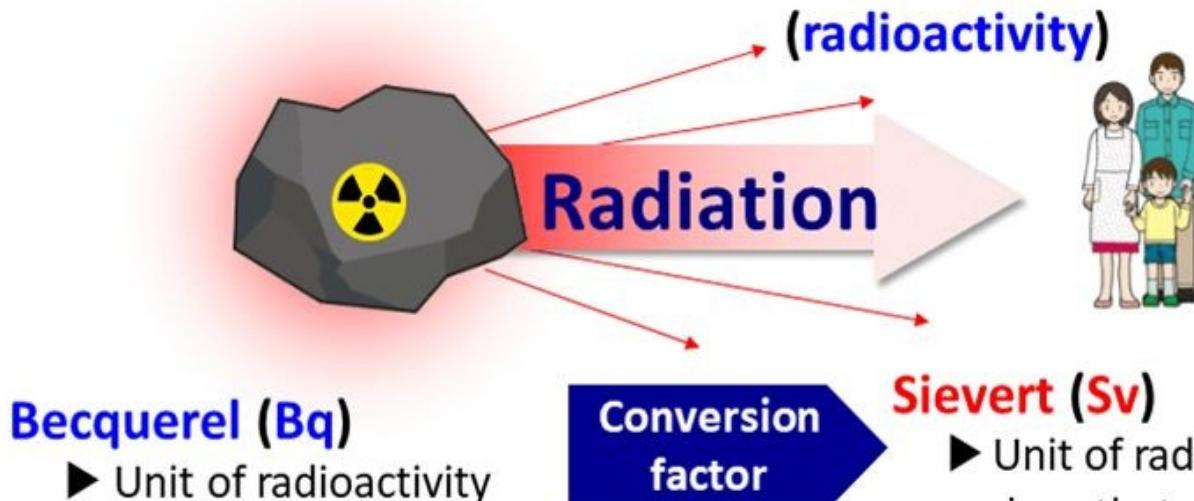
Radioactivity

- Lightbulb = Has the ability to emit light



Lux (lx)
► Unit of brightness

- Radioactive materials = Have the ability to emit radiation

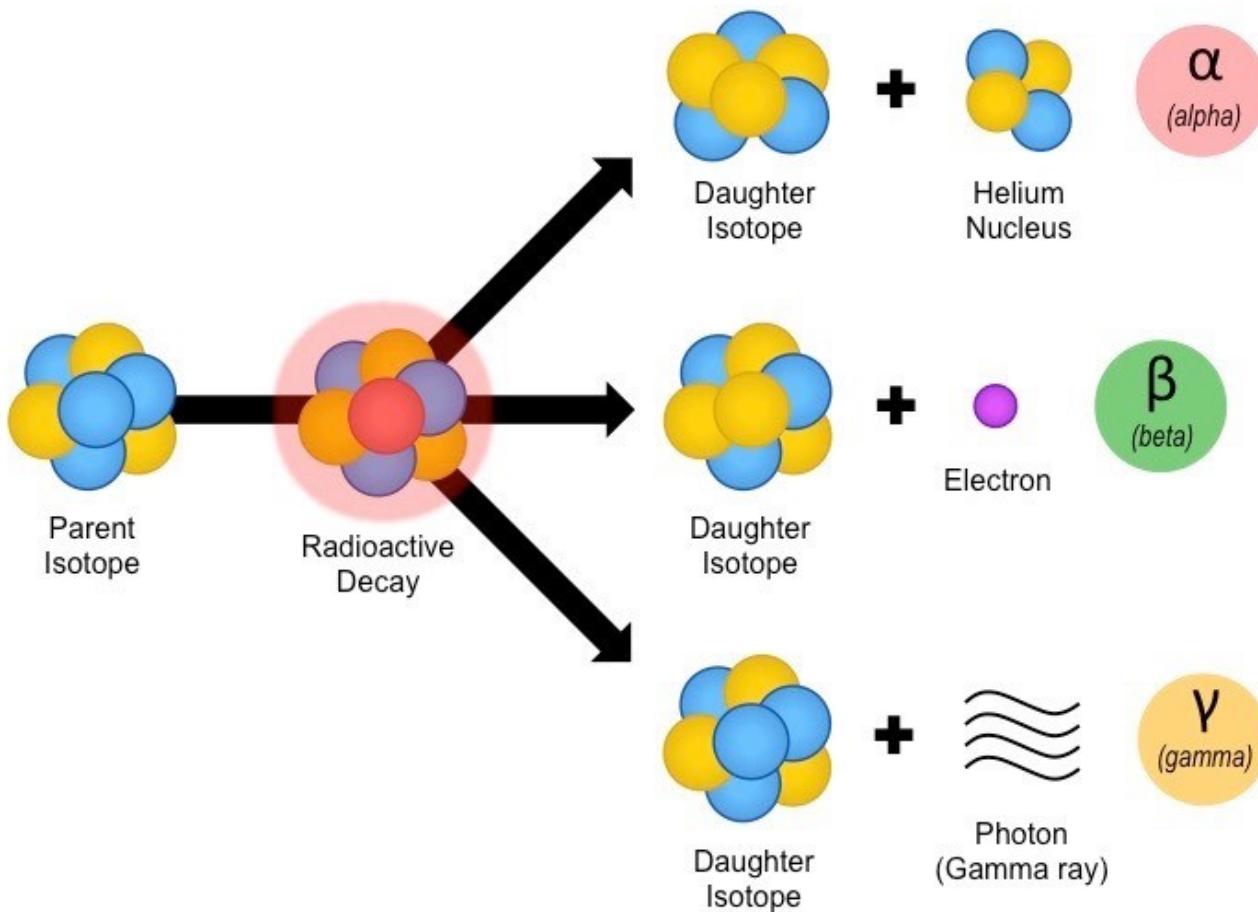


Sievert (Sv)
► Unit of radiation exposure dose that a person receives

*Sievert is associated with radiation effects.

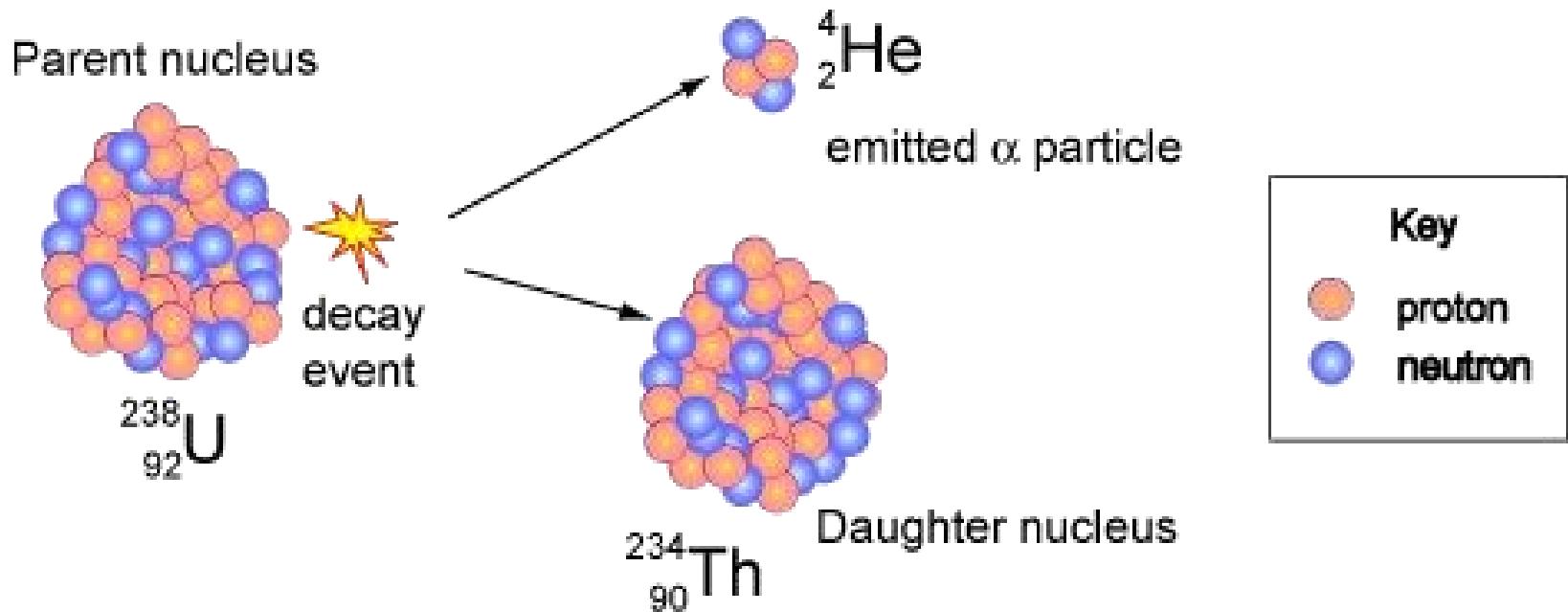
Nuclear fission

- Alpha Decay
- Beta Decay
- Gamma Decay

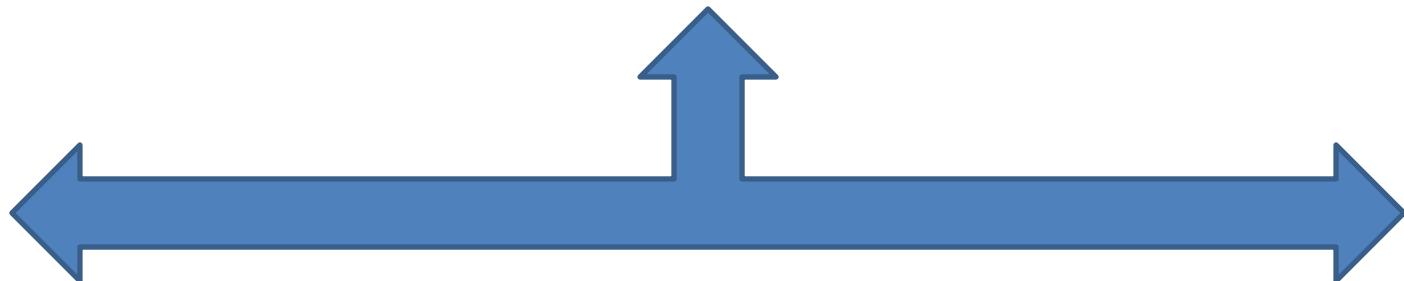


Alpha Decay

Alpha Decay of a Uranium-238 nucleus



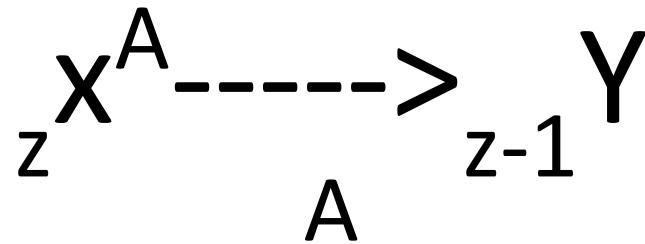
BETA DECAY



Beta +

$p \gg n$

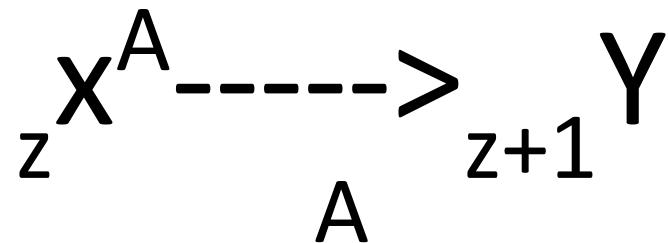
$p \rightarrow n + \text{positron} + \text{neutrino}$



Beta -

$n \gg p$

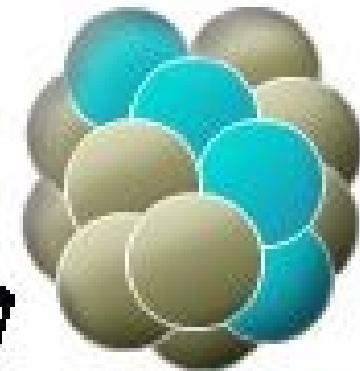
$n \rightarrow p + \text{electron}$



Gamma Decay

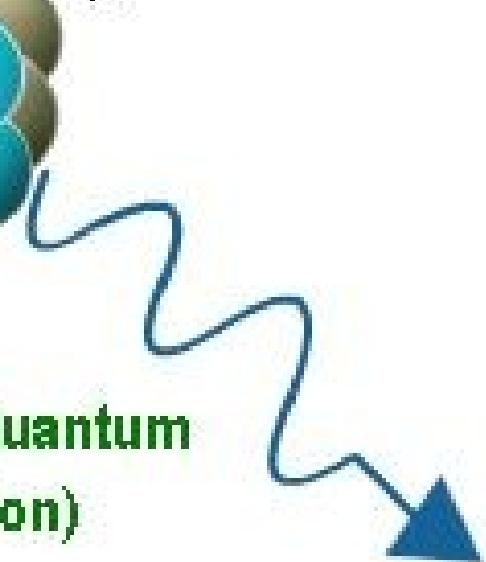
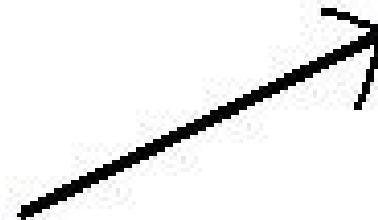
Excited State

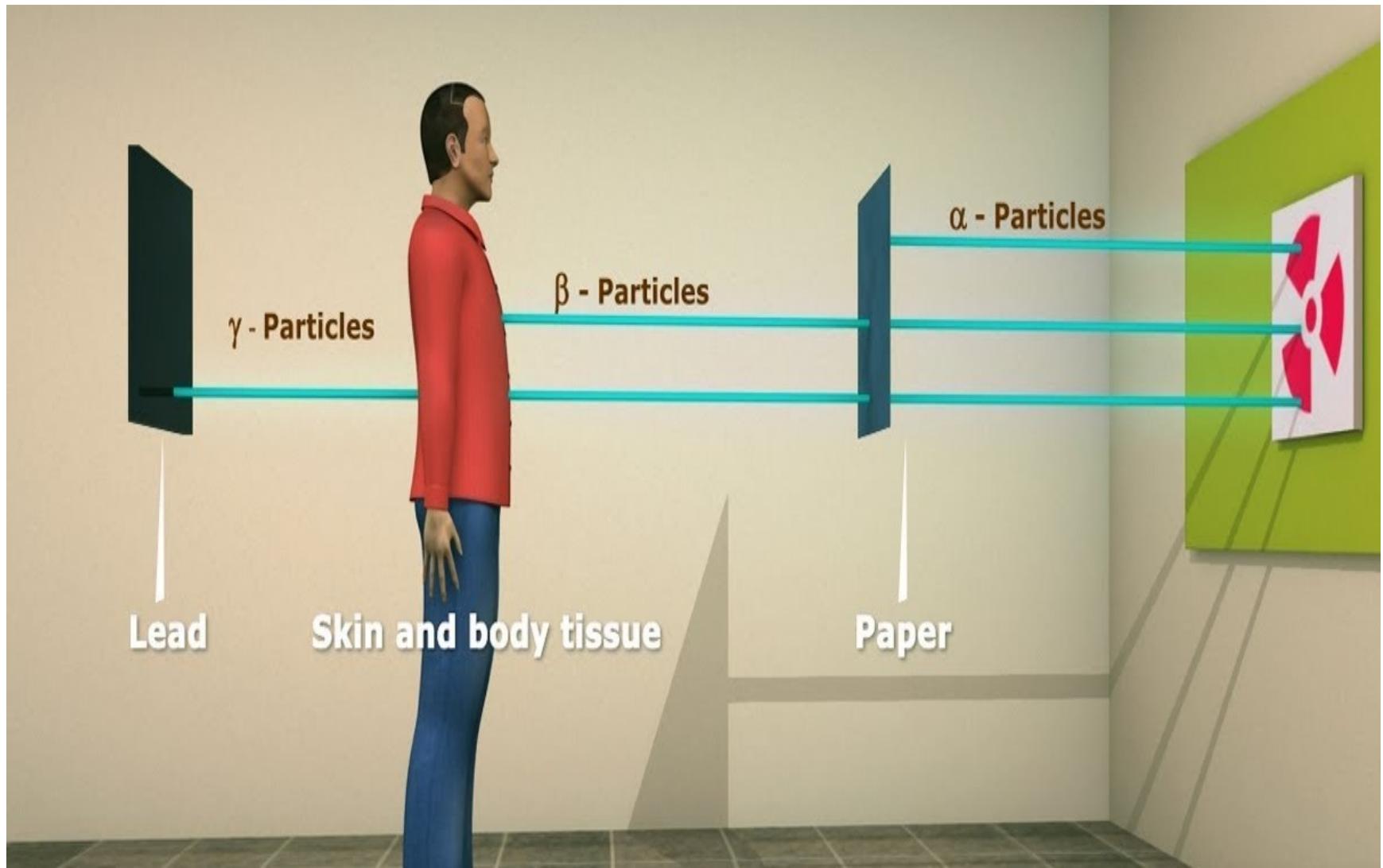
$^{137}_{56}\text{Ba}$



$^{137}_{56}\text{Ba}$

Gamma Quantum
(Photon)



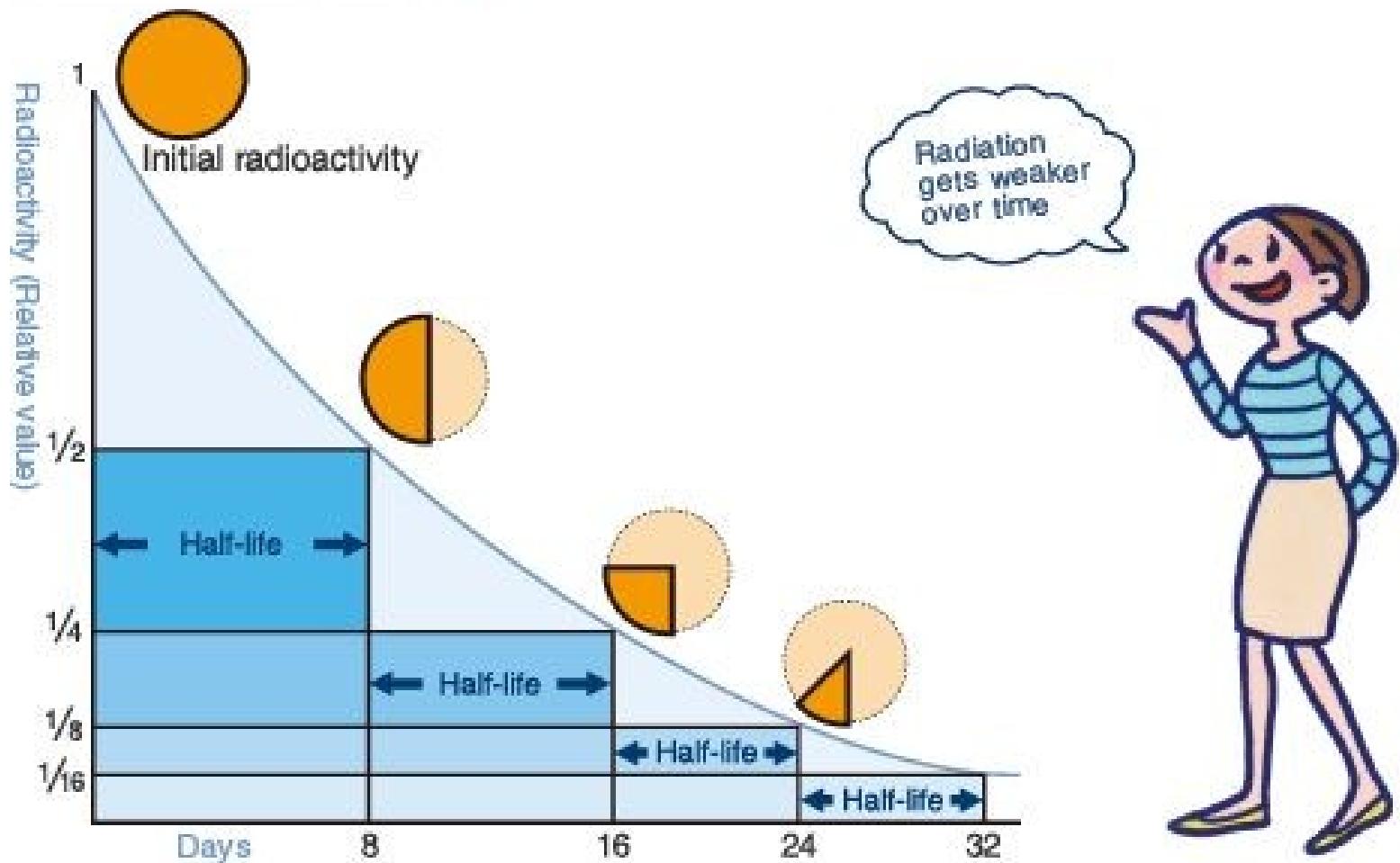


Nuclear Fusion

- $\text{H} + \text{H} \xrightarrow{\hspace{1cm}} \text{He} + \text{Stellar Energy} + \text{Neutrino}$

Half life

[How radioactivity decays] Iodine 131

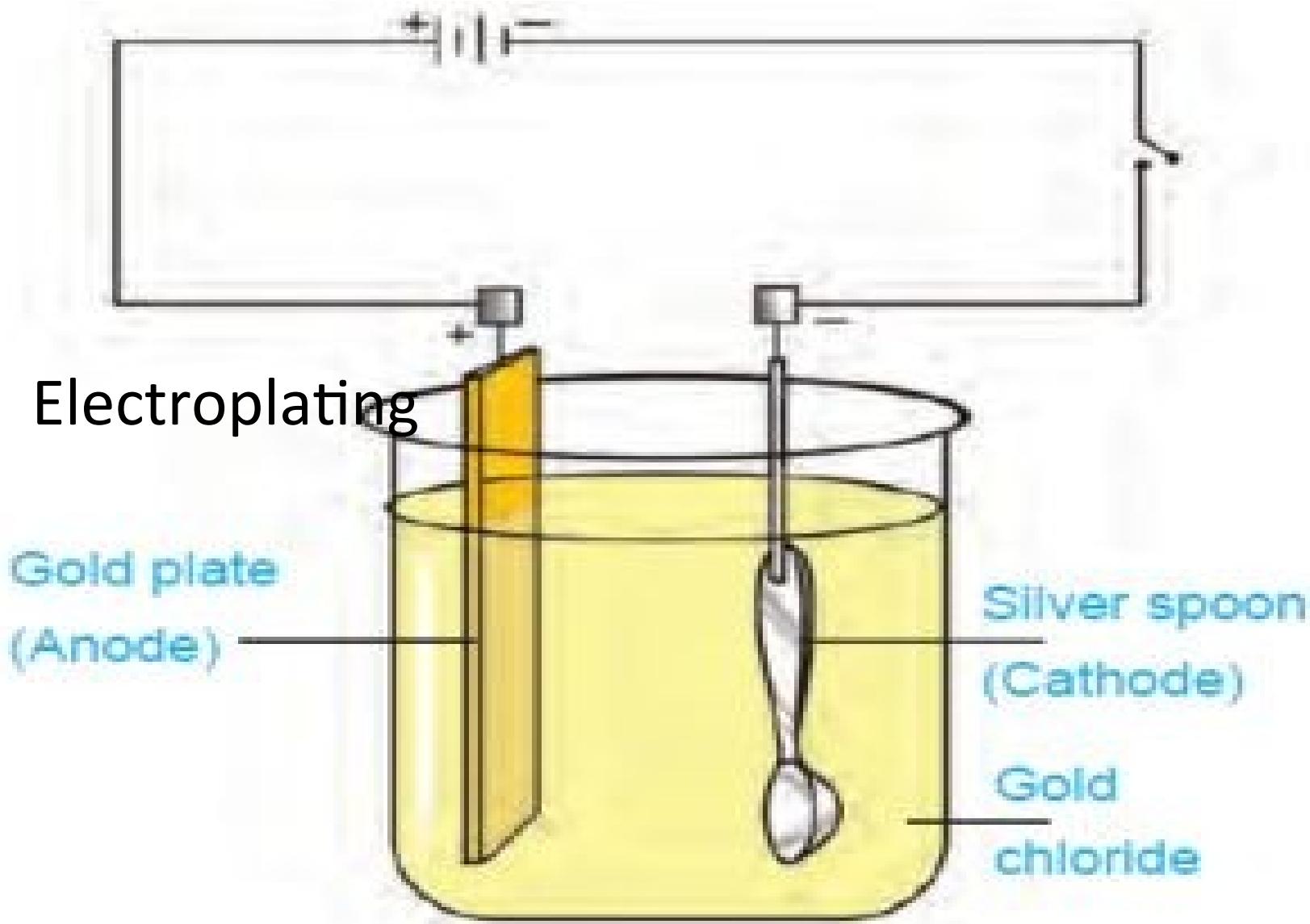


- **The function of heavy water in a nuclear reactor is to [UPSC 2011 (CS-P)]**
- Slow down the speed of neutrons
- Increase the speed of neutrons
- Cool down the reactor
- Stop the nuclear reaction
- Ans- A

- Radioactivity is measured by [UPSC 2008]
- Geiger-Muller counter
- Polarimeter
- Calorimeter
- Colorimeter
- Ans- A

- The phenomenon of radioactivity was discovered by [UPSC 2008]
- Madam Curie
- J.J. Thomson
- Roentgen
- Becquerel
- Ans-D

Electrochemistry



Corrosion vs Galvanisation





bewajah marta main hi hoon

Allotropes

- Some chemical elements are known to exist in two or more different forms because the atoms are bounded together in different manners.

Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Group Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	1 H																2 He		
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6	55 Cs	56 Ba	57 La	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	*	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
	*	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu				
*	*	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr				

Metals and Non Metals

																		Metal	Metalloid	Nonmetal				
H																					He			
Li	Be																		B	C	N	O	F	Ne
Na	Mg																	Al	Si	P	S	Cl	Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr							
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe							
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn							
Fr	Ra	Ac-Lr																						

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu							
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr							

- **Which one of the following non-metals is not a poor conductor of electricity? [UPSC Civil Services, 2007]**
- Sulphur
- Selenium
- Bromine
- Phosphorus
- Ans- B

Halogens

- A gas used as a disinfectant in drinking water is [UPSC 2008]
- Hydrogen
- Oxygen
- Fluorine
- Chlorine
- Ans- D

Inert Gases

Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
↓ Period	H	He																
1	1 H																2 He	
2	3 Li	4 Be															10 Ne	
3	11 Na	12 Mg															18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
Lanthanides		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu		
Actinides		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr		

The Noble Gases →

Uses of Inert gases

THE NOBLE GASES

noble gases

several inert gases



Because they are unreactive they are safe to use. When a current is passed through them they **glow**.

Gas	Uses
Helium	-it is lighter than air it is used to fill balloons and airships, it does not catch fire
Argon	-as a filler in light bulbs -protect metals that are being welded (does not react)
Neon	-advertising signs, glows red but colour can be changed if mixed with other gases
Krypton	-lasers (eye surgery) -car headlights
Xenon	-gives a light similar to daylight but with a blue tinge -car headlights, lighthouse lights, operating rooms

Rare Earth Elements

H	Rare Earth Elements														He
Li	Be														B
Na	Mg														C
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te
Cs	Ba	Lanth.	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po
Fr	Ra	Act.	Rf	Db	Sg	Bh	Hs	Mt							At

Lanthanides

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Actinides

Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
----	----	----	---	----	----	----	----	----	----	----	----	----	----	----

Uses of Rare Earth Elements

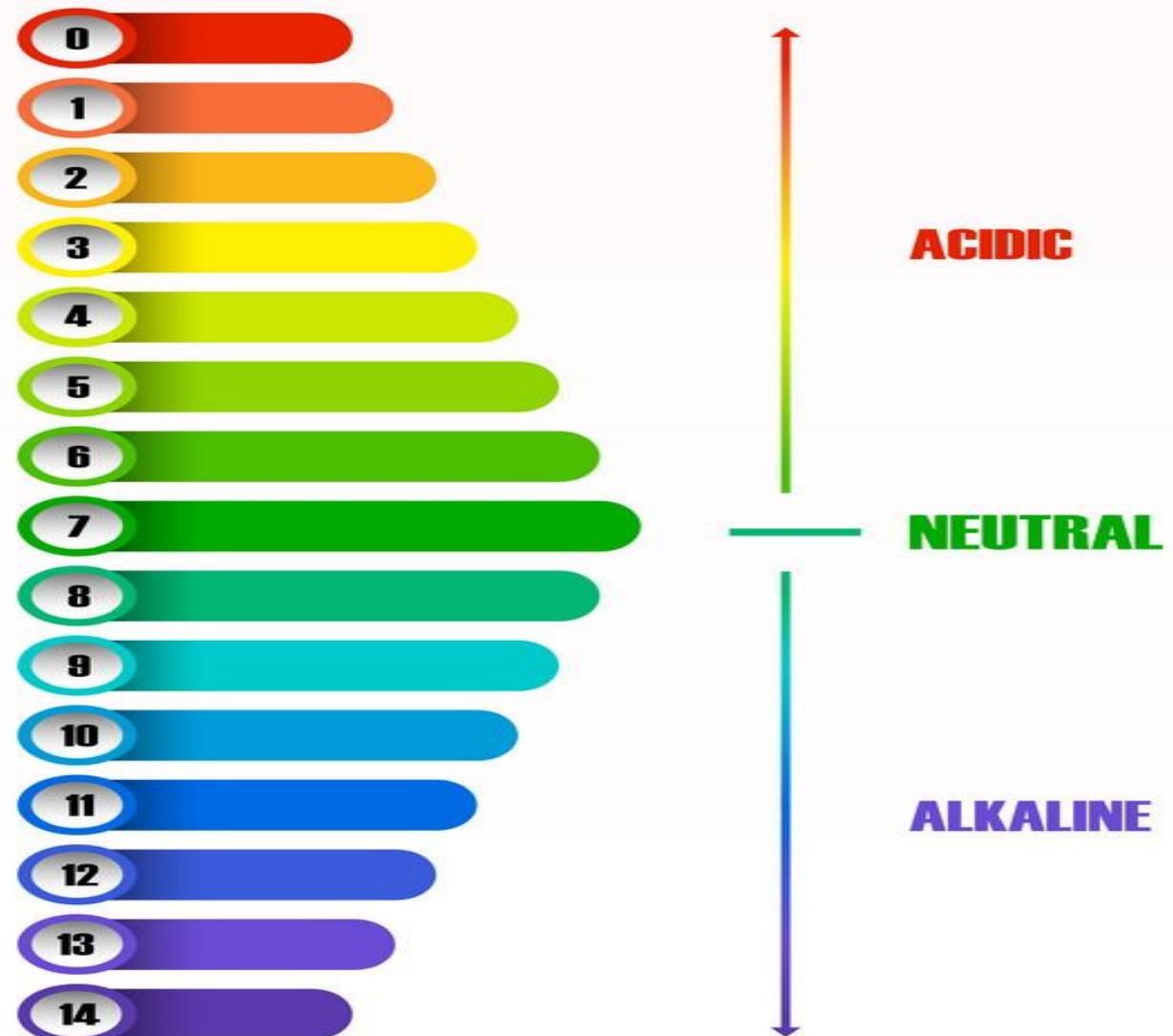


- **Recently, there has been a concern over the short supply of a group of elements called ‘rare earth metals’. Why?**
- 1. China, which is the largest producer of these elements, has imposed some restrictions on their export.
- 2. Other than China, Australia, Canada and Chile, these elements are not found in any country.
- 3. Rare earth metals are essential for the manufacture of various kinds of electronic items and there is a growing demand for these elements.
- Which of the statements given above is/are correct?
- [A]1 Only
- [B]2 & 3 Only
- [C]1 & 3 Only
- [D]1,2 & 3
- Ans C

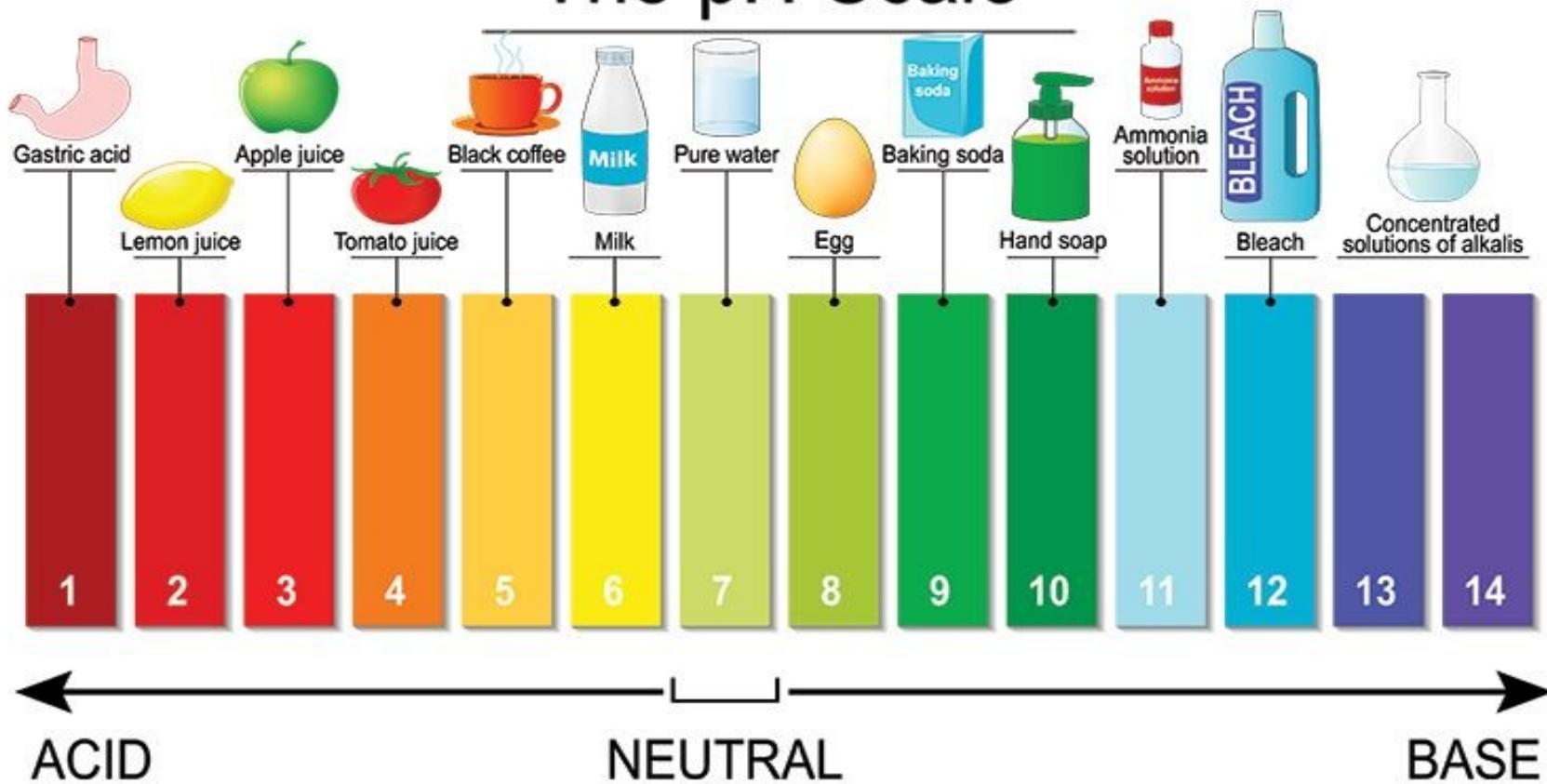
- **Salts of which of the following elements provide colours to fireworks? [UPSC Civil Services, 2004]**
- Zinc and sulphur
- Potassium and mercury
- Strontium and barium
- Chromium and nickel
- **Ans- C**

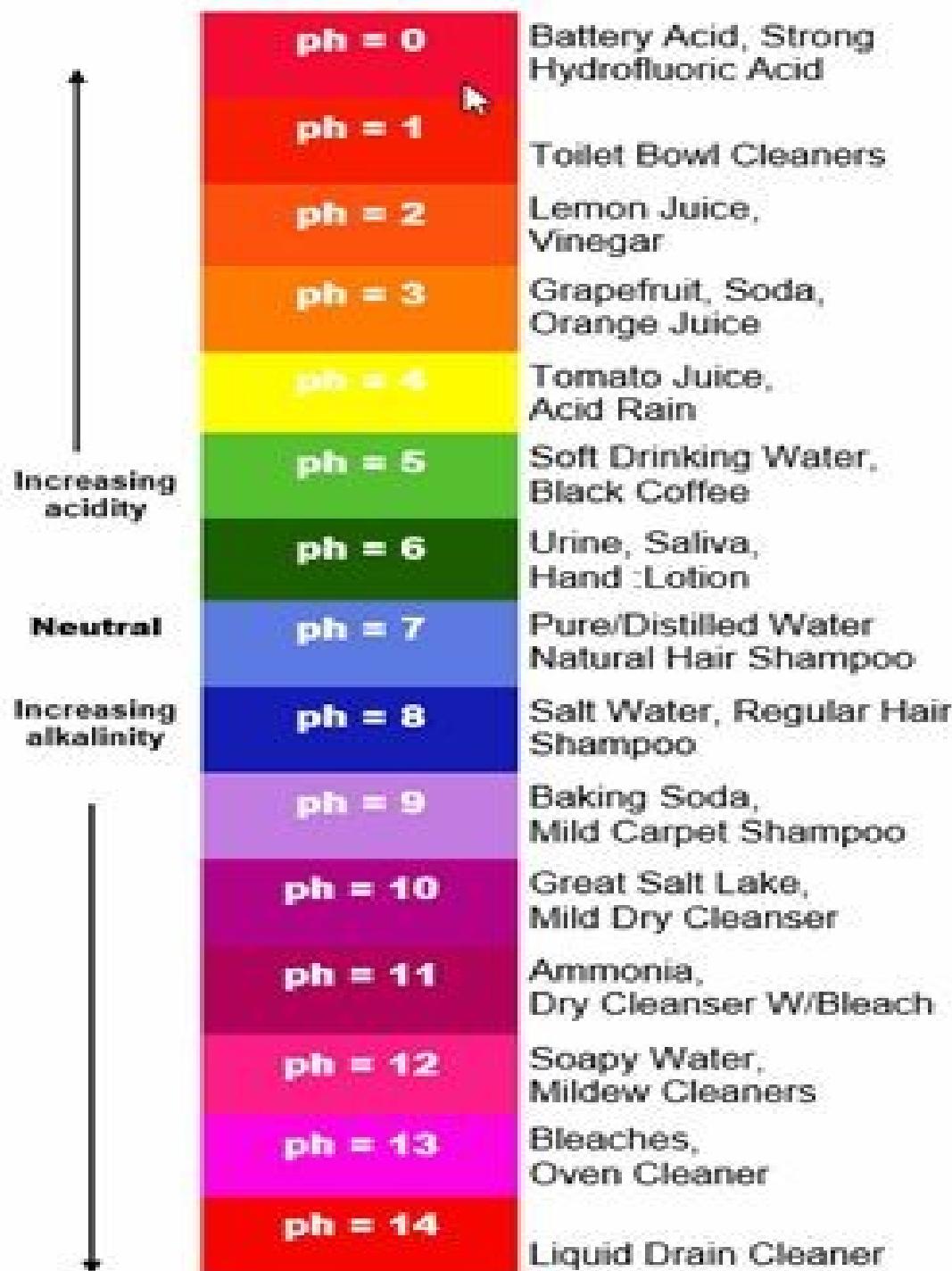
PH Scale

The
pH
scale



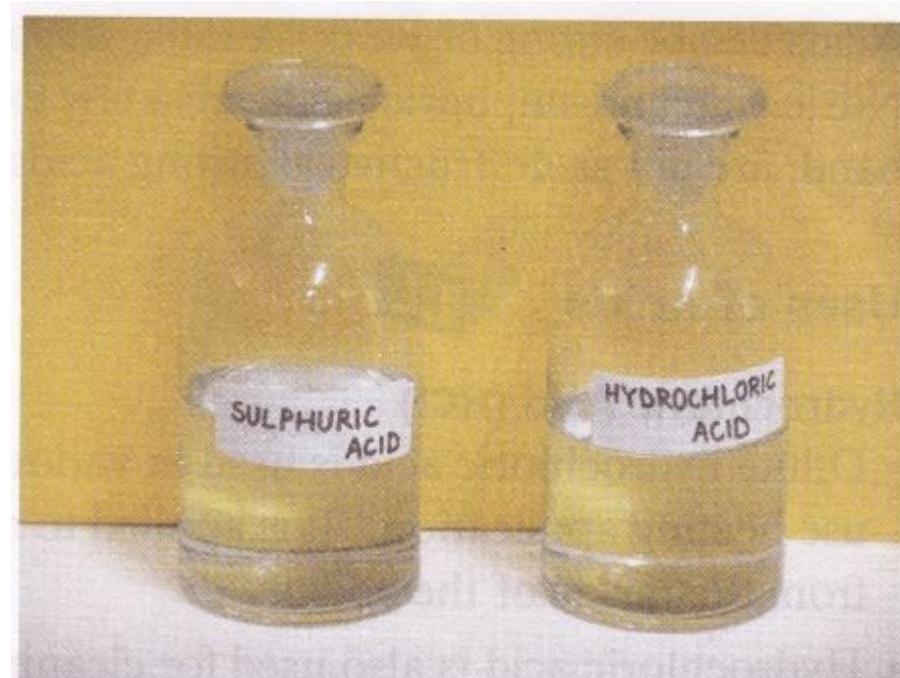
The pH Scale





Acids

- Organic vs Inorganic acids



Base



Salt



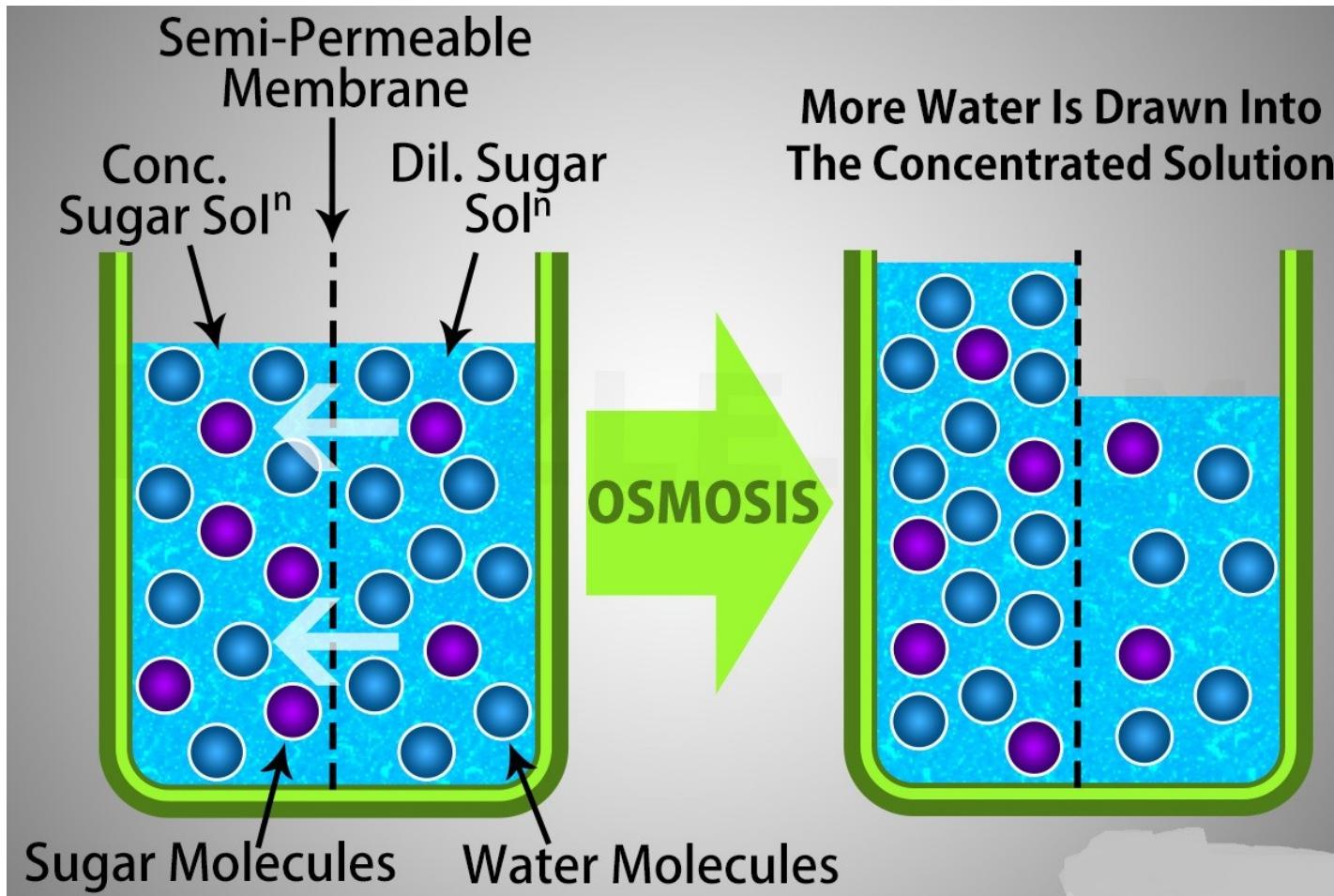
Viscosity



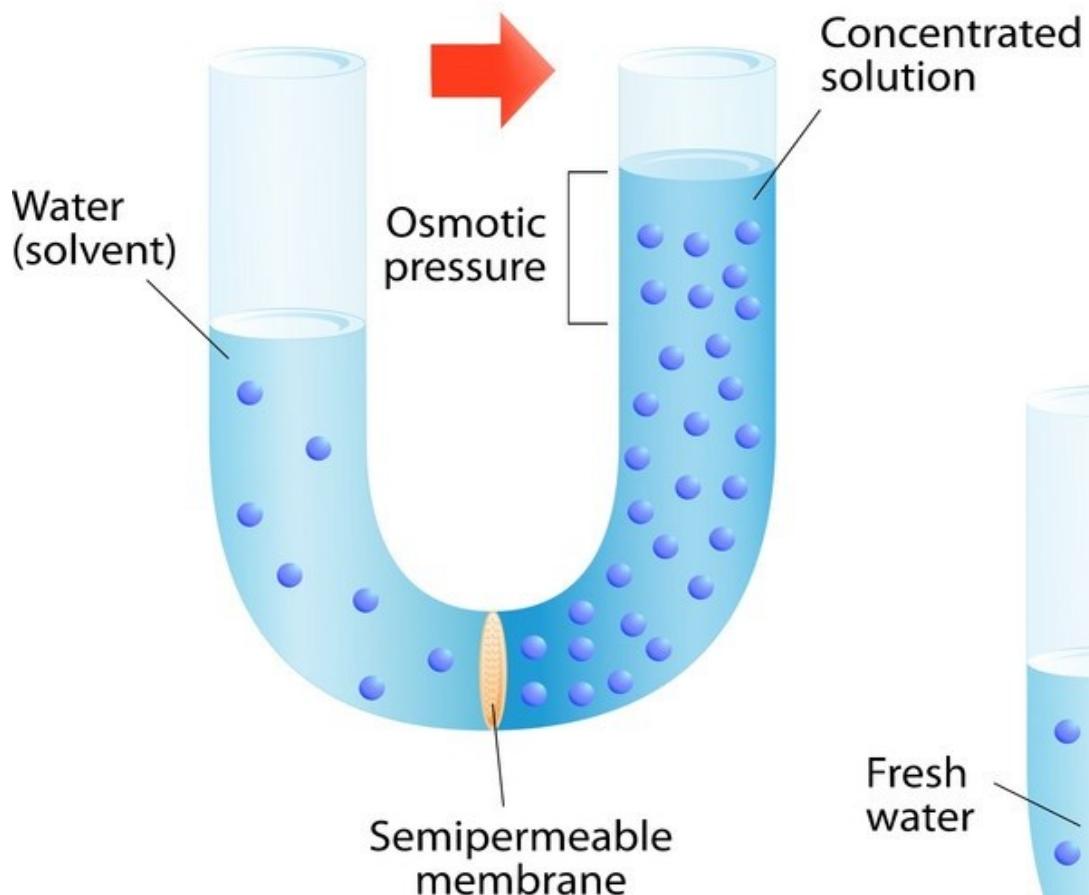
Endothermic Vs Exothermic Reactions



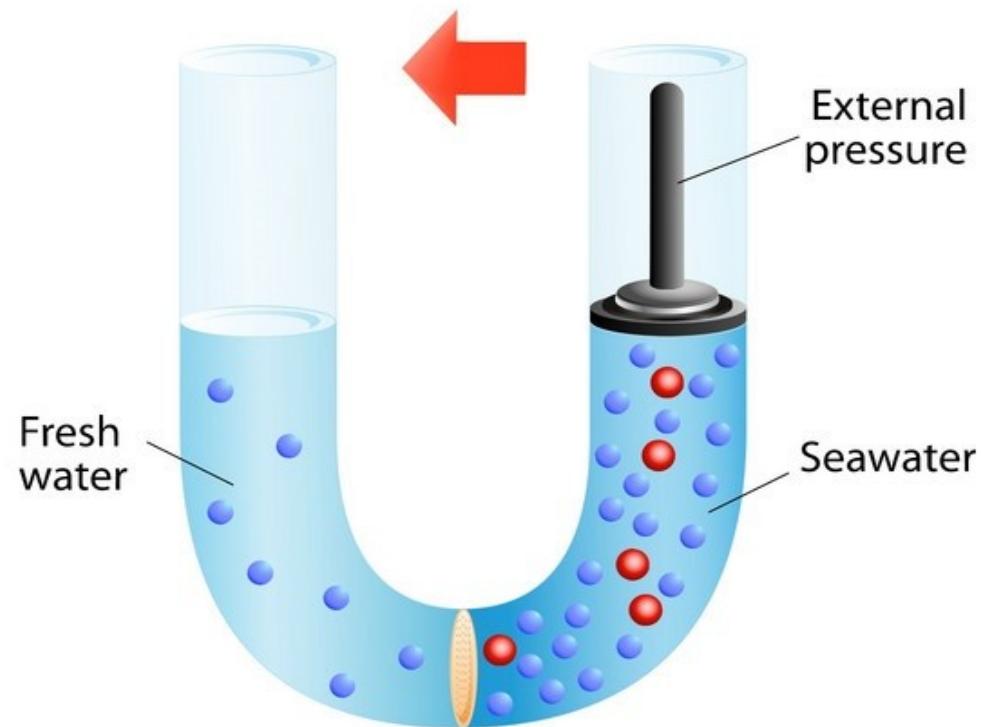
Osmosis



Reverse Osmosis Osmosis



Reverse osmosis



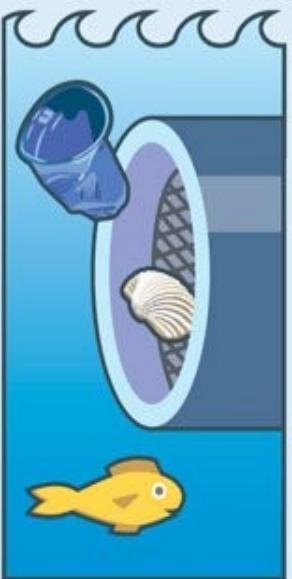
How seawater desalination works

M&G

1

SCREENING

Seawater intake pipes have screens to keep out sea life and debris



2

FILTERING

Sediment, sewage and bacteria are filtered out of the seawater



3

DESALINATION

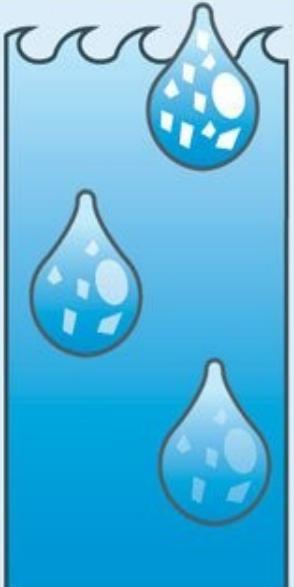
The seawater is forced through a membrane that lets through water molecules but not salt particles



4

WASTEWATER

Any leftover seawater is highly salted and needs to be diluted before it is returned to the sea



5

CHLORINATION

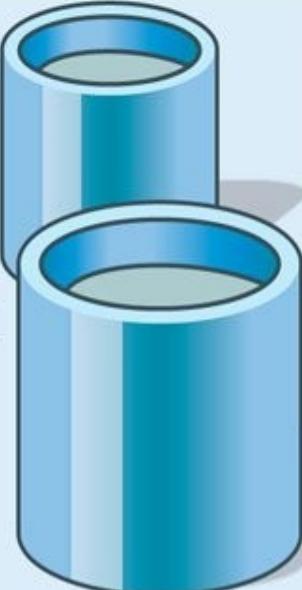
The desalinated water is treated with chlorine to keep it fresh



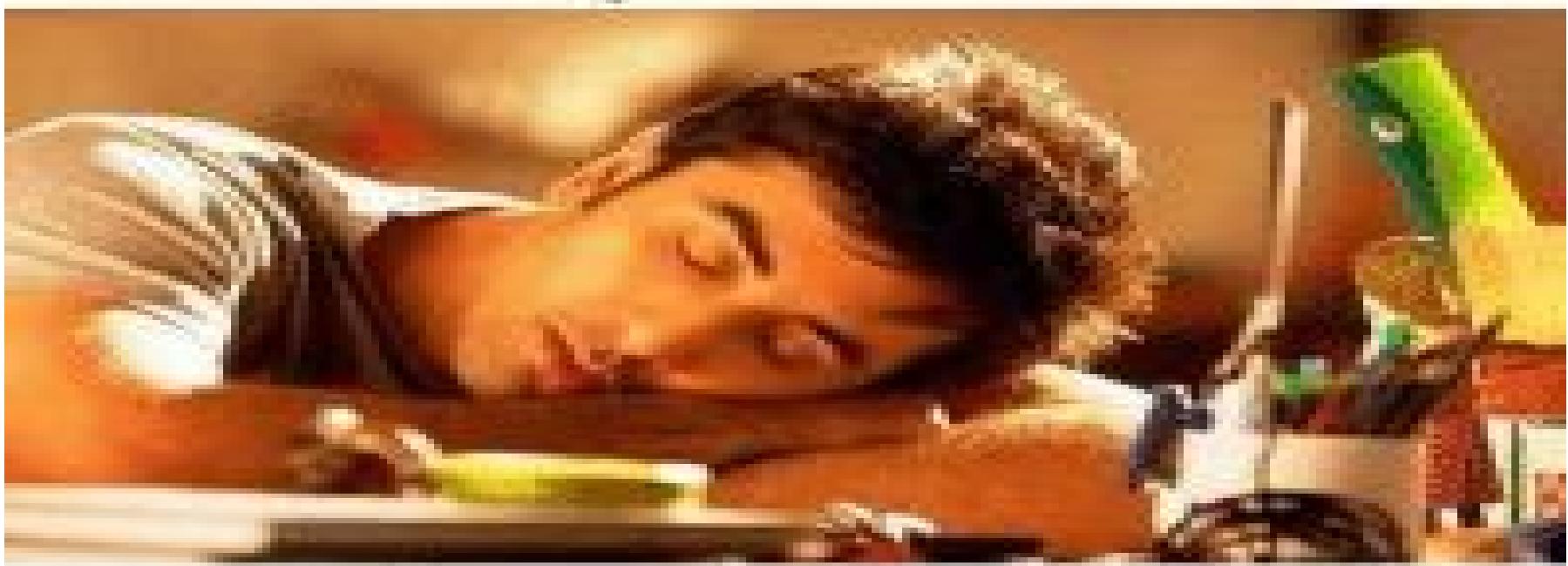
6

WATER SYSTEM

The chlorinated water is kept in storage tanks until needed for the municipal water supply

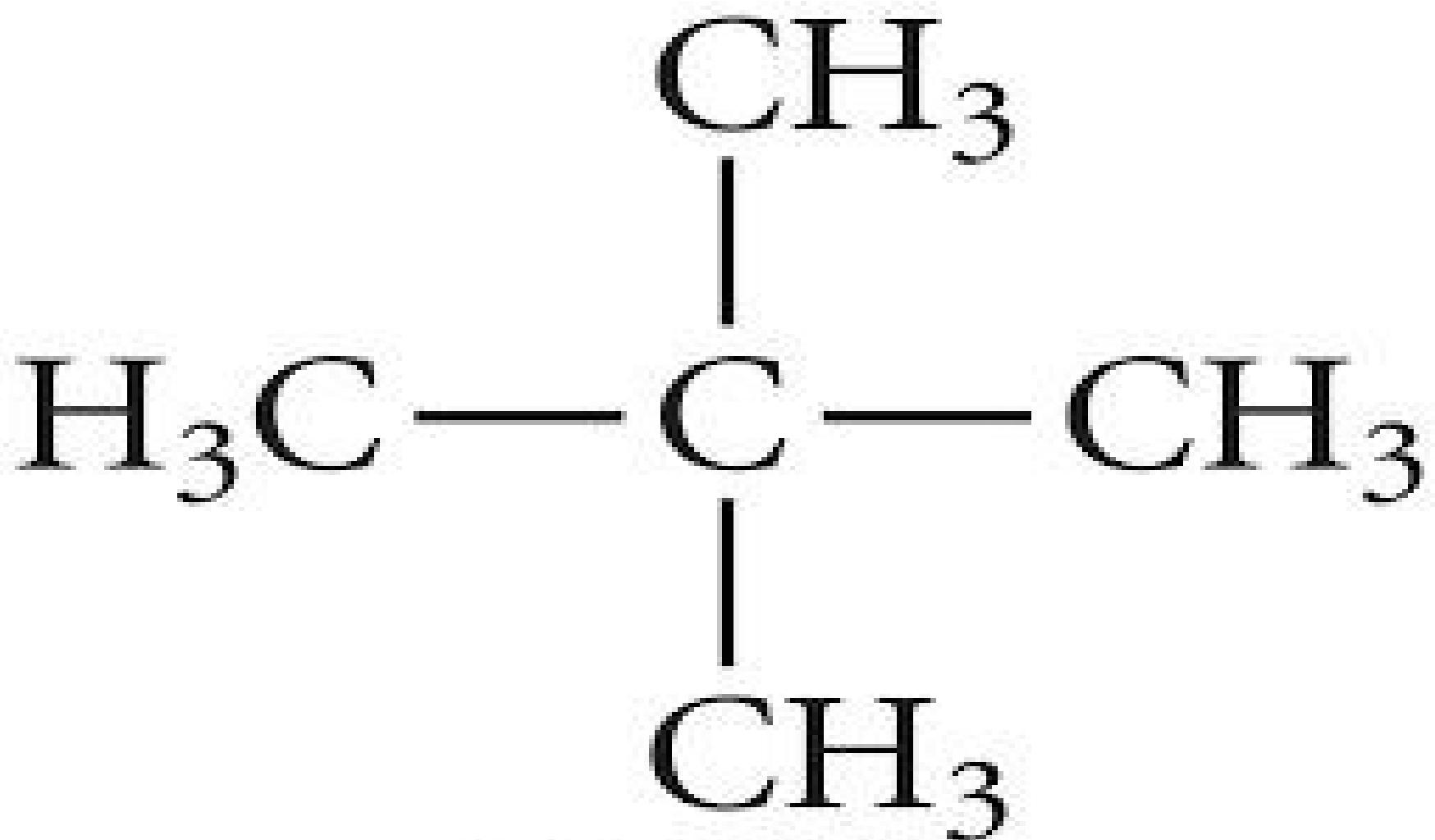


**I Wish I could just Sleep
on my Textbooks**



**And Learn Everything
Through Osmosis.**

Hydrocarbons around us



Alcoholic Beverages

- **Distilled beverage**
- **Un-distilled beverage**

Distilled beverage	% alcohol	Sources
Whisky	40-50%	Barley
Rum	45-55%	Sugar Cane
Brandy	40-50%	Grapes
Gin	35-40%	Maize

Un-distilled beverage	% alcohol	Sources
Bear	3-6%	Barley
Champagne	10-15%	Grapes
Port & Sherry	15-25%	Grapes
Cider	2-6%	Apple

Chemical Explosives

- RDX (Research & Development Explosive)
- TNG (Tri Nitro Glycerine)
- TNT (Tri Nitro Toluene)
- Dynamite
- TNP (Tri Nitro Phenol)

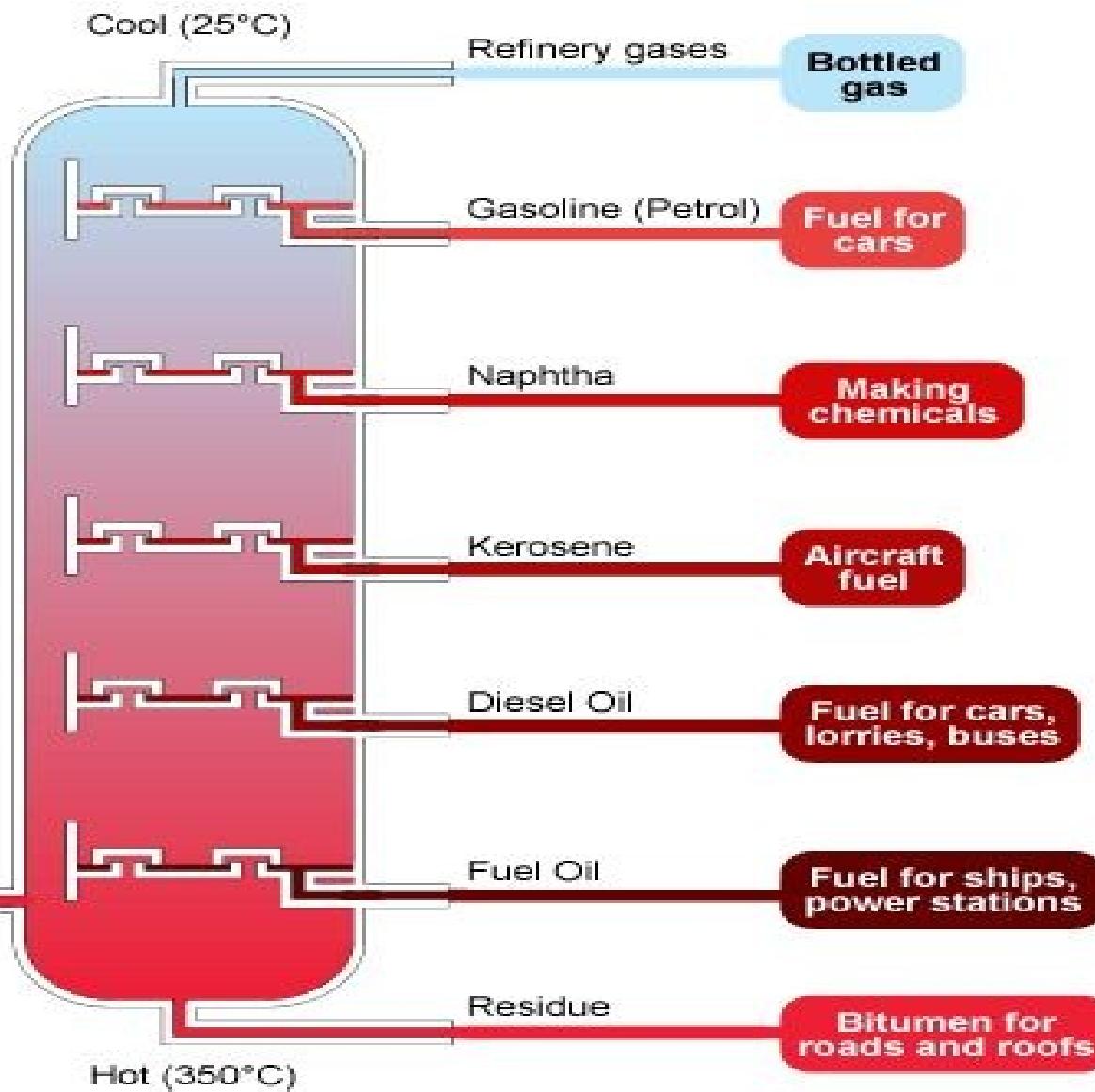
Fuels

- Solid fuel
- Liquid fuel
- Gaseous fuel

Solid fuel

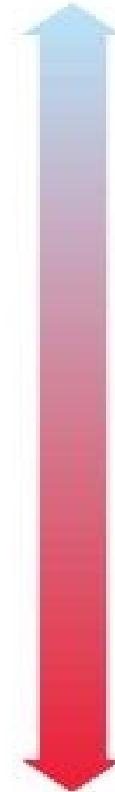
- Coal
- Wood
- Charcoal
- Cow dung cakes

Extraction of fuel from crude oil



Small molecules:

- low boiling point
- very volatile
- flows easily
- ignites easily

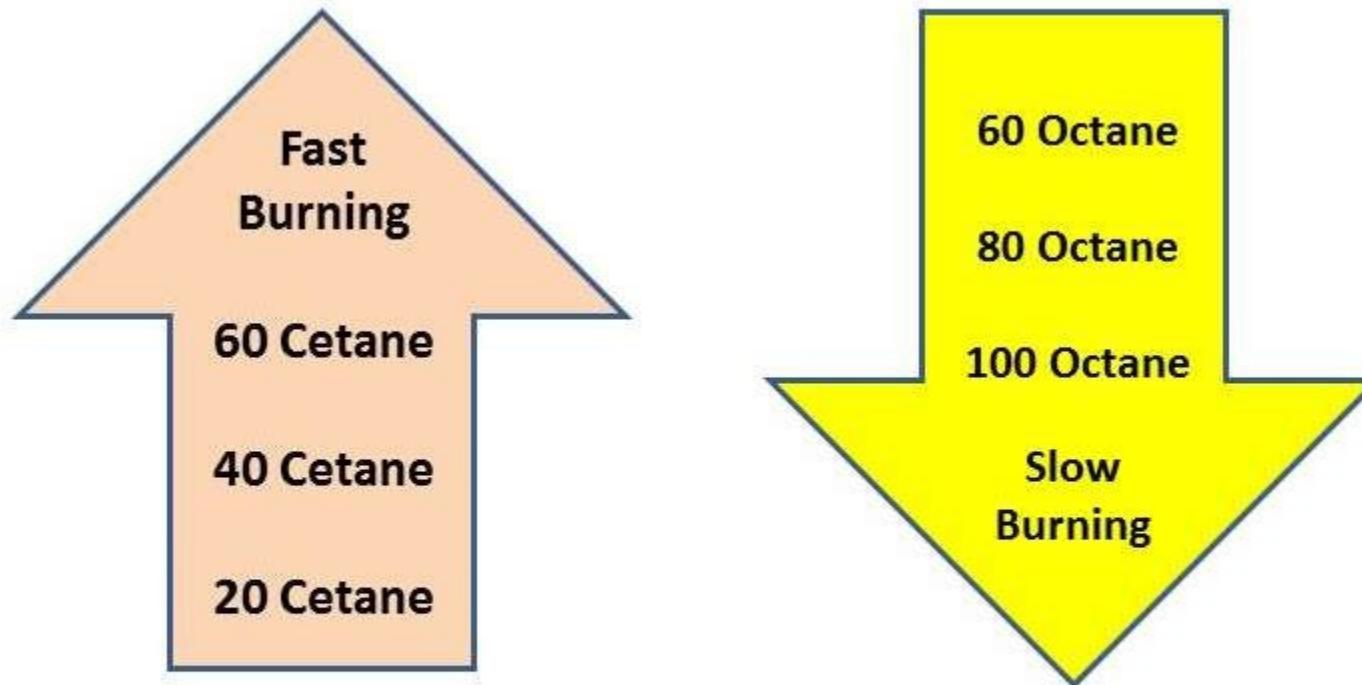


Large molecules:

- high boiling point
- not very volatile
- does not flow easily
- does not ignite easily

Knocking of engine

- Octane vs cetane number



Cetane Rating
(Diesel)

Octane Rating
(Gasoline)

Aviation turbine fuel



Gaseous fuels

- Water Gas, Producer Gas, Coal gas
- Natural gas, Biogas
- LPG, CNG

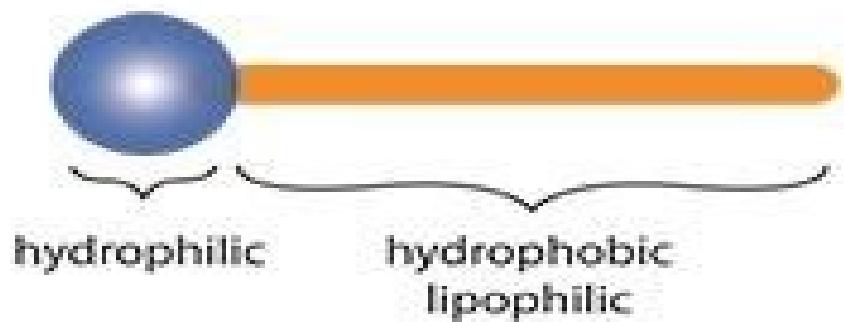
LPG

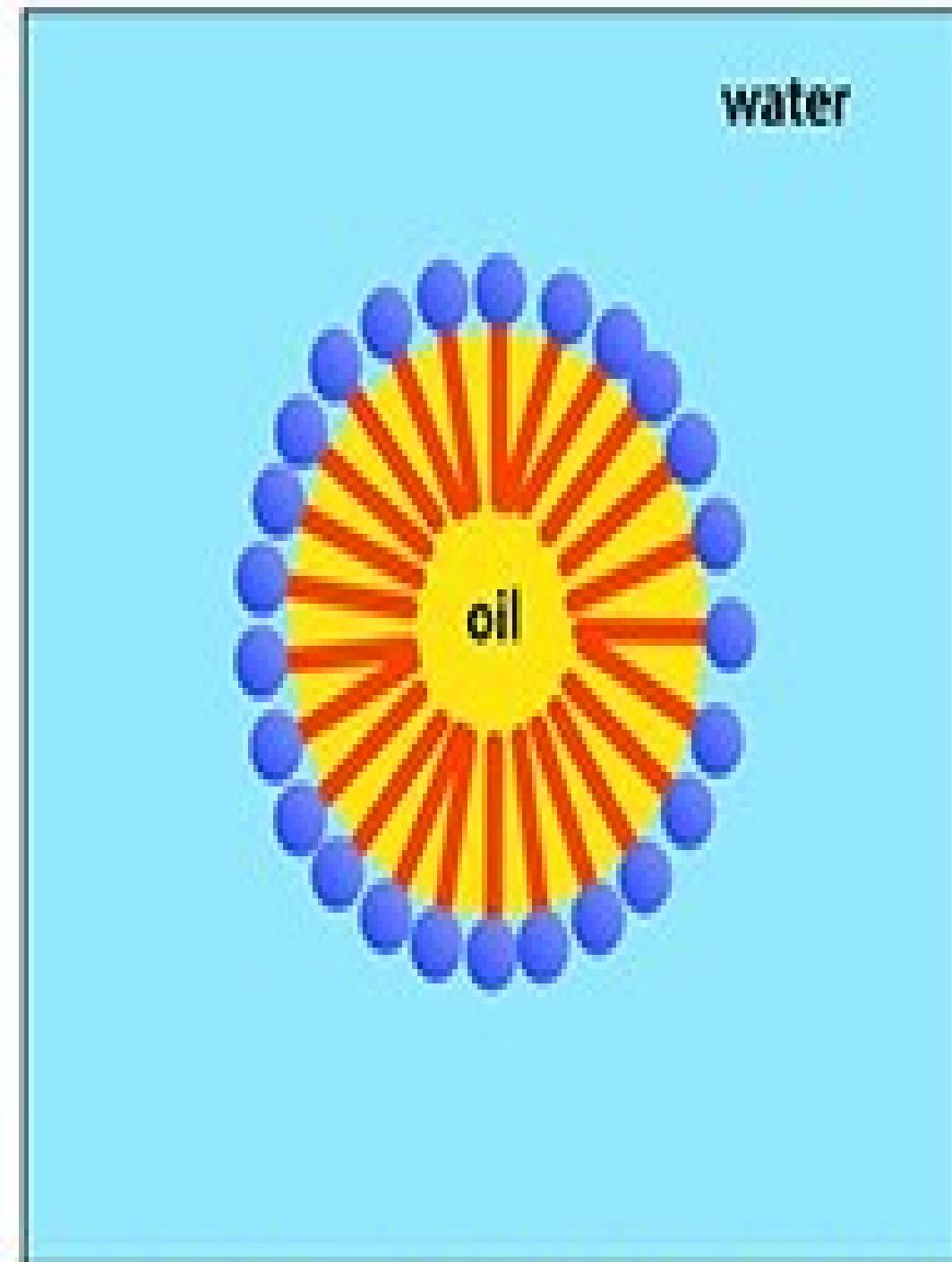
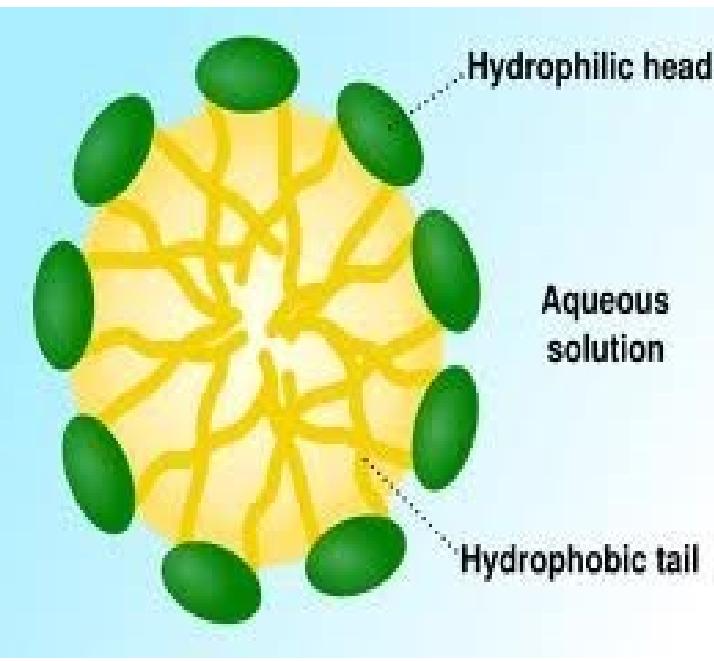


CNG



Soaps and Detergents : Chemistry of Surfactants





A cluster of glowing green jellyfish against a dark background.

Efflorescence

WKF

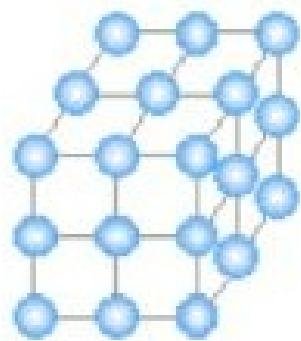


Agenda

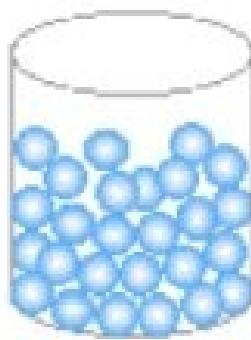
- States of matter
- Structure of atom – Definitions and introduction to basics like proton, neutron, lepton, quarks etc
- Radioactivity- alpha, beta and gamma ray, nuclear fission and fusion
- Periodic table
- PH scale- acids, bases and salts
- Concepts like osmosis
- Hydrocarbons in daily life – fuels, soaps etc
- Bioluminescence

Matter

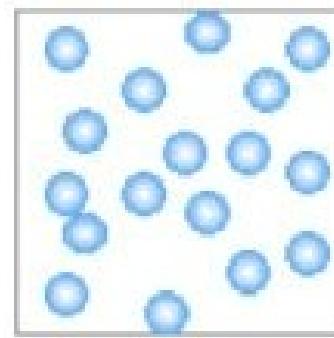
States of Matter



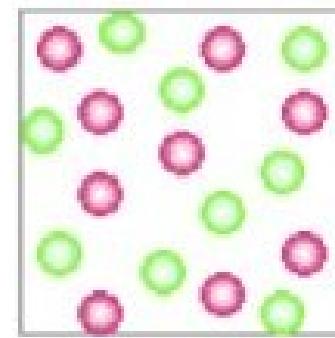
SOLID



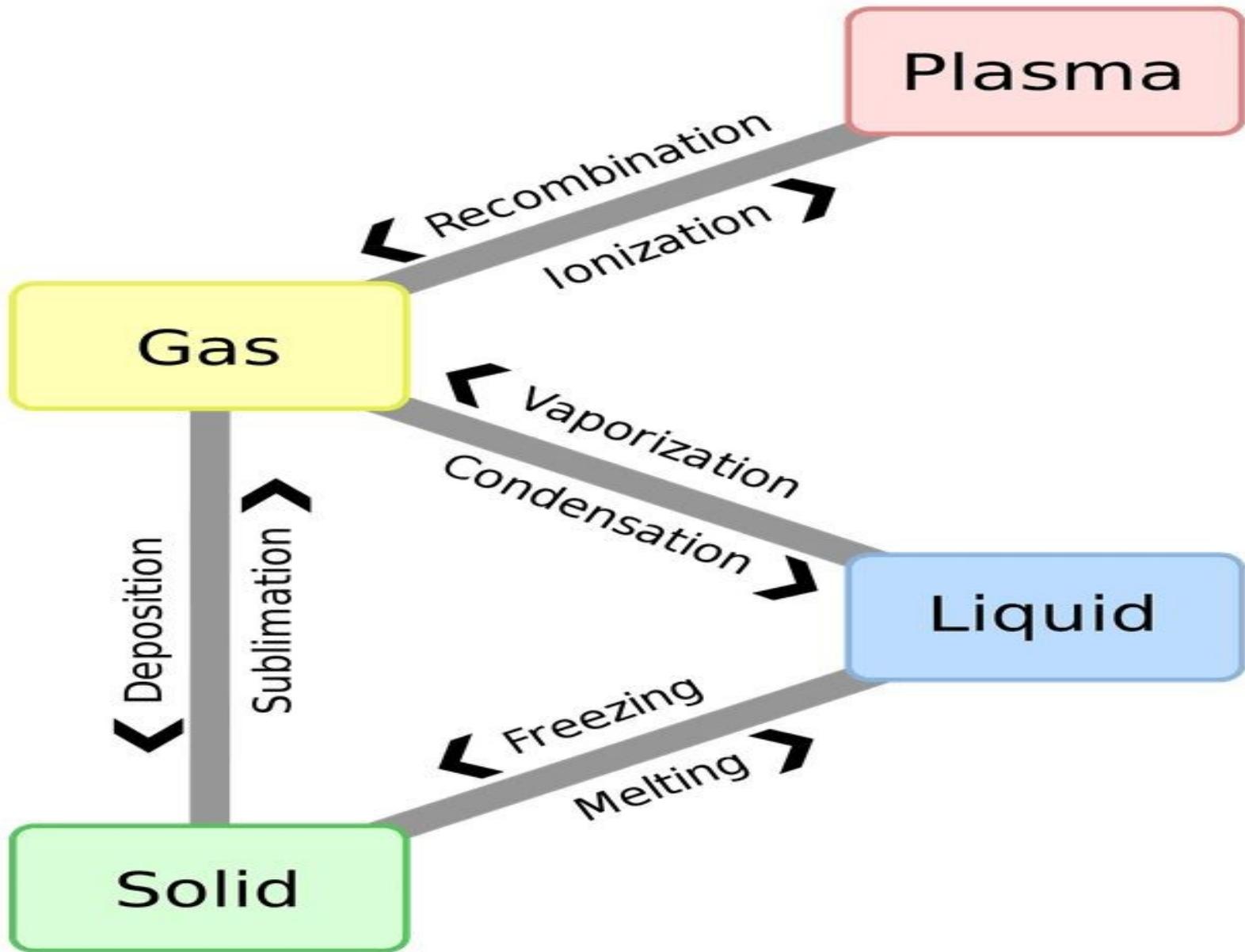
LIQUID



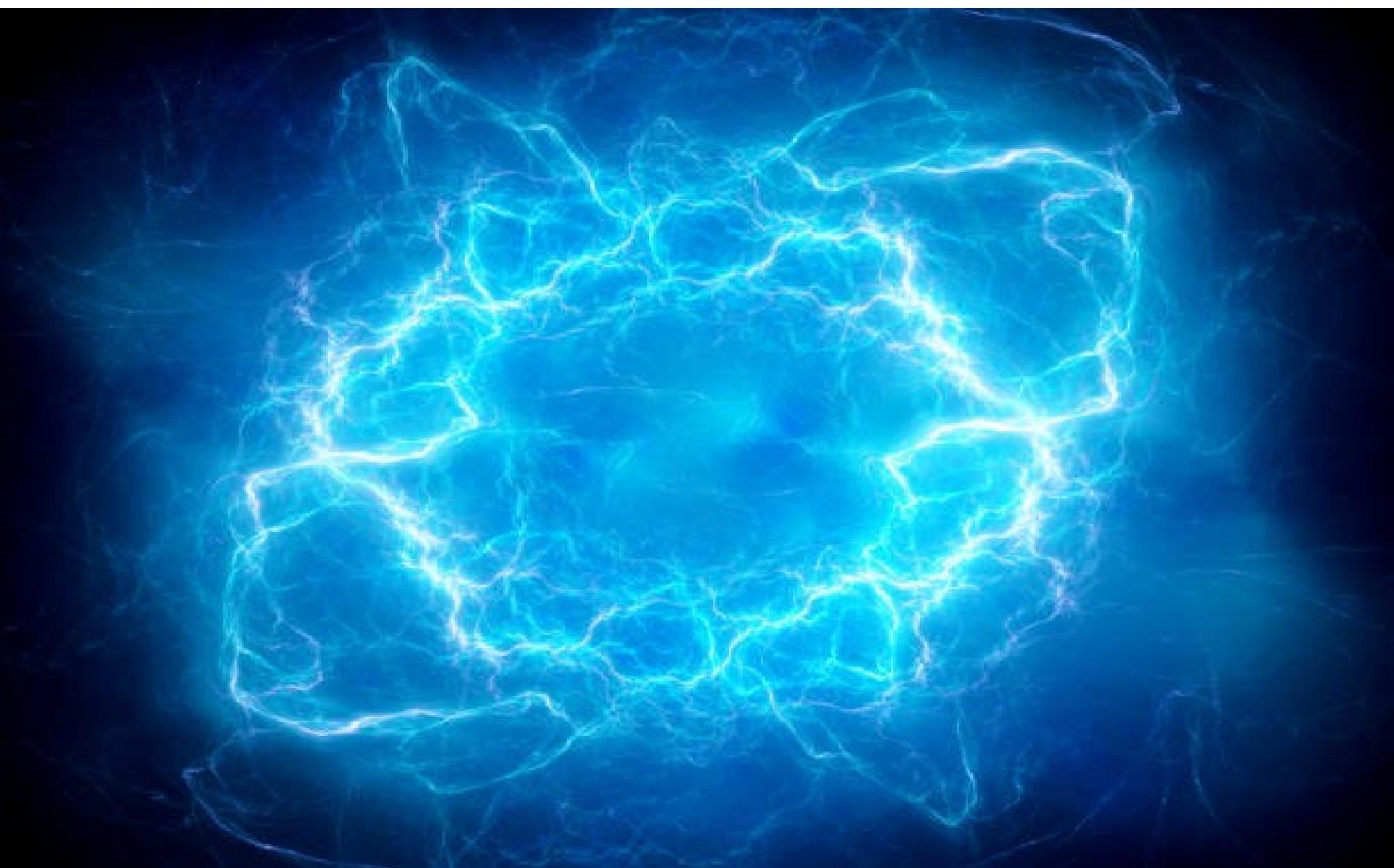
GAS



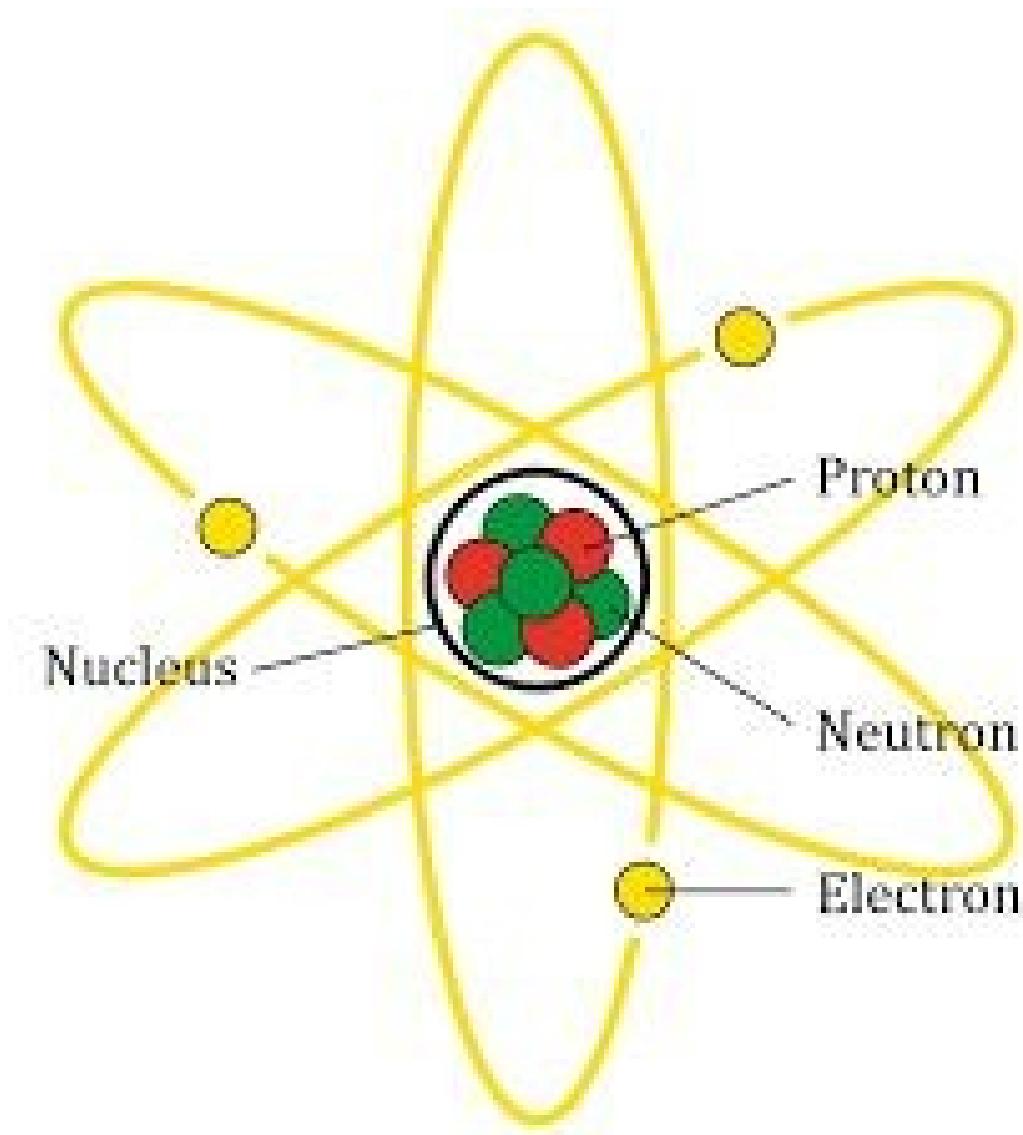
PLASMA



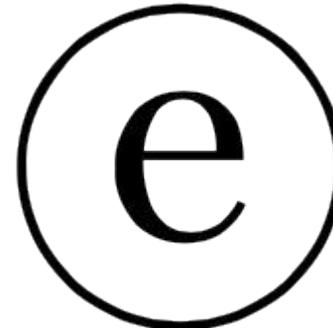
Plasma



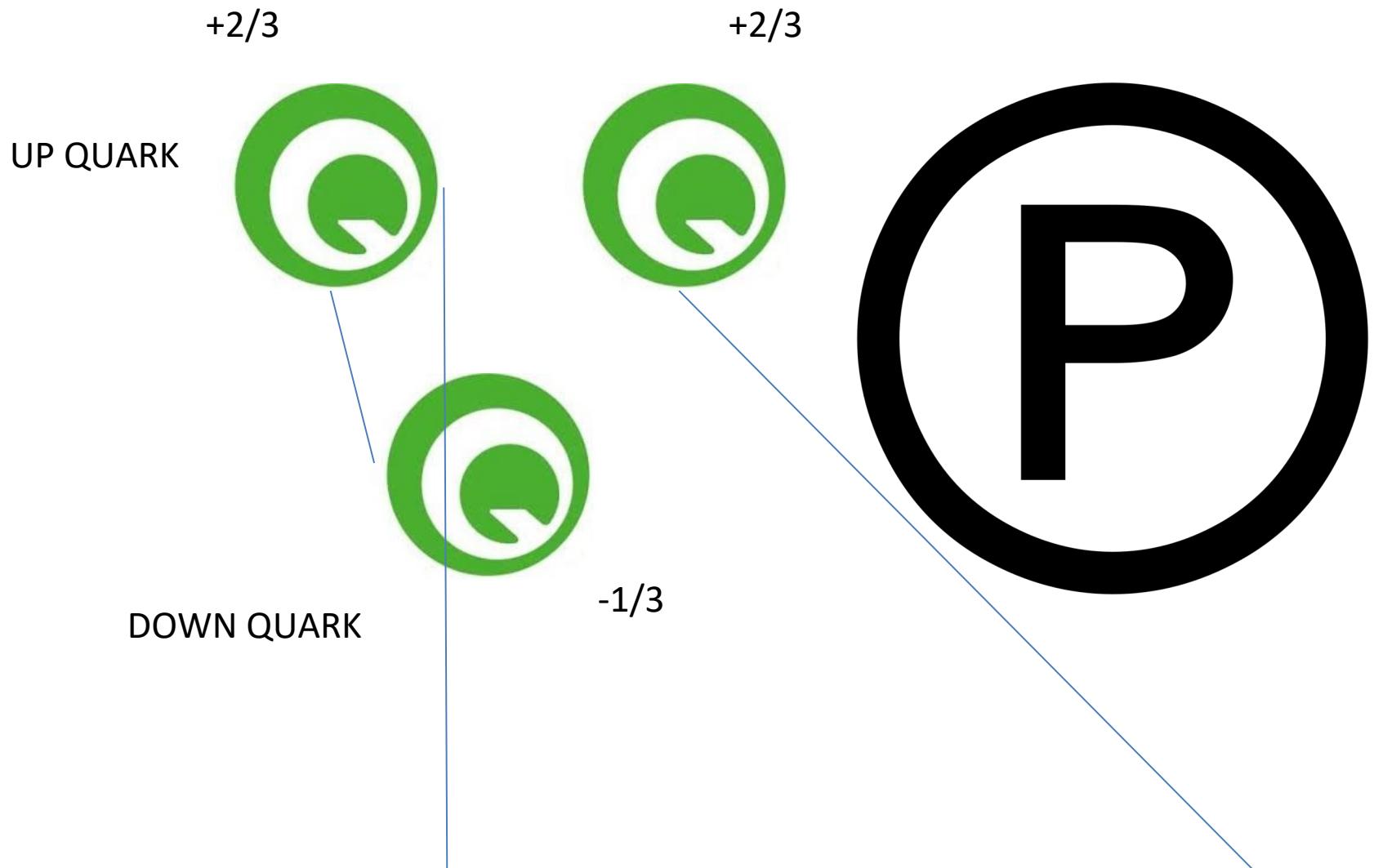
Atom

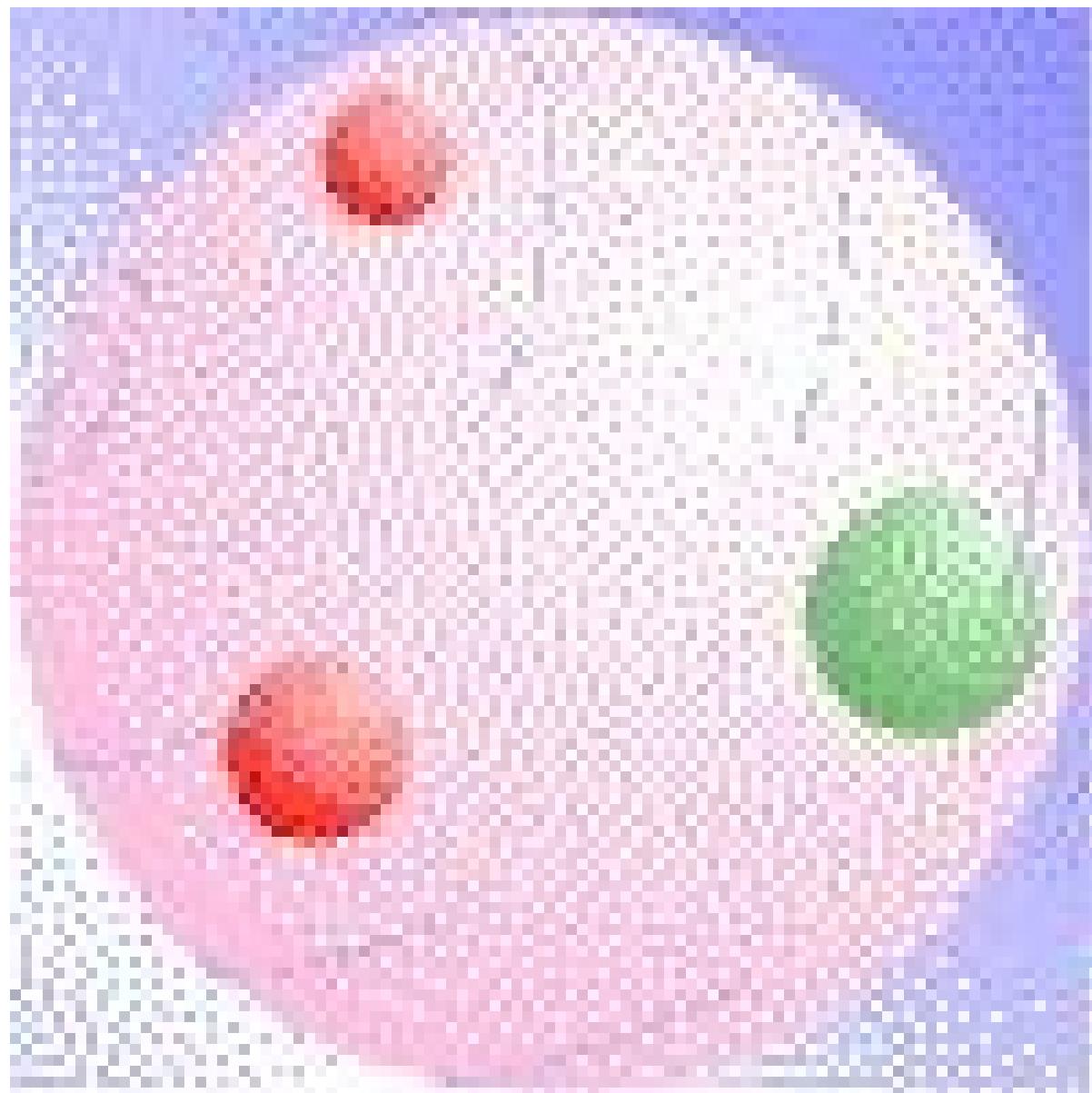


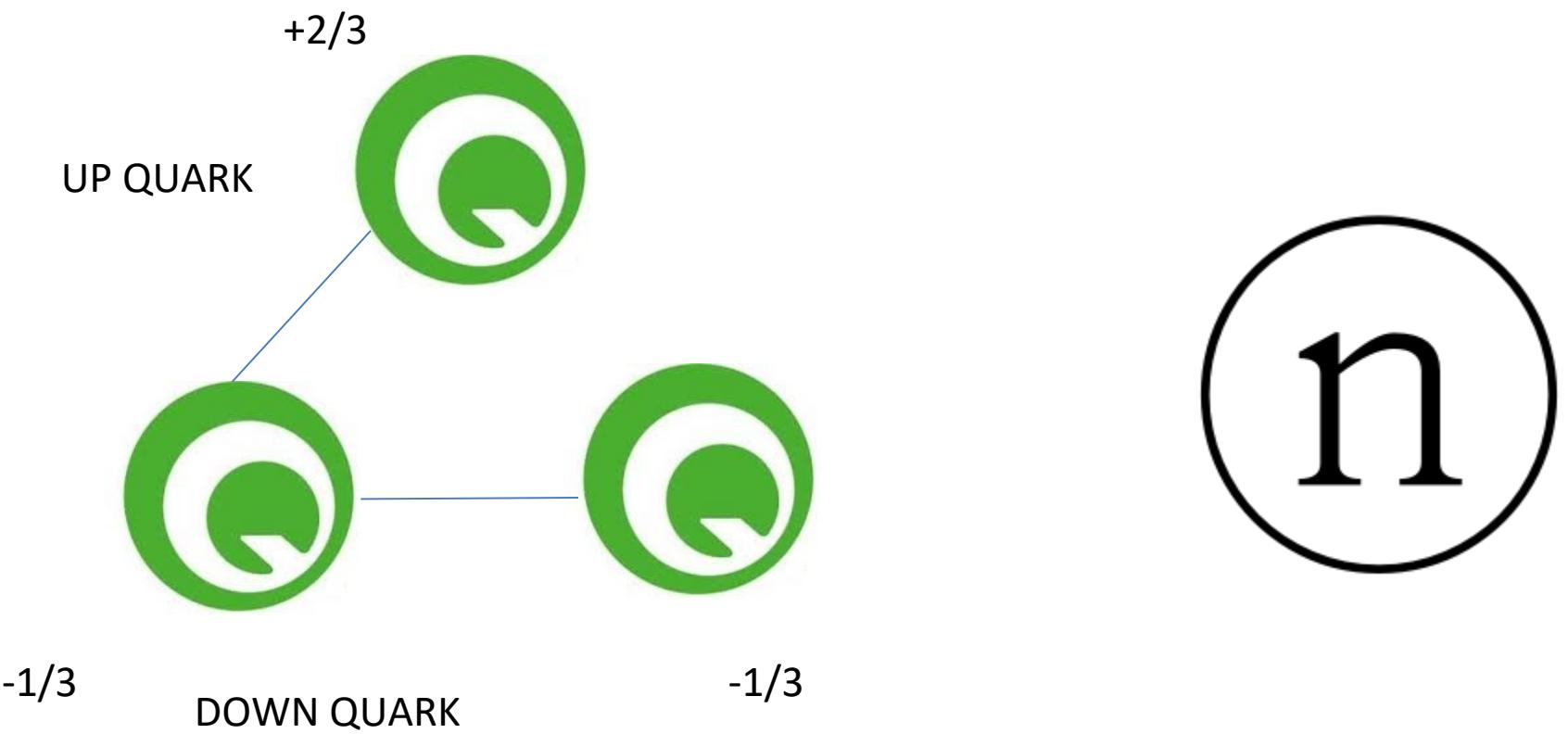
Lepton

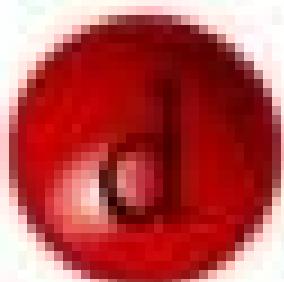


Quark

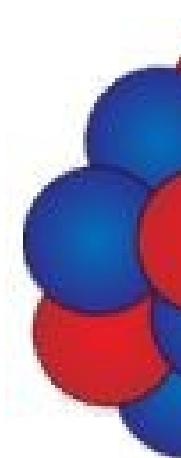






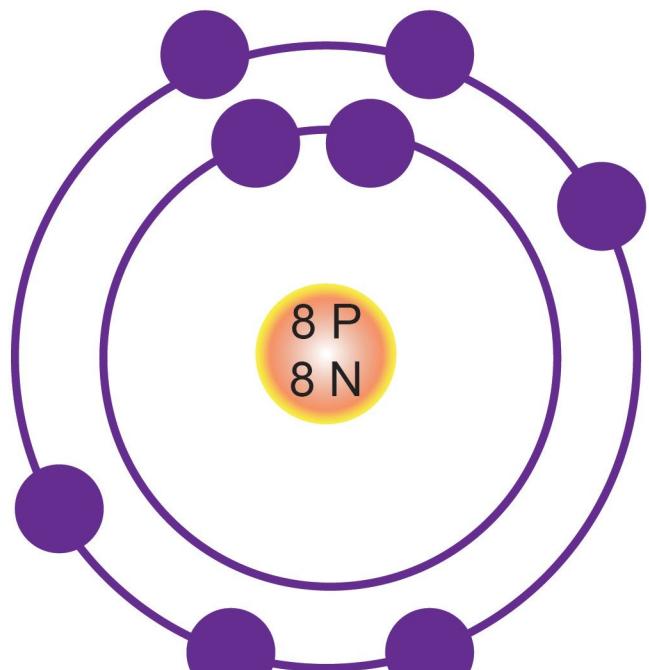


Isotope

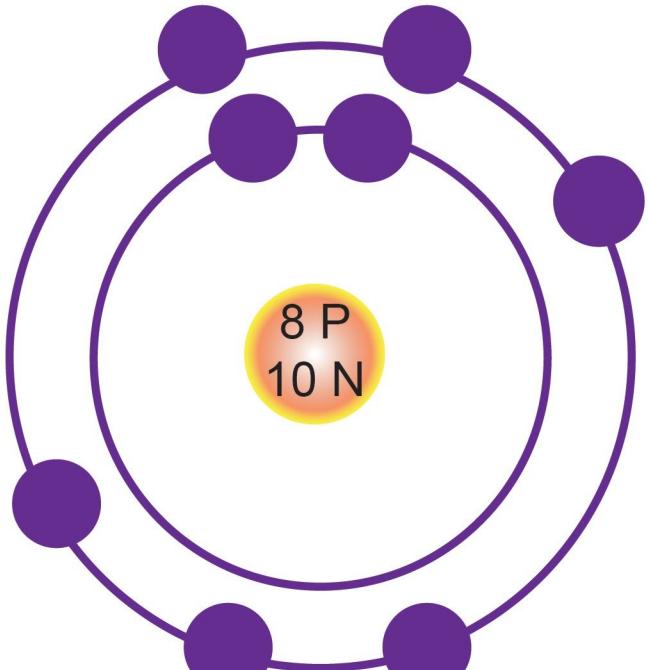


Ca

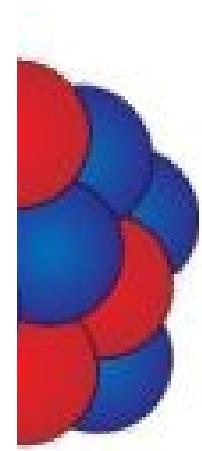
6
6



^{16}O Isotope



^{18}O Isotope



1-14

%

OOS

ons

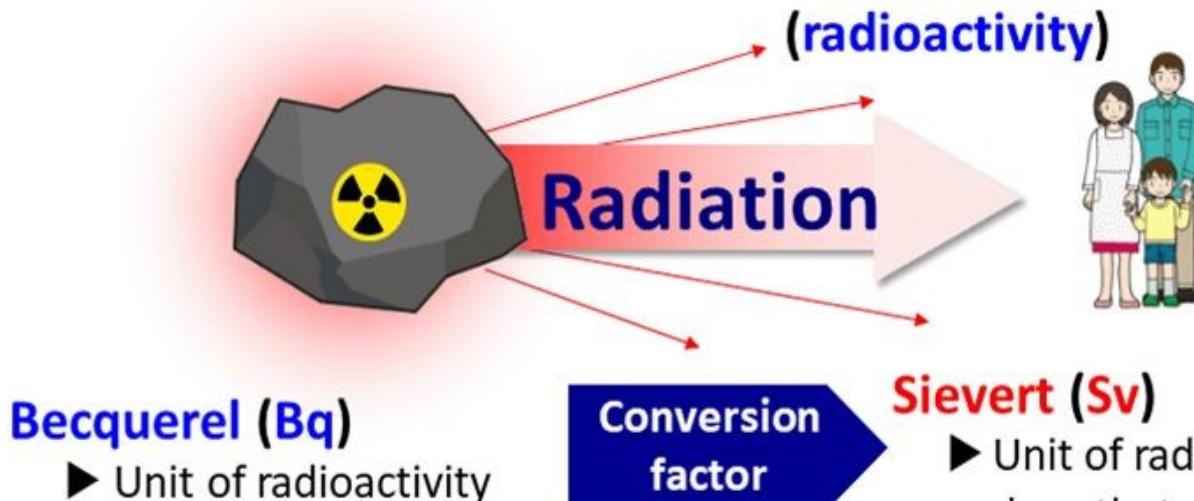
Radioactivity

- Lightbulb = Has the ability to emit light



Lux (lx)
► Unit of brightness

- Radioactive materials = Have the ability to emit radiation

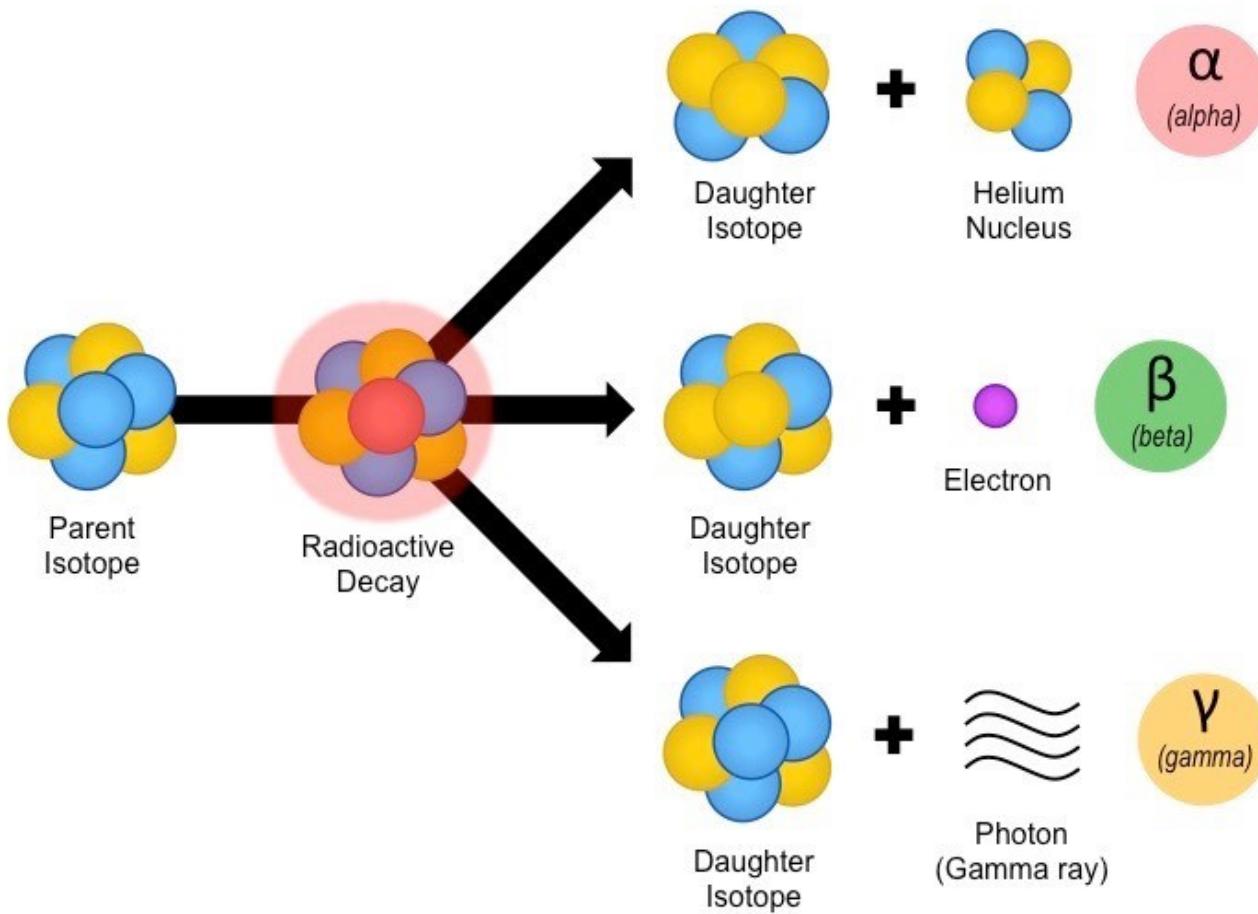


Sievert (Sv)
► Unit of radiation exposure dose that a person receives

*Sievert is associated with radiation effects.

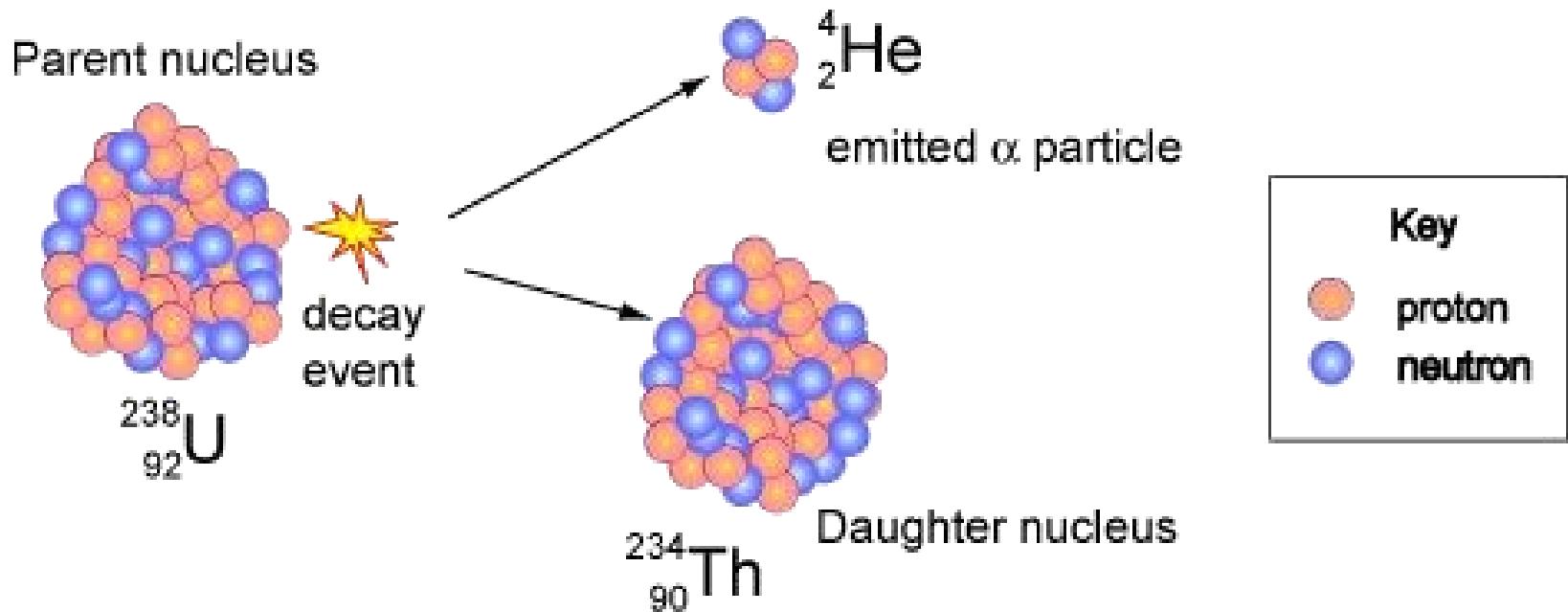
Nuclear fission

- Alpha Decay
- Beta Decay
- Gamma Decay

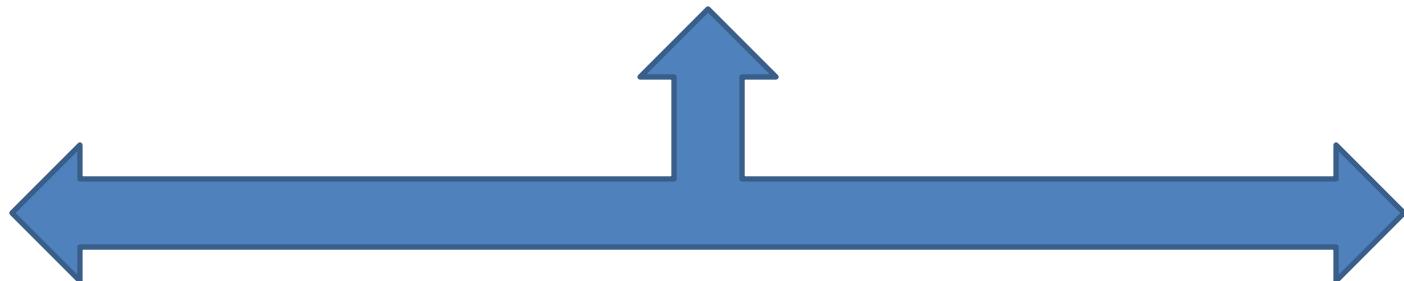


Alpha Decay

Alpha Decay of a Uranium-238 nucleus



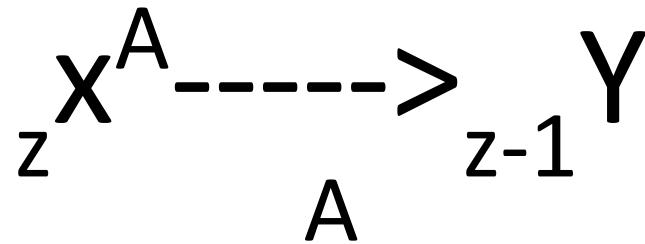
BETA DECAY



Beta +

$p \gg n$

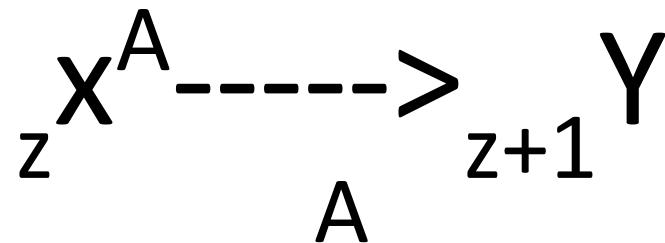
$p \rightarrow n + \text{positron} + \text{neutrino}$



Beta -

$n \gg p$

$n \rightarrow p + \text{electron}$



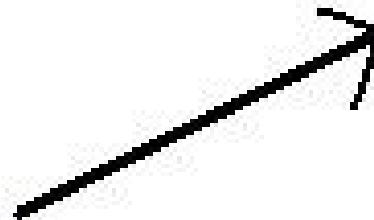
Gamma Decay

Excited State

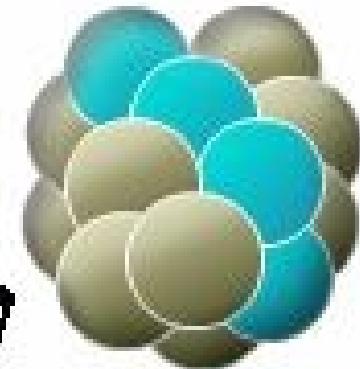
$^{137}_{56}\text{Ba}$

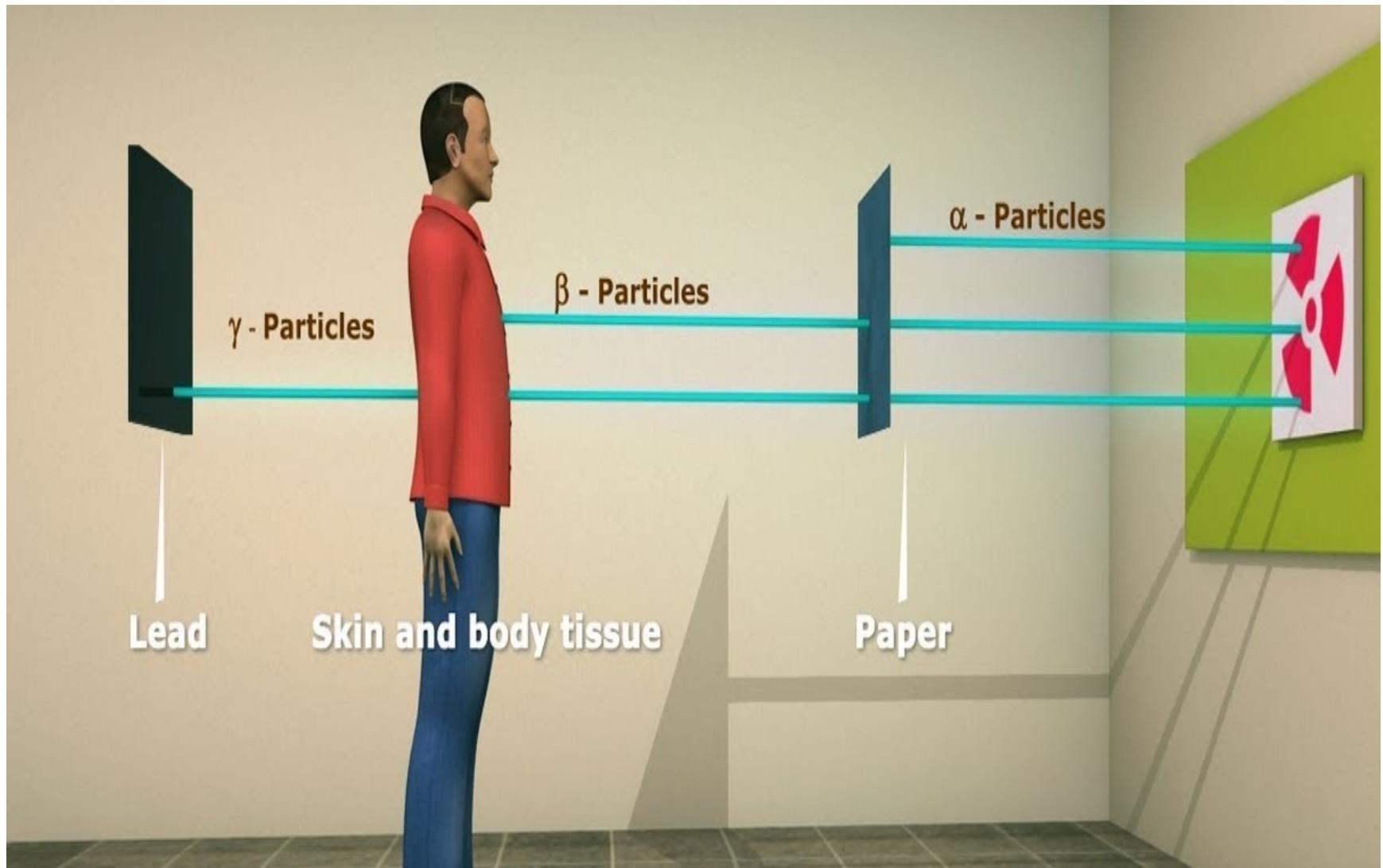


Gamma Quantum
(Photon)



$^{137}_{56}\text{Ba}$



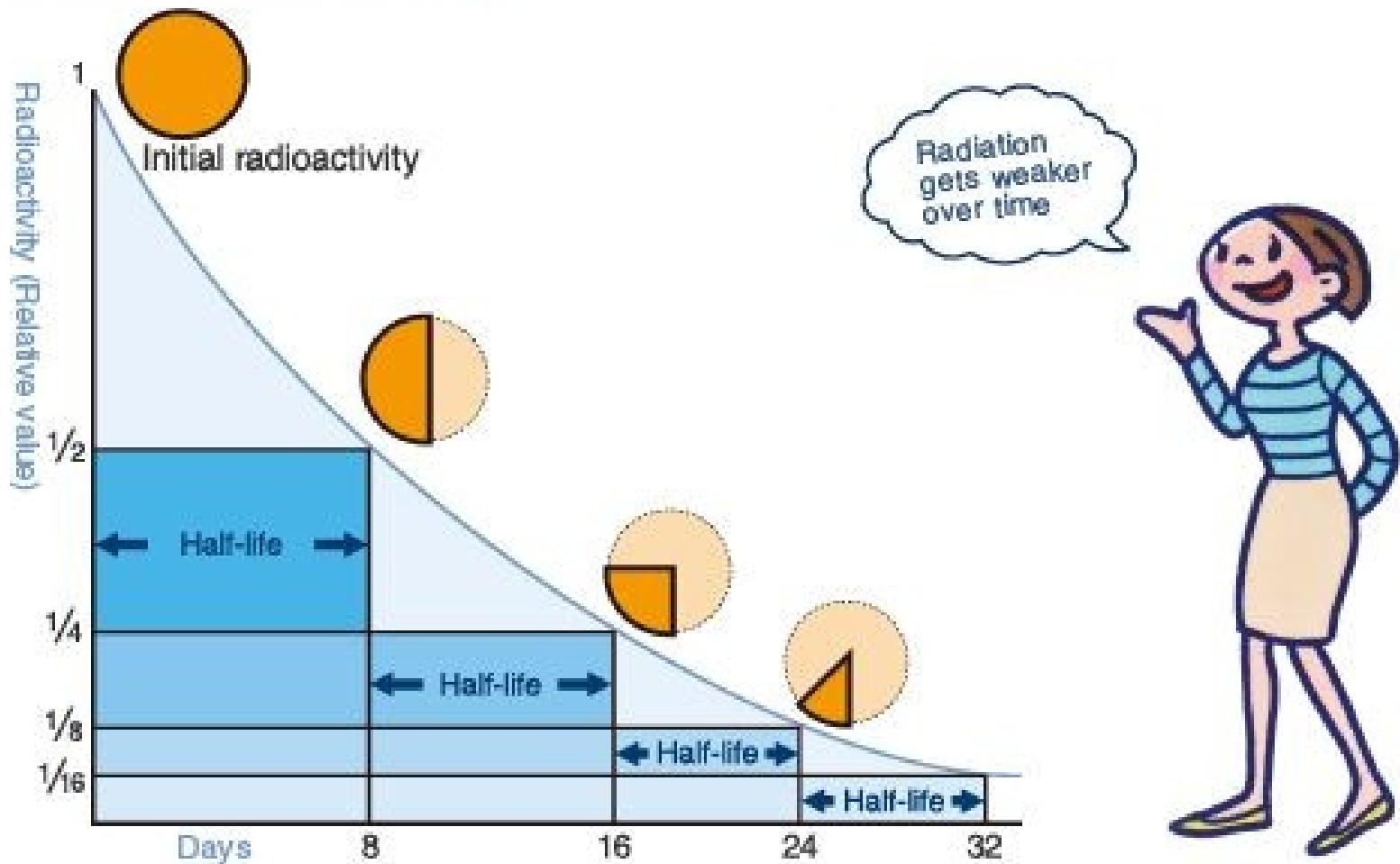


Nuclear Fusion

- $\text{H} + \text{H} \xrightarrow{\hspace{1cm}} \text{He} + \text{Stellar Energy} + \text{Neutrino}$

Half life

[How radioactivity decays] Iodine 131

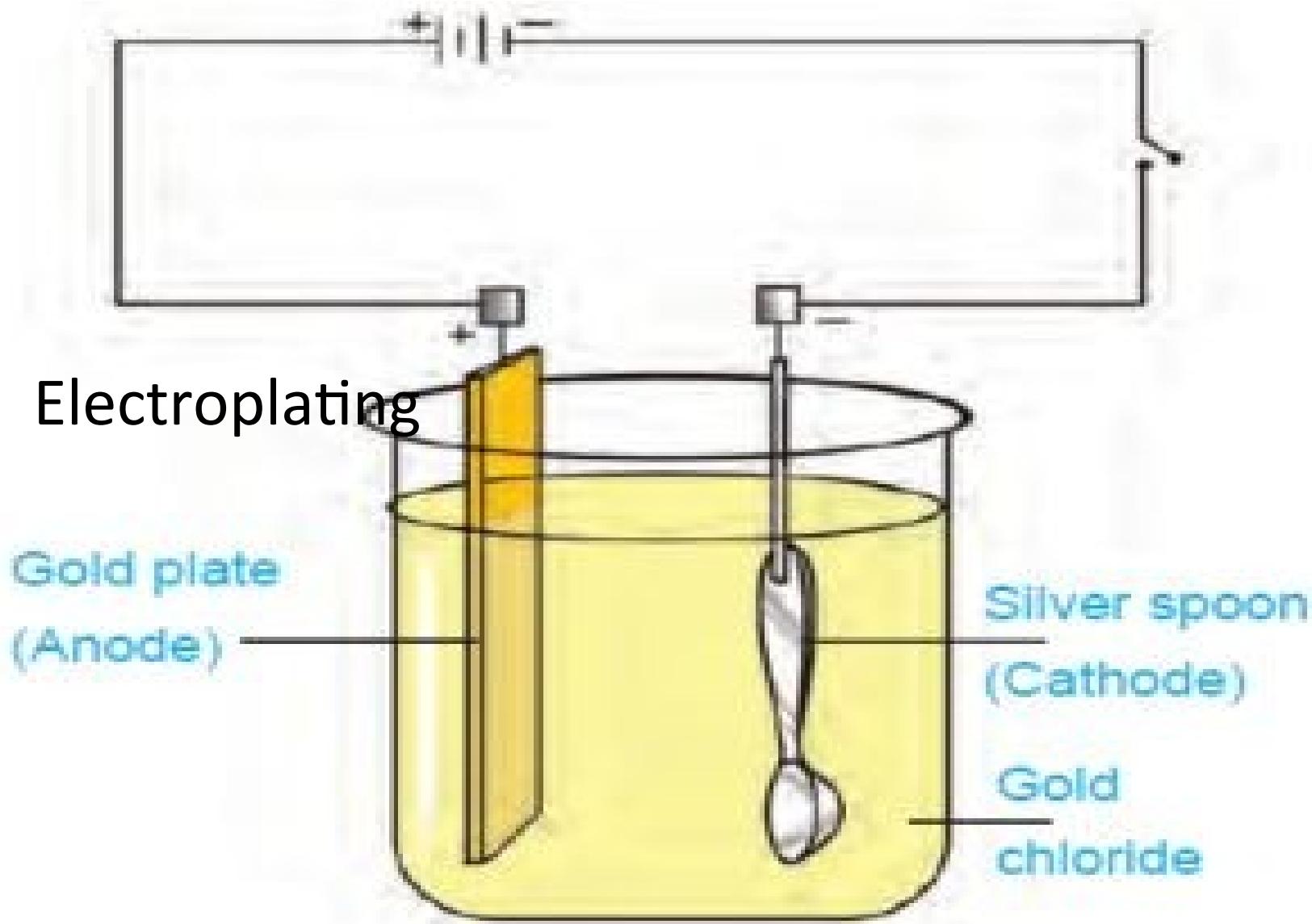


- **The function of heavy water in a nuclear reactor is to [UPSC 2011 (CS-P)]**
- Slow down the speed of neutrons
- Increase the speed of neutrons
- Cool down the reactor
- Stop the nuclear reaction
- Ans- A

- Radioactivity is measured by [UPSC 2008]
- Geiger-Muller counter
- Polarimeter
- Calorimeter
- Colorimeter
- Ans- A

- The phenomenon of radioactivity was discovered by [UPSC 2008]
- Madam Curie
- J.J. Thomson
- Roentgen
- Becquerel
- Ans-D

Electrochemistry



Corrosion vs Galvanisation





bewajah marta main hi hoon

Allotropes

- Some chemical elements are known to exist in two or more different forms because the atoms are bounded together in different manners.

Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Group Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	1 H																2 He		
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6	55 Cs	56 Ba	57 La	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	*	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
	*	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu				
*	*	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr				

Metals and Non Metals

																		Metal	Metalloid	Nonmetal				
H																					He			
Li	Be																		B	C	N	O	F	Ne
Na	Mg																	Al	Si	P	S	Cl	Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr							
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe							
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn							
Fr	Ra	Ac-Lr																						

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu							
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr							

- **Which one of the following non-metals is not a poor conductor of electricity? [UPSC Civil Services, 2007]**
- Sulphur
- Selenium
- Bromine
- Phosphorus
- Ans- B

Halogens

- A gas used as a disinfectant in drinking water is [UPSC 2008]
- Hydrogen
- Oxygen
- Fluorine
- Chlorine
- Ans- D

Inert Gases

Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
↓ Period																		
1	1 H																2 He	
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
Lanthanides		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu		
Actinides		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr		

The Noble Gases



Uses of Inert gases

THE NOBLE GASES

noble gases

several inert gases



Because they are unreactive they are safe to use. When a current is passed through them they **glow**.

Gas	Uses
Helium	-it is lighter than air it is used to fill balloons and airships, it does not catch fire
Argon	-as a filler in light bulbs -protect metals that are being welded (does not react)
Neon	-advertising signs, glows red but colour can be changed if mixed with other gases
Krypton	-lasers (eye surgery) -car headlights
Xenon	-gives a light similar to daylight but with a blue tinge -car headlights, lighthouse lights, operating rooms

Rare Earth Elements

H	Rare Earth Elements														He
Li	Be														B
Na	Mg														C
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te
Cs	Ba	Lanth.	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po
Fr	Ra	Act.	Rf	Db	Sg	Bh	Hs	Mt							At

Lanthanides

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Actinides

Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
----	----	----	---	----	----	----	----	----	----	----	----	----	----	----

Uses of Rare Earth Elements

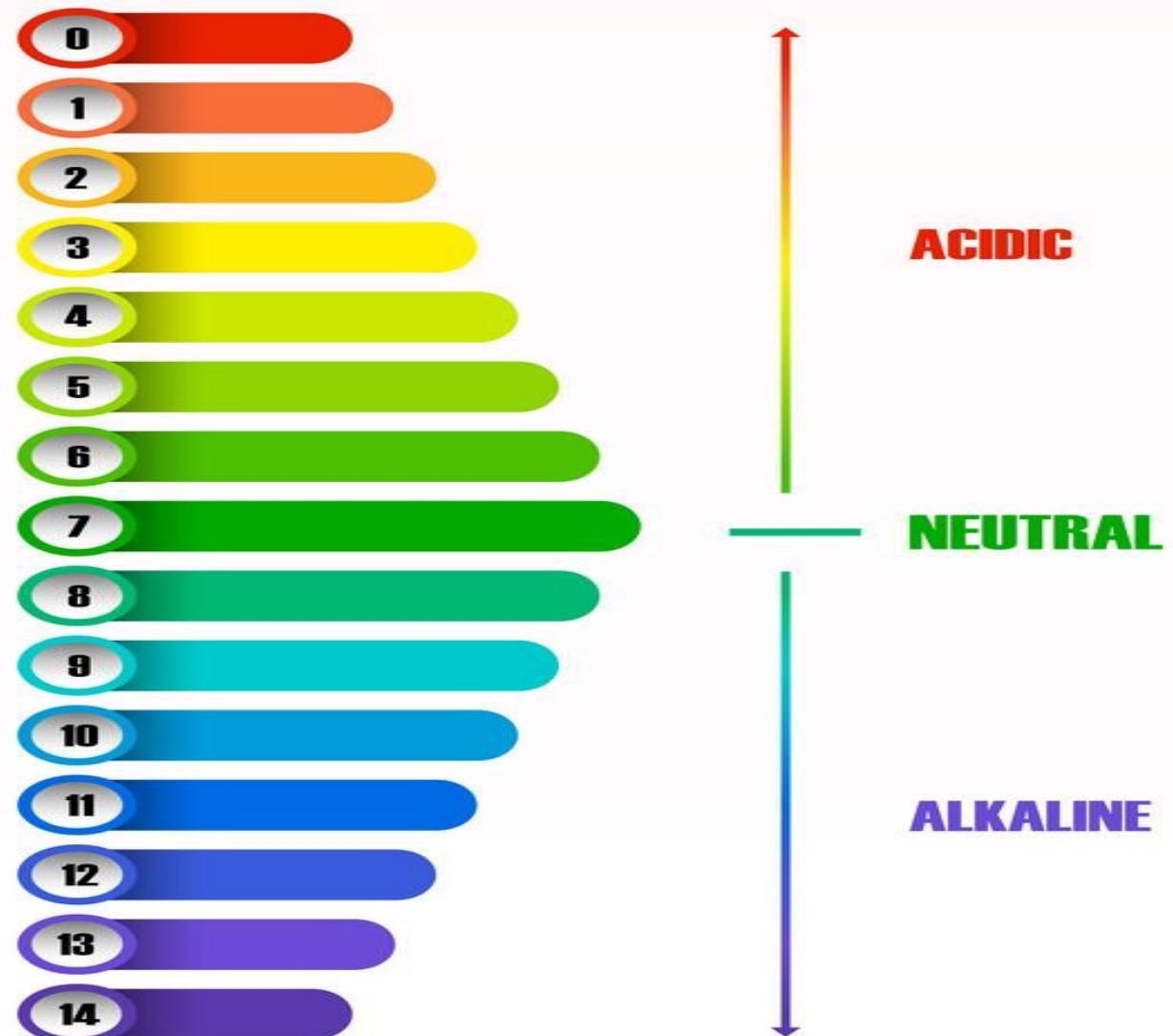


- **Recently, there has been a concern over the short supply of a group of elements called ‘rare earth metals’. Why?**
- 1. China, which is the largest producer of these elements, has imposed some restrictions on their export.
- 2. Other than China, Australia, Canada and Chile, these elements are not found in any country.
- 3. Rare earth metals are essential for the manufacture of various kinds of electronic items and there is a growing demand for these elements.
- Which of the statements given above is/are correct?
- [A]1 Only
- [B]2 & 3 Only
- [C]1 & 3 Only
- [D]1,2 & 3
- Ans C

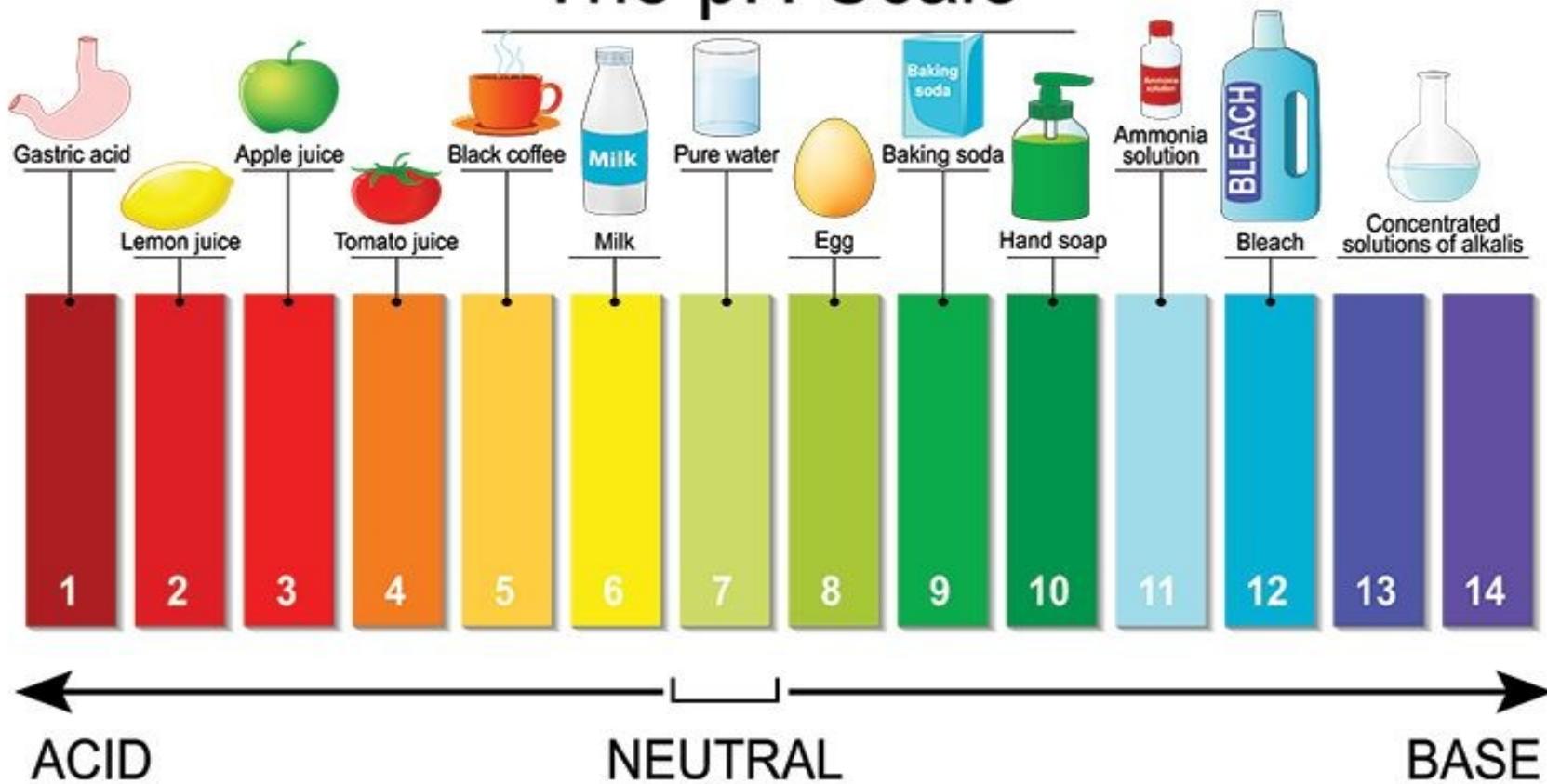
- **Salts of which of the following elements provide colours to fireworks? [UPSC Civil Services, 2004]**
- Zinc and sulphur
- Potassium and mercury
- Strontium and barium
- Chromium and nickel
- **Ans- C**

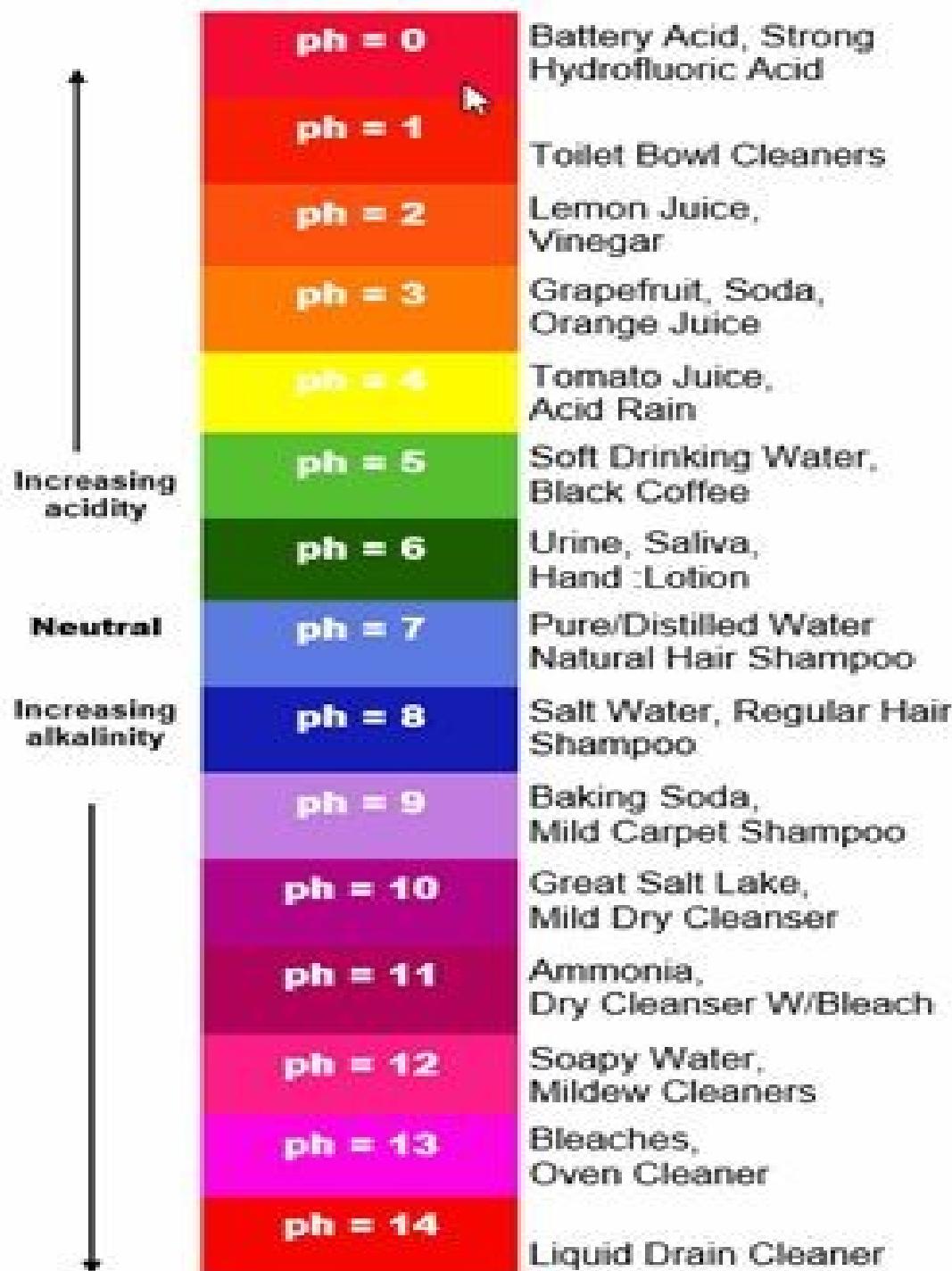
PH Scale

The
pH
scale



The pH Scale





Acids

- Organic vs Inorganic acids



Base



Salt



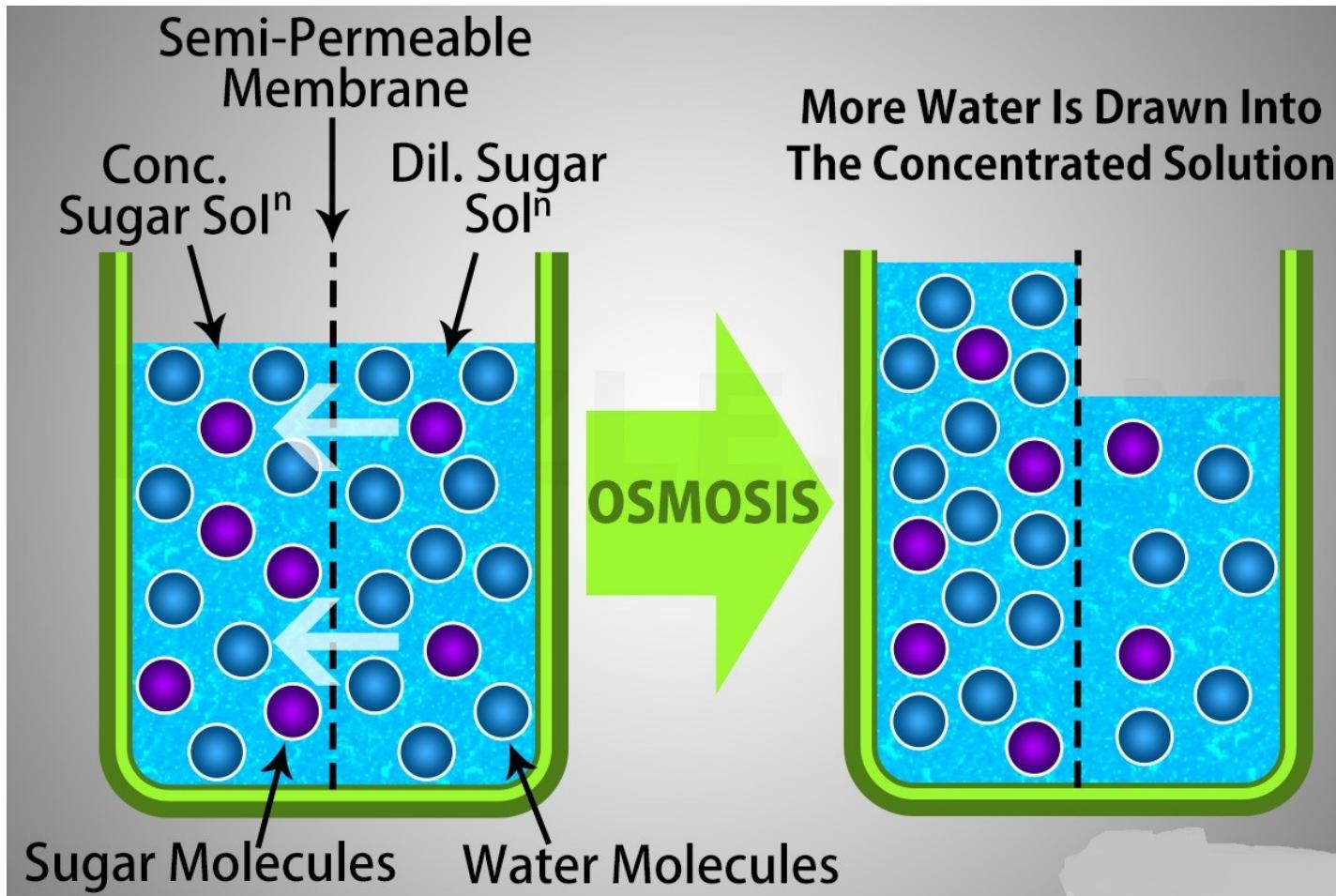
Viscosity



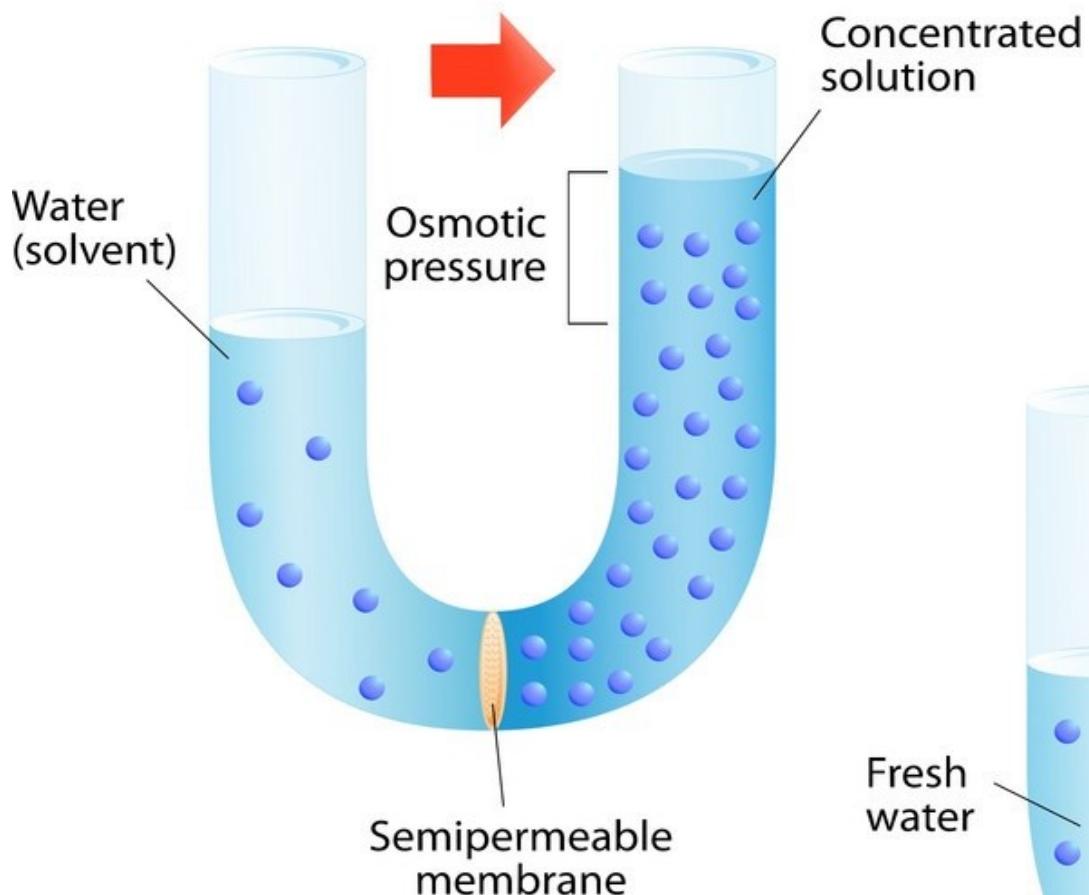
Endothermic Vs Exothermic Reactions



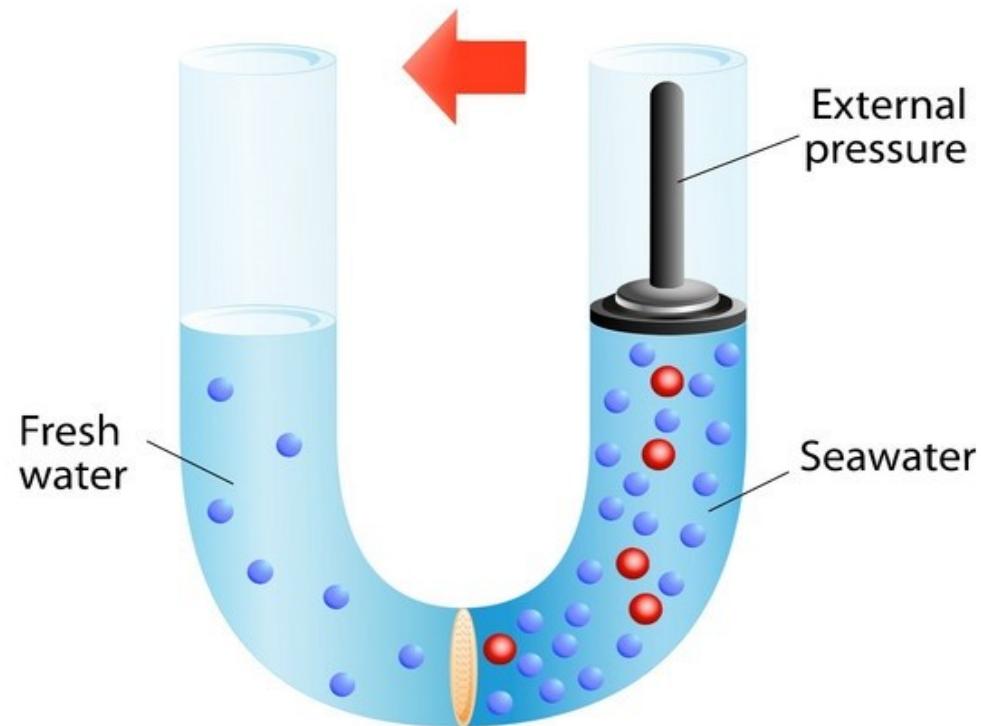
Osmosis



Reverse Osmosis Osmosis



Reverse osmosis



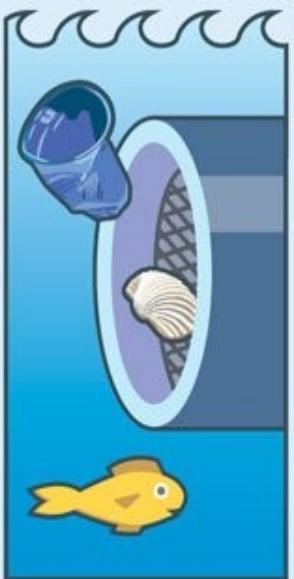
How seawater desalination works

M&G

1

SCREENING

Seawater intake pipes have screens to keep out sea life and debris



2

FILTERING

Sediment, sewage and bacteria are filtered out of the seawater



3

DESALINATION

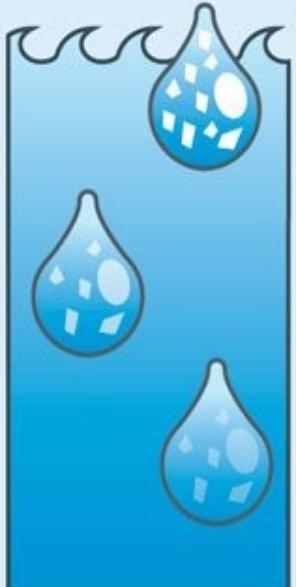
The seawater is forced through a membrane that lets through water molecules but not salt particles



4

WASTEWATER

Any leftover seawater is highly salted and needs to be diluted before it is returned to the sea



5

CHLORINATION

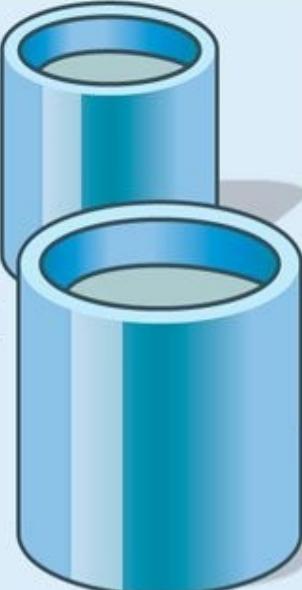
The desalinated water is treated with chlorine to keep it fresh



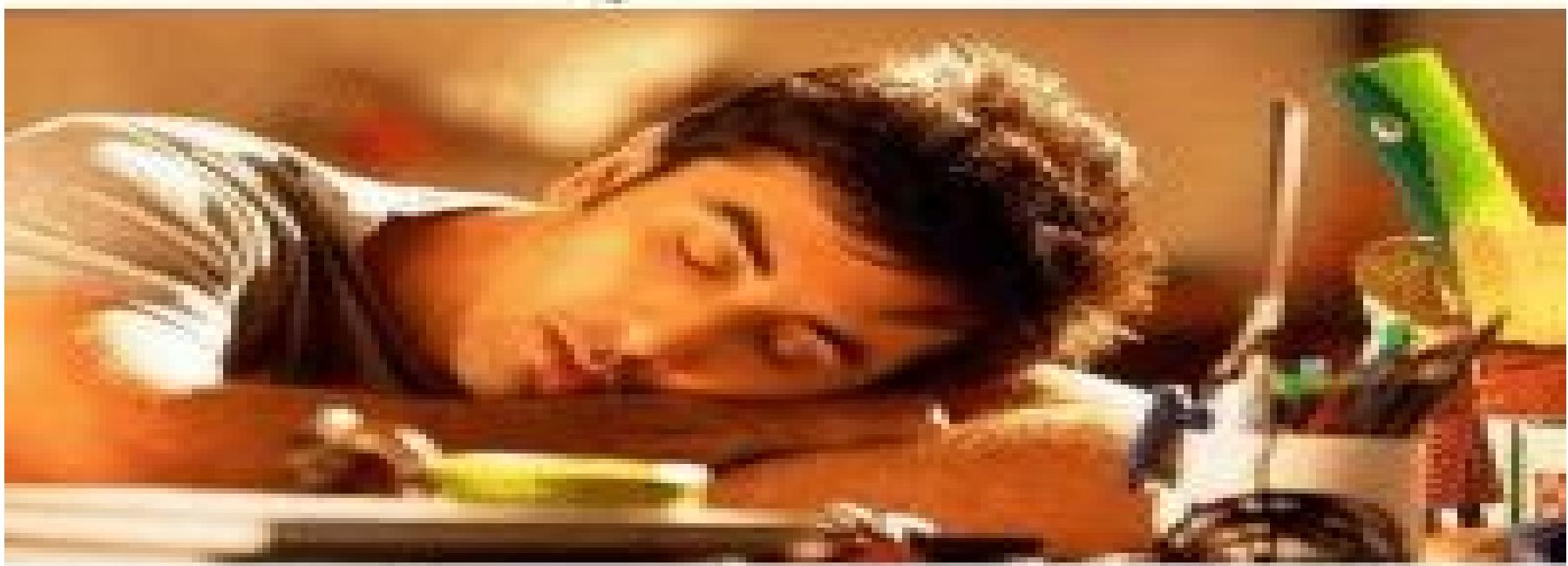
6

WATER SYSTEM

The chlorinated water is kept in storage tanks until needed for the municipal water supply

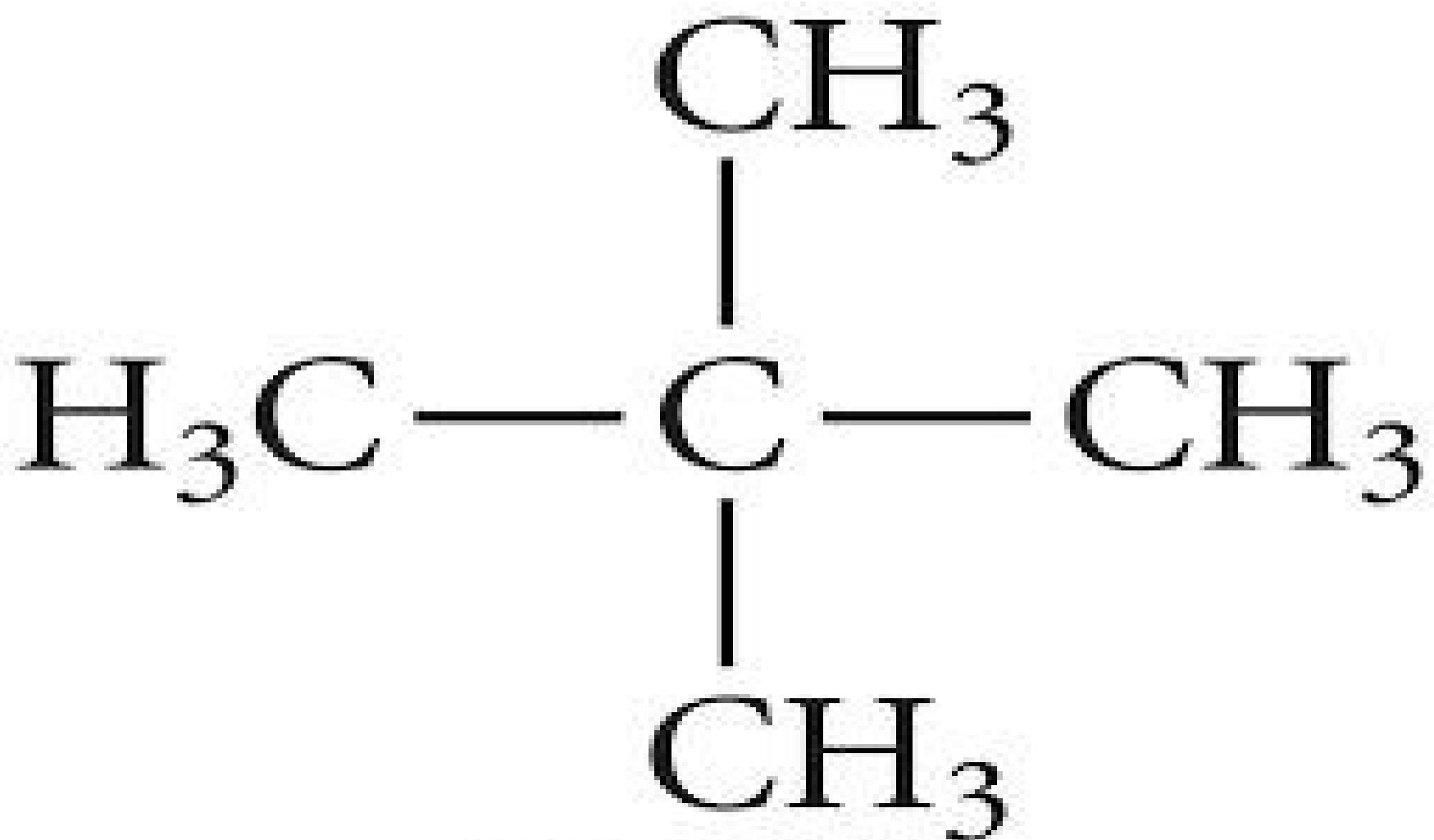


**I Wish I could just Sleep
on my Textbooks**



**And Learn Everything
Through Osmosis.**

Hydrocarbons around us



Alcoholic Beverages

- **Distilled beverage**
- **Un-distilled beverage**

Distilled beverage	% alcohol	Sources
Whisky	40-50%	Barley
Rum	45-55%	Sugar Cane
Brandy	40-50%	Grapes
Gin	35-40%	Maize

Un-distilled beverage	% alcohol	Sources
Bear	3-6%	Barley
Champagne	10-15%	Grapes
Port & Sherry	15-25%	Grapes
Cider	2-6%	Apple

Chemical Explosives

- RDX (Research & Development Explosive)
- TNG (Tri Nitro Glycerine)
- TNT (Tri Nitro Toluene)
- Dynamite
- TNP (Tri Nitro Phenol)

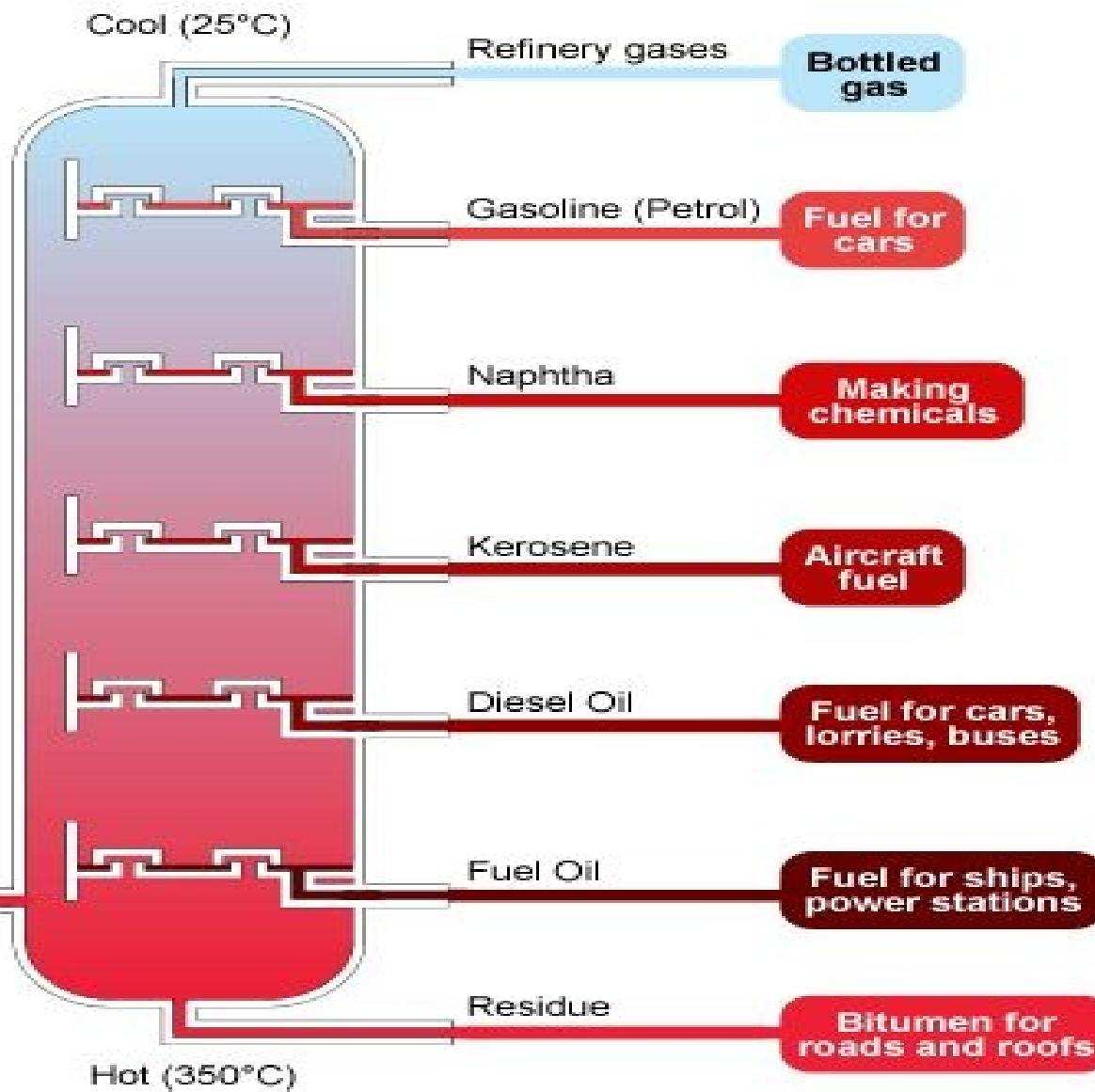
Fuels

- Solid fuel
- Liquid fuel
- Gaseous fuel

Solid fuel

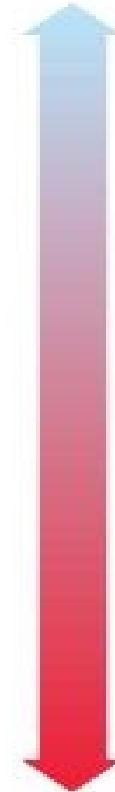
- Coal
- Wood
- Charcoal
- Cow dung cakes

Extraction of fuel from crude oil



Small molecules:

- low boiling point
- very volatile
- flows easily
- ignites easily

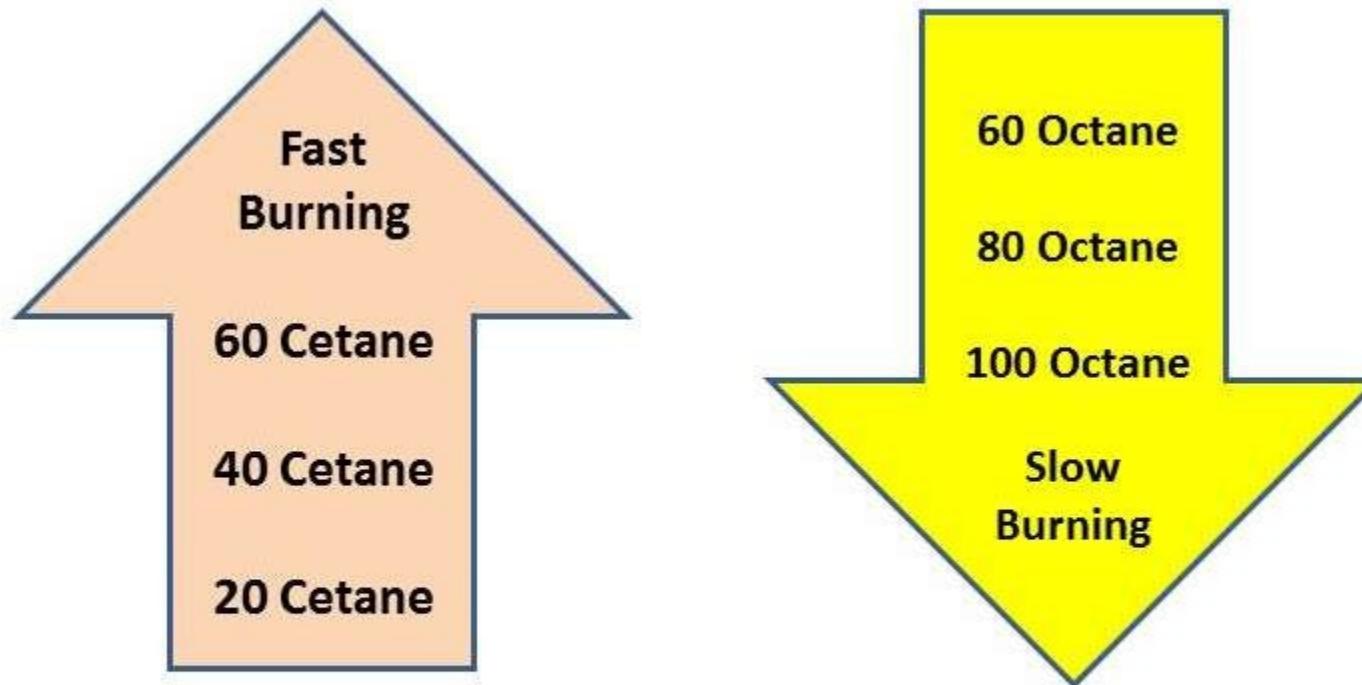


Large molecules:

- high boiling point
- not very volatile
- does not flow easily
- does not ignite easily

Knocking of engine

- Octane vs cetane number



Cetane Rating
(Diesel)

Octane Rating
(Gasoline)

Aviation turbine fuel



Gaseous fuels

- Water Gas, Producer Gas, Coal gas
- Natural gas, Biogas
- LPG, CNG

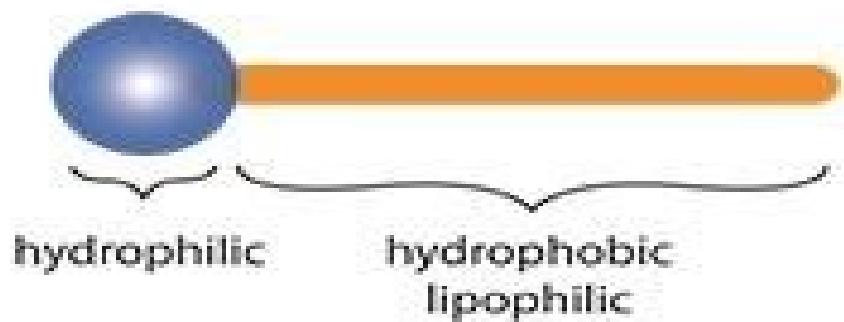
LPG

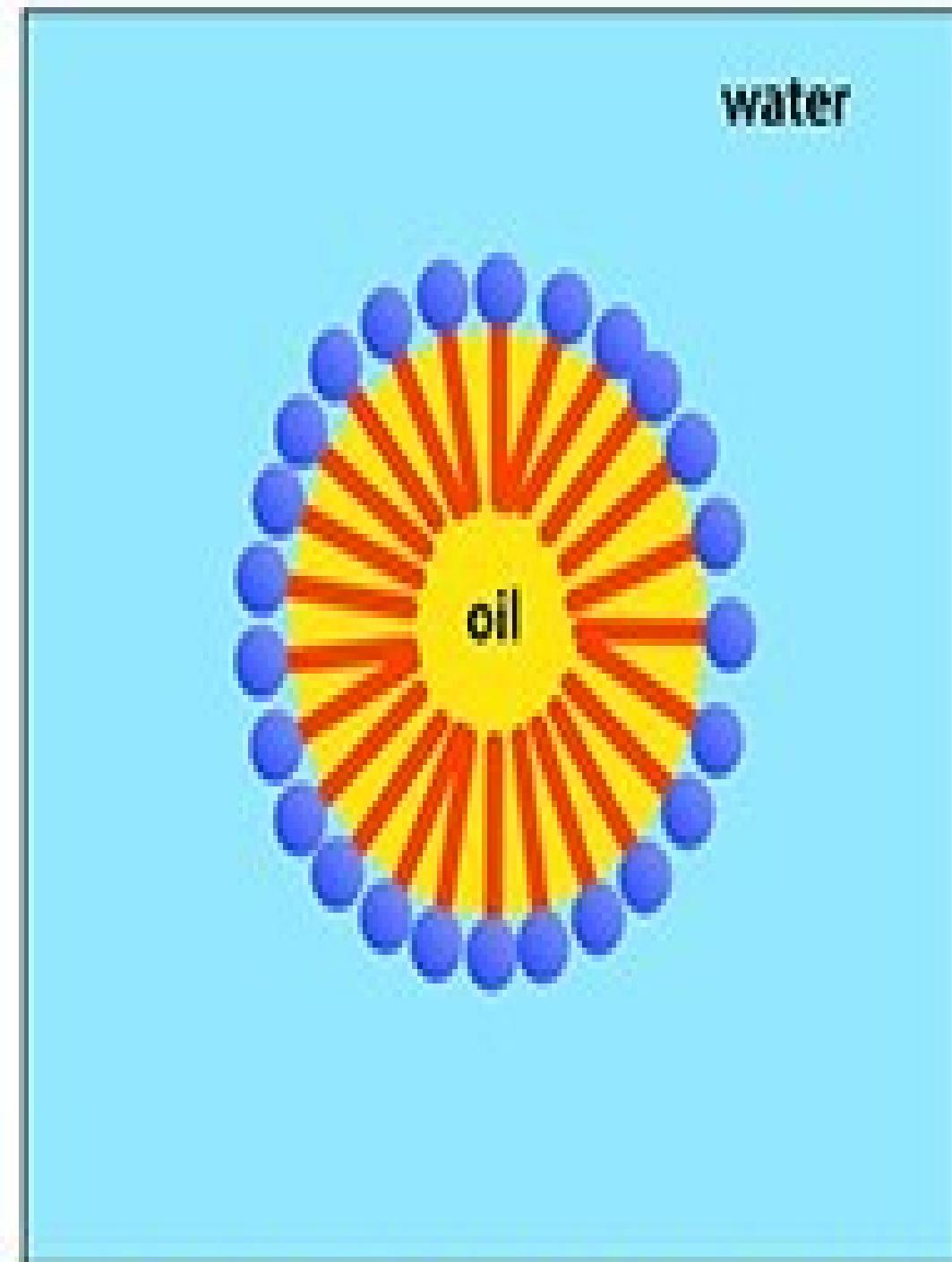
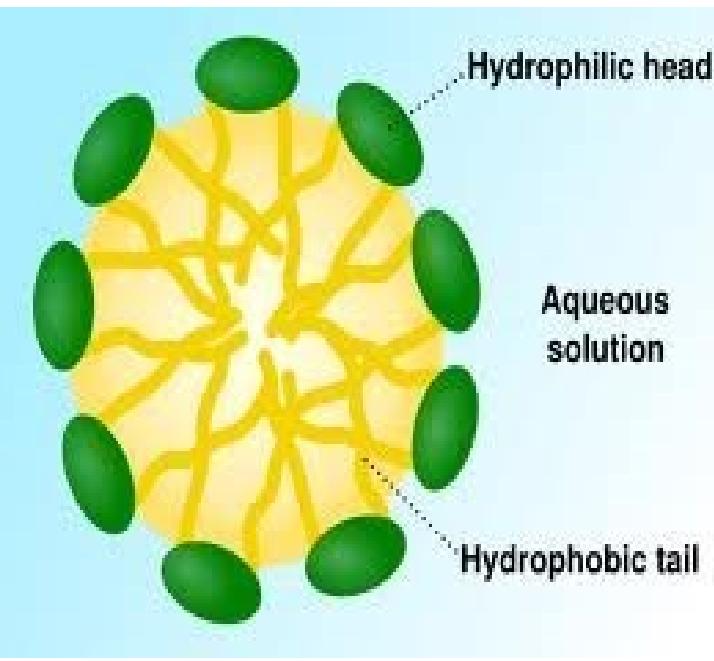


CNG



Soaps and Detergents : Chemistry of Surfactants

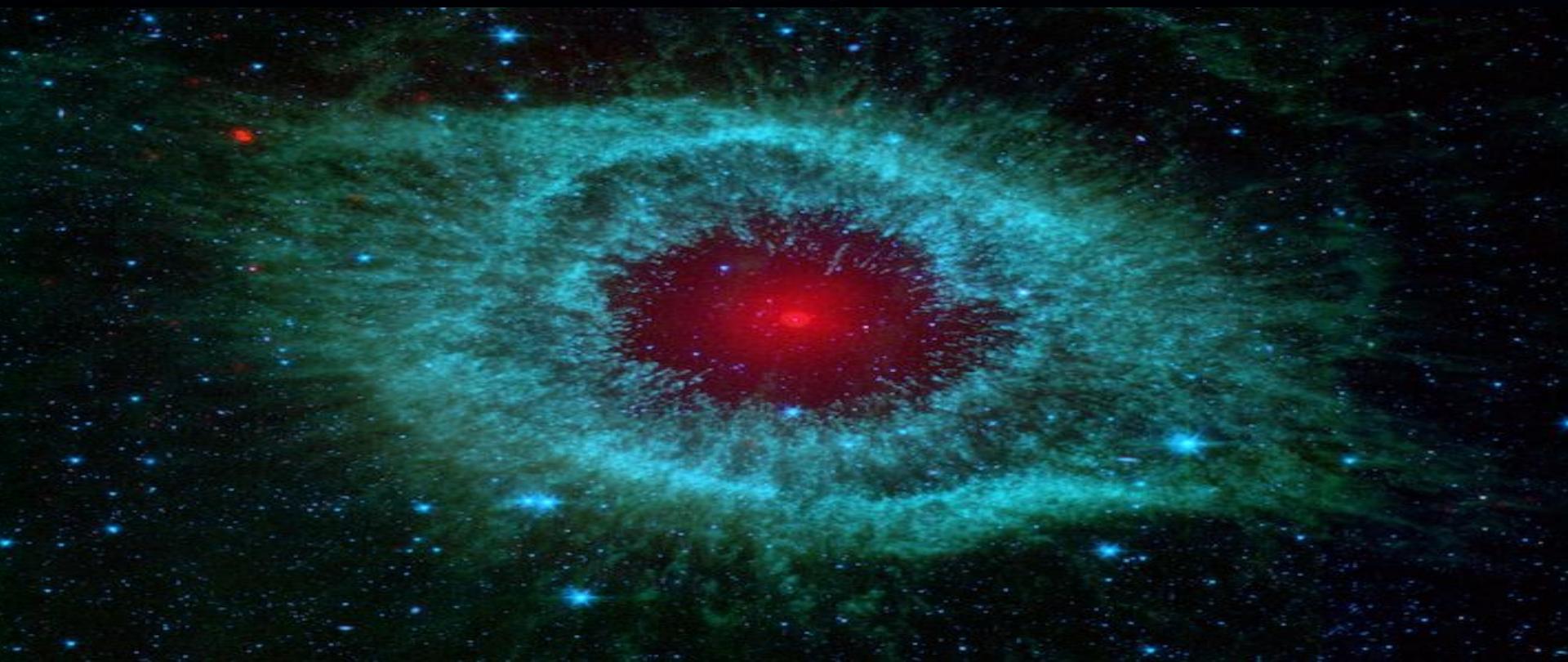
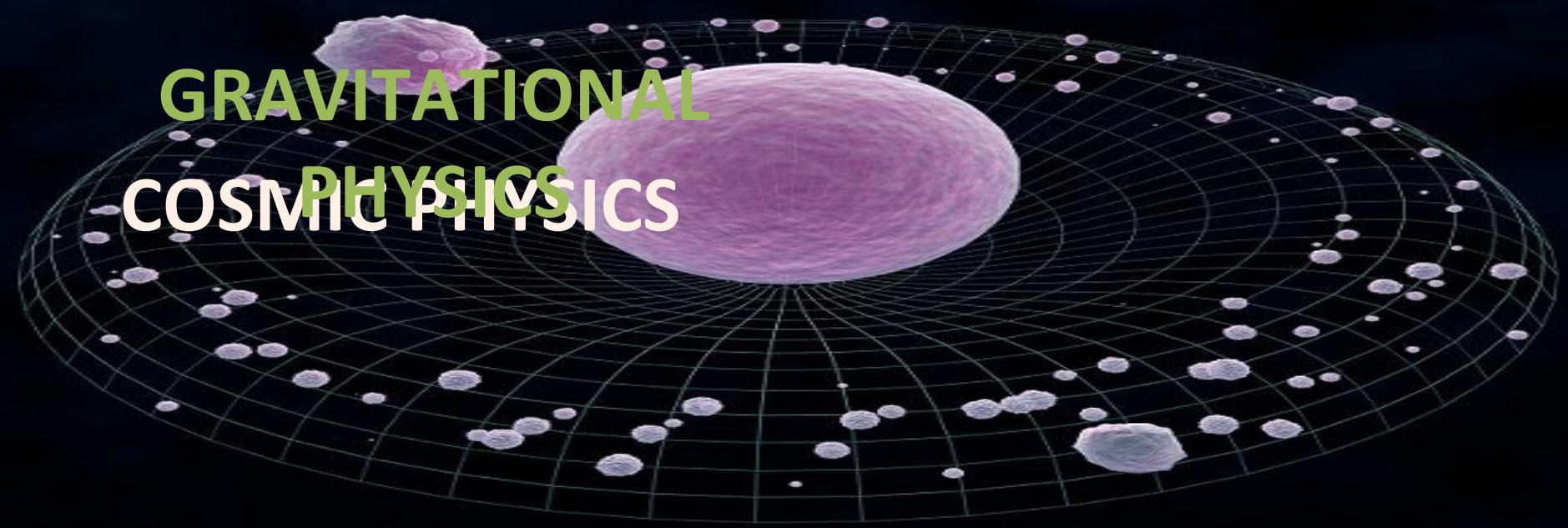




A cluster of glowing jellyfish against a dark background. The jellyfish are illuminated from within, appearing bright blue or cyan. They have large, rounded bell shapes and long, trailing tentacles. The tentacles are thin and wispy, with some having distinct, serrated edges. The overall effect is ethereal and luminescent.

Efflorescence

GRAVITATIONAL COSMIC PHYSICS



Agenda

- Laws of Gravitation- Newton's laws, kepler's law, escape velocity
- Cosmic Physics- Definitions like galaxy, dark matter, black hole
- Concepts of antimatter, fundamental particles
- Concept of big bang, Lifecycle of star
- Theory of relativity

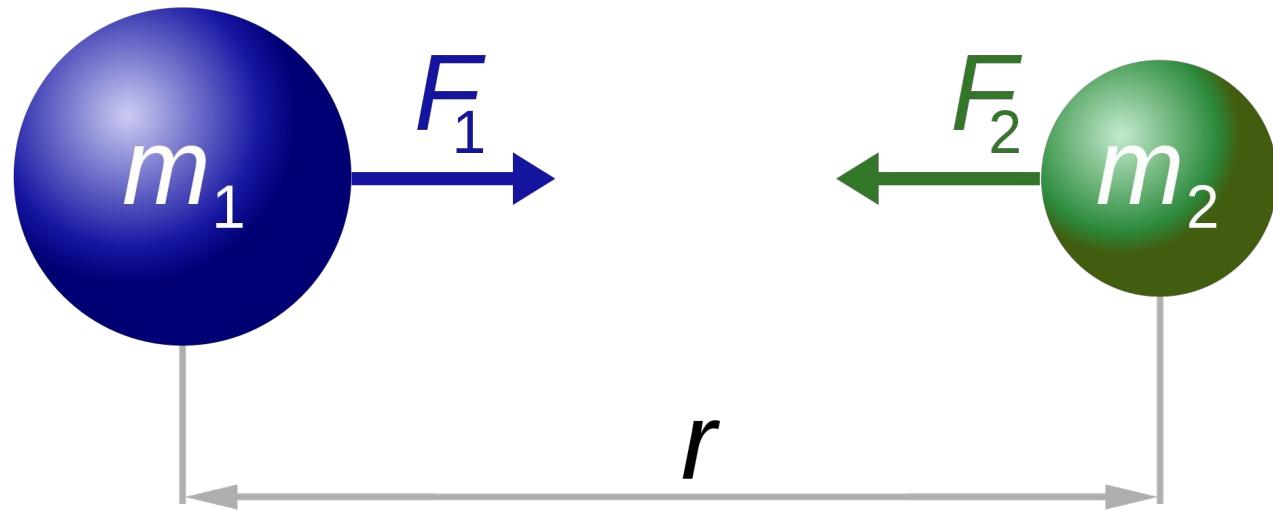
Gravitation



#86182546



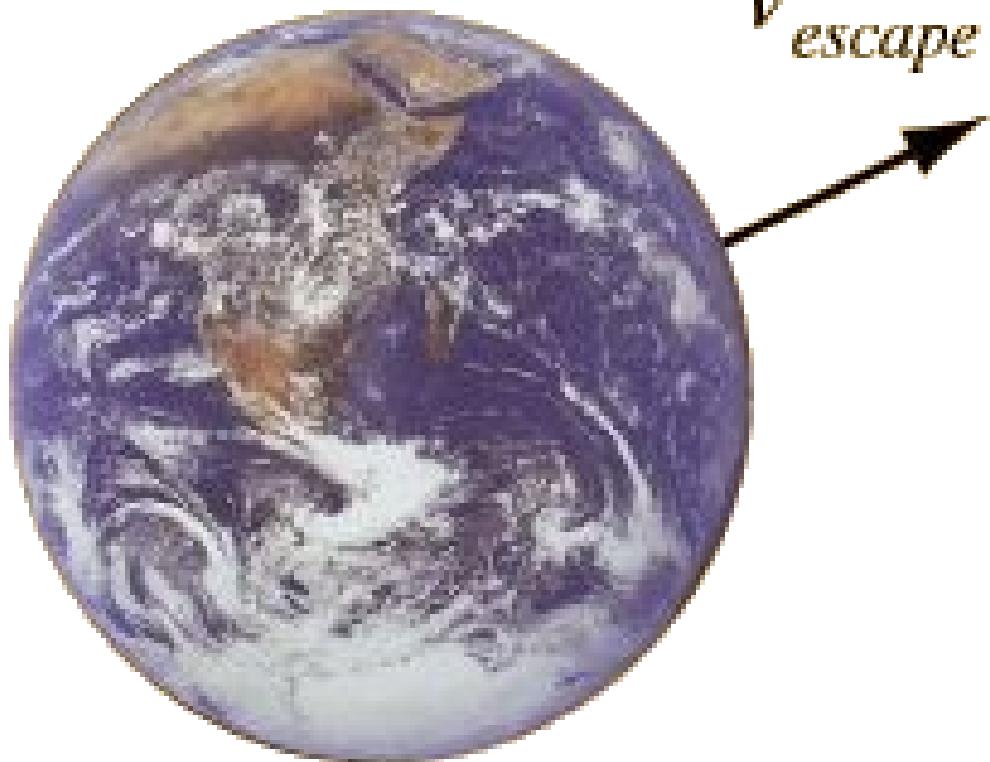
Newton's laws of gravitation



$$F_1 = F_2 = G \frac{m_1 \times m_2}{r^2}$$

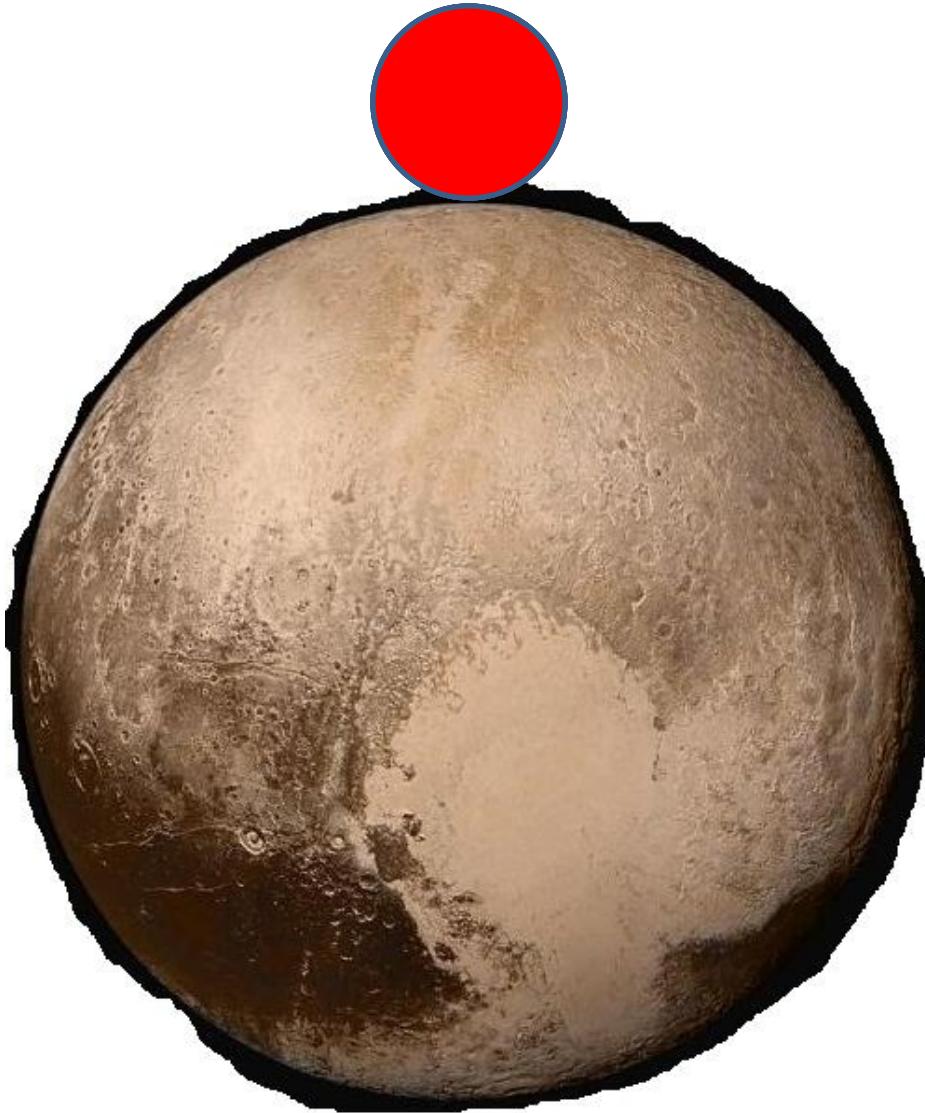
Escape velocity

$$v_{\text{escape}} = 11.2 \text{ km/s}$$

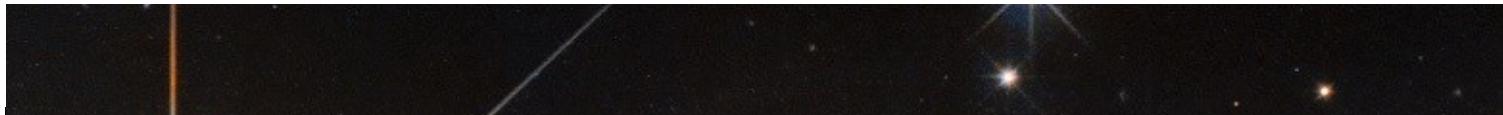


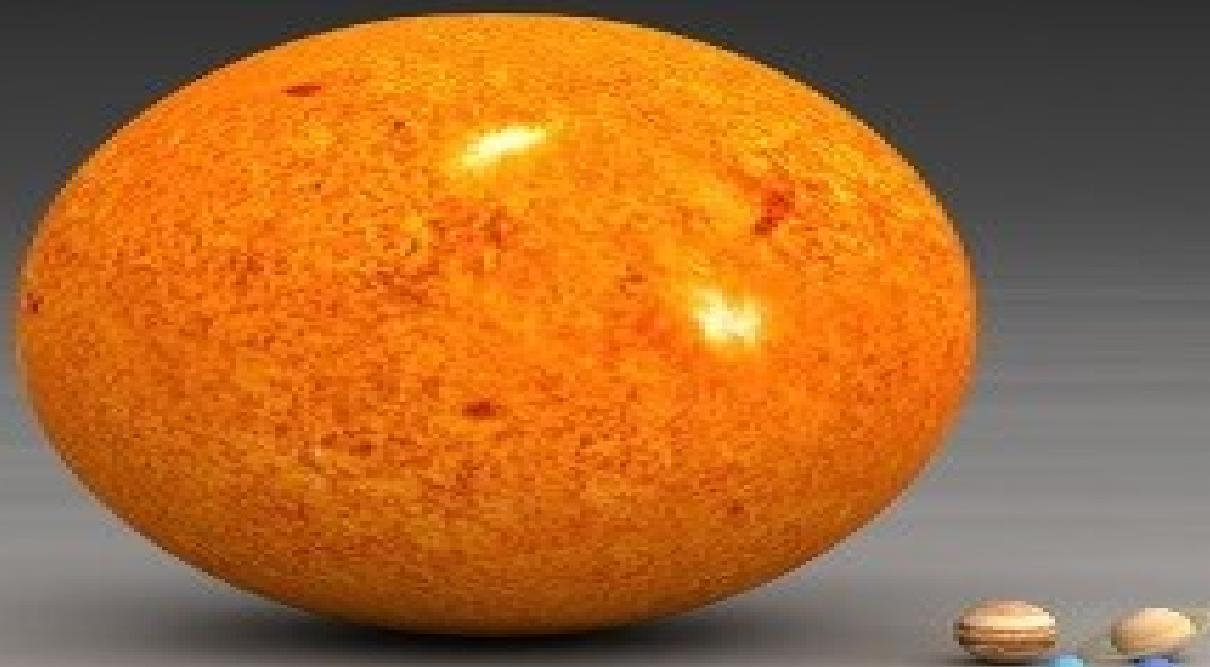
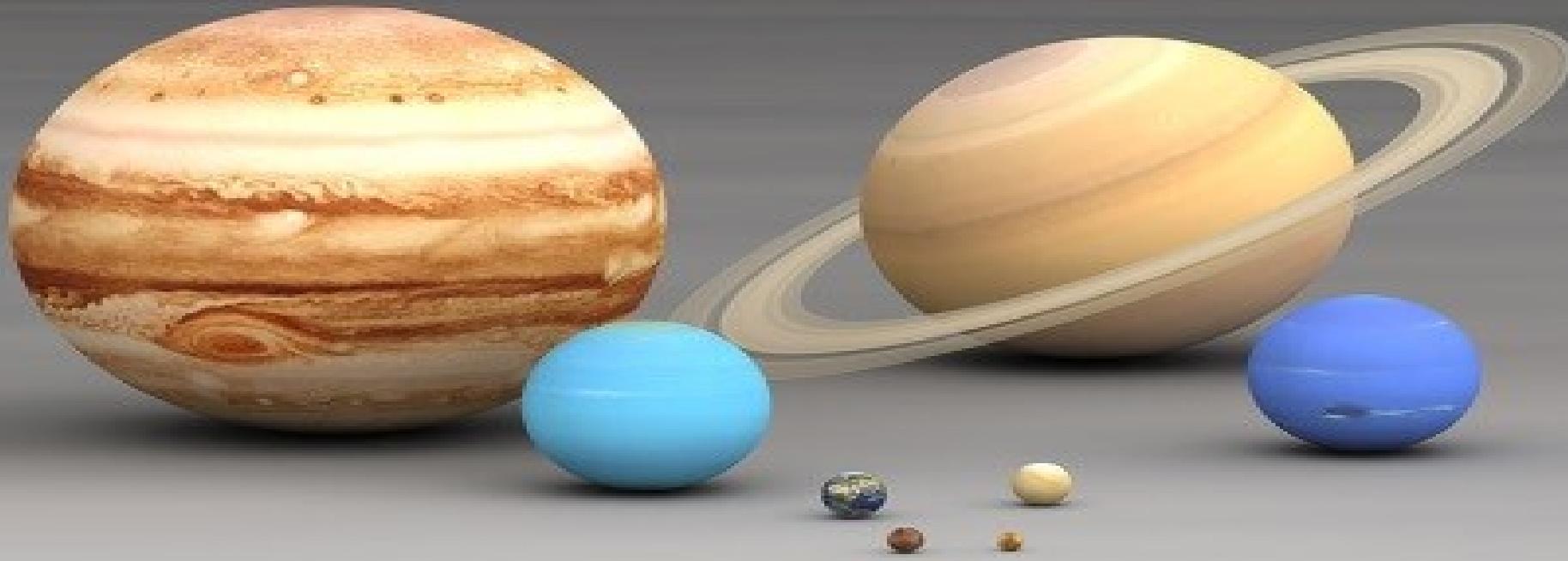
$$\frac{1}{2}mv^2 = \frac{GMm}{r}$$

$$v_{\text{escape}} = \sqrt{\frac{2GM}{r}}$$



Star, planet, asteroid, satellite





Comet





Asteroid



Comet



Meteoroid



Meteoroid



Atmosphere



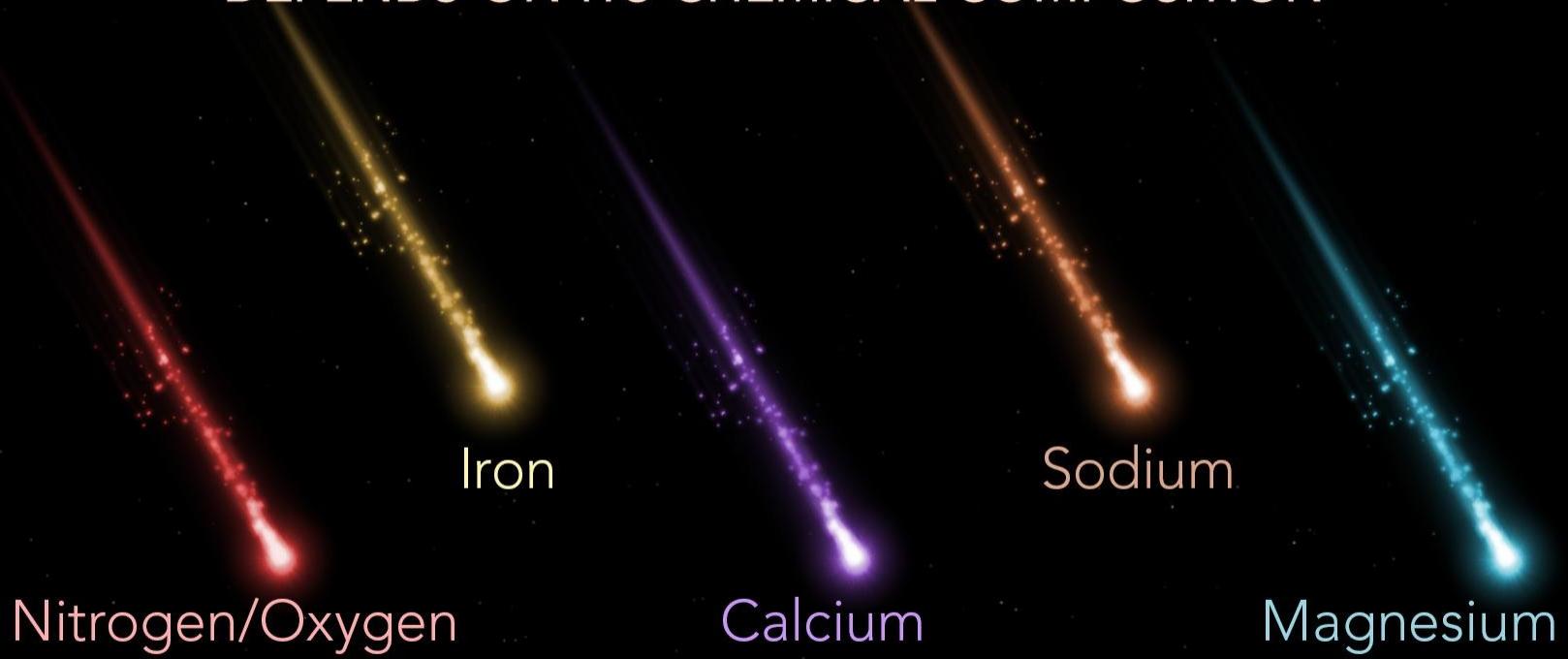
Meteor



Meteorites

Comet, meteors, meteorites

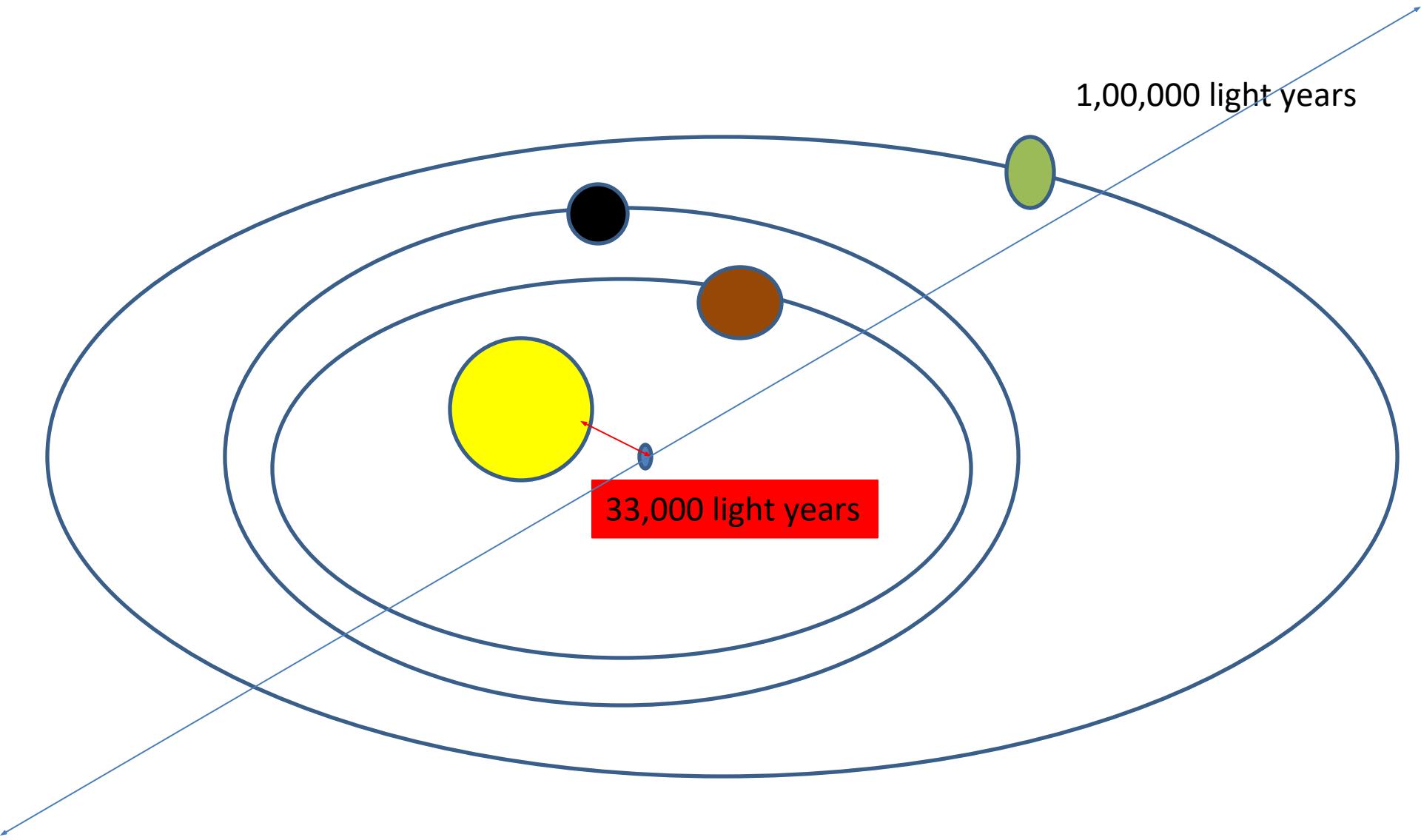
THE COLOR OF A METEOR
DEPENDS ON ITS CHEMICAL COMPOSITION



Planet
Asteroid
Comet

1,00,000 light years

33,000 light years



H finished; He fuse; More heat Expansion



Fusion in progress



Fusion just started



Rate of fusion decline; Energy declines and hence volume



Complete flush out of energy

SUPERNOVA

H finished; He fuse; More heat Expansion



Fusion in progress



Fusion just started



Every nuclei flushed out except iron

$E \rightarrow 0$; Heat $\rightarrow 0$; $v \rightarrow 0$; Density & Gravity \rightarrow infinite



Chandrashekhar Limit



- The energy of sun is produced by
 - A) Nuclear fission
 - B) Ionization
 - C) Nuclear fusion
 - D) Oxidation
-
- Ans C

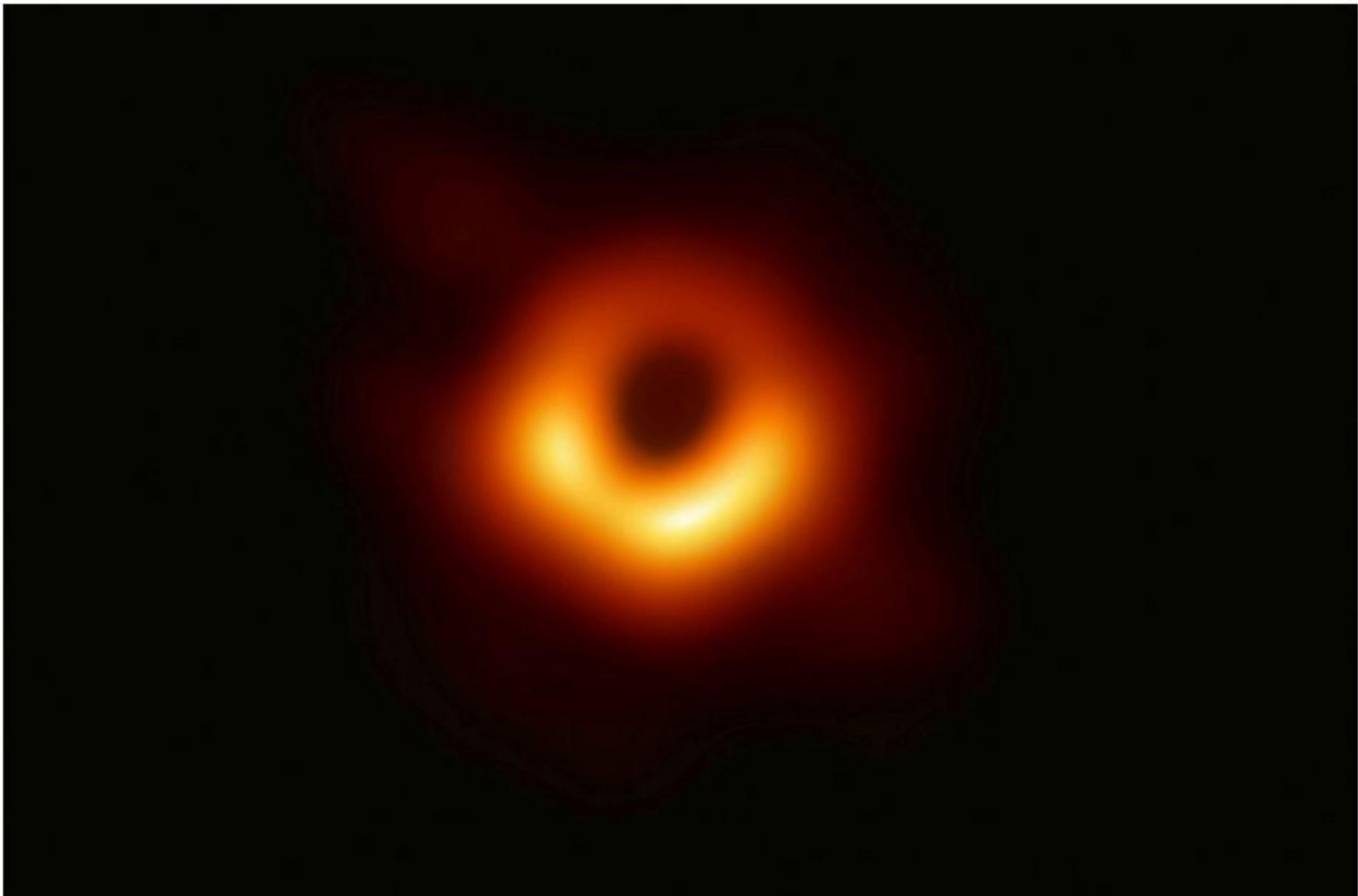
- The colour of the star is an indication of its
- A) Distance from the earth
- B) Distance from the sun
- C) Temperature
- D) Luminosity
- Ans C

- Which of the following stars is known as Fossil star'?
 - A) Proto star
 - B) Dog Star
 - C) Red Giant
 - D) White Dwarf
-
- Ans D

- Which of the following does not belong to solar system'?
 - A) Asteroids
 - B) Comets
 - C) Planets
 - D) Nebulae
-
- Ans D

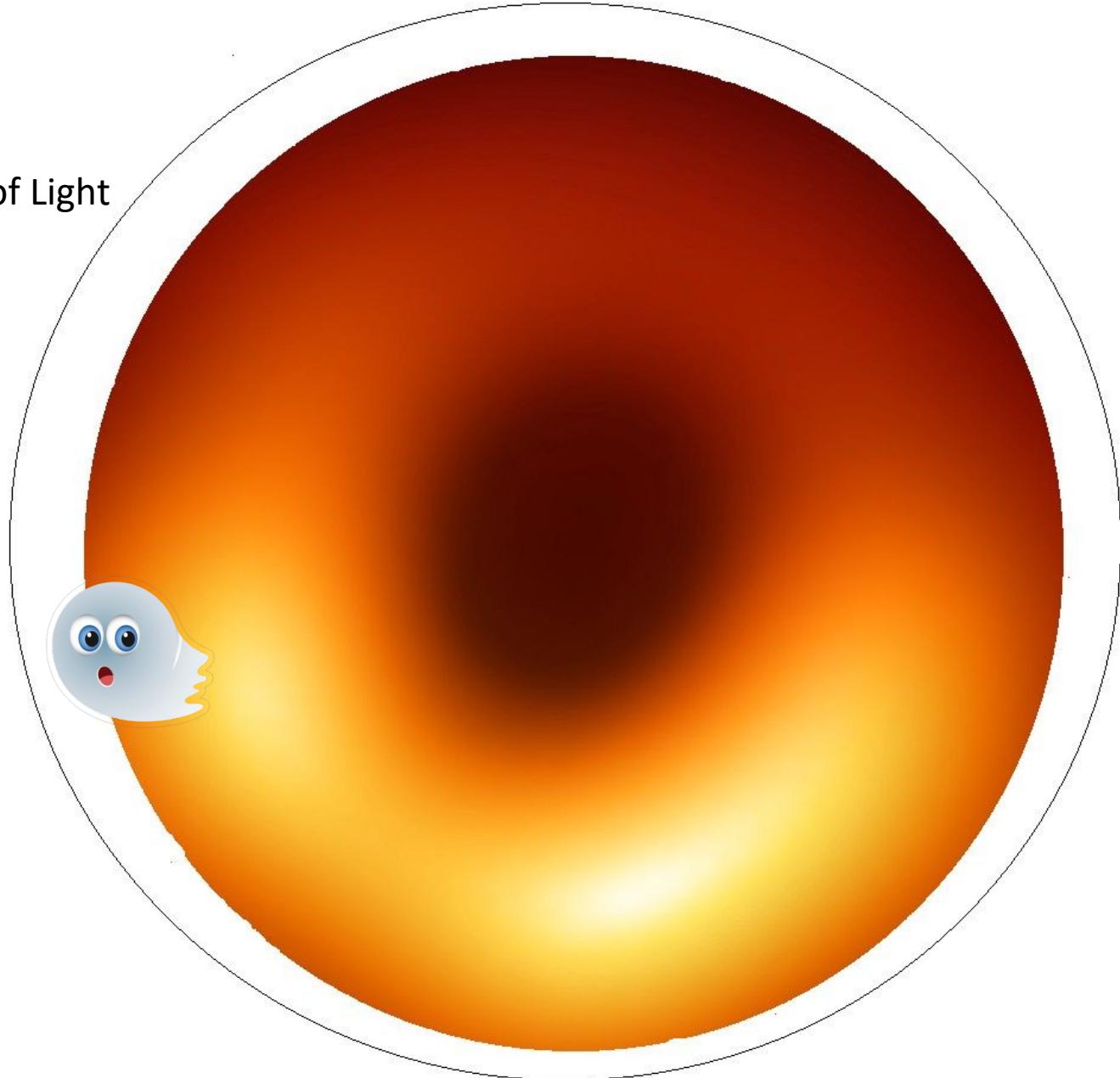
- Which of the following stars is also known as Pulsar?
 - A) Red Giant
 - B) White Dwarf
 - C) Neutron Star
 - D) Massive Star
-
- Ans C

Black Hole



Event Horizon

Escape Velocity > Speed of Light



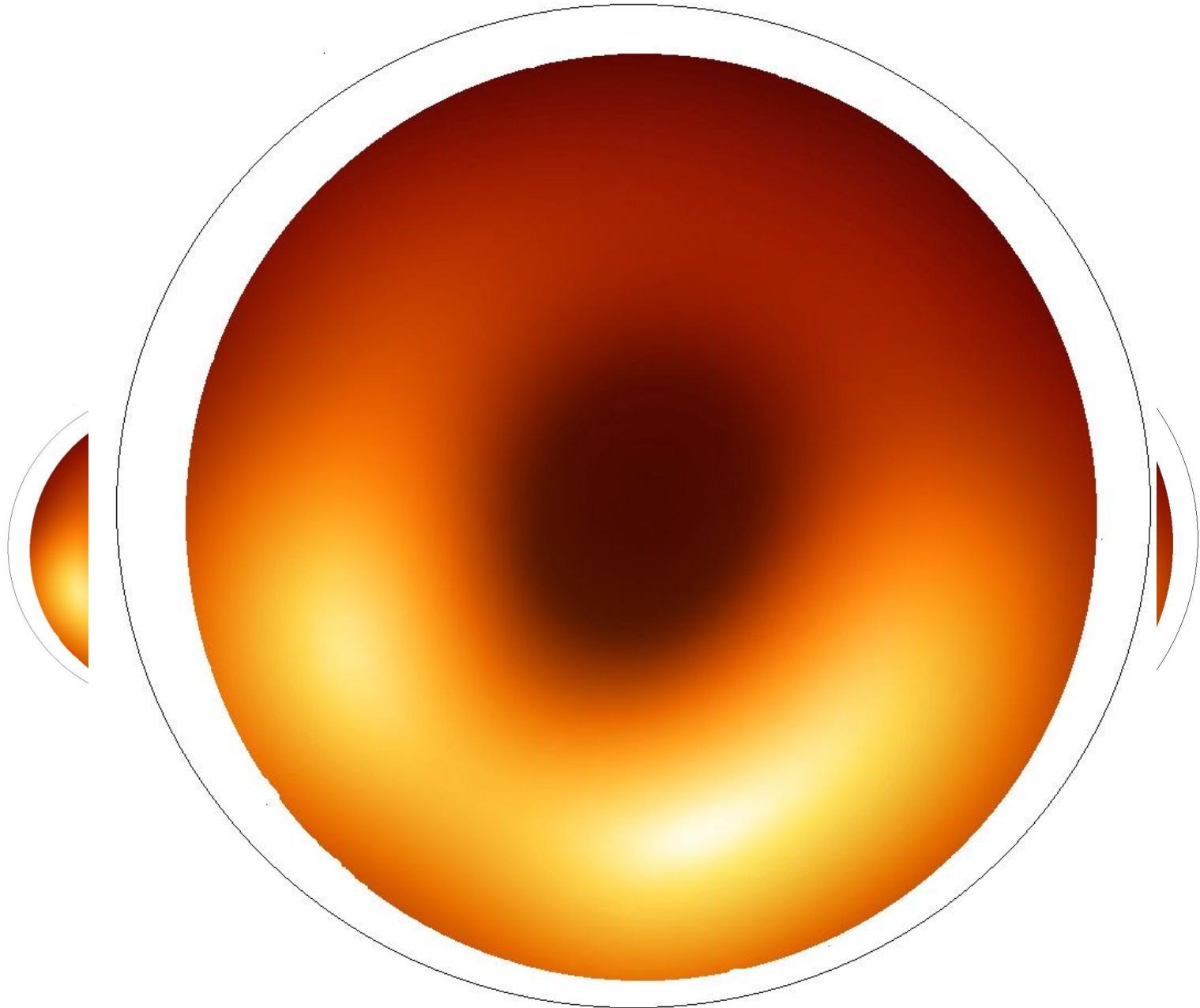
A diagram illustrating the spacetime geometry around a black hole. A central point labeled "Singularity" is surrounded by a red circle labeled "Horizon". Blue arrows represent the direction of spacetime flow. The arrows point inward toward the singularity and outward from the horizon, indicating the curvature of spacetime.

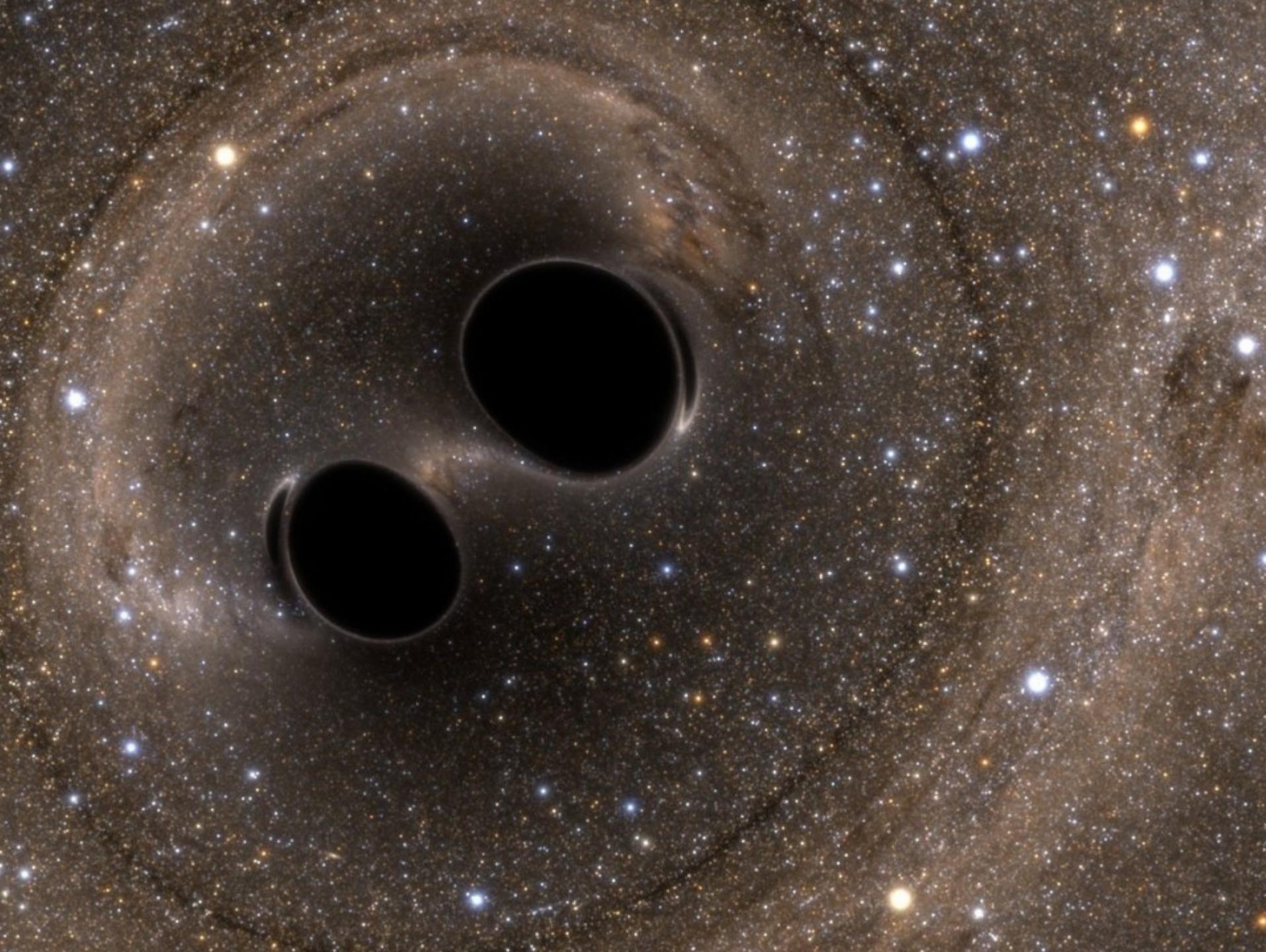
Horizon

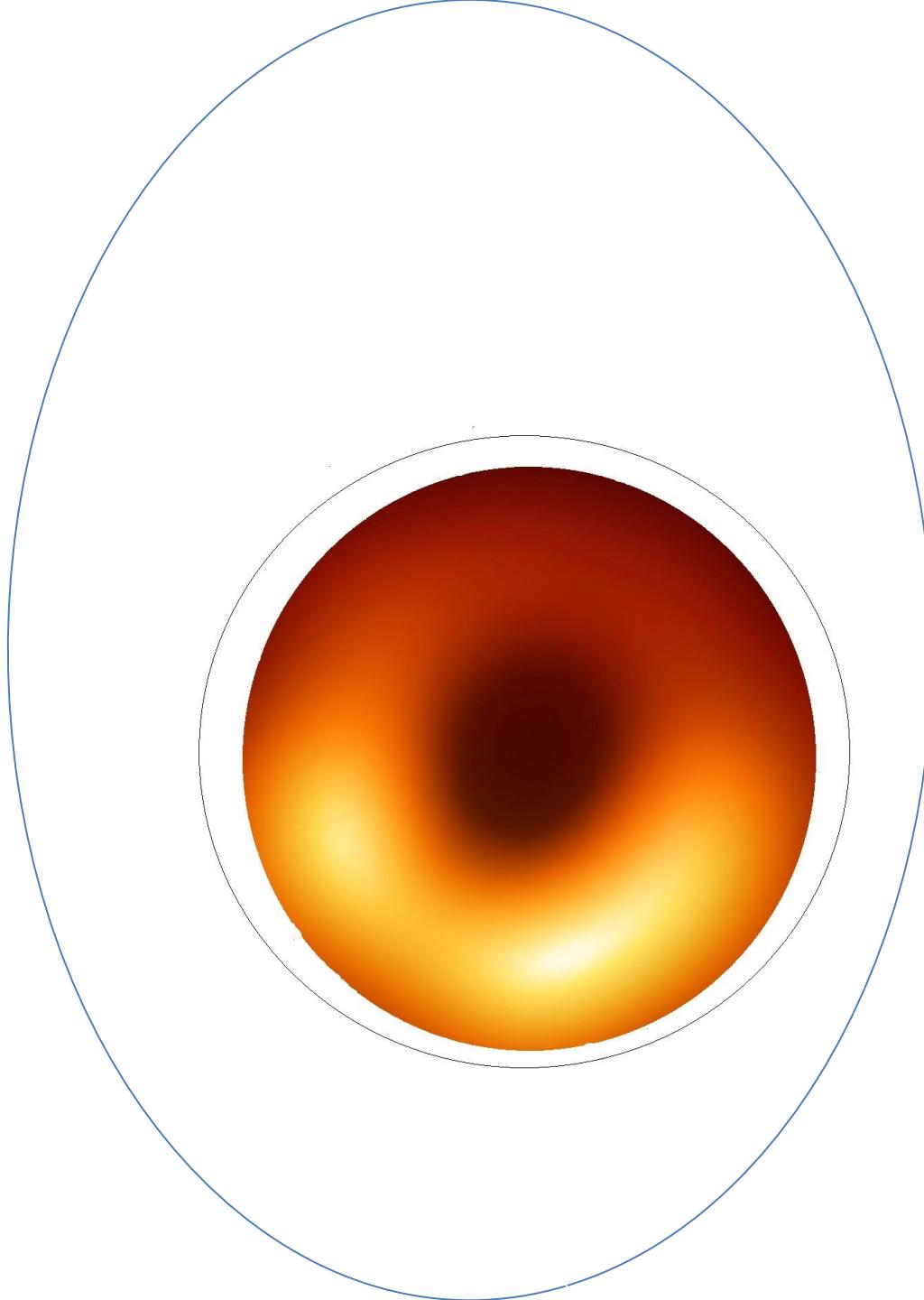
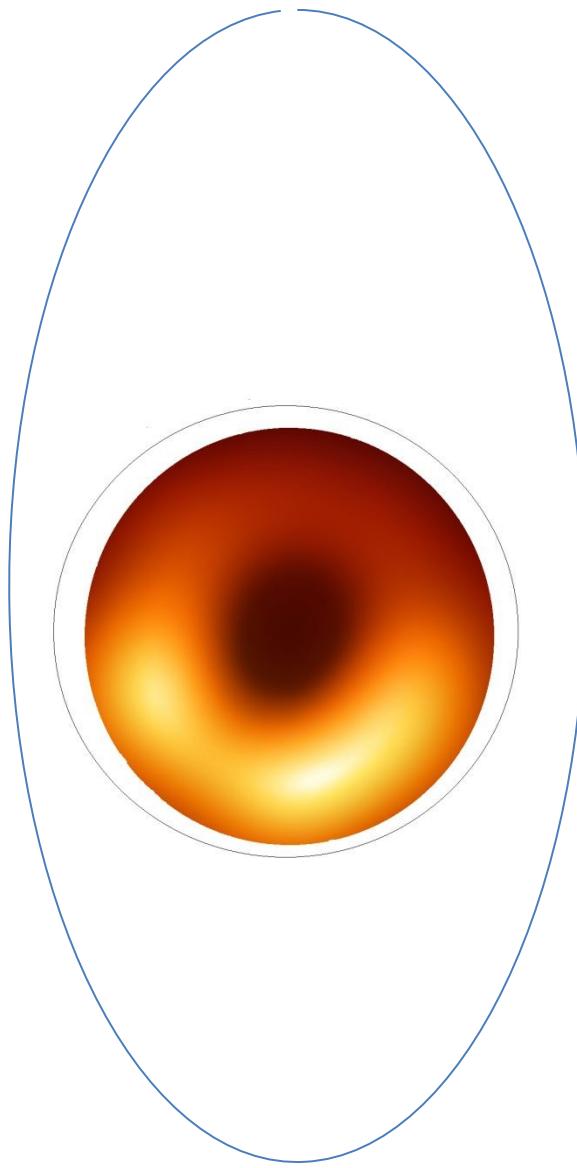
Singularity

Galaxy

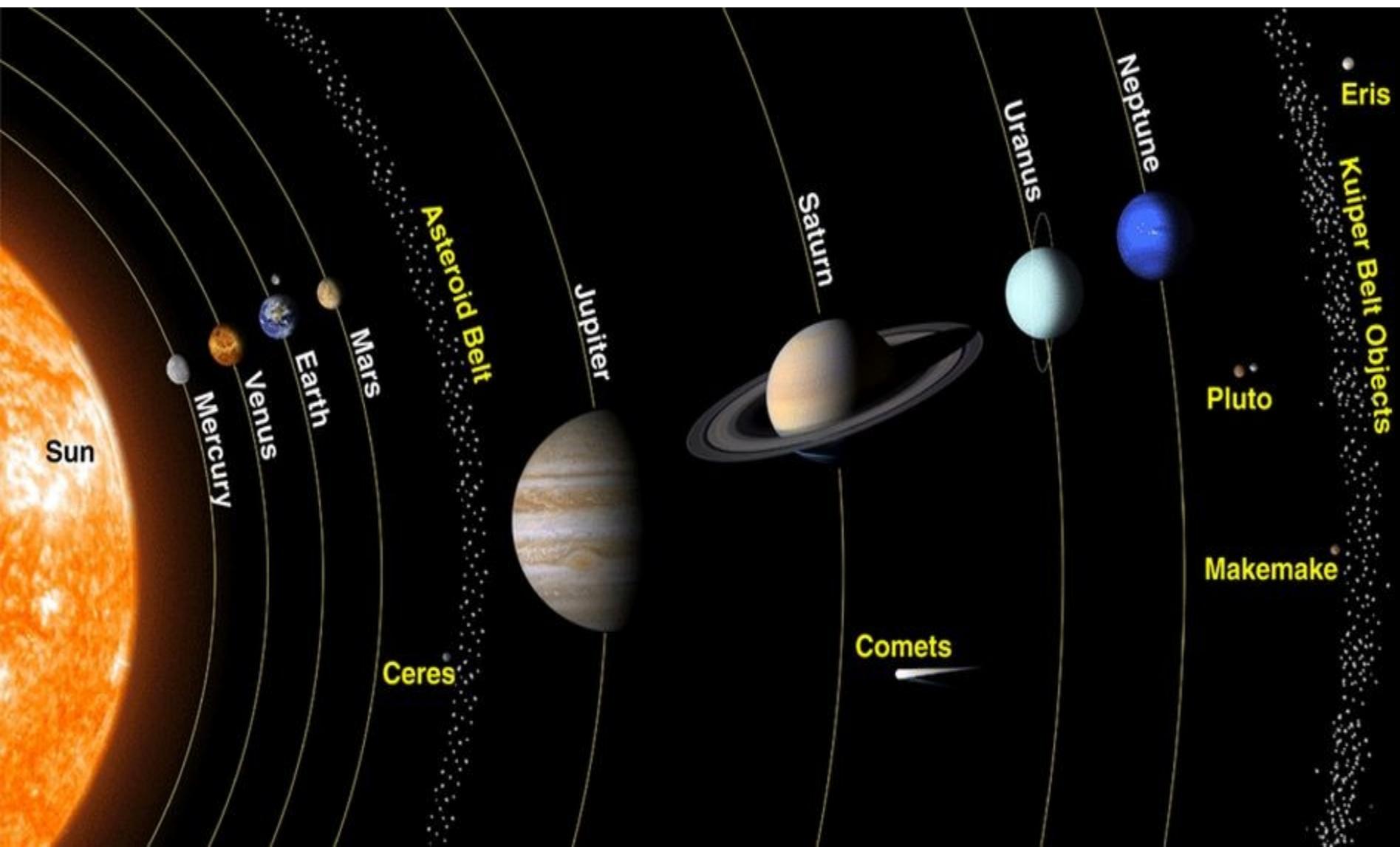




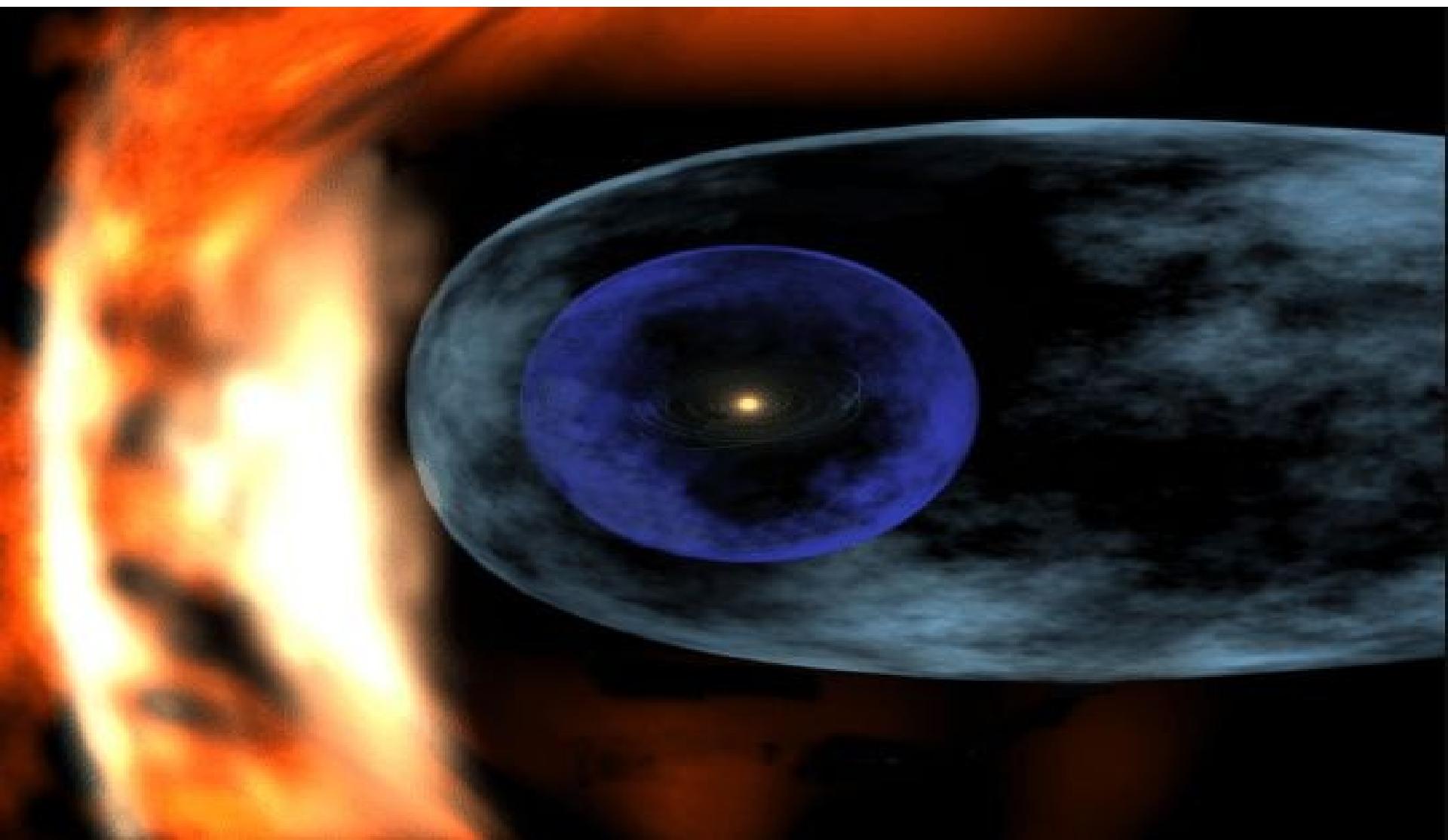




Kuiper belt

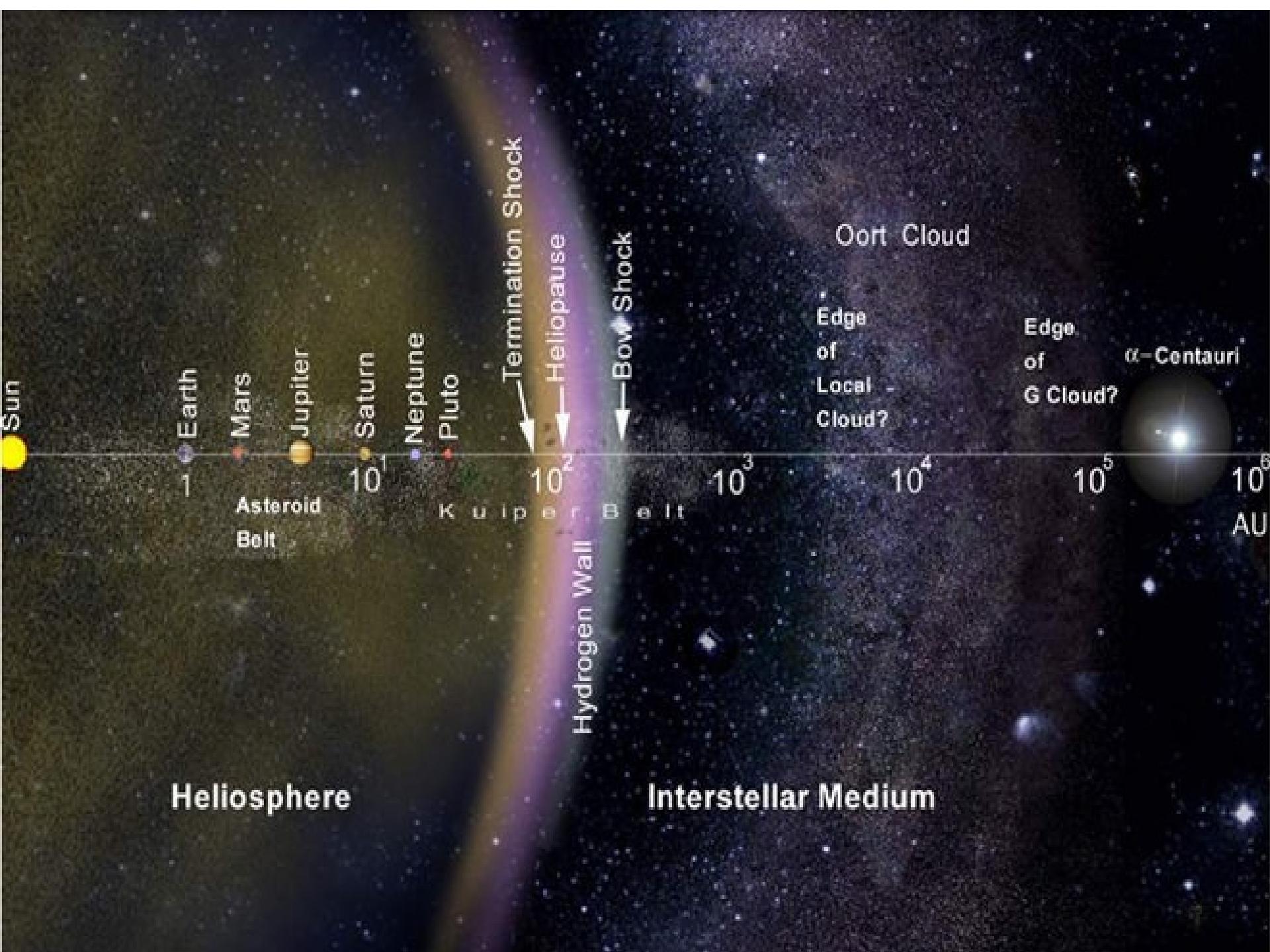


Heliosphere & Hydrogen wall

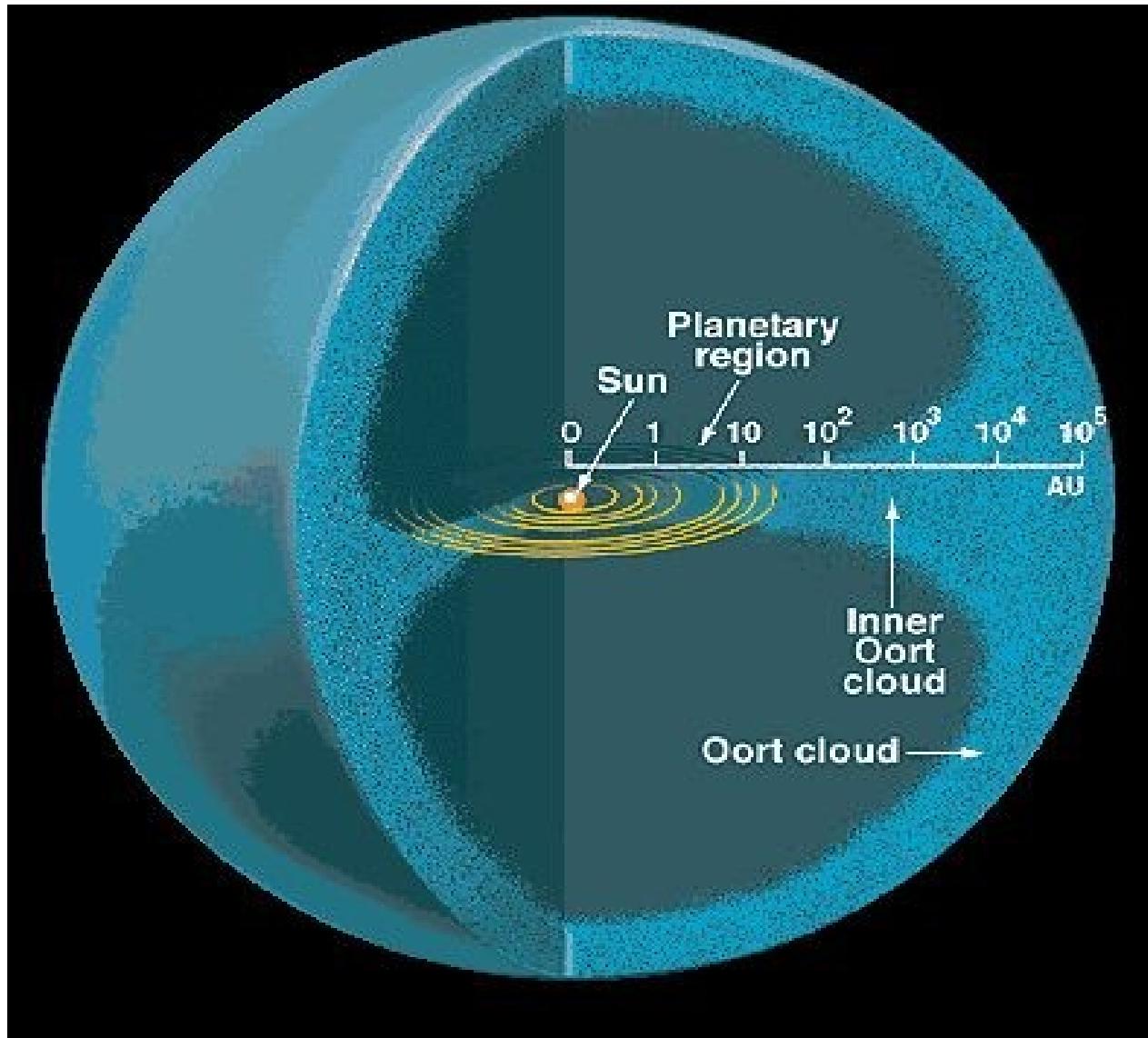


Interstellar medium





Oort Cloud



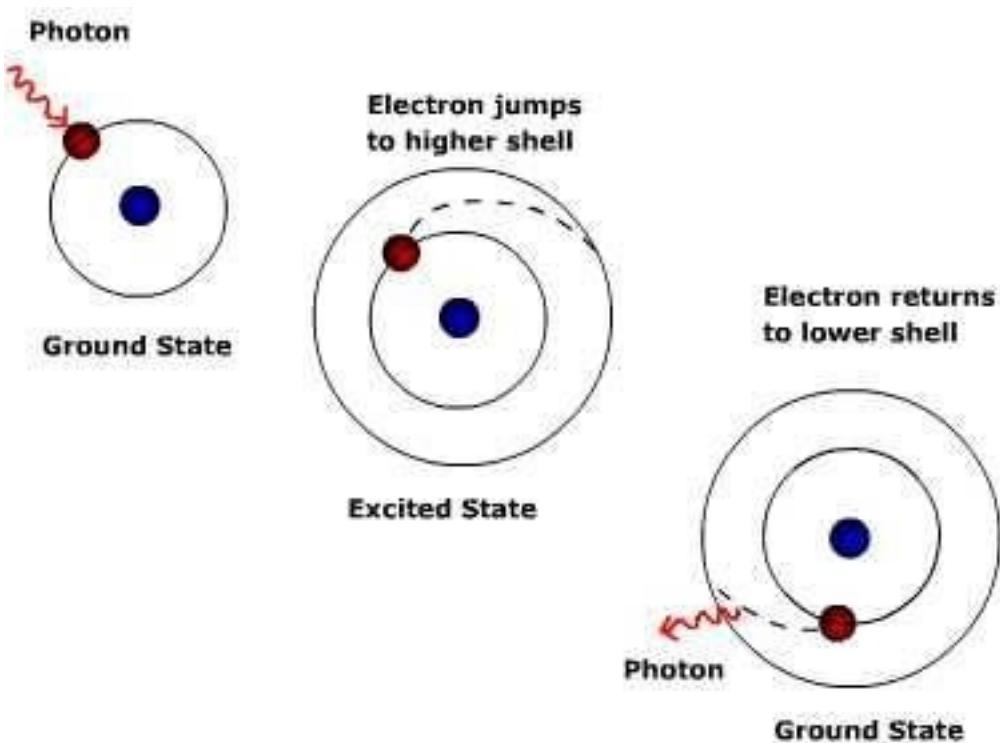
- The term ‘Goldilocks Zone’ is often seen in the news in the context of [Prelims 2015]
- a. the limits of habitable zone above the surface of the Earth
- b. regions inside the Earth-like planets in outer space
- c. search for the Earth-like planets in outer space
- d. search for meteorites containing precious metals

Ans C

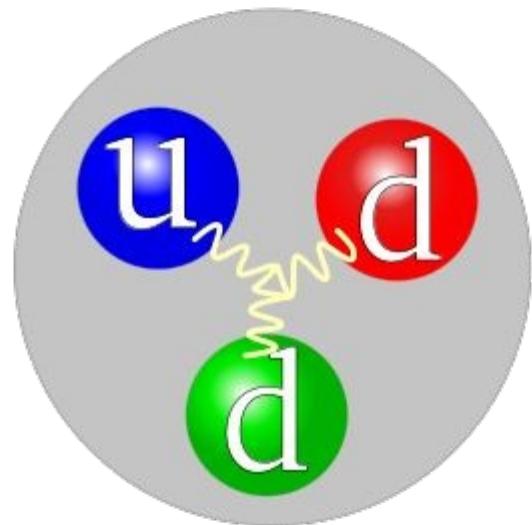
Force Carriers

- Photon
- Boson (W&Z)
- Graviton
- Gluons

Photon



Gluon



Boson W & Z

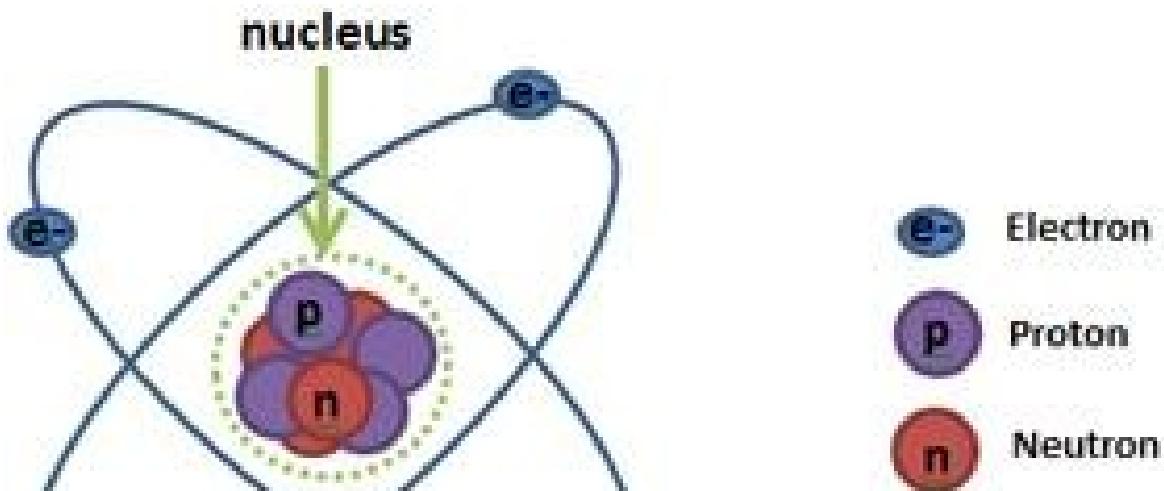
- W+ Positron
- W- Electron
- Z (Neutral) Neutrino

- The known forces of nature can be divided into four classes, viz., gravity, electromagnetism, weak nuclear force and strong nuclear force. With reference to them, which one of the following statements is not correct? [UPSC Civil Services, 2013]
- Gravity is the strongest of the four
- Electromagnetism acts only on particles with an electric charge
- Weak nuclear force causes radioactivity
- Strong nuclear force holds protons and neutrons inside the nucleus of an atom
- Ans - A

Elementary particles

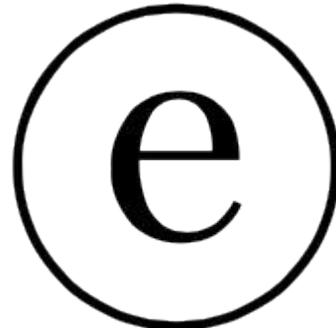
- Electron
- Proton
- Neutron
- Lepton
- Quark

Electron, Proton, Neutron

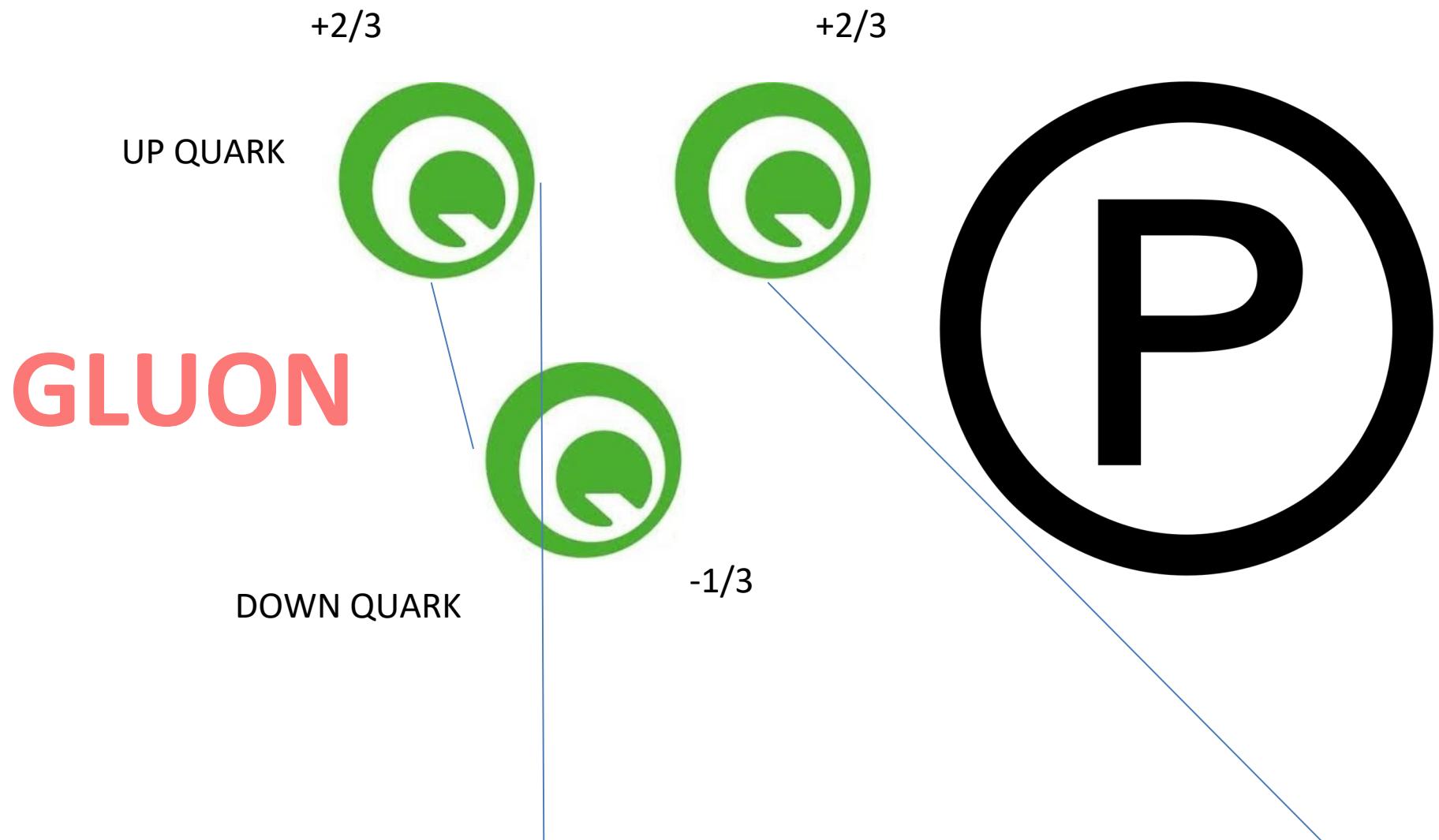


Atom

Lepton



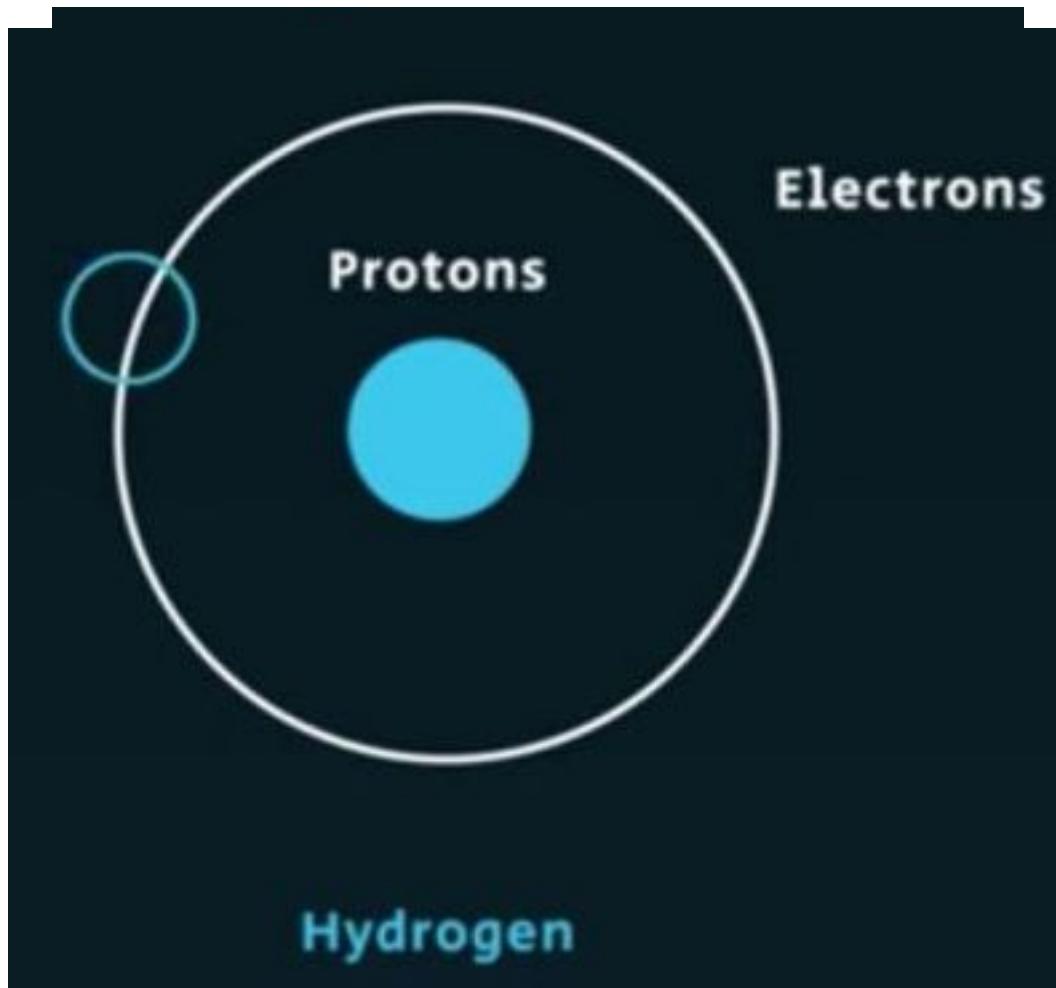
Quark



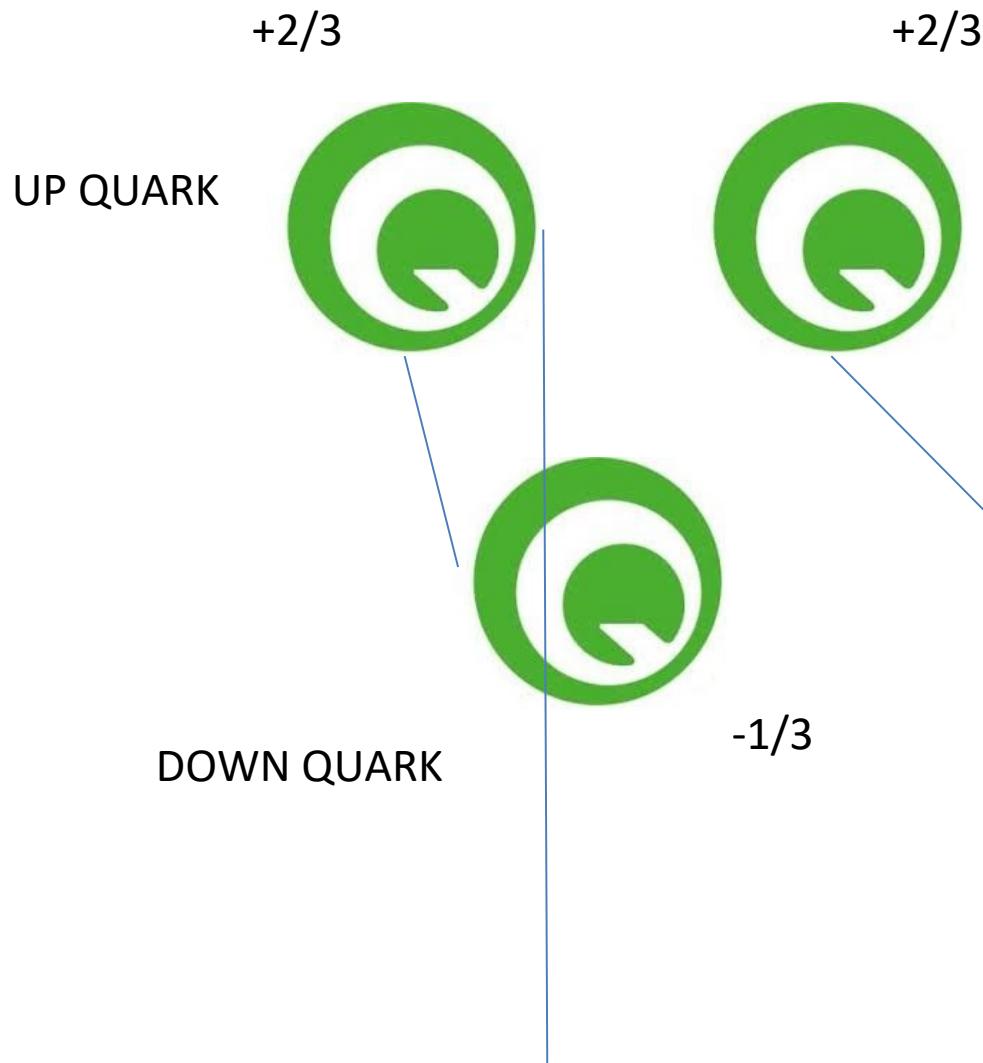


Antimatter

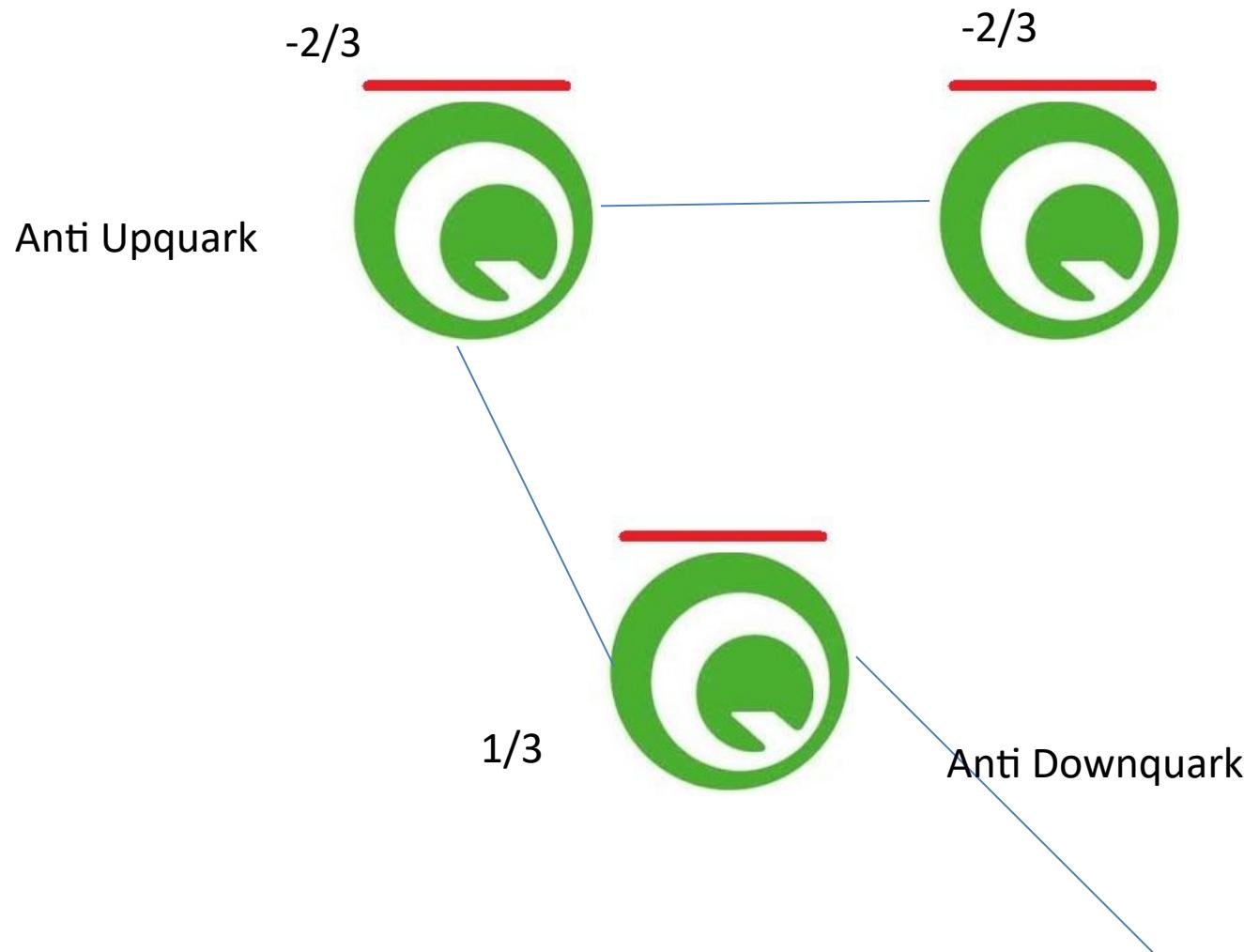




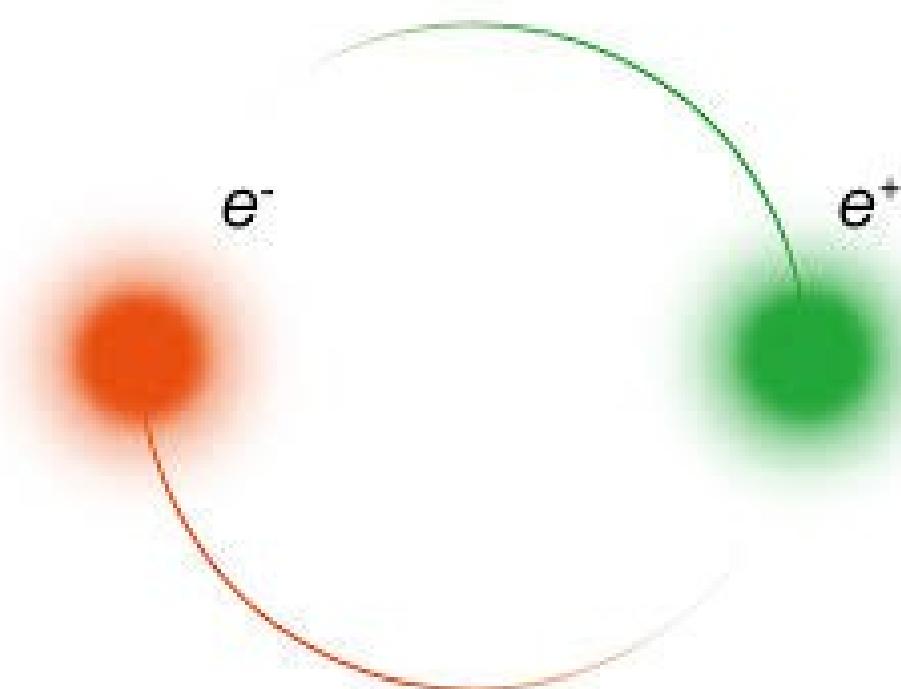
Proton Recap



Antiproton

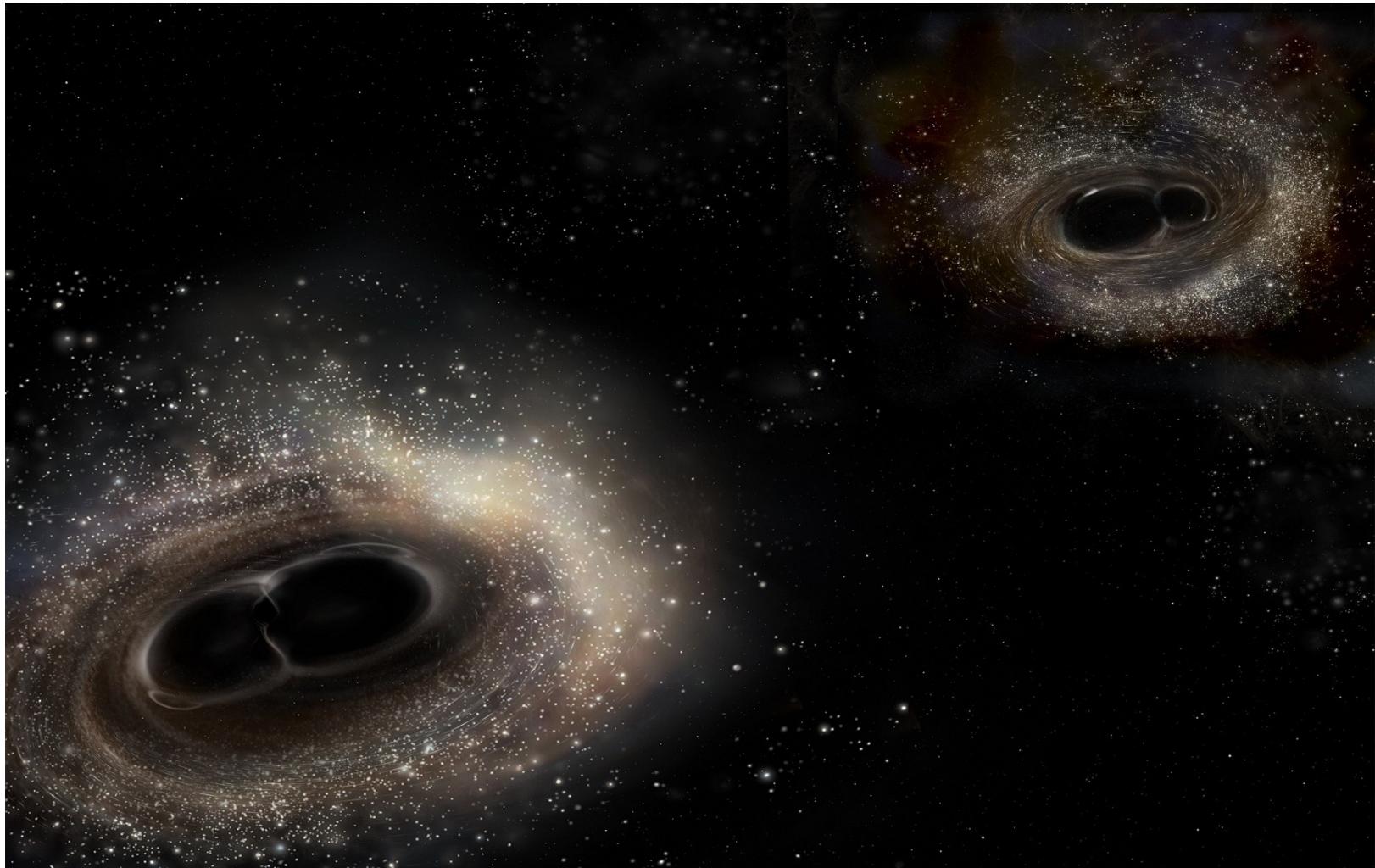


Positron

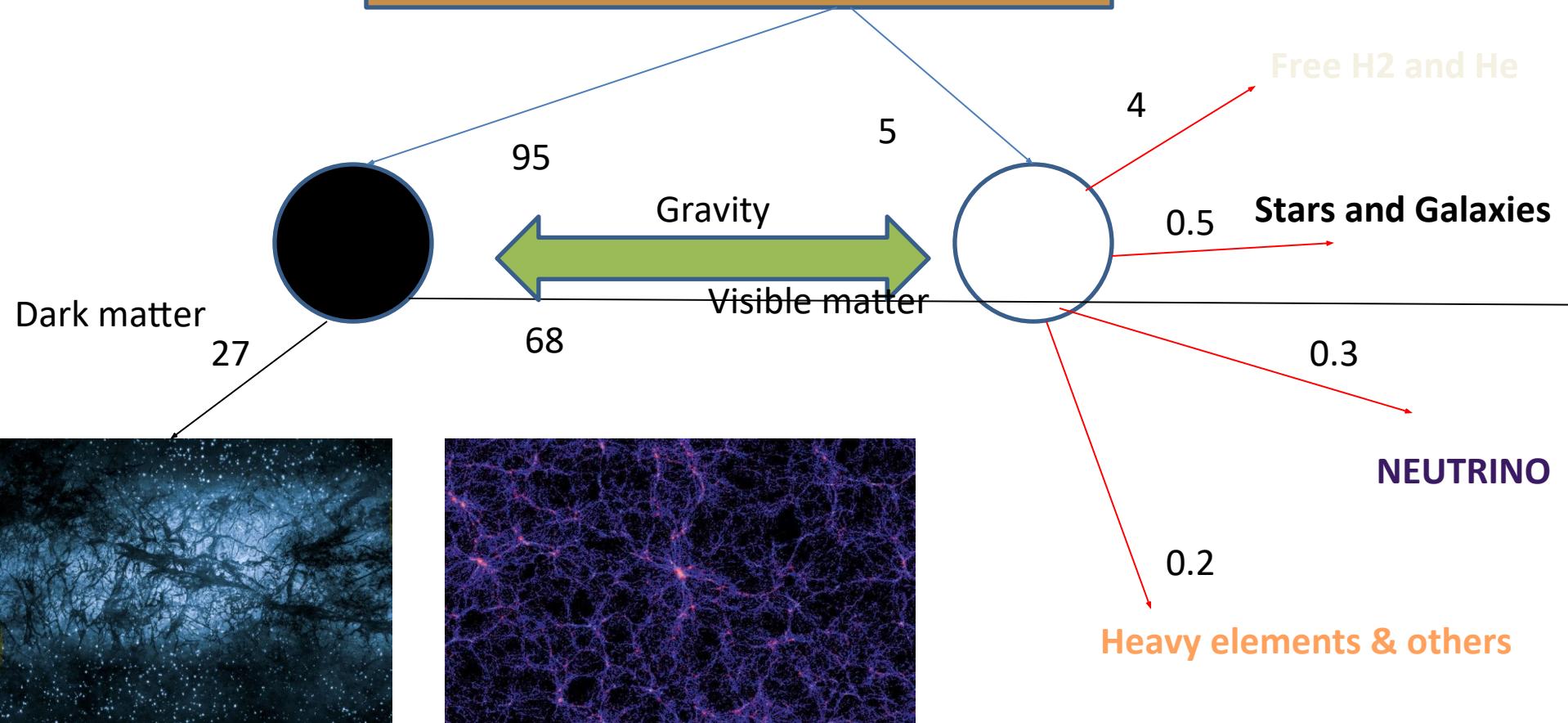


- **A team of scientists at Brookhaven National Laboratory including those from India created the heaviest anti-matter (anti-helium nucleus). What is/are the implication/ implications of the creation of anti-matter?**
- 1. It will make mineral prospecting and oil exploration easier and cheaper.
- 2. It will help probe the possibility of the existence of stars and galaxies made of anti-matter.
- 3. It will help understand the evolution of the universe.
- Select the correct answer using the codes given below :
- [A]1 Only
- [B]2 & 3 only
- [C]3 Only
- [D]1,2 & 3
- Ans B

Dark matter



Universe 100

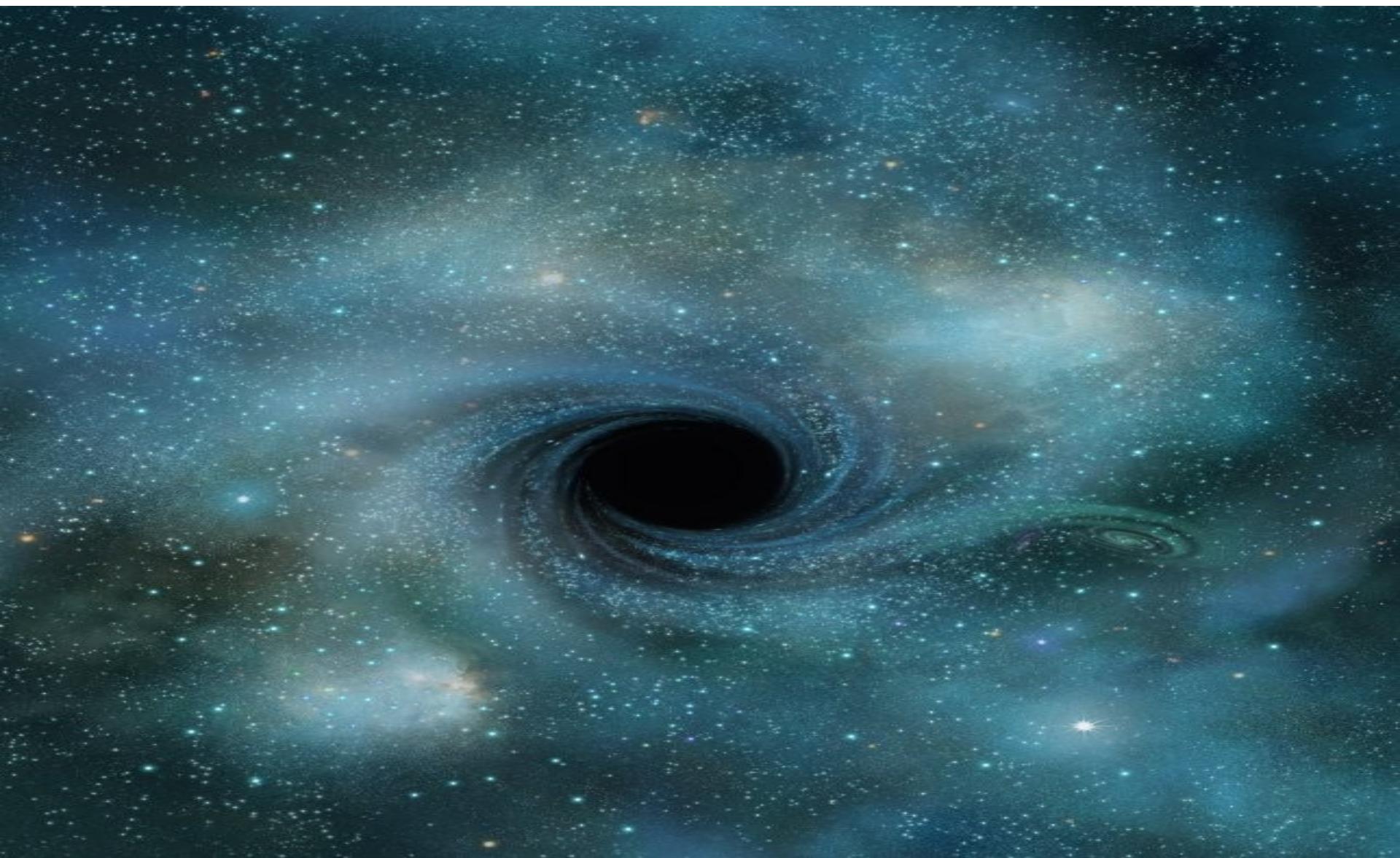


Dark Matter

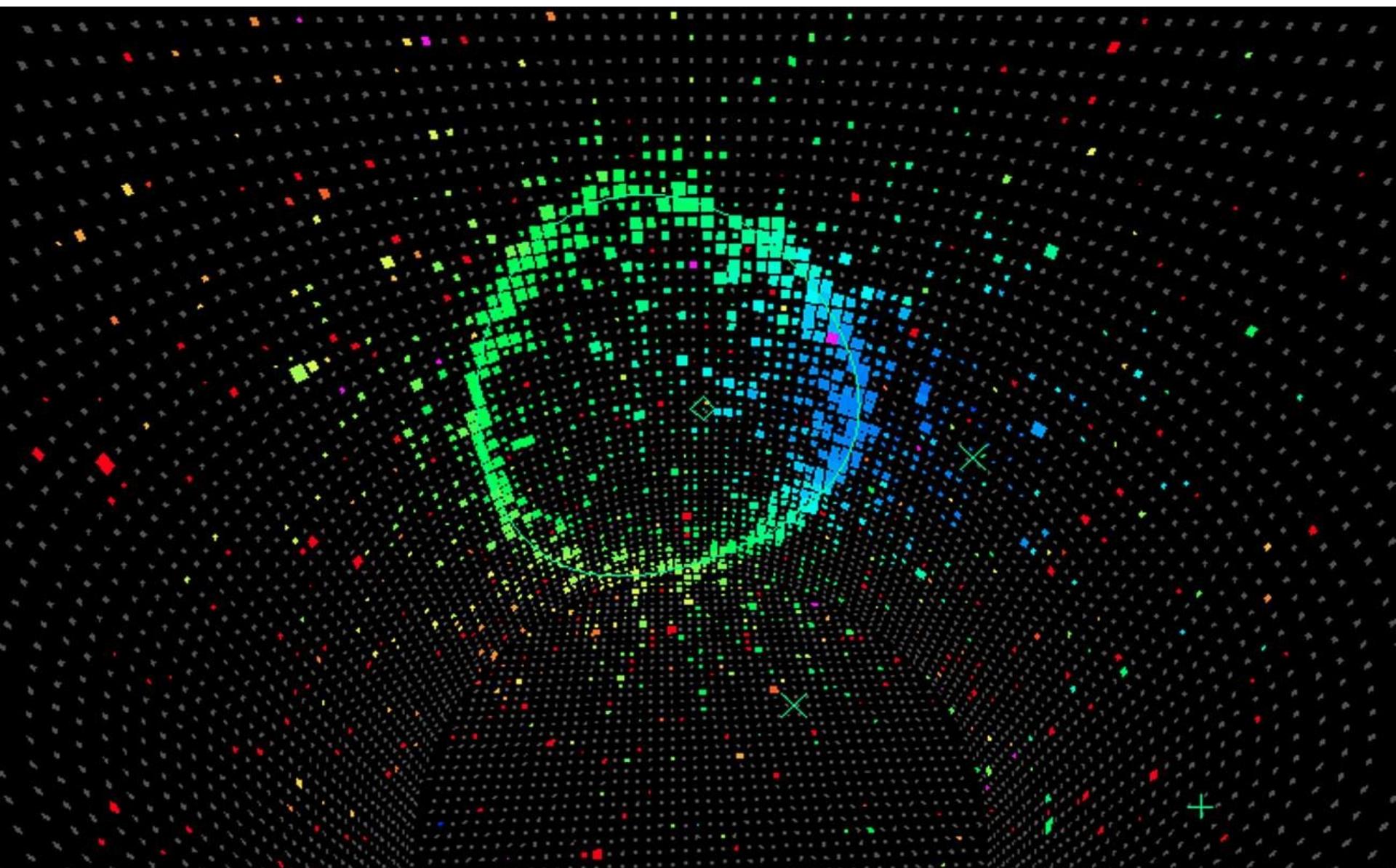
Dark Energy

99% of visible matter is in plasma state

Is Black hole dark matter ?



Neutrino



Higgs Boson theory





COSMIC HIGGS FIELD

N

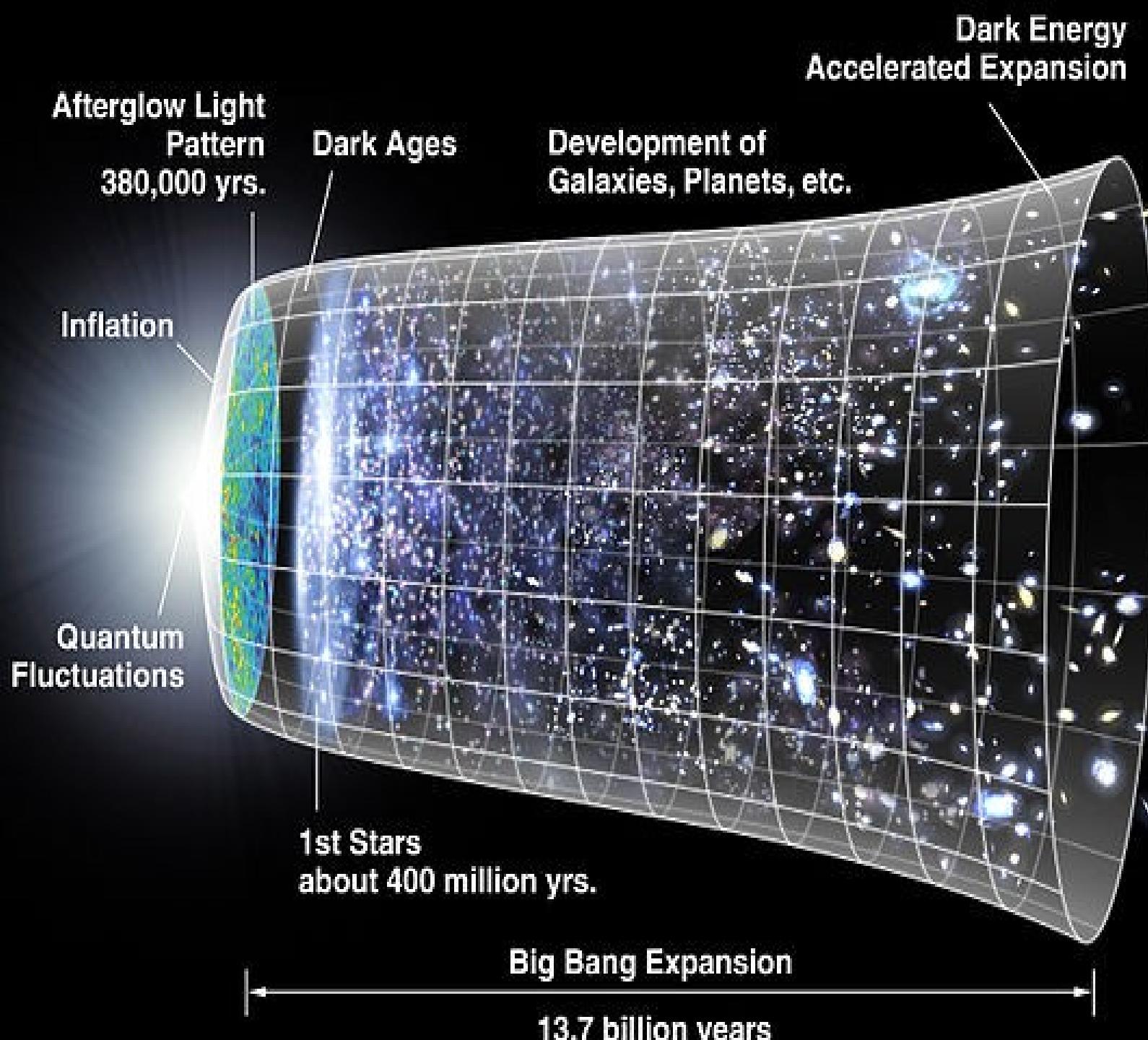
P

e

n

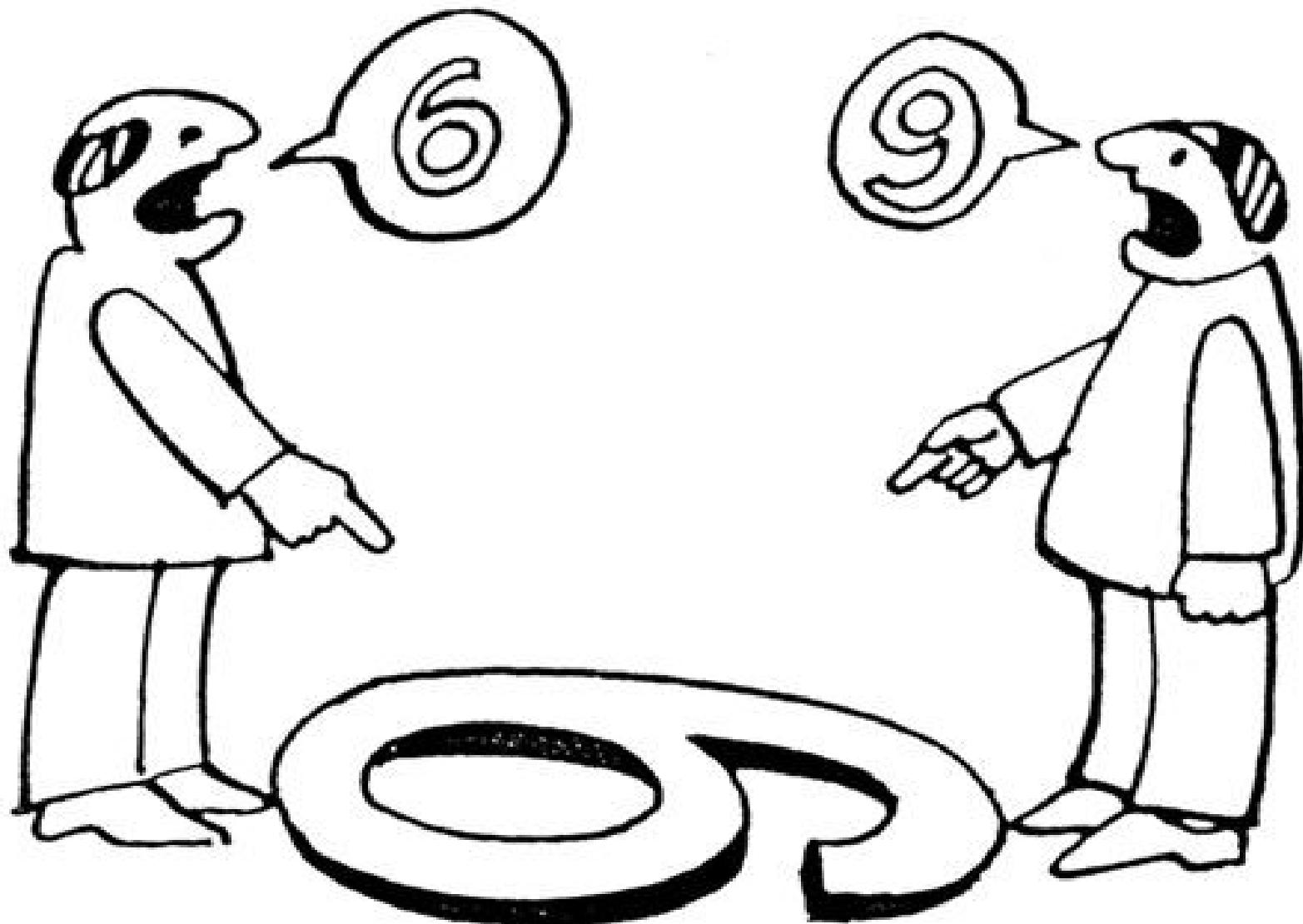
METHANE,AMMONIA FORMATION



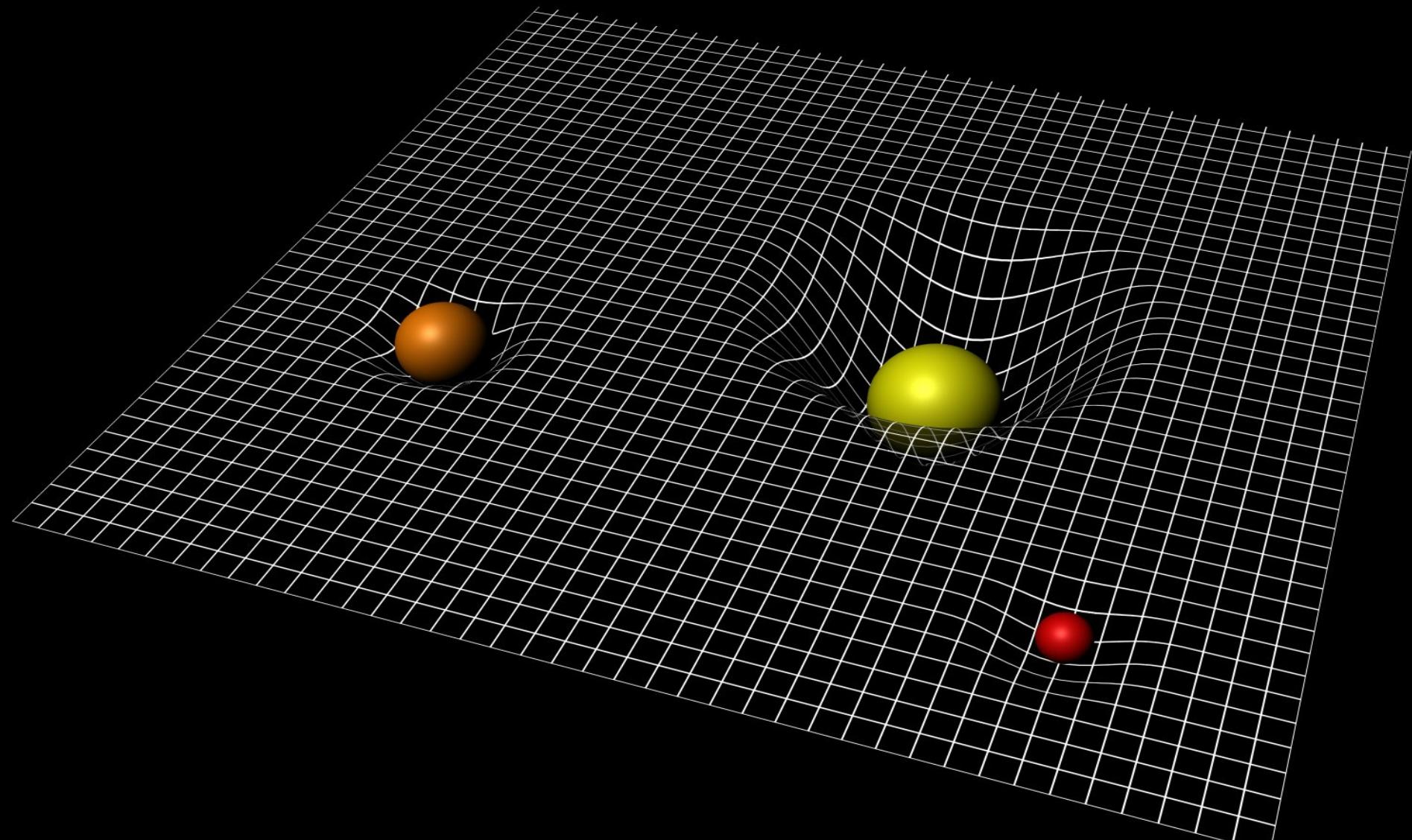


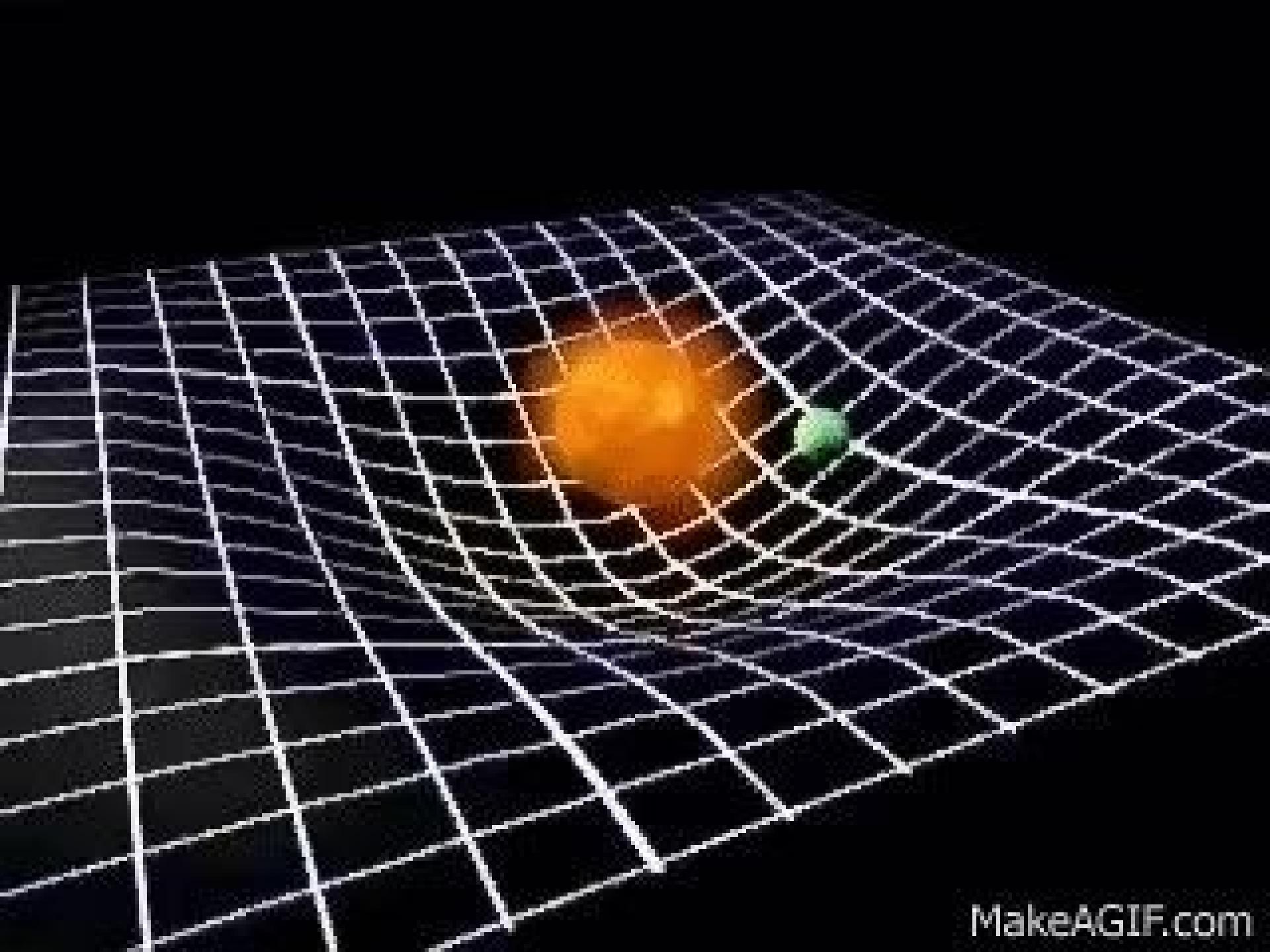
- **The efforts to detect the existence of Higgs boson particle have become frequent news in the recent past. What is /are the importance/importance of discovering this particle? (2013)**
- 1. It will enable us to understand as to why elementary particles have mass.
2. It will enable us in the near future to develop the technology to transferring matter from one point to another without traversing the physical space between them.
3. It will enable us to create better fuels for nuclear fission.
- **Select the correct answer using the codes given below:**
- (a) 1 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3
- **Solution: A**

Theory of relativity

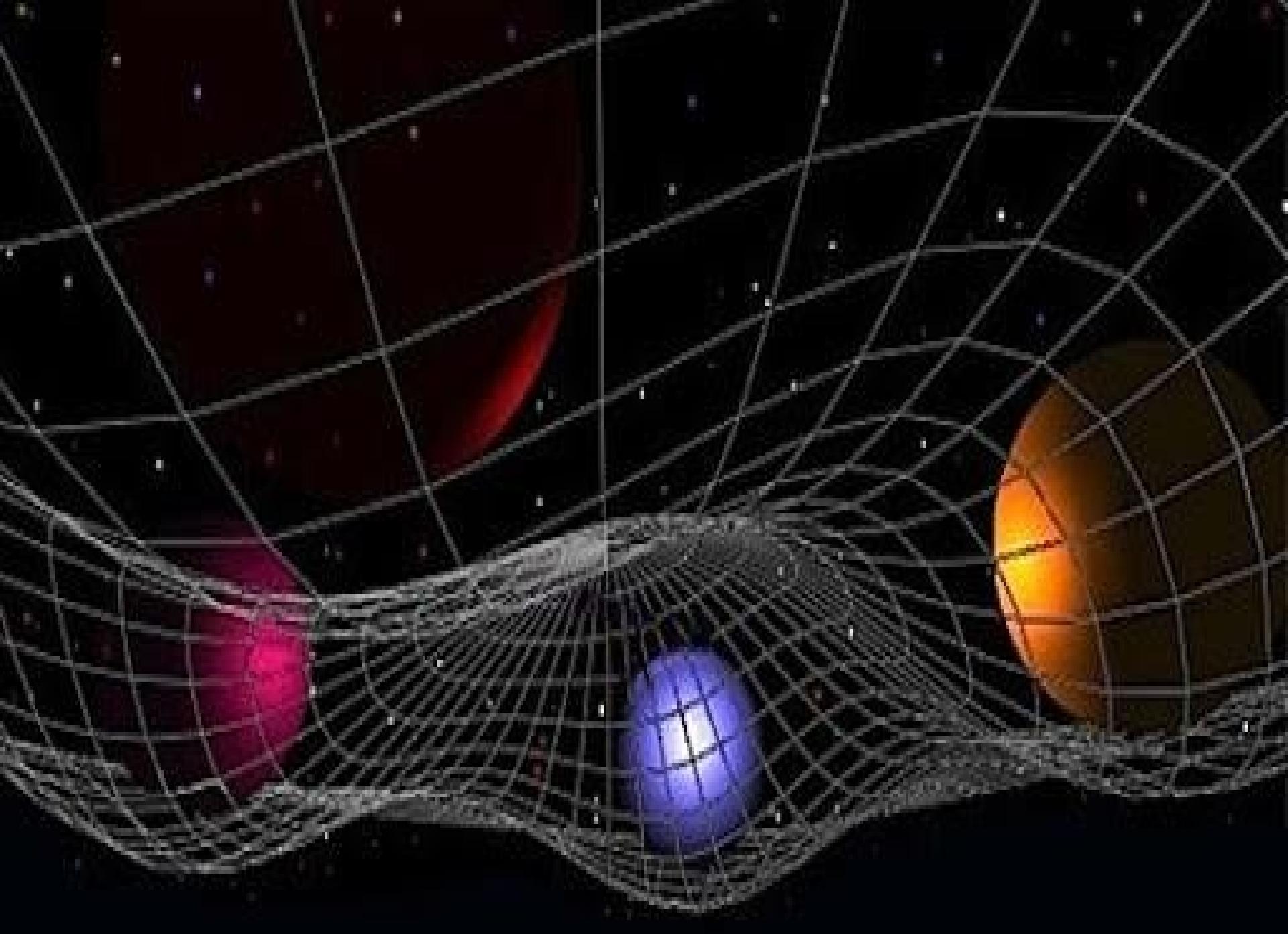


Space time fabric



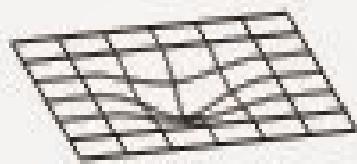


MakeAGIF.com

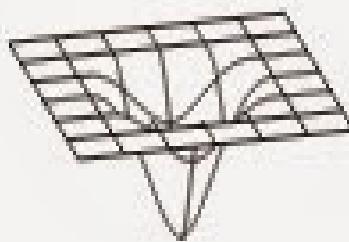


30
80
80
80

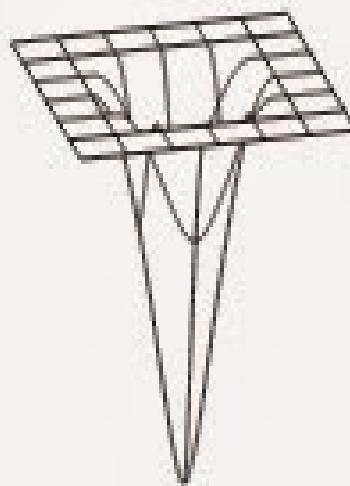
Sun



White dwarf



Neutron star

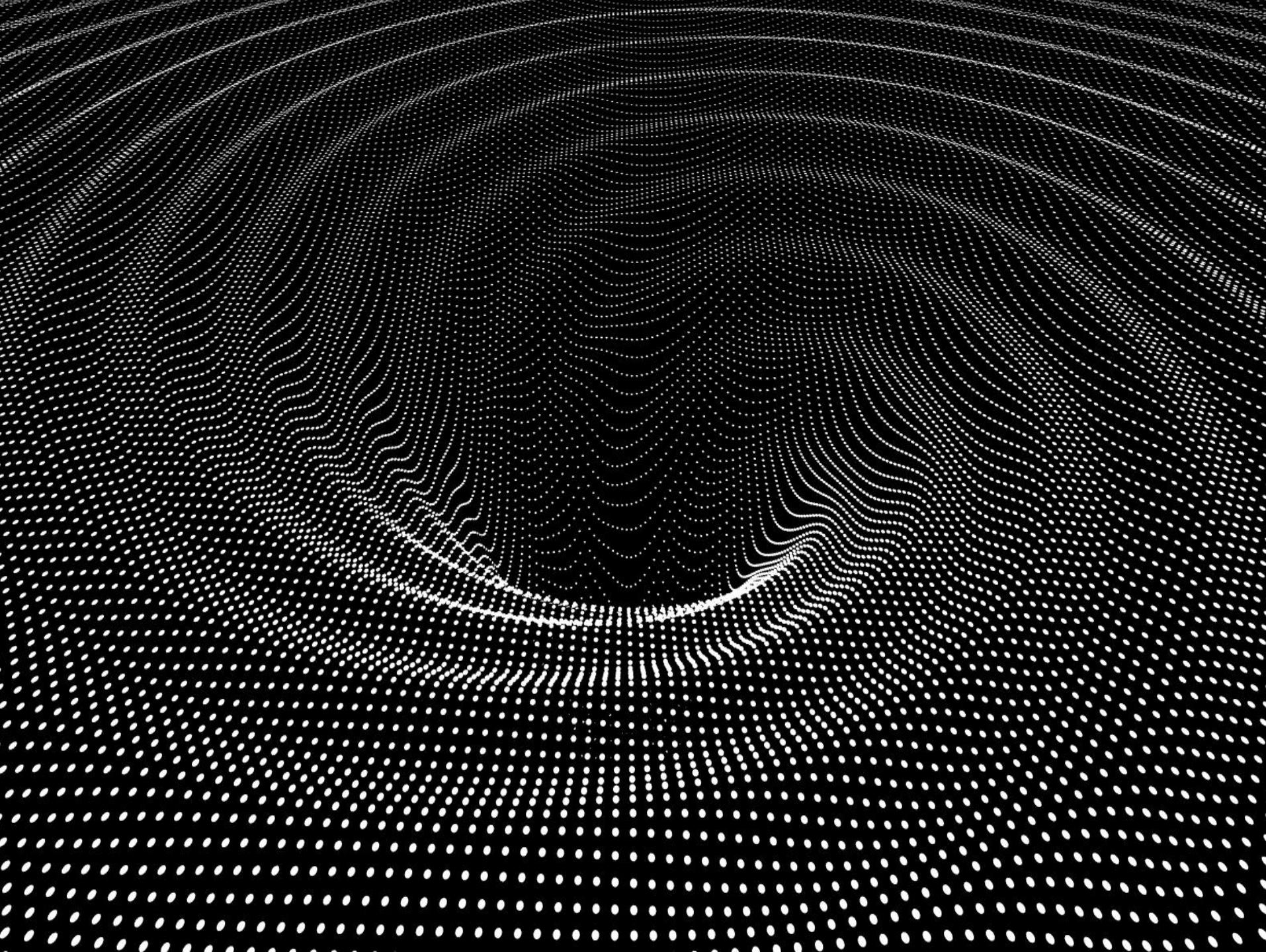


Black hole

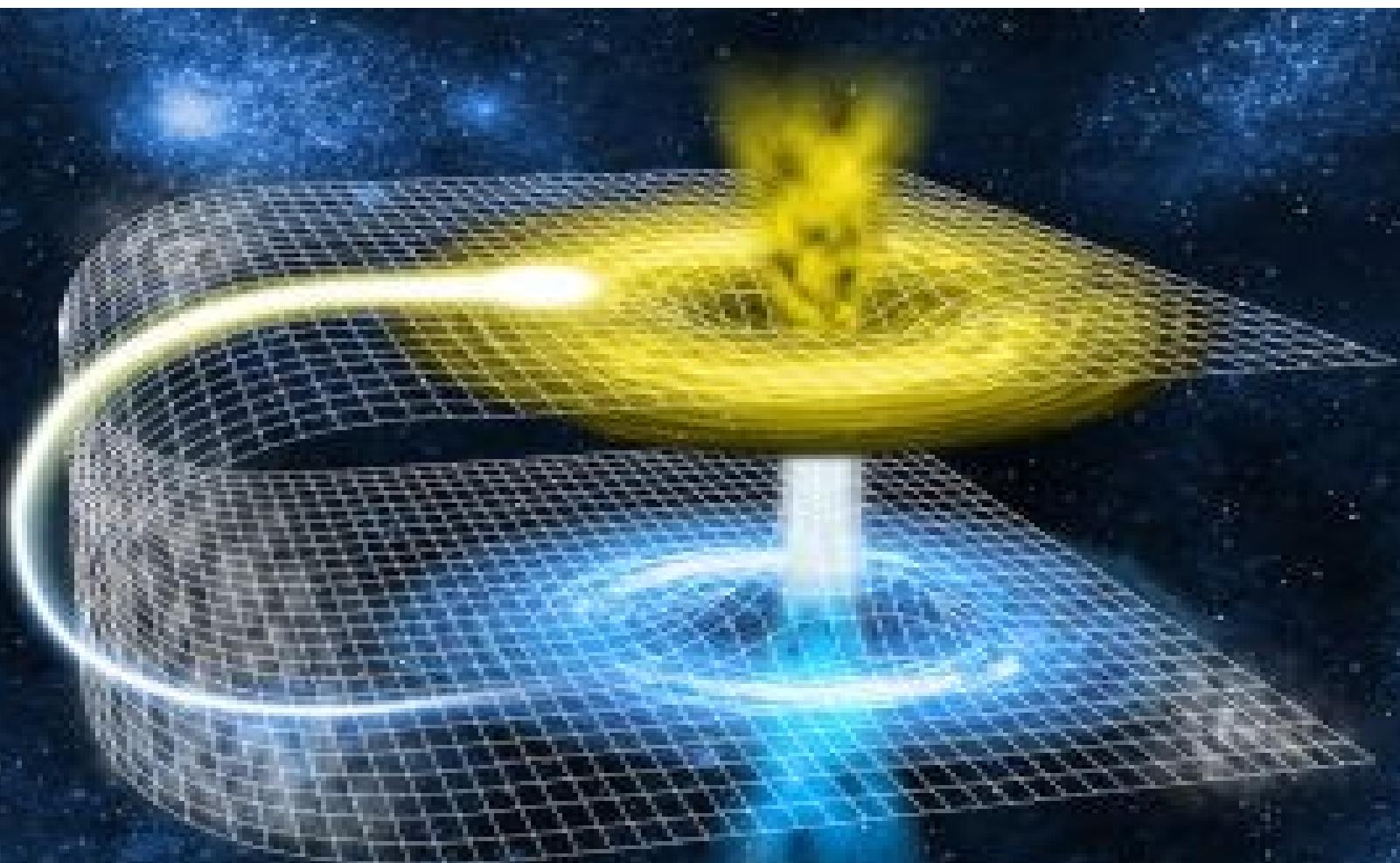


Approximate size of Earth
if it collapsed to a black
hole; it would weigh the
same as Earth today.

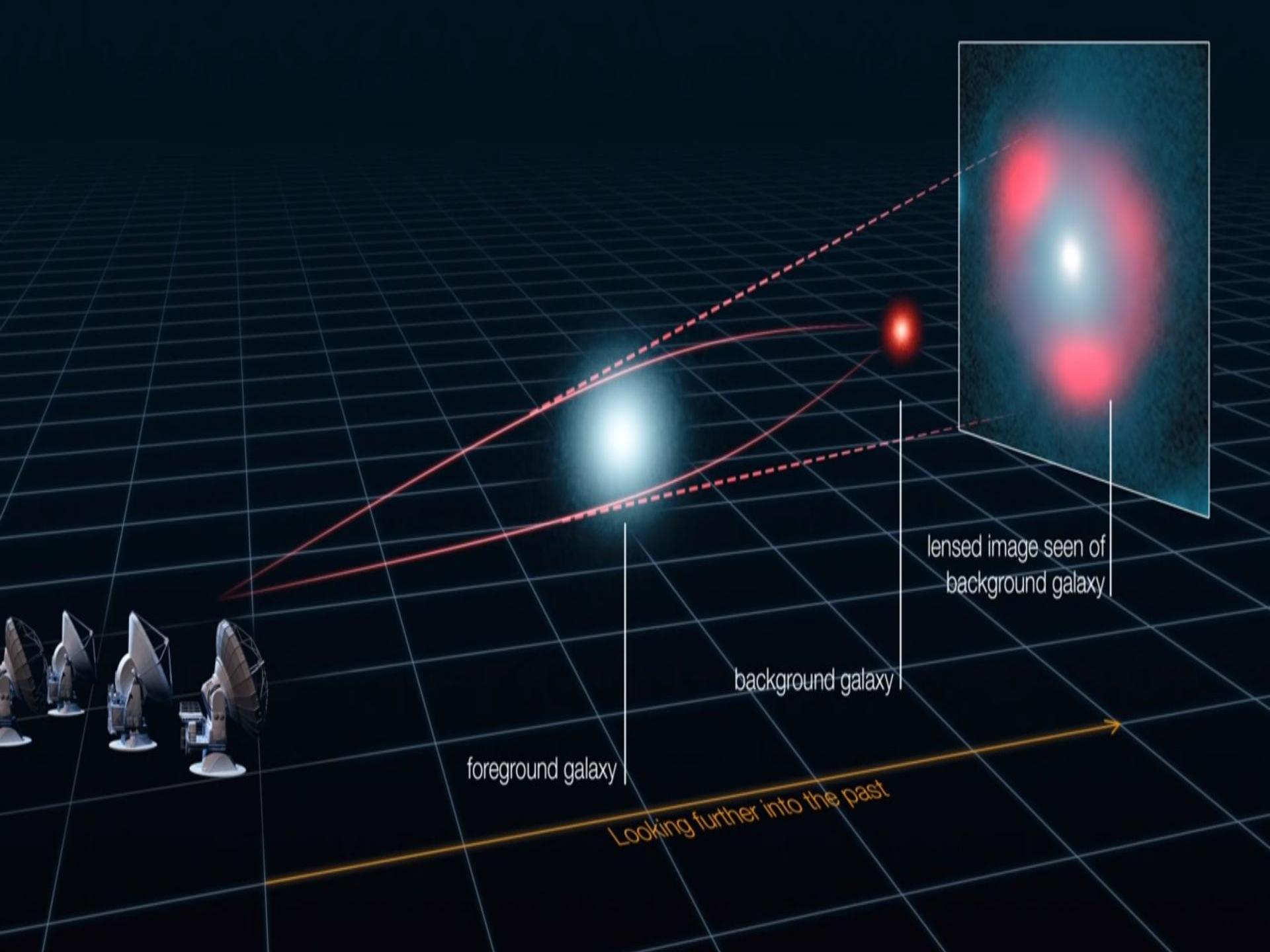
— 0.7 inch —



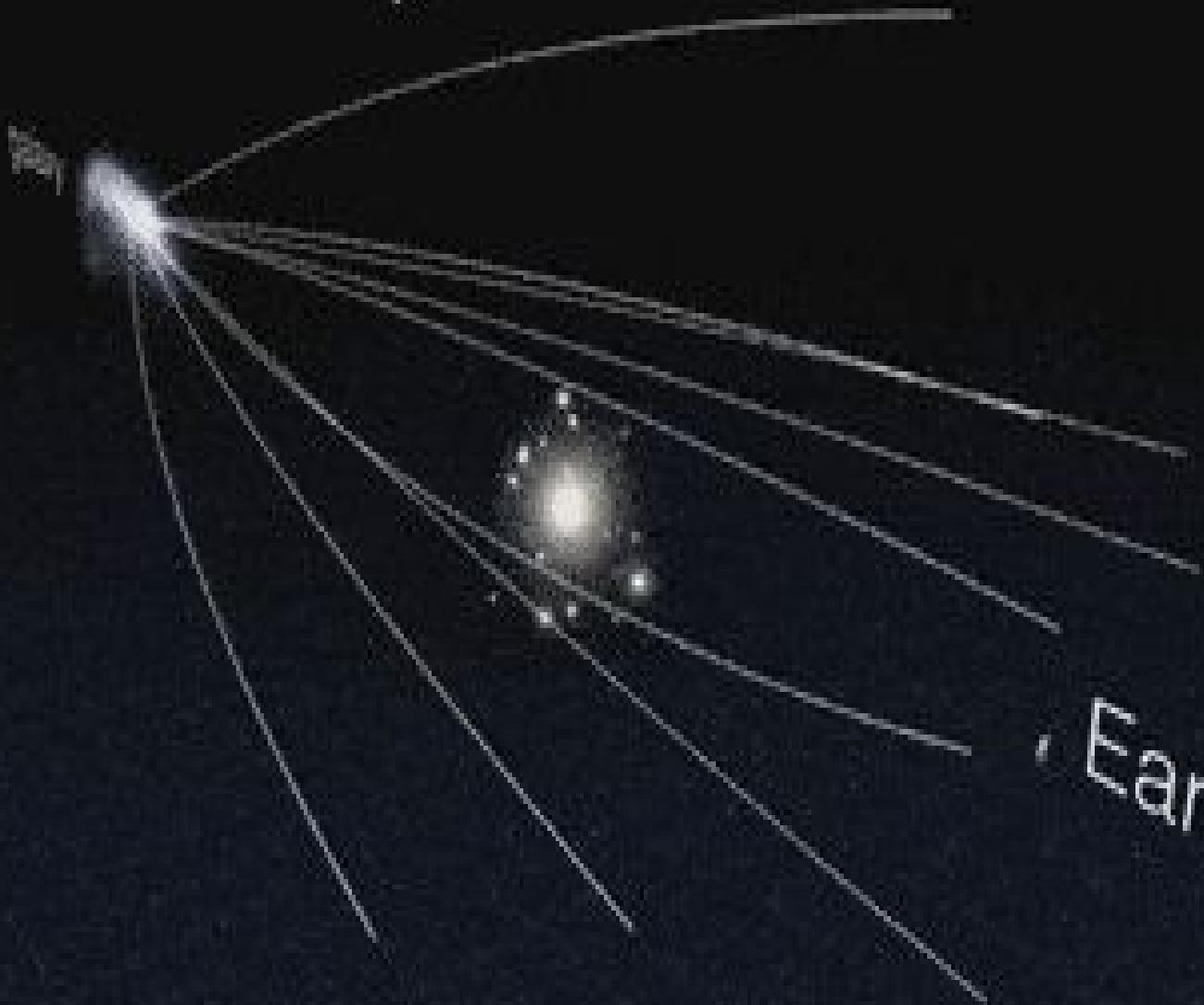
Einstein-Rosen bridges



- Recently, scientists observed the merger of giant ‘blackholes’ billions of light-years away from the earth. What is the significance of this observation?
 - (a) ‘Higgs boson particles’ were detected.
 - (b) ‘Gravitational waves’ were detected.
 - (c) Possibility of inter-galactic space travel through ‘wormhole’ was confirmed.
 - (d) It enabled the scientists to understand to ‘singularity’.
- Ans B

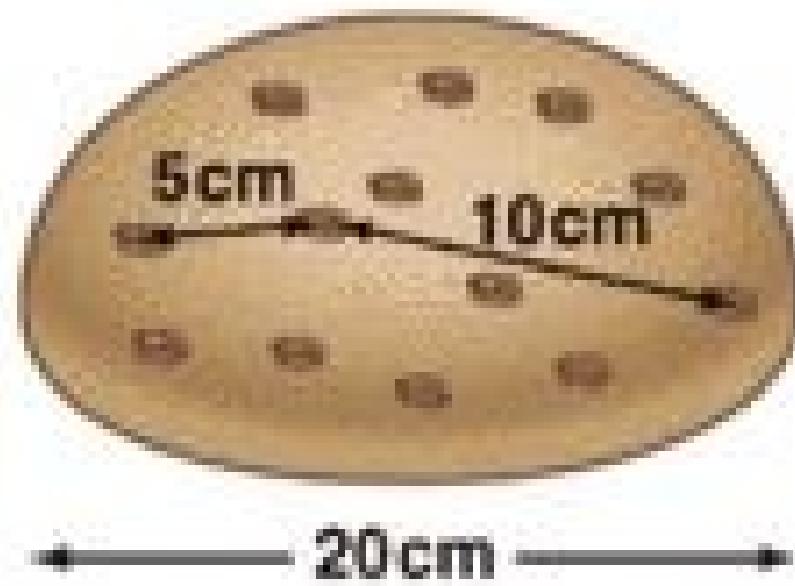


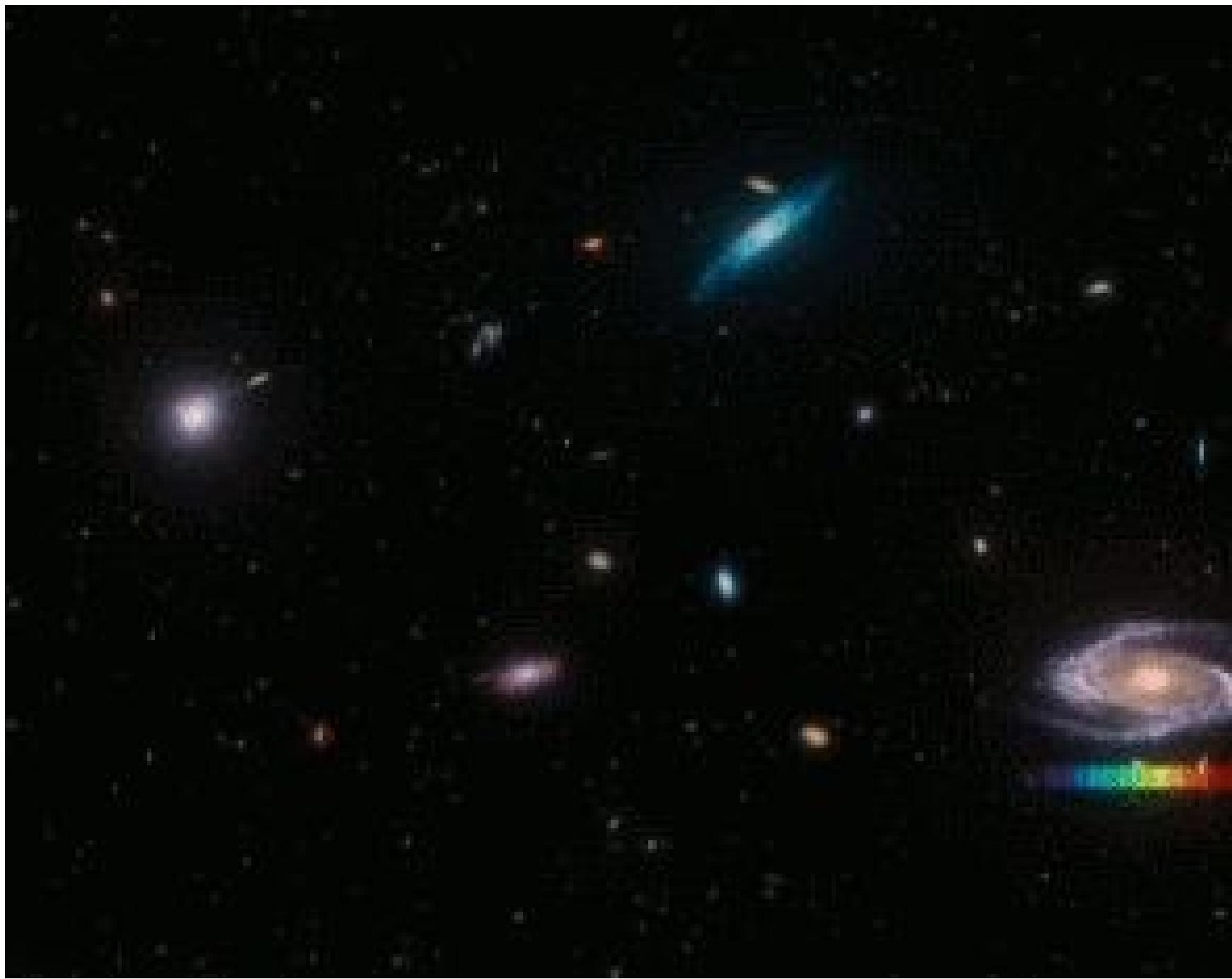
light rays



Earth

Expanding universe





- Einstein's mass energy relation is given by the expression [UPSC 2008]
- $E = 1/2 mv^2$
- $E = mc^2$
- $E = mgh$
- None of the above

Ans B

- Consider the following phenomena: [Prelims 2018]
 - 1. Light is affected by gravity.
 - 2. The Universe is constantly expanding.
 - 3. Matter warps its surrounding space-time.
- Which of the above is/are the prediction/predictions of Albert Einstein's General Theory of Relativity, often discussed in media?
 - (a) 1 and 2 only
 - (b) 3 only
 - (c) 1 and 3 only
 - (d) 1,2 and 3
- Ans D

- **Which of the following is /are cited by the scientists as evidence/ evidences for the continued expansion of universe? (2012)**
- 1. Detection of microwaves in space
 2. Observation of redshift phenomenon in space
 3. Movement of asteroids in space
 4. Occurrence of supernova explosions in space
- **Select the correct answer using the codes given below:**
- - (a) 1 and 2
 - (b) 2 only
 - (c) 1, 3 and 4
 - (d) None of the above can be cited as evidence
- **Solution: A**