"The Planets"

Astro/EPS C12 (CCN 17045 or 32505)

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LEC: 2 LeConte TWTh, 2:40–5:00pm
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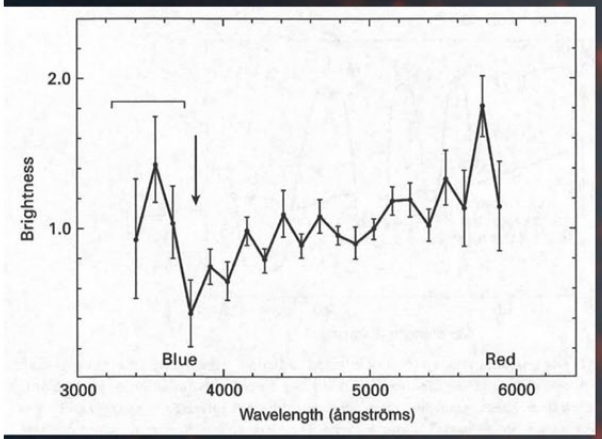
Mon 3–4 and Tue 5–6

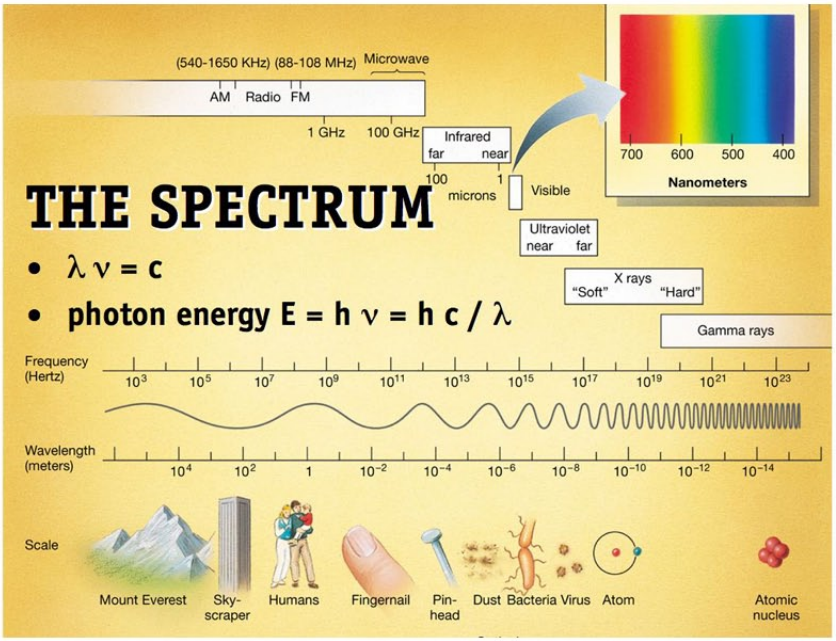
FIRST PLUTO SPECTRUM



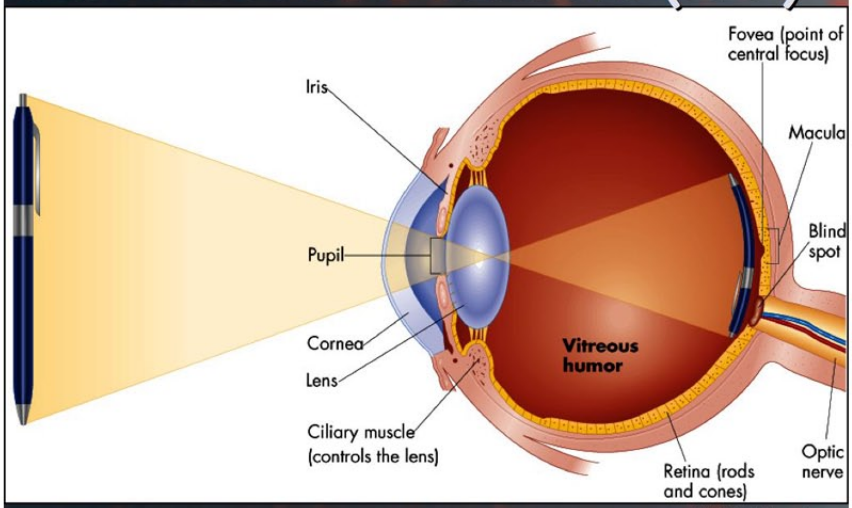
- 1970
- error bars quantify uncertainty in the results
- related to SIGNIFICANT DIGITS...

THE SPECTRUM

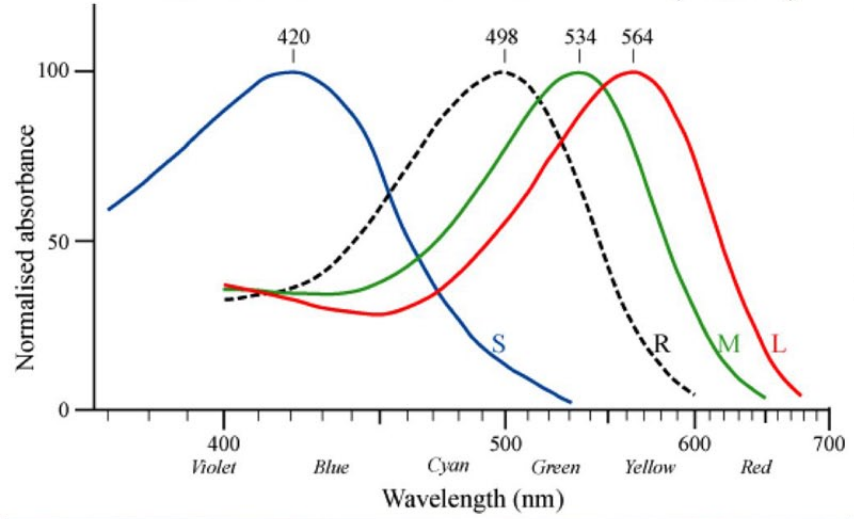
- $\lambda \nu = c$
- photon energy $E = h \nu = h c / \lambda$



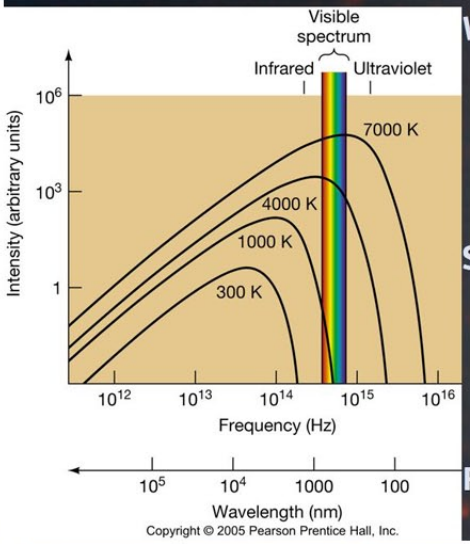
VISIBLE LIGHT SENSOR (EYE)



VISIBLE LIGHT SENSOR (EYE)



BLACKBODY RADIATION



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WEIN'S LAW:

$\lambda_{max} T = 2900\ \mu m\ K$

$= 0.29\ cm\ K$

$= 2.9 \times 10^7\ Å\ K$

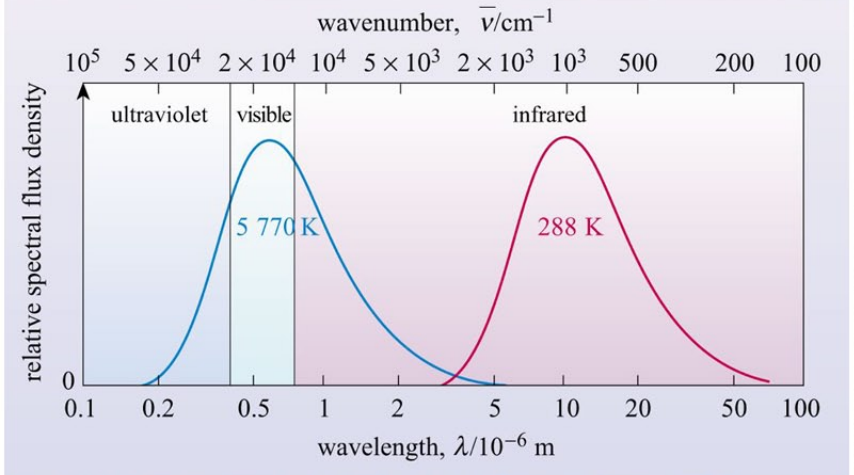
STEFAN-BOLTZMANN LAW

$E = \sigma T^4$

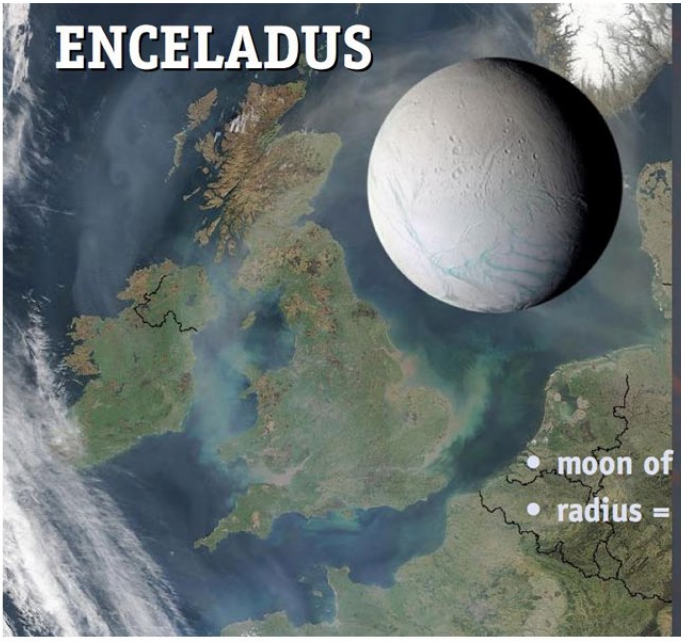
(E is energy emitted per unit area per second)

PLANCK FUNCTION

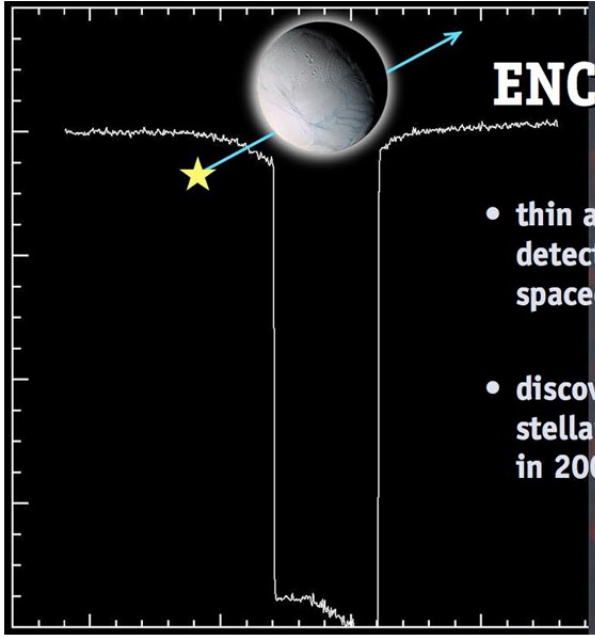
THERMAL RADIATION



ENCELADUS



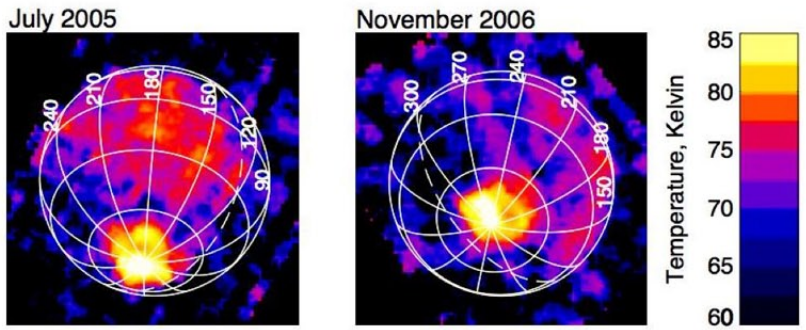
- moon of Saturn
- radius = 252 km



ENCELADUS

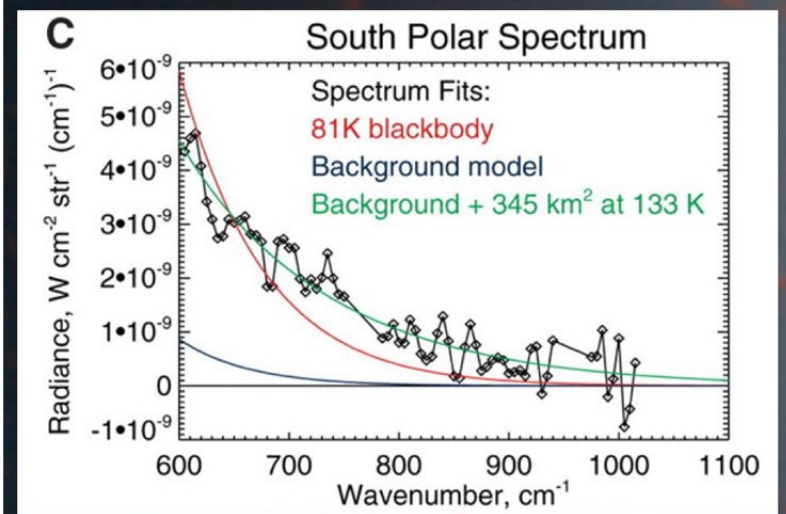
- thin atmosphere detected by Cassini spacecraft
- discovered using stellar occultation in 2005

MEASURING TEMPERATURES



- high temperatures near south pole
- "hot" areas detected by their thermal radiation

MEASURING TEMPERATURES



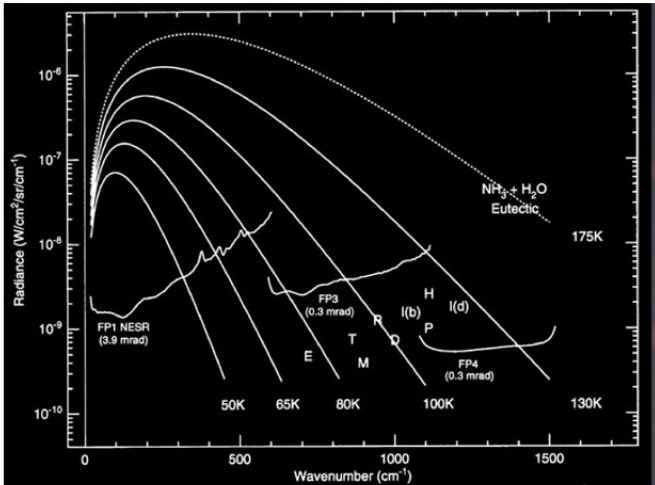
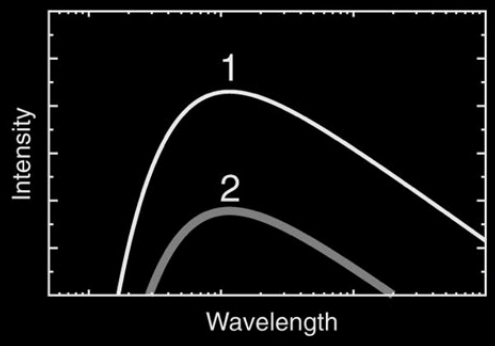


Figure 23. An overview of CIRS's capability for temperature sensing on the icy satellites. The irregular curves represent the NESR of the three CIRS focal planes (and their pixel sizes) for low spectral resolution short scans (15.5 cm^{-1}, 4.75 sec). Blackbody curves are shown for reference. Letter symbols in the lower center of the figure lie on blackbody curves corresponding to maximum expected surface temperatures for the icy satellites; all temperatures are calculated using a thermal inertia of 3×10^4 erg $cm^{-2}s^{-1/2}K^{-1}$. Temperatures are Mimas = M: 88 K; Enceladus = E: 73 K; Tethys = T: 91 K; Dione = D: 101 K; Rhea = R: 100 K; Hyperion = H: 118 K; Iapetus' (bright) = I(b): 109 K; Iapetus (dark) = I(d): 126 K; Phoebe = P: 112 K. The freezing temperature of a eutectic mixture of ammonia and water is approximately 175 K; in the event of current endogenic activity, material of this temperature might be observed.

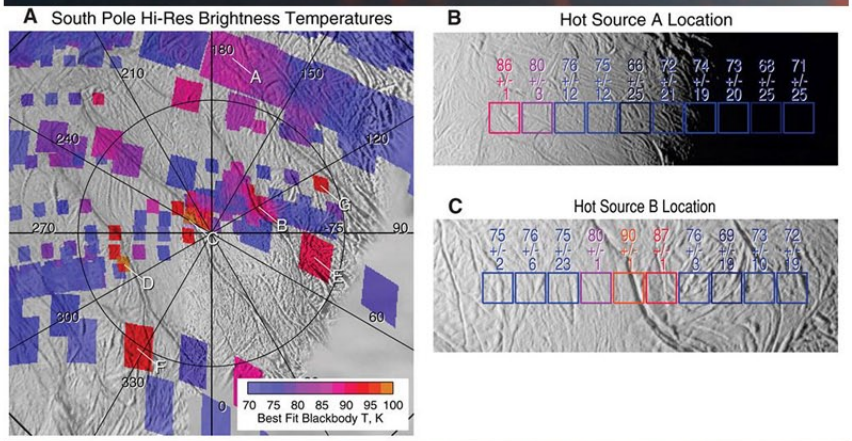
- how Cassini measures temperature

MENTAL EXERCISE



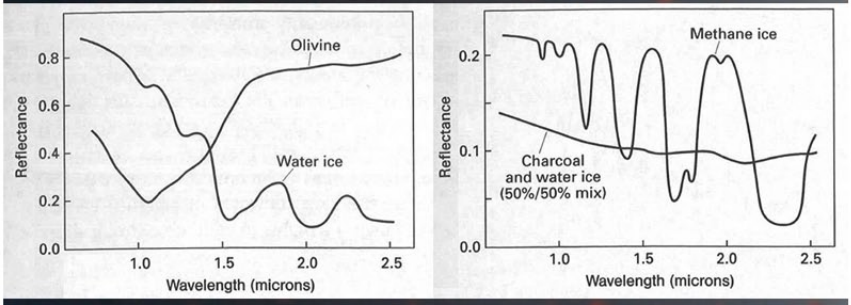
A. 1 has a higher temperature than 2
B. 1 and 2 are identical but 1 is closer than 2
C. 1 has a larger area than 2
D. (A and B) or (A and C)

ENCELADUS

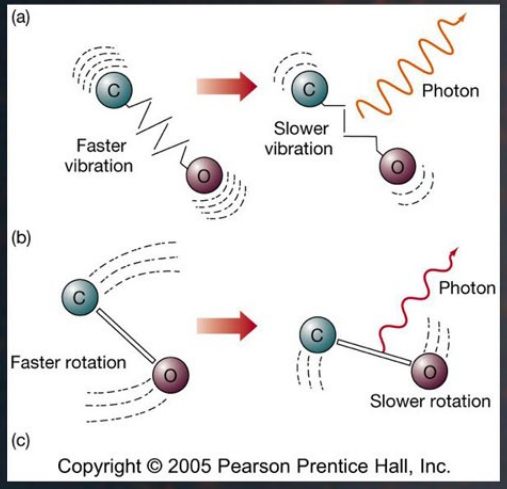


- hottest areas are "tiger stripes"

COMPOSITION AFFECTS REFLECTANCE SPECTRA



MOLECULES



- molecules can be in one of many different vibrational or rotational ENERGY STATES
- changing states may involve emission or absorption of light
- molecules can give each other E by collisions too

VIBRATIONAL/ ROTATIONAL TRANSITIONS

- a molecule is like a blender,with many different speed settings

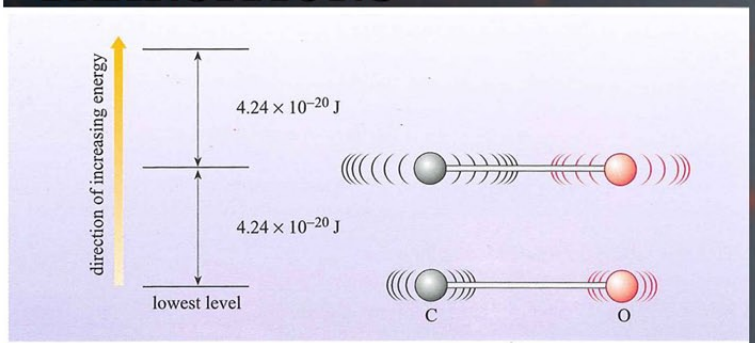
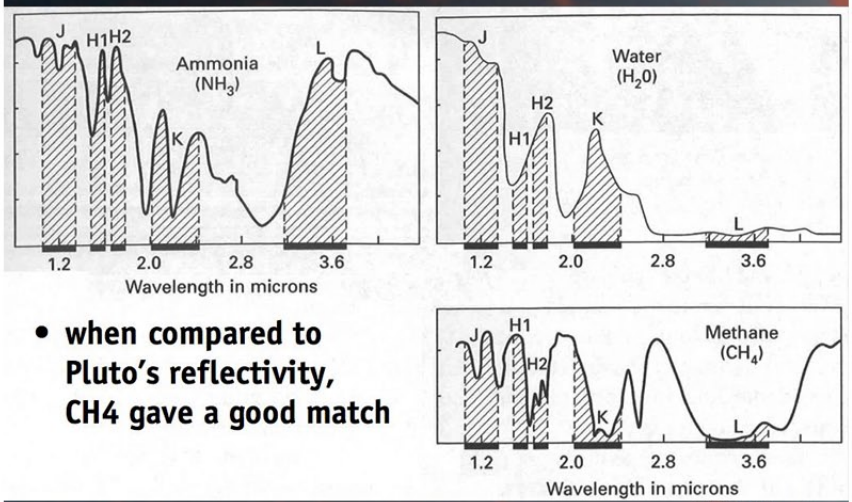


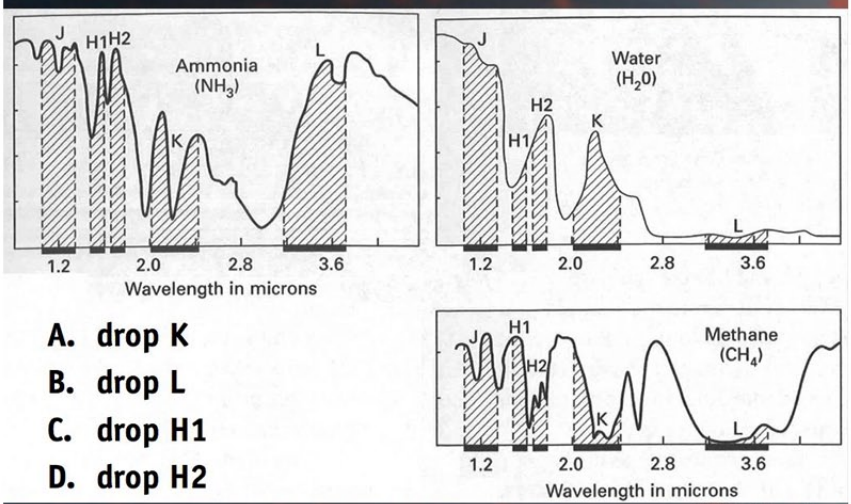
Figure 5.12 Vibrational transitions and vibrational energy levels in CO. To the right are the vibrational states corresponding to the lowest two energy levels.

FROST SPECTRA



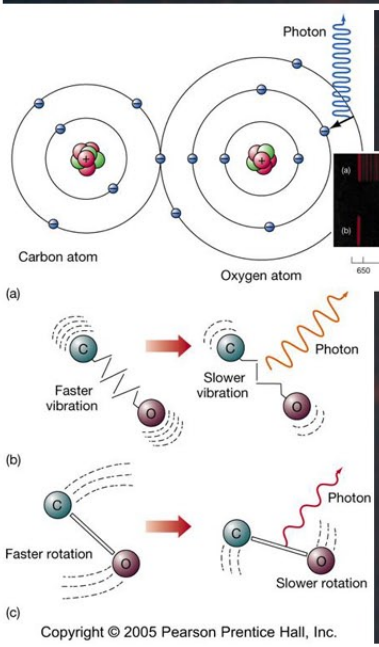
- when compared to Pluto's reflectivity, CH4 gave a good match

MENTAL EXERCISE



A. drop K
B. drop L
C. drop H1
D. drop H2

MOLECULES



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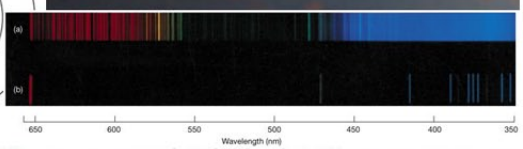
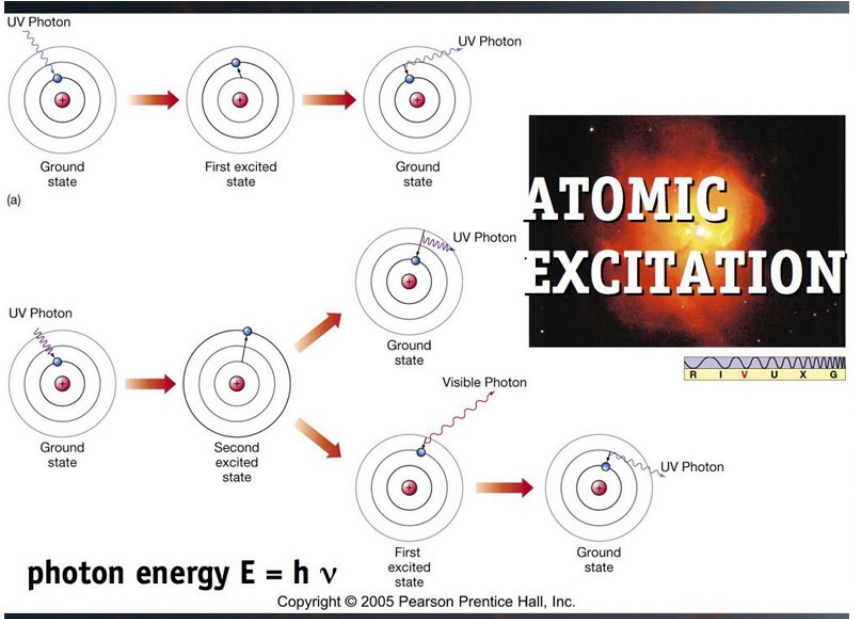
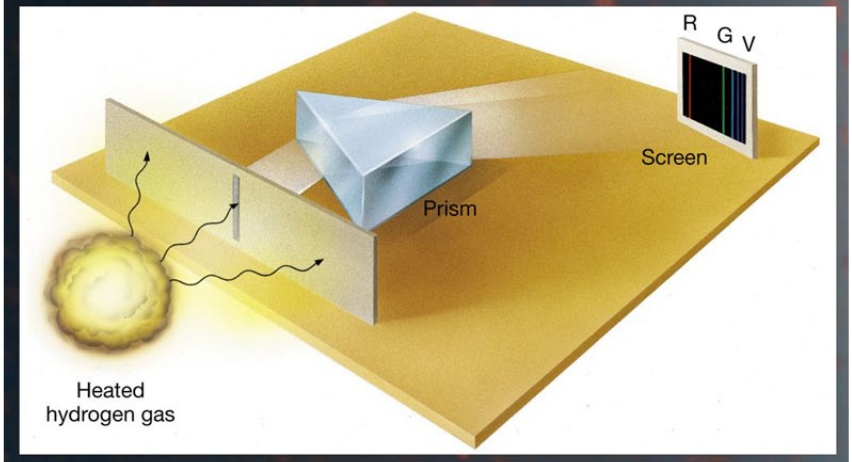
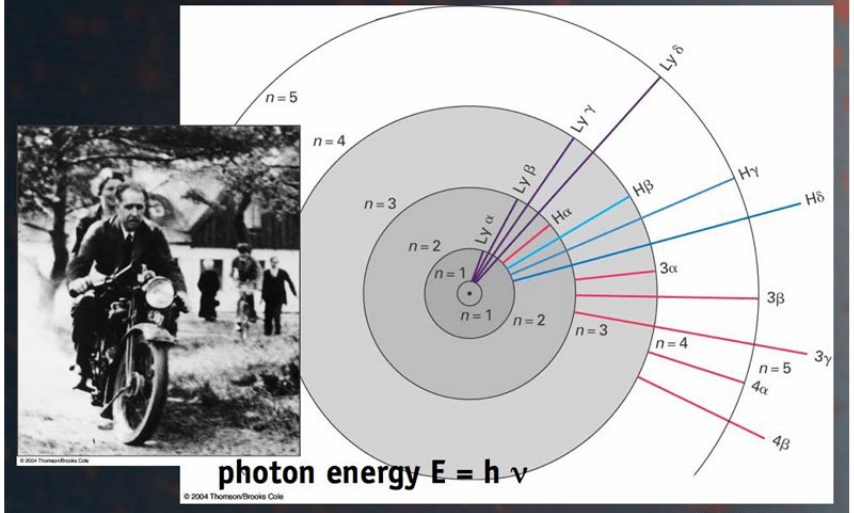




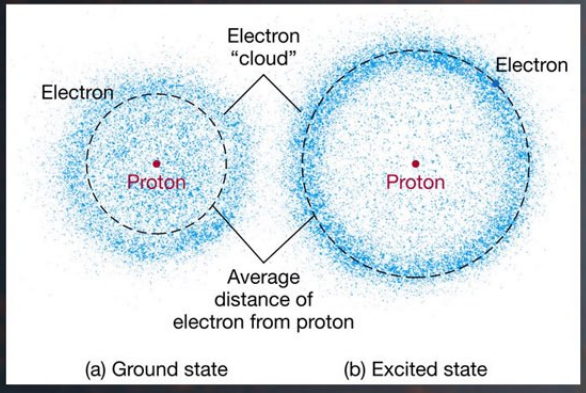
ATOMS, SPECTRAL LINES



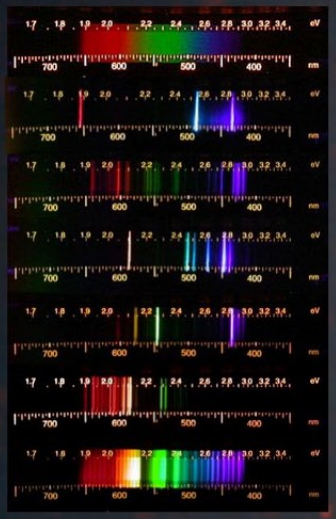
THE BOHR MODEL



THE QUANTUM MODEL



ATOMS, SPECTRAL LINES



Continuous

Hydrogen

Argon

Helium

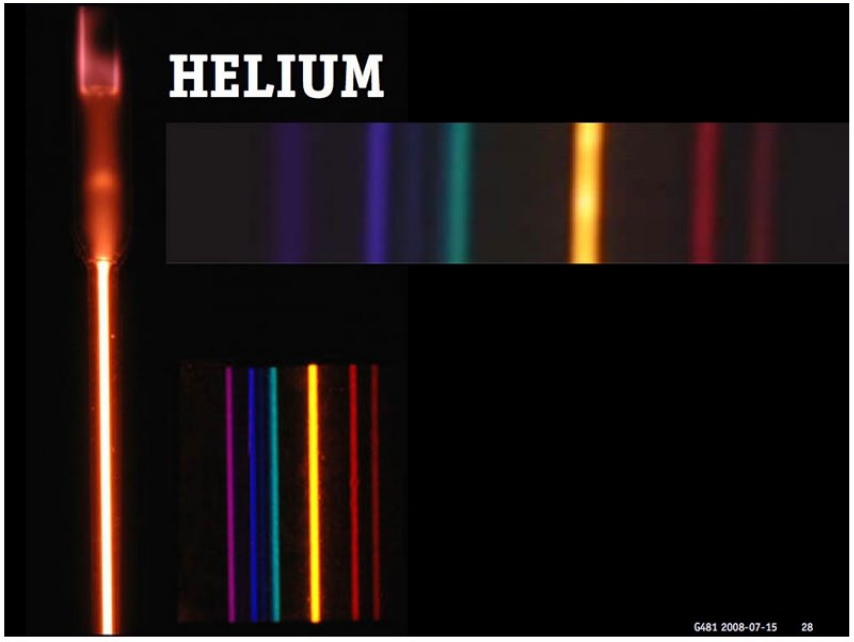
Mercury

Neon

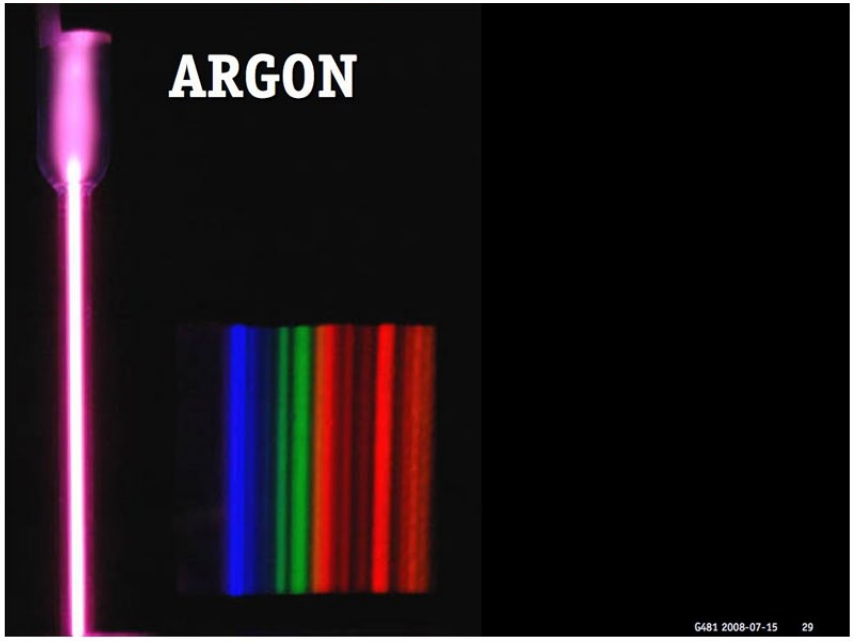
Air

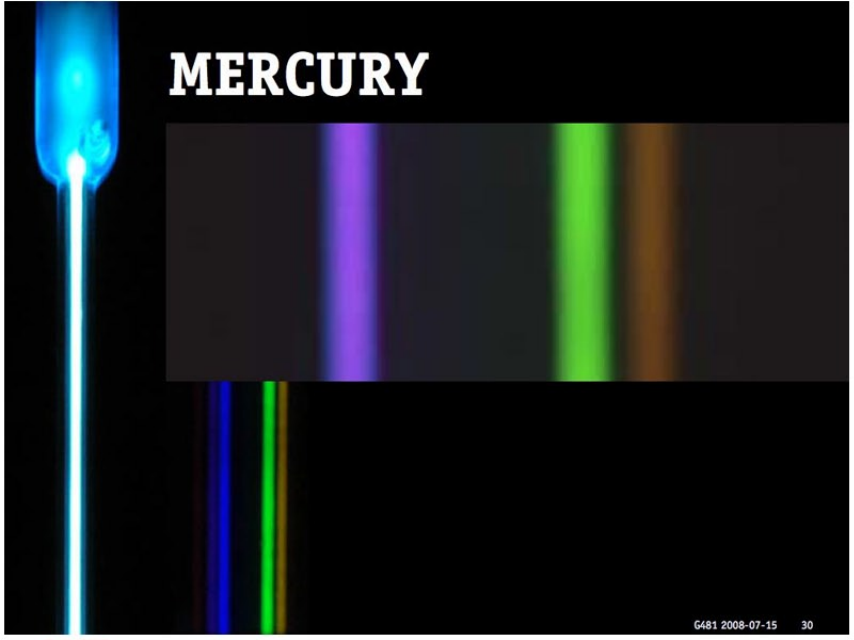
HYDROGEN

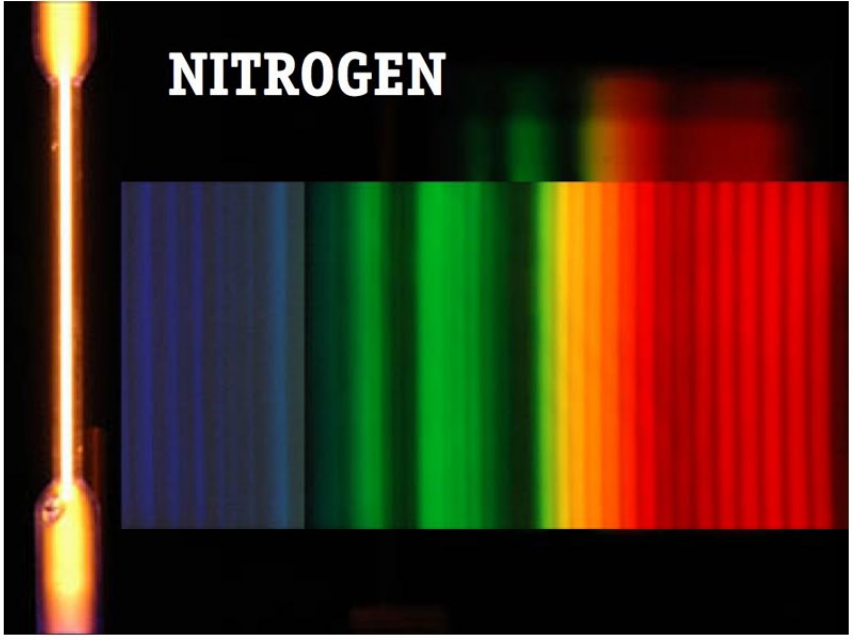
HELIUM

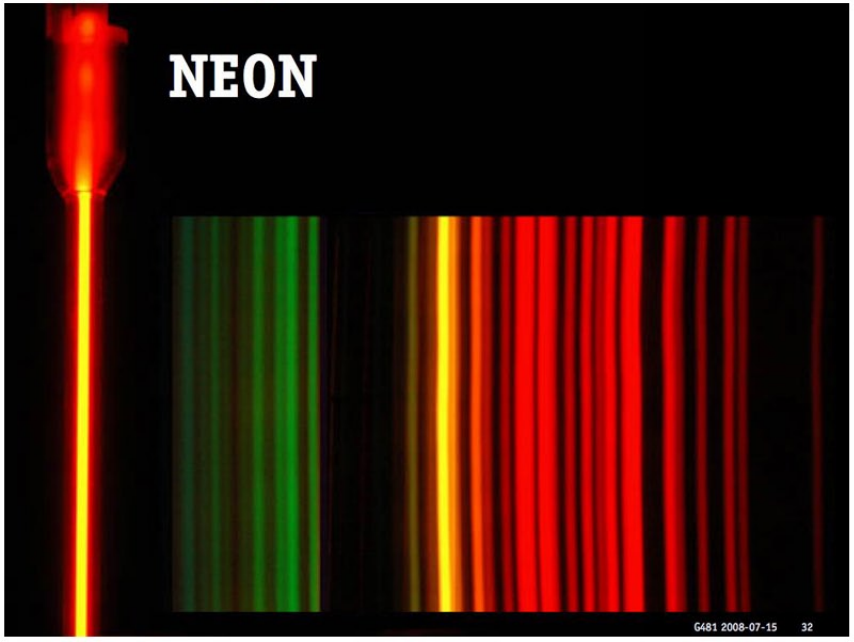


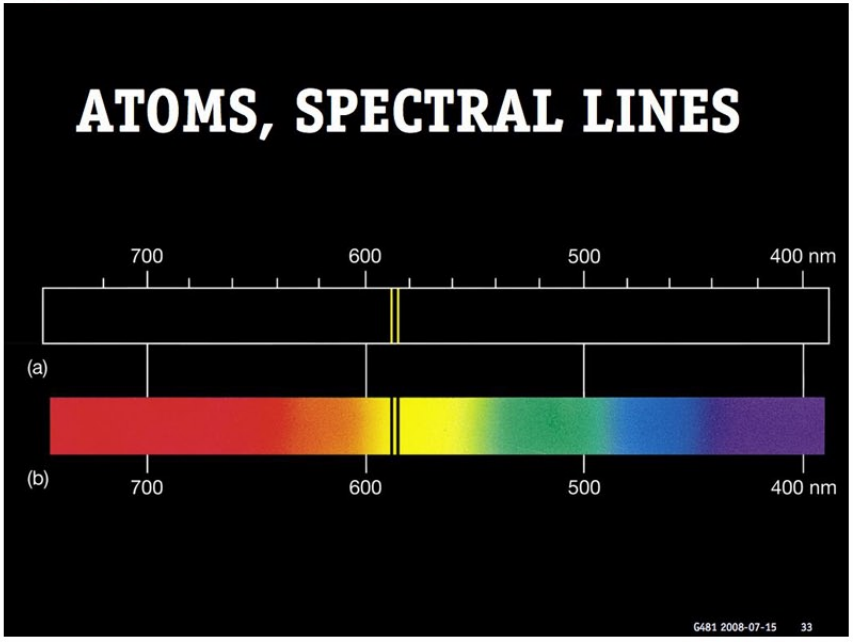
ARGON

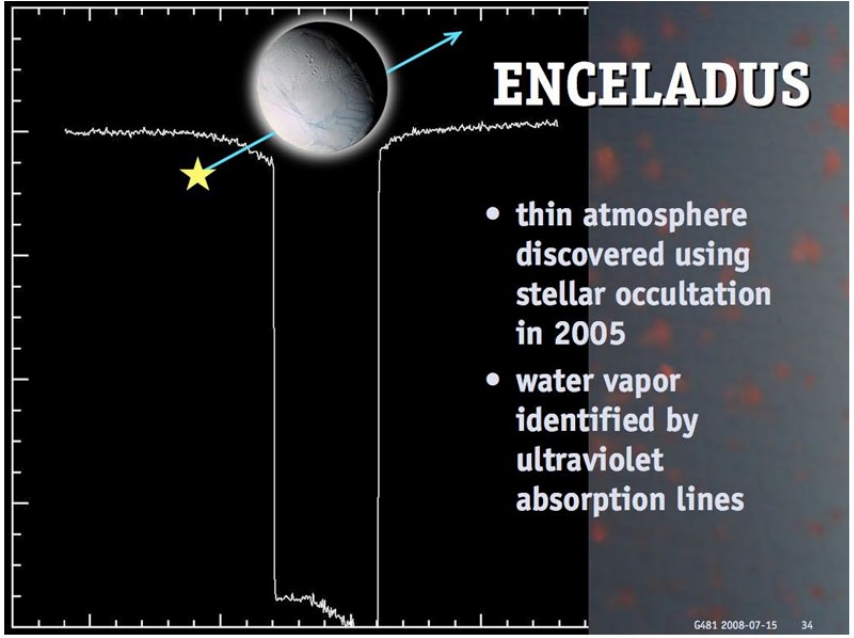


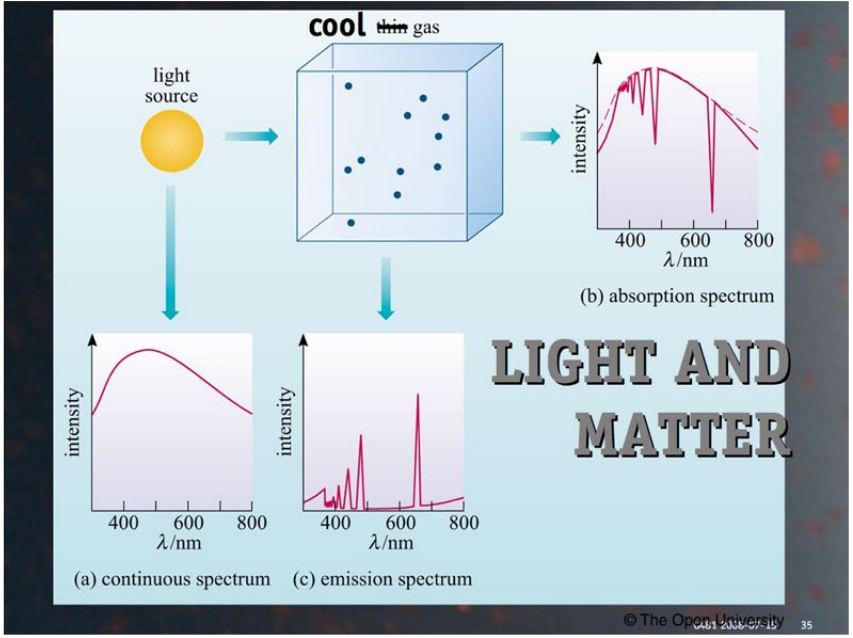

MERCURY
G481 2008-07-15 30


NITROGEN


NEON
G481 2008-07-15 32


ATOMS, SPECTRAL LINES
700
600
500
400 nm
(a)
(b)
700
600
500
400 nm
G481 2008-07-15 33


ENCELADUS
• thin atmosphere discovered using stellar occultation in 2005
• water vapor identified by ultraviolet absorption lines
G481 2008-07-15 34


cool ~~thin~~ gas
light source
intensity
400 600 800
λ/nm
(b) absorption spectrum
(a) continuous spectrum
(c) emission spectrum
LIGHT AND MATTER
© The Open University
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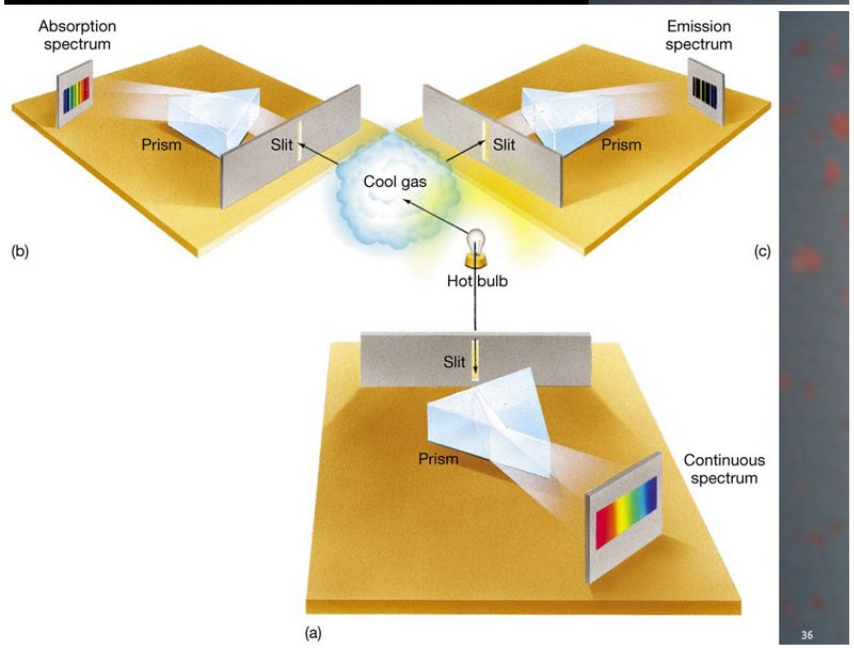
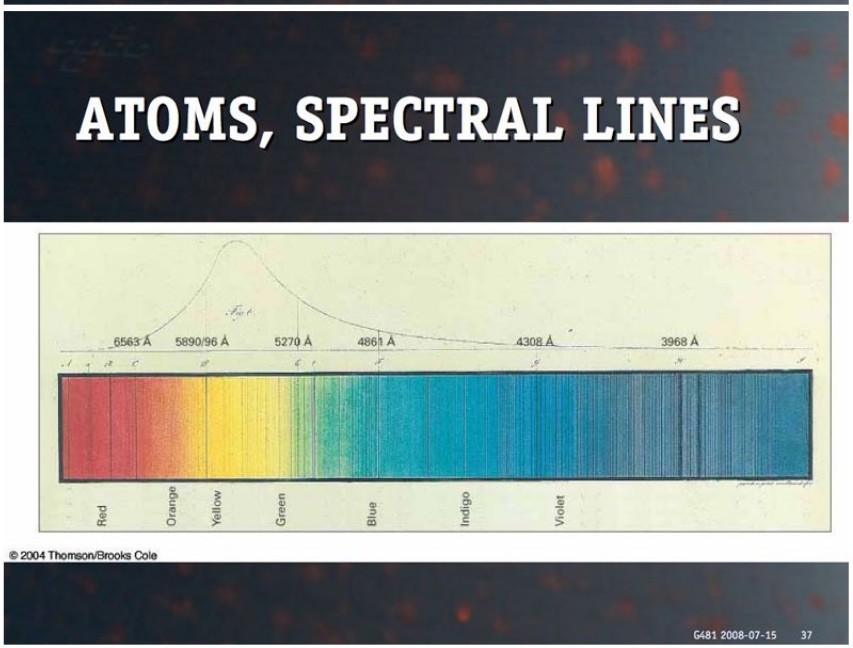

Absorption spectrum
Emission spectrum
Prism
Slit
Cool gas
Hot bulb
(b)
(c)
Continuous spectrum
(a)
36


ATOMS, SPECTRAL LINES
6563 Å
5890/96 Å
5270 Å
4861 Å
4308 Å
3968 Å
Red
Orange
Yellow
Green
Blue
Indigo
Violet
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