



School of Optricks

Presents  
**Optricks**

for a

**Greener World**

**Donn M. Silberman**  
The Optics Institute  
of Southern California

The Optics Institute  
Of Southern California





# Tycho Brahe's Observatory ~ 1600's





# HUBBLE SPACE TELESCOPE



Telescopes to look out into space at stars and galaxies.



Keck I exterior



Close-up of primary mirror

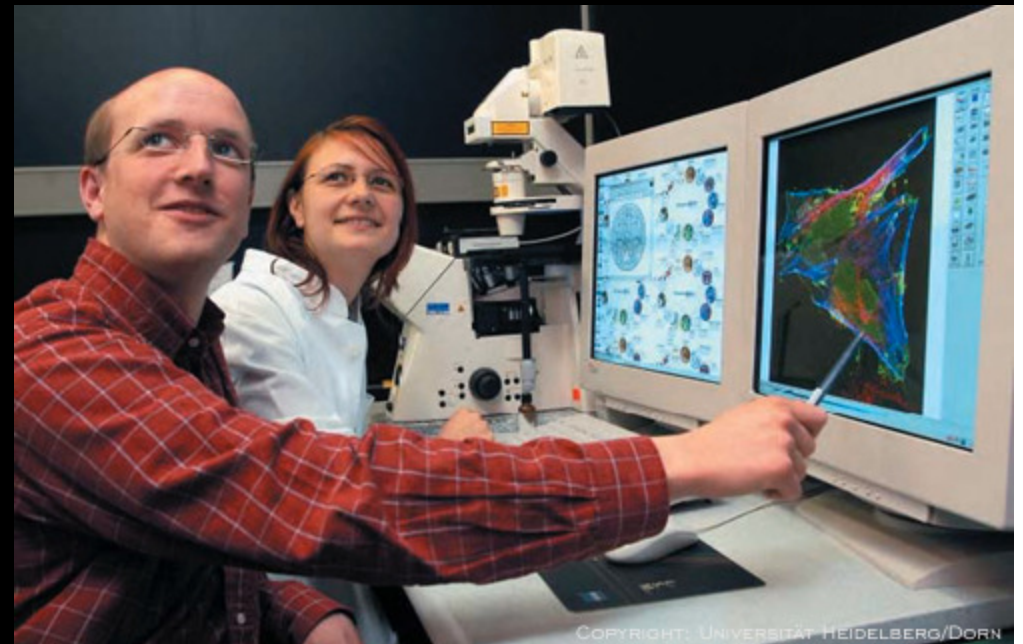


Young students like you  
Learning how to use  
Microscopes.



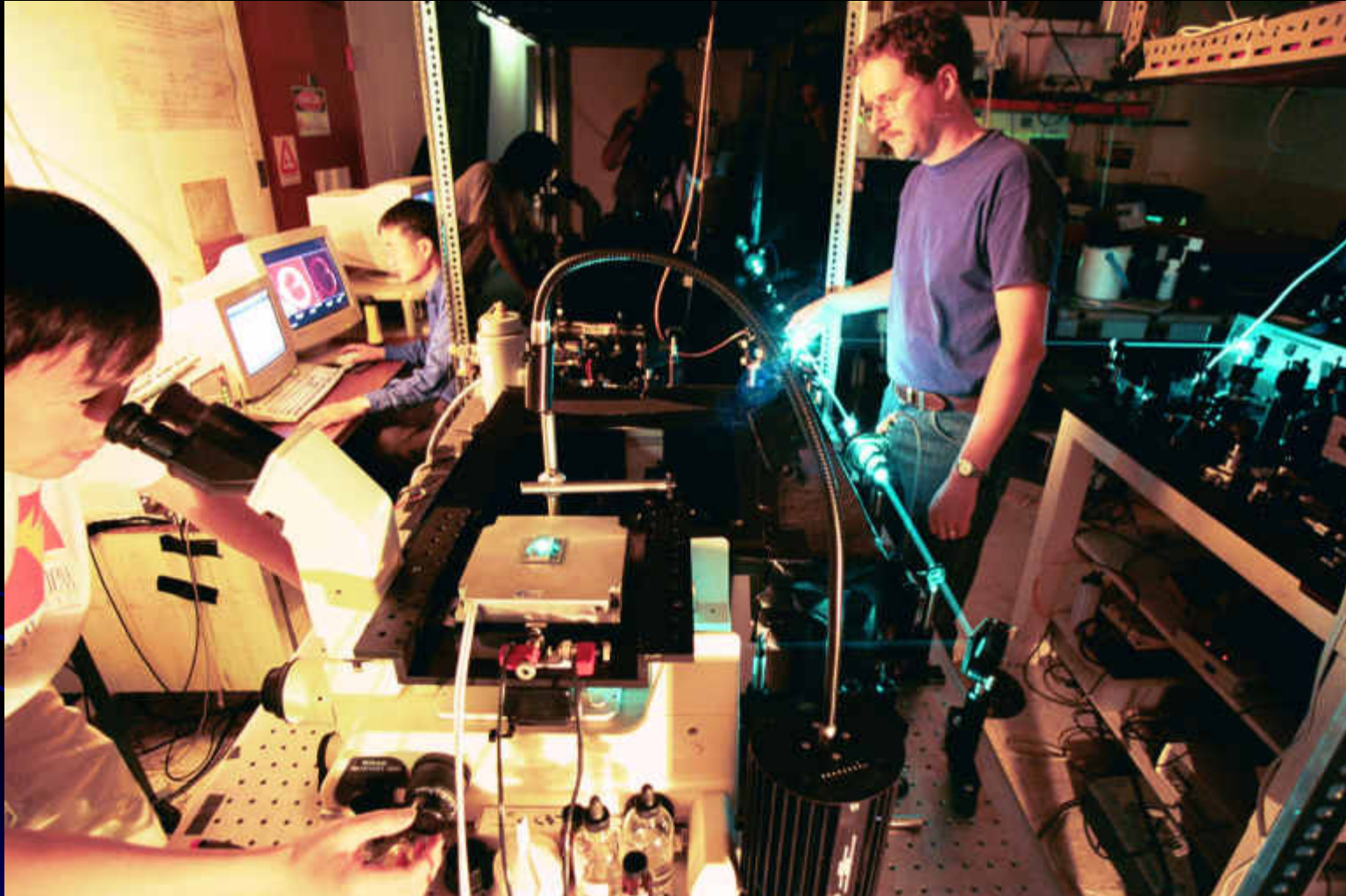
Microscopes for looking at small and very small things.

Researchers in a 'clean room'.





# Laser Spectroscopic Microscope in a university research laboratory

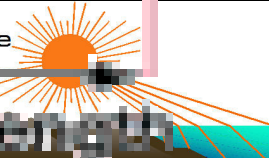
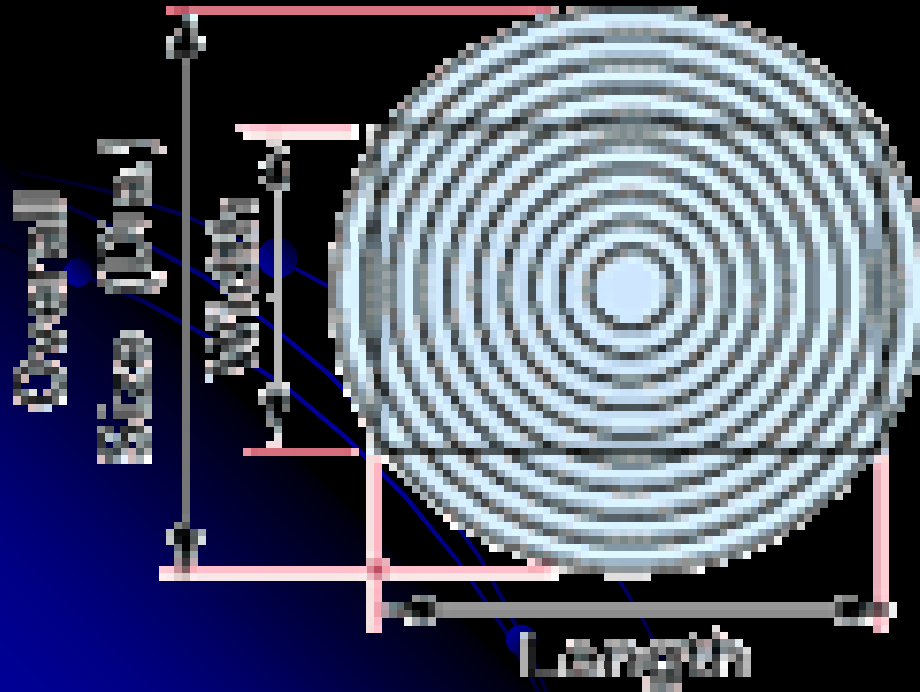


# How Do We “See” the World Around Us?

**'Frisson de la Science'**



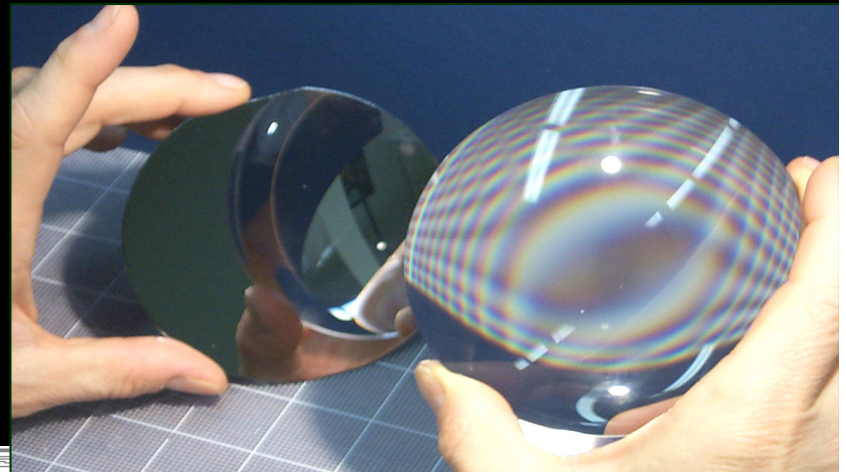
# What's a Fresnel Lens Anyway?





# Optical Engineers Work with Materials That Reflect or Transmit Light

Si – polished silicon wafer mirror-like reflector



## PERIODIC TABLE OF THE ELEMENTS

<http://www.ck12.org/periodic-table/>

GROUP	1 IA	2 IIA	3	4	5	6	7	8	9	10	11	12	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	H 1.0079 HYDROGEN																	He 4.0026 HELIUM
2	Li 6.941 LITHIUM	Be 9.0122 BERYLLIUM																Ne 20.180 NEON
3	Na 22.990 SODIUM	Mg 24.305 MAGNESIUM																Ar 39.948 ARGON
4	K 39.098 POTASSIUM	Ca 40.078 CALCIUM	Sc 44.956 SCANDIUM	Ti 47.867 TITANIUM	V 50.942 VANADIUM	Cr 51.996 CHROMIUM	Mn 54.938 MANGANESE	Fe 55.845 IRON	Co 58.933 COBALT	Ni 58.693 NICKEL	Cu 63.546 COPPER	Zn 65.39 ZINC	Ga 69.723 GALLIUM	Ge 72.64 GERMANIUM	As 74.922 ARSENIC	Se 78.96 SELENIUM	Br 79.904 BROMINE	Kr 83.80 KRYPTON
5	Rb 85.468 RUBIDIUM	Sr 87.62 STRONTIUM	Y 88.906 YTTORIUM	Zr 91.224 ZIRCONIUM	Nb 92.906 NIOBIUM	Mo 95.94 MOLYBDENUM	Tc 98.906 TECHNETIUM	Ru 101.07 RUTHENIUM	Rh 101.07 RHODIUM	Pd 106.42 PALLADIUM	Ag 107.87 SILVER	Cd 112.41 CADMIUM	In 114.82 INDIUM	Sn 118.71 TIN	Sb 121.76 ANTIMONY	Te 127.60 TELLURIUM	I 126.90 IODINE	Xe 131.29 XEON
6	Cs 132.91 CAESIUM	Ba 137.33 BARIUM	La-Lu Lanthanide	Hf 178.49 HAFNIUM	Ta 180.95 TANTALUM	W 183.84 TUNGSTEN	Re 186.21 RHENIUM	Os 190.23 OSMIUM	Ir 192.22 IRIDIUM	Pt 195.08 PLATINUM	Au 196.97 GOLD	Hg 200.59 MERCURY	Tl 204.38 THALLIUM	Pb 207.2 LEAD	Bi 208.98 BISMUTH	Po 209 POLONIUM	At 210 ASTATINE	Rn 222 RADON
7	Fr 223 FRANCIUM	Ra 226 RADIUM	Ac-Lr Actinide	Rf 261 RUTHERFORDIUM	Db 262 DUBNIUM	Sg 266 SEABORGIUM	Bh 264 BOHRIUM	Hs 277 HASSIUM	Mt 268 MEITNERIUM	Uun 281 UNUNBIUM	Uub 285 UNUBIUM	Uuq 289 UNUQUADIUM						

**LEGEND:**  
 Metal: Blue, Semi-metal: Red, Nonmetal: Green  
 Alkali metal: Light Blue, Alkaline earth metal: Light Green, Transition metals: Yellow  
 Lanthanide: Purple, Actinide: Pink  
 Chalcogens element: Light Purple, Halogens element: Light Orange, Noble gas: Light Green  
 STANDARD STATE (25 °C, 101 kPa): Ne - gas, Fe - solid, Ga - liquid, Tc - synthetic

**LANTHANIDE:**  
 57 138.91 La, 58 140.12 Ce, 59 140.91 Pr, 60 144.24 Nd, 61 (145) Pm, 62 150.36 Sm, 63 151.96 Eu, 64 157.25 Gd, 65 158.93 Tb, 66 162.50 Dy, 67 164.93 Ho, 68 167.26 Er, 69 168.93 Tm, 70 173.04 Yb, 71 174.97 Lu

**ACTINIDE:**  
 89 (227) Ac, 90 232.04 Th, 91 231.04 Pa, 92 238.03 U, 93 (237) Np, 94 (244) Pu, 95 (243) Am, 96 (247) Cm, 97 (247) Bk, 98 (251) Cf, 99 (252) Es, 100 (257) Fm, 101 (258) Md, 102 (259) No, 103 (262) Lr

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SiO<sub>2</sub> – clear silica lens focuses light



# What is Light??

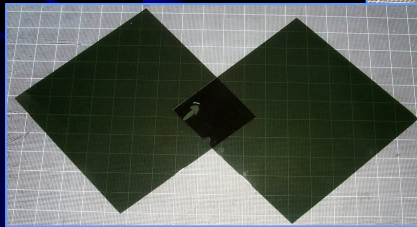
## Light is Like a Vibrating Wave

- We can make a slinky vibrate like a wave of light.
- A slinky vibrating with one length is like light of one wavelength.
- We can stretch the slinky to make longer wavelengths or different colors of light.
- Light is like pure energy with no rest mass (because it is never at rest!!)

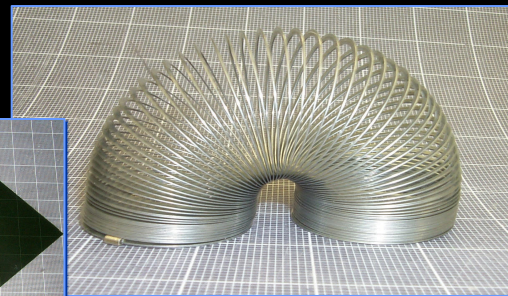


# Light is Like a Vibrating Wave

- We can make a slinky vibrate like a wave of light.
- A slinky vibrating in one direction is like “polarized” light.
- Optical engineers use polarizers to make light vibrate in one direction.



Polarizers

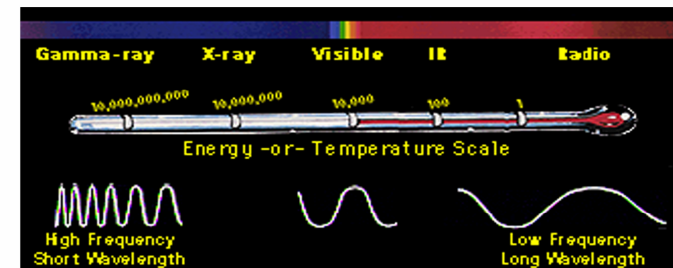


Slinky

- Polarizers have a “secret code.”

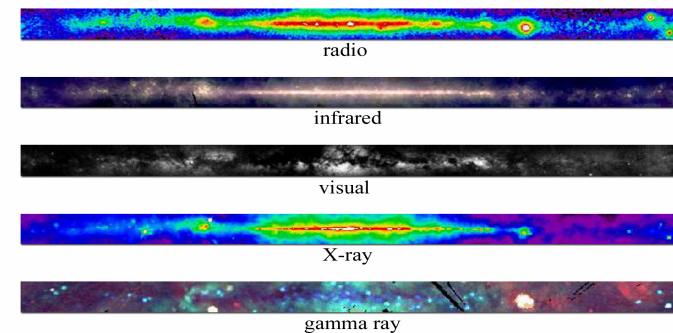
## It takes more than one kind of telescope to see the light

Why we need different types of telescopes to look at outer space



The electromagnetic spectrum. Radio has long wavelengths and low energies, while gamma rays have very short wavelengths and high energies.

### The Multi-Wave Milky Way Galaxy

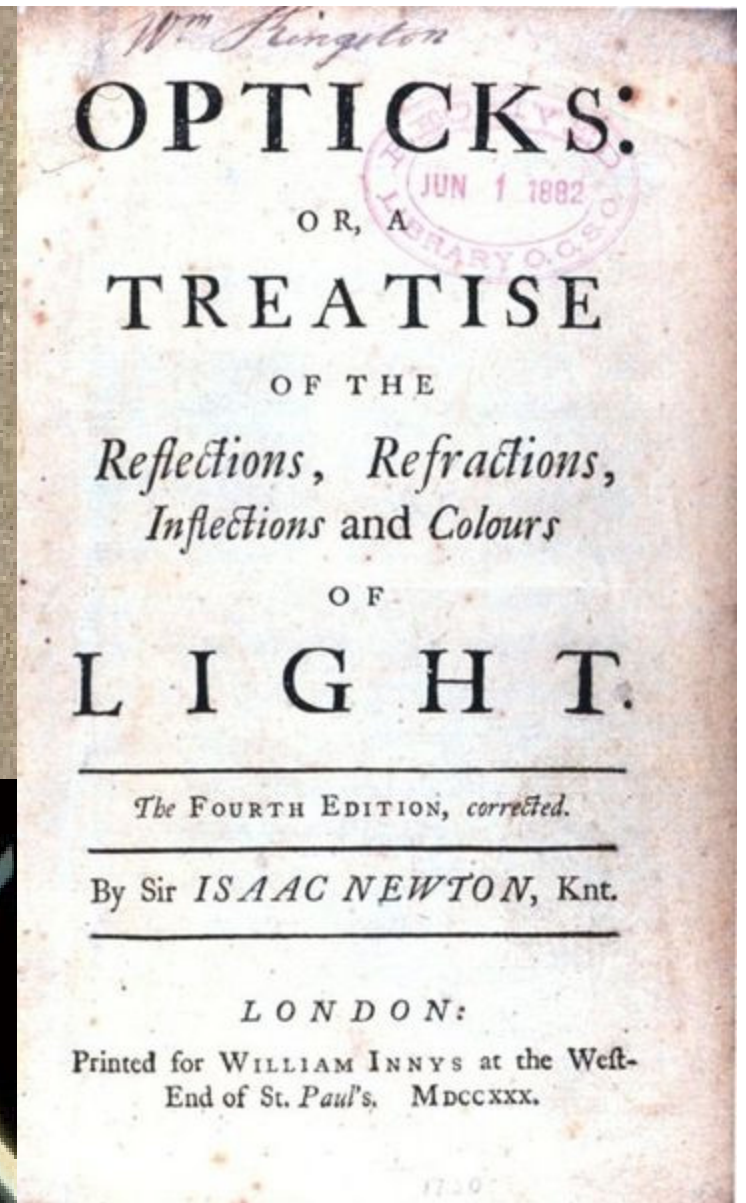


[http://science.nasa.gov/newhome/headlines/features/ast20apr99\\_1.htm](http://science.nasa.gov/newhome/headlines/features/ast20apr99_1.htm)

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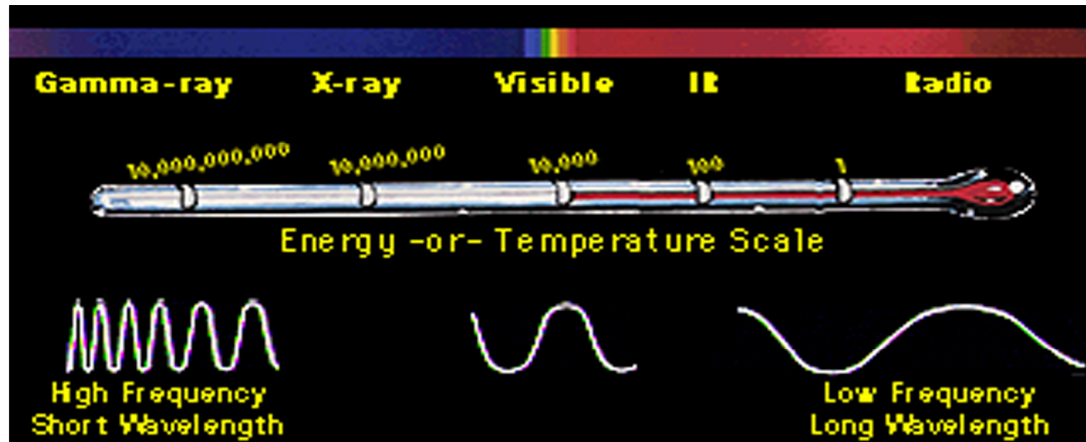


Wavelength = Color



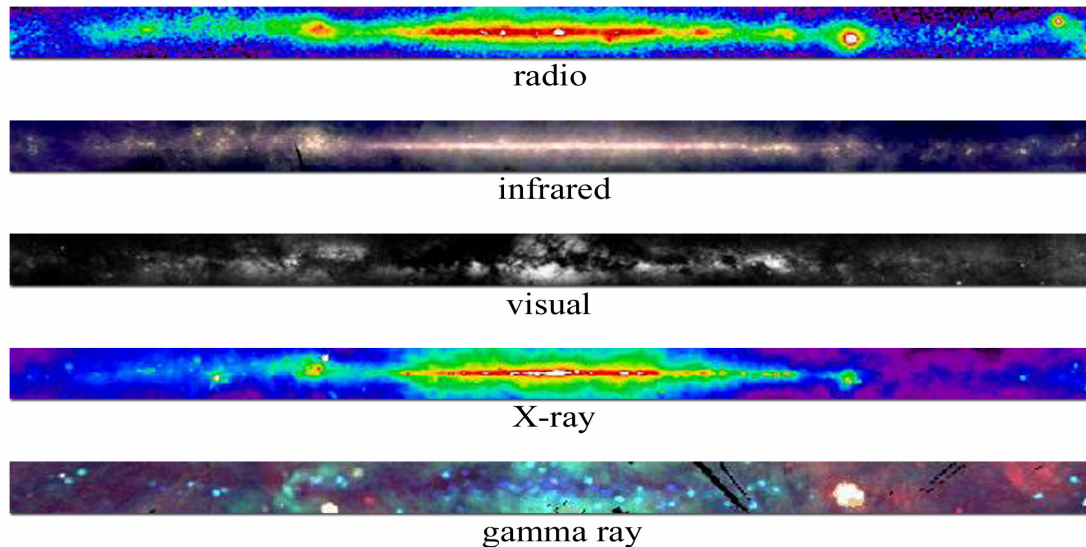
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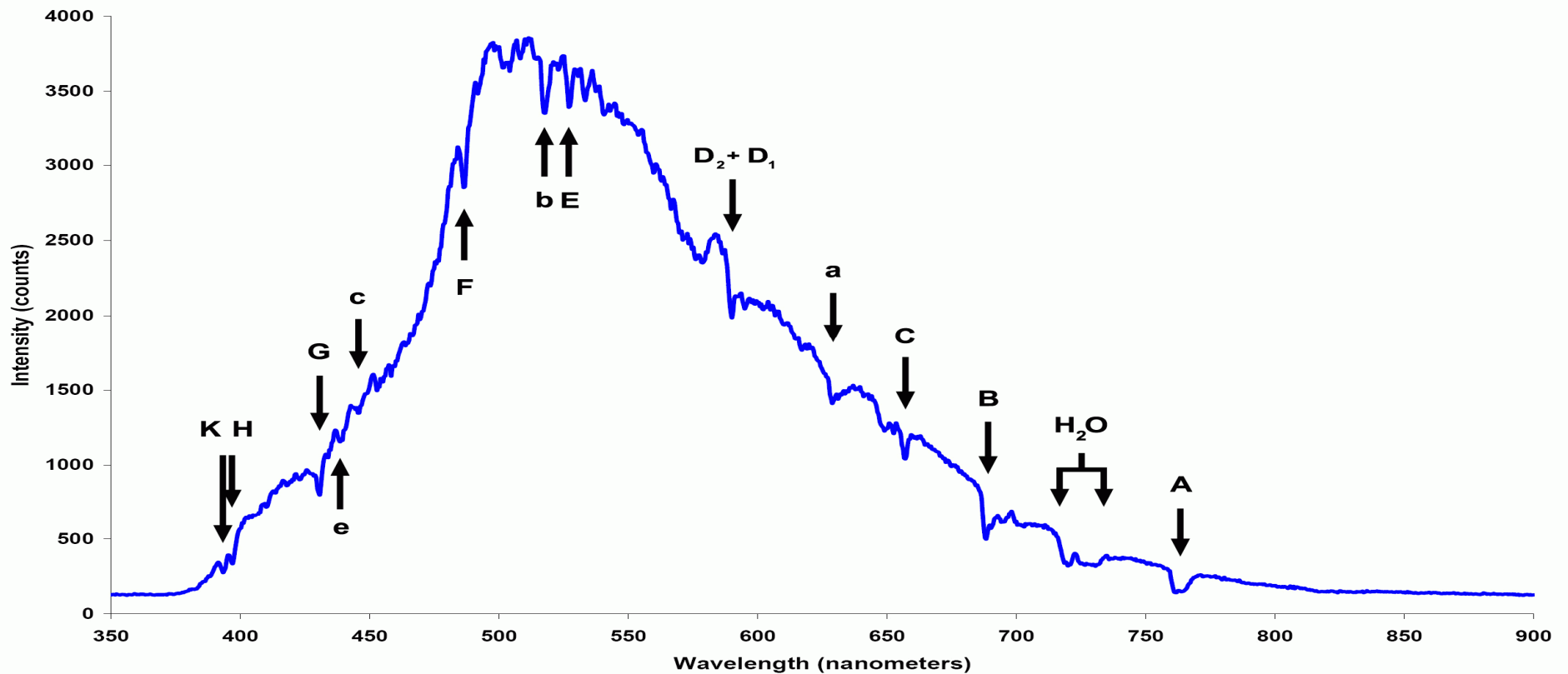
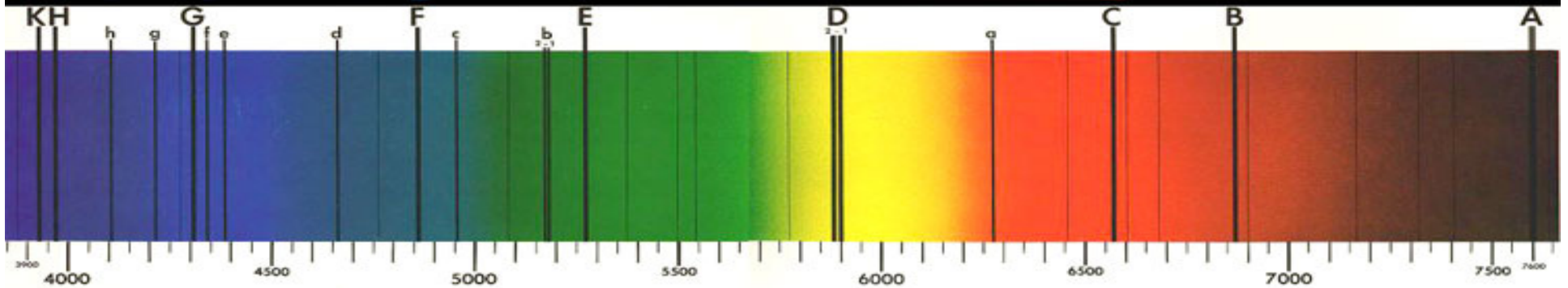
[http://science.nasa.gov/newhome/headlines/features/ast20apr99\\_1.htm](http://science.nasa.gov/newhome/headlines/features/ast20apr99_1.htm)

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# Fraunhofer Spectral Lines

Top: Hydrogen emission spectrum  
Bottom: Fraunhofer lines in solar spectrum





# *Rainbow Peephole<sup>®</sup>*

## *Diffraction Gratings*

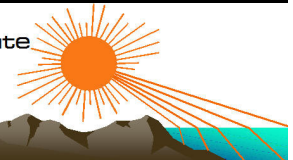
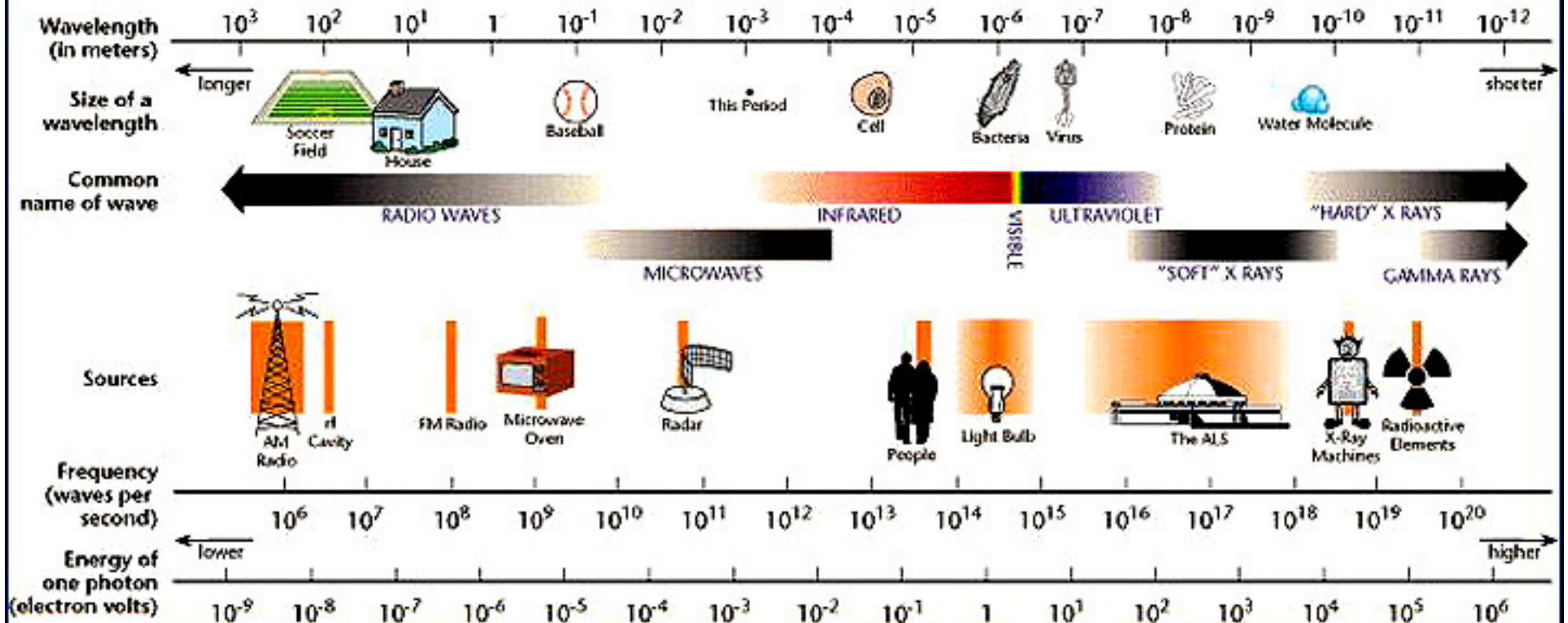
- Light is “redirected” in passing through the plastic peephole to the eye.
- Where do the colors come from?
- Do you see a regular pattern?
- Identify the colors. Are they the same in each spot?
- Does the pattern change if the light is close or far from the peephole? How?
- Do you see colors from the room lights?
- The regular array of bumps on the plastic peephole's surface allows us to see the color in white light through “diffraction.”



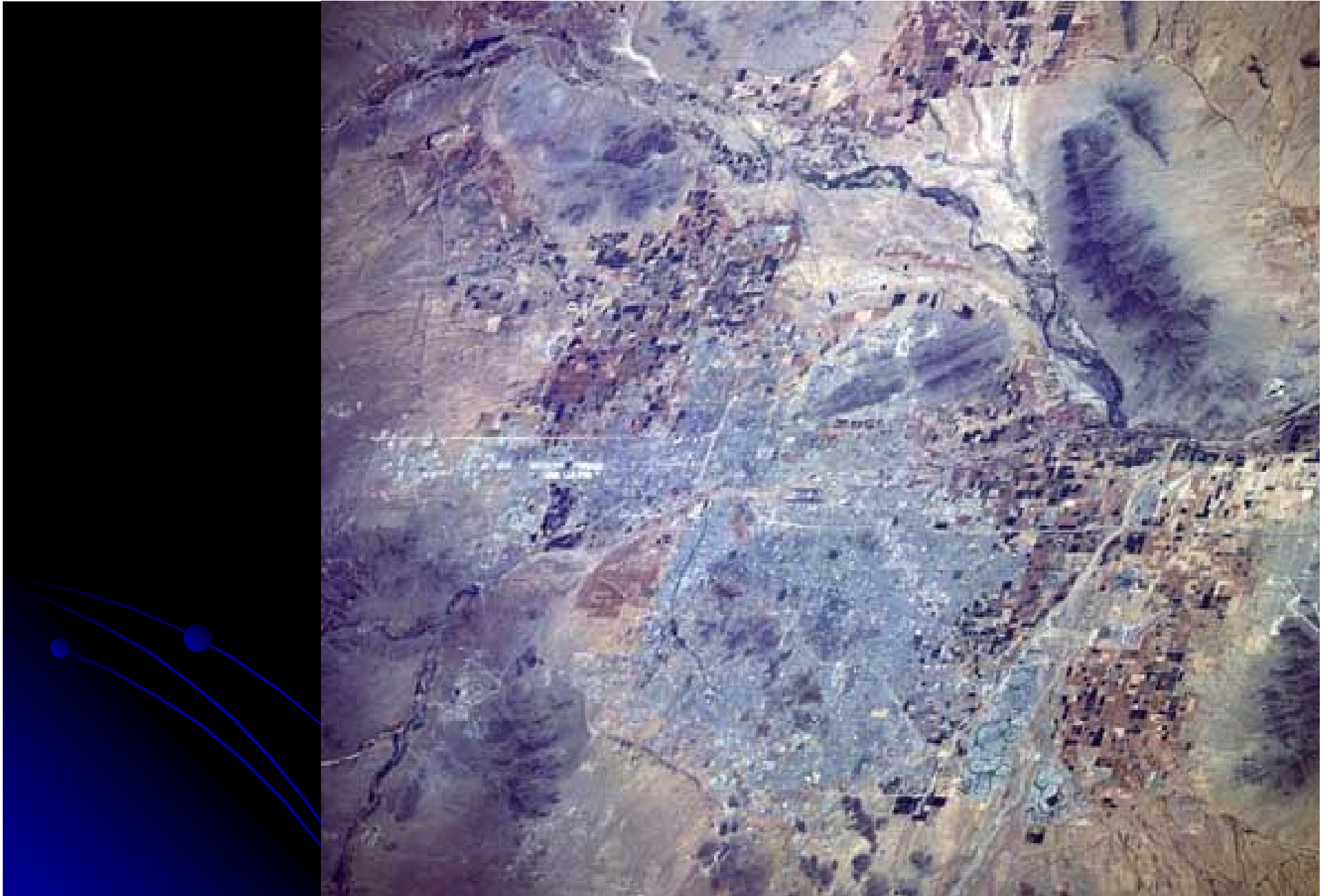
# the remote sensing tutorial



# THE ELECTROMAGNETIC SPECTRUM







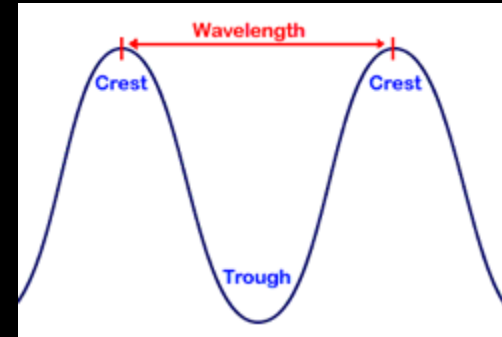
This is a photo of Phoenix, Arizona taken from the Space Shuttle.  
**What can we learn about the earth from this photo?**



What are waves?

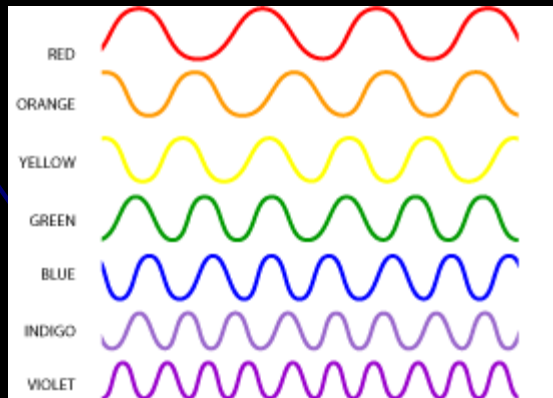
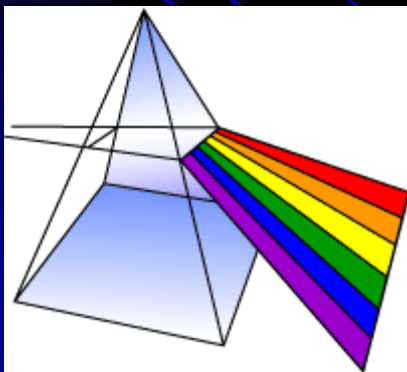


What are electromagnetic waves?

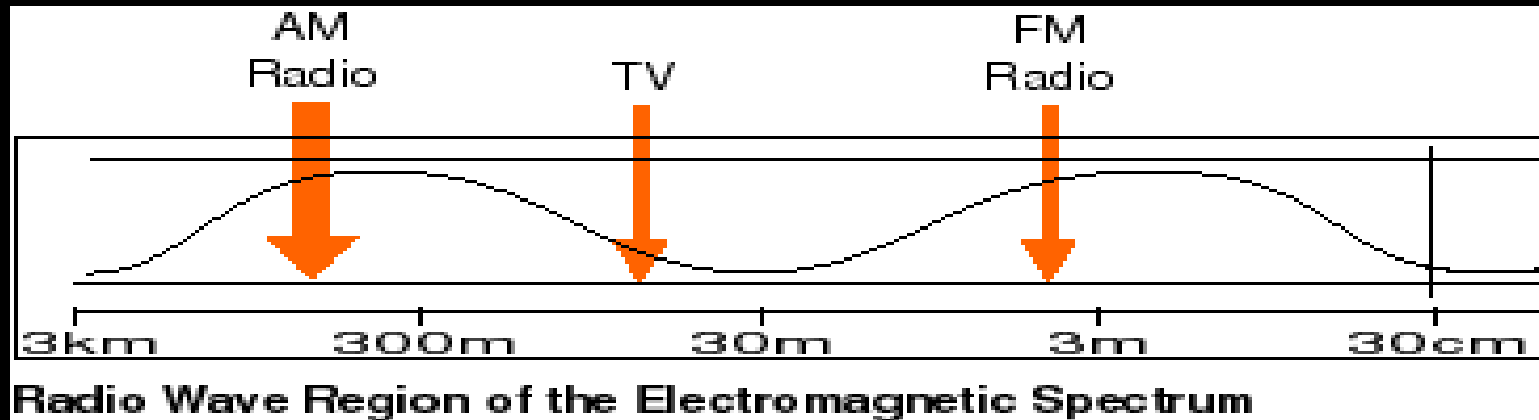


How are they different?

Waves in the electromagnetic spectrum vary in size from very long radio waves the size of buildings, to very short gamma-rays smaller than the size of the nucleus of an atom.

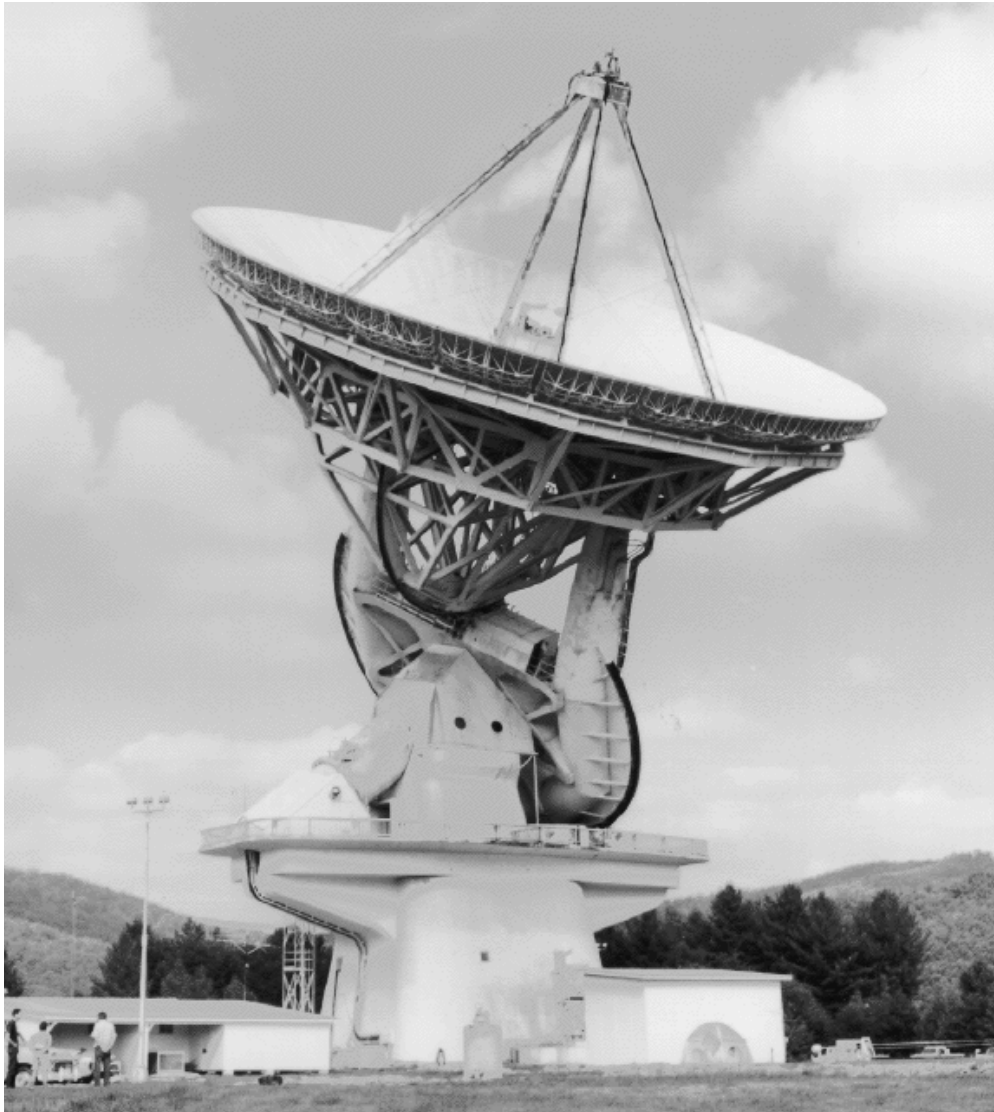


# Radio Waves



Why are antennae on cell phones smaller than antennae on your radio?





NRAO operates the 140 Foot Robert C. Byrd Green Bank Radio Telescope



The Arecibo radio telescope is currently the largest single-dish telescope in the world.

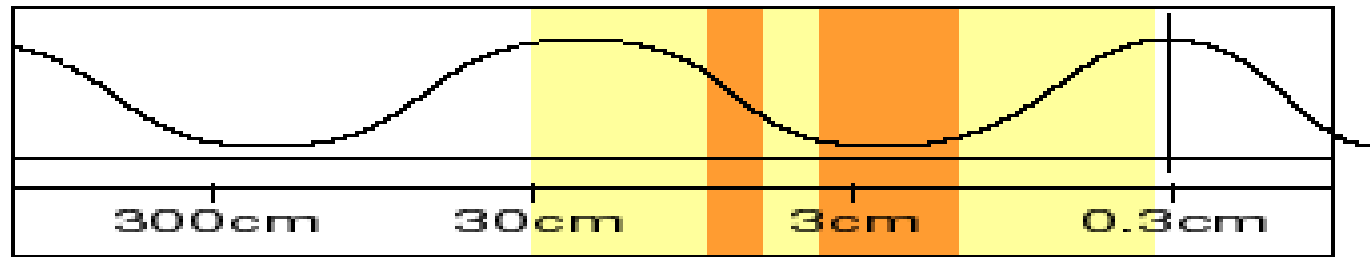


VLA as seen from the north



Close-up of antenna

## Microwave region of the Electromagnetic Spectrum



Radar Bands:

L

S

C

X

K

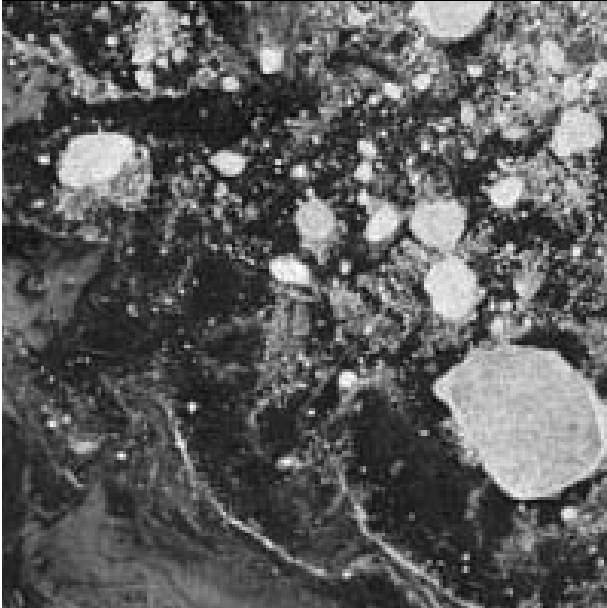


Microwaves have wavelengths that can be measured in centimeters! The longer microwaves, those closer to a foot in length, are the waves which heat our food in a microwave oven.

This microwave tower can transmit information like telephone calls and computer data from one city to another.

Radar is an acronym for "radio detection and ranging". Radar was developed to detect objects and determine their range (or position) by transmitting short bursts of microwaves. The strength and origin of "echoes" received from objects that were hit by the microwaves is then recorded.

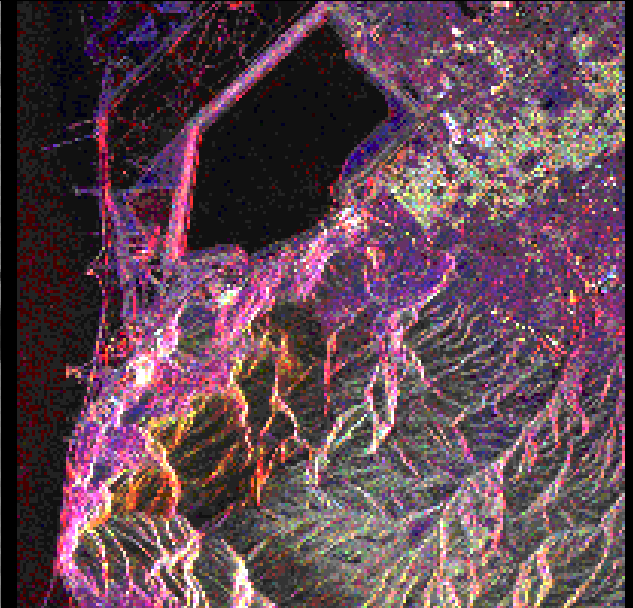
# What do Microwaves show us?



Because microwaves can penetrate haze, light rain and snow, clouds and smoke, these waves are good for viewing the Earth from space.



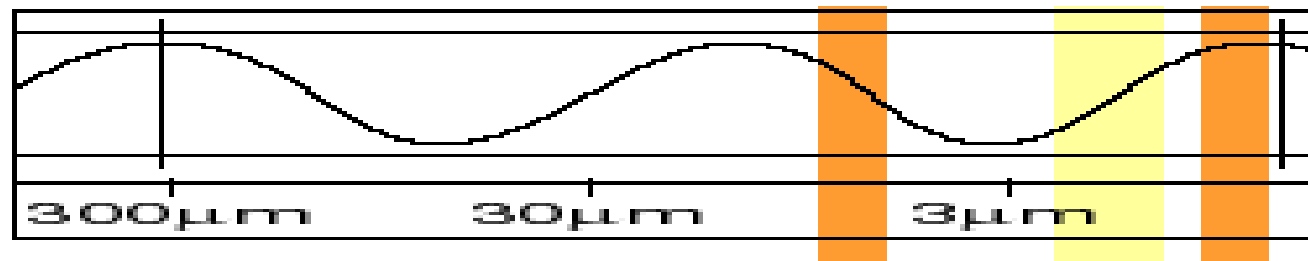
The JERS satellite uses wavelengths about 20 cm in length (L-band). This is an image of the Amazon River in Brazil.



This is a radar image acquired from the Space Shuttle. It also used a wavelength in the L-band of the microwave spectrum. Here we see a computer enhanced radar image of some mountains on the edge of Salt Lake City, Utah.



## Infrared Region of the Electromagnetic Spectrum



Far

Mid

Near



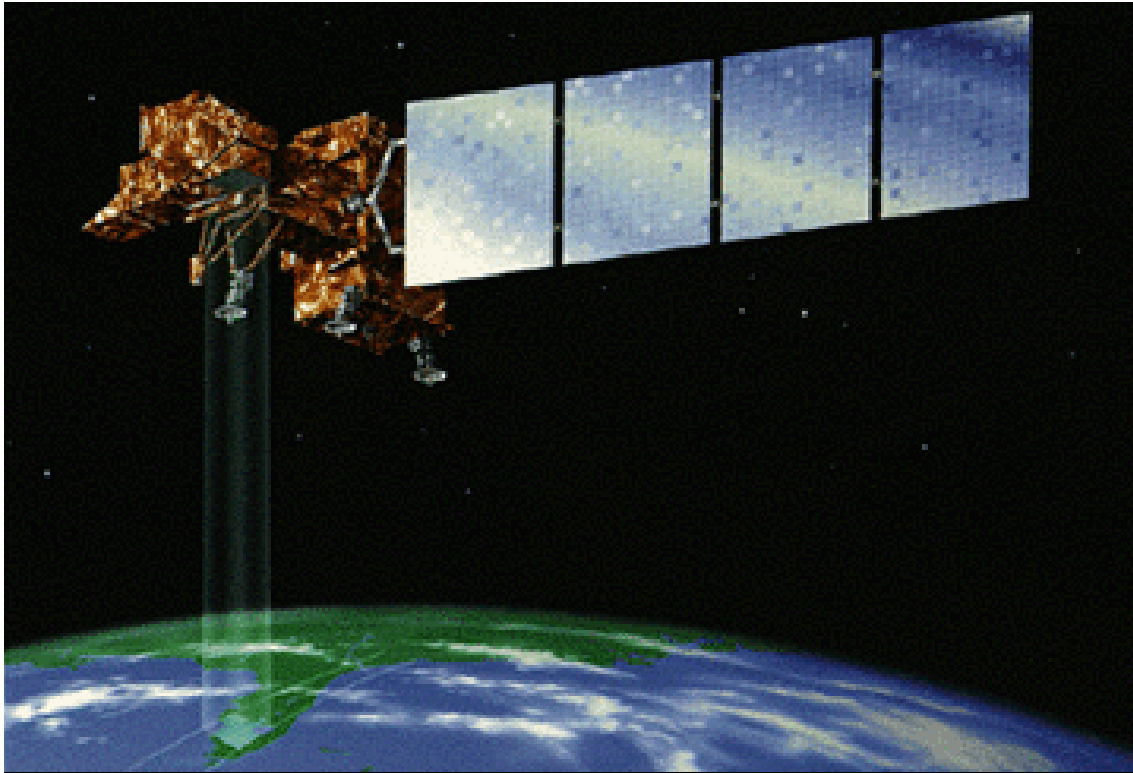
Far infrared waves are thermal. In other words, we experience this type of infrared radiation every day in the form of heat! The heat that we feel from sunlight, a fire, a radiator or a warm sidewalk is infrared.



Shorter, near infrared waves are not hot at all - in fact you cannot even feel them. These shorter wavelengths are the ones used by your TV's remote control.



Humans, at normal body temperature, radiate most strongly in the infrared at a wavelength of about 10 microns. This image ( which is courtesy of the Infrared Processing and Analysis Center at CalTech), shows a man holding up a lighted match!



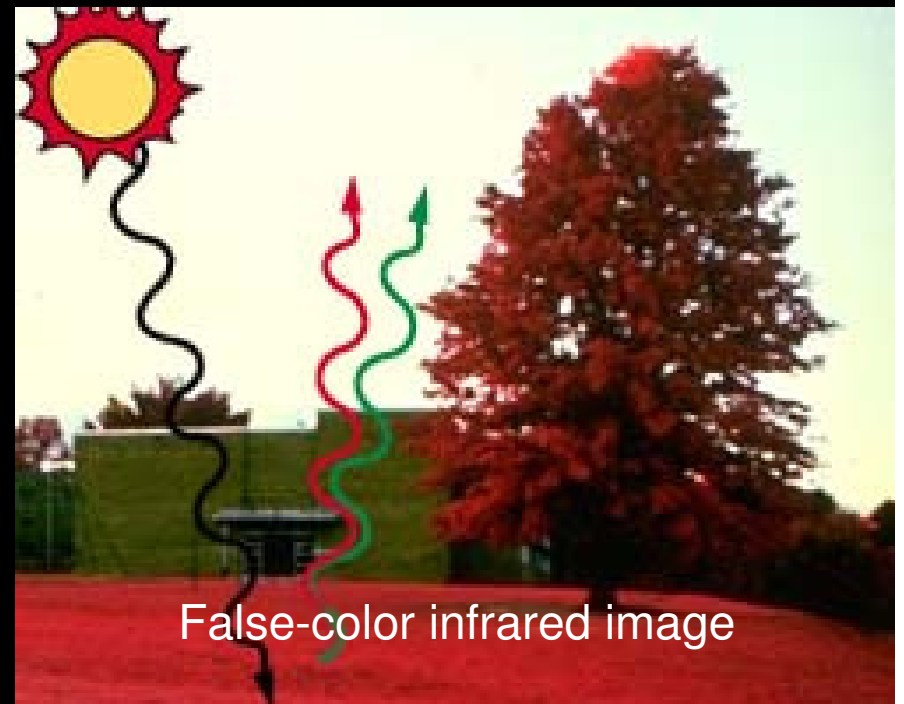
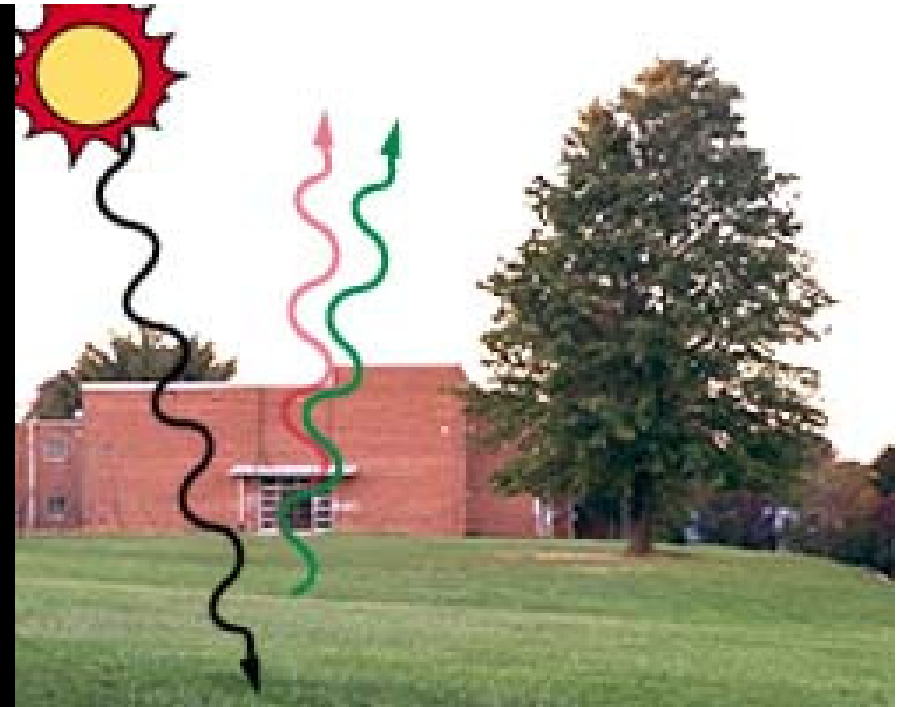
Satellites like GOES 6 and Landsat 7 look at the Earth. Special sensors, like those aboard the Landsat 7 satellite, record data about the amount of infrared light reflected or emitted from the Earth's surface.

This is an infrared image of the Earth taken by the GOES 6 satellite in 1986. A scientist used temperatures to determine which parts of the image were from clouds and which were land and sea. Based on these temperature differences, he colored each separately using 256 colors, giving the image a realistic appearance.

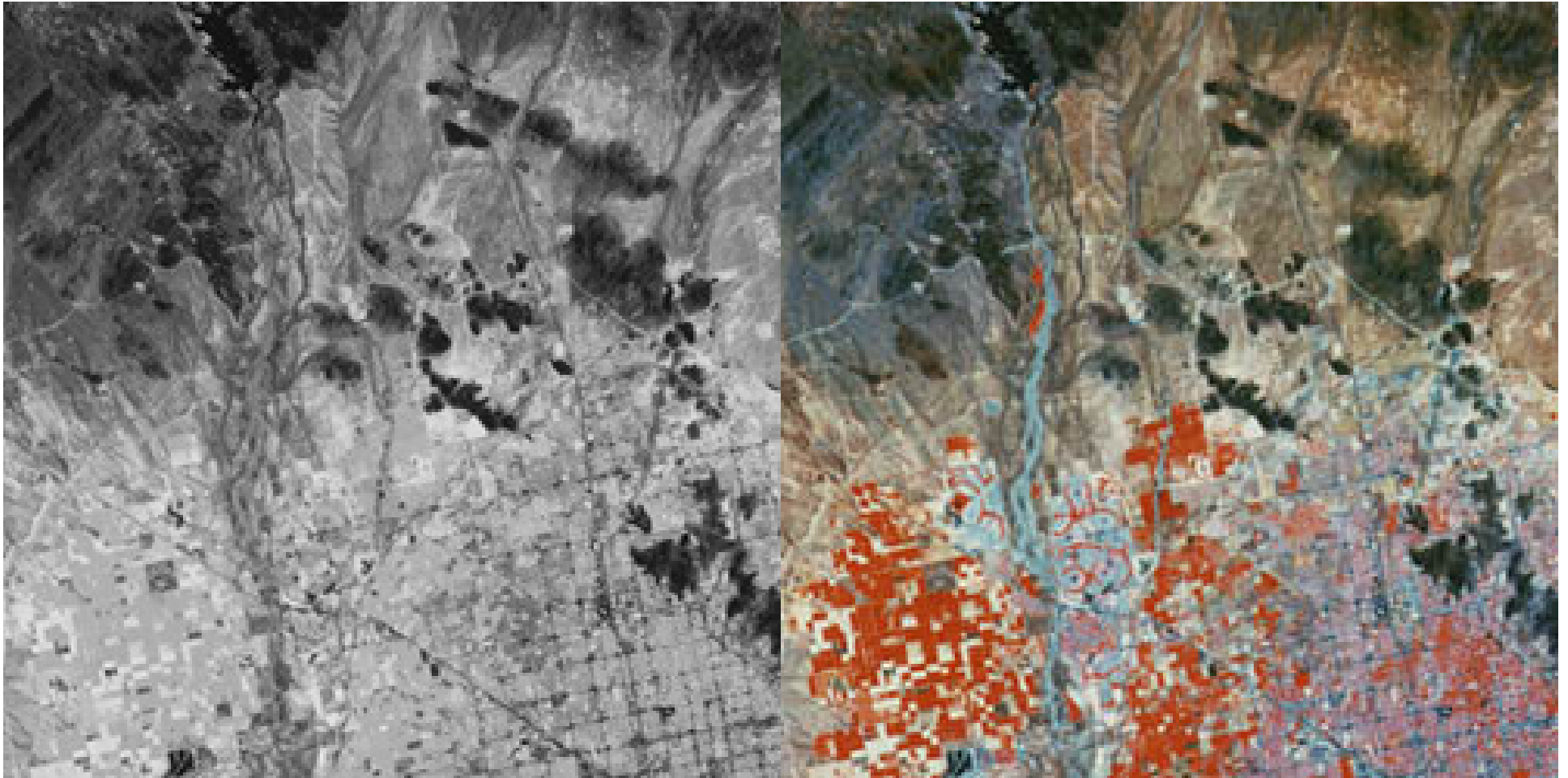


This image of a building with a tree and grass shows how Chlorophyll in plants reflect near infrared waves along with visible light waves. Even though we can't see the infrared waves, they are always there. The visible light waves drawn on this picture are green, and the infrared ones are pale red.

This image was taken with special film that can detect invisible infrared waves. This is a false-color image, just like the one of the cat. False-color infrared images of the Earth frequently use a color scheme like the one shown here, where infrared light is mapped to the visible color of red. This means that everything in this image that appears red is giving off or reflecting infrared light. This makes vegetation like grass and trees appear to be red. The visible light waves drawn on this picture are green, and the infrared ones are darker red.







This is an image of Phoenix, Arizona showing the near infrared data collected by the Landsat 5 satellite. The light areas are areas with high reflectance of near infrared waves. The dark areas show little reflectance. What do you think the black grid lines in the lower right of this image represent?

This image shows the infrared data (appearing as red) composited with visible light data at the blue and green wavelengths. If near infrared is reflected off of healthy vegetation, what do you think the red square shaped areas are in the lower left of the image?

Would you like to help make the World a **Greener** Place?



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- Optics
- Color
- Spectroscopy
- Remote Sensing

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Win lots of cool prizes!!!

Visit us upstairs for:

Telescope Challenge

Spinning Your  
(color) Wheels

Teen Optricks Benches

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