

#### Introduction to EE 217

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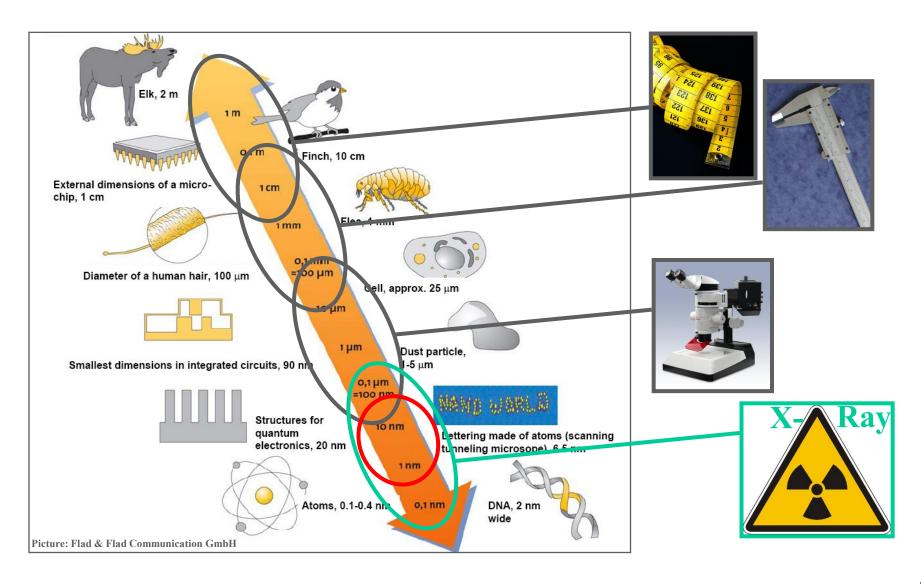
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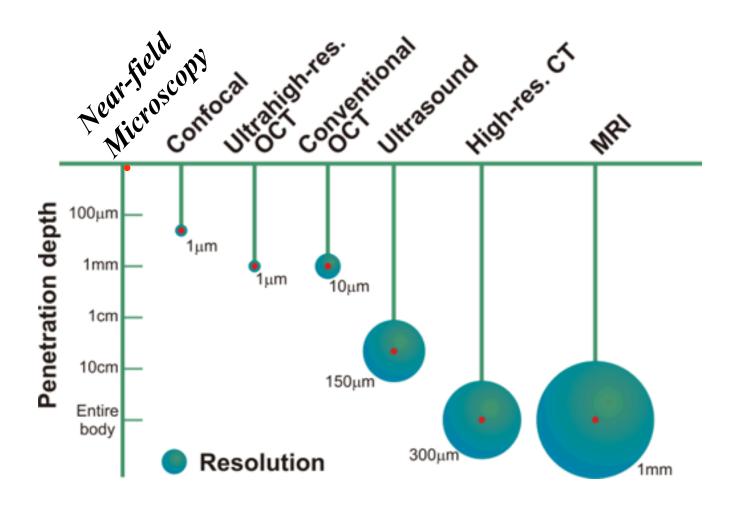


# Imaging & Diagnostics at different scales need different tools





## Overview of various imaging modalities



#### Chart of the Electromagnetic Spectrum reference man's height paperclip Size cells atom thickness subatomic bacteria particles → baseball water molecule football field thickness 1 ft 1 pm 1 cm 1 mm 1 mil 1 nm wavelength μ λ (m) $10^{2}$ 10-2 10-9 $10^{3}$ 10 10-1 10-3 10-4 10-5 10-6 $10^{-7}$ 10-8 10-10 10-11 $10^{-12}$ wavenumber (cm<sup>-1</sup>) 10<sup>-5</sup> 10-4 10-3 10-2 10-1 10 $10^{2}$ $10^{3}$ 104 105 10<sup>6</sup> $10^{7}$ 108 10<sup>9</sup> 1010 electron volt 10-6 10-5 $10^{-3}$ 10<sup>2</sup> $10^{-7}$ 10-4 $10^{-2}$ $10^{3}$ 105 10<sup>6</sup> (eV) 10-9 10-8 $10^{-1}$ 10 104 1 MHz 1 GHz 1 THz 1 PHz 1 EHz 1 ZHz frequency (Hz) $10^{7}$ 105 109 1014 1015 10<sup>18</sup> $10^{19}$ 1021 106 108 1010 1011 1012 1013 1016 $10^{17}$ 1020 Bands **Radio Spectrum Terahertz** Infrared **Ultraviolet** Gamma X-ray Near IIV Extreme UV Far IR Mid IR IR **Broadcast and Wireless Microwave** Soft X-ray Hard X-ray electronics optics Visible wavelengths (nm) Fiber telecom **Dental Curing** 0.7-1.4 µ 200-350nm Sources and Uses of Medical X-rays Bands FM radio 10-0.1 Å Mobile Phones 88-108 MHz AM radio 900MHz-2.4GHz Radar Cosmic ray 600kHz-1.6MHz Visible Light observations 1-100 GHz Bio imaging Frequency 425-750THz <<1 Å 1-10 THz 700-400nm Baggage screen Remotes 10-1.0 Å TV Broadcast Wireless Data 850 nm 54-700 MHz ~ 2.4 GHz Ultrasound **PET** imaging Screening 1-20 MHz Suntan 0.1-0.01 Å 0.2-4.0 THz 400-290nm Sound Waves Crystallography "mm wave" ← 20Hz-10kHz 2.2-0.7 Å Night Vision Microwave Oven "sub-mm" 10-0.7 µ

2.4 GHz



## Brief History of Microscopy

- 1611 **Kepler** suggests a way of making a compound microscope.
- 1655 **Hooke** uses a compound microscope to describe small pores in sections of cork he calls "cells".
- 1674 **Leeuwenhoek** reports his discovery of protozoa. He sees bacteria for the first time nine years later.
- 1838 **Schleiden** and **Schwann** propose the cell theory, stating that the nucleated cell is the unit of structure and function in plants and animals.
- 1876 **Abbé** analyzes the effects of diffraction on image formation in the microscope and shows how to optimize microscope design.
- 1882 **Koch** uses aniline dyes to stain microorganisms and identifies the bacteria that cause tuberculosis and cholera.
- 1886 **Zeiss** makes a series of lenses, to the design of **Abbé**, that enable microscopists to resolve structures at the theoretical limits of visible light.
- 1898 **Golgi** first sees and describes the Golgi apparatus by staining cells with silver nitrate.
- 1932 **Zernike** invents the phase-contrast microscope.
- 1952 **Nomarski** devises and patents the system of differential interference contrast for the light microscope that still bears his name.
- 1984 **Agard and Sedat** use computer deconvolution to reconstruct *Drosophilia* polytene nuclei.
- 1988 Commercial confocal microscopes come into widespread use.
- 1994 **Chalfie** and collaborators introduce green fluorescent protein (GFP) as a marker in microscopy.