

# Contrast Microscopy

Koehler Illumination

Dark Field

**Phase Contrast**

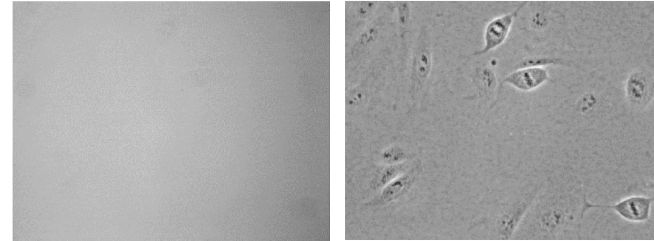
**Differential Interference Contrast**

**Hoffman Modulation**

## Phase Contrast Images

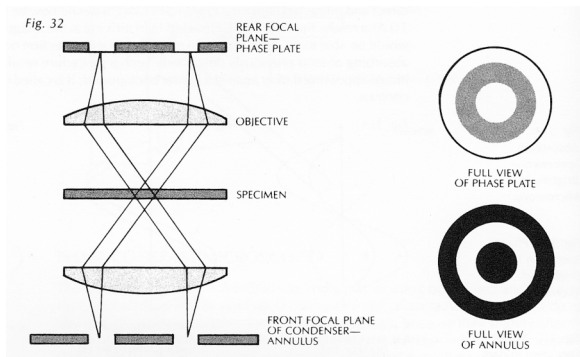
Brightfield

Phase Contrast

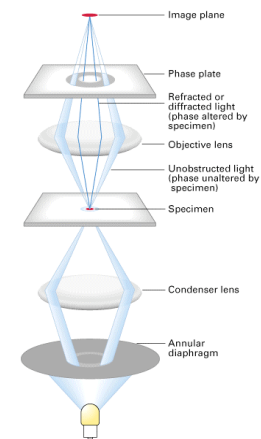


## Phase Contrast Microscopy

F. Zernike, 1930s



## Phase Contrast Microscopy

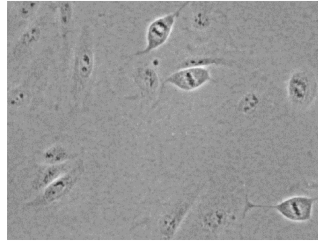


## Phase Contrast Images

Brightfield



Phase Contrast



## Contrast Microscopy

Koehler Illumination

Dark Field

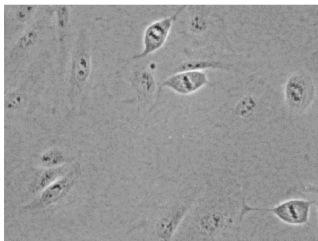
Phase Contrast

Differential Interference Contrast

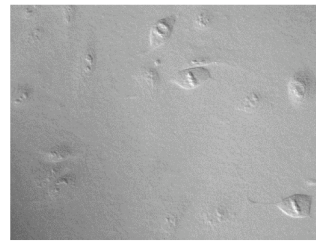
Hoffman Modulation

## DIC (Nomarski) Images

Phase Contrast



Nomarski Optics

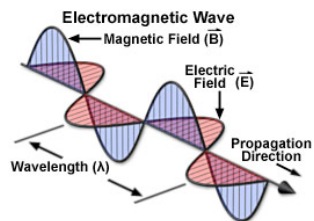


James Maxwell  
(1831-1879)

Electromagnetism

Electromagnetic  
Theory of Light

## Wave Nature of Light



Under some conditions, light behaves as an electromagnetic wave (Maxwell, 1855). In this model, electric and magnetic fields oscillate perpendicular to one another and to the direction of propagation of the light wave.

## Polarization of Light Waves

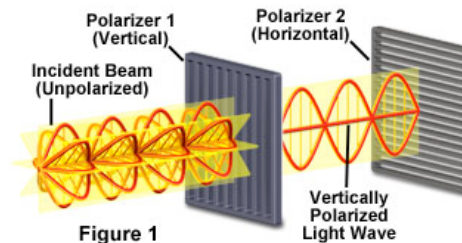
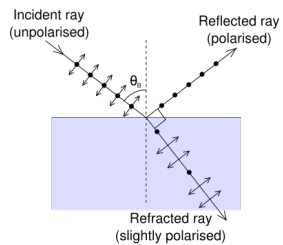


Figure 1

## Refractive Polarization



David Brewster  
(1781 - 1868)



Brewster Angle  
[ $53^\circ - 56^\circ$ ]

## Action of Polarized Sunglasses

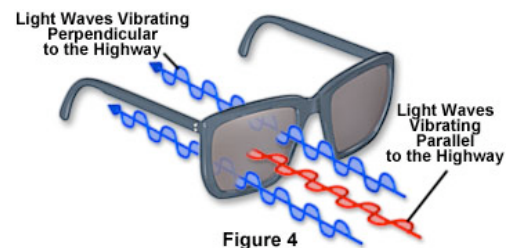
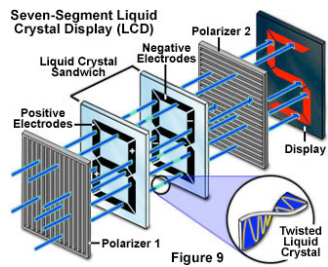
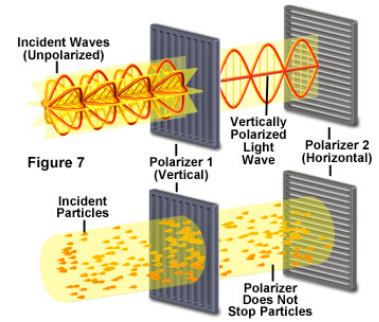


Figure 4

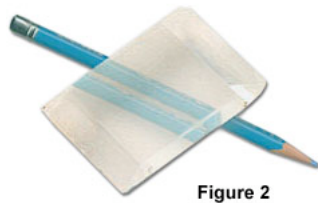


Particles and Waves Through Crossed Polarizers

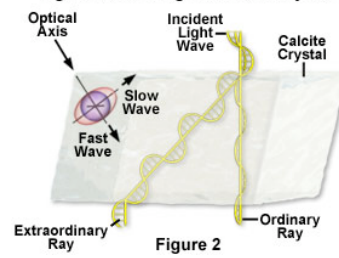


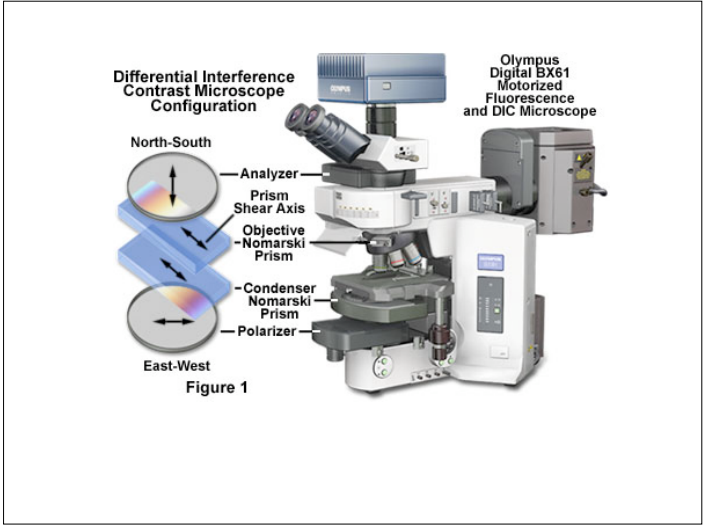
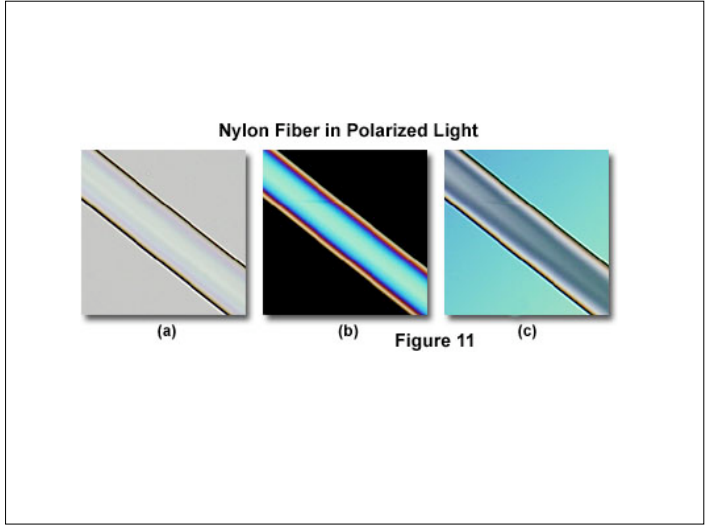
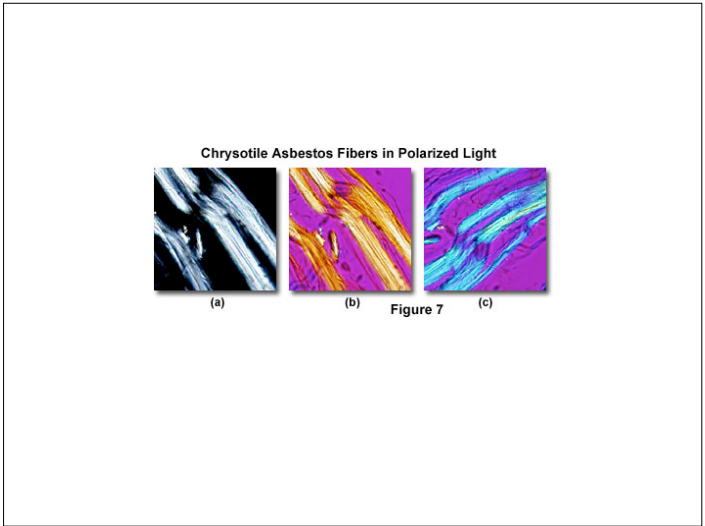
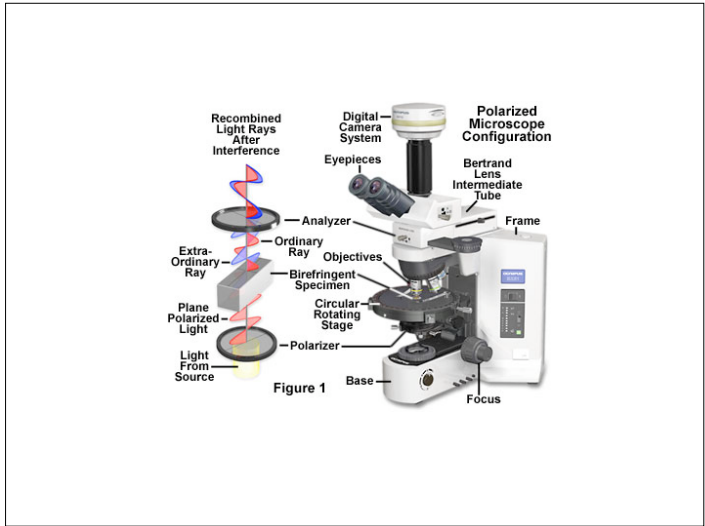
## Optical Birefringence

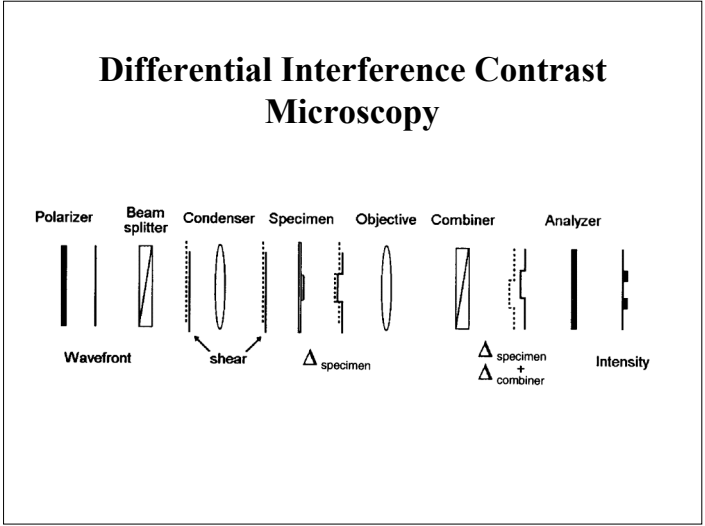
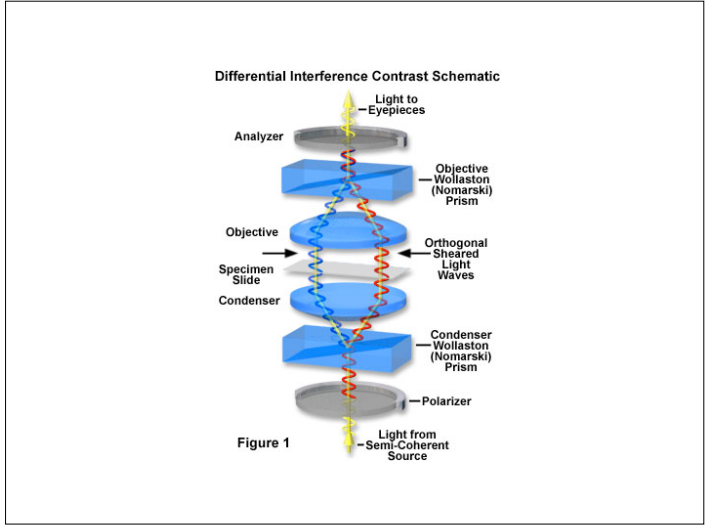
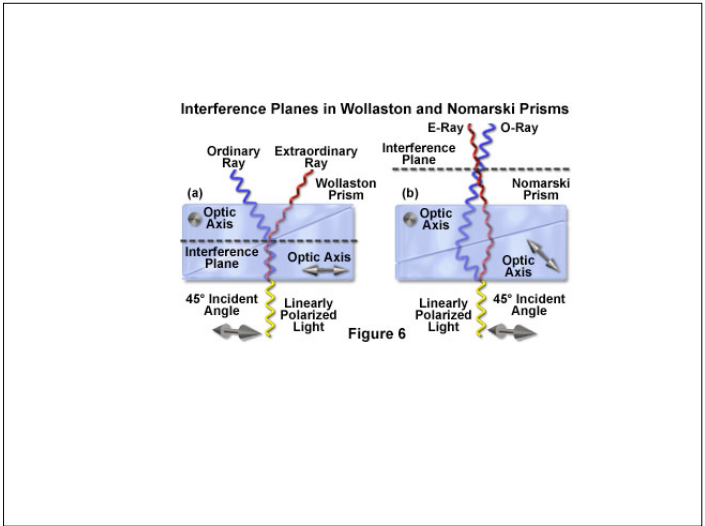
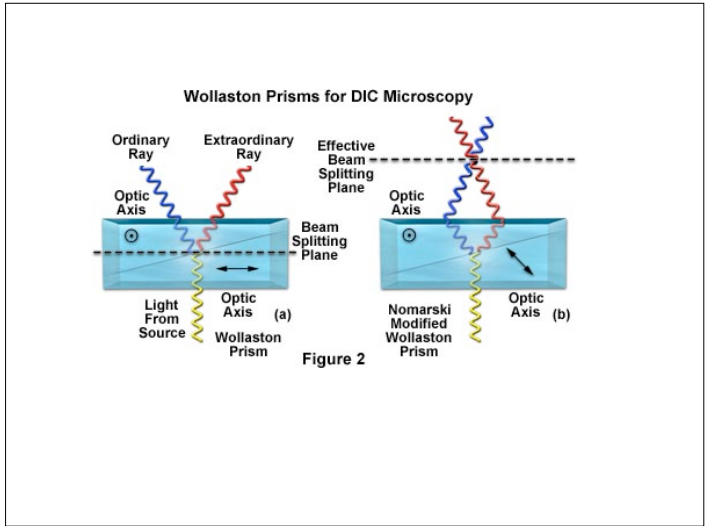
Bi-Refraction in Calcite Crystals



Light Path Through A Calcite Crystal







**Specimen Optical Path Difference and DIC Amplitude Profile**

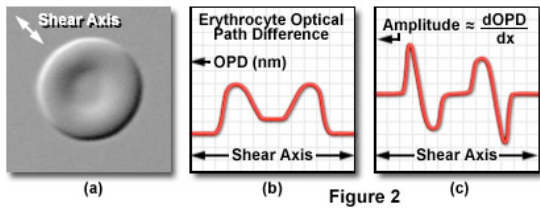


Figure 2

**DIC Image Plane Wavefront Interference**

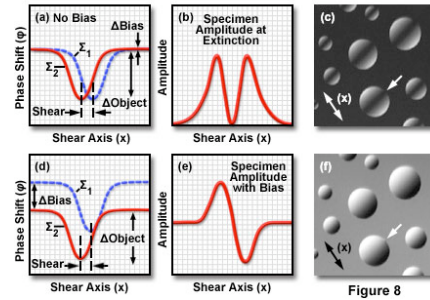


Figure 8

**Transparent Specimens in Phase Contrast and DIC**

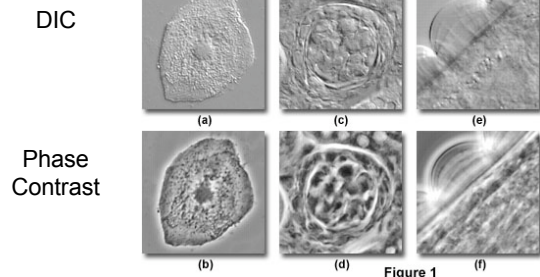


Figure 1

**Halos in Phase Contrast and DIC Microscopy**

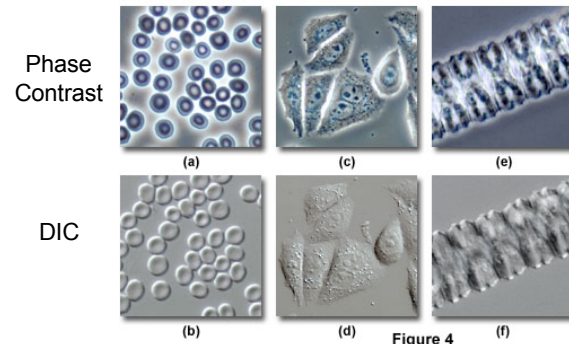
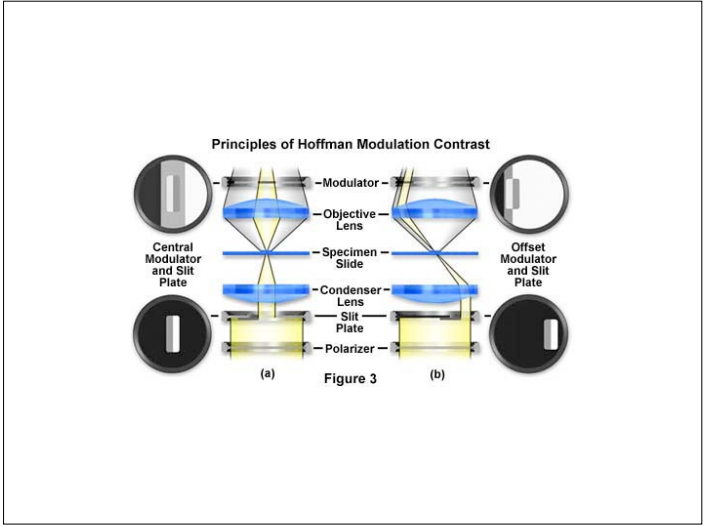
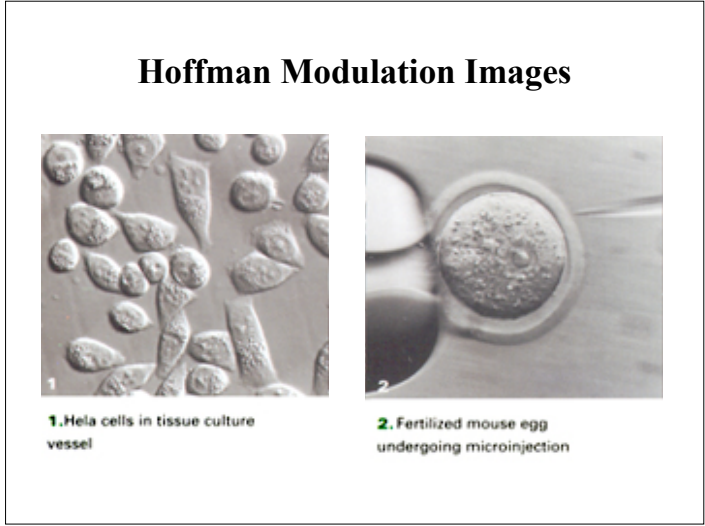
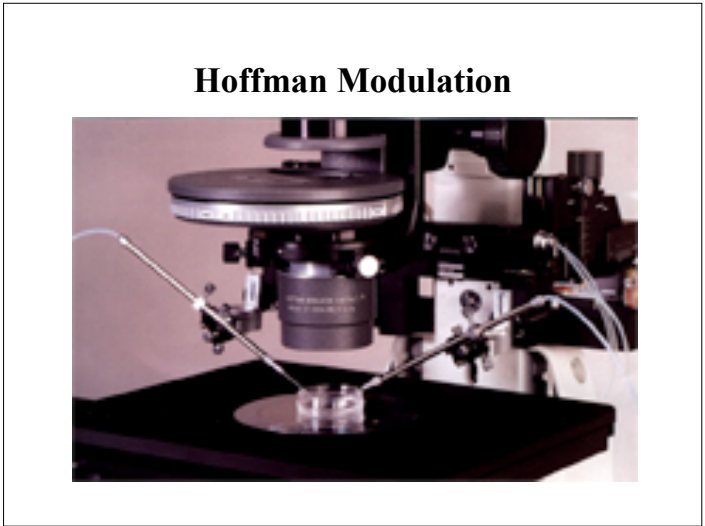
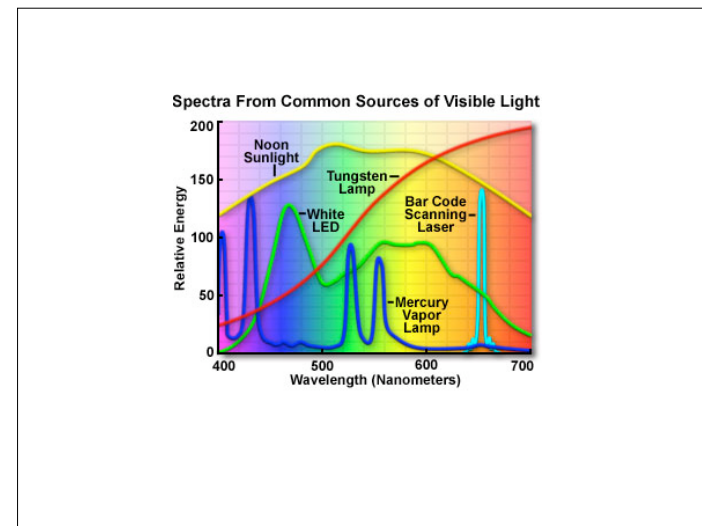
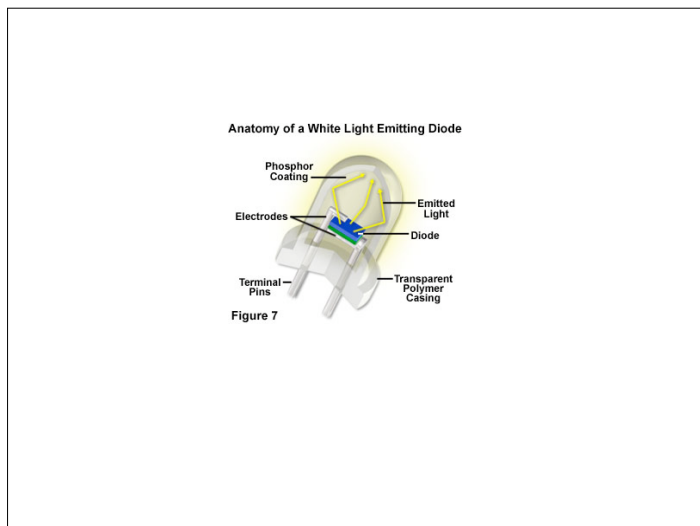
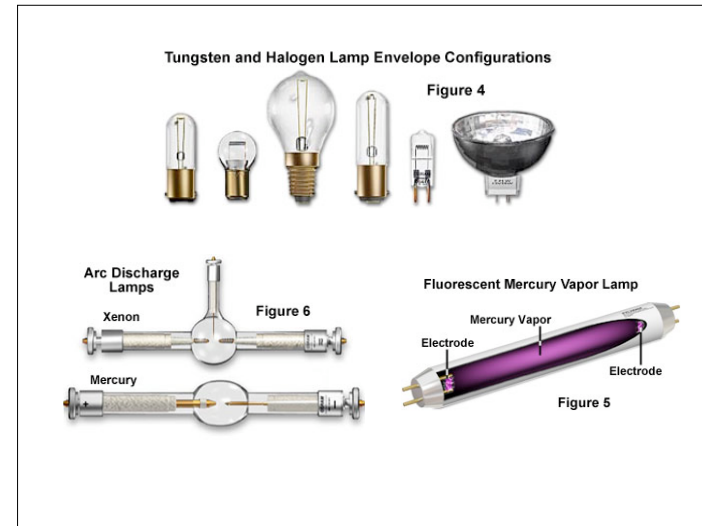
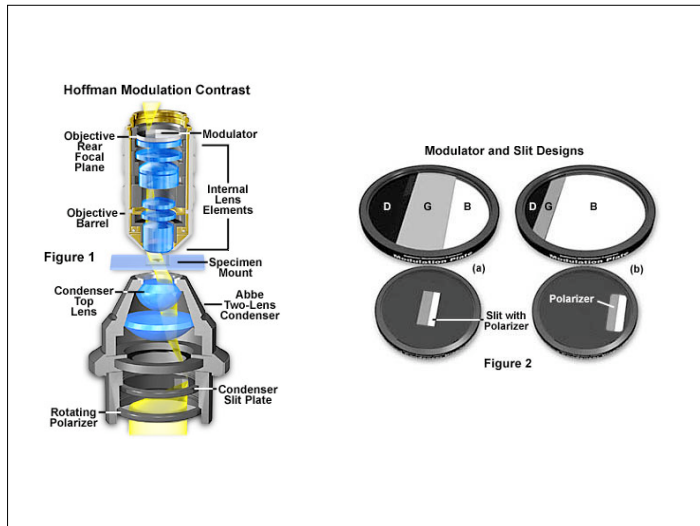


Figure 4









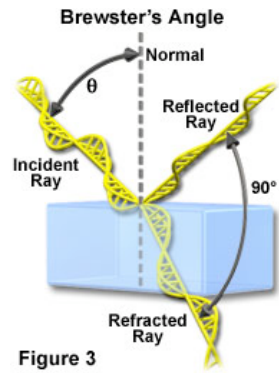
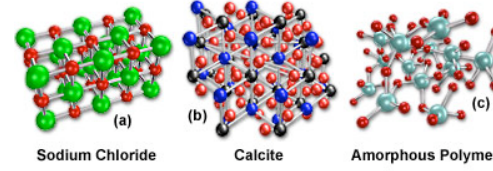


Figure 3

Crystalline Structure of Isotropic and Anisotropic Materials



Sodium Chloride

Calcite

Amorphous Polymer

Figure 1