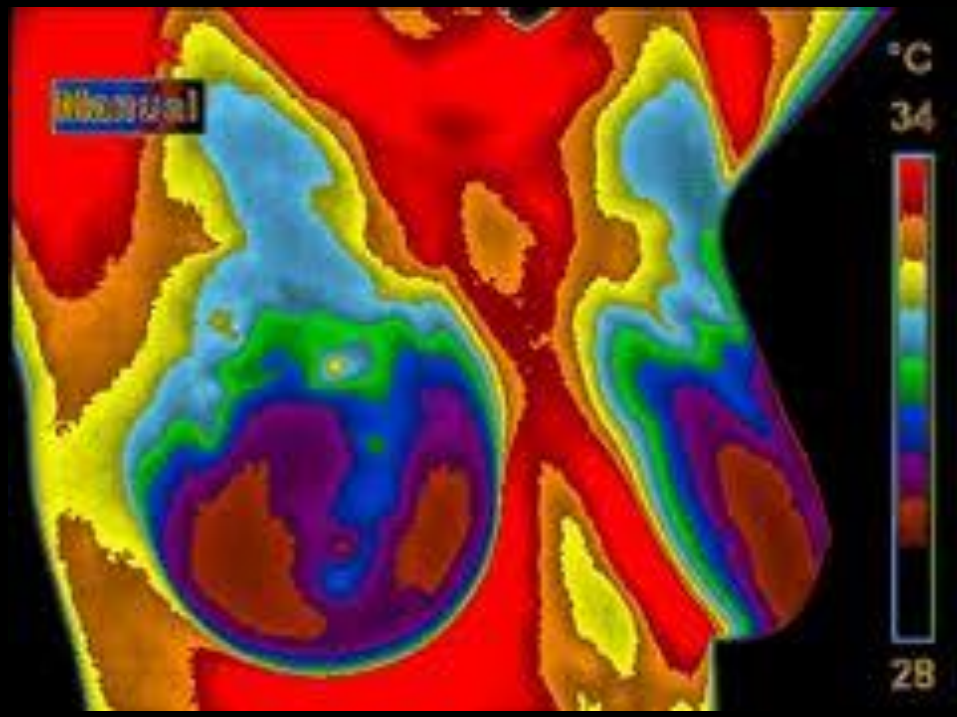
Breast Thermography

Physics 221

University of Northern Colorado



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OVERVIEW

⇒ History and Statistics

⇒Early detection principle

⇒ Why choose thermography?

⇒ Biology of cancer

⇒ Physics of digital infrared thermal imaging (DITI)

History of Breast Thermography

- 1956- first time thermography was used for detection of breast cancer
- 1982- FDA approves it as a legitimate procedure
- 2005- FDA reapproves breast thermography

Breast Cancer Statistics

- Four stages of cancer
- 1 out of 8 women will have breast cancer in their lifetime
- 95% preventable
- 230,000 cases in the U.S. annually
- 1% of all breast cancers occur in men

More!

Survival rates

Stage one: 88%

Stage two: 81%

Stage three: 67%

Stage four: 15%

Probability of Developing Breast Cancer Within the Next 10 years	
By age 20	1 out of 1,681
By age 30	1 out of 232
By age 40	1 out of 69
By age 50	1 out of 42
By age 60	1 out of 29
By age 70	1 out of 27
Lifetime	1 out of 8

Early Detection is the Key

→ In today's fight against cancer, the most important key to survival is early detection

→ Early-detection tool used by healthcare providers to identify possibly cancerous tissue in the breasts

Why Choose Thermography?

- → Abnormal breast infrared image = highest risk factor for developing breast cancer
- → Can detect abnormalities before physical exam, mammography, or other types of structural imaging

Why Choose Thermography?

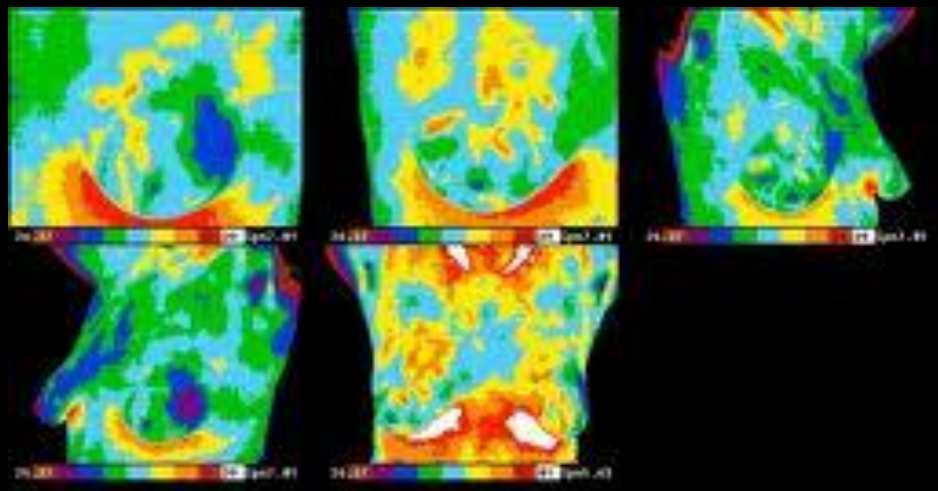
- → Mammograms = problematic when patients are on hormone replacement, are nursing or have fibrocystic, large, dense, or enhanced breasts

- → 20% of all breast cancer types cannot be detected by mammography

Biology of Breast Cancer

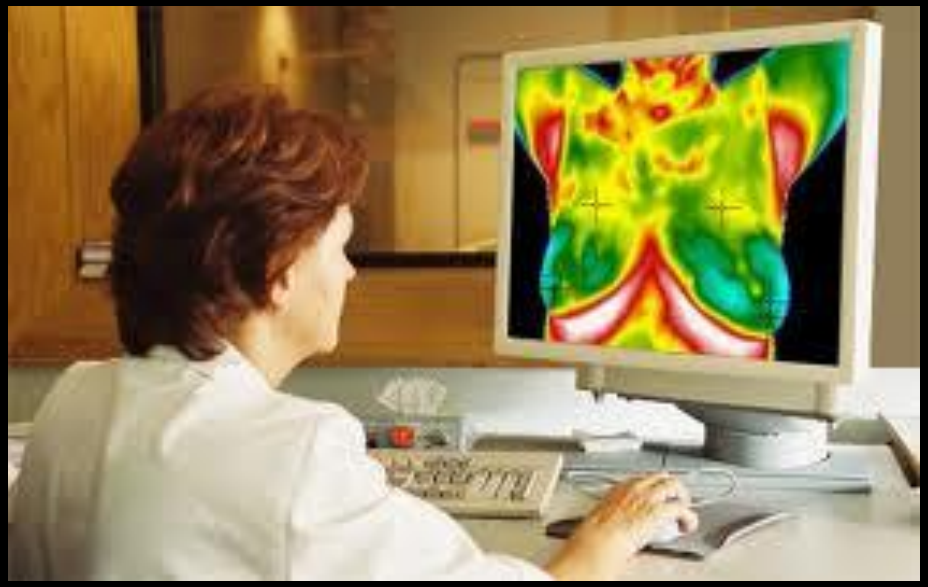
→ Cancerous tumors increase circulation to cells by:
- → Holding open existing blood vessels
- → Opening dormant vessels
- → Creating new ones in a process known as *neoangiogenesis*

→ Increases in metabolic activity and circulation typically result in increased surface temperatures of the breast



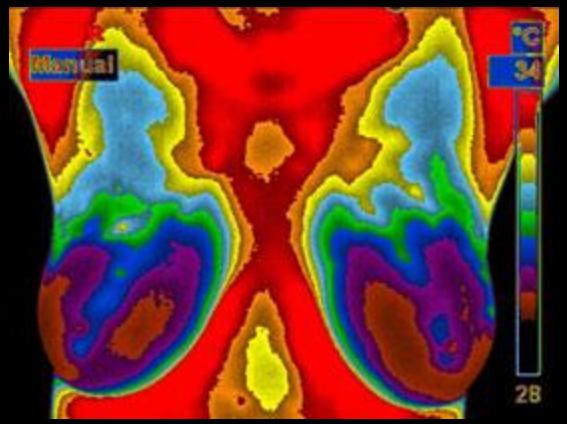
Biology of Breast Cancer

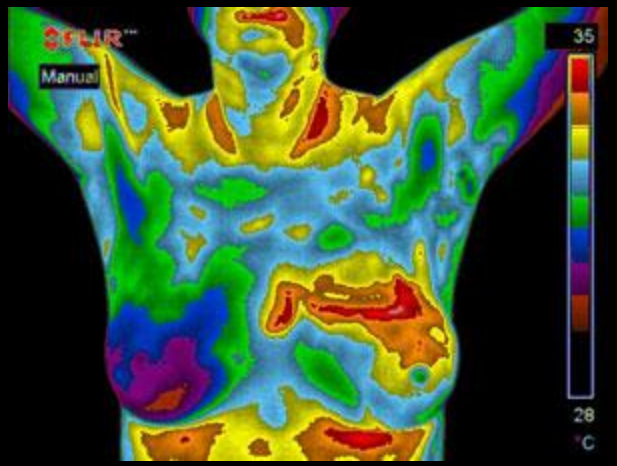
- → More chemical reactions are taking place in the tissue; more cellular respiration, and generally more blood is reaching the area (increased vascularity)
  - → More energy is being released
- → Cancerous growth also means surface area is increasing so it will show up on the image

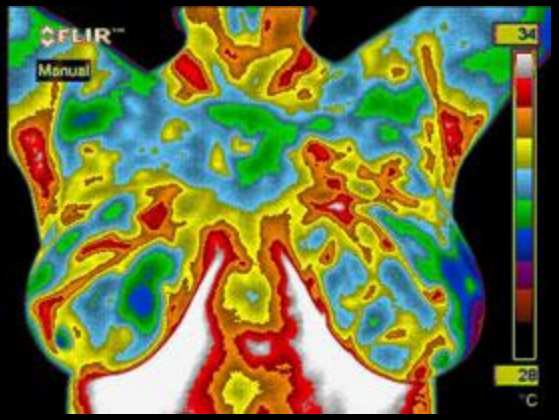


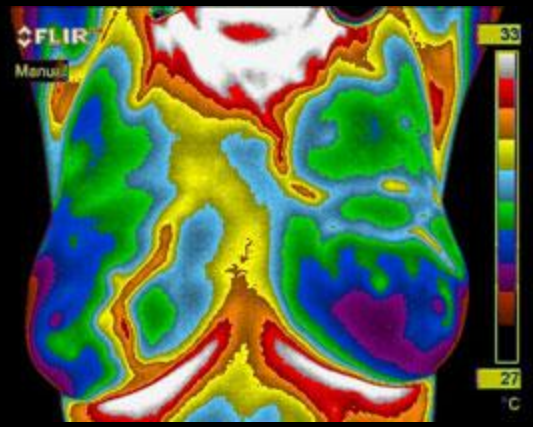
Normal healthy breasts

Abnormal breasts







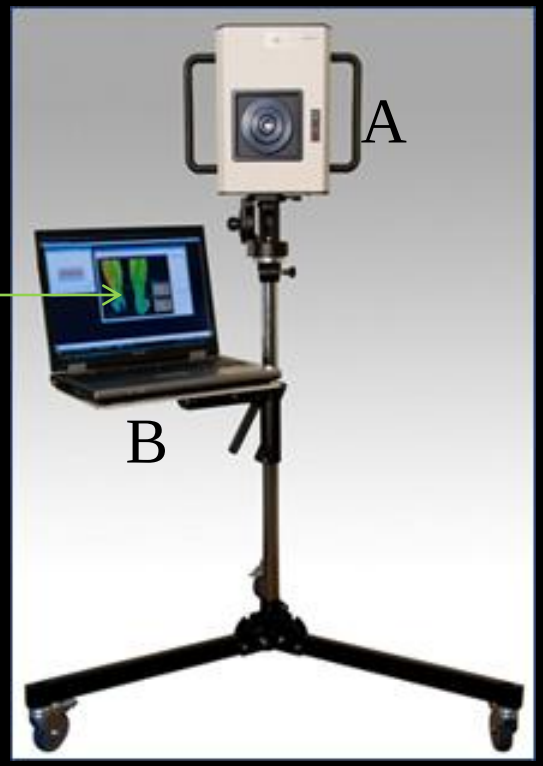


The Physics

- → Can detect wavelengths in the infrared range (9-14 μm)
- → Each wavelength detected is computer processed to convert each separate wavelength into a visible color
  - → Then projected onto a monitor
- → This is possible even without visible illumination

Main components of DITI device

- Infrared Sensor (a)
- Microprocessor (b)
- Digital Display (c)



Infrared Sensor

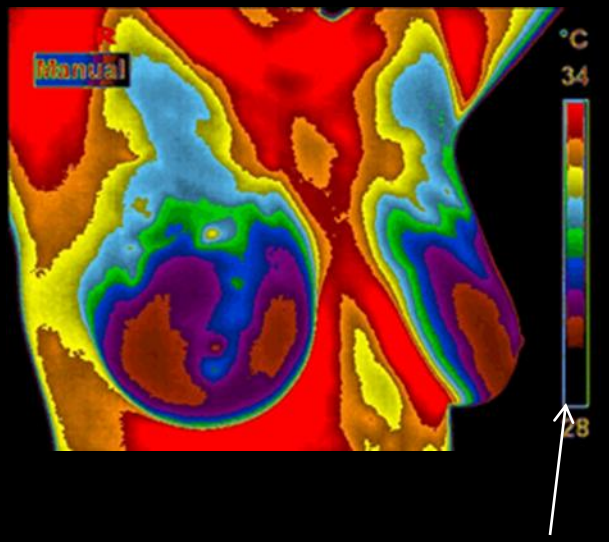
- Composed of lithium tantalite ($LiTaO_3$)
- The change in the material's temperature causes a realignment of the atoms in the crystalline structure. The work done on the crystalline structure creates a polarization or voltage generation across the molecule.

Microprocessor

- Receives the various electrical signals from the detector and convert it into a binary signal (0s and 1s)
- Binary signal produced by the microprocessor is graded according to a predetermined IR intensity scale

Digital Display

- LCD or LED display
- The IR scale correlates with the various colors produced by the pixels in the display screen.
- Typically the most radiation producing areas of an object are white and least producing areas show up as blue with intermediate colors grading the amount of radiation detected between the two extremes



The Physics

→ Changes in temperature bring about changes in a given object's radiance

→ As temperature increases so does the amount of radiation emitted by the object

→ Increased surface area will also proportionally increase the amount of emitted radiation

→ As the temperature increases the wavelengths of the emitted radiation become shorter

→ Increasing in energy

The Physics

Black Body Radiation Law

→ All objects above absolute zero emit infrared radiation

→ A “perfect absorber” absorbs radiation of all wavelengths

→ Also emits radiation known as black body radiation (making it the perfect emitter)

→ Intensities of the various wavelengths emitted depend on the temperature of the black body

The Physics

Emissivity

→Relative ability to emit energy by radiation

→A “perfect” black body would have an emissivity of 1

The Physics

Emissivity

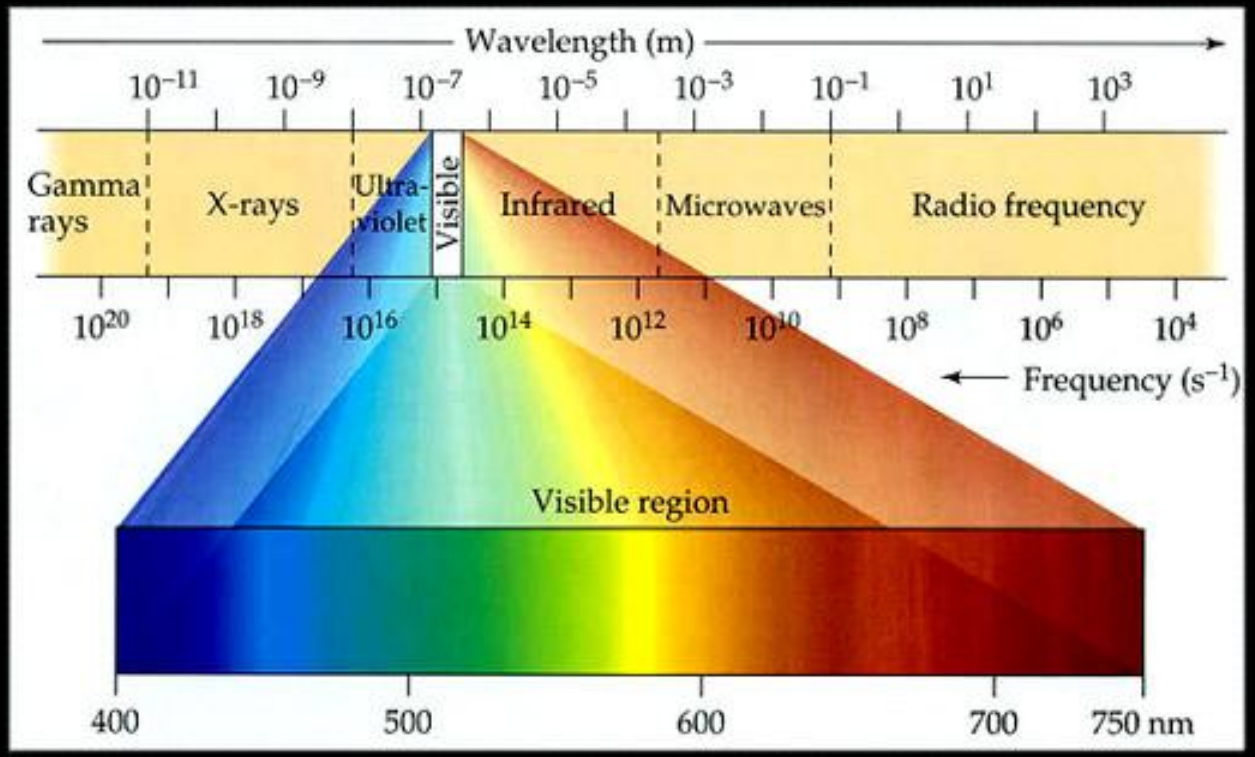
→Several things affect emissivity

- → Geometric shape of the black body
- → Uniformity of the black body's temperature
- → Wavelengths of the emitted radiation

→Doctors eliminate variables by taking multiple readings at different angles

Wavelength spectrum

The frequency of Infrared radiation falls between 1 to 400 THz and has a wavelength ranging from .74 micrometers to 300 micrometers respectively



Energy of Electromagnetic Radiation and Planck's Constant.

Planck's Constant = 6.626×10^{-34} J*s

$$E = hf$$

Frequency Range for IR: $(1 \times 10^{11}/s)$ to $(4 \times 10^{14}/s)$

Frequency Range for Visible Light: $(4.223 \times 10^{14}/s)$ to $(7.687 \times 10^{14}/s)$

Energy Range for IR: $(6.626 \times 10^{-23}$ J) to $(2.65 \times 10^{-19}$ J)

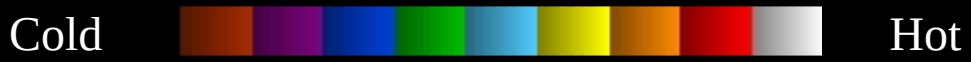
Energy Range for Visible Light: $(2.796 \times 10^{-19}$ J) to $(5.093 \times 10^{-19}$ J)

The Physics

→ Higher energy radiation shows up red

→ Counterintuitive considering that red photons (visible light) have the lowest energy

→ Our culture identifies blue as cold and red as hot for readability and faster interpretation



SUMMARY

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⇒Early detection principle

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Literature Cited

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Early Detection Saves Lives

Questions?

Early Detection Saves Lives