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Your Vision, Our Future

Color Imaging in Endoscopy and Laparoscopy

May. 08. 2013

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Outline

1. Introduction - Endoscopy Imaging Systems
2. Factors that affect color in endoscopic imaging
3. White light endoscopy
4. Narrow band imaging (NBI)
5. Color management
6. Summary & Area for practical improvement

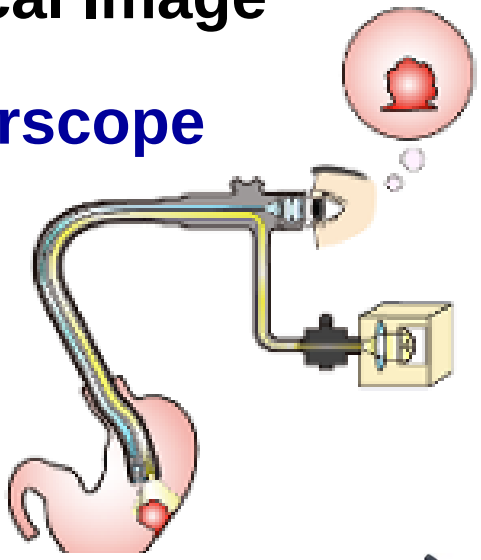
Chap.1

Introduction: Endoscopy imaging systems

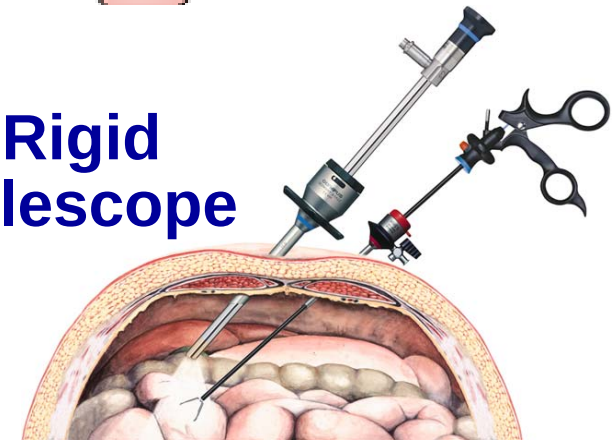
Basic types of Endoscopes:

Direct Viewing – Optical Image

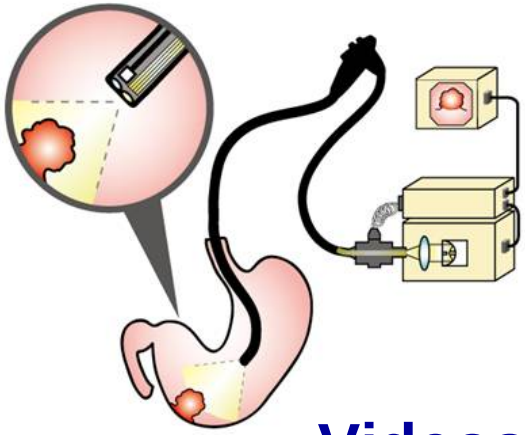
Fiberscope



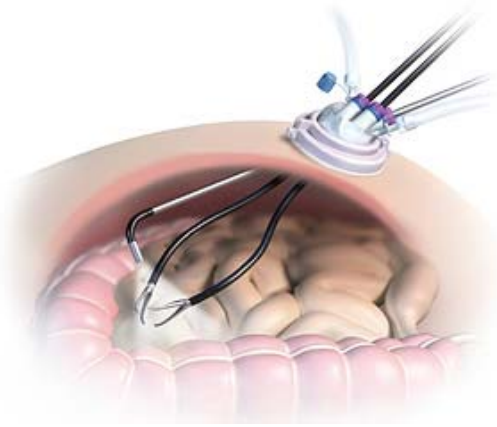
Rigid Telescope



Video Endoscopes – Displayed on Monitor



Videoscope



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Self Contained Endoscopes

Battery-powered, portable endoscope

Capsule endoscope

Video Imaging System

Flexible Video Endoscope

Fiberoptic Flexible Endoscope + External Camera

Rigid Video Endoscope

Rigid Telescope + External Camera

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General Surgery

Gastroenterology

Intubation

Thoracic

Gynecology

ENT

Urology

Orthopedics

Urology

ENT

Gynecology

Esophagoscopy

Bronchoscopy

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Chap.2

Factors that affect color in endoscopic imaging

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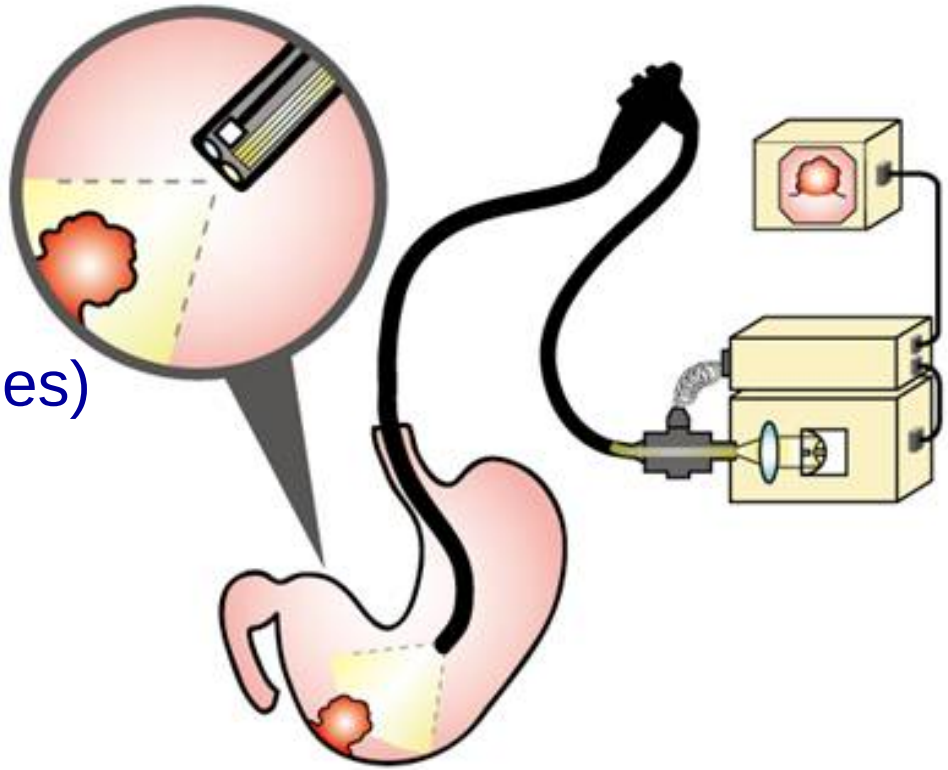
Factors affecting color

Illumination system:

- Light source
- Endoscope

Observation system:

- Optical System
  (direct viewing endoscopes)
- Image Sensor
  (video endoscopes)
- Video processor
- Monitor



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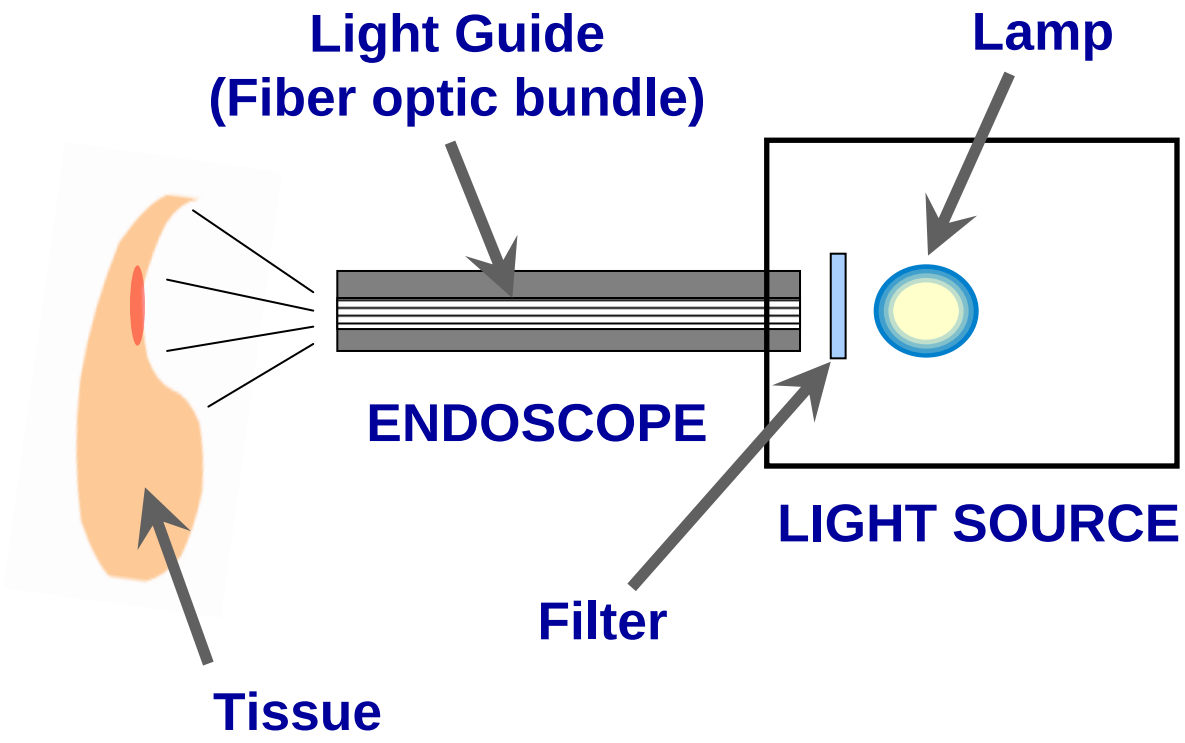
Illumination System

Simplified model of illumination system



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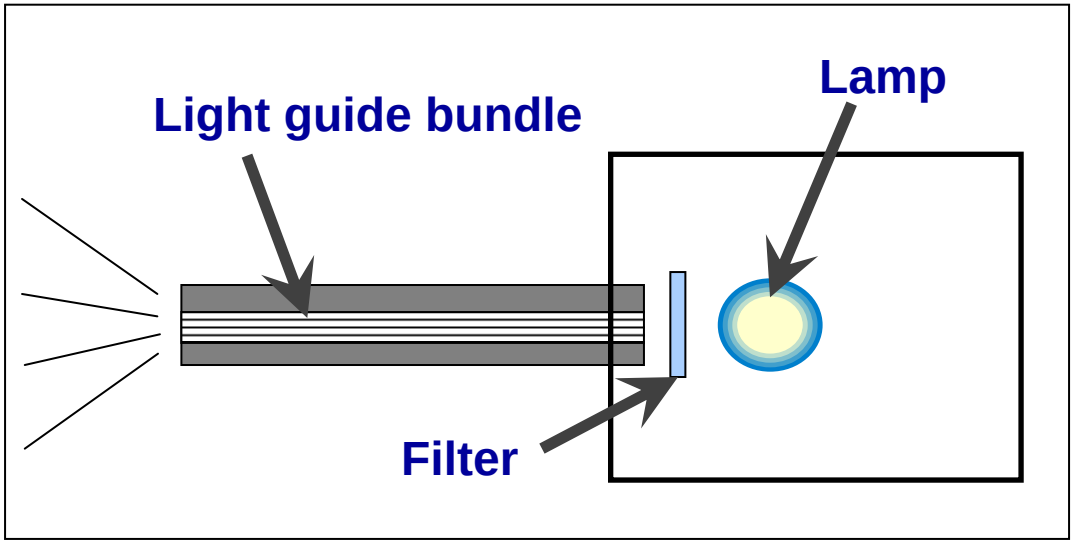
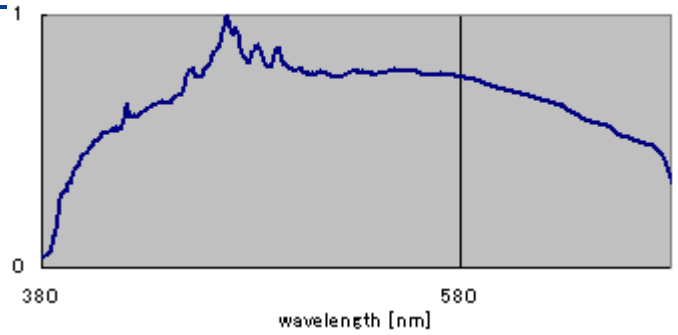
Illumination System

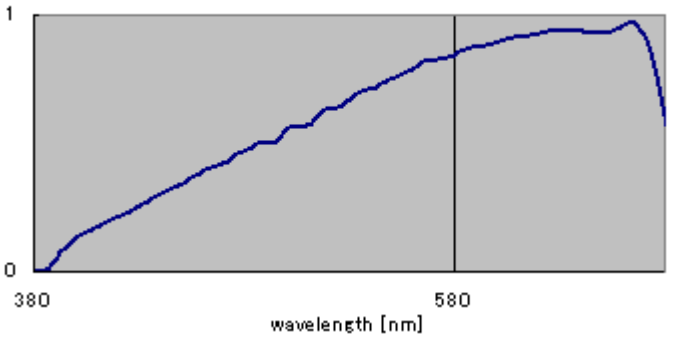
Different types of illumination systems have different color characteristics



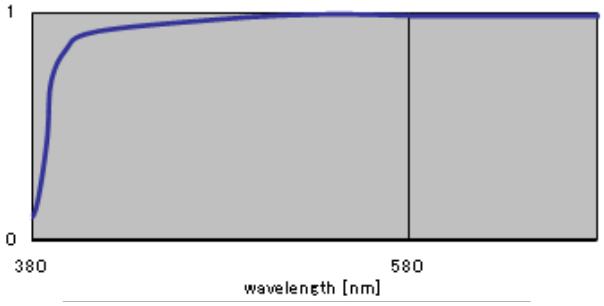
Xenon Lamp



Halogen Lamp

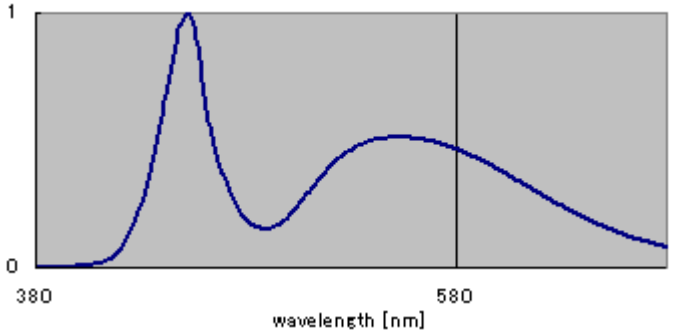


Characteristics of Light Guide Bundle



Characteristics of the Lamp

LED



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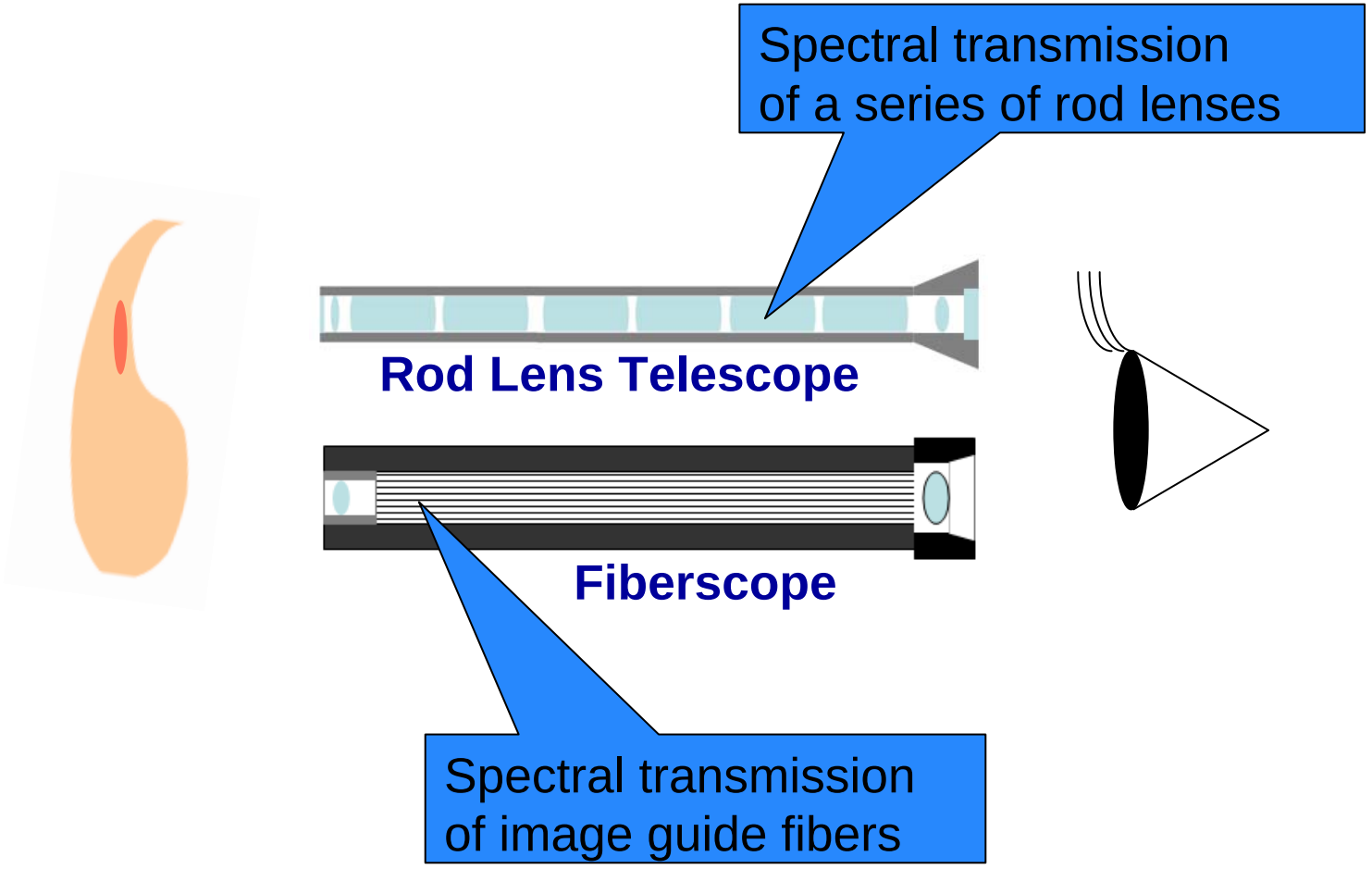
Direct Viewing Endoscopes

Simplified model of observation system



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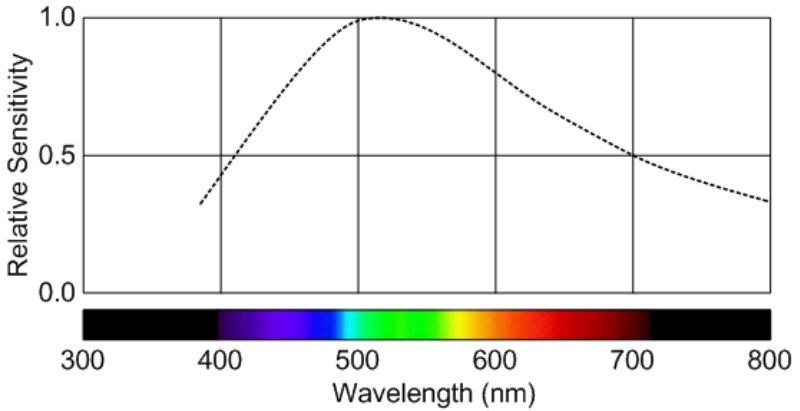
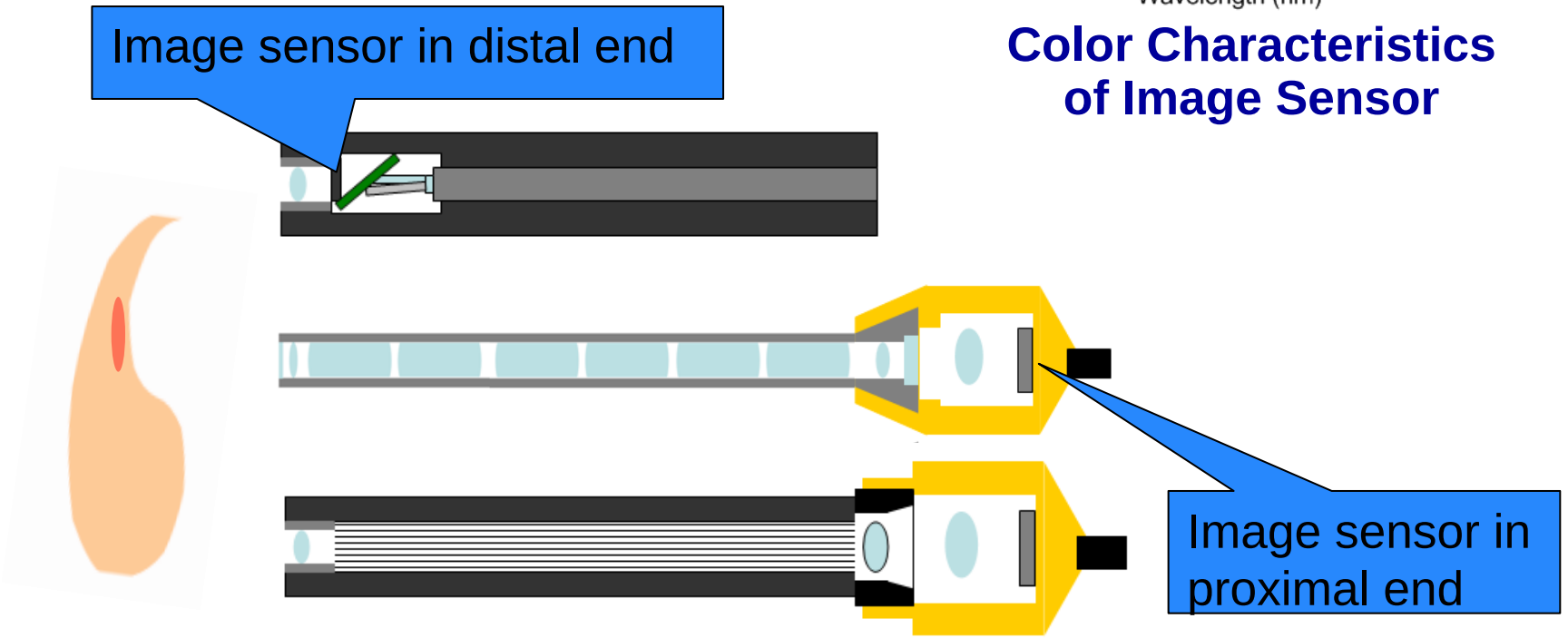
Video Endoscopes



Color Characteristics of Image Sensor



Observation Monitor

Video Monitor

Chap.3

White Light Endoscopy

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Gastroenterological endoscopy

- Basic images for clinical examination
- Users are looking for ‘natural’ looking color
- Identifying abnormal tissue & targeting a biopsy

Chap.4

Narrow Band Imaging (NBI)

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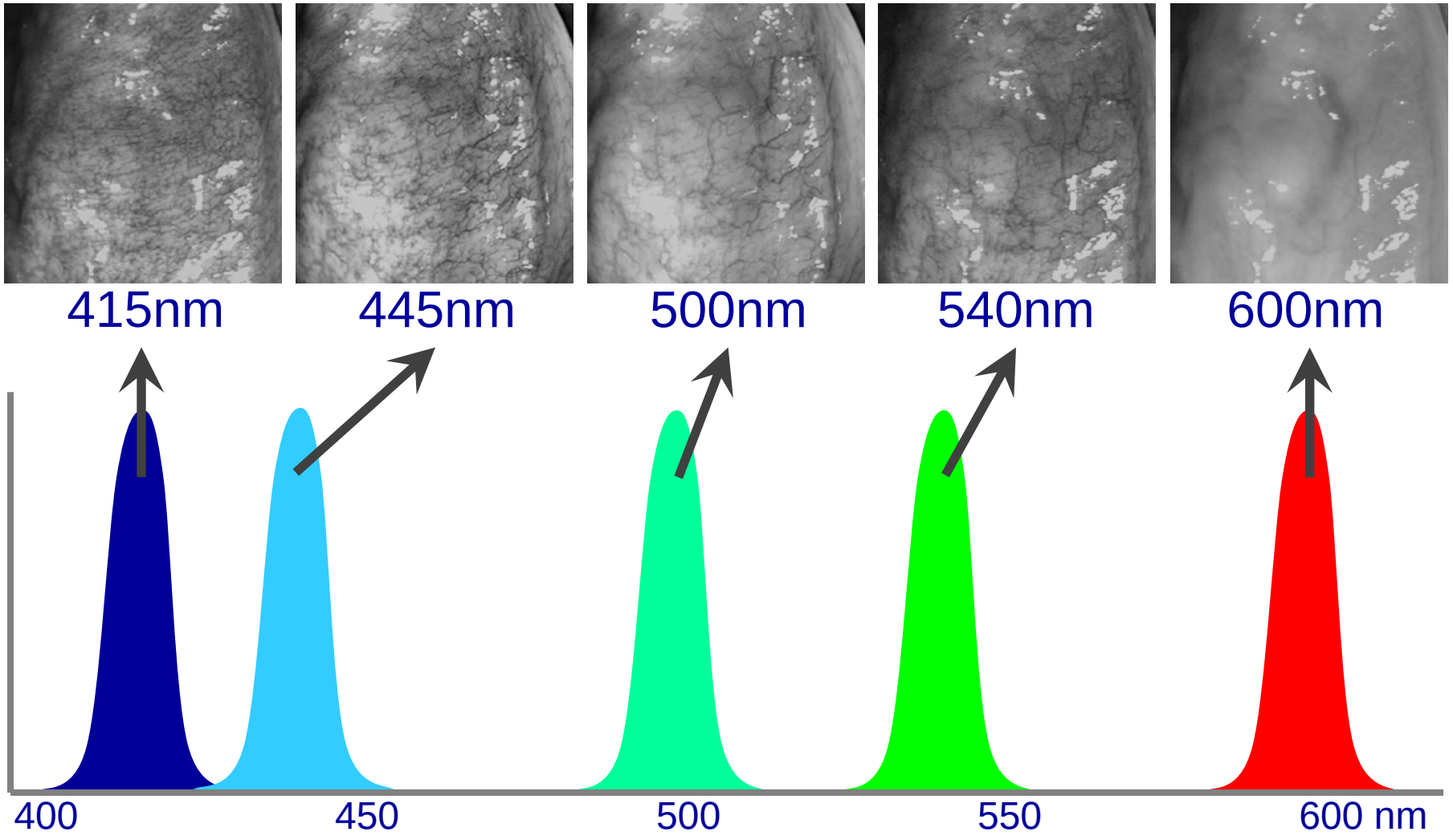
Narrow Band Imaging (NBI)

Human Tongue: Image varies with wavelength



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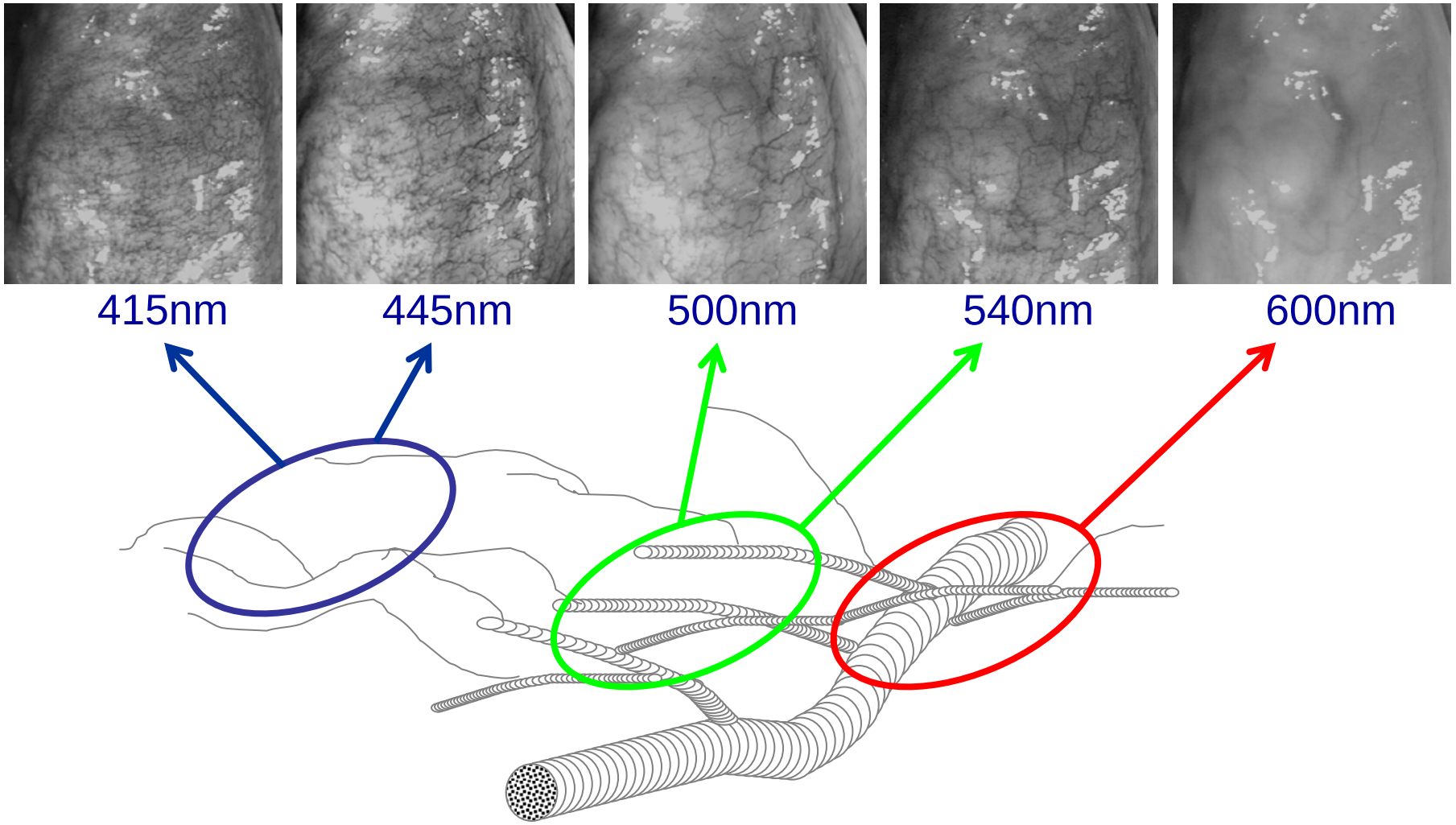
Narrow Band Imaging (NBI)

Structure of Vessels in Human Tongue



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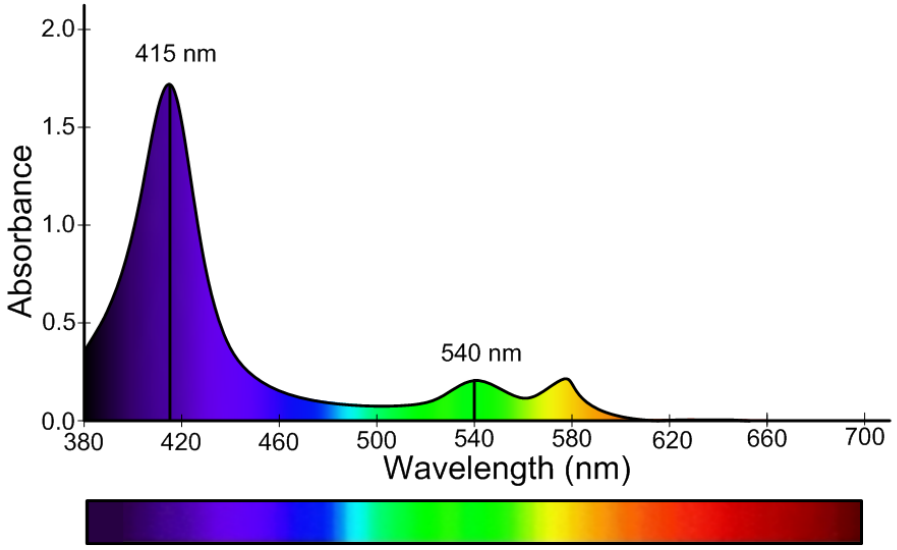
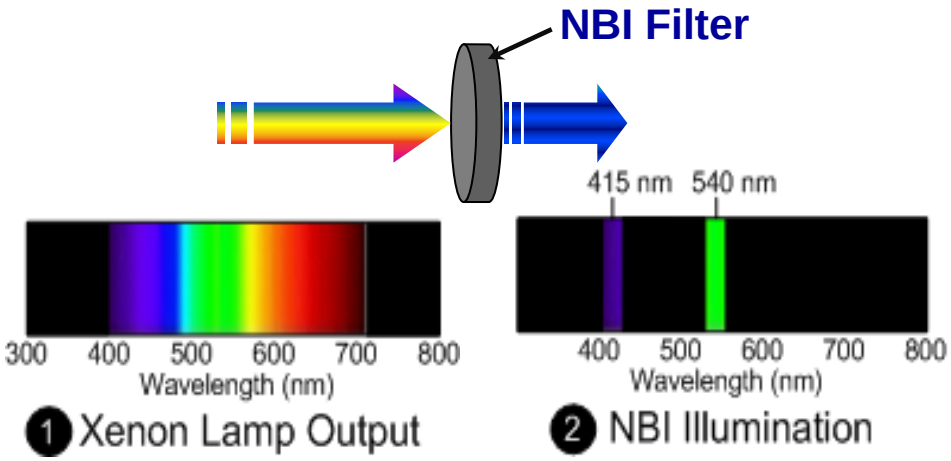
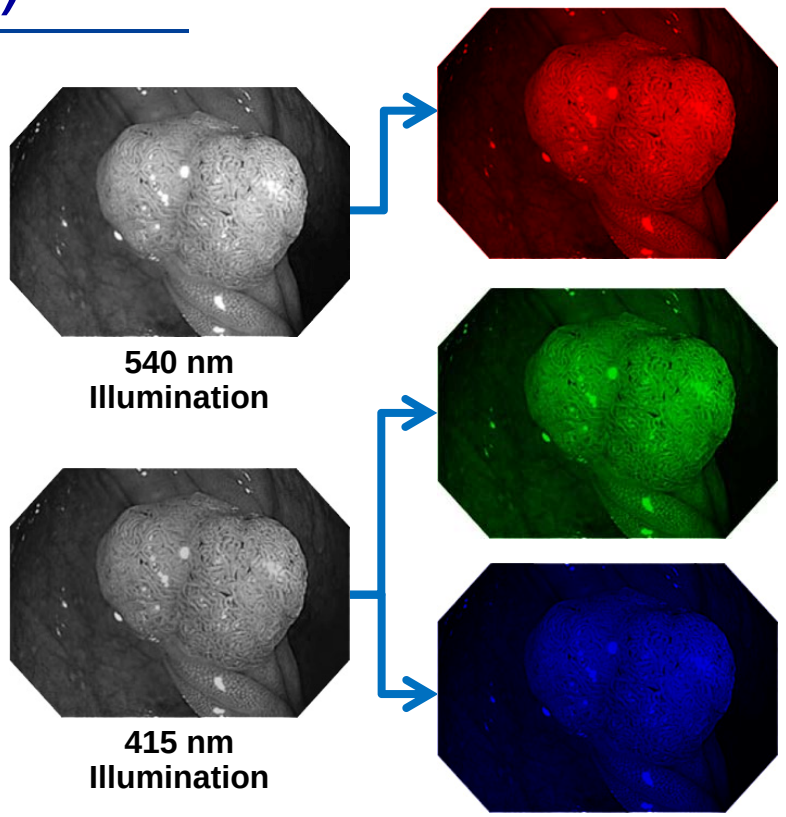
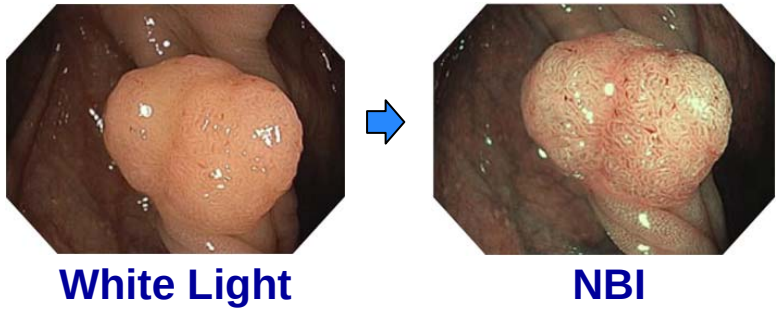
Narrow Band Imaging (NBI)





Narrow-Band Illumination





Clinical images courtesy of Roy Soetikno, MD

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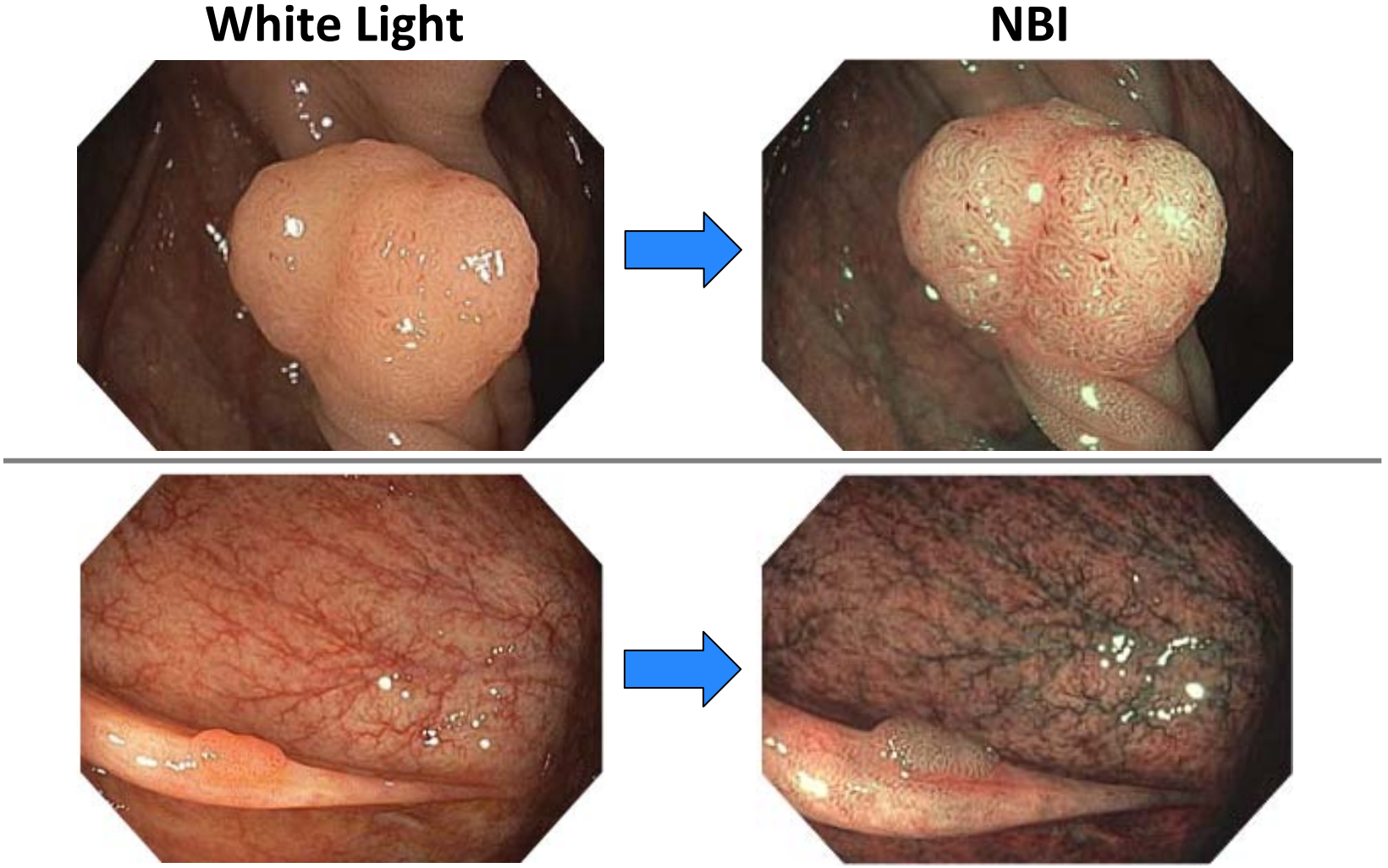
Narrow Band Imaging (NBI)

NBI enhances microvasculature and surface morphology



Clinical images courtesy of Tonya Kaltenbach, MD & Roy Soetikno, MD

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Chap.5

Color management

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Color Management

Things that cannot be (easily) changed:

- Color temperature of various types of lamps (xenon vs. halogen)
- Light sources change their color output as their lamps age
- Color transmission characteristics of glass and fiberoptic bundles

Color Management

Factors under the control of the manufacturer:

- Manufacturing variations from device to device
- Provision of an “auto white-balance” feature
- Attempt to produce the most “natural” color possible given the constraints of customer requirements, even with low-cost, battery-powered, portable systems.

Color Management

Factors NOT under the control of the manufacturer:

- Users mix components from various manufacturers
- Users adjust the controls on the monitor to their own liking

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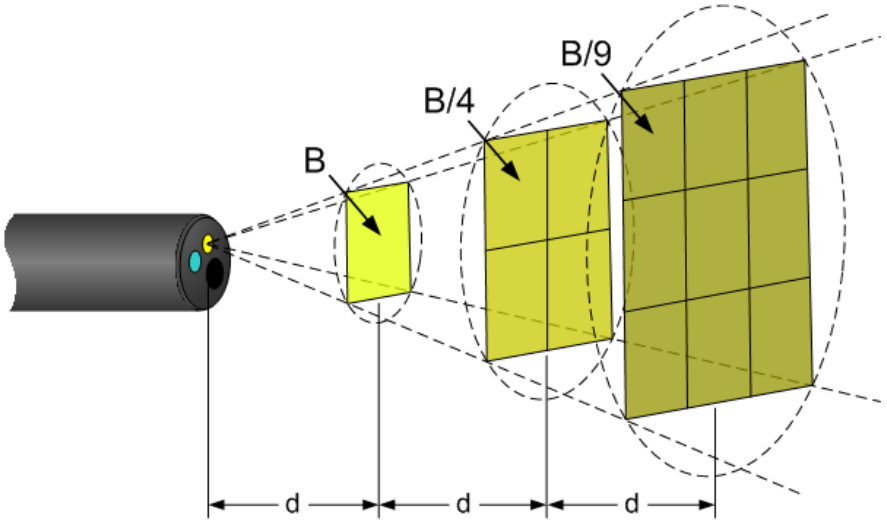
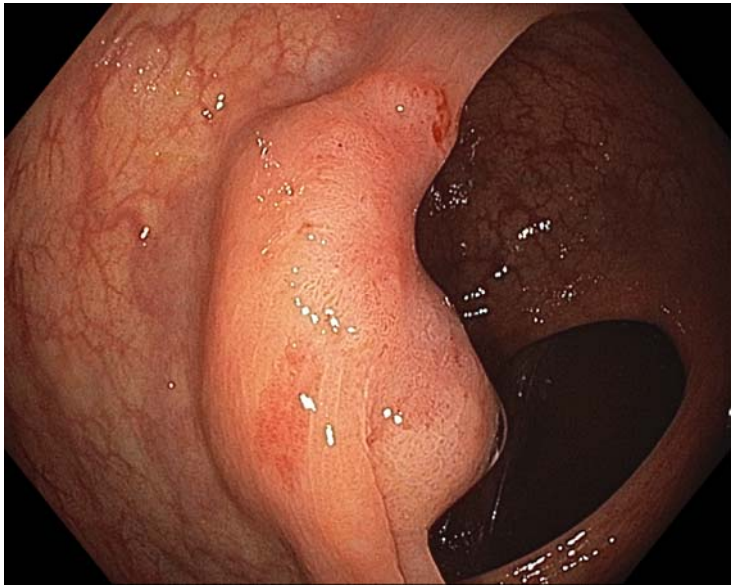
Color Management

- Due to the nature of endoscopy, the level of tissue illumination is often very uneven.
- Illumination follows an inverse square law.
- Color varies with brightness.



Brightness varies inversely by the square of the distance



Clinical image courtesy of Roy Soetikno, MD

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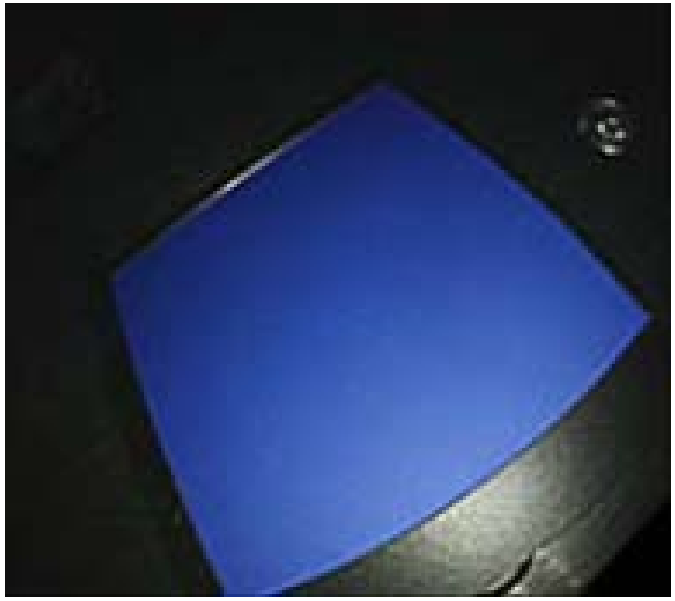
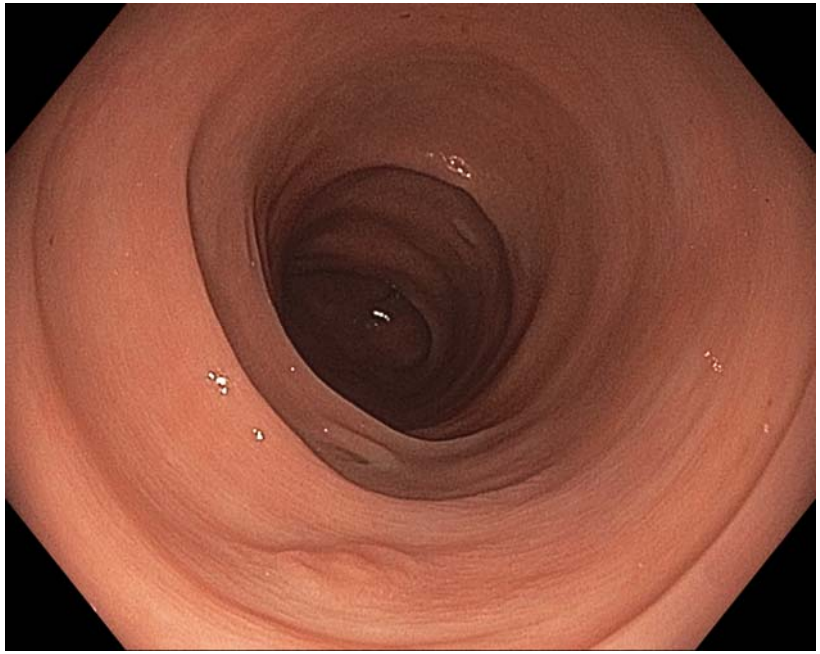
Color Management

- Therefore, even if an endoscope provided accurate color reproduction under ideal test conditions, actual tissue color will vary constantly during live endoscopy.



Endoscopic photo of test card with uniform color



Clinical image courtesy of Roy Soetikno, MD

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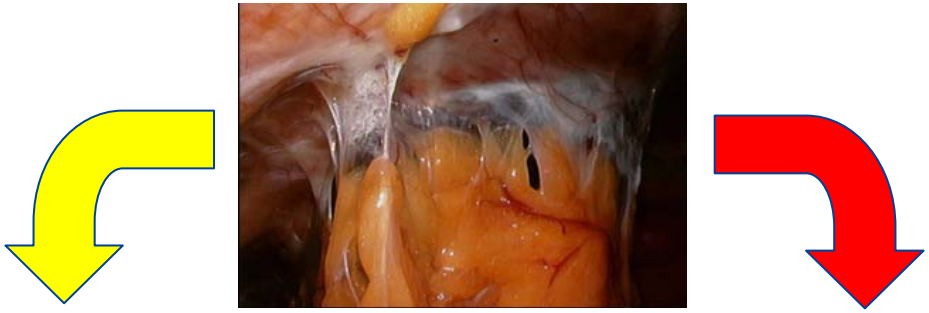
Color Fidelity

- Prior to the mid 1980's gastroenterologists were accustomed to seeing the reddish-yellow images produced by fiber optic instruments with halogen light sources.
- When video endoscopes were introduced, the new technology allowed for image color similar to viewing under sunlight (i.e., higher color temperature). However, users complained that the video image did not appear to be "natural" and requested that the video endoscope's color be adjusted to match the fiberscope's image.

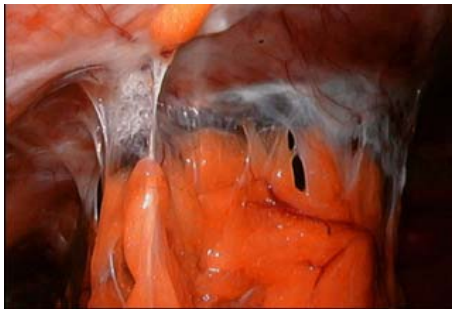
Color Fidelity

- In the 1990s, laparoscopy was quickly and widely adopted. Initially, laparoscopic image color was designed to be similar to that of open surgery under operating room lights.



Original picture

Yellowish color



Reddish color

Color Fidelity

- The goal is not to realize the precise color reproduction equivalent to the color seen under sunlight.
- The monitor and video processor can be adjusted to match the user's own color preferences.
- The important point for endoscopic color imaging is to provide the specific image information that the user wants to see.

Chap.6

Summary
&
Area for practical improvement

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Summary

- There are many different types of endoscopes
- Endoscopic systems can be complex
- The color of the endoscopic image is affected by the source of illumination, the physical components of the endoscope, the method of observation, and the video monitor.
- Many of the factors which affect color cannot be changed. Others are uncontrolled.
- However, the current level of color across the broad spectrum of endoscopes appears to be acceptable to end users.

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Area for practical improvement

- While endoscopists generally focus on real-time imaging, image documentation is gradually becoming more important.
- As PACS systems and electronic medical record (EMR) systems become more integrated, there is a need for a standard format & common method of sharing and archiving color endoscopic images.
- In the area of filing system, for example, extended file format with color parameters for displaying images would be practical improvement.

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