

Biomedical Imaging

Endoscopy

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Endoscopes

- Mostly Optical
 - Relay Lenses (e.g. Hopkins Relay)
 - Fiber Bundles (About 30,000 Fibers)
 - Scanners
 - Small Cameras
- Some Ultrasound (e.g. Intra–Vascular Ultrasound)
- Combine Imaging with Therapy/Surgery
- Rigid vs. Flexible
- Side or Forward View
- Diameter
 - Mostly 2 to 14 mm (3 French = 1 mm)
 - Imaging Channel May Be Smaller
 - Remember λ/NA

Some Diameters

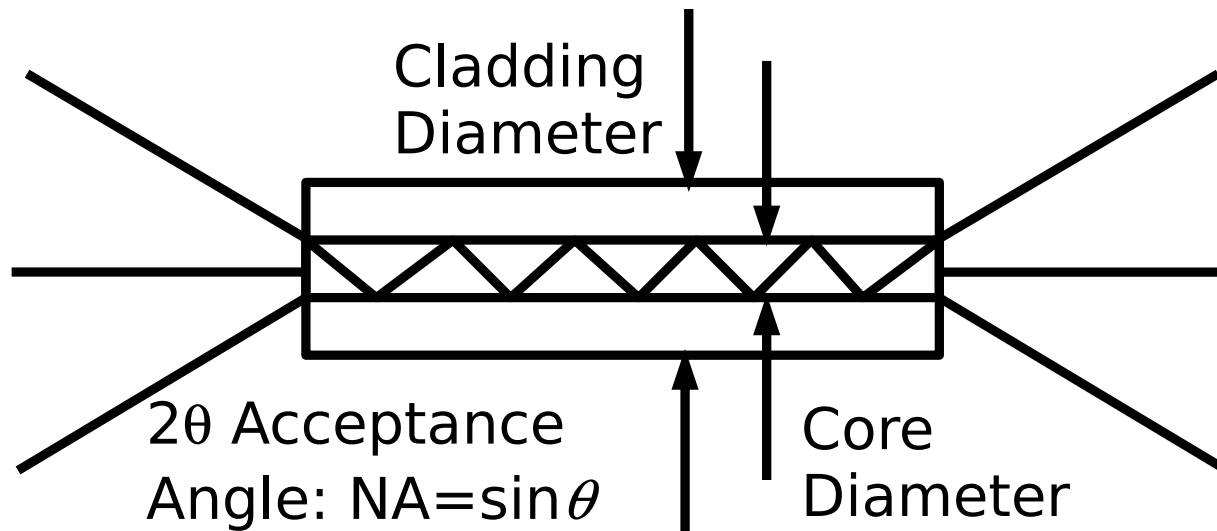
| Application | Technology | Diameter |
|----------------------------------|----------------|---------------------------------------|
| Laposcopic surgery (eg. knee) | Hopkins relay | 5mm to 1cm, some smaller |
| Bronchoscopy | Fiber or video | Few mm. Some rigid endoscopes to 1 cm |
| Rhinoscapy | Hopkins relay | 4 mm |
| Esophagus | HDTV | Few mm |
| Urethra or bladder | Fiber bundle | 2 to 7 mm or Hopkins relay to 5.4mm |
| Ureter or kidney | Fiber bundle | 2mm |
| Uterus or fallopian tubes | Fiber bundle | 2 to 10 mm |
| Colonoscopy | Video camera | Few mm up to 1.4cm |

Relay Lenses

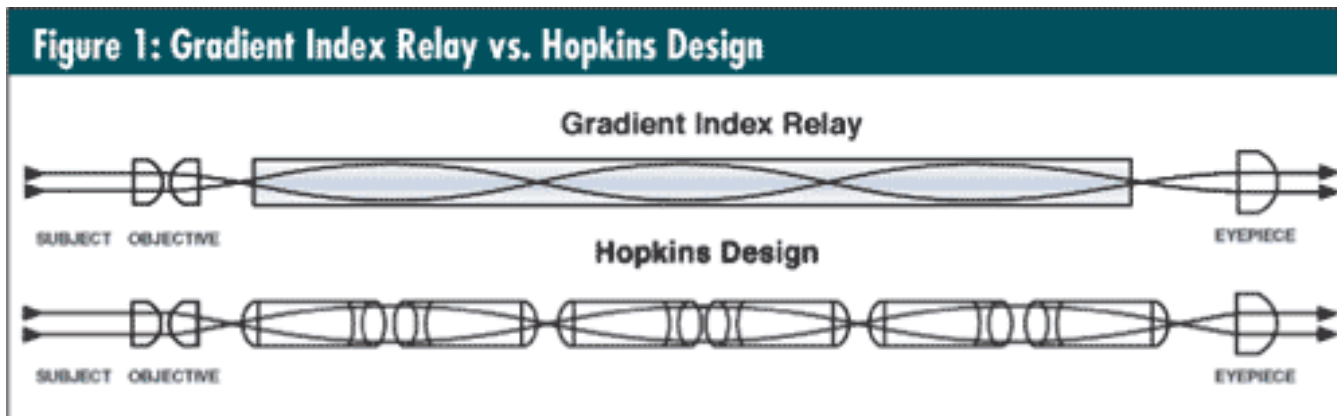
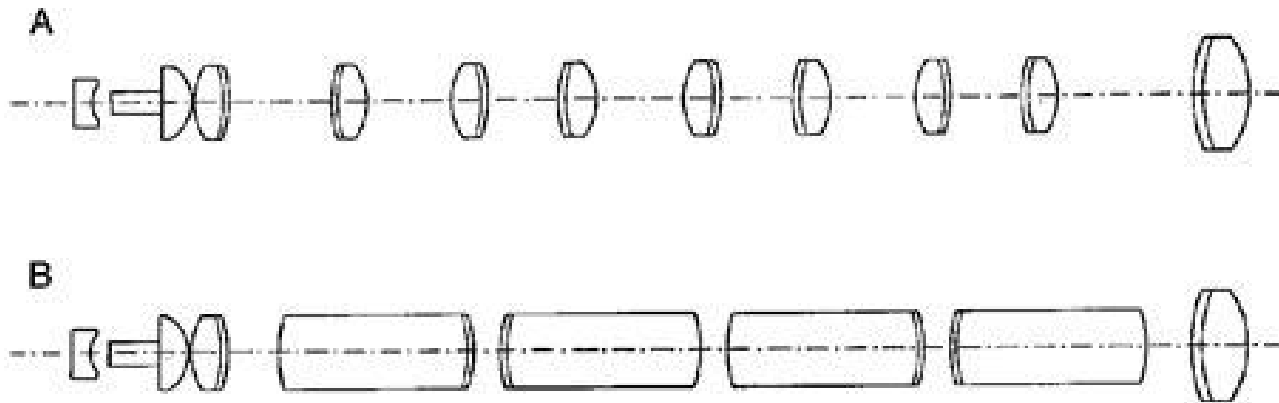
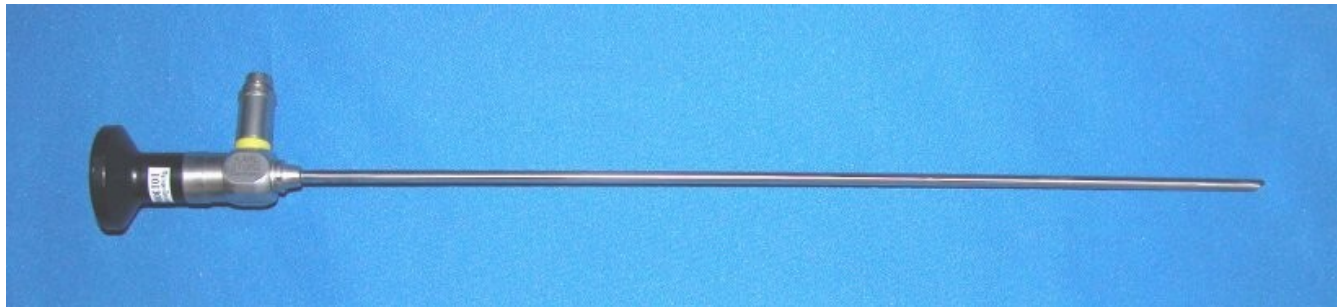
- Reasonably Flexible
- Limited NA
- No Scanning Required
- Hopkins Relay
 - Glass Rods as Lenses

Optical Fibers

- Total Internal Reflection: $NA = \sqrt{n_{core}^2 - n_{clad}^2}$
- Etendue: $\frac{\pi^2 D^2}{2} \left(1 - \sqrt{1 - NA^2}\right) \approx? \frac{\pi^2 D^2 NA^2}{4}$
- Single-Mode: $NA \approx \frac{\lambda}{D}$ Multi-Mode: $NA > \frac{\lambda}{D}$
- SM Etendue: $\frac{\pi^2 \lambda^2}{4}$



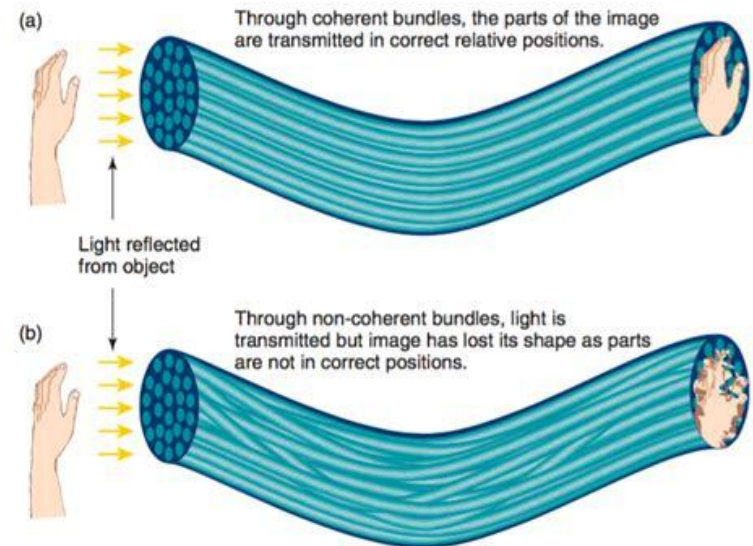
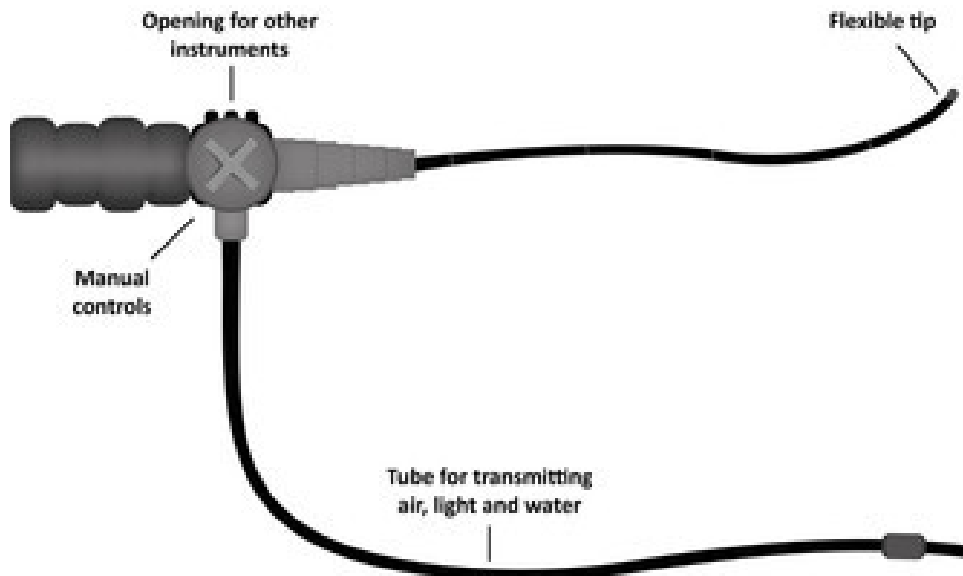
Relays



Fiber Bundles

- “Coherent Bundle”
- Fiber Size
- Fiber NA
- Cross-Talk
- Discrete Imaging

The Endoscope



https://t1.ftcdn.net/jpg/00/92/31/62/240_F_92316242_MATcuDeNm6E1YJUEK4sQUudImauFoUn0

<https://www.solospectrum.com/xrays-cat-and-endoscopes.html>

Cameras

- Only Need Wires and Illumination
- Probably White Light
- Pixel Size
- Pixel Number
- Lens (NA)

Scanners

- Rotating
- MEMS Azimuth and Elevation

https://washington-seattle.digication.com/jonliu/Point-of-care_pathology

- Oscillating Fiber End

Spectral Encoding

- Grating on a Fiber
- Diameter 0.5 mm or Less
- Wavelength Encodes Angle
- Varifocus Lens (Water) for Depth

<https://wp/optics.arizona.edu/dkang/>

- Intravascular Ultrasound
- Coronary Artery
- Side-Viewing
- Theta Dimension by Rotating
- Radial Dimension by Time-of-Flight
- Axial Dimension by Pulling
- Also IV-OCT