OPTICS = ??

But also,

Fiber-optic communications

Display Technology

Night vision goggles

Sight-saving technology
Sight-Saving Optics-Based Technologies

Refractive Surgery (e.g., LASIK)

Intraocular Lens Implant Surgery

Retinal Imaging Technologies
LASer In-situ Keratomileusis (LASIK)

- Laser etching of corneal surface to replace eyeglasses

1. Specialized camera creates nanometer-scale map of ocular imperfections

2. 1st laser (infrared) cuts partway through cornea to create flap

3. 2nd laser (ultraviolet) creates corrected corneal shape

- Approximately 700,000 procedures/year in the US
Intra-Ocular Lens (IOL) Implant Surgery

• Age-related cataract is the leading cause of visual impairment among elderly persons, affecting more than 20.5 million Americans
• IOL surgery most frequently performed surgical procedure in the Medicare-insured population

1. Specialized camera measures corneal refractive power
2. Correct power IOL is chosen and inserted through small incision
3. IOL expands to replace natural lens

• Nearly 1/3 of persons in the United States 69 years or older undergo this procedure in at least 1 eye
Many therapeutic ophthalmic technologies (e.g. LASIK, IOL surgery) had rapid commercial development.

Diagnostic technologies often have longer-term value proposition.

Many ophthalmic imaging techniques have been significantly aided by government-funded academic and small business research prior to commercial success.

Prime example: Optical Coherence Tomography (OCT)

Optical Coherence Tomography (OCT)

Cross-Sectional Retinal Imaging (video rate)

3D Retinal Imaging (3-4 seconds)
OCT Clinical Utility

Example: Age-Related Macular Degeneration (AMD)

- More than 1.75M Americans have AMD; risk in population over 75 is ~30%

Effect on eyesight

Standard Retinal Exam Photo

OCT Retinal Cross Section

OCT Displaces Conventional Diagnostics

Annotation of pathology on OCT 3D dataset:

- Borders of RPE disruption
- Cystoid macular edema
- Retinal thickening
- Sub-retinal fluid

Correlates with results of conventional tests:

- Fluorescein Angiography: hyperfluorescence confined to margin of RPE disruption
- Microperimetry: Poor retinal sensitivity extends to margins of retinal thickening

Critical need: technologies for automated 3D image analysis for early diagnosis

OCT Development Timeline

Scientific Publications

First scientific article
First commercial product
OCT CPT code
>10 commercial vendors
Technology displacement

In 2010:
- Total OCT reimbursements in US >$750M
- ~23% of Medicare beneficiaries >65yo had OCT
- OCT used between 3% and 12% of total ophthalmology clinic visits


Medicare Covered Eye Exams

36% annual growth rate 2000-2009
>$1B OCT worldwide market

OCT Citations in Web of Science

Allowed CPT 92135 Medicare Services vs Year

36% annual growth rate 2000-2009
>$1B OCT worldwide market
US Government Funding and ROI

Federal OCT R&D Investment
- All US gov’t funding ~$500M over last 10 years
- National Institutes of Health (NIH) total ~$340M
  - National Eye Institute ~$130M


ROI for Ophthalmic OCT
- New/less invasive standard of care for diagnosis and treatment monitoring of major blinding diseases
  - Macular degeneration
  - Diabetic retinopathy
  - Glaucoma
- Reimbursed cost per exam less than alternative tests and decreasing further[^4]
- Approaching $1B/yr US market
Commercialization of Retinal OCT

1995-2005: 1st Generation Technology
Carl Zeiss Meditec (Dublin, CA)

2005- Now >10 Manufacturers Worldwide
2nd Generation Technology

Carl Zeiss Meditec
OptoVue
Topcon
Optopol
Ophthalmic Technologies, Inc
Bioptigen, Inc.
Heidelberg Engineering
Bioptigen, Inc.

- Duke University spinoff company founded 2004
- Employs 19 North Carolinians
- 2007 Frost & Sullivan Excellence in Research Award
- Received 5 Phase I SBIR, 4 Phase II SBIR grants enabling product development

Research-grade OCT systems for emerging applications

- Hand-held imaging for babies, children, bedridden patients
- Small animal imaging for basic research and drug development

Next-Generation Ophthalmic OCT Research

Eliciting retinal function from blood flow imaging
(University of California/Cal Tech)

Improving retinal surgery using intra-operative OCT
(Duke University)

Cone cell dynamics using adaptive-optics technology
(Indiana University)

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