Telling the Biological Story with Multi-Modality Imaging

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JULY 12–16 2020 VIRTUAL
JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

THE UNIVERSITY OF TEXAS MD Anderson Cancer Center | UTHealth The University of Texas Health Science Center Houston
Graduate School of Biomedical Sciences

Driving Force in Imaging

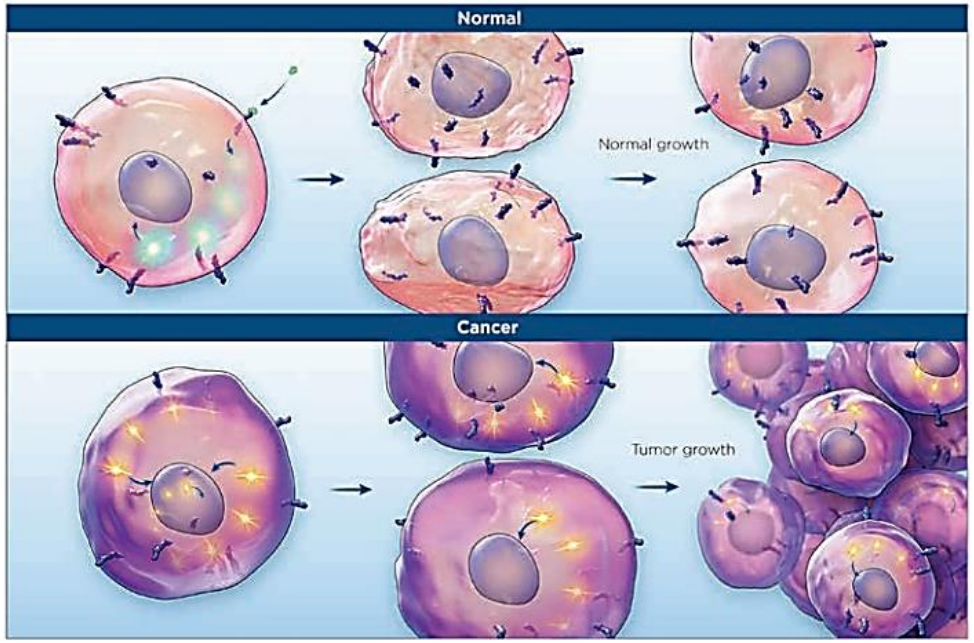
I. Introduction
II. Telling the Biological Story
III. Research Opportunities
IV. Conclusion

Overarching Question:

- Tumor vs. normal cells
- Exploit differences for visibility

Treatment Specifics:

- Changing characteristics
- Quantify treatment progress
- Outcomes and follow up



Proliferative signaling of cancer cells allows tumor growth as normal cellular growth suppressors, such as the TP53 gene, are mutated.
ThermoFisher Scientific, Handbook of Cancer Cell Culture Basics

Multiple Modality Imaging

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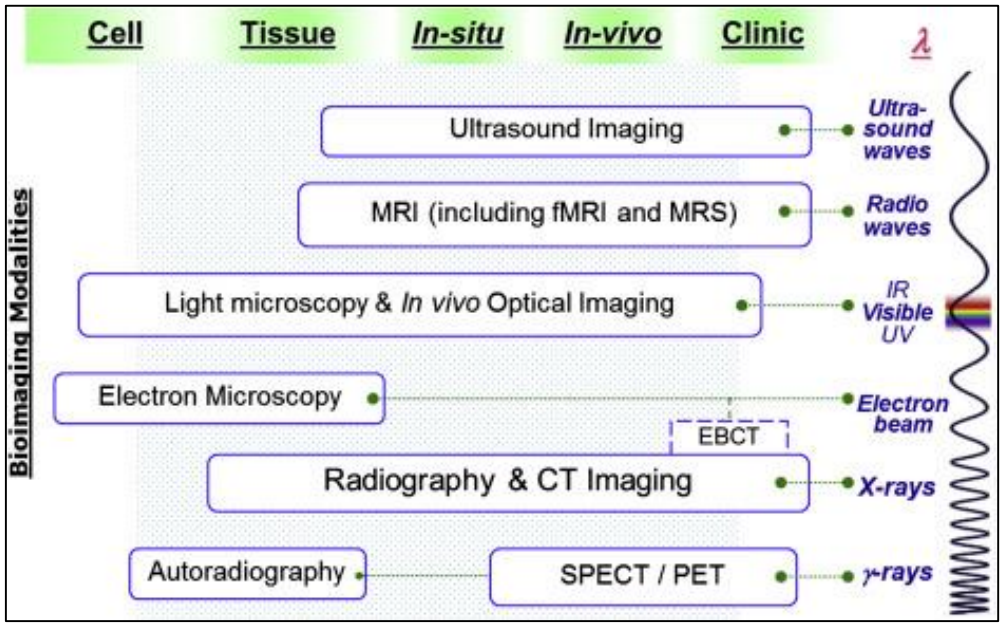

Source: (Ying et al., 2017)

What is multi-modality imaging?

- Incorporating information from 2 or more imaging modalities
- Scans can be done in a single examination (preferred) or separate examinations

Benefits:

- Enables anatomic and functional imaging
- Considering multiple characteristics at the same time can provide a more comprehensive analysis

The Biological Story: Early Stages

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Patient presents with the following symptoms:

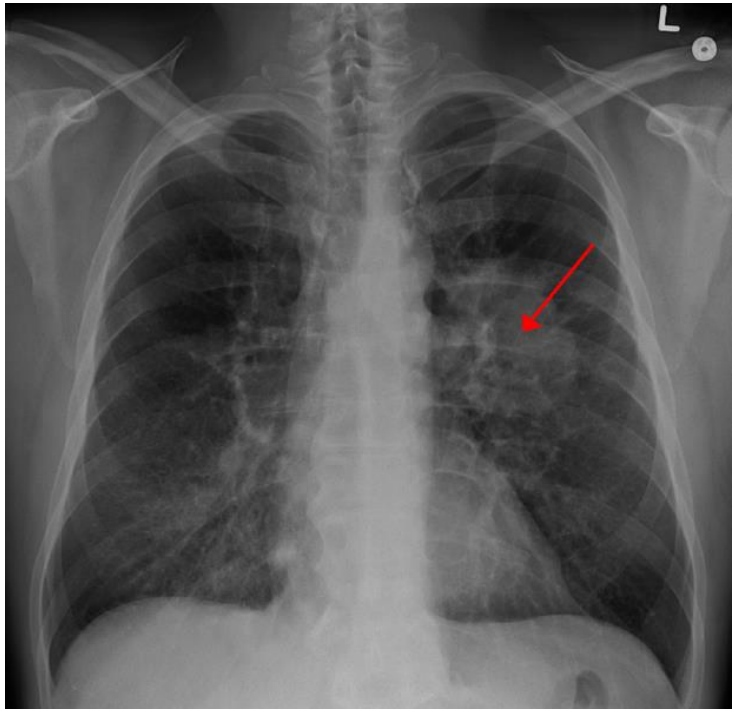
- Persistent cough
- Chest pain
- Pneumonia
- Loss of appetite
- Wheezing

Patient risk factors:

- Age: 74
- Smoking history: 10-pack-years
- COPD
- Overweight

Physician orders a chest radiograph and finds a focal lesion.

*Note: this patient example uses a hypothetical patient that will undergo a hypothetical diagnosis and treatment plan.



Lung cancer as seen on chest radiograph with red arrow.
Source: James Heilman, MD

The Biological Story: Next Steps

I. Introduction

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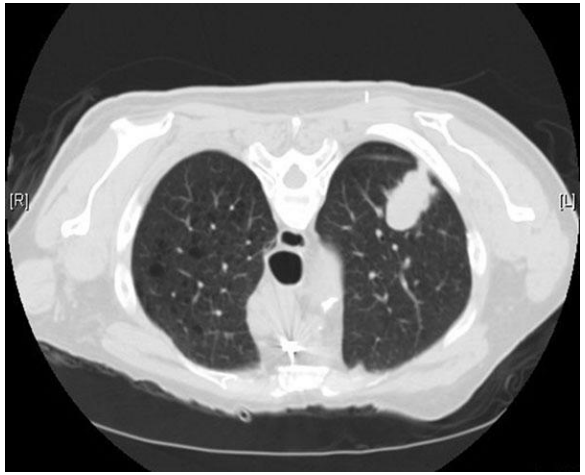
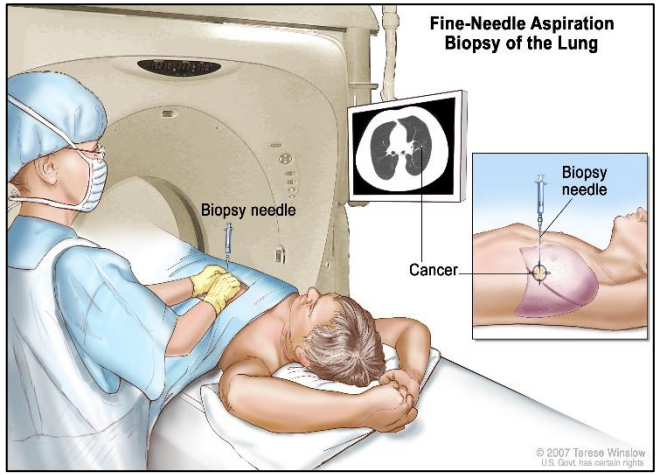
Patient undergoes chest CT scan



Source: Wikimedia, CC BY-SA 2.0

Fine-needle aspiration biopsy of lung tumor



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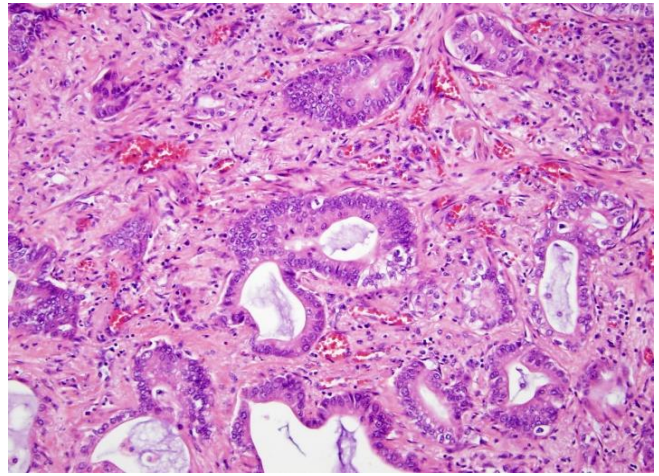
Histopathology confirms diagnosis of non small cell lung cancer (NSCLC)



(*Non-Small Cell Lung Cancer*, 2019)

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The Biological Story: Identifying Metastases

I. Introduction

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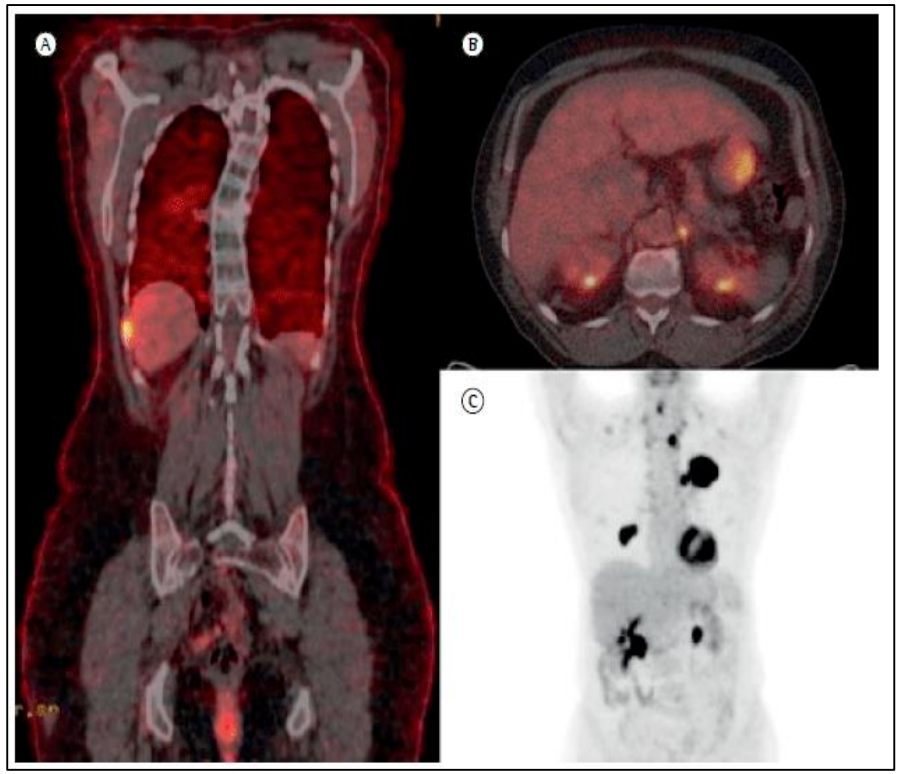
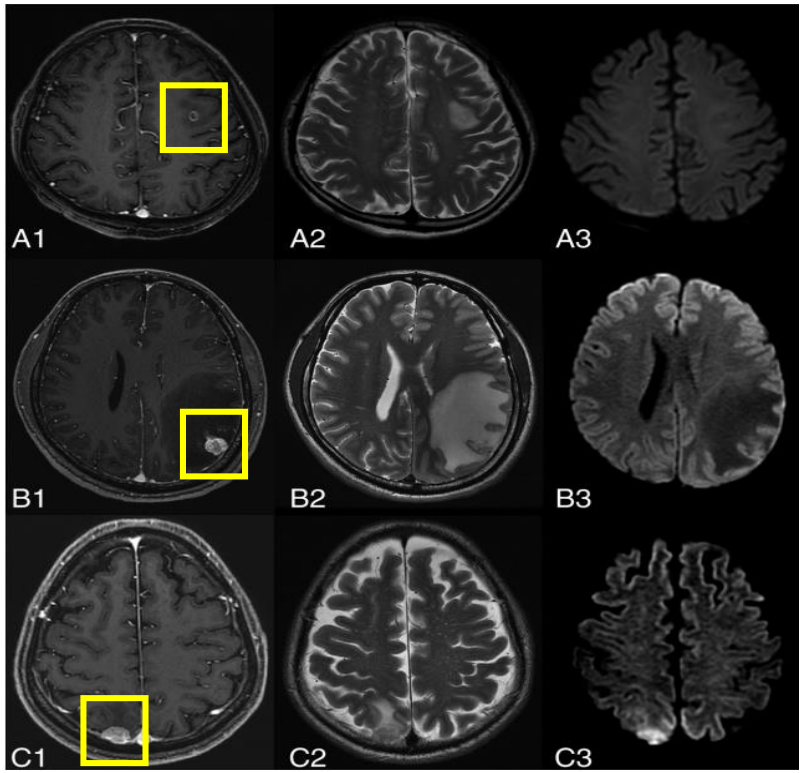
PET/CT to identify metastases



(Hochhegger et al., 2015)

Brain MRI to identify metastases



(Jung et al., 2018)

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The Biological Story: Treatment Planning

I. Introduction

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Patient is prescribed radiation therapy:

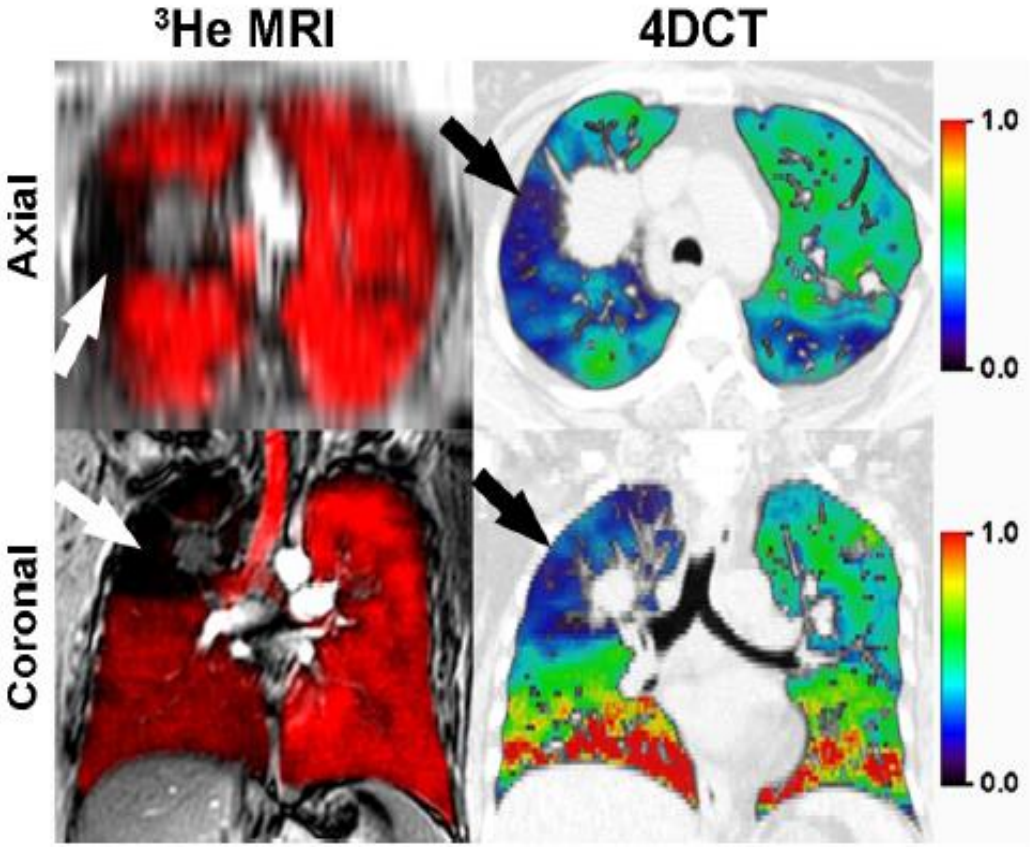
- IMRT (6000cGy)

As a physicist, how can we help create the most effective treatment plan?

- Sufficient dose to most aggressive areas of tumor
  - FDG uptake on PET
  - Hypoxia imaging
- Minimize side effects
  - Radiation pneumonitis
- Maximize healthy tissue sparing
  - Perfusion imaging to identify functional areas of lung

Molecular characterization to determine concurrent therapy:

- EGFR tyrosine kinase inhibitors for patients with EGFR mutations
- ALK inhibitors for patients with ROS1 or EML4-ALK oncogene



(Simon et al., 2012)

The Biological Story: Treatment Outcomes

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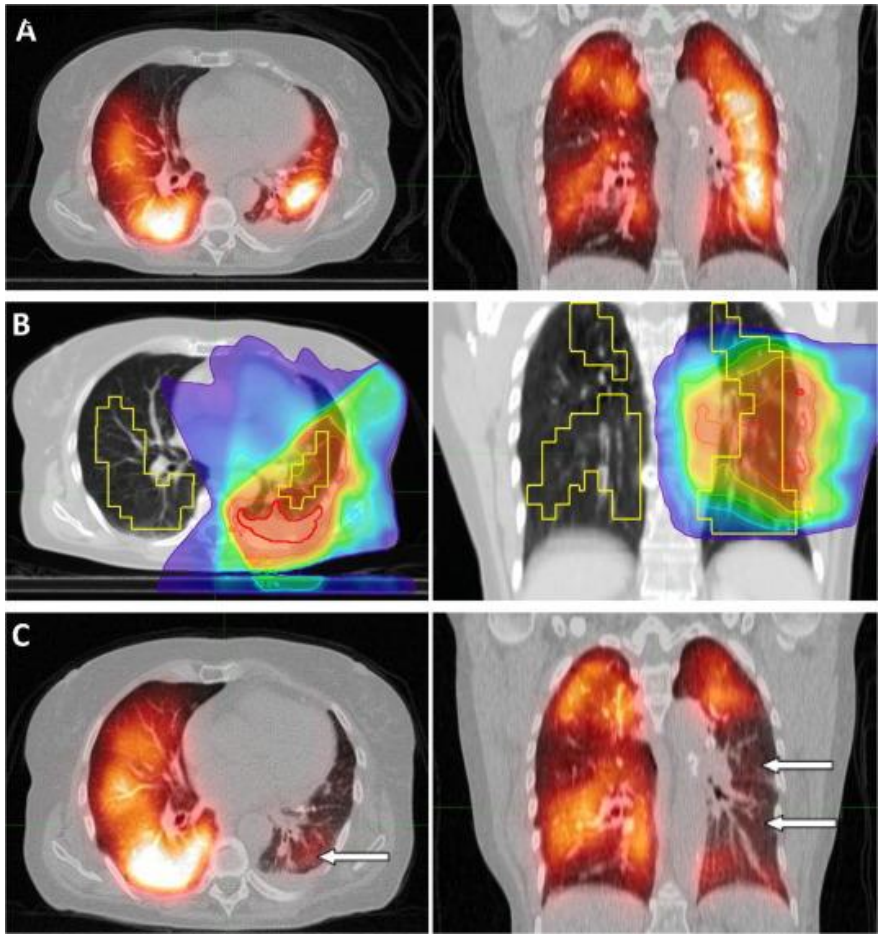

(Farr et al., 2018)

Considerations:

- How do we classify treatment completion?
- What is the patient's quality of life?
  - Can we do anything to improve this?
- What does surveillance look like?
  - How does this fit into the patient's lifestyle?
- Are there other imaging metrics we can use that are more representative of patient progress?

The Biological Story: Digging Deeper

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How can we improve treatment outcomes?

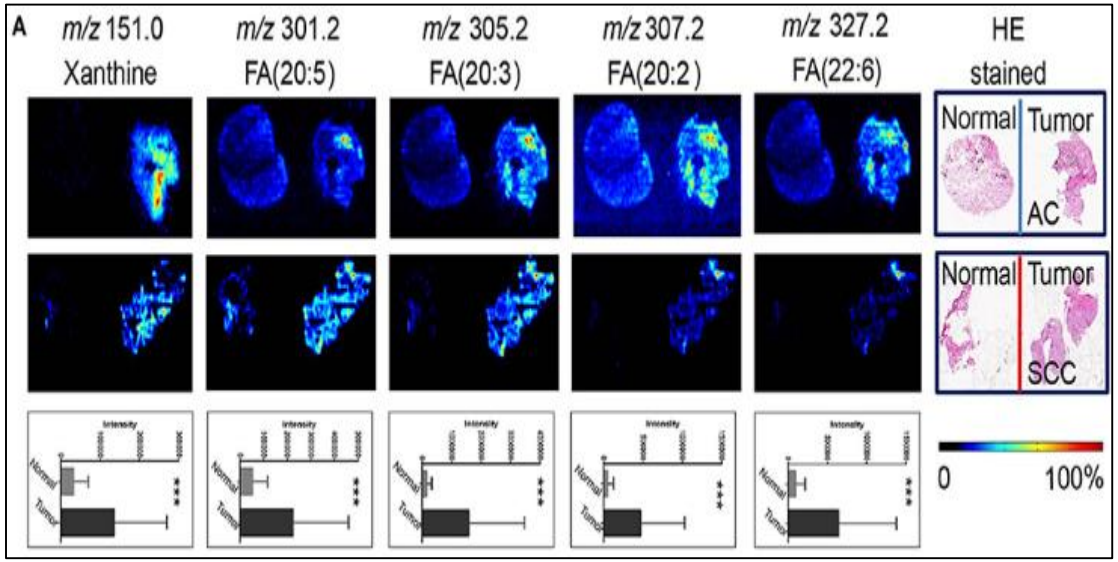
- Higher radiation doses
- More effective tissue sparing

What if we were able to better characterize this tumor on a molecular level?

- Radiosensitizers
- Concurrent chemotherapy
- Concurrent immunotherapy
- Personalized treatment

How can we learn more about the tumor microenvironment?

- Mass spectrometry imaging (MSI)
- Imaging biomarkers
  - PET, MRI



(Zhang et al., 2019)

How can you get involved?

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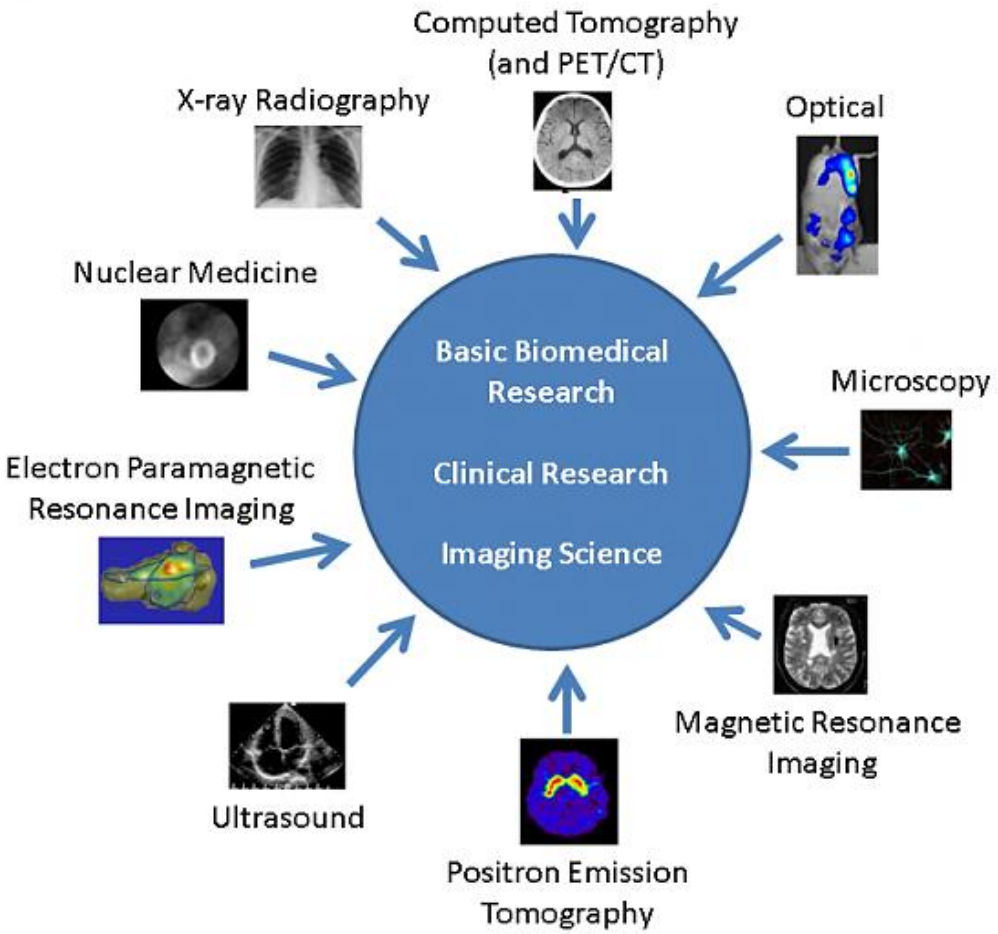

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<u>Endless research opportunities</u>:

- Functional imaging
- Bioluminescence imaging
- MRI pulse sequences
- Biomarkers
- Image registration
- Image quality
- Image-guided therapy
- Adaptive therapy
- Hypoxia imaging
- Radiomics
- Deep learning
- Image segmentation
- And many more…

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Related Areas of Research

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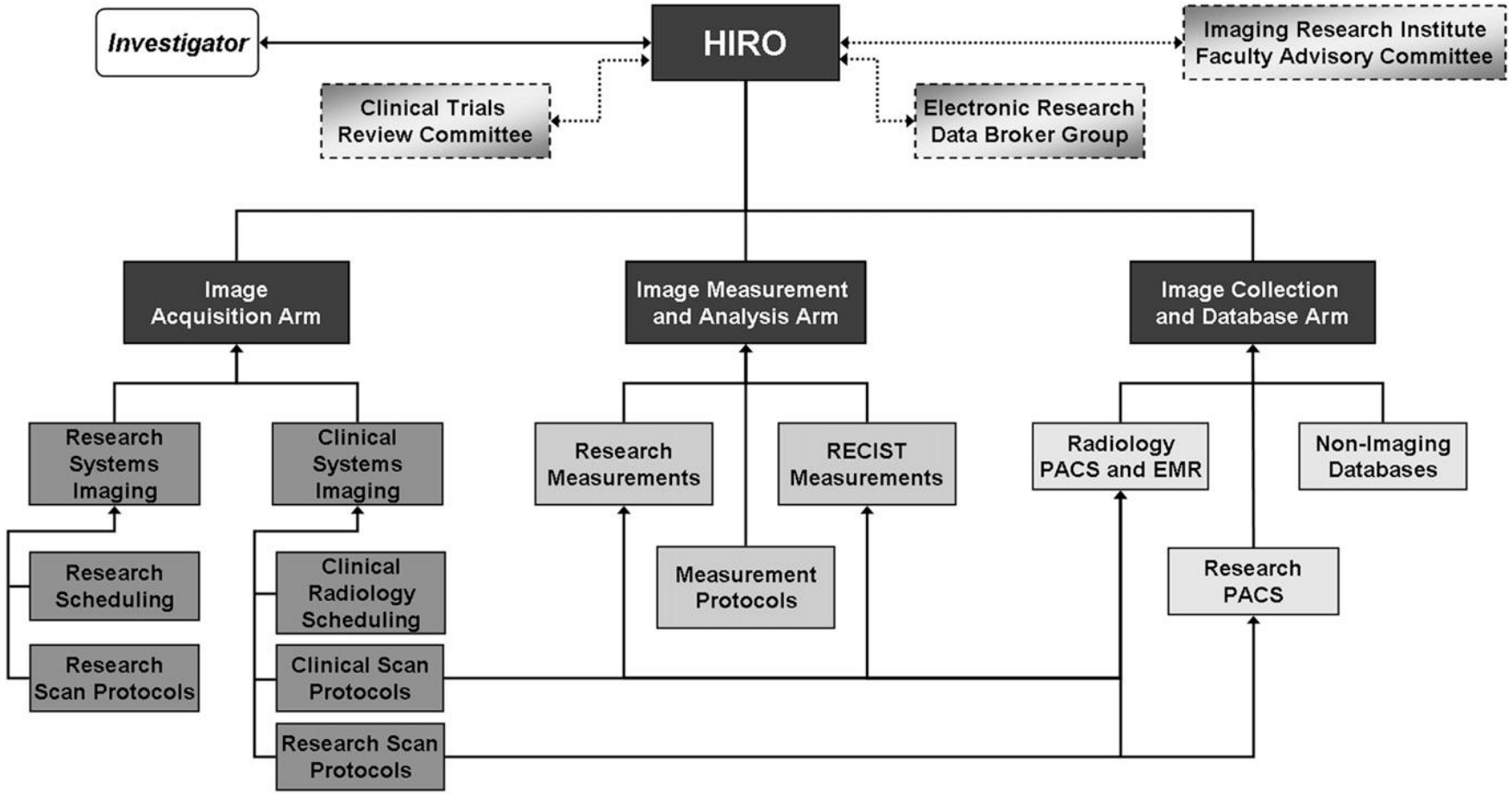

Figure 1. Organizational structure of the Human Imaging Research Office.

(Armato et al., 2012)

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Future Importance

I. Introduction

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Source: GE Healthcare: Why Doctors of the Future May Know Code

Future:

- Evolving role of imaging
- Collaborations with researchers in the basic sciences
  - What imaging techniques do they use?
  - How can we incorporate with current imaging?
- Move towards individualized patient care

Exciting time in imaging research!

References and Resources

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