Introduction to Career as a therapeutic Medical Physicist

YANJING LI, PHD DABR
RADIATION ONCOLOGY, NEWTON WELLESLEY HOSPITAL
CAREER SEMINAR, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
SEP 26TH, 2022
Previous related talks

- Dustin Wooten
  https://ws.engr.illinois.edu/sitemanager/getfile.asp?id=2930

- Lonnie Edelheit
  https://ws.engr.illinois.edu/sitemanager/getfile.asp?id=2933

- Gregg Franklin
Outline

- Overview of the field
  - Scope, focus and subfields
  - Working environment and schedule
  - Some statistics
- Therapeutic and Imaging Modalities involved
- Research areas/topics
- Educational pathways
- My personal experience
Overview of the field
Medical Physics is

- an applied branch of physics

- Apply physics concepts and methods to the diagnosis and treatment of human disease
Medical Physics is an interdisciplinary field that integrates core knowledge in traditional physics disciplines with specific domain knowledge in:

- the science of healthcare delivery, particularly in ensuring the accuracy and safety of medical diagnostic and therapeutic procedures;
- bioeffects related to exposures to ionizing and non-ionizing electromagnetic radiation, ultrasonic energy, and strong magnetic fields;
- optimization of imaging and therapeutic procedures to maximize benefit and minimize risk to the patient and healthcare provider;
- evaluation and communication of benefits and risks to patients and healthcare providers;
- image science and image analysis;
- data analysis and statistics;
- clinical trial design, implementation and oversight;
- quality assurance and quality improvement processes;
- electrical, mechanical, and biomedical engineering;
- control systems, including computer controlled, mechanical, and electronic systems;
- mathematics;
- computer science;
- computational modeling;
- detector design and fabrication.
Subfields

- Medical physicists commonly practice in one of these areas:
  - Therapeutic medical physics.
  - Clinic, Radiation Oncology
  - Diagnostic medical physics.
  - Clinic, Radiology
  - Consulting
  - Nuclear medical physics.
  - Clinic, Nuclear Medicine
  - Medical health physics.
  - Clinic
    - research, industry, education, environmental protection, and enforcement of government regulations
  - Magnetic resonance imaging physics.
  - Clinic, Radiology
Some statistics

- Not very big
  49,555 (APS) vs. 8000 (AAPM)
- Jobs mainly located in metropolitan areas
- AAPM member survey (2021)
  - 77% therapeutic
  - 2.8% self employed consultants
  - Women ~25%
- Average primary salary
  $207,500
Clinical medical physicists

- ABR Certification

- Therapeutic medical physicists:
  - Responsible for treatment machines
  - Best design of patient treatments
  - Safety
  - Research & development
  - Clinical implementation of new technology

Clinic is a must-have

Research is optional - depends on the appointment

Joost Verburg, PhD
Intro to Radiation therapy

- **Radiation therapy** uses carefully targeted and regulated doses of high-energy radiation to kill cancer cells.
- Radiation causes some cancer cells to die immediately after treatment, but most die or become incapacitated as a result of the radiation-induced damage to the cancer cell's chromosomes and DNA.

Photo source: Mayo Clinic
Work environment & schedule

- Work environment
  - Clinic or Industry (consulting Company)
  - Cancer center/Institution (academic) or Private Clinics
  - Big Center or Community hospital

- Schedule
  - Regular clinic hour + After hour
  - Really depends on the clinic & subfields

- People
  - Internal: dosimetrists, physicists, physicians, (patients), nurses, therapists, admin
  - External: engineers, vendors
Modalities
THERAPY + IMAGING
Therapeutic Medical Physicists

- Hardware (imaging + therapy)
  - CT, MRI, PET
  - External beam
    - Gantry based Linear accelerator
    - Gamma knife, Cyberknife, tomotherapy
  - Brachytherapy
  - MR-Linac
  - Proton

- Software
  - Record and verify system
  - Treatment planning system
  - Quality assurance system
  - ...
Linear accelerator

Photo source: Varian
How it works

Schematic diagram of a typical medical linear accelerator. (reproduced from Van Dyk, J. The modern technology of radiation oncology Madison, WI, USA: Medical Physics Publishing; 1999. p1073.)
Gamma knife

Photo source: Elekta
Cyberknife

Photo source: Accuray
Proton therapy

Cyclotron

Energy selection system

Photo source: IBA
Brachytherapy

Photo source: Mayo clinic
MR-Linac
Research
A List of topics

- Biological Modeling
- Drug-Radiation Interaction
- Image Registration
- Monte Carlo
- Motion Management
- Optimization
- Outcome Assessment
- Proton Therapy
- Systems Biology
- Therapy Imaging
- ...

Clinical-driven direct application to patient care

Joost Verburg, PhD
The Nobel Prize in Physics 1915

- for their services in the analysis of crystal structure by means of X-rays
The Nobel Prize in Physiology or Medicine 1979

CT

for the development of computer assisted tomography

Allan M. Cormack
Prize share: 1/2

Godfrey N. Hounsfield
Prize share: 1/2
Nobel prizes related to MR

- 1954
  - Felix Bloch and Edward M. Purcell
  - development of new methods for nuclear magnetic precision measurements and discoveries in connection therewith.
- 1991
  - Richard Robert Ernst
  - the development of the method of high-resolution nuclear magnetic resonance (NMR) spectroscopy.
- 2003
  - Paul Lauterbur and Sir Peter Mansfield
  - discoveries concerning magnetic resonance imaging
for their discoveries of how cells sense and adapt to oxygen availability.
Experimental Prompt gamma

- Clinical needs – where the proton stops?
- Rang uncertainty - multiple Coulomb scattering
- Prompt gamma rays – radiation produced by proton interactions with atomic nuclei within the patient.
Skin cancer Classified By CNN

l lung density change after proton vs. photon SBRT

3 months

6 months

3 months +

6 months +

Li et al. Radiotherapy & Oncology (2019)
Educational pathways
Current Medical Physics Pathways

Graduate Degree: Medical Physics CAMPEP

- DMP ($$$$)
- MS ($$ ?)
- PhD

PhD in Physics, Engineering, or related

- CAMPEP Certificate ($)
- Postdoc

Residency

- ABR Certification

Postdoc

Research supported Faculty position

Industry

David Gierga, PhD
Clinical Physics Pathway Summary

Courses (CAMPEP Certificate)
- ABR part 1 exam

Residency (CAMPEP)
- ABR part 2 exam

Practice
- ABR part 3 exam

Board Certified
Certificate Programs

- didactic coursework offered by a CAMPEP-accredited graduate or residency program
- enable individuals with a doctoral degree in physics or a related discipline to meet the didactic requirements needed to enter a CAMPEP-accredited residency program.

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<th>Institution</th>
<th>Accreditation</th>
<th>Expiration</th>
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<td>Cleveland State University</td>
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<td>Dalhousie University</td>
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<td>Dartmouth College</td>
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<td>2022</td>
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<td>Western University</td>
<td>2015</td>
<td>2022</td>
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Residency Programs

- Full list: https://campep.org/campeplstres.asp
- 153 accredited programs (115 therapy / 38 diagnostic)
- # of residents per year: 140 therapy / 15 diagnostic (2018)
My experience
Path

  - ABR board part 1, 2019

- 2019 – 2021, Medical Physics Residency Program at Rutgers University
  - ABR board part 2, 2021

- 2021 July -2022 Apr, Saint Vincent Hospital
  - ABR board part 3, Certified 2022

- 2022 Apr – present, Newton Wellesley Hospital
Certificate Program at Harvard

- To apply
  - https://harvardmedphys.org/certificate-program/
- 6 courses (can be done within a year)
- Tuition fee $28,000
- Clinical exposure
- research opportunities

<table>
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<tr>
<th>Credits</th>
<th>Course</th>
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<td>Physics I (Physics and dosimetry)</td>
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<td>3</td>
<td>Physics II (Radiation therapy)</td>
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<td>3</td>
<td>Radiation Biology</td>
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<tr>
<td>3</td>
<td>Medical Imaging Modalities</td>
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<td>3</td>
<td>Radiation Protection Safety</td>
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<tr>
<td>2</td>
<td>Anatomy and Physiology</td>
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Residency Program at Rutgers

- Apply, interview and then match
- 2 years of clinical training
- Work in the clinic while learn from dosimetrist and qualified physicists
- A nice varieties of modalities

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<tr>
<th>Duration</th>
<th>Rotation</th>
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<tbody>
<tr>
<td>6 mons</td>
<td>Treatment planning</td>
</tr>
<tr>
<td>3 mons</td>
<td>Machine and QA</td>
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<tr>
<td>4 mons</td>
<td>Brachytherapy</td>
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<tr>
<td>3 mons</td>
<td>Commissioning and special procedures (TBI, TSET)</td>
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<tr>
<td>2 mons</td>
<td>Medical Imaging</td>
</tr>
<tr>
<td>3 mons</td>
<td>SRS (Gamma Knife)</td>
</tr>
<tr>
<td>3 mons</td>
<td>Proton therapy</td>
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</tbody>
</table>
Daily work

- Treatment planning
- Quality Assurance
  - Machines and equipment
  - Chart check
  - Patient specific QA
- Introduction and commissioning of new techniques
- Machine issues
Opportunities & Challenges

- Non-academic
  - Project Management
  - Leadership
- Academic center
  - Research
  - Teaching
- Radiation Safety
  - Accuracy of dose and positioning
  - Accidents happen
- Interaction with people
  - Colleagues (interdisciplinary team)
  - Patients
- Emergency situations
  - Machine issues
  - Clinical decisions
Acknowledgement

- Nadya Mason
- Lance Cooper
- Lonnie Edelheit
- David Gierga
- John Beatty
Reference

- AAPM: The American Association of Physicists in Medicine
  https://www.aapm.org

- American board of Radiology
  https://www.theabr.org/

- Harvard Medical Physics Certificate Program
  https://harvardmedphys.org/certificate-program/

- Rutgers University Medical Physics Residency Program
  https://rwjms.rutgers.edu/departments/radiation-oncology/educational-programs/medical-physics-residency-program
Questions

- yli94@mgh.Harvard.edu
Glossary

- **DMP**
  A professional doctorate program, typically leading to a degree of Doctor of Medical Physics (DMP) consists of at least two years of didactic education followed by at least two years of clinical education.

- **CAMPEP (Commission on Accreditation of Medical Physics Education Programs)**
  is a nonprofit organization, independent of its Sponsoring Organizations, whose objectives are the review and accreditation of educational programs in medical physics.

- **ABR (American Board of Radiology)**
  is an independent, not-for-profit organization and is one of 24 national medical specialty boards that make up the American Board of Medical Specialties (ABMS). We were founded to protect the public by assessing and certifying doctors who meet specific educational, training, and professional requirements.

- **Residency**
  This Residency Program training involves full participation of the physics resident in the clinical routine, under the supervision of experienced radiation oncology physicists.