Medical Physics

Profession and Science:

based on use of Physics and High Technology in Medicine for diagnosis and treatment of disease:

- Profession
  - Recognized since 2008
  - Radiotherapy
  - Imaging
  - Health physics

- Science
  - Applied
  - Translational
  - Multidisciplinary
  - Incremental
Physics in Medicine

- The study and use of ionizing radiation in medicine started with three important discoveries:
  - X rays by Wilhelm Conrad Roentgen in 1895.
  - Natural radioactivity by Henri Becquerel in 1896.
  - Radium-226 by Pierre Curie and Marie Curie in 1898.
“X rays will prove to be a hoax”

William Thomson
Lord Kelvin
(1824 - 1907)

who had been appointed a professor of mathematics and physics at the age of 22 and who became one of the greatest scientist of his day.
## Medical Physics: Areas of Activity

- **Service**  
  *(Raison d’être)*

- **Research**  
  *(Road to advancement)*

- **Teaching**  
  *(Hope for the future)*

- **Administration**  
  *(“Necessary evil”)*

### Imaging Technologies
- Ultrasonic imaging
- Scanning electron microscopy
- Magnetic resonance imaging (MRI)
- Computerized tomography (CT)
Professional Aspects of Medical Physics

• Concentration of Medical Physicists around the World
• Recognition of Medical Physics as Profession
• Medical Physics Organizations
• Best route to Medical Physics Profession

Medical Physics in North America (Canada and U.S.)

Accreditation and Certification

Teaching and Research

Conclusions
Professional Aspects of Medical Physics

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Medical Physics Worldwide

Concentration of Medical Physicists

- **World Population:** ~6 800 million
- **Number of Medical Physicists:** ~18 500
- **Mean concentration:** ~2.7 per million population
  - In developed countries: (~15 – 20) per million population
  - In developing countries: (~1 – 5) per million population
  - In many undeveloped countries: 0
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Medical Physics: Profession

United Nations

International Labour Organization (ILO)

Founded in 1919
Headquarters: Geneva

International Standard Classification of Occupations (ISCO)
1958 (ISCO-58); 1968 (ISCO-68); 1988 (ISCO-88); 2008 (ISCO-08)
Purpose of ISCO:

To organize jobs into a defined set of groups according to the tasks and duties undertaken in the job.

**ISCO-08**

- **Major groups:** 10
- **Minor groups:** 28
- **Unit groups:** 116
- **Subgroups:** 390
ISCO-08: 10 Major groups

0  Armed (defense) forces
1  Managers
2  Professionals
3  Technicians and associate professionals
4  Clerks
5  Service, shop and market sales workers
6  Skilled agricultural, forestry and fishery workers
7  Craft and related trade workers
8  Plant and machine operators and assemblers
9  Elementary occupations
2 Professionals

21 Science and engineering professionals
22 Health professionals
23 Teaching professionals
24 Business and administration professionals
25 Information and communication technology professionals
26 Legal, social, and cultural professionals
2 Professionals

21 Science and engineering professionals

211 Physical and earth science professionals

2111 Physicists and astronomers (59 titles)

- Astronomers
- Astrophysicists
- Medical physicists
- Nuclear physicists
- Biophysicists
- Radioastronomers
- 52 other physics titles

2112 Meteorologists

......
2 Professionals

21 Science and engineering professionals

22 Health professionals

221 Medical doctors

2211 Generalist medical practitioners

2212 Specialist medical practitioners

- Anaesthetists
- Cardiologists
- Nuclear medicine specialists
- Radiation oncologists
- Radiologists
- Surgeons
Medical Physics Worldwide

Medical Physics Organizations

- International
- Regional
- Sub-regional
- National
- Sub-national

IAEA also deals with Medical Physics

Department of Nuclear Sciences and Applications
Division of Human Health
Dosimetry and Medical Radiation Physics Section
IAEA: International organization that promotes the peaceful use of nuclear energy.

Established in 1957 as an independent international organization reporting to the United Nations General Assembly and Security Council.

Headquarters in Vienna, Austria

Member states: 151

The IAEA also promotes the development of medical physics in developing countries.
Department of Nuclear Sciences and Applications
Division of Human Health
Dosimetry and Medical Radiation Physics Section
International Council for Science

International Union for Physical and Engineering Sciences in Medicine

International Union of Pure and Applied Physics
To stimulate and facilitate international cooperation in physics and the worldwide development of science.

International Union of Pure and Applied Chemistry

+ 22 other Scientific Unions
Sponsoring Organizations of the IUPESM:

- International Organization for Medical Physics (IOMP)
- International Federation for Medical and Biological Engineering (IFMBE)
Medical Physics: Science and Profession

Regional, Sub-regional and National Medical Physics Organizations
Medical Physics Worldwide

- International Organization for Medical Physics (IOMP)
  - Formed in 1963
  - Inaugural sponsors: Canada, Sweden, UK, and USA
  - Sponsored by: 80 national medical physics organizations.
  - Representing about 18,500 medical physicists worldwide.
Regional Organizations (4 existing + 2 pending)

- Asia-Oceania Federation of Organizations for Medical Physics (AFOMP) (16 countries)
- European Federation of Organizations for Medical Physics (EFOMP) (38 countries, 5000 members)
- Southeast Asian Federation for Medical Physics (SEAFOMP) (7 countries)
Regional Organizations (cont)

- Latin American Medical Physics Association (ALFIM)
  (13 countries)

- American Association of Physicists in Medicine (AAPM)
  (7000 members)
Regional Organizations (pending)

- Federation of African Medical Physics Organizations (FAMPO) (5 countries)
- Middle East Federation of Organizations for Medical Physics (MEFOMP)
  - Middle East Federation of Organizations of Medical Physics
    - a regional organization member of the International Organization for Medical Physics (IOMP)
  - (12 countries) Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia (SAMPS), Syria, United Arab Emirates, Yemen
Medical Physics Worldwide

Founded in 1980

Current membership: over 5000 belonging to 35 national organizations (27 EU countries + 8 adjacent countries) and 3 affiliated national organizations

Official journal:

European Journal of Medical Physics
Sub-regional Medical Physics Organizations

- Nordic Association of Clinical Physicists (NACP)  
  (5 Nordic countries)
- Alpe – Adria Association for Medical Physics  
  (4 Countries)
- Chapters of the AAPM  
  (20 Chapters)
- Western Canada Medical Physics Association  
  (Western Canadian Provinces)
Medical Physics Journals

- Medical Physics (since 1973)
  - EDITOR: William Hendee

- Physics in Medicine and Biology (since 1956)
  - EDITOR: Steve Webb

- Physica Medica (since 1984)
  - EDITOR: Fridtjof Nusslin
## Medical Physics Organizations in North America (Canada and U.S.)

<table>
<thead>
<tr>
<th>Organization</th>
<th>Year established</th>
<th>Current membership</th>
</tr>
</thead>
<tbody>
<tr>
<td>CANADIAN ORGANIZATION OF MEDICAL PHYSICISTS</td>
<td>1955</td>
<td>540 (70)</td>
</tr>
<tr>
<td>American Association of Physicists in Medicine</td>
<td>1958</td>
<td>7000 (355)</td>
</tr>
<tr>
<td>THE CANADIAN COLLEGE OF PHYSICISTS IN MEDICINE</td>
<td>1979</td>
<td>300</td>
</tr>
<tr>
<td>AMERICAN COLLEGE OF MEDICAL PHYSICISTS</td>
<td>1982</td>
<td>450</td>
</tr>
</tbody>
</table>
OUTLINE

- Professional Aspects of Medical Physics
  - Concentration of Medical Physicists around the World
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  - Medical Physics Organizations
    - Best route to Medical Physics Profession

- Medical Physics in North America (Canada and U.S.)

- Accreditation and Certification

- Teaching and Research

- Conclusions
Best route to medical physics profession

- B.Sc. in physics
- M.Sc. and/or Ph.D. in medical physics from an accredited academic program.
- Residency in a medical physics specialty in an accredited residency program:
  - Diagnostic radiology physics
  - Health physics
  - Nuclear medicine physics
  - Radiation oncology physics
- Certification examination from a national or international certification body.
Professional Aspects of Medical Physics

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Medical Physics in Canada (2010)

- High level of professionalism.
- Strong national medical physics organizations.
- Concentration of medical physics clinical and academic work in larger centers across Canada.
- Access to academic tenure-track positions.
- Strong academic and residency programs in medical physics.

540 members
70 work in the U.S.
Medical Physics in Canada (2010)

Strong ties with the AAPM:

- 355 AAPM members work in Canadian institutions.
- Canadians participate in the AAPM on:
  - Board of Directors
  - Councils
  - Committee
  - Task Groups
- AAPM meetings in Canada in conjunction with the COMP:
  - 1976 Ottawa (18-th)
  - 1992 Calgary (34-th)
  - 2002 Montreal (44-th)
  - 2011 Vancouver (53-rd)

Population ratio Canada / U.S. = 34 mil. / 304 mil. = 0.11
American Association of Physicists in Medicine

Awards (Canada vs. U.S.)

**Farrington Daniels Award** (since 1975)  
14 of 36  
CAN / U.S. = 14 / 22 = 0.64

**Sylvia Sorkin Greenfield Award** (since 1983)  
7 of 28  
CAN / U.S. = 7 / 21 = 0.30

**Coolidge Award** (since 1972)  
4 of 39  
CAN / U.S. = 4 / 35 = 0.12

1976, 1988, 2006, and 2010

CAN / U.S. (expectation value) = 0.11
Profession of MEDICAL PHYSICS

- Work of medical physicists directly or indirectly affects patient safety and well-being.

Therefore:

- Standards for education and professional conduct are set and maintained by various professional and governmental bodies through:
  - Educational Accreditation
  - Professional Certification
  - Professional Licensure
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- Conclusions
Accreditation of Teaching Programs

- Issued to educational institutions (e.g., universities, health care institutions,..) for academic and clinical programs in medical physics.

- Appropriate accreditation bodies issue accreditation certificates, typically for a period of 5 years.
Accreditation of Teaching Programs

Carried out mainly by National Agencies that are sponsored or co-sponsored by Medical Physics organizations

- Institute of Physics and Engineering in Medicine (U.K. and Ireland)
- CAMPEP (U.S. and Canada)
- ACPSEM (Australia and New Zealand)
- European Federation of Organizations for Medical Physics
- Asia-Oceania Federation of Organizations for Medical Physics
Accreditation of:
  Graduate Education Programs
  Residency Education Programs
  Continuing Education Programs

Board of Directors:
  8 members; 2 from each sponsoring organization

Sponsoring Organizations:
  American Association of Physicists in Medicine (AAPM)
  American College of Medical Physics (ACMP)
  American College of Radiology (ACR)
  Canadian College of Physicists in Medicine (CCPM)
**CAMPEP-accredited graduate academic programs**
in Medical Physics

<table>
<thead>
<tr>
<th>Institution</th>
<th>Initial Accreditation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carleton University</td>
<td>2010</td>
</tr>
<tr>
<td>Columbia University</td>
<td>2009</td>
</tr>
<tr>
<td>Duke University Medical Center</td>
<td>2008</td>
</tr>
<tr>
<td>East Carolina University</td>
<td>2006</td>
</tr>
<tr>
<td>Louisiana State University</td>
<td>2006</td>
</tr>
<tr>
<td>McGill University</td>
<td>1993</td>
</tr>
<tr>
<td>University at Buffalo (SUNY) School of Med</td>
<td>2009</td>
</tr>
<tr>
<td>University of Alberta - Cross Cancer Institute</td>
<td>2002</td>
</tr>
<tr>
<td>University of British Columbia</td>
<td>2004</td>
</tr>
<tr>
<td>University of Calgary - Tom Baker Cancer Centre</td>
<td>2005</td>
</tr>
<tr>
<td>University of California - Los Angeles</td>
<td>1994</td>
</tr>
<tr>
<td>University of Chicago</td>
<td>2008</td>
</tr>
<tr>
<td>University of Cincinnati</td>
<td>2009</td>
</tr>
<tr>
<td>University of Florida</td>
<td>2001</td>
</tr>
<tr>
<td>University of Kentucky Medical Center</td>
<td>1998</td>
</tr>
<tr>
<td>University of Manitoba - CancerCare Manitoba</td>
<td>2008</td>
</tr>
<tr>
<td>University of New Mexico</td>
<td>2009</td>
</tr>
<tr>
<td>University of Oklahoma HSC</td>
<td>2005</td>
</tr>
<tr>
<td>University of Texas HSC - Houston</td>
<td>1989</td>
</tr>
<tr>
<td>University of Texas HSC - San Antonio</td>
<td>1997</td>
</tr>
<tr>
<td>University of Toledo Medical Center</td>
<td>2009</td>
</tr>
<tr>
<td>University of Victoria - BC Cancer Agency</td>
<td>2009</td>
</tr>
<tr>
<td>University of Wisconsin</td>
<td>1988</td>
</tr>
<tr>
<td>Vanderbilt University School of Medicine</td>
<td>2003</td>
</tr>
<tr>
<td>Wayne State University</td>
<td>1988</td>
</tr>
</tbody>
</table>

Currently

**25 programs**

18 of 25 in the U.S. (72 %)

7 of 25 in Canada (28 %)

CAN / U.S. = 7 / 18 = 0.39

CAN / U.S. (exp. value) = 0.11
## CAMPEP-accredited residency programs

In Medical Physics

### 39 programs

- **35 in radiotherapy**
- **4 in imaging**

#### Radiotherapy programs

- 27 of 35 in the U.S. (77%)
- 7 of 35 in Canada (20%)
- 1 of 35 in Ireland (3%)

#### Imaging programs

- 3 of 4 in the U.S. (75%)
- 1 of 4 in Canada (25%)

- CAN / U.S. = 8 / 30 = 0.27
- CAN / U.S. (exp. value) = 0.11

### Therapy

<table>
<thead>
<tr>
<th>Institution</th>
<th>Initial Accreditation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CancerCare Manitoba</td>
<td>2009</td>
</tr>
<tr>
<td>Cancer Institute of New Jersey, UMDNJ-Robert Wood Johnson Medical School</td>
<td>2010</td>
</tr>
<tr>
<td>Cross Cancer Institute - University of Alberta</td>
<td>2005</td>
</tr>
<tr>
<td>Duke University Medical Center</td>
<td>2009</td>
</tr>
<tr>
<td>Ireland Radiation Oncology Physics</td>
<td>2009</td>
</tr>
<tr>
<td>Kansas City Cancer Center</td>
<td>2009</td>
</tr>
<tr>
<td>London Regional Cancer Program</td>
<td>2006</td>
</tr>
<tr>
<td>M.D. Anderson Cancer Center Orlando</td>
<td>2008</td>
</tr>
<tr>
<td>Mayo Clinic</td>
<td>2003</td>
</tr>
<tr>
<td>McGill University</td>
<td>2010</td>
</tr>
<tr>
<td>Northwest Medical Physics Center</td>
<td>2009</td>
</tr>
<tr>
<td>Rush University Medical Center</td>
<td>2009</td>
</tr>
<tr>
<td>Scott and White Clinic</td>
<td>2009</td>
</tr>
<tr>
<td>Stanford University</td>
<td>2007</td>
</tr>
<tr>
<td>Stony Brook University Medical Center</td>
<td>2009</td>
</tr>
<tr>
<td>The Ottawa Hospital Cancer Center</td>
<td>2007</td>
</tr>
<tr>
<td>Thomas Jefferson University Hospital-Bodine Center for Cancer Treatment</td>
<td>2008</td>
</tr>
<tr>
<td>University of California - Irvine Medical Ctr</td>
<td>2008</td>
</tr>
<tr>
<td>University of California at San Francisco</td>
<td>2009</td>
</tr>
<tr>
<td>University of Chicago Medical Center</td>
<td>2004</td>
</tr>
<tr>
<td>University of Florida</td>
<td>2000</td>
</tr>
<tr>
<td>University of Iowa</td>
<td>2007</td>
</tr>
<tr>
<td>University of Louisville School of Medicine</td>
<td>2003</td>
</tr>
<tr>
<td>University of Michigan</td>
<td>2009</td>
</tr>
<tr>
<td>University of Minnesota Medical School</td>
<td>2000</td>
</tr>
<tr>
<td>University of Nebraska Medical Center</td>
<td>2008</td>
</tr>
<tr>
<td>University of Pennsylvania</td>
<td>2009</td>
</tr>
<tr>
<td>University of Texas M.D. Anderson Cancer Center</td>
<td>2006</td>
</tr>
<tr>
<td>University of Texas Southwestern Medical Center</td>
<td>2009</td>
</tr>
<tr>
<td>University of Toronto</td>
<td>2008</td>
</tr>
<tr>
<td>University of Virginia</td>
<td>2010</td>
</tr>
<tr>
<td>University of Wisconsin</td>
<td>2004</td>
</tr>
<tr>
<td>Virginia Commonwealth University</td>
<td>2007</td>
</tr>
<tr>
<td>Washington University School of Medicine</td>
<td>1997</td>
</tr>
</tbody>
</table>

### Imaging

- Cross Cancer Institute - University of Alberta                            | 2005                  |
- Henry Ford Health System                                                  | 2009                  |
- Stony Brook University Medical Center                                     | 2009                  |
- University of Texas M.D. Anderson Cancer Center                           | 2002                  |
Professional Aspects of Medical Physics

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Medical Physics in North America (Canada and U.S.)

Accreditation and Certification

Teaching and Research

Conclusions
CERTIFICATION IN MEDICAL PHYSICS

- Run by national medical physics organization either alone or in collaboration with a medical organization.
- Attests that the candidate is able to competently execute a job or task covered by the certification.
- Attained through a rigorous examination process.
- Does NOT confer legal right to practice.
CERTIFICATION in MEDICAL PHYSICS

Carried out by national medical physics organization either alone or in collaboration with a medical organization.

International Board of Medical Physics (IBMP)?

EUROPEAN BOARD OF MEDICAL PHYSICS?
Certification of Medical Physicists in Canada

- National certification board run for medical physicists by medical physicists (CCPM)
- Rigorous certification examination process.
- Levels of certification:
  - Basic level: Membership MCCPM
  - Advanced level: Fellowship FCCPM
- Maintenance of certification (MOC) process.
- Continuing Professional Education (CPE) and Continuing Professional Development (CPD).
- CCPM sponsors CAMPEP
Current number of CCPM Members and Fellows: over 300

**Great Grandfathers** (6)
- S.O. Fedoruk
- A.F. Holloway
- H.E. Johns
- J.C.F. MacDonald
- R.M. Mathieu
- M.E.J. Young

**Fellows** (20)
(Grandfathered)

**Primary Fellows** (15)
(written and oral exam)

**Current rules:**
(Membership and Fellowship exam)
Two categories of certification: **Membership and Fellowship**

- **Membership (MCCPM)**
  
  - Graduate degree (Medical Physics, Physics, Science ....)
  - Minimum of 2 years of clinical experience.
  - 3 letters of reference (2 from medical physicists, 1 from physician)
  - Written and oral examination.
Two categories of certification: **Membership** and **Fellowship**

**Fellowship (FCCPM)**

- CCPM Membership certification
- Significant contributions in clinical service, education, and research related to medical physics.
- Minimum of 7 full time equivalent years of experience in medical physics.
- 3 letters of reference (2 from medical physicists, 1 from physician)
- Oral examination.
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Conclusions
Modes of Education

Education

- Instruction
- Teaching

Good instruction transmits knowledge and produces competent technicians.

Good teaching provides understanding and produces competent professionals.
Teaching of Medical Physics:

- Should go beyond instruction.
- The teacher should not just convey a collection of facts but must also explain to reasonable detail and depth the physics behind the facts.
Characteristics of Good Teaching

- Talent and motivation for teaching.
- Knowledge of subject and of what to teach.
- Ability
  - to communicate.
  - to make material interesting and relevant.
- Receptive audience.
- Mutual respect between student and teacher.
- Discipline.
Education in Medical Physics

Good teaching is:

- **Very important** for the advancement of society in general.
- **Extremely important** for the profession of Medical Physics.
- **Difficult to define** because it means different things to different people.
Education in Medical Physics

Teacher should be a practicing medical physicist with:

- Solid knowledge of subject material.
- Solid knowledge of underlying physics.
- Ability to express enthusiasm for physics.
- Ability to convey understanding of physics in a clear manner.
Education in Medical Physics

Medical Physicist as Teacher / Educator

- Graduate students in Medical Physics
- Residents in Medical Physics
  - Residents in Radiation Oncology Physics
  - Residents in Imaging Physics
- Medical Residents
  - Residents in Radiation Oncology
  - Residents in Diagnostic radiology
  - Residents in Nuclear Medicine
- Technology students
  - Radiotherapy Technology students
  - Imaging Technology students
- Radiation Dosimetry students
Education in Medical Physics

- Medical Physicists (didactic and clinical teaching)
- Medical Residents in Imaging and Radiotherapy
- Medical Technologists
- Medical Dosimetrists

Course descriptions for the four groups are similar in breadth but differ in depth to which the material is covered.
## Education in Medical Physics

<table>
<thead>
<tr>
<th>Graduate Student</th>
<th>Physics Resident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to teach in a larger group.</td>
<td>Needs more attention, coaching and supervision.</td>
</tr>
<tr>
<td>6 - 12 students per program.</td>
<td>2 - 4 residents in accredited program.</td>
</tr>
<tr>
<td>Graduate student stipend</td>
<td>“Costs” more than graduate student.</td>
</tr>
<tr>
<td>In the second year can help with QA.</td>
<td>Close to graduation can work independently.</td>
</tr>
</tbody>
</table>
Expected outcome for Medical Residents

Medical Physics teaching should:

- Make students understand that:
  - To attain excellence in their profession they must know a fair amount of physics and engineering.
  - The driving force behind technological advances in their field are medical physics and technological development.

- Provide the students with sufficient knowledge in physics and technology, so that they can pass their specialty exams and function independently in their profession.

- Make students appreciate medical physics as a profession and science specialty.

- Show the relevance of physics to clinical practice.
Didactic component (graduate program) should:

- Provide the students with in-depth theoretical knowledge of medical physics:
  - Covering all major areas of medical physics (radiation oncology, diagnostic radiology, nuclear medicine, health physics).
  - Including understanding of the underlying physics.

- Instill in students:
  - Appreciation of medical physics as profession and science.
  - Discipline and ethics in professional conduct.
  - Compassion for patients.
Expected outcome for Medical Physicists

Clinical component (residency) should:

- Provide students with practical clinical physics experience in all aspects of chosen specialty:
  - To allow them to work independently.
  - To pass the specialty examination.

- Reinforce in students:
  - Appreciation of medical physics as profession and science.
  - Discipline and ethics in professional conduct.
  - Compassion for patients.
What are students expected to know?

Recommendations in the form of:

- Syllabi provided by various organizations.
- Institution-based syllabi.
- Accreditation requirements by accreditation boards.
- Recommendations from certification boards.
- Requirements by government radiation safety agencies.
What are students expected to know?

Teaching syllabi for education and training of medical physicists are readily available from the AAPM:

**Didactic component**
AAPM Report 197

**Clinical component**
AAPM Report 90
What are students expected to know?

Recommendations in the form of syllabus:

- American Association of Physicists in Medicine (AAPM).
  Education Council: Task Group reports

- International Organization for Medical Physics (IOMP)
  Education and Training committee

- International Atomic Energy Agency (IAEA).
  Teaching Syllabi and slide series

- Australian College of Physical Scientists and Engineers in Medicine (ACPSEM).

- Institute of Physics and Engineering in Medicine (IPEM).
What are students expected to know?

Motivation for following appropriate syllabus:

- To achieve Accreditation by Accreditation Board.
- To attain Certification by Certification Board.
- To fulfill Requirements by Radiation Protection Agencies.
There are no shortcuts to education.

- Hard work and steady work from both the student and the teacher are essential.
- Progress is slow and painstaking; rewards are large.
- Success of students depends strongly on the quality of teaching but good teaching is difficult to define.
- Computers and virtual web-based teaching enhance the learning experience but should not be considered a replacement for traditional “good teaching”.
- The creation of a good class requires an immense amount of work and discipline from both the teacher and the student.
OUTLINE

- Professional Aspects of Medical Physics
  - Concentration of Medical Physicists around the World
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  - Medical Physics Organizations
  - Best route to Medical Physics Profession

- Medical Physics in North America (Canada and U.S.)

- Accreditation and Certification

- Teaching and Research

- Conclusions
Medical Physics Research

Research in medical physics is characterized as:

- Applied
- Translational
- Multidisciplinary
- Incremental
Medical Physics Research in Canada

During 1960s and 1970s

Princess Margaret Hospital (PMH), Toronto

- Installation of high energy linac (Clinac 35).
- Development of treatment planning software.
- TBI and HBI.
- Use of CT in treatment planning.
- Study of radiation pneumonitis.
- Development of remote afterloader for brachytherapy.
- Development of cobalt unit dedicated for TBI.
Princess Margaret Hospital
Ontario Cancer Institute
Toronto
500 Sherbourne St.

(1958 – 1995)

Harold Johns
Jack Cunningham
Bill Rider
Ray Busch
Derek Jenkin
John Simpson
Harold E. Johns (1915 – 1997)

H.E. Johns and J.R. Cunningham “The Physics of Radiology”

Harold E. Johns:
Inducted into Canadian Medical Hall of Fame in 1998

Canada Post: 1988
Cobalt-60 teletherapy machine
Canada’s gift to the world

Table HCT-1. First cobalt-60 treatments in the world, 1951

<table>
<thead>
<tr>
<th></th>
<th>Saskatchewan</th>
<th>W. Ontario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt-60 source delivered</td>
<td>July 30</td>
<td>October 16</td>
</tr>
<tr>
<td>Unit installed</td>
<td>August 17</td>
<td>October 23</td>
</tr>
<tr>
<td>Calibration</td>
<td>11 weeks</td>
<td>—</td>
</tr>
<tr>
<td>First patient treated</td>
<td>November 8</td>
<td>October 27</td>
</tr>
</tbody>
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1980 - watershed year in Canadian Medical Physics:

- Harold E. Johns retired.
- Canadian College of Physicists in Medicine (CCPM) formed.
- Several clinical centers around Canada established or reorganized through rejuvenation or expansion.
- Several new graduate programs in medical physics opened.
- X-ray division of the National Research Council (NRC) expanded and reorganized.
Medical Physics Research in Canada

During 1980s

- Medical Physics research spread out from the PMH to many other provincial centers across Canada:
  - Vancouver, Edmonton, Calgary, Winnipeg, London,
  - Toronto Sunnybrook, Montréal, Québec, Halifax

- Imaging research became strong in many institutions:
  - Reichman Research Institute in Toronto Sunnybrook Hospital
  - Robarts Research Institute in London
At the end of 1980s many senior medical physicists in U.S. and Canada believed that radiotherapy physics was a completed discipline with exhausted research opportunities.

Imaging was the place to be in medical physics.
In 1990s research in radiotherapy physics exploded, mainly because of rapid advances in:

- Treatment planning
- Technology of dose delivery
- Imaging for radiotherapy

**NEW EQUIPMENT**

- CT-simulator
- MR simulator
- Tomotherapy
- CyberKnife
- Hadron therapy

**NEW TECHNIQUES**

- Stereotactic radiosurgery (cranial and extracranial)
- Conformal radiotherapy
- Intensity modulated radiotherapy (IMRT)
- Intensity modulated arc therapy (IMAT)
- Image guided radiotherapy (IGRT)
- Adaptive radiotherapy (ART)
- Respiration gated radiotherapy (RGRT)
Radiotherapy Physics Research: Example 1

Linac target and flattening filter study

Princess Margaret Hospital

Toronto
Princess Margaret Hospital, Toronto

Megavoltage radiotherapy in early 1970s:

- **Cobalt machine**
  Manufactured by Atomic Energy of Canada, Ltd (AECL), Ottawa

- **Betatron**
  Installed during 1960s
  Manufactured by Allis-Chalmers, Milwaukee, WI
  Operated at 25 MV

- **Linac**
  Installed in 1972
  Manufactured by Varian, Palo Alto (Model Clinac-35)
  Operated at 25 MV
Linac versus betatron at 25 MV

Main characteristics:

Output
- Betatron: up to 50 cGy/min
- Linac: up to 1000 cGy/min

Isocentric configuration
- Betatron: only partial beam rotation
- Linac: full gantry rotation

Electron beam energy striking the target: 25 MeV

Assumptions:
- Same photon spectrum produced in both machines
- Same penetration into tissue achieved with both machines
Percentage depth dose: Betatron versus Linac

The diagram shows the percentage depth dose for different energies and modes of radiation therapy equipment.

- **Betatron 25 MV**
- **Linac 25 MV**
- **Betatron 16 MV**

**Parameters:**
- **10 x 10 cm²**
- **SSD = 100 cm**
Central axis percentage depth doses in water

Pb target / Pb flattening filter compared to Al target / Al flattening filter
Central axis percentage depth doses

Betatron: 25 MV (solid curve) compared to Linac: 25 MV (data points)
Radiotherapy Physics Research: Example 2

Dynamic Stereotactic Radiosurgery

Montreal General Hospital
Simultaneous couch and gantry rotation (Varian 2010)
Issues in contemporary medical physics

- Is a Ph.D. necessary for a career in medical physics?
  
  Yes, for an academic career.
  
  No, for work as clinical physicist.
Issues in contemporary medical physics

Does our profession need:

- Undergraduate degrees in Medical Physics?
- Physics assistants?
- Professional Doctorates in Medical Physics?
Issues in contemporary medical physics

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OUTLINE

- Professional Aspects of Medical Physics
  - Concentration of Medical Physicists around the World
  - Recognition of Medical Physics as Profession
  - Medical Physics Organizations
  - Best route to Medical Physics Profession

- Medical Physics in North America (Canada and U.S.)

- Accreditation and Certification

- Teaching and Research

- Conclusions
Conclusions: Medical Physics

Science

Applied
Translational
Multidisciplinary
Incremental

Profession

Started soon after Röntgen’s discovery of x rays
Has been recognized by the ILO since 2008.
Accepted as modern applied branch of physics.
Conclusions: Medical Physics

Concentration of Medical Physicists:

- World: ~18,000
- World average: ~2.7/million population
- Developed countries: ~15/million population
- Many undeveloped countries: 0
Medical Physics in North America is in excellent shape but is affected to a certain degree by health care financing model in the U.S. and Canada.

Teaching and accreditation are organized well.

Certification has been available for many years but rules are still under development.

Number of residency positions is much too small for actual needs.
High Technology plays an important role in medical physics.

Imaging physics and radiotherapy physics converge.

Imaging plays an increasingly more important role in radiotherapy:

PET scanner       Cone Beam CT       Tomotherapy       CyberKnife

In contrast to standard anatomical imaging which relies on changes in tissue density, atomic number, or water content, molecular functional imaging promises non-invasive methods for cellular imaging using biomarkers.

Close collaboration of medical physicists with radiation oncologists is of utmost importance.
Current Trends in Medical Physics

- High Technology:
  - PET/MR hybrid machine.
  - MR simulator.
  - MR machine integrated with cobalt-60 machine.
  - MR machine integrated with linac.
  - Compact proton accelerator in linac bunker.

- Convergence of radiotherapy and imaging.
- Monte Carlo Treatment Planning.
- Definition of Biological Target.
Medical Physics is growing in importance both as a profession and as science, driven by the technological developments of societies in general and medicine in particular.
Medical Physics around the world

- Medical Physics teaching programs (both academic and clinical) have difficulties meeting the demand for well educated medical physicists.
- Research is very important for advancement of medical physics as a profession and science.
Health Care

The most important characteristics of a health care system are:

Quality - Cost - Access
“A healthy man has a thousand wishes, a sick man has only one”.

Slovenian proverb