**Module MPE02: Radiation biology for medical physicists in radiology**

**ABSTRACT**

**Title: Radiation biology for medical physicists in radiology**

**Module Code: MPE02**

**Module Level:** EQF level 8

**Aims:** This course will provide a thorough understanding of the biological response of humans to radiation exposure as well as the radiobiological basis for estimating subsequent risks. This will provide sound background information from which the MPE will be able to provide advice on the safety of planned and unplanned exposures to patients, staff, and the public from radiological procedures. The daily routine is full of exceptional cases, and it is essential that the MPE can contribute from the basis of a deeper knowledge of the risks to individuals than is provided by routine radiation protection training.

**Learning Outcomes:** At the end of the module the participants will be able to:

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| MPE02.01 | Provide advice on the risks to individual patients from planned and unplanned exposures to ionizing radiation |
| MPE02.02 | Provide counselling to patients who have been exposed ionizing radiation |
| MPE02.03 | Provide advice on the optimization of medical exposures so as to minimize the risk to the patient |
| MPE02.04 | Provide advice on the occupational risks from the use of ionizing radiation in interventional procedures |
| MPE02.05 | Participate as part of a multidisciplinary team planning research into the risks from exposures to ionizing radiation |
| MPE02.06 | Provide training to medical staff on the radiobiological basis of the risks from the use of ionizing radiation |

**Date and Location of Face-to-Face Component**:
April or May 2015, Pavia

**Module Leaders:**

Prof. Andrea Ottolenghi
Curriculum Vitae

**Faculty:**
**Prof. K.R.Trott, Dr. O Nuta, Dr. R. Padovani, Dr. G. Babini, Dr. G Baiocco and others to be confirmed**

**Delivery of the module:** Combination offline/online.

**Total participant effort time:** 80 hours

**Assessment Mode**: written examination 180 minutes after face to face programme

| MODULE DATA | |
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| **Module Homepage** | www.eutempe-rx.eu |
| **Module Code** | MPE02 |
| **Module Leader/s**<br><br>Please limit CV to a max of 250 words and to what is relevant to this particular module. | Prof. Andrea Ottolenghi<br><br>Doctor in Physics (laurea cum laude), Specialization in Medical Physics (cum laude)<br>Academic positions:<br>- 1992-2001 researcher at the University of Milano, Faculty of Medicine, member of the Physics Department.<br>- since 2001 Professor of Physics and of Radiobiology at the University of Pavia, member of the Department of Physics.<br><br>Teaching activity: courses of Physics and of Radiobiology at the Faculty of Medicine; courses of Radiation Biophysics and Radiobiology at the Faculty of Science; course of Radiobiology for the Physics Doctorate and for the specialisation in Medical Physics (for physicists), and in Radiology and in Radiation Therapy (for medical doctors). Member of the Faculty committee of the Physics Doctorate (previously at Milan University and now at Pavia University); Until 2009, Deputy Director of the School of Medical Physics of Milan, jointly managed by the Universities of Milan, Pavia and Varese. Supervisor of several thesis for the Physics “laurea” and doctorate, and for the specialization in Medical Physics.<br>The research activity of Andrea Ottolenghi on radiation effects have been on the development of models and simulations, experiment designs and data analysis, relative to: radionuclide transport in atmosphere after nuclear explosions and accidents; dose estimates in organs using compartment analysis, short- and long-term effects on humans; cell growth, inactivation, transformation and chromosomal aberrations after in vitro irradiation, and their dependence on radiation characteristics, dose rate etc.; radiation induced DNA damage and repair processes (and relevance in inducing biological end-points); bystander effects; radiation track structure and transport codes (with the integration of radiobiological models); shielding effects using anthropomorphic phantoms; optimisation studies for radiotherapy, with photons and hadrons. He has published more than 150 peer-reviewed papers on these topics. He has organised national and international workshops and symposia on these topics. He is peer-reviewer for the most important international Journals of this scientific area.<br><br>Andrea Ottolenghi<br>Dipartimento di Fisica<br>Università degli Studi di Pavia<br>Via Bassi 6<br>I-27100 Pavia, Italy<br>e.mail Andrea.Ottolenghi@pv.infn.it |

<table>
<tr><td>Teaching Staff<br><br>Teaching staff should be either recognised MPEs or in possession of a PhD. If not please contact the Secretary of the QAC.</td><td colspan="3">A. Ottolenghi<br>K. Trott<br>O. Nuta<br>R. Padovani<br>G. Babini<br>G. Baiocco and others to be confirmed</td></tr>
<tr><td rowspan="2">Candidate Assessment<br>(all assessments open book)</td><td colspan="2">Written Assessment (open book):</td><td>Assignment of 4 half-page essays on 4 radiation risk topics using radiobiological reasoning</td></tr>
<tr><td colspan="2">Practical Assessment (open book):</td><td>None</td></tr>
<tr><td rowspan="2">Module Duration<br><br>The TOTAL number of hours of participant effort should be about 80. (including lectures, reading of assigned compulsory texts, participation in online fora etc)</td><td>Online phase<br><br>Asynchronous methods should be used whenever possible so that participants would not need to take time off their clinical duties and there will not be a problem with time zones. However synchronous methods (evenings or weekends only) should be used when crucial.</td><td colspan="2">60 hours the online phase is primarily based on self-learning by reading recommended book chapters (free download) and papers one each on the 10 topics listed below (supplied as pdf files). Altogether 30 questions will be sent out which should be answered in free text (about ½ page each, 3 to every topic). Since students come with very different levels of knowledge of biology and medicine, self-learning using well selected texts appears more suitable than recorded lectures.<br><br>Two weeks before the face to face module, participants will receive 10 papers, one for each topic, which discuss those practical problems of radiation risks which will be in the focus of the face to face discussions All this will be asynchronous. No video lectures are envisaged, however, students are encouraged to contact the teacher responsible for teaching particular topics to ask questions. All questions and responses will be made available to all participants unless the student requests otherwise.</td></tr>
<tr><td>Face-to-face phase<br><br>Must include 1 day for revision and 1 day for the assessment proper.</td><td colspan="2">30 hours, 3 hours revision of what the student should have learnt in the on-line phase followed by, 20 hours discussion with the whole group of 6 issues of practical radiation protection based on realistic scenarios, 3 – 4 hours each, 1 day written assessment, discussion of assessment questions in group and individual oral examination (depending of the number of participants)</td></tr>
<tr><td>Date and location of Face-to-Face</td><td colspan="3">April or May 2015, Pavia</td></tr>
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| **Date of Assessment**<br>Normally last day of face-to-face phase. | April or May 2015, Pavia | |
| **Breakdown of participant effort time** | **Module Component** | **Estimated Time** |
| | Online tutorials, for all | 10 hours |
| | Online compulsory reading | 50 hours |
| | Face-to-face tutorials, fora | 20 hours |
| | Face-to-face technical demonstrations | 0 hours |
| | Face-to-face laboratory/clinical exercises | 0 hours |
| | **Total participant effort time** | 80 hours |
| | **Free day for exam preparation day (same for all modules)** | **1 day** |
| | **1 day for assessment (same for all modules)** | **1 day** |

| PRE-REQUISITES FOR THE MODULE | |
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| **Minimum entry qualifications, training and years of experience for *all* modules**<br><br>Same for all modules | EQF Level 6 in Physics (BSc Physics or equivalent) or<br>EQF Level 7 in Medical Physics (MSc Medical Physics or equivalent) or<br>2 year equivalent clinical training in D&IR for clinical Medical Physicists or<br>2 year equivalent Industry/Radiation Authority experience for Industry/Radiation Authority personnel. Or |
| **Assumed previous KSC for *all* modules from the 'Inventory of Learning Outcomes for the MPE in Europe' (Annex I of the 'European Guidelines on the MPE')**<br><br>Same for all modules | GENERIC SKILLS : Generic Skills Required at EQF level 7<br>KSC FOR THE MPE AS PHYSICAL SCIENTIST: All Knowledge learning outcomes to EQF level 7<br>KSC FOR THE MPE AS A HEALTHCARE PROFESSIONAL: All Knowledge learning outcomes to EQF level 7<br>KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION: All Knowledge learning outcomes to EQF level 7<br>KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY: All Knowledge learning outcomes to EQF level 7<br>The Skills and Competences included in the IAEA document 'Clinical Training of Medical Physicists Specializing in Diagnostic Radiology' (IAEA Training Course Series, 47, 2010) to EQF level 7. |
| **Pre-requisite EUTEMPE-RX online summary modules for *all* modules**<br><br>Same for all modules | |
| **Additional pre-requisite EUTEMPE-RX online summary modules for *this* module**<br><br>Different for each module. | |

This EUTEMPE-RX module will provide the MPE with good understanding of the response of the human organism to ionizing radiation. Some basic knowledge of initial molecular damage to DNA, chromosomes and cells will be communicated however the main emphasis is on late tissue responses including cancer, non-cancer late effects, heritable effects and in utero effects. This will take the participant beyond the standard population-based approach used for setting safety limits by the ICRP and enable the assessment of the risks and expected outcomes from specific types of exposure to individual patients. The participant will learn both the current state of knowledge in the area and the research basis from which the knowledge comes.

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| MPE02.01 | evaluate and discuss the risks to individual patients from planned and unplanned exposures to ionizing radiation |
| MPE02.02 | Provide counselling to patients who have been exposed ionizing radiation |
| MPE02.03 | research optimization of medical exposures so as to minimize the various and often competing risks to the patient |
| MPE02.04 | Provide advice on the occupational risks from the use of ionizing radiation in interventional procedures |
| MPE02.05 | Participate as part of a multidisciplinary team planning research into the risks from exposures to ionizing radiation |
| MPE02.06 | Provide training to medical staff on the radiobiological basis of the risks from medical uses of ionizing radiation |

| MODULE CONTENT: TARGET KSC TO BE DEVELOPED TO EQF LEVEL 8<br>From the 'Inventory of Learning Outcomes for the MPE in Europe' (Annex I of the 'European Guidelines on the MPE') | |
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| **KSC targeted in *all* modules**<br><br>These learning outcomes are common to and permeate *all* modules, although to a varying degree according to the topic of the module. | GENERIC SKILLS : All 'Generic Skills Required at EQF level 8'<br><br>KSC FOR THE MPE AS PHYSICAL SCIENTIST: All Skills and Competences to EQF level 8<br><br>KSC FOR THE MPE AS A HEALTHCARE PROFESSIONAL: All Skills and Competences to EQF level 8<br><br>KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION (AND OTHER PHYSICAL AGENTS AS APPROPRIATE): All KSC for Scientific Problem Solving Service to EQF level 8<br><br>KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY: All KSC for Scientific Problem Solving Service to EQF level 8 |
| ***PRIMARY KSC* targeted in *this* module**<br><br>These are the KSC which would be developed to Level 8 during this module. These should be mostly Skills and Competences. However, Knowledge learning outcomes should also be included when the knowledge normally acquired during Level 7 programmes is insufficient for the development of the skills and competences to level 8.<br><br>The KSC codes from the 'European Guidelines on the MPE' should be inserted for easy reference. | **KSC FOR THE MPE AS A HEALTHCARE PROFESSIONAL**<br><br>K13. Discuss the principles of epidemiology.<br>K14. Discuss the principles and processes of quantitative and qualitative research involving human subjects. (?)<br><br>**KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION (AND OTHER PHYSICAL AGENTS AS APPROPRIATE)**<br><br>**Scientific problem solving service**<br>**Dosimetry measurements**<br>**Patient safety/risk management**<br>K31. discuss the radiation dosimetry quantities used in patient risk assessment and their use in the radiation protection of patients.<br>S14. Calculate patient risk from measurement data of the dosimetry quantities used to assess adverse biological effects for the various types of ionizing radiations.<br>S15. Assess patient risks from given procedures in own area of medical physics practice from measured patient dose data and dose-effect relationships.<br>S23. Assess patient risks for a given experimental procedure.<br>C24. Manage accidental/unintended exposures<br><br>**Occupational & public safety/risk management**<br>S28. Assess occupational risks for a given experimental procedure.<br><br>**KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY**<br>**Patient safety/ dose optimisation** |

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| | K55. Explain radiobiological dose-effect relationships relevant to Diagnostic and Interventional Radiology with respect to patient safety including discussion of the physical and biological background, response of tissues to radiation on molecular, cellular and macroscopic level, models of radiation induced cancer and hereditary risks and radiation effects on humans in general, children and the conceptus.<br>S18. Use radiobiological dose-effect relationships relevant to Diagnostic and Interventional Radiology to estimate patient risks (including adverse incidents involving high exposures).<br><br>**Occupational & public safety/ dose optimisation**<br>K71. Explain radiobiological dose-effect relationships relevant to Diagnostic and Interventional Radiology with respect to occupational/public safety including discussion of the physical and biological background, response of tissues to radiation on molecular, cellular and macroscopic level, models of radiation induced cancer and hereditary risks and radiation effects on humans in general, children and the conceptus.<br>S22. Use radiobiological dose-effect relationships relevant to Diagnostic and Interventional Radiology to estimate occupational/public. |
| ***SECONDARY KSC* targeted in *this* module**<br>(EQF Level 8)<br><br>These are the KSC that are included in the module but would be given less attention owing to time constraints.<br><br>Please insert the KSC code from the 'European Guidelines on the MPE' project KSC Inventory. | **KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION (AND OTHER PHYSICAL AGENTS AS APPROPRIATE)**<br>Under consideration<br><br>**KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY**<br>Under consideration |
| ***NEW KSC* which are NOT** INCLUDED in the 'Inventory of Learning Outcomes for the MPE in Europe'. | **KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION (AND OTHER PHYSICAL AGENTS AS APPROPRIATE)**<br><br>Proposed amendments to existing KSCs:<br>**Scientific problem solving service**<br>K4new. Explain quantitatively the adverse biological effects of ionizing radiations and the various physical agents associated with medical devices, the factors influencing the magnitude and the severity of the health effect and the way these can be manipulated to improve clinical outcomes. In the case of ionizing radiation this would include radiobiological models, radiation epidemiology, mutagenesis, carcinogenesis (including leukaemogenesis), genetic effects on offspring from irradiation of gametes, developmental injury on the conceptus, early and late skin injury, cataracts and other eye effects, cardiovascular effects, neurocognitive effects, immunological effects, chromosomal damage, the dependence of cell survival on absorbed dose, type of radiation, dose rate etc. The importance of dose inhomogeneity and how to consider this in risk estimation will be of particular emphasis<br>K5new. Critically explain the application of the terms deterministic/stochastic, early/late and teratogenic/genetic effects in relation to radiation |

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| | exposure.<br>S6new. Design quantitative clinical and biomedical studies based on rigorous statistical design and proper biolmedical endpoints and severity criteria.<br><br>**Dosimetry measurements**<br>K13new. Explain the principles of biological monitoring / dosimetry. Perform proper anatomical dose distributions and present data in biologically meaningful way<br><br>**Patient safety/risk management**<br>K19new. Critically discuss the difference between deterministic and stochastic, early and late and developmental and genetic effects of ionizing radiations in relation to patient risk.<br>S18new. Calculate risks to the unborn child in the case of exposure of pregnant women to ionizing radiations.<br><br>**Occupational & public safety/risk management**<br>K36new. Describe the possible adverse biological effects (including mechanism) to workers / public from ionizing radiations (and other physical agents if approp) including the factors impacting the magnitude and severity of the biological effects.<br>S25new. Assess occupational risk from medical procedures and practice from ionizing radiations using measured occupational dose data and dose-effect relationships. |

| OUTLINE TEACHING PLAN | |
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| **Online phase** | **1.** Topic: Basic radiation biology and physics (e.g. radiation effects on DNA, chromosomes and cells)<br>**2.** Topic: Human radiation genetics<br>**3.** Topic: Radiation effects on the developing embryo and fetus<br>**4.** Topic: Radiation-induced cancer: mechanisms and epidemiology<br>**5.** Topic: Radiation-induced cancers after medical radiation exposures<br>**6.** Topic: Cardiovascular radiation effects<br>**7.** Topic: Radiation effects in the brain and the eyes<br>**8.** Topic: Important effect modifications: dose fractionation, dose rate, time, age at exposure, attained age<br>**9.** Topic: Dose specification and risk estimation in situations of very inhomogeneous dose distribution |
| **Face-to- Face Phase** | Time table face-to-face session<br>Monday: Morning: Introduction: outline of the course<br>Basic radiation biology revision<br>Afternoon: Medical manifestations of radiation-induced health disorders<br>Tuesday: Morning: Radiation-induced cancer risk<br>Afternoon: Risk of radiation-induced heritable disease<br>Wednesday Morning: Radiation effects from exposure in utero<br>Afternoon: Management of radiation accidents<br>Thursday Morning: Occupational radiation risks<br>Afternoon: Cardiovascular and other non-cancer risks from low-dose radiation exposures<br>Friday All day: Self-study and preparation for examination<br>Afternoon: 2 h free discussions with lecturers<br>Saturday Morning: Written examination<br>Afternoon: Discussion of examination questions |

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| | These topics will be discussed using scenarios such as:<br>1. A young woman of 35 years is diagnosed with breast cancer. As a girl of 10 years she had several CT examinations of the thorax for suspected cardiac disorders. What to do? What is the probability that this cancer was induced by the CT radiation?<br>2. After an accident, a young man of 20 years had 6 CT examinations over a period of 10 years. He is about to get married and wants to have children. What to do, which radiation-induced health problems will he and his offspring face?<br>3. A young woman has lower back pain for unclear reasons and receives several pelvic X-rays and 2 CT examinations, over a period of six weeks. She then realizes that she is pregnant. What to do?<br>4. A young woman (radiology technician) is delivered to the A&E department, in severe distress and vomiting. She says that she was in the LINAC room setting up a patient and did not realize that the LINAC was switched on. What to do?<br>5. An old cardiologist is found to have exceeded the old dose limits but feels fine. At which is he?<br>6. In a follow-up examination, a young woman of 40 who had been treated at the age of 14 for Hodgkin`s disease is diagnosed with valvular heart disease. What to do?<br><br>And more of this type |