RCSI FACULTY OF RADIOLOGISTS

Faculty of Radiologists
Diagnostic Radiology Curriculum

Authors:
Dr Paul Foran
Dr Kevin Cronin
Dr Barry Hutchinson
Dr Niall Sheehy

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The curriculum (Version 2.0 Autumn 2020) was reformatted to mirror the present format of the Royal College of Radiologists (RCR) curriculum whilst using the 2016 ESR curriculum to identify learning outcomes in physics.

An updated list of mandatory courses was added to the curriculum.

A table mapping the generic professional capabilities of the Faculty of Radiologists training programme to the Medical Council's Domains of Good Professional Practice was added to section
10.

Section 14 was updated to reflect the current summative and formative assessment methods used in the Faculty of Radiologists training programme.

Section 15 was updated to detail the progression criteria currently used by Faculty of Radiologists training programme for SpRs who passed the Primary Examination in Radiology, in or after May 2016.

1. Introduction: Diagnostic Radiology Curriculum

a. The Diagnostic Radiology curriculum provides a structure for radiology training from entry to the training scheme through to Certification of Satisfactory Completion of Specialist Training (CSCST). It lays down the standards of specialty-based knowledge, clinical judgement, procedural skills and professional skills and behaviour, which must be acquired and the expected levels of progress during training.

b. Diagnostic Radiology is the use of imaging to diagnose, treat and monitor various disease processes. Patients are referred to radiologists for assistance in both diagnosis and deciding on the best management of a patient's condition. Radiologists are trained to use and interpret diagnostic imaging methods including radiographs (X-rays), ultrasound, computed tomography (CT), Nuclear Medicine Imaging techniques (NM), magnetic resonance imaging (MRI), positron emission tomography (PET) and hybrid forms (e.g. PET/CT).

c. Radiologists are medical doctors and use this medical training combined with their radiology training to guide the referring clinician to the most appropriate investigation, taking into account side-effects, safety and the clinical relevance of specific tests. The radiologist interprets the findings from this investigation, allowing diagnosis and appropriate treatment, and also recommends any additional tests required.

d. Radiologists are trained in image-guided procedures such as fluoroscopy, as well as performing biopsies and inserting tubes and drains. Some radiologists specialise further in interventional radiology, using image-guided techniques for diagnostic and therapeutic purposes.

e. Radiologists are trained in the use of radiopharmaceuticals for diagnostic purposes. Some radiologists specialise in the therapeutic use of radionuclides.

f. Radiologists work in a variety of settings from general roles in small acute hospitals to providing specialised services in tertiary centres. The curriculum aims to produce radiologists who are appropriately trained but also flexible and adaptable enough to fit into this wide range of roles.

2. Purpose of this document

a. The diagnostic radiology curriculum is in a continuous state of development as patient, population, professional, workforce and service needs evolve.

b. This document aims to summarise the specific skills that are required by a radiologist and to document the steps that trainees must complete to achieve a CSCST in this specialty.

c. The curriculum has four broad areas
   i. Teaching and learning - how the content is communicated and developed, including the methods by which trainees are supervised
   ii. Syllabus - what trainees are expected to know, and be able to do, in the various stages of their training
   iii. Assessment and feedback - how the attainment of outcomes are measured/judged with formative feedback to support learning
   iv. Training systems and resources - how the educational programme is organised, recorded and quality assured

d. The goal of the diagnostic radiology curriculum is to produce clinical radiologists with the ability to provide general and emergency radiology in any Irish healthcare system environment and specialist skills in one or more areas. This allows provision of acute imaging services vital to supporting the swift and accurate diagnoses of patients reporting to emergency departments, to guide General Practitioners in the management of patients in a community setting and to meet the increasing demand for specialist diagnostic and treatment services.

e. Patient management is enhanced by multidisciplinary team meetings in which radiologists are pivotal members with leadership roles, with few decisions made about patient management without radiology input. Developing and training other practitioners in aspects of diagnostic imaging and intervention requires radiologists with leadership, management and education skills. This curriculum aims to equip radiologists with the skills to fully engage in these roles.

3. Training in Diagnostic Radiology

a. Specialty training in diagnostic radiology will normally be a five-year programme that will include exposure to all imaging modalities, body systems and patient groups with the objective of producing radiologists who at the time of CSCST will be equipped to deliver a general, acute and emergency service.

b. Patients who require access to specialist diagnostic and treatment services require radiologists with advanced skills who can deliver specialist imaging in addition to general radiology. Whilst working as a consultant, most radiologists will focus on one or two areas of special interest in order to be able to provide this. The curriculum allows for some focus on an area of special interest in the fifth year of training. Trainees may undertake further subspecialty training after completing five years of training.

c. The curriculum includes the interventional capabilities, such as image-guided biopsies, required by general radiologists but excludes the specialist skills acquired by dedicated interventional radiologists.

d. The curriculum allows for exposure to sub-specialty areas including paediatric radiology, breast imaging, interventional neuroradiology and others. This is intended to give sufficient time for the trainee to acquire the knowledge of these areas to function as a general radiologist but further training will be required for full clinical practice in these areas.

4. Structure of training

a. Training Years 1-5.
    i. Diagnostic radiology training is entered following completion of at least two years of clinical practice, including internship, as a minimum. Therefore, all trainees will have gained experience in other specialties (e.g. medicine, surgery etc.) before commencing radiology training.
    ii. Trainees are required to enrol with the Royal College of Surgeons Ireland (RCSI) and become trainee members of the Faculty of Radiologists prior to the commencement of their training. Trainees are required to maintain Faculty membership throughout training for the Faculty to be able to recommend them as eligible for award of a CSCST.
    iii. In years 1-4 trainees will work with all the relevant modalities in order to gain experience and skills required for general practice. From year 5, trainees will transition to further study in an area of special interest. Special interest training will allow development of crucial generic skills, for example managing multidisciplinary team meetings, providing an expert opinion and adapting to technological developments and research.

b. Call
    i. On-call work is an integral part of radiology training. Trainees are expected to undertake on-call work after successful completion of their first year of training. The on-call rota will depend on the requirements of the local training sites.

c. Paediatric radiology & Neuroradiology rotations
    i. As part of their training in general radiology, trainees will rotate through specialist paediatric radiology and neuroradiology centres. The paediatric radiology rotation will consist of ten weeks (or equivalent) in a paediatric hospital, working directly with paediatric radiologists. The neuroradiology rotation will consist of two weeks in a neurosurgical centre working directly with neuroradiologists.

d. Scientific Basis of Imaging
    i. In their first year, trainees maust take the Faculty course on the scientific basis of imaging. This consists of a series of lectures and tutorials on a syllabus listed in Appendix 2. This will be examined in a summative fashion as part of the FFR1 examination.

5. Mandatory Courses

   a. Attendance at a number of study days, courses and modules is mandatory for attainment of CSCST. These include the following:
      i. Ultrasound physics day
      ii. Radiation protection course
      iii. Interventional Skills day
      iv. Emergency radiology course
      v. Systems-Based Practice and Management Course
      vi. Practice-Based Learning module
      vii. Audit Module
      viii. Multisource Feedback
      ix. Human Factors Training Modules

6. Protected Training Time

    a. Radiology Specialist Registrars are entitled to protected training time as per the NCHD contract. Details are available on the Faculty website at: https://www.radiology.ie/images/uploads/2012/02/Supporting-NCHD-access-to-Protected-Training-Time-11th-July-142.pdf

7. Leave

    a. Specialist registrars (SpRs) in approved training positions are entitled to annual and educational leave as per the NCHD contract. Details are available on the Faculty website at https://www.radiology.ie/images/uploads/2012/02/Leave-entitlements-Updated-Final-March-2017.pdf

8. Less than full-time training

    a. Trainees are entitled to opt for less than full-time training programmes at the discretion of their local training site and in compliance with current guidance from the HSE. Less than full-time trainees should assume that their clinical training will be of a duration pro-rata with the indicative time for full-time trainees, but this should be reviewed in accordance with the current HSE guidelines. Further information is currently available at: https://www.hse.ie/eng/staff/leadership-education-development/met/ed/flex/

9. Domains of Good Professional Practice

a. The Medical Council has defined eight domains of good professional practice. These domains describe a framework of competencies applicable to all doctors across the continuum of professional development from formal medical education and training through to maintenance of professional competence. They describe the outcomes which doctors should strive to achieve and doctors should refer to these domains throughout the process of maintaining competence. These domains are:

i. Patient Safety and Quality of Patient Care

Patient safety and quality of patient care should be at the core of the health service delivery that a doctor provides. A doctor needs to be accountable to their professional body, to the organisation in which they work, to the Medical Council and to their patients thereby ensuring the patients whom they serve receive the best possible care.

ii. Relating to Patients

Good medical practice is based on a relationship of trust between doctors and society and involves a partnership between patient and doctor that is based on mutual respect, confidentiality, honesty, responsibility and accountability.

iii. Communication and Interpersonal Skills

Medical practitioners must demonstrate effective interpersonal communication skills. This enables the exchange of information, and allows for effective collaboration with patients, their families and also with clinical and non-clinical colleagues and the broader public.

iv. Collaboration and Teamwork

Medical practitioners must cooperate with colleagues and work effectively with healthcare professionals from other disciplines and teams. He/she should ensure that there are clear lines of communication and systems of accountability in place among team members to protect patients.

v. Management (including Self Management)

A medical practitioner must understand how working in the healthcare system, delivering patient care and how other professional and personal activities affect other healthcare professionals, the healthcare system and wider society as a whole.

vi. Scholarship

Medical practitioners must systematically acquire, understand and demonstrate the substantial body of knowledge that is at the forefront of the field of learning in their specialty, as part of a continuum of lifelong learning. They must also search for the best information and evidence to guide their professional practice.

vii. Professionalism

Medical practitioners must demonstrate a commitment to fulfilling professional responsibilities by adhering to the standards specified in the Medical Council's "Guide to Professional Conduct and Ethics for Registered Medical Practitioners".

viii. Clinical Skills

The maintenance of Professional Competence in the clinical skills domain is clearly specialty-specific and standards should be set by the relevant Post-Graduate Training Body according to international benchmarks.

b. These eight domains outline the 'minimum common regulatory requirement' of performance and professional behaviour for those completing a CSCST or its equivalent. These attributes are common, minimum and generic standards expected of all medical practitioners achieving a CSCST or its equivalent.

c. The domains are directly identifiable in the diagnostic radiology curriculum. They are mapped to each of the generic and specialty professional capabilities, which are in turn mapped to the assessment methods.The domains must be demonstrated during training as part of the development of radiologists and will be specifically assessed in the annual trainee assessment.

d. The overall aim of annual assessments is to identify issues that may impair fitness to practice at as early a stage as possible and to minimise the possibility that any deficit is identified during the final phases of training or in post-CSCST practice.

10. Professional Capabilities - Generic and Radiology-Specific

a. The practice of Diagnostic Radiology requires the generic and specialty-specific knowledge, skills, attitudes and procedural competencies to diagnose and manage patients referred for imaging, to investigate symptoms and conditions and perform image-guided procedures. It involves particular emphasis on diagnostic reasoning, communicating uncertainty and working with referrers to ensure appropriate speciality opinion or care is sought when required.

b. To achieve CSCST trainees are expected to demonstrate achievement of the generic and specialty-specific high level outcomes, known as 'Professional Capabilities'. These describe the professional capabilities required of a consultant radiologist. Each competency can be mapped to the Medical Council's Domains of Good Professional Practice.

c. Trainees may demonstrate their progress against the Professional Capabilities in a variety of different ways, reflecting their strengths, areas of interest and the resources available to them, and should be encouraged to find innovative ways to achieve this. Trainees may also complete activities that provide evidence for more than one competency.

d. The level at which trainees meet each Professional Capability is expected to progress throughout training. Trainees will develop at different rates and some may be able to demonstrate a higher level of progress in some competencies than others. However, all trainees will be expected to maintain a minimum level of progression over the scheme. The annual assessment forms a critical part of this curriculum and outlines the minimum expected levels of achievement that trainees must make each year. Annual sign off will require supervising consultants to make entrustment decisions on the level of supervision required for each competency or underlying activity at each progression point. Every trainee will be expected to be at the minimum level expected for their level of training. More detail is provided in the assessment section of the curriculum.

e. Professional Capabilities

i. To achieve CSCST trainees are expected to demonstrate the Professional Capabilities described by the generic and specialty-specific high level outcomes, or 'competencies', as detailed below:

f. Generic Professional Capabilities

i. Demonstrate the professional values and behaviours expected of all doctors as outlined in the Medical Council's 'Guide to Professional Conduct and Ethics for Registered Medical Practitioners.

ii. Successfully function within the health service and healthcare systems in Ireland.

iii. Understand organisational and management systems in Irish healthcare so that they can engage positively with them and optimise patient care.

iv. Engage in reflection, clinical governance and quality improvement processes to ensure good practice.

v. Engage in evidence-based practice and safeguard data, including imaging data.

vi. Acquire the skills used by all doctors to practise evidence-based medicine.

vii. Act as a clinical teacher and supervisor.

viii. Teach medical students, junior doctors and other healthcare professionals

ix. Work well within a variety of different teams, communicating effectively with colleagues and demonstrating the skills required to lead a team

x. Diagnostic radiology relies on a multi-professional team and good communication is an essential component of sound practice, team working and patient-centred care. Radiologists must be able to resolve conflict, develop good working relationships and support team development and possess the qualities and behaviours necessary to lead but also to follow, when necessary, in dealing with difficult situations and conflicting attitudes.

These Generic Professional Capabilities are mapped to the Medical Council's domains of good professional practice as shown in the Table 1 below:

Generic Professional Capability	**Mapped to following Domains of Good Professional Practice**
Demonstrate the professional values and behaviours expected of all doctors as outlined in the Medical Council's 'Guide to Professional Conduct and Ethics for Registered Medical Practitioners	Patient Safety and Quality of Patient Care Relating to Patients Communication and Interpersonal Skills Collaboration and Teamwork Management (including Self Management) Scholarship Professionalism Clinical Skills
Successfully function within the health service and healthcare systems in Ireland	Communication and Interpersonal Skills Collaboration and Teamwork Management (including Self Management) Professionalism
Understand organisational and management systems in Irish healthcare so that they can engage positively with them and optimise patient care	Collaboration and Teamwork Management (including Self Management) Professionalism
Engage in reflection, clinical governance and quality improvement processes to ensure good practice	Management (including Self Management) Scholarship Professionalism Clinical Skills
Engage in evidence-based practice and safeguard data, including imaging data	Patient Safety and Quality of Patient Care Scholarship Professionalism Clinical Skills
Acquire the skills used by all doctors to practise evidence-based medicine	Patient Safety and Quality of Patient Care Scholarship Professionalism

	Clinical Skills
Act as a clinical teacher and supervisor	Communication and Interpersonal Skills Scholarship Clinical Skills
Teach medical students, junior doctors and other healthcare professionals	Scholarship
Work well within a variety of different teams, communicating effectively with colleagues and demonstrating the skills required to lead a team	Patient Safety and Quality of Patient Care Communication and Interpersonal Skills Collaboration and Teamwork Management (including Self Management) Professionalism Clinical Skills
Diagnostic radiology relies on a multi-professional team and good communication is an essential component of sound practice, team working and patient-centred care. Radiologists must be able to resolve conflict, develop good working relationships and support team development and possess the qualities and behaviours necessary to lead but also to follow, when necessary, in dealing with difficult situations and conflicting attitudes	Patient Safety and Quality of Patient Care Relating to Patients Communication and Interpersonal Skills Collaboration and Teamwork Professionalism Clinical Skills

Table 1: List of Generic Professional Capabilities mapped to specific domains of Good Professional Practice as set out by the Medical Council.

g. Specialty-specific Professional Capabilities

i. Appropriately select and tailor imaging to patient context and the clinical question.

ii. Discuss clinical cases with referrers and advise on appropriate imaging according to the individual patient, clinical background and the clinical question. Imaging investigations have varying health and safety risks that need to be considered. Radiologists weigh up the relative clinical risk/benefit when advising on imaging according to clinical information provided by referrers this is done with particular regard to radiation exposure.

iii. Have the Knowledge, Skills, Competences and Attitudes in the various clinical specialties as listed in the next section. They should also have sub-specialist knowledge relevant to their area of practice.

iv. Provide reports that are timely, clear, concise and actionable. Discuss findings with referrers as required. Be able to report investigations for common presenting complaints. In addition, be able to report more complex investigations as appropriate to special interest. This may include recommendations regarding onward imaging investigations, imaging follow up and/or other clinical management based on their expert knowledge.

v. Appropriately manage imaging examination lists/procedures according to clinical need and professional expertise.

vi. Be able to directly examine a patient in real time with imaging such as ultrasound and perform image-guided procedures suitable to their area of practice.

vii. Evaluate image quality and utilise knowledge of imaging physics to maximise the diagnostic certainty of an imaging test.

viii. Safely manage the imaging and image-guided intervention needed to support care.

ix. Be competent in interpreting and performing imaging examinations and/or procedures that are required in the emergency context and where appropriate will suggest use of image-guided intervention or onward referral.

x. Effectively contribute a clinical/imaging opinion to a multidisciplinary team (MDT) meeting. Consultant radiologists review imaging of cases to be discussed at MDT meetings and present relevant findings pertinent to clinical decision making. They will provide explicit recommendations regarding onward imaging investigations and/or image-guided procedures.

xi. Participate in the management of imaging departments and in the overall management of hospitals and other care environments.

Specialty-Specific Professional Capability	Mapped to following Domains of Good Professional Practice
Appropriately select and tailor imaging to patient context and the clinical question	Patient Safety and Quality of Patient Care Scholarship Clinical Skills
Discuss clinical cases with referrers and advise on appropriate imaging according to the individual patient, clinical background and the clinical question. Imaging investigations have varying health and safety risks that need to be considered. Radiologists weigh up the relative clinical risk/benefit when advising on imaging according to clinical information provided by referrers this is done with particular regard to radiation exposure	Patient Safety and Quality of Patient Care Communication and Interpersonal Skills Collaboration and Teamwork Professionalism Clinical Skills
Have the Knowledge, Skills, Competences and Attitudes in the various clinical specialties as listed in the next section. They should also have sub-specialist knowledge relevant to their area of practice	Patient Safety and Quality of Patient Care Relating to Patients Communication and Interpersonal Skills Collaboration and Teamwork Professionalism Clinical Skills
Provide reports that are timely, clear, concise and actionable. Discuss findings with referrers as required. Be able to report investigations for common presenting complaints. In addition, be able to report more complex investigations as appropriate to special interest. This may include recommendations regarding onward imaging investigations, imaging follow up and/or other clinical management based on their expert knowledge	Patient Safety and Quality of Patient Care Communication and Interpersonal Skills Professionalism Clinical Skills
Appropriately manage imaging examination	Patient Safety and Quality of Patient

lists/procedures according to clinical need and professional expertise	Care Communication and Interpersonal Skills Collaboration and Teamwork Professionalism Clinical Skills
Be able to directly examine a patient in real time with imaging such as ultrasound and perform image-guided procedures suitable to their area of practice	Patient Safety and Quality of Patient Care Relating to Patients Clinical Skills
Evaluate image quality and utilise knowledge of imaging physics to maximise the diagnostic certainty of an imaging test	Patient Safety and Quality of Patient Care Scholarship
Safely manage the imaging and image-guided intervention needed to support care	Patient Safety and Quality of Patient Care Clinical Skills
Be competent in interpreting and performing imaging examinations and/or procedures that are required in the emergency context and where appropriate will suggest use of image-guided intervention or onward referral	Patient Safety and Quality of Patient Care Clinical Skills
Effectively contribute a clinical/imaging opinion to a multidisciplinary team (MDT) meeting. Consultant radiologists review imaging of cases to be discussed at MDT meetings and present relevant findings pertinent to clinical decision making. They will provide explicit recommendations regarding onward imaging investigations and/or image-guided procedures	Patient Safety and Quality of Patient Care Communication and Interpersonal Skills Collaboration and Teamwork Professionalism
Participate in the management of imaging departments and in the overall management of hospitals and other care environments	Communication and Interpersonal Skills Collaboration and Teamwork Management (including Self Management)

	Professionalism

Table 2: List of Specialty-Specific Professional Capabilities mapped to specific domains of Good Professional Practice as set out by the Medical Council.

11. System-Based Knowledge

a. Diagnostic radiology utilises a wide range of imaging modalities and techniques to identify and characterise pathology in the body and can be used to investigate any body system or anatomical region.

b. Radiology trainees are expected to become competent in protocolling, performing and/or reporting all of the commonly used imaging modalities (e.g. radiographs, fluoroscopy, ultrasound, CT, MRI, radionuclide studies) and to remain up to date with validated new techniques, imaging procedures and protocols.

c. The approach in this document is to provide general guidance. The tables in Appendix 1 outline at a high level the knowledge, skills and competencies that trainees should acquire in each specialist area. Any attempt to comprehensively list all clinical presentations, pathological conditions, imaging modalities and techniques would be extensive, but inevitably incomplete, and would rapidly become out of date. The approach here is to provide general guidance and not exhaustive detail.

d. These lists are not comprehensive; they must be viewed as a guide and interpreted with common sense. The trainees may subdivide these areas of learning into:
   i. Developing an appropriate imaging strategy for the clinical presentations
   ii. Recognise imaging features of common pathological processes
   iii. Developing skills in image interpretation and procedures appropriate to their level of training and practice.

e. These are taught to the trainees through a combination of lectures, hospital-based teaching and self-directed learning.

f. By the end of their training all radiology trainees will be expected to advise on the optimum imaging strategy for a given presentation or condition, including

selection of the most appropriate modality and protocol for the examination. This should include radionuclide / molecular imaging techniques where appropriate.

g. All radiologists are required to be trained in a number of basic image-guided procedures such as performing biopsies and inserting tubes and drains, as well as performing diagnostic procedural work such as fluoroscopy. It is expected that all trainees will have knowledge of appropriate interventional radiology strategies when investigating the range of common presentations and conditions listed in Appendix 1 and demonstrate the ability to select and use basic interventional radiology techniques. There are a number of practical techniques and procedures in which competence should be developed. The extent to which a trainee engages in these procedures will be dependent on their level of training and range from an awareness of the procedure to independent performance. Generic procedures are listed below and more specific examples are given in Appendix 1.
    i. Image-guided biopsy
    ii. Image-guided drainage
    iii. Image-guided vascular access and basic catheter/wire manipulation
    iv. Contrast studies of lines and tubes
    v. Fluoroscopically-assisted nasogastric tube insertion
    vi. Contrast studies of the adult and paediatric GI and GU tract

h. The level of competence in each system based skill is defined as follows:
    i. Core Skill: These are examples of imaging procedures in which all radiology trainees will develop skills to be capable of fully independent practice by CSCST.
    ii. Experience: These are examples of imaging procedures in which as a minimum all radiologists will have knowledge of the role, indications, contra-indications and limitations. They will be able to advise on when and how to refer for these procedures even if they do not undertake the examination personally.
    iii. Specialist: These are examples of examinations and procedures which are necessary to support specialist services. They are skills which will be developed by a limited number of radiology trainees, in response to service need.

i. Nuclear Medicine and PET/CT
    i. Radionuclide radiology comprises those diagnostic-imaging techniques, which use radio-labelled tracers for diagnosis, while molecular imaging provides images of metabolic and physiological processes at the molecular

and cellular level. Techniques utilised in these areas of radiology can be applied to all of the systems in Appendix 1, as well as being used to study physiological and metabolic processes at a cellular level. Trainees should demonstrate a basic knowledge of the spectrum of techniques utilised in these areas of radiology and the biological processes in disease that can be probed using these methods. Examples of clinical use of radionuclide imaging, along with an outline of imaging and therapy approaches and the biological processes that can be interrogated using molecular imaging are given below:

ii. Clinical uses of radionuclide imaging:

1. Staging and response assessment of malignant disease
2. Differentiating neurodegenerative disorders
3. Imaging of musculoskeletal disorders
4. Parathyroid imaging
5. Thyroid imaging and adrenal imaging
6. Neuroendocrine tumour imaging
7. Sentinel node localisation

12. Academic radiology and emerging techniques.

a. Academic training
    i. All trainees are required to demonstrate an understanding of research methodology and critical appraisal linked to clinical practice. Trainees are required to complete the Practice-Based Learning (PBL) module, usually in the second year of training, including completion of PBL and Audit projects which are presented at respective meetings. All trainees should develop their critical appraisal skills and regularly appraise and discuss current research papers – for example as part of regular journal clubs.
    ii. Occasionally, a trainee may choose to undertake a combined clinical and academic training programme. Such trainees require prior approval from the Faculty of Radiologists' Fellowship Advisory Committee (FAC) prior to undertaking such a programme.
    iii. The Wellcome - Health Research Board Irish Clinical Academic Training (ICAT) Programme is an integrated, multi-year programme spanning 6-7 years of supported and mentored academic and clinical training targeting future academic leaders. This allows the trainee to pursue a chosen PhD while remaining in parallel clinical training. Radiology trainees wishing to undertake the ICAT programme should request approval from the relevant LTC and the FAC prior to applying for this programme. Further details are available at:
    https://icatprogramme.org

b. Emerging technologies
    i. Trainees are expected to keep up to date and to embrace emerging technologies, such as where these act as an adjunct to imaging analysis and interpretation. Artificial intelligence tools are being developed to assist with diagnostic assessments and trainees should be prepared to adopt these tools into clinical practice once validated.

c. Emerging imaging techniques
    i. Trainees should be aware of emerging imaging techniques and to undertake training in these techniques where these become available according to their specialist interest. Examples of this include:
        1. Hybrid imaging in the form of PET/CT is well established in clinical practice but other newer forms of hybrid imaging may

evolve into clinical routine. Trainees should be aware of the potential of new hybrid technologies and new radiopharmaceuticals.

2. CT post-mortem imaging is being performed more frequently and there is likely to be increasing demand for radiologists' skills in interpreting these examinations in future.

ii. While core radiology skills can be applied to image analysis in these emerging techniques, trainees should understand that this is not sufficient alone and that specific training in the emerging technique will be required.

13. Teaching and learning methods

a. Responsibility for delivering the training needed to meet the curriculum requirements rests with the Faculty of Radiologists and individual local training hospitals. This includes mechanisms for addressing underperformance and providing remediation. Progression through the programme will be determined by the annual assessment. The successful completion of radiology training will be dependent on achieving an expected level in all Professional Capabilities and procedural skills. The programme of assessment will be used to monitor and determine progress through the programme. Training will predominantly take place in the local training hospitals.

b. The sequence of training should ensure appropriate progression in experience and responsibility. The curriculum will be delivered through a variety of learning experiences and will allow trainees to achieve the capabilities described through a variety of learning methods. There will be a balance of different modes of learning from formal teaching programmes to experiential learning 'on the job'. The proportion of time allocated to different learning methods may vary depending on the nature of the workload in a given training site. Training should be constructed to enable trainees to experience the full range of educational and training opportunities available and there will be robust arrangements for quality assurance in place to ensure consistent implementation of the curriculum. This section identifies the types of situations in which the trainee will learn.

c. Workplace-based learning

The content of workplace-based learning is decided by the local training site but includes active participation in:

1. Radiological practice encompassing increasing experience with gradual reduction in supervision as judged by trainers. A major component of training in radiology is achieved by the trainee undertaking an increasing number and variety of radiological tasks.
2. Multidisciplinary team meetings: These inter-disciplinary meetings provide excellent learning opportunities.
3. On-call and emergency provision: On-call work should be a positive learning opportunity and this requires appropriate levels of supervision by the consultant on-call with trainees and appropriate

levels of workload. Whilst the Faculty cannot define working arrangements that can be put in place by each training site, it is expected that on-call work be structured to maximise learning with appropriate rest time provided.

4. The degree of responsibility taken by the trainee will increase as competency increases. There should be appropriate levels of supervision throughout training with increasing independence and responsibility as learning outcomes are achieved.

d. Formal postgraduate teaching

This can take a variety of forms and may include:

i. A programme of formal, regular teaching sessions to cohorts of trainees
ii. 1st Year: https://www.radiology.ie/images/uploads/2012/02/Part_I_Lecture_Schedule_2019.2020.pdf
iii. 2nd Year: https://www.radiology.ie/images/uploads/2012/02/Part_II_2nd_Year_Lecture_Schedule_2019.2020.pdf
iv. 3rd Year: https://www.radiology.ie/images/uploads/2012/02/Part_II_3rd_Year_Lecture_Schedule_2019.2020.pdf
v. Case presentations
vi. Journal clubs
vii. Research and audit projects
viii. Lectures and small group teaching
ix. Grand Rounds
x. Radiological skills demonstrations and teaching
xi. Joint meetings with clinical specialties
xii. Attendance at training programmes designed to cover aspects of the training programme outlined in this curriculum

e. Independent self-directed learning

Trainees will use this time in a variety of ways depending upon their stage of learning. Suggested activities include:

i. Preparation for assessment and examinations
ii. Reading, including journals and web-based material
iii. Audit, quality improvement and research projects
iv. Achieving personal learning goals beyond normal expectations.

f. Formal study courses

Time to be made available for formal courses is encouraged, subject to local conditions of service. Examples include management courses and communication courses.

g. Learning experiences

Consultant supervisors and local training coordinators (LTCs) are encouraged to identify learner-centred educational opportunities in the course of clinical work, maximising the wide variety of learning opportunities in the clinical radiological workplace. These may include:

i. Learning from practice: Trainees will spend a large proportion of work-based experiential learning involved in supervised radiological practice in a hospital setting. Learning will involve closely supervised practice until competences are achieved. The learning environment will be in all areas of the imaging department and in other areas where imaging services are provided (e.g. bedside ultrasound).

ii. Learning with peers: There are many opportunities for trainees to learn with and from their peers. Local postgraduate teaching opportunities allow trainees of varied levels of experience to come together for small group sessions. Examination preparation encourages the formation of self-help groups and learning sets.

iii. Learning in formal situations: There are many opportunities for formal teaching in the local teaching sessions and at national and international meetings.

iv. Personal study: Time will be provided during training for personal study (see sections 6 and 7 for policies related to protected training time and educational leave respectively).

v. Specific teacher inputs: Individual hospitals within a training programme will identify where specific teaching sessions will be provided. These will vary from site to site. Examples include:

1. Special interest teaching in a radiological environment from a recognised specialist
2. Structured teaching sessions
3. Journal Clubs
4. Local Radiology QI meetings

h. Simulation

Simulation is recognised as a useful modality to supplement training in clinical situations. It provides experiential learning and an opportunity to reflect on and learn from mistakes in a safe environment. Trainees will participate in simulated training exercises as part of the IR skills courses and in human factors training.

14. Summative and Formative Assessment methods

a. Evidence of progress

i. Radiological practice will be assessed using an integrated package of formative workplace-based assessments (WBAs) and summative examination of knowledge and radiological skills, which will sample across the curriculum. The assessments are supported by structured feedback.

ii. The methods of assessment listed in this section of the curriculum will provide evidence of progress though evidence of progress may also be gathered from other sources and trainees are encouraged to demonstrate their progress against the Professional Capabilities in a variety of different ways, reflecting their strengths, areas of interest and the resources available to them. The trainee will collect evidence to support their self-assessment, and the local training coordinator will use it to reach a global assessment.

b. Summative Assessment

i. There are two examinations that must be passed in order for trainees to be awarded fellowship of the Faculty of Radiologists, Royal College of Surgeons Ireland [FFR(RCSI)]. The First FFR Examination consists of the Scientific Basis of Imaging, Radiological Anatomy and Techniques. The second examination examines the entire radiology curriculum and is divided into Part 2A and Part 2B.

ii. The First FFR Examination tests knowledge through multiple choice questions, film viewing (requiring the identification of normal anatomical structures on images) and viva sessions. The Final FFR Part 2A Examination test knowledge through single best answer (SBA) questions and extended matching questions (EMQ). The FFR Part 2B Examination assesses clinical competence (interpretative, analytical and communication skills) through long cases, rapid reporting and viva sessions. Further guidance for trainees on the structure and content of these exams is available on the Faculty website.

iii. Those assessment tools which are not identified individually as summative will contribute to summative judgements about a trainee's progress as part of the programme of assessment. A suitable number and range of these will ensure reliable assessment of progress and achieve coverage of the curriculum.

c. Formative Assessments

i. **Workplace-based assessment (WBA)**

1. Workplace-based assessment (WBA) provides assessment for day-to-day practice. Reflection and feedback is an integral component to all WBAs to enhance and drive learning. The assessments should be seen as opportunities for identifying strengths and areas for further development; they are not tests that must be passed per se but should be seen as a useful indicator of one's stage of competency relative to expected capabilities at a given stage of training. Activities to be assessed should be agreed in advance and it is the responsibility of the trainee to arrange this.

2. In order for trainees to maximise benefit, reflection and feedback should take place as soon as possible after an assessment. Feedback should be of high quality and should include an action plan for future development. Both trainee and trainer should recognise and respect cultural differences when giving and receiving feedback.

3. A range of assessment tools are available to support WBA and these are listed below. Minimum numbers of each type WBA are given, although it is anticipated that trainees may undertake many more, as the WBAs are the vehicles by which the trainee will guarantee one-to-one teaching and ensure appropriate curriculum coverage during their clinical attachments.

4. Image Interpretation and Reporting Exercise (IIREx)

a. This tool evaluates an observed radiology interpretation/reporting episode. The IIREx can be used at any time and in any setting when an assessor is available. Assessors should be consultant radiologists trained in giving feedback and understand the role of assessment. Wherever possible, a different assessor should be used for

each IIREx. Trainees should agree the timing, casemix and assessor, although assessors may also carry out unscheduled assessments. Trainees should receive immediate feedback to aid learning.

b. Trainees should complete a minimum of six IIREXs in each year of training (or equivalent for LTFT trainees). IIREXs should sample across different radiological problems as summarised in Table 1.

5. Radiology-direct observation of procedural skills (Rad-DOPS)
    a. A Rad-DOPS is a structured checklist for assessing the interaction of a radiology trainee with the patient when performing a practical procedure. Assessors must be consultant radiologists trained both in the procedure and feedback methodology. Different assessors should be used for each encounter wherever possible. Trainees should agree the timing, procedure and assessor, although assessors may also carry out unscheduled assessments. Trainees should receive immediate feedback to identify strengths and areas for development.
    b. Trainees should complete a minimum of six Rad-DOPS in each year of training (or equivalent for LTFT trainees), sampling a wide range of different procedures/skills. Rad-DOPS can be undertaken as many times as the trainee and their supervisor feel is necessary and may be used to inform decisions about when a trainee can be regarded as competent to perform a procedure independently.

ii. Multisource Feedback (MSF)

1. This tool is a method of assessing generic skills such as communication, leadership, team working, reliability etc. across the domains of Good Professional Practice. This provides systematic collection and feedback of performance data on a trainee, derived from a number of colleagues. For each assessment, the trainee should nominate at least 20 assessors. Assessors are individuals with whom the trainee works, including supervising consultants, fellow radiology trainees, other colleagues within the radiology department and doctors working outside the radiology department with whom the trainee interacts as part of their work.

2. The recommended mix of raters/assessors is:
    a. 6 Consultant Radiologist colleagues including the LTC
    b. 5 Radiology NCHD colleagues
    c. 5 Radiographers/ Nurses/Allied health professionals
    d. 5 healthcare professionals (usually NCHDs or consultants) based outside the radiology department
3. The trainee will not see the individual responses by raters. Feedback is given to the trainee by an appropriately trained coach.
4. MSF should usually take place once during training, typically towards the end of the second year (or at appropriate intervals for LTFT trainees), although the local training coordinator may choose to recommend an additional MSF to assist a doctor in difficulty. It is mapped to a self assessment tool with identical domains.

iii. Form 2A (Local Training Coordinator report and trainee self reflection)

1. The local training coordinator (LTC) will annually give an overview of their progress in a formal structured LTC's report (Form 2A). The overall judgment of a trainee will include a triangulated view of the doctor's performance, which will include their participation in educational activities, appraisals and the assessment process. The LTC will assess the trainee's level of progress in each of the generic and radiology-specific professional capabilities. The LTC's report can incorporate commentary or reports from longitudinal observations, such as from supervisors or formative assessments demonstrating progress over time.
2. The trainee will also be asked to submit a special version of form 2A in which they are asked to assess their own progress. This is expected to be an exercise in self-reflection and is intended to form a basis for a discussion between the trainee and the LTC.

iv. Annual Assessment

1. Individual progress will be monitored by an annual review, the Annual Assessment. This should be used to integrate and systematically review evidence about a doctor's performance and progress in a holistic way to facilitate decisions regarding progression through training, as well as identifying any requirements for targeted or additional training where necessary.

2. The trainee will be assessed against their expected level progression in relation to the generic and radiology-specific professional capabilities. Each trainee will be expected to have demonstrated sufficient progress in each area such that they are practicing at the level considered appropriate for their level of training.
3. Annual Assessments are organised by the Faculty. It is suggested that trainees have an informal assessment in their local base hospital prior to the Faculty's annual assessment which provides an opportunity for early detection of trainees who are failing to gather the required evidence for Annual Assessment.
4. For the Annual Assessment, at least two panel members are required, one of whom should be the relevant LTC, the other a Faculty representative such as the national training coordinator, other LTC or board member. The assessors will fill out Form 2B during the assessment which will be placed on the trainees record.
5. Satisfactory progression across all domains within the decision aid will lead to progress into the next year of training.
6. Unsatisfactory progression will be informed by some or all of the following (the decision being undertaken by the Annual Assessment panel): lack of curriculum coverage; inadequate or poor outcomes in workplace based assessments and/or examinations; and areas of concern within Form 2A. This will result in one of two outcomes:
    a. Conditional progress into the next year of training; a specific action plan will be formulated with the trainee to redress deficiencies in performance. Progress will be re-assessed as appropriate within the next year of training.
    b. Directed training without progression; if the trainee is so far short of the objectives for their stage of training such as to prevent them continuing into the next stage of training, directed training is recommended to achieve those objectives. The Faculty recommends that repetition of the entire indicative year should only be recommended for exceptional reasons

d. Appeals

There are formal mechanisms for appealing against decisions taken at all stages of training. Appeals against decisions of the Annual Assessment

panel are conducted locally by the Faculty Advisory Committee. Appeals related to examination results are conducted by the Chief Examiner. Appeals against a failure to award a CSCST may be made to the Medical Council. It is important to be aware that time limits within which appeals must be lodged may apply.

15. Progression Criteria

a. These progression criteria apply to SpRs who passed the Primary Examination in or after May 2016.

b. First Year of Training
   i. A candidate in the training programme of the Faculty of Radiologists cannot be fully accredited for the 1st year of training until they have passed Part 1. If they pass their 2nd attempt at the examination in September (Q1) of chronological year 2 of training, they may proceed in 2nd year with their starting cohort. If not, they must repeat 1st year with the new cohort of 1st year SpRs.
   ii. SpRs not accredited for a year of training because of examination failure in FFR Part 1 and repeating the training year do not need to repeat rotations / modules for which they have obtained credit.
   iii. In the Irish Radiology Training Programme, the CSCST date of SpRs not accredited for a year of training because of examination failure in FFR part 1 will be extended by 12 months.

c. Years 2-5 of Training
   i. Candidates can progress through training years 2-5 notwithstanding examination failure if deemed to be operating at an appropriate level at assessment by the relevant Local Training Coordinator, with input from Fellowship Advisory Committee (FAC) and possibly the Chief Part 2 Examiner. FFR Part 2A examination can be attempted after the candidate has passed assessments for the first three years of training as recognised by the Faculty of Radiologists. FFR Part 2B cannot be attempted before Part 2A has been passed. However, CSCST requires completion of 5 years accredited training, passage of FFR Part 2B and completion of all mandatory modules and rotations. The maximum time within which to complete 5 years of accredited training is 9 years. In exceptional circumstances such as:
      1. maternity/family leave, long term illness
      2. relevant PhD
      3. other such instances in which the FAC may recommend to the board that this period of time may be extended for an individual trainee.

d. Fifth year

i. During the fifth year of training, trainees should endeavour to develop skills and knowledge in one or more subspecialty areas. While it is envisaged that most trainees will undertake their fifth year of training within the Irish healthcare system as part of a Faculty-approved fifth year training post, trainees may elect to undertake their fifth year of training abroad as part of a pre-approved fellowship.

e. Out Of Programme Experience (OOPE)
   i. Trainees may apply for Out Of Programme Experience (OOPE), typically in place of their fifth year of training. Prior to departure for such fellowship, the application for OOPE must be pre-approved by the FAC. The application form for OOPE is available at the Faculty's website, currently: https://www.radiology.ie/images/uploads/2012/02/Out-of-Programme-Requirement-for-Pre-Approval.pdf

f. Post-Fellowship Training
   i. This is defined as training that takes place after a trainee has achieved CSCST. Trainees may do this in Ireland or in international centres.

Appendix 1

System-based knowledge

16. The level of competence in each system based skill is defined as follows:
    a. Core Skill: These imaging procedures in which all radiology trainees will develop skills and be capable of fully independent practice by CSCST.
    b. Experience: These are examples of imaging procedures in which as a minimum all radiologists will have knowledge of the role, indications, contra-indications and limitations. They will be able to advise on when and how to refer for these procedures even if they do not undertake the examination personally. They will form part of training in fifth year positions.
    c. Specialist: These are examples of examinations and procedures which are necessary to support specialist services. They are skills which will be developed by a limited number of radiology trainees, in response to service need. This will typically be encompassed in fifth year training or post CSCST years.

System	**Develop an appropriate imaging strategy for the following presentations**	**Recognise imaging features of the following conditions**	**Develop skills in the following imaging modalities and techniques**

Breast Radiology	Breast lump Nipple changes/ discharge Skin changes Inflammation Recall from screening Implant-related concerns Male breast concerns Breast pain Incidental breast abnormality on cross-sectional imaging Axillary lump	Breast tumour: -Primary: in situ/invasive -Metastatic:regional/ distant -Recurrent -Metastatic from elsewhere Benign and atypical breast lesions Implant rupture Gynaecomastia	Experience: Mammography Tomosynthesis; Ultrasound breast and axilla MRI US-guided aspiration, biopsy and localisation Specialist: Advanced biopsy techniques
Cardiac Radiology	Acute chest pain Stable chest pain Cardiovascular chest trauma Shortness of breath Stroke and paradoxical embolism Syncope Sudden collapse Palpitation with confirmed arrhythmia	Cardiac arrhythmias Cardiac failure Coronary heart artery disease and its complications Imaging findings post cardiac surgery Valvular heart disease Common congenital heart disease Cardiomyopathy Heart failure Diseases of the arteries including aortic dissection Acute aortic syndrome Diseases of the pulmonary circulation Pericardial diseases Pulmonary embolism Stroke and paradoxical embolism Cardiac tumours and masses	Core Skills: Plain radiography of cardiac disease CT including ECG-gated cardiac and thoracic aorta CT Experience: Cardiac MRI nuclear cardiology, Specialist: echocardiography advanced cardiac MRI
Gastrointestinal	The Acute Abdomen Abdominal trauma Abdominal pain -	GI tract tumours Liver tumours Pancreatico-biliary	Core Skills: Plain film Fluoroscopic contrast

Radiology	acute/ chronic Abdominal mass Dysphagia Change in bowel habit Gastrointestinal haemorrhage Anaemia Weight loss Diarrhoea, steatorrhea Jaundice/ abnormal LFTs	tumours Diseases of the oesophagus, stomach, small bowel, colon and rectum Adrenal masses Malabsorption Continence disorders Diseases of the gallbladder and biliary tree Diseases of the pancreas including acute and chronic pancreatitis Diseases of the liver – focal and diffuse. Herniae, volvulus and intussusception	studies of the GI tract Image-guided NG tube Insertion Ultrasound (perform and interpret), CT/ CT Angiography, MRI/ MRCP Image-guided biopsy and drainage Experience: Radionuclide imaging CT Colon
Head and Neck Radiology	Neck lump Stridor and hoarseness Swallowing difficulties Hearing loss Tinnitus and vertigo Facial, oral, dental and neck pain and swelling Facial and skull base trauma Trismus and TMJ dysfunction Epistaxis Otalgia and aural discharge Epiphora Proptosis Nasal polyps Anosmia / hyposmia	Head, neck and skull base tumours Lymph node pathology Thyroid and parathyroid diseases Orbital disease Temporal bone, inner and middle ear disorders Vestibular dysfunction TMJ diseases Cranial nerve disorders Salivary gland disease Paranasal sinus disease Dental disease Vascular and lymphatic malformations	Core Skills: Plain film Fluoroscopy / contrast swallow Ultrasound (perform and interpret) CT MRI US-guided FNA thyroid/node Experience: US / CT-guided biopsy Radionuclide imaging Specialist: Sialography, dacrocystography CT-guided biopsy
Musculoskeletal	Bone pain / deformity Joint pain / deformity	Trauma (acute and chronic) Infection	Core Skills: Plain film Fluoroscopy

Radiology	Back pain Soft tissue / bony lump Acute and chronic injuries of tendons, muscles and ligaments Symptoms of cord or nerve root compression Scoliosis Rash and weakness	Tumours / tumour-like lesions Spinal cord / cauda equina compression Haematological disorders Metabolic bone disorders Endocrine bone disorders Degenerative and infective disc disease Congenital and developmental lesions Multisystem rheumatic disorders Connective tissue disorders Crystal-related arthropathies Osteoarthritis Osteoporosis Rheumatoid arthritis Spondyloarthritidies	CT MRI (Spine, knee, shoulder and pelvis); Experience:, Ultrasound (perform and interpret) Radionuclide imaging MRI of smaller joints MRI arthrography CT-guided bone biopsy Image-guided injection, aspiration and biopsy Specialist: Advanced intervention e.g. Ablation, Image guided nerve block
Vascular and Interventional Radiology	Painful limb with reduced or absent pulses Pulsatile mass Trauma Haemorrhage Swollen limb Presentations listed in other systems that might require image-guided intervention	Acute ischaemia Chronic ischaemia Diabetic vasculopathy Aneurysm Vasculitides AVM Deep venous thrombosis SVC obstruction	Core Skills: Plain film Duplex ultrasound for DVT MR / CT Angiography Contrast studies of lines Vascular access and basic catheter and guidewire manipulation PICC placement Experience: Advanced vascular access techniques Duplex ultrasound for carotid or peripheral arterial disease

			Specialist: Angiography Angioplasty, Embolisation Percutaneous biliary drainage Advanced biopsy e.g. transjugular biopsy, TIPPS Vertebroplasty Nephrostomy Antegrade ureteric stent Varicocele embolisation Tumour embolisation

Neuroradiology	Abnormal sensory or motor function Speech disturbance Autonomic dysfunction Abnormal behaviour Confusion Memory loss and intellectual decline Head injury Headache Seizures Visual loss Cranial nerve palsy and pain Symptoms of cord or nerve root compression Congenital malformations / syndromes	Head and spine trauma Intracranial and spinal haemorrhage Ischaemia and infarction Venous sinus thrombosis Atheroma and dissection Vascular malformations Brain and spinal cord tumours Dementia and cognitive disorders Chronic neurological disability Motor neurone disease Movement disorders CNS infections e.g. meningitis, encephalitis and abscess Demyelination Neurosarcoid and vasculitis Headache syndromes e.g. migraine Epilepsy Congenital disorders and phakomatoses Myopathies Peripheral neuropathy (acute and chronic) Suspected cord compression & Cauda equina syndrome	Core Skills: Head CT for all relevant acute emergency conditions including head injury and CTA/ CT Perfusion for suspected stroke MRI spine for cord / cauda equina compression Experience: Image-guided lumbar puncture Specialist: Cerebral angiography Spinal intervention
Thoracic Radiology	Dyspnoea Cough Haemoptysis Chest pain Chest wall mass Hoarseness	Respiratory tract tumours Pleural diseases including pneumothorax Mediastinal and hilar	Core Skills: Plain films Ultrasound (perform and interpret) CT including CTPA/ HRCT

	Stridor/wheeze Thoracic trauma Abnormal lung function tests Incidental lung nodule	masses Airspace pathology including respiratory infection small airways disease Bronchiectasis Chronic obstructive pulmonary disease Interstitial, inflammatory, granulomatous and autoimmune lung disease Immune-mediated respiratory disease Occupational lung disease Cystic lung disease Smoking-related disease Pulmonary vascular disease and pulmonary embolism Trauma Acute lung injury / ARDS	US-guided drainage of pleural fluid Experience: CT guided chest biopsy Radionuclide imaging including ventilation / perfusion scintigraphy, Specialist: MRI thorax CT-guided tumour ablation

Paediatric Radiology	Abdominal pain, vomiting, mass Cough, breathlessness, wheeze, stridor Precocious / delayed puberty, ambiguous genitalia Failure to thrive Limp Trauma including suspected non accidental injury UTI Haematuria Testicular pain Pelvic pain, mass Headache, diplopia, epilepsy Back pain, paralysis	Acute neonatal and childhood abdominal conditions Acute and chronic chest conditions in neonates and children Cardiac and mediastinal abnormalities Conditions affecting the genitalia Childhood tumours Non-traumatic childhood skeletal conditions Accidental and non-accidental injury in children Disorders of the urinary tract Acute neurological conditions Congenital conditions Systemic diseases in children	Core Skills: Plain film Ultrasound (perform and interpret) CT MRI Experience: Fluoroscopic-guided contrast procedures of GI and GU tract Radionuclide imaging Intussusception reduction. Specialist: Image guided biopsy / intervention e.g. line insertion
Uroradiology	Haematuria Dysuria Polyuria Proteinuria Loin pain Urosepsis Renal failure Hypertension Micturition difficulties Raised PSA Scrotal pain Scrotal mass Renal and genitourinary trauma	Renal tumour Ureteric / bladder tumour Prostate tumour Testicular tumour Benign renal / adrenal masses Acute and chronic renal failure Renal replacement therapies Nephrotic syndrome Urolithiasis Renovascular disease Cystic renal disease Urinary tract infections Urinary tract	Core Skills: Plain film Ultrasound (perform and interpret) CT MRI Experience: Fluoroscopic-guided contrast studies of GU tract Radionuclide imaging Trans-Rectal Prostate Biopsy

		obstruction Benign prostatic hyperplasia	

Obstetric and Gynaecological Radiology	Dysfunctional menstrual bleeding Abnormal vaginal bleeding Abdominal/pelvic pain Pelvic mass Abdominal distension Primary and secondary amenorrhoea Abnormal tumour markers Infertility Prolapse symptoms Postpartum complications	Ovarian cysts and tumours Polycystic ovaries Congenital uterine anomalies Uterine tumours Cervical tumours Adenomyosis Endometriosis Pelvic Inflammatory Disease Fallopian tube disease Pelvic floor dysfunction Early pregnancy and complications Ectopic pregnancy Gestational trophoblastic disease Postpartum complications	Core Skills: Ultrasound (transabdominal and transvaginal) CT MRI Experience: Sonohysterography Specialist: Obstetric ultrasound and MRI Hysterosalpingography Dynamic pelvic floor imaging (MRI and fluoroscopy)
Oncologic Radiology	Anaemia Lymphadenopathy Paraproteinaemia Splenomegaly Weight loss Hypercalcaemia	Haematological malignancies (including lymphomas) Bone marrow failure Haemoglobinopathies Paraneoplastic conditions	Core Skills: Plain film Ultrasound CT MRI US / CT-guided biopsy Experience: PET/CT Clinical trial scoring
Others	Incidental findings Post-operative appearances and complications Iatrogenic conditions Trauma Sepsis Detection of acute bleeding		Experience: PET/CT Advanced Image reconstruction techniques Specialist: Post-mortem CT

Appendix 2: Scientific Basis of Imaging Syllabus

PHYSICS RELATED TRAINING CURRICULUM FOR RADIOLOGY

1. Background
    a. The curriculum for the Part 1 Physics programme was reviewed in 2018. Broad alignment with the 2016 RCR curriculum was maintained while using the 2016 ESR curriculum to identify learning outcomes.

2. Broad Learning Objectives
    a. Those who have followed the syllabus should be able to:
        i. Describe the structure and properties of matter, the phenomena of radioactivity and magnetism, the nature of ionising radiation, RF radiation, optical imaging and ultrasound and how they interact with matter and the differences between ionising and non-ionising radiation.
        ii. Distinguish and compare between different types of diagnostic medical images and understand how such images are created, reconstructed, processed, transmitted, stored and displayed
        iii. Describe the construction and function of medical imaging equipment including the radiation, optical or ultrasound source, image forming components and image or signal receptor and detectors used for QA and monitoring
        iv. Indicate how imaging equipment is operated and describe the imaging techniques that are performed with such equipment
        v. Identify and compare the type of information contained in images from different modalities
        vi. Distinguish between different indices of image quality, explain how they are interrelated and indicate how they are affected by changing the operating factors of the equipment
        vii. Explain the physical principles of how contrast agents enhance image contrast
        viii. Explain how the performance of imaging equipment is measured and expressed
        ix. Describe the principles of QA and outline how QC tests of imaging equipment are performed and interpreted
        x. Recognise artefacts in medical images and identify how they are removed

or their impact reduced

xi. Recognise the hazards and risks to patients, members of staff and members of the public associated with medical imaging and describe how their impact is reduced without compromising diagnostic image quality

xii. Identify the major pieces of UK legislation and guidance that affect the practice of medical imaging and interpret their requirements

xiii. Describe the use of functional and molecular imaging to probe biological processes in disease (Note: this is taught but not examined in the RCR programme)

3. Learning Outcomes

a. The 2016 ESR Curriculum has been used to provide learning outcomes for the RCSI Physics curriculum. Where differences were noted with the UK Curriculum, the outcomes were amended to more closely align with the UK Curriculum. The ESR curriculum embodies the concepts of Knowledge, Skills and Competences (KSCs) but for the purposes of the taught First Year Physics programme, only the topics identified under 'Knowledge' have been considered.

4. Matter and Radiation

i. To describe the structure of matter, the atom and the nucleus

ii. To explain the concept of radiation including electromagnetic waves and charged particles

iii. To describe the nature and properties of charged particles and electromagnetic radiation

iv. To list the sources and properties of ionising radiation

v. To describe electron band structure in solids and the phenomenon of luminescence

vi. To list and explain mechanisms of radioactive decay

vii. To list and explain the mechanisms of interaction between ionising radiation and matter/tissues

viii. To describe the attenuation of radiation by matter

ix. To explain the phenomena of X-ray interaction with matter and the consequences for image generation, image quality and radiation exposure

5. Principles of Imaging Technology & Molecular Imaging

a. In this section, the requirements under the heading 'Knowledge' are detailed for

Radiography, CT, MRI, Ultrasound, Imaging Informatics, Signal Processing and Molecular Imaging.

6. Radiography
    a. To understand the mechanism of X-ray production
    b. To list the components of an X-ray unit and explain the process of X-ray generation
    c. To have an in-depth understanding of the physical basis of image formation of conventional X-ray
    d. To describe X-ray production, with emphasis on the effects on dose and image quality of altering kV and mA and on the trade-off between diagnostic quality imaging and minimising the effective dose
    e. To describe the structure, role and function of filters, collimators and grids
    f. To explain the principles of radiographic image acquisition
    g. To list the common analogue and digital detectors, explain their function and their relative pros and cons
    h. To explain (briefly) the role of screens (in analogue radiography) and grids and their effect on image quality and exposure
    i. To describe image receptors for computed and digital radiography
    j. To explain the principles of digital image acquisition / digital radiography
    k. To describe the principles of image processing and its relevance in digital radiography including mammography
    l. To list and describe the factors affecting image quality in conventional and digital radiography
    m. To describe the principles of dual energy radiography
    n. To describe the principles of soft tissue radiography, e.g. in mammography
    o. To describe radiographic tomography and tomosynthesis
    p. To explain the principles of specimen radiography

7. Fluoroscopy
    i. To describe the principles of fluoroscopy
    ii. To describe the construction, function and operation of a fluoroscopy system
    iii. To describe image receptors for fluoroscopy; compare and contrast flat panel and image intensifiers
    iv. To describe scatter rejection in fluoroscopy
    v. To list techniques to enhance image quality and to reduce radiation in fluoroscopy
    vi. To describe image digitisation , angiography with contrast media including digital subtraction techniques
    vii. To describe the associated radiation hazards and identify appropriate methods of

optimisation

8. Computed Tomography – CT
    a. To have an understanding of the physical basis of image formation of computed tomography and of the physics of helical and multidetector CT
    b. To have a basic understanding of dual-source CT
    c. To list the major sources of artefacts in CT
    d. To define the scale of Hounsfield units and to explain the principle of window centre and width
    e. To list the normal levels of attenuation (in HU) for some organs in the body
    f. To understand CT fluoroscopy
    g. To understand gated imaging in CT
    h. To understand the principles of perfusion imaging with CT
    i. To understand the principles of CTA protocols, including contrast materials used and reconstruction techniques
    j. To explain the principles of reconstruction algorithms and kernels
    k. To understand iterative reconstruction
    l. To have a detailed understanding of CT-dosimetry
    m. To have a detailed understanding of radiation safety and factors affecting radiation dose

9. Magnetic Resonance Imaging – MRI
    a. To explain the fundamentals of MR physics
    b. To have a good understanding of the physical basis of image formation in MRI
    c. To explain the principles of pulse sequences and relaxation times
    d. To explain the principles of spin echo and gradient echo sequences
    e. To describe the principles and main diagnostic applications for the most commonly used sequences in MRI, including T2-weighted sequences, T1-weighted sequences, STIR sequences, FLAIR sequences, other inversion recovery sequences, and T2*- / susceptibility weighted sequences
    f. To understand the sequence technology for MR angiography (MRA) including time of flight (TOF) MRA and contrast-enhanced MRA
    g. To understand the physical principles underlying the use of different contrast materials for MRA
    h. To discuss the differences between time-of-flight, phase contrast, and contrast-enhanced techniques pertaining to MRA
    i. To introduce the principles of diffusion-weighted imaging (DWI) and diffusion

tensor imaging (DTI)

j. To describe typical artefacts on MR imaging and to discuss their respective causes
k. To explain the absolute or relative contraindications against MR imaging and how to handle MR examination of patients with relative contraindications requiring examination in special coils, etc.
l. To explain the safety issues in the MR environment with regard to patients and staff
m. Layout of MR Suite
n. Legislative requirements

10. Ultrasound

a. To describe the nature of ultrasound waves, their propagation, velocity, intensity and the equations that describe them
b. To describe the principles of acoustic impedance and to list the tissue properties that determine it
c. To describe the frequency of transmission to achieve satisfactory imaging
d. To describe the physical principles of the piezoelectric phenomenon
e. To list factors that determine the resonance frequency of the piezoelectric element
f. To explain the principles of continuous and pulsed emission ultrasound
g. To list the factors that focus and unify the ultrasound beam
h. To describe the differences between the A, B and TM modes of ultrasound
i. To explain the principles of spatial and temporal resolution of ultrasound images as applied to good image formation
j. To explain the principles of the Doppler effect and the application of angled beam and direction of flow
k. To describe the application of pulsed and continuous wave Doppler and spectral waveform analysis
l. To describe the thermal and mechanical biological effects of ultrasound waves, including production of the cavitation phenomenon
m. To describe the different types of transducers in ultrasound imaging and how design affects how they are used
n. To list the appropriate transducers according to the organs imaged
o. To describe criteria for a good ultrasound image
p. To describe the major artefacts on ultrasound imaging including reflection, diffusion and speckle and to list their respective causes
q. To describe microbubble and particle suspension contrast agents
r. To describe the physical effects arising from the interaction of ultrasound with tissue – heating, streaming, cavitation and mechanical damage

s. To explain thermal and mechanical indices
t. To explain the concepts of intensity and energy limits
u. To explain the factors that influence patient and staff safety
v. To describe the measures that should be put in place to ensure safety in ultrasound

11. Imaging Informatics

a. To explain the infrastructure of imaging informatics, including Picture Archiving and Communication Systems
b. (PACS), Radiological Information Systems (RIS) and Electronic Patient Records
c. To list informatics standards, including DICOM, HL7 and IHE
d. To have an understanding of image processing and analysis tools, including 2D and 3D reconstructions, 2D and 3D image analysis, quantitative imaging, image fusion, virtual reality, augmented reality, functional analysis, and computer aided diagnosis
e. To have an understanding of structured reporting
f. To describe the technology and performance characteristics of display monitors
g. To have an understanding of how Artificial Intelligence can be used in Radiology

12. Signal Processing and Post-Processing

i. To have a basic understanding of the principles of signal processing
ii. To describe the principles of linear systems including convolution, Fourier transformation, Nyquist, image enhancement, and deconvolution
iii. To describe the principles of image display
iv. To have an in-depth understanding of image quality, including noise, contrast, resolution, and noise amplification during processing
v. To be familiar with the principles of quantification including ROI analyses, time–activity curves
vi. To understand the principles of image processing including edge, detectors, smoothing, segmentation, image reconstruction, image fusion, registration, and display

13. For all relevant imaging modalities – General Radiography, Fluoro, CT , Mammo, NM & PET

a. To understand the physics of image production and how it impacts on image quality
b. To describe the principles of digital imaging and image processing pertinent to the

modality

c. To understand the influence of imaging parameters on image quality and radiation dose (where applicable)
d. To understand the way that agents can influence image contrast
e. To recognise artefacts and understand the underlying causes
f. To describe the essential elements of a QA programme and the relevant quality control measures
g. To specify typical doses from imaging modality
h. To identify measures that can affect patient and staff dose
i. To understand techniques to reduce exposure doses
j. To identify any special radiation protection considerations for a modality
k. To appreciate the effect of the properties of the machine/scanner on image
l. To understand the best compromises between risk-benefit-ratio, image quality and radiation exposure on a case-by-case basis.
m. To define Quality Assurance (QA) in radiology, QA management and responsibilities, outline a QA and radiation protection programme for diagnostic radiology
n. To describe the concept of Diagnostic Reference Levels (DRLs) and how they are used in practice

14. Nuclear Medicine

a. The requirements listed under knowledge in the Nuclear Medicine Chapter are detailed below and all of these would be covered as part of the physics module. The requirements listed under Skills and Competences are more relevant to the radiology and anatomy programmes.
b. To describe basic principles of atomic and nuclear physics including the basic atomic structure, principles of radioactivity and basic of radioactive decay
c. To be familiar with basic principles of radiopharmaceuticals, including the production of radionuclides, the manufacturing of radiopharmaceuticals, the desirable characteristics and physiological clearance of radiopharmaceuticals
d. To explain the principles of biological and effective half-life
e. To understand standardized uptake values (SUV)
f. To describe the basic physical principles of nuclear medicine imaging technology, including gamma cameras, single photon emission computed tomography (SPECT), positron emission tomography (PET)
g. To understand the basic physical principles of hybrid imaging, including PET-CT, SPECT-CT, and MR-PET
h. To be familiar with imaging performance parameters, including uniformity of

response, system sensitivity, spatial resolution, spatial linearity, count rate performance, and image quality

i. To understand safety aspects in nuclear medicine, including patient dosimetry, staff dosimetry, contamination monitoring, choice of equipment, quality control and safety/risk management

15. Molecular Imaging

i. To understand the basic principles of the most commonly used molecular imaging methods, including nuclear medicine (PET, micro-PET, micro-SPECT)
ii. To list the most commonly used tracers in molecular imaging
iii. To understand PET image analysis and data processing

16. Radiation Protection

a. Within the existing programme, there is a two day seminar allocated to cover radiation protection. The scope of this seminar is broad and wide ranging. Radiation protection should also be integrated into the entire programme and be a fundamental element within the various modality lectures over the course of the year. Trainees should be able to describe the physical principles underlying the various imaging modalities, to understand the associated doses, to be able to apply techniques to reduce exposure dose and to have mastered basic image processing concepts and practical skills. Radiation protection should also be actively integrated into the training element of the programme with appropriate emphasis on the application of key knowledge into routine practice.

b. Specific requirements relating to Radiation Protection are listed below.
    i. To list and explain definitions, quantities and units of kerma, absorbed energy dose (Gy), organ and effective doses (Sv), as well as exposure rate and dose rate
    ii. To describe radiation effects on cells and DNA
    iii. To describe cellular mechanisms of radiation response, repair and cell survival
    iv. To describe radiation effects upon tissues and organs
    v. To define and explain stochastic, deterministic and teratogenic radiation effects
    vi. To describe types and magnitudes of radiation risk from radiation exposure in medicine

vii. To describe the basic principles of radiation protection, as outlined by the ICRP (International Commission on Radiological Protection)
viii. To specify types and magnitudes of radiation exposure from natural and artificial sources
ix. To describe concepts of dose determination and dose measurement for patients, occupationally exposed personnel and the public
x. To explain the nature of radiation exposure and the relevant dose limits for the worker, including organ doses and dose limits for pregnant workers, comforters, careers, and the general public
xi. To define As Low As Reasonably Achievable (ALARA) and its applicability to diagnostic radiology settings
xii. To explain the concepts and tools for dose management in diagnostic radiology with regard to adult and paediatric patients
xiii. To explain the factors influencing image quality and dose in diagnostic radiology
xiv. To describe the methods and tools for dose management in diagnostic radiology: radiography, fluoroscopy, CT, mammography, and those for paediatric patients
xv. To explain the basic concepts of patient dose measurement and calculation for the different modalities in diagnostic radiology
xvi. To describe the key considerations relevant to radiation protection when designing a diagnostic radiology department
xvii. To list expected doses (reference person) for frequent diagnostic radiology procedures
xviii. To explain quantitative risk and dose assessment for workers and the general public in diagnostic radiology
xix. To explain the principle of diagnostic reference levels (DRLs)
xx. To list national and international bodies involved in RP regulatory processes
xxi. To specify the relevant regulatory framework (ordinances, directives, etc.) governing the medical use of ionising radiation in the respective country and the EU
xxii. To specify the relevant regulatory framework governing the practice of diagnostic radiology in the respective country and in the EU
xxiii. To understand the effects of poor-quality images
xxiv. To have a basic understanding of dosimetry
xxv. To have a basic understanding of radiation biology