**AUSTRALIAN AND NEW ZEALAND
COLLEGE OF VETERINARY SCIENTISTS**

FELLOWSHIP GUIDELINES

Veterinary Radiology

ELIGIBILITY

1.   The candidate must meet the eligibility prerequisites for Fellowship outlined in the *Fellowship Candidate Handbook*.

2.   Membership of the College must be achieved prior to the Fellowship examination.

3.   Membership must be in Veterinary Radiology.

OBJECTIVES

To demonstrate that the candidate has attained sufficient knowledge, training, experience, and accomplishment to meet the criteria for registration as a specialist in veterinary radiology.

LEARNING OUTCOMES

The field of veterinary radiology includes the study of all domestic animals. There is no provision for sub-specialisation within the discipline.

The candidate will have a **detailed[1] knowledge** of:

1. Radiation physics as it applies to veterinary radiography
    1.1.   atomic and nuclear physics including atomic composition, structure and binding forces
    1.2.   forms of electromagnetic radiation
    1.3.   production of x-rays, interaction of x-rays with matter, components and function of the x-ray tube, components and function of x-ray detection systems (both film-screen and digital radiography)

---

[1] **Knowledge Levels**:
    Detailed knowledge - candidates must be able to demonstrate an in-depth knowledge of the topic including differing points of view and published literature. The highest level of knowledge.
    Sound knowledge – candidate must know all of the principles of the topic including some of the finer detail, and be able to identify areas where opinions may diverge. A middle level of knowledge.
    Basic knowledge – candidate must know the main points of the topic and the main literature.

1.4.   radiographic artefacts (both film-screen and digital radiography).

2. Digital radiography including image formation, different capture devices, resolution, storage, the processing of photostimulable phosphor plates (PSP), the advantages and disadvantages of different types of digital radiography.

3. Computed Tomography (CT) physics:
    3.1.   image formation including CT construction and scanner types, image manipulation
    3.2.   factors that affect CT image quality
    3.3.   CT artefacts.

4. Magnetic Resonance Imaging (MRI)physics:
    4.1.   image formation, including equipment, magnet field strengths, and an understanding of the principles of acquisition of SE, FSE, GRE sequences of different tissue weightings.
    4.2.   factors that affect MRI image quality
    4.3.   MRI artefacts
    4.4.   practical applications of MRI safety.

5. Ultrasound physics:
    5.1.   image formation including equipment
    5.2.   physical characteristics of the ultrasound beam and the interaction of ultrasound with matter
    5.3.   physics of Doppler, harmonic and compound imaging
    5.4.   ultrasound artefacts

6. Contrast media:
    6.1.   radiographic, CT and MRI contrast media including mechanism, side effects, administration and dose.

7. Anatomy,physiology and pathophysiology as related to veterinary radiology of dogs, cats and horses.

8. Clinical and pathophysiological features as related to veterinary radiology of canine, feline and equine disease of all body systems.

9. Practical applications of all modalities.

The candidate will have a **sound knowledge** of:

1. Radiation safety in veterinary medicine:
    1.1.   principles of radiation protection including the ALARA concept
    1.2.   interactions of electromagnetic and particulate radiation with matter
    1.3.   biological effects of radiation in a clinical radiology context
    1.4.   mechanisms of acute and late radiation injury
    1.5.   radiation monitoring, safety equipment and regulations

> 1.6. relevant Australian and New Zealand laws and Codes of Practice as they apply to the use of ionising radiation.

2. Embryology of the cardiovascular, urinary and neurological systems as it relates to development of congenital conditions of these systems.

3. Radiation physics as it applies to:
    3.1. fluoroscopy and the image intensifier
    3.2. nuclear scintigraphy

4. Ultrasound contrast media including mechanism of action, side effects, administration and dose.

The candidate will have a **basic knowledge** of:

1. Anatomy, physiology and pathophysiology of disease as related to veterinary radiology of production animals, native and exotic species, avian, and pocket pet species.

2. Radiation oncology:
    2.1. principles of radiation therapy
    2.2. radiobiology of the cell cycle.

3. The biological effects of ultrasound.

The candidate must be able to demonstrate a **detailed[2] level of expertise** in:

1. Image acquisition, interpretation and reporting:
    1.1. radiographic, ultrasound, CT and MRI images in dogs, cats and horses.

2. Image guided biopsy:
    2.1. techniques, including fine needle aspiration and percutaneous biopsy

3. Critical evaluation of the current literature and concepts in the field of Veterinary Radiology.

The candidate must be able to demonstrate a **sound level of expertise** in:

1. Image acquisition, interpretation and reporting:
    1.1. nuclear medicine (NM) studies in both small and large animals.
    1.2. radiographic, ultrasound, CT and MR images of species other than dogs, cats and horses

---

[2] **Skill levels:**
  Detailed expertise – the candidate must be able to perform the technique with a high degree of skill, and have extensive experience in its application. The highest level of proficiency.
  Sound expertise – the candidate must be able to perform the technique with a moderate degree of skill, and have moderate experience in its application. A middle level of proficiency.
  Basic expertise – the candidate must be able to perform the technique competently in uncomplicated circumstances.

EXAMINATIONS

Exam Format:
The examination will comprise of three components:

1. Two written examinations each of 180 minutes each

2. A practical examination comprising of 370 minutes

3. An oral examination comprising of at least 60 minutes, and no longer than 120 minutes.

Written exams: Two (2) written examinations of three (3) hours duration each (total of 6 hours).

Each written examination will comprise of
• 4 x essay-type questions of 30 minutes each. Questions can be broken into multiple sub-parts. TOTAL TIME: 120 minutes
• 12 short-answer questions (5 minutes each) TOTAL TIME: 60 minutes

Candidates are required to answer showing reference to the literature (e.g. citing relevant studies that inform their answers). Ideally citations should include the primary author, journal abbreviation and publication year; in cases where this recall is not possible, as much detail as possible should be included.

Candidates will often be expected to use their own clinical experience in answering questions, demonstrating experience with modalities.

Perusal time of 20 minutes will be provided at the start of each written paper; candidates are recommended to use this time to *read carefully* the questions and plan their essay answers. During this time candidates may make notes on the examination paper but not write in the answer book. Care should be taken to address the question posed.

Written Paper 1:
Designed to test the Candidate's knowledge and clinical application of physics, anatomy and pathophysiology as described in the Learning Outcomes.

Written Paper 2:
Designed to test the Candidate's ability to apply the principles of Radiology to particular cases/problems or tasks. The candidate may be required to draw on their knowledge of pathophysiology, physics and anatomy to answer the questions.

Practical examination: Two (2) examinations of three (3) hours duration writing time (total of 6 hours).

Each practical examination will test the candidate's ability to produce written case reports. Each examination will have a five (5) minute rest break in the middle hour. During this break, the candidate will put down their pen, cease writing and turn their paper over. No talking will be allowed. Candidates may use the bathroom during this period. Each examination will last for 185 minutes (including rest breaks). No perusal time will be given.

Practical exam format:

- The case material presented will be in a digital format. At least one large monitor per candidate will be provided for viewing studies.
- The first examination will comprise of radiographic (XR) cases. 15 Fifteen minutes will be allocated to each case for a total of 12 cases in 180 minutes. 5 minutes of rest break will be allocated between questions 6-7. Candidates are allowed to work through the cases at their own pace and need to manage time allocation to each case appropriately.
- The second examination will comprise of advanced imaging (approx. 30% CT, 30% MRI, 30% US and 10% Nuclear Medicine). 20Twenty minutes will be allocated to each case (20 minutes per CT and MR, with a combination of US/NM cases occupying the remaining time). 5 minutes of rest break will be allocated between questions 5-6.
- Approximately equal numbers of cases of thoracic, abdominal, musculoskeletal and neurological body systems will be presented across both examinations.
- eFilm will be used as a universal DICOM Viewer, unless otherwise informed by the College. Candidates should be familiar with the basic functions (pan, zoom, magnify, alteration of window/level, flip orientation functions) of this viewer. Free versions are available to download from the internet.
- For XR, US, NM and MR studies, candidates will be presented with the appropriate images in an appropriate format to make a diagnosis.
- For CT studies, candidates will be presented in a format where the pathology is visible (candidates will not be expected to make reconstructions or multiplanar reformats in different windows from those presented).

Practical answer style:

- Each case presented in an exam section is worth a total of 20 points.
- Candidates will be provided with information about the study (whether XR, US, CT etc), signalment and limited history.
- Examiners are looking for a systematic evaluation of the study
- Candidates will be awarded points marks for the following:
    - Detailed description of imaging abnormalities.
    - Interpretation of the imaging abnormalities in light of the patient's history and clinical signs.
    - Formulation of a ranked list of differential diagnoses or diagnosis where appropriate.
- Candidates must demonstrate to the examiners their thought processes, prioritisation and conclusions.
- Normal findings need not be described, unless relevant to answer the clinical question.
- Candidates should not comment on artefacts unless they are pertinent to interpretation of the study.
- Individual candidate style will not affect the allocation of marks (e.g. descriptive sentences or dot points can both be valid answers for the observation of imaging abnormalities or conclusions) however as marks are awarded for a systematic appraisal, regardless of style.
- Terminology should utilise the Nomina Anatomica Veterinaria, and avoid colloquial language.

Oral Examination:

• Questions will be provided in a digital format using a proprietary viewer or Power Point.

• These questions aim to test how the candidate arrives at their radiographic conclusions.

• Candidates will be provided with information about the study such as signalment and limited history.

• For imaging studies consisting of large data sets, the relevant images (single images, series, sequences) will be provided.

• Candidates may request additional imaging studies.

• The candidates must demonstrate to the examiners their thought processes, prioritisation and conclusions.

• Candidates will be awarded points for the following:

> • Description of imaging abnormalities.

> • Formulation of rational imaging conclusions and a ranked differential diagnosis list, or diagnosis where appropriate

> • Ability to synthesise imaging findings with the patient's clinical history and signs. Candidates should demonstrate an understanding of the pathophysiology of observed abnormalities and rational justification for the use of ancillary tests.

> • Ability to make appropriate recommendations for additional patient management recommendations, including both imaging-related diagnostics and other pertinent diagnostic testing. The candidate may recommend and ask for further imaging studies. E.g.For example, if it is appropriate after reading a radiographic study to recommend ultrasound, the candidate may ask whether such a study is available.

• Normal findings need not be described, unless relevant to answer the clinical question.

• Candidates should not comment on artifacts unless they are pertinent to interpretation of the study

Examples of questions:

1. Thoracic radiograph series of a dog. "This is a 7 year old Doberman with recent onset tachypnoea. Give your radiographic description and conclusions".

2. Two transverse images of an MRI study of a canine brain, pre and post contrast. "Describe briefly the pathology that you see. What are you differentials for this lesion" (The images demonstrate a typical meningioma).

3. An image showing a spectral Doppler trace through a normal LVOT: "What is this image depicting? What would you expect to see if a patient had aortic stenosis?"

4. "Describe the artefact you see and discuss how this occurred"

5. An image depicting a brand of contrast medium. "What is this chemical? What are the indications and contraindications for its use?"

Additional notes for the Practical and Oral Examination

In the practical and oral examinations, candidates will be provided with information about the study they are receiving. They will not be awarded marks for describing that a study is a three-view thoracic radiographic study, or an echocardiogram of a cat's heart, etc.

Examples:
1. Three-view thorax. History and signalment provided.
2. MRI brain, T1W pre and post, transverse, sagittal planes, T2W transverse sagittal plane, FLAIR, transverse plane, GRE transverse plane. History and signalment provided.
3. Thoracic CT: lung window, soft tissue window pre and post. Sagittal MPR (post-contrast soft tissue window). History and signalment provided.

An exception to this may be a specific question requiring recognition of MRI sequences, naming radiographic projections or similar.

TRAINING PROGRAMS
Refer to the *Fellowship Candidate Handbook*, Section 3.3.

In addition to the stipulations of the *Fellowship Candidate Handbook*:

1. The Radiology Chapter requires a three year training program (144 weeks)

2. Clinical training should include primarily exposure to dogs, cats and horses with some exposure to production animals, camelids, native and exotic animals, pocket pets and birds.

3. Clinical training should include the following: radiography, radiology, contrast procedures, fluoroscopy/image intensification, digital radiography, sonography, sonology, scintigraphy, computed tomography and magnetic resonance imaging.

4. The candidate should interpret a minimum 3000 radiographic examinations of small animals (primarily dogs and cats), 500 radiographic examinations of large animals (primarily horses), 1000 sonographic examinations, and a minimum of 500 examinations that demonstrate adequate knowledge and interpretive skills in CT, MRI and nuclear medicine.

The cases to be included in the case log will be those cases in which the candidate has produced a written report that has been reviewed by a Supervisor. If, for example, a case has an osteosarcoma of its radius and thoracic radiographs for a metastasis check then this may be counted as two cases if a report is produced for both regions.

The training program should be targeted, with achievable goals set by the Supervisor and candidate for each 6 months. It is anticipated that the first year should be spent initially learning some radiography, then concentrating on radiology and ultrasound with some exposure to the other modalities. The second year is spent consolidating the first with more CT, nuclear medicine with shifting emphasis in the third year to more CT and MRI and nuclear medicine with further consolidation of radiology and ultrasound. It should be expected that the candidate's case log output is lower in the first year but that they become more independent and productive in their second and third years.

Sonography and Sonology Assessment:
The candidate's supervisor will continually assess the Candidate's development of sonography and sonology skills. If the Candidate's skills were found to be less than satisfactory at the end of the third year of their approved training program, the Candidate will be required to undertake further training before being further assessed. The Candidate will not proceed to formal examinations until they have been determined to have adequate sonography and sonology skills. A pro-forma letter (Appendix 1) will be completed by the Candidate's supervisor and submitted with the Fellowship training credentials documentation, to state whether the Candidate is considered technically proficient in ultrasound, and to justify the reasons for the assessment.

TRAINING IN RELATED DISCIPLINES
Refer to the *Fellowship Candidate Handbook*, 2.4.2.

Candidates for Fellowship in Veterinary Radiology must spend time as stipulated by the *Fellowship Candidate Handbook* in any four of the following related disciplines: Pathology, Small Animal Medicine, Canine Medicine, Feline Medicine, Cardiology, Small Animal Surgery, Equine Medicine, Equine Surgery, Neurology, Oncology.

EXTERNSHIPS

Refer to the *Fellowship Candidate Handbook*, Section 2.4.1.

ACTIVITY LOG SUMMARY

An Activity Log Summary should be provided for each imaging modality (Radiology, Ultrasound, Special Radiographic Procedures, CT, MRI and Nuclear Medicine) according to the template provided in Appendix 2. Each summary should be submitted with the annual supervisor's report, with a cumulative total for the total training period. For each imaging modality, cases are recorded by species and the region imaged (as listed below). This allows the candidate and their supervisor to monitor their case load for each modality (e.g. numbers of canine abdominal ultrasounds, numbers of equine musculoskeletal radiographs, etc), and assess whether the targets mentioned above (section 4 under the 'Training Programs' heading) are being achieved.

Radiology:
Thorax
Abdomen
Musculoskeletal
Neurological
Other

Ultrasound:
Thorax - non cardiac
Thorax - cardiac
Abdomen
Musculoskeletal
Small Parts (eg thyroid, eye, etc)
Biopsies/FNA

Special Radiologic Procedures:
Myelography
Urinary contrast studies
Oesophagrams
Other contrast studies
Fluoroscopy (non-contrast)

CT:
Thorax
Abdomen
Musculoskeletal
Neurological

MRI:
Neurological
Other

Nuclear Medicine:
   Musculoskeletal
   Thyroid
   Hepatic
   Other

Species list for each modality:
   Canine
   Feline
   Equine
   Production animals (cows, sheep, goats, alpacas, pigs)
   Avian/Other

Note that an imaging study of a region is considered a case. If multiple regions are imaged of a single patient (e.g. radiographs of a long bone and thorax for metastasis check) these would be considered two cases; one musculoskeletal and one thorax – non cardiac, provided both are reported.

PUBLICATIONS and PRESENTATION
Refer to the *Fellowship Candidate Handbook*, Section 2.10.

RECOMMENDED READING LIST

The candidate is expected to research the depth and breadth of the knowledge of the discipline. This list is intended to guide the candidate to some core references and source material. The list is not comprehensive and is not intended as an indicator of the content of the examination. Candidates at Fellowship level are expected to have library search skills and maintain a watching brief over relevant literature.

Physics

Bushberg JT, Seibert JA, Leidholdt Jr EM, Boone LM (2011) The Essential Physics of Medical Imaging 3 ed. Lippincott, Williams and Wilkins

Curry T.S. et al (1990) Christensen's Physics of Diagnostic Radiology 4th ed. Lea and Febiger, Philadelphia.

Kremkau F.W. (2010) Sonography Principles and Instruments. 8th ed W.B Saunders CO. Philadelphia.

Radiation Protection and Safety

Relevant Australian State or New Zealand legislation and codes of practice governing the safe use of ionising radiation.

Anatomy

Coulson A and Lewis N (2006) An Atlas of Interpretive Radiographic Anatomy of the Cat and Dog, 2nd ed. Blackwell Publishing

Denoix JM (2005) The Equine Distal Limb – An Atlas of Clinical Anatomy and Comparative Imaging. Manson Publishing, London.

Evans HE and Christensen CC (1993) Miller's Anatomy of the Dog. 3rd Ed. W.B. Saunders Co. Philadelphia.

Getty R (1975) Sisson and Grossman's Anatomy of Domestic Animals. 5th ed. W.B. Saunders Co. Philadelphia.

Schebitz H and Wilkens H (1986) Atlas of Radiographic Anatomy of the Horse. Verlag Paul Parey, Berlin.

Schebitz H and Wilkens H (1986) Atlas of Radiographic Anatomy of the Dog and Cat. Verlag Paul Parey, Berlin.

Silverman S and Tell L (2005) Radiology of Rodents, Rabbits, and Ferrets. Pub Elsevier Saunders, Missouri.

Smith SA and Smith BJ. (1992) Atlas of Avian Radiographic Anatomy. Saunders. Philadelphia

Imaging

Barr FJ and Kirberger RM (2006) BSAVA Manual of Canine and Feline Musculoskeletal Imaging. Pub BSAVA

Berry C.R. and Daniel G.B. (2006) Textbook of Veterinary Nuclear Medicine, North Carolina State University, Raleigh.

Boon JA (2011) Manual of Veterinary Echocardiography, 2nd ed. Wiley-Blackwell

Butler J.A. et al (2008) Clinical Radiology of the Horse, 3rd ed. Blackwell Scientific Publications, Oxford.

Dennis R, Kirberger R, Wrigley R. (2010) Handbook of Small Animal Radiological Differential Diagnoses, 2nd ed. W. B. Saunders

Ettinger SJ, Feldman (2010) Textbook of Veterinary Internal Medicine. 7th ed. W.B. Saunders Co. Philadelphia.

Gavin P, Bagley RS (2011) Small Animal Practical MRI. Wiley Blackwell

Kidd, Lu, Frazer. (2014) "Atlas of Equine Ultrasonography", Wiley-Blackwell

Kittleson and Keinle (1998) Small Animal Cardiovascular Medicine. Mosby, St Louis

Lavin. (2013) Radiography in Veterinary Technology. 5th ed. Saunders, Philadelphia.

Mattoon JS and Nyland TG (2015) Veterinary Diagnostic Ultrasound. 3rd ed. Saunders Philadelphia.

Morgan JP (2002) Radiology of Veterinary Orthopedics: Features of Diagnosis. Wiley.

Morgan JP, Leighton RL (1995) Radiology of Small Animal Fracture Management. WB Saunders Co. Philadelphia

Morgan JP, Wind A and Davidson AP (2000) Heriditary Bone and Joint Diseases in the Dog. Schlutershe & Co , Germany

Murray E (2010) Equine MRI. Wiley Blackwell

O'Brien T.R. (1978) Radiographic Diagnosis of Abdominal Disorders in the Dog and Cat. W.B. Saunders Co. Philadelphia.

Penninck D and D'Anjou M (2008) Atlas of Small Animal Ultrasonography Blackwell Publishing

Rantanen NW and McKinnon AO (1998) Equine Diagnostic Ultrasonography. Williams and Wilkins

Reef VB (1998) Equine Diagnostic Ultrasound. W. B. Saunders. Philadelphia

Ross M.W., Dyson S.J. (2003) Diagnosis and Management of Lameness in the Horse

Schwartz T and Johnson VJ (2008) BSAVA Manual of Canine and Feline Thoracic Imaging. BSAVA

Schwartz T and Saunders J. (2011) Veterinary Computed Tomography. Wiley Blackwell

Sharp NJH and Wheeler SJ. (2005) Small Animal Spinal Disorders 2nd ed. Elsevier

Stashak TS (2001) Adam's lameness in horses. 4th ed. Lea and Febiger, Philadelphia.

Suter PR (1984) Thoracic Radiography. A text atlas of thoracic diseases of the dog and cat. Peter F. Suter, Wettswil, Switzerland

Thrall DE (2012) Textbook of Veterinary Diagnostic Radiology. 6th edition. Saunders Co. Philadelphia.

Withrow S J MacEwan EG (2012) Small animal clinical oncology. 5 t h e d . Saunders., Philadelphia

FURTHER INFORMATION

For further information contact the College Office

Telephone: International +61 (07) 3423 2016

Fax: International +61 (07) 3423 2977

Email: examinations@anzcvs.org.au

Web: www.anzcvs.org.au

Postal Address: Building 3, Garden City Office Park, 2404 Logan Road
                    EIGHT MILE PLAINS QLD 4113 Australia

Appendix 1:

Ultrasound Proficiency Report, Veterinary Radiology Fellowship (template)

Date:
Candidate's name:
Fellowship Subject:

Supervisor's name and qualifications:
Supervisor's position:

This report certifies that I have continually assessed the Candidate's development of sonography and sonology skills throughout the period of directly supervised training.

The Candidate *has/has not* [delete the inappropriate string] developed these skills to a satisfactory level during this time.

Comments:
[Please enter any comments that justify your assessment].

Supervisor's signature.

Appendix 2:

ACTIVITY LOG SUMMARY: By Technical Procedure and Species

CANDIDATE:

SUMMARY FOR THE PERIOD OF:

Radiology

	Canine	Feline	Equine	Production Animals	Avian/Other	**Total**
Thorax						
Abdomen						
Msk/Neuro						
Other						
Total						

Ultrasound

	Canine	Feline	Equine	Production Animals	Avian/Other	**Total**
Thorax - ncd						
Thorax - cardiac						
Abdomen						
Msk						
Biopsies/FNA						
Other						
Total						

Special Radiographic Procedures

	Canine	Feline	Equine	Production Animals	Avian/Other	**Total**
Myelography						
Urinary contrast						
Oesophagram						
Osc						
Fluoroscopy (nc)						
Total						

CT

	Canine	Feline	Equine	Production Animals	Avian/Other	**Total**
Thorax						
Abdomen						
Msk						
Neurological						
Total						

MRI

	Canine	Feline	Equine	Production Animals	Avian/Other	**Total**
Neurological						
Other						
Total						

Nuclear Medicine

	Canine	Feline	Equine	Production Animals	Avian/Exotic	**Total**
Msk						
Thyroid						
Hepatic						
Other						
Total						

Msk   musculoskeletal
nc   non - contrast
ncd   non – cardiac
Ocs   other contrast studies