Chapter

Introductory Chapter: Veterinary Anatomy and Physiology

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1. History of veterinary anatomy and physiology

The anatomy of animals has long fascinated people, with mural paintings depicting the superficial anatomy of animals dating back to the Palaeolithic era [1]. However, evidence suggests that the earliest appearance of scientific anatomical study may have been in ancient Babylonia, although the tablets upon which this was recorded have perished and the remains indicate that Babylonian knowledge was in fact relatively limited [2].

As such, with early exploration of anatomy documented in the writing of various papyri, ancient Egyptian civilisation is believed to be the origin of the anatomist [3]. With content dating back to 3000 BCE, the Edwin Smith papyrus demonstrates a recognition of cerebrospinal fluid, meninges and surface anatomy of the brain, whilst the Ebers papyrus describes systemic function of the body including the heart and vasculature, gynaecology and tumours [4]. The Ebers papyrus dates back to around 1500 BCE; however, it is also thought to be based upon earlier texts. In the early third century, a school of anatomy was founded in Alexandria and became the first of its kind carrying out human dissection [5]. It was based on the Greek system, following Hippocratic teachings. Hippocrates (ca. 460–370 BCE) had described the human brain as being in two halves divided by a thin vertical membrane, as it was in other animals. The most renowned Alexandrian physicians were Herophilus and Erasistratus. Many graduates of this medical school travelled and practiced throughout the Mediterranean basin.

Many renowned Greek anatomists studied in Alexandria, but as Egypt entered a slow decline, developments in Greek philosophical and scientific culture began to surpass all current knowledge of anatomy and physiology [4]. The early scientist Alcmaeon of Croton, a Greek medic is widely credited for attributing the mind to the brain in around 500 BCE [6]. He also observed that the arteries and veins in his animal dissections appeared dissimilar to each other [7]. Herophilus progressed these theories around the brain and identified the organ as the centre of the nervous system [8]. Herophilus was born in 335 BCE, studied in Alexandria and remained there during the reigns of the first two Ptolemaios Pharaohs and is said to be the first anatomist to perform a systematic dissection of the human body. Erasistratus concentrated on physiology and mechanisms rather than the pure anatomy. This was not always a popular method of describing the body during either his life or later on.

Roman Marcus Aurelius (161–180 CE) highlighted that physicians were more likely to maim or kill their patients they were not aware of the anatomy required. He was famous for his mission to understand anatomy and physiology in a range of animals extending from monkeys and snakes to cattle and cats, in both adults and young. He even noted the similarities between macaques and humans. Ultimately it was the Greek Aristotle who became known as the father of comparative anatomy through his dissections performed on a variety of animals, including mammals, reptiles and insects [9].

Moving into the second century, the Greek anatomist Galen pioneered a number of anatomical and physiological theories, mainly through animal dissection [5]. Galen was responsible for the discovery of the recurrent laryngeal nerve [10], and had many advanced theories on wound healing [11]. His work remained influential in anatomical and physiological science for fifteen centuries and allowed significant advancements in medicine [12].

In the following years, until the twelfth century, much of the anatomical study that took place was therapeutically focussed and completed following the written works of early authors such as Galen [13]. The appearance of anatomist Mondino dei Luzzi in the thirteenth century induced progression in anatomical and physiological study based upon his work with human cadaver dissection [14]. Whilst Andreas Vesalius, an important figure in the Renaissance, pushed forward physiological study with accurate accounts of the mechanics of pulmonary ventilation, among many other revelations in his 1543 work entitled 'De Humani Corporis Fabrica' [15].

A number of years later, born in 1578 in England, William Harvey was the first to correctly describe the circulatory system, identifying the blood flow returning to the heart and the heart acting as a muscular pump [16]. Harvey also proposed the idea of capillary anastomoses joining the arterial and venous systems, although their existence was not proven until after his death by Marcello Malpighi in 1661 [16].

The eighteenth and nineteenth centuries saw dissection became a more prominent feature in anatomical study, when William Hunter encouraged students to carry out their own dissection on cadavers. This however led to 'body-snatching', and as a result, The Anatomy Act (1832) was enforced in order to regulate the acquisition of human cadaveric material [17]. This regulation favoured the anatomy schools based in hospitals and as such, the professionalisation of the science was observed [18].

At the present time, anatomy and physiology are unarguably fundamental aspects of medical education and can be taught in many ways including dissection, 'self-directed learning' and 'problem based learning' [19]. Recent developments in technology have allowed digital anatomical models to be implemented into university curricula, allowing wider access to the study of anatomy for the contemporary student [20].

2. Imaging technology within anatomy and physiology

In the days of the first anatomists and physiologists discussed above, fewer tools and techniques were available to allow visualisation of the body. Over the years many techniques have been developed by scientists that have been essential for veterinary and human anatomists and physiologists alike. Dissection and drawing were always essential skills and are still used today. As the first microscopes were developed the ability to see within the tissue and cell both anatomy and physiology were advanced, alongside medical practice. The first modern microscope developed by Hans and Zacharias Janssen in 1590 has certainly changed over the years [21]. There is also much evidence to suggest the use and theories on early microscopes and lens magnification from early China 4000 years ago and even the ancient Greeks and Romans. Hooke also designed a microscope and wrote the now famous 'Micrographia' and Antonie van Leeuwenhoek-the Father of the Microscope developed this work and his publications to the Royal Society were validated by non-other than Hooke [21]. The modern microscope has advanced greatly with optical microscopy utilising a nonlinear optical phenomenon, electron microscopy, confocal microscopy and even hand held microscopes now available for the pursuit of anatomical, physiological and medical research and diagnosis.

Since the discovery of X-rays, developments in medical imaging have provided a powerful tool of investigation allowing visualisation of the body in detail never before seen [22]. The combination of postmortem cadaveric dissection and imaging techniques of live patients has proven to be an important technique in understanding the anatomy and physiology of the live animal [23].

1895 saw X-rays observed for the first time by German physicist Wilhelm Roentgen [24]. By imaging his wife's hand, Roentgen deducted that bone and metal were opaque on radiographs and medical uses of the technology quickly followed [25]. Marie Curie used a portable X-ray unit to visualise skeletal trauma in soldiers on French battlefields [22]. Whilst, the use of X-ray crystallography was vital in understanding the genetic code, which in turn has had an enormous impact upon the understanding of physiology [24].

In later years, Godfrey Hounsfield expanded the use of X-rays by developing computer software that could integrate multiple radiographic images to give a three-dimensional view inside the body [26]. This was the discovery of computed tomography (CT) [27]. CT had a significant advantage over radiographs alone as it allowed the distinction of different soft tissue types to be visualised [28]. In 1971 the first CT scan of patient took place, successfully scanning the brain for a tumour in the frontal lobe [29]. The invention of CT had vital practical applications, and as a result, Hounsfield was awarded the Nobel Prize for Physiology or Medicine in 1979 [26].

The risks of using ionising radiation were acknowledged, particularly regarding imaging of the foetus, and as such, a reduction in use of X-rays was seen and replacement with ultrasonography and magnetic resonance imaging occurred [24]. Ian Donald pioneered the use of ultrasound in obstetrics and gynaecology in a paper published in 1958 [30]. Since this time, two-dimension ultrasound techniques have been significantly developed and three-dimension ultrasound can map and quantify blood flow [31]. Ultrasound has been a critical milestone for medical imaging and a fundamental method of non-invasive research [32].

However, the breakthrough of magnetic resonance imaging (MRI) has become a vital diagnostic and research tool in recent years [33]. Nuclear magnetic resonance was originally discovered by Felix Bloch and Edward Purcell in 1946 and formed a foundation for the development of modern day MRI. The use of NMR was developed by Paul Lauterbur when he applied gradients to magnetic fields to create a two-dimensional image and Sir Peter Mansfield developed methods of/slice selection and creating and interpreting images. These advance resulted in the development of MRI as we know it now [33] and the men shared the Nobel Prize in Medicine or Physiology in 2003. MRI is an important medical imaging tool, using no ionising radiation and providing a practical alternative to invasive procedures [34].

A recent development in imaging is that of imaging mass spectrometry that allows tissue samples to be visualised on a molecular level without labelling with chemicals or antibodies [35]. The mass spectrometry imaging technology was developed by a group of physicists, including Caprioli and the technique is particularly sensitive for use on proteins and peptides [36]. This technology however cannot map the transcriptome and a new technique, mass spectrometric imaging, has been developed as a result [37].

Moving forwards, it is predicted that radiography will progress to tomography based methods as opposed to projection based and molecular imaging may become more popular [38, 39]. It is also very likely that the field of imaging will continue to develop and give us deeper insights into anatomy and physiology [38]. Imaging is a key part of both anatomy and physiology but by no means the only tool used. We can see the advances made in imaging but many tools have either developed over the years or been discovered in more recent years. Genetics has revolutionised the worlds of anatomy and physiology for example. Understanding cellular and molecular biology alongside anatomy and physiology has become essential in the research we undertake today. Anatomy seeks to understand the structure, location and composition of the parts within organisms and their relationships with each other. Physiology seeks to understand the functions and processes of organisms, how they work and ultimately assist with understanding and treating diseases and disorders. Therefore whilst imaging is essential for both of these practices, the continued development and discovery of more tools are needed in order to further our research. Much of the work in this book uses these techniques, or a combination of them in the pursuit of advancing anatomical and physiological knowledge and understanding.

3. Women in veterinary medicine, anatomy and physiology

This book is part of the IntechOpen's 'Women in Sciences Book Collection'; therefore, it seems appropriate to discuss some of the women who have worked in anatomy and physiology, the history of women in veterinary medicine and the present day situation. As with most of the sciences, the majority of people already discussed in this introductory chapter are men. It is not that women were not making advances in science, rather that they were historically less likely to be working in these areas.

Claude Bourgelat founded the first veterinary school in Lyon 1762 [40]. The UK's first veterinary school, The Veterinary College in London, was not opened until 1791 [41]. At that time, there were no regulations to study veterinary medicine and practitioners often had no formal training [42, 43]. Fifty years later the Royal Charter 1844 allowed the Royal College of Veterinary Surgeons to be created, giving the profession recognition [44, 45]. The Veterinary Surgeons Act 1881 distinguished qualified practitioners from those who were unqualified [45]. Veterinary work was originally centred around the horse, with many veterinarians employed in the army and public services [41, 46]. When engines evolved and horses less in demand, the number of equine veterinarians diminished so the profession then began to focus on farm animals and livestock [41, 46, 47]. During the mid-twentieth century the interest in companion animal care increased and the small animal sector grew [46].

The number of women in anatomy and physiology research has grown over the years. These women have a background either in veterinary medicine or in the basic sciences (biology, anatomy, animal science) or even transfer from human medicine and anatomy to veterinary research. The first UK female veterinary surgeon was Aleen Cust who completed her training in 1900 at Edinburgh Veterinary College. At this time, the Royal College of Veterinary Surgeons refused her membership and therefore Cust could not obtain a diploma from the RCVS [48]. It was not until 1922 when Cust obtained her full RCVS membership aided by The Sex Disqualification (Removal) Act of 1919, which forbade the discrimination of women [48].

Mary Brancker was the first woman president of the British Veterinary Association and a key founding member in the Society of Women Veterinary Surgeons [49, 50]. Brancker was incredibly influential and she obtained an OBE for her work during the foot and mouth disease outbreak in 1967–1968. Additionally she was awarded CBE for her contribution to animal health and welfare in 2000 [49. The influence of women in veterinary medicine continued to grow as Dame Olga Uvarov became the first woman president of the RCVS in 1976 [51].

In recent years, the veterinary profession has seen a substantial increase in the number of female veterinary surgeons, despite being a previously male-dominated occupation. Removal of gender discrimination, such as the Women's Education Act of 1974 in the UK and similar movements and laws around the world, has been fundamental in allowing females to gain admission to veterinary colleges [52, 53]. In 2006, 51% of UK working veterinary surgeons were female [54] and by 2014, this number had increased to 57.6% [55]. Women now represent around 80% of veterinary medicine and science graduates in many countries including the United Kingdom, Slovenia and the United States of America however there is still thought to be a divide in the types of areas they later decide to work in [52]. The decrease in the number of men applying to veterinary colleges is thought to be due to declining salaries and pre-emptive flight—men are discouraged from entering the profession due to the increasing number of women [56, 57]. Although there are many historical reasons why fewer women entered the profession, it is clear that throughout the world the numbers of women entering the profession are increasing.

The demographic shift of the profession is not unique to the UK—it has occurred globally. In 1963 there were as few as 277 qualified female veterinary surgeons in the United States [58]. In 2017 females accounted for 55.7% of the total United States veterinary professionals [59]. Similarly, statistics in Canada showed that, in 2017, 55.8% of veterinary surgeons were women [60] and females now make up 80% of the Canadian veterinary student population [61]. In Australia 2010, 50% of registered veterinarians were female [44].

In other countries, feminisation of the veterinary profession has occurred at a slower rate. In Turkey, the proportion of female graduates was 26.2% between 2000 and 2005 compared to only 4.9% between 1975 and 1979 [62]. In Iran, women were previously banned from studying veterinary medicine. However since these restrictions were lifted the number of female veterinary students increased to 51.1% in 2003 [63].

In the past, many veterinary colleges stated they did not want female admissions—many believed women were not strong enough to handle large animals and were too sentimental to cope with the challenges of the work [43, 53]. Today sentimentality is considered vital in veterinary medicine, particularly when working with emotional clientele in companion animal practice [43]. The trend that more female than male graduates enter companion animal practice [43, 59, 60, 64] has posed the question whether the large animal industry will suffer [57]. However it has been highlighted the use of safer chemical restraints has eliminated the significance of physical strength, making the large animal sector more appealing to woman practitioners [53].

Despite increased numbers of female veterinary surgeons, practice ownership is still largely male dominated [46, 54, 65]. Only 6.5% of UK female veterinary surgeons held a director position in 2014 [66]. It is widely known that employees earn lower incomes in comparison to practice owners and directors [46, 65, 67]. The under-representation of women in practice ownership and increasingly low incomes of female employees could potentially stagnate the income of the entire profession [43, 46, 56, 57, 68]. Although, one study found that 73% of UK female veterinary students aspired to own a practice after graduating [69], indicating that women do wish to take on senior roles in a veterinary business; however may not get the opportunity. Therefore there is a significant wage gap between male and female veterinary surgeons but this also extends to starting wages. Full time starting salaries of male veterinarians were $56,433 compared to the female veterinarian mean full time starting salary of $48,722 in the United States [64]. One of our recent reviews also looked at women in academia in the sciences, including veterinary medicine and the basic sciences in order to show details such as reduced career progression, reduced income and other gender inequalities still present in academic institutions throughout the world [70].

At the beginning of this introductory chapter we listed just a few of the anatomists and physiologists from throughout history but documenting women in anatomy and physiology is sometimes more difficult. For many years women were not expected, allowed or encouraged to undertake education or the sciences in general. A quick look at Wikipedia (as of November 2018) showed just 10 pages for 'women anatomists' and 29 for 'women physiologists' [71]. It is difficult to correlate with the pages for men as these are not a subcategory in their own rights. Some of the anatomists and physiologists included on this site are international renowned, whilst others have made huge advances but are less well known. Italian Alessandra Giliani (1307–1326) was the first documented female anatomist although there is some debate around this matter, but she not only created prosections but was also a surgical assistant and is said to have undertaken research into the circulatory system [72]. In many ways the Italian universities really started a more modern revolution in that women were allowed to study and become academics. Anna Morandi Manzolini (1714–1774) worked as a professor at the University of Bologna as an anatomist, became a member of the Russian Royal Scientific Association and the British Royal Society [73]. Many years later Marion Bidder (1862–1932) an English physiologist became the first woman to do independent research at Cambridge University and also the first women to present her own work at the Royal Society [74]. Vera Mikhaĭlovna Danchakof (1879–1950) a Russian anatomist worked in the field and is often known as 'the mother of stem cells' [75]. At a similar time Katharine Julia Scott Bishop (1889–1975) born in the United States of America co-discovered vitamin E [76]. Around this time more women were able to work within universities worldwide. Ruth Bowden (1915–2001) from India became known for her work on striated muscle disease and leprosy [77] and Ruth Smith Lloyd (1917–1995) was the first African- American to achieve a PhD in anatomy working on fertility in both anatomical and physiological terms. Marian Diamond (1926–2017) born in the United States of America is often considered as one of the founders of modern neuroscience [78]. Mary Anne Frey (1945-present) was not only the chief scientist at NASA but also made real advances in the effects of gravity on the body [79]. Although it is not usual to source from Wikipedia, the aforementioned links may be useful for people interested in obtaining further information about these scientists.

Naturally over the last century a number of women have also won Nobel Prizes. These include Gerty Theresa Cori, Rosalyn Yalow, Barbara McClintock, Rita Levi-Montalcini, Gertrude B. Elion, Christiane Nüsslein-Volhard, Linda B. Buck, Françoise Barré-Sinoussi, Carol W. Greider, Elizabeth H. Blackburn, May-Britt Moser, and Youyou Tu [80]. Whilst not all of these scientists were specifically veterinary anatomists or physiologists, many did use these disciplines to help with their discoveries ranging from therapies against malaria, discovery of HIV, understanding chromosomes and DNA, understanding the olfactory system, early embryonic development, drug treatment discoveries, growth factors and countless other essential works throughout their lives.

The world is not filled with Nobel Prize winning scientists or pages on Wikipedia. It is difficult to ascertain the exact numbers of women in anatomy and physiology worldwide as this encompass both veterinary surgeons and scientists from the biological and biomedical fields. Many teach undergraduate and post graduate students, undertake research, work in industry and have other roles in educational establishments. International organisations such as the World, European, African and American Associations of Veterinary Anatomists and the international nomenclature committees all have female members, committee members and/or presidents and certainly other leading societies have similar situations [81–84]. Looking at the International Union of Physiological Sciences, Federation of

European Physiological Societies, American Physiology Society, Federation of the Asian and Oceanian Physiological Societies and the societies that they represent a similar pattern is observed [85–89].

Attending conferences, looking at the committee members, fellows, members, organising and scientific committees and looking at the literature being produced through books and peer reviewed papers it is clear that women now take substantial leading roles in the instruction of, and research into, veterinary physiology and anatomy. It has to be noted that many societies now also have equality officers (or equivalent) and even sub committees concentrating on women in science, for example the American Physiological Society has a 'Women in Physiology' committee to promote excellence in mentoring, to promote the visibility and success of women in physiology among many other aims [87]. Whilst specific committees, networks or similar activities are not always evident it is important to note that over the centuries and more recent decades the people involved in the sciences in general, and of course physiology and anatomy has changed. Grant funding bodies are starting to recognise that people may take career breaks including parental leave and undertaking blind reviewing of grants, more journals are trying to combat unconscious bias in all areas by conducting blind reviews of papers, many institutions across the world have, or are implementing equality charters.

Evidently, women may still face challenges with regards to unequal pay, gaining leadership roles, recognition within their fields and even in many parts of the world being able to achieve an education which allows them to succeed. A similar situation can be observed for many men of course. However, there has been considerable progression for women in the field of sciences since the 1900s so hopefully these issues will be overcome in future years.

This book contains anatomical and physiological reviews and original research from across the world. Perhaps one of the greatest strengths of veterinary anatomy and physiology is the diverse research which we see from all over the world. This book contains work in a variety of species including the horse, dog, cattle and chickens. It covers areas such as the heart, tendons, prostate gland, and the hoof. In addition it covers not only normal anatomy and physiology but also diseases, disorders and blends in information for those in the veterinary professions.

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